Association of Southeast Asian Institutions of Higher Learning Seminar

PROCEEDINGS

The Role of the ASAIHL in Combating Health Hazards of Environmental Pollution

June 17 - 20, 1992
The University of Hong Kong

Editors

A J Hedley, I J Hodgkiss, N W M Ko,
T L Mottershead, J Peters, W W-S Yim

HKU 80TH ANNIVERSARY
香港大學八十週年

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THE ROLE OF THE ASAIHL IN COMBATING HEALTH HAZARDS OF ENVIRONMENTAL POLLUTION

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Correspondence

External Relations Office
The University of Hong Kong
Pokfulam Road
Hong Kong
Tel: (852) 859 2608
Fax: (852) 858 4986

ASAIHL Seminar on The Role of ASAIHL in Combating Health Hazards of Environmental Pollution

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CONTENTS

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SEMINAR ON THE ROLE OF THE ASAIHL IN COMBATING HEALTH HAZARDS OF ENVIRONMENTAL POLLUTION

Wang Gungwu
Vice-Chancellor's Office, The University of Hong Kong

It gives me very great pleasure to welcome you to Hong Kong and to this ASAIHL Seminar hosted by The University of Hong Kong in its eightieth anniversary year. It is a great honour for me to be invited to deliver this keynote address. My qualifications to do so must be regarded as distinctly suspect. Historian by training, Vice-Chancellor by trade, and part-time public administrator dealing, in the best amateur tradition, with a wide range of perplexing and apparently intractable issues. Just enough knowledge to get into trouble; not enough to find the solutions.

THE UNIVERSITY OF HONG KONG

Before I address the main theme of this seminar, perhaps I may be forgiven if I dwell for a few moments on the place of The University of Hong Kong. As you already know, this seminar marks the beginning of a year long programme of celebration of the eightieth anniversary of the start of teaching at the University. You might think that an eightieth anniversary is of little significance except perhaps as a sign of moderate longevity. But we see this anniversary as a first step in moving towards our centennial anniversary. We are not merely embarking on a celebratory programme but upon a programme of effective work and development for the University which will extend over the next twenty years and into the new century. This will be a time of great change for Hong Kong and for the University. It will be essential for the University to have a firm sense of identity and mission in its future activities. To this end we are discussing within the University the nature of its mission and identifying the objectives and goals that will help the University chart its path through the nineties and into the twenty-first century. One element of that process depends upon the University continuing to recognize that it is part of the community in Hong Kong and, wider afield, part of many international communities including that represented by the ASAIHL.

INTRODUCTION

It would be inappropriate in this address to try to direct you to the conclusions which may emerge at the end of this seminar. What I would like to do is to address to you some of the concerns and values which I believe are important to ordinary people. And, as the head of an ASAIHL institution, perhaps I have some standing to comment on the theme of the seminar: the role of the ASAIHL institutions in combating health hazards of environmental pollution.

Ten years ago the ASAIHL held a seminar in Bangkok on the 'Role of the University in rural development'. The Proceedings of that seminar make brief mention of environmental and health issues but it cannot be said that they were a major theme. Ten years later it is difficult to imagine that, if such a seminar were repeated, it would be possible to avoid giving considerable attention to the impact of development on the environment and on public health. Environmentalism and 'green' politics have become an accepted and increasingly influential feature of public life in many countries.

Today ecology, and the environment, are recognized as vital issues that must be dealt with and are the subject of much popular discussion. A quick glance along the public library shelves will show that this is a leading topic in today's literature. Eyecatching titles abound: 'High tech holocaust'; 'Ecocide'; 'Blue-print for a green economy'; 'Reclaiming paradise'; 'Ozone crisis'; 'Your money or your life'; 'Acid Earth'; and 'The big smoke'. There is no difficulty today in recognizing that we have a problem; the difficulty is to translate that knowledge into effective programmes of action.

We are now all too aware of the paradox of progress. We recognize that industry-based development, pioneered in the western world and now emulated world-wide, brings with it very heavy costs. Richard Feynman, who was to receive the Nobel Prize for Physics, spoke in 1955 on the value of science. He quoted a Buddhist saying:

> 'To every man is given the key to the gates of heaven; the same key opens the gates of hell.'

The key, Feynman said, may be a dangerous object to use. But it obviously has value since how can we enter heaven without it?

Mankind has to resolve the dilemma of how to make use of this limited resource, the Earth, without turning it into a hell.

Feynman was speaking about scientific knowledge but what he said applies with equal cogency to the process of seeking solutions to our environmental problems. He recognized that how scientific knowledge is used, and whether it is used for the good of the society or to its detriment, is not a matter for the scientist alone but for everyone. And environmental problems demand solutions that depend not only upon technology but also upon political and other social factors. Feynman recognized that, in dealing with scientific knowledge, we have to contend with feelings of ignorance, doubt and uncertainty; and that these feelings are inseparable from the process of making progress: we must recognize our ignorance and leave room for doubt. Doubt and discussion, he said, were essential to enable us to progress into the unknown.

> 'If we want to solve a problem that we have never solved before, we must leave the door to the unknown ajar.... We are at the very beginning of time for the human race. It is not unreasonable that we grapple with problems. But there are tens of thousands of years in the future. Our responsibility is to do what we can, learn what we can, improve the solutions, and pass them on. It is our responsibility to leave the people of the future a free hand.'

Surely this is the perspective from which we should be considering environmental problems. But are we leaving the people of the future a free hand? It is all too easy for us to play down the costs of development, or to pretend that we have dealt with them, or to hope that our descendants will find some way to pay them off. They'll be more advanced than us. Won't they?

Yet we surely have at the very least a moral obligation to mitigate the ill-effects arising from our pursuit of progress. That should be motive enough for us to develop policies for the environment and to do our best to minimize pollution and the dangers it represents. But even if we are not so forward-looking, even if we turn a blind eye to our descendants, it has become an inescapable fact that many of the costs of progress have to be paid now. We ourselves are threatened by the dangers of pollution, and no less so because we have brought them about ourselves.

Environmental awareness has become a matter of self-interest and surely that must be a powerful incentive for us to do something about it!

As it is we can accept on an intellectual plane that pollution causes immense harm. And yet we still try to evade the consequences; we explain away our actions; we avoid the inconvenience that changing our lifestyles would bring about; we make excuses - we cannot call them reasons - to justify our lack of effective action.

The problems that you are to address over the next few days do not belong only to one country or one continent. Let me quote Feynman again:

> 'the imagination of nature is far, far greater than the imagination of man.'

We are dealing with elemental forces beyond our present understanding. What we do today may have profound consequences that we can only guess at. It has been argued, especially since the end of the Second World War, that the pace of progress has become so rapid that it threatens to run out of control and to bring disaster. Mankind, it is said, stands at a watershed and how it chooses to direct its relationship with its environment will determine the very future of mankind. I cannot pretend to judge how close we have come to the point of no return. The threat of nuclear warfare, at least among the great powers, appears to be receding. But surely it would be rash to rule out the possibility that by some more insidious, unconscious means we may be storing up the seeds of our own destruction. We may not know until it is too late. In our present state of knowledge and understanding we are hardly in a position to judge the possible consequences of our present actions. The Earth is resilient and over billions of years has undergone extensive changes. We ourselves are not so resilient. Many more species have come and gone than now exist. We have drawn an evolutionary tree and have placed ourselves at the top creating the illusion that we are the purpose of it all. But we are deluding ourselves if we believe our own propaganda and assume that we have acquired the right to plunder the Earth's resources without fear of reprisal. It is surely right for us to draw upon those resources, but we must do so intelligently, making full use of the moral and intellectual qualities and capabilities which we believe have brought us to predominance.

We must achieve harmony between satisfying our needs on the one hand and, on the other hand, mitigating the consequences which the satisfaction of those needs may bring to ourselves and to later generations.

POLLUTION IN SOUTHEAST ASIA

Pollution and destruction of the environment are commonly associated with the older industrialized countries in North America, Europe and the former Soviet Union. We in Southeast Asia however can claim no exemption from these problems. I would mention two reasons: one is that the inter-relationship of all things on this planet is so complex that ultimately whatever happens in one country is likely to affect all other countries; and the second is that in the last twenty or thirty years the countries of Southeast Asia have undergone very rapid industrialization which has transformed their way of life and has brought with it many of the problems previously associated mainly with what used to be called the 'developed' world. For better or worse the western lifestyle has many attractions and is much emulated, sometimes, it must be said, without adequate consideration being given to the difficulties which have arisen in the original industrialized countries.

Hong Kong well encapsulates many of the difficulties associated with rapid progress. There is much to admire here in terms of initiative and hard work but behind the cliches - 'the bustling city'; 'the crossroads for Asia' - lie the reality of over-crowded housing, heavily polluted waters, recreational beaches unfit for human use, noise, excessive traffic, incessant building works, and filthy air. We have made tentative steps towards better control of noise, waste disposal, fouling of the air, and the like. But it's a long hard road. It is not difficult to understand why. More responsible environmental policies require a great commitment by the individual. Is it fair to expect small businesses, profit margins razor thin, to pay the cost of the new machinery and processes needed for industry to work in more environmentally friendly ways? From the community point of view the answer might well be yes. But what incentive is there for the individual when the benefits of his sacrifices may not be seen in his time? The individual's contribution is important. But effective environmental policies need to be organized on a massive scale. And that can only be done by governments.

What we need most - and lack most - is political will. And this demands that governments everywhere accept the problem of pollution as one of the most important political and social issues of our time. There is a real conflict of interests here. There are many governments - and Southeast Asia has its fair share - whose purpose is national or personal enrichment regardless of the consequences. Spending money on the environment is not seen as a good investment.

This is not just a local problem for Hong Kong or a regional one for Southeast Asia. The global political community has a poor record in facing up to the world-wide threat created by environmental pollution. This is not for want of fine talk. This month in Brazil the environment has been the subject of what might have been one of the most influential conferences ever held. It is a sign of the importance of the subject that such an event should take place, and that the movers and shakers of the world should feel obliged to be seen there, however reluctantly. But it is disappointing - not to say chilling - to read widely publicized assessments that the conference has had no real value in developing effective world-wide policies for the environment. It is a sad reflection on the nature of the international political and diplomatic process that such wealth of political talent should assemble with so little result.

The political will to deal with pollution will come about only if there is widespread and deeply felt social concern about the environment and the effects of pollution on the community.

Whatever its failures, perhaps the Earth Summit in Rio may remind each of us that our future lies in our own hands. As the world has rediscovered in recent times, people find value, meaning and significance in their own lives, their own families and communities. Action on a global scale will come about only when pressure for it wells up from millions of individual and small communities throughout the world.

THE ASAIHL INSTITUTIONS

The theme of this seminar is 'The Role of the ASAIHL in Combating Health Hazards of Environmental Pollution'. I said earlier that I would not try to suggest what conclusions this seminar might reach, but I can't help offering a few comments. I would suggest that the ASAIHL institutions are uniquely well-placed to play a vital role in combating pollution and the hazards which it poses to our health.

The breadth of academic interest in these issues may be seen from the membership of the organizing committee for this seminar which includes members from every faculty in The University of Hong Kong; and from the diverse backgrounds of the participants: the biological and physical sciences, education, medicine, environmental planning, psychology and law. In every member country of the ASAIHL the institutions of higher learning are deeply concerned about the problems of pollution and health. The institutions are helping to identify these problems through their research. They are promoting and developing awareness of the problems through their teaching. They are training specialists in the medical and other fields who will play a key role in monitoring community health and in providing health care and education. They are providing graduates in other disciplines with an understanding of environmental and pollution issues that will stand them in good stead in careers in industry, community service and public life. They offer independent advice to governments on policies to minimize pollution of the environment. They provide the expertise in technology and management that is essential for those policies to be put into effect.

The institutions of higher learning are repositories of meticulously acquired knowledge and experience. They are multi-disciplinary and can bring many points of view to bear on problems. They are dedicated to excellence and integrity in the conduct of their teaching and research. They are a source of new technologies that offer ways to develop alternative industrial processes and materials.

Most importantly of all, our institutions of higher learning can offer leadership, not in the sense of directing the community, but of enlightening and informing it through soundly based rational exposition. Education has long been recognized as a powerful and influential tool in shaping nations. Let us use it as a tool to combating pollution as a threat to life and health.

We have grounds for hope. We have acknowledged the problem and this is an essential first step. We have begun, in small ways, to introduce environmental awareness into our primary and secondary school curricula. I am glad to say that in Hong Kong the subject is being integrated into the school timetable and not just as an isolated topic but as a part of many subjects.

WORK ON POLLUTION BEING CARRIED OUT HERE

I don't want to seem parochial or to seem to be blowing the University's own horn but, since I have mentioned the very serious pollution problems in Hong Kong, let me mention also some of the work that is going on in higher institutions here that we hope may result in reducing the problem. As you would expect, the Faculty of Medicine has a strong interest in the health hazards of environmental pollution. The Department of Community Medicine has taken a leading role and is carrying out research in collaboration with the Department of Paediatrics on the effects of air pollution on the respiratory health of primary school children. It is also looking at the effects on children's health of smoking in the home. The Department of Paediatrics has surveyed over 6,000 school children from all over Hong Kong and, I am glad to say, has learned that lead overload seems to be much less of a problem here than in some other major cities. They have also found, however, that lead overload is very common among fishermen's children, perhaps because of the use of lead-based paints on boats and the use of lead weights.

The Department of Civil and Structural Engineering has been carrying out work over the last ten years which has led to better understanding of the assimilation of sewage in the sea. This will result in better design of sewage outlets and help to maintain water quality standards. Recent research findings by the Department have been endorsed by the United Kingdom Water Research Centre and have gained international acceptance. The Department has also been carrying out research into the algal blooms and red tides which can cause severe oxygen depletion in the sea and kill fish in vast numbers.

The Department of Electrical and Electronic Engineering is studying the effects of fluorescent lighting on the eye. The flickering of these lights is too fast to detect with the naked eye but may cause damage to sense, is thought to cause fatigue to the iris. The Department is also working on advanced electric vehicles which may contribute to reducing carbon dioxide admissions and noise levels.

The Department of Industrial and Manufacturing Systems Engineering has studied exposure to noise and hearing loss among industrial workers. And the Department of Mechanical Engineering is working on catalytic and thermal incineration techniques for controlling combustibles and odours, and for dispersing pollutants. This work has practical use in determining the location of heavily polluting industries, something of particular importance in a place as small and densely populated as Hong Kong.

The Faculty of Science has a number of first-degree and graduate courses on the use and protection of environment. The BSc programme in environmental science covers aspects such as the general ecology of Hong Kong and world habitats; the physical environment, the chemistry of pollution, environmental physics, health risks, and conservation and pollution control. These courses include teaching from outside the Faculty, especially by the Departments of Computer Science, Geography and Geology, and Statistics. The masters programme in environmental management involves teaching by eight of the nine faculties. It deals with management of the environment by defining problems, outlining and implementing solutions, and monitoring the results from the points of view of economics, public health, and legal and political constraints. Research in the Faculty deals, for example, with accumulation of heavy metals and other toxins by plants and animals; sewage and animal waste pollution in freshwater and in the sea; monitoring of food additives, mercury and organic vapours in the environment; and methods for controlling various environmental pollutants.

Many members of the University take an active role in promoting environmental awareness among the general public through membership of government committees and other organizations such as the World Wide Fund for Nature, and through the press and broadcasting.

I mention these activities at our own University because they are, as it were, close to home. But I do not want to give the impression that no one else in Hong Kong is working on pollution problems. Our sister institutions, the other universities and the polytechnics, all have extensive programmes of research and teaching on environmental matters; and in order to combat pollution hazards successfully, it is essential that the problems be tackled comprehensively by such widely-based efforts.

And, lest omission be taken to imply neglect, I must pay tribute too to the Government Environmental Protection Department which provides an important channel through which those of us with an interest in, and knowledge of, pollution hazards may inform and influence policy makers in the Government.

In addition, I should also mention the system of consultation between the Hong Kong government and the public which allows us a further avenue of activity, with staff of the local institutions sitting on Boards and Committees advising the government on the environment and thus directly influencing the development of government policy and legislation. It would be invidious for me to single out any of my many colleagues who give up their time to advise the government in this way. I will, therefore, limit my remarks to the Advisory Committee which I have chaired for nearly four years: the Environmental Pollution Advisory Committee, or EPCOM, as an example of what can be done.

EPCOM is the government's principal advisory body on pollution control matters. The Committee is there to keep under constant review the state of pollution in the outdoor environment; and also to advise the government on appropriate measures to be taken to combat pollution of all kinds. It is a statutory requirement that EPCOM should be consulted on issues relating to new legislative proposals and implementation of existing pollution control measures. EPCOM's advice is also sought during the formulation of major policy initiatives on environmental protection. The Committee includes representatives of major groups, notably elected members of the Legislative, Urban and Regional Councils and District Boards as well as environmentalists, industrialists and academics.

Some of the recent concerns of EPCOM are directly related to the health of the community. For example, the strategic plan for sewage disposal for the whole territory. The Committee recommended that individual Sewerage Master Plans be produced for different areas to ensure that all sewage and industrial effluents get into the foul sewerage system. After treatment, these effluents will eventually be disposed into a long sea outfall. Given the limited resources available for new projects and the large capital commitment required for implementation of this strategy, the Committee has been greatly concerned about the funding requirements for the various sewage related capital programmes. EPCOM advised urgent action and the government has agreed to explore financing alternatives in order to get this much needed work done. This is now being pursued and extensive consultation is going on to find a feasible solution.

It has to be said that progress has been made over the past few years. As another example, I might mention that the entire territory was declared an Air Control Zone, and air quality objectives were set in order to provide a sound basis for air quality management. This was followed by controls on the sulphur content of industrial liquid fuel and dark smoke emissions; also controls to combat pollution from vehicle emissions. The most recent piece of legislation recommended is an amendment to an earlier air pollution control bill and this will go to the Legislative Council later this month. It will tighten general control over polluters and in particular help us control a well-known health hazard, asbestos in buildings.

EPCOM has also given special emphasis to environmental planning. Although there has been a greater desire within society at large to address environmental matters in recent years, the lack of adequate planning controls in Hong Kong has tended to lead to the creation of new environmental problems by permitting incompatible uses to be developed in unduly close proximity to one another. This has led EPCOM to pay special attention to current government practice on the handling of Environmental Impact Assessment (EIA) studies. As a result, the government has agreed that all EIA reports will in future be made available for public information. This means that various interested and expert groups, including my colleagues in the tertiary institutions, will have access to such information. In this way, our tertiary institutions can be more actively involved not only in reducing pollution but also in preventing it. I certainly look forward to the time when government and the universities and polytechnics can work ever more closely together on such key matters affecting the health of the community.

After those practical comments, let me end on a more general note. The Southeast Asian institutions of higher learning serve diverse communities and nations each with its own traditions, priorities and ambitions. Inevitably their nature and their missions must be defined largely by the needs and directions of their own countries. The imperatives of national development and of social and economic progress make heavy demands upon citizens. Sometimes these demands may seem incompatible with the ideals of academic freedom of enquiry and expression. Whatever ideals we may have about academic freedom and independence, our institutions must also reflect the values and aspirations of their own societies. Nonetheless, I believe that, without any suggestion of disloyalty to one's own culture or country or society, the institutions of higher learning, and their members, owe further obligations not only to the international community but also to humanity. In conducting our research and teaching, let us fulfil all our obligations with integrity. Only then can we defend our work and make it count in meeting the real dangers which the world faces today.

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SINGAPORE
THAILAND

AUSTRALIAN APPROACHES TO FINGERPRINTING SOURCES OF ENVIRONMENTAL LEAD WITH ISOTOPES

BL Gulson
CSIRO Division of Exploration Geoscience, NSW, Australia

INTRODUCTION

Lead is a neurotoxin with no useful physiological function and is especially dangerous to children[1,2]. This metal is also ubiquitous in the environment, with levels in both man and his environment occurring at levels about 1000 times above natural concentrations[3].

It is of critical importance to be able to identify the source(s) of Pb in humans where they are present above "levels of concern"; the U.S. Centre for Disease Control (CDC) has recently recommended that at a blood lead level (PbB) of >15 mg/dL in children, intervention measures are undertaken. The normal method for identifying sources is to analyse samples for Pb (and sometimes other metals) content but this approach only gives estimates of the amount of Pb present, or illustrates that there is a potential problem, for example, from leaded paint.

An alternative approach is to use the lead isotope "fingerprinting" method. Lead has four isotopes 208, 207, 206 and 204, the first three of which can vary in abundance depending on their geological source. For example, geologically old (about 1700 million years) Broken Hill Pb in Australia has an abundance of 206Pb to 204Pb (the 206Pb/204Pb ratio) of 16.0 whereas many of the geologically young deposits (<100 million years) of Southern China have values >18.5.

The lead isotope method has not been widely exploited in environmental/health studies because sophisticated laboratory and measuring facilities are required. Chemical separations for Pb are carried out in "clean" laboratories and the isotope abundances recorded as ratios are measured by thermal ionisation mass spectrometry.

The potential of the lead isotope method[4,5] will be illustrated by four examples, one involving a lead mining community, two involving water systems and the fourth, on food (wine).

TYPES AND SOURCES OF LEAD POLLUTION

Example 1: Source of lead in the population of the Broken Hill lead mining community: Even though mining (and earlier on, smelting) has been carried out for more than one hundred years in this city of 25,000 inhabitants, lead as a public health issue has only been recognized in the past 12 months. The issue arose from publicity over high lead (Pb) dust levels in ceilings of houses (up to 3.6% Pb), three children born with delayed visual maturation, and later, a NSW Health Department survey of 899 children aged 1-4 years which identified about 59% of them having a Pb blood level of >15 mg/dL, the CDC level of intervention[6]. As the city is built around mining dumps, they have been identified as the probable source of Pb in the children. To establish the veracity of this hypothesis, lead isotopes were compared in blood and urine from mothers and children with environmental samples including vacuum dust, house dust, ceiling dust, water, food and air. The past exposure experience of some of the children was assessed from analysis of deciduous teeth.

Ceiling dust and house dust from the majority of houses have lead isotope profiles which are similar to that of the ore. House dust from dwellings >1.5 km from the dumps has a more complex profile indicating that the lead may come from a number of sources including petrol and dust from the surrounding region.

Blood lead levels of adult females are low (none >10 mg/dL). In adult males, the levels are variable and appear to be dependent on occupation. Lead isotope profiles in the women are quite different from those in the house dust. This means that although a small amount of lead in their blood at the present time could come from the mine, other more dominant sources have to be considered, the most likely being food, water and air.

Of the 16 children aged between 1 and 14 tested to the end of 1991, none had a blood lead level >25 mg/dL. This, however, does not mean that there is no lead problem in Broken Hill, because the blood lead levels represent recent exposure only and can change dramatically over just a few months. The lead isotope profiles in the children are generally different from those of their mothers and most are quite different from the mine lead profile found in the house dusts. There is, however, a fairly good correlation between the isotope profiles and blood lead contents. That is, the children with higher amounts of lead in their blood have a larger contribution of mine lead but the variability in the data demonstrates that the sources of lead are complex.

Preliminary analyses of dust from air filters indicate that the lead comes from a variety of sources which may depend on wind directions. For example, at one sampling site, on one day the dust appeared to be derived mainly from mine dumps whereas on another day it was from a different source, which may be petrol.

Preliminary analyses of cold tap water gave low but variable lead contents ranging from 0.1 to 3 parts per billion. The lead isotope profiles in the water also vary considerably and cover the range in values detected in the blood.

An estimation of the contribution of food to blood Pb was obtained from *Quarterly Market Basket Surveys* of a city which is the main source of supply to Broken Hill. The lead contents of the food are <10 ppb and this would contribute only a small amount to the body burden of children[7].

In summary: Mine dust is a significant contributor to the body burden of some children in Broken Hill but other sources including air (petrol?), food and water have an input.

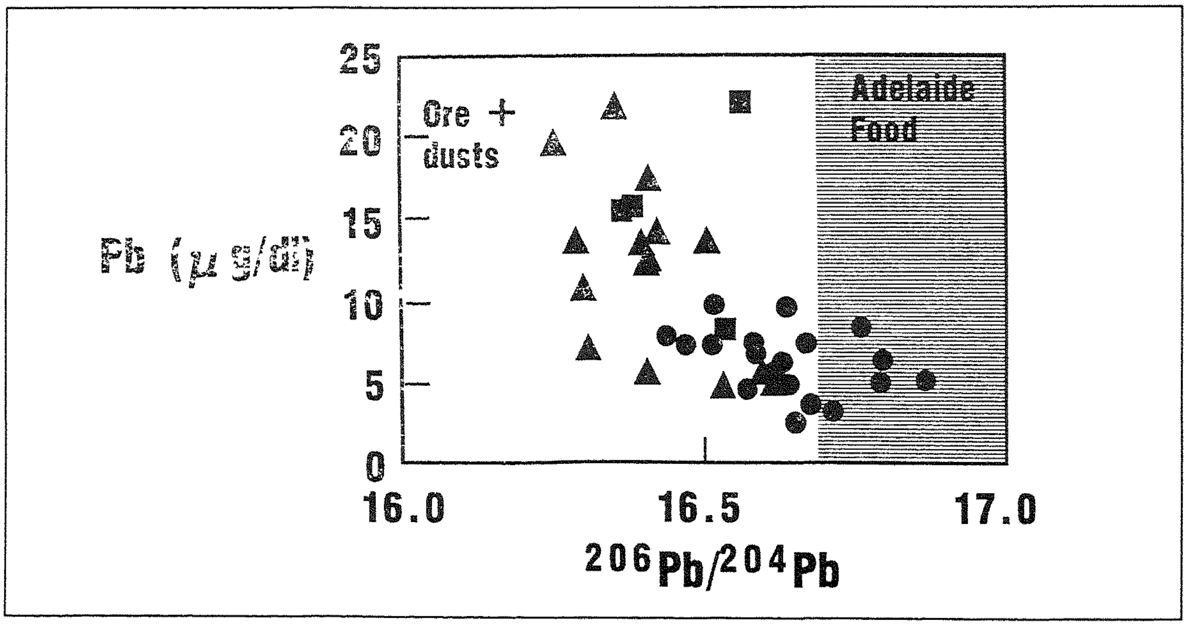

Figure 1: *Blood lead (in mg/dL) vs isotopic values (as 206Pb/204Pb) compared with the range in isotopic values measured in a quarterly market basket survey of food from Adelaide, from whence most of the Broken Hill food is derived. The range for dusts from houses within 1 km of the mine dumps is illustrated by the diagonal hatching. O, adult females; □, fathers; Δ, children.*

Example 2: Monitoring leakage around a uranium tailings dam: Ranger uranium mine in the Northern Territory of Australia has been operating for 11 years. Waste from the milling of the ore is stored in a dam covering about 110 hectares. Any potential leakage from the dam could contaminate the groundwaters and the environmentally sensitive Kakadu National Park.

Lead isotopes in uranium ores have a characteristic fingerprint with 206Pb/204Pb values often >10,000 and low amounts of the thorium-derived 208Pb. For this study, Pb isotopes and Pb contents were compared in water and particulates filtered from the water from the tailings dam and from monitoring bores around the dam.

The 206Pb/204Pb value in the tailings water is >10,000 whereas that in the 'background' bores is generally from 17 to 20. Particulates (0.45 mm+) generally give an enhanced 'signal' compared with the waters of any leakage from the tailings dam as shown in Figure 2. It is possible, using Pb isotopes in the particulates, to observe isotopic differences in different aquifer systems.

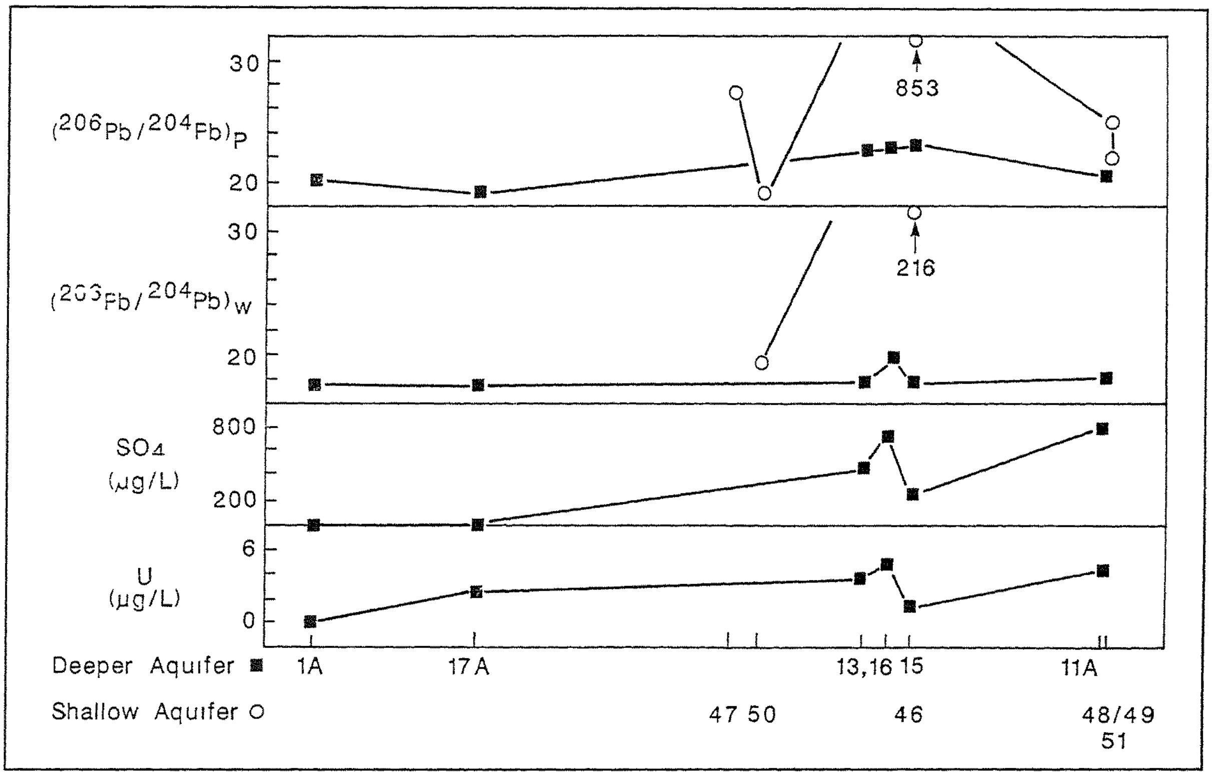

Figure 2: *Variation in uranium (U), Sulphate (SO4) and 206Pb/204Pb values in waters (w) and particulates (p) for sites along the north wall of the Ranger tailings dam for both deep and shallow aquifers*

Example 3: Source of lead in women from Hong Kong: A pilot study with Dr W.S. Yim and Professor C.Y. Yeung of the University of Hong Kong was undertaken to determine if the main source of lead in Hong Kong residents was from drinking water. The Shing Mun (Jubilee) Reservoir in the New Territories obtains its water from streams draining mineralized areas.

Lead isotopes were measured in water from the Shing Mun (Jubilee) reservoir and stream sediments and stream waters draining the reservoirs. These data were compared with blood and urine from females of varying ages from Professor Yeung's staff; the biological samples were collected as a guide for another project on lead in pregnancy.

The blood lead contents for the seven females range from 2.9 to 7.3 mg/dL and compare with the 1980 Hong Kong Study in which the blood Pb for 577 females varied from 1-49 mg/dL with a mean of 13.9; 6.5 mg/dL[8]. The 206Pb/204Pb value for 6 of the 7 women ranges from 17.86 to 18.00.

The isotope values for the bloods are totally different from those in the stream sediments (18.7, 18.8), and some of the stream waters (17.7, 18.3) and reservoir water (17.95, 18.5). These isotopic differences between the blood and some of the waters/stream sediments combined with the very low Pb content of the reservoir water (0.25-0.53 ppb) indicate that the Shing Mun reservoir water has not been substantially contaminated with lead from mines in neighbouring countryside. Furthermore, from this pilot study, it is unlikely that elevated blood leads found in certain Hong Kong residents derive from the water supply, at least at its source in the reservoir.

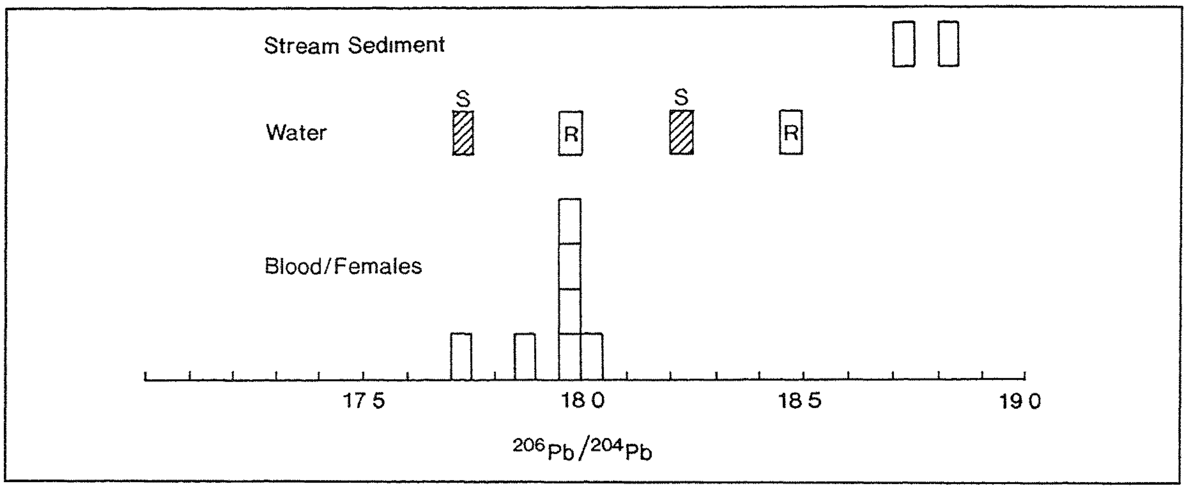

Figure 3: *Histogram showing differences in isotope values for blood from Hong Kong female residents and stream sediments and stream waters and water from the Shing Mun reservoir.*

Example 4: Contribution of tin-lead capsules as a source of lead in wine: Food authorities in many countries have moved to reduce the dietary intake of lead. In this context, wine with a lead content of 0.1 mg/kg is a significant dietary source of lead for a person who consumes moderate amounts of wine daily; e.g. consumption of 250 ml daily, would constitute about 6% of the provisional tolerable weekly intake for an adult as recommended by FAO/WHO[9].

From recent studies it appears that the 'natural' lead content of wine falls in the range 0.05-0.100 mg/kg[10,11]. However, for many years a proportion of wines has been found to contain lead significantly in excess of this range[10,12,13,14]. The data suggest that the latter wines are contaminated with the soluble corrosion products of the tin-lead capsule, either by migration of the corrosion products through or past the cork into the wine or during the pouring process. The corrosion products, which have been shown to consist of lead carbonate hydroxide and its hydrated form are considered to form from the reaction of the acidic wine with the capsule[15].

The problem was solved using Pb isotopes based on the expectations that:

1) the Pb capsules were manufactured from Pb from different mines and would have a variable Pb isotope signature different from the wine, and
2) because of the low Pb concentration in the wine (usually <50 ppb), any Pb drawn back through the cork would be obviously identified by both the Pb content and isotopic value of the cork.

Wines, cork, capsules and corrosion products were analysed from >50 bottles of Australian and some German wines, including bottles with and without capsules, the former with varying states of corrosion. The Pb isotopic composition of the wine was the same for bottles with and without

Pb capsules even though the wine leaked out through the cork and reacted with the capsules. Furthermore, no Pb concentrations or Pb isotopic gradients were discernible from analyses of different segments of corks - except for the top 1-2 mm. However, for bottles with corroding Pb capsules, Pb can be introduced into the wine either by pouring, during which the wine dissolves the soluble Pb compounds on the neck of the bottle, or by entrainment of Pb through the cork if the bottom of the cork is pierced during its removal.

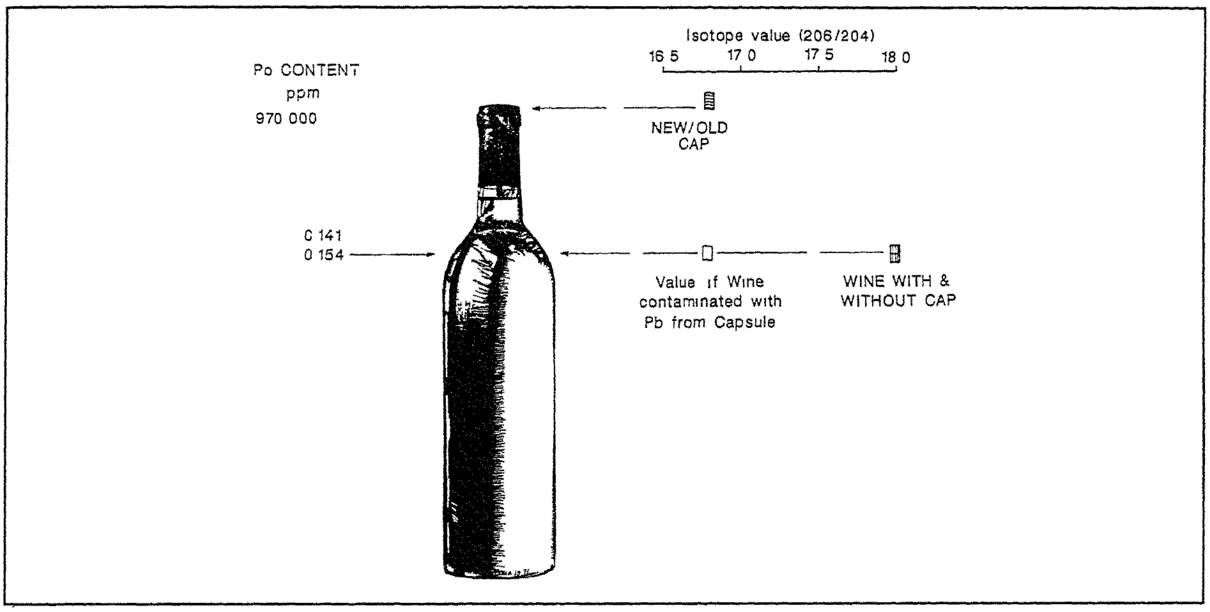

Figure 4: *Lead isotope and lead concentration data for a 1976 German white wine with and without tin-lead capsules. The capsule contains ~97% Pb.*

CONCLUSIONS

The lead isotope method is probably the most powerful available at the present time to identify the sources of lead in the environment and in animals. Other methods can only identify if there is lead contamination or not, and indirectly assign sources.

The lead isotope method is not only useful in assigning sources to higher levels of lead, such as in lead compounds, but as lead is found as a trace element in many other metallic ores (e.g. copper, zinc and mercury) it may be used indirectly to identify the sources of pollutants.

The main disadvantage of the method, as with all others, arises where there are many sources of lead and this mixing gives rise to a mixing of the isotopes. In such cases, it may be difficult to attribute major contributions.

Although inductively coupled plasma mass spectrometry is widely publicised as a low cost approach for measuring lead isotopes, at present, the precision obtainable is too poor to be of significant use, except in the most obvious cases where there are large isotopic differences.

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THE CONTRIBUTION OF HEALTH CARE DEPARTMENTS IN TERTIARY INSTITUTIONS IN HONG KONG TO COMBATING THE HAZARDS OF POLLUTION

AR King
Rehabilitation Sciences Department, Hong Kong Polytechnic

INTRODUCTION

Health care has been undergoing a revolution in the last twenty five years, a sea change in which health care workers have gradually begun to re-evaluate their roles and functions, away from a primary concern with the diagnosis and treatment of disease towards a concentration on the business of prevention. In part this change represents advances in the field of social medicine where it has been progressively shown that improvements in the health status of the population result primarily from changes in people's lifestyles and improvements to the environment, and only secondarily from advances in medical care and the delivery of services. When I was a young man this statement would have been considered very radical and would probably have got me thrown out of the clinic where I worked, now it is pretty much accepted as a platitude, oversimplified but a key concept in our thinking.

A new concern with the environment and the effect it can have on the health status of the population means that health care workers, among many other requirements, need to be better educated concerning the risks that arise from environmental pollution. Unfortunately, it is not self evident how this can easily be done in an already overloaded curriculum which is still dominated by the twin concerns of the diagnosis and treatment of disease. In medical schools around the world, because of their relative poverty, departments of community medicine tend to be small and, dare I say it, not the most politically influential in their institution: As a consequence making space for this work at the possible expense of other concerns is not easy. In the allied health field where I come from, a somewhat different situation exists in so far as teaching still strongly emphasises the acquisition of the necessary techniques for safe practice as the main consideration, with little time left for a more holistic approach to health care provision. Yet the world is changing and, as far as Hong Kong is concerned, there are some good things happening.

In setting out to prepare the country report for Hong Kong I have limited the scope of my enquiry to examining what provision, if any, is made within the undergraduate curriculum of health care workers to sensitise them to the relationships between the environment, health and disease. The results are both encouraging and challenging; good examples of provision being made yet, at the same time, important omissions can be found which challenge our understanding of the needs of health care graduates as they move beyond the year 2000.

TOWARDS A COMPREHENSIVE CURRICULUM ON THE ENVIRONMENT

Before giving some specific examples from Hong Kong, it is helpful to set the scene by summarising current thinking about the nature of the curriculum which ought to be developed for all our graduates, irrespective of discipline, if they are to be considered literate in relation to environmental issues.

Table 1: Necessary conceptual frameworks in environmental education

Modified from McNeil (1986)

Ecological Concepts: carrying capacity, limiting factors, energy flow, biogeochemical cycles, entropy, information, feedback, stability, inter-relatedness, selfishness.

Economic Concepts: scarcity value, resource cost, opportunity cost, benefit discounting.

Socio Political Concepts: ownership, progress, development, world view, culture, altruism, responsibility.

Policy Formulation Concepts: institution, power, boundary, risk, perception, planning, management, significance, phenomenon, problem, issue, policy, trade-off, limited good.

Table 1, which is taken from a recent review of curriculum issues, in relation to environmental education at university level, sets out the necessary conceptual frameworks. I will not go into any of these in detail except to pose the question to my audience as to how many of their students go out into the world at this level of literacy, mine do not. Beyond the delivery of concepts there are many intervention skills to be learned. Not least are those which can be identified from recognising that environmental problems are relative to the costs and the benefits to the individual who engages in the issue. When more than one party is concerned, there is rarely a consensus about what should be done; so that those who intervene on the issue need to see the world as others see it and learn to tackle conflicting views with the skills of advocacy and empowerment in order to be effective in the public arena. This calls for a high level of sophistication in analysing the issues from a variety of different perspectives, as summarised in the decision tree shown in Figure 1. The final point in this summary treatment of curriculum issues concerns the learning objectives we need to achieve in our students if teaching is to be credible, these involve high levels of abstraction as shown in Table 2. This means that a substantial amount of time must be devoted to achieving them, using approaches to teaching and learning which encourage students to be reflective and relational in their thinking.

Table 2: Some desirable behavioural objectives in environmental education

Consider Integrate Examine Develop Relate Emphasise Enable Become	Note: all these behavioural objectives require a high level of abstraction on the part of a student which means that time must be given to developing the relevant competencies. In an already crowded curriculum, establishing a priority for this type of work will require strong leadership and powers of persuasion.

Taking the two issues together, the curriculum and how it should be taught, it is worth going back a few years to an article by Lars Emmelin on the requirements for an ecological education which would be sensitive to the requirements for the year 2000[1]. Here we see an excellent discussion which defines the dimensions which must be explored in any higher education curriculum to make students more able to appreciate environmental issues.

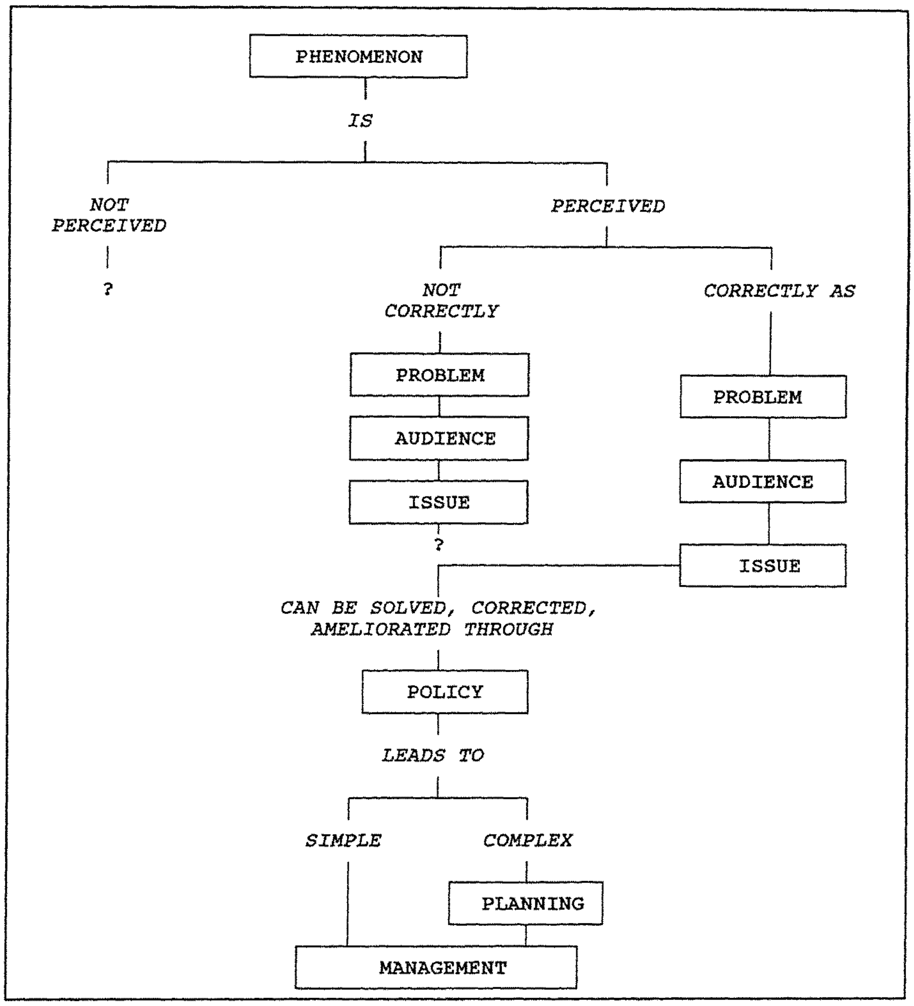

Figure 1: *Concept map environmental education from awareness to action.*

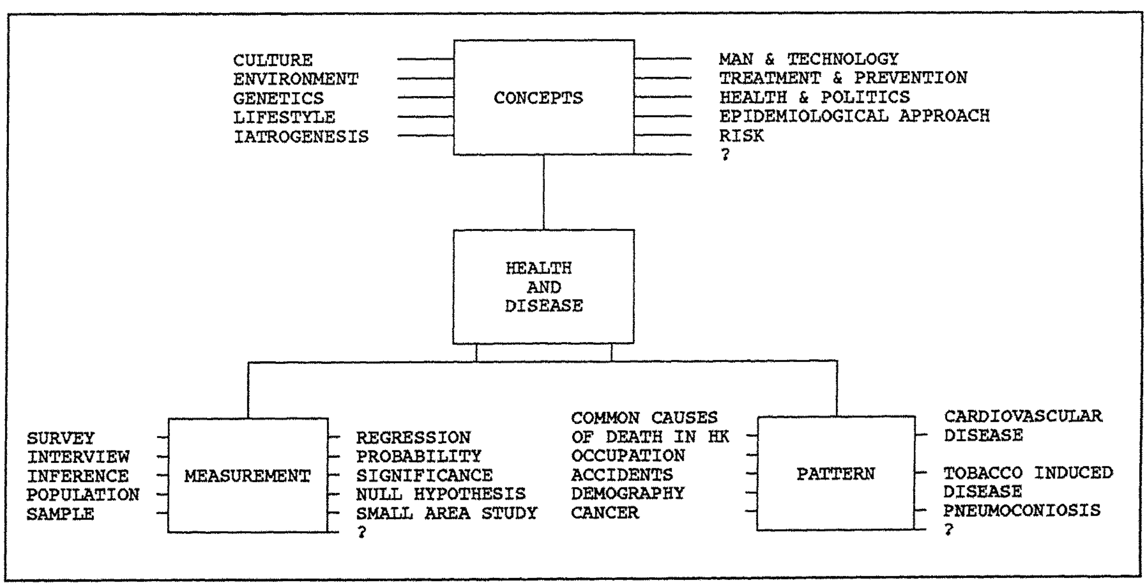

Figure 2: *Key concepts related to environment in HKU programme "Health, Behaviour and Medical Care".*

HEALTH, DISEASE AND THE ENVIRONMENT - A HONG KONG PERSPECTIVE

I now pass to a consideration of what seems to be happening in Hong Kong where I have limited the scope of my enquiry to undergraduate health care workers, as they can be considered as shock troops who will command particular respect in the community when they are able to comment in an informed way on environmental issues. Here I found a particularly good example of the emphasis currently being given to health in relation to the environment in a teaching programme at the Hong Kong University Department of Community Medicine. There, a substantial programme is given to undergraduate medical students under the general title of Health Behaviour and Medical Care, a series of modules taught by specialists in their field. It looks at issues in relation to health and disease in terms of the fundamental concepts, approaches to measurement and the patterns of health and disease that result. A demanding programme of lectures, practical classes, seminars, tutorials and a substantial group project is undertaken early in the undergraduate years so that ample opportunity exists for integration of what is learned in the later clinical years. Figure 2 is a conceptual framework showing many of the key concepts that are introduced to students under various headings; in terms of approach the whole course has a strong bio-social-psychological orientation in which man is situated in relation to his environment and the nature of the resulting interactions explored, with particular reference to the consequences for health and disease. It is a good example of what has been identified as a trend in environmental education, a move from a multidisciplinary technocratic orientation emphasising "reductive analysis of linear cause-effect relations ..... to reflective, contextual analysis of interactive structures, linking parts to wholes"[2].

Pollution finds its place through the many references and cross references to its health consequences, this is covered by material on air and water quality, noise, occupational hazards, environmental tobacco smoke and comparative studies linking the etiology of respiratory illness to those parts of Hong Kong that are particularly affected by poor air quality. The apex of the course is a group study carried out in the summer vacation when groups of about ten students action a live project that they have been designing during the course. While these studies cover a wide range of public health issues, various aspects of pollution seem to have been popular, the following being a sample of the project reports I was able to read recently when I visited the Department library.

- the association between lead exposure and renal function in Aberdeen boatmen.
- respiratory health in Primary 5 and 6 students; effects of smoking and air pollution
- sound pollution in schools; noise related complaints from students and teachers in three schools.
- the contributions of smoking and non-smoking risk factors in chronic obstructive airway disease among HK Chinese.
- will window type air conditioning increase, decrease or have no effect on the prevalence of outdoor air pollution associated symptoms

One feature of these studies which particularly impressed me was the care with which they had been designed, background literature having been reviewed so that clear hypotheses could be set out concerning the likely effects to be observed. All the results were analysed using appropriate statistical techniques, with subsequent discussion showing that students recognised the limitations of the results obtained and the need for further work.

Time does not permit reference to other programmes relating health care students to their environment at undergraduate level in Hong Kong, however, it is fair to state that such work as I was able to find elsewhere did not approach the intensity or the sophistication of the HKU programme. Where this work exists elsewhere, it is often a project which is the culmination of a more specialised professional education so that, for example, students with skills in microbiology can be found analysing water samples; other examples are speech therapists looking at noise problems and radiographers looking at radon emissions in local rock formations. The strength of the HKU approach is to be found in the broad context in which the course operates, giving tools to students to read a wide range of literature intelligently and a research methodology in terms of analysing risk factors to push their ideas forward.

CURRICULUM DEVELOPMENT FOR THE FUTURE

In thinking of the future and the ways in which other institutions like my own might implement a similar curriculum, I find the HKU approach very attractive, however, it consumes a lot of time - several hundred hours in fact - this may be appropriate for medical students but it might be difficult to sell for all the allied health care workers that are trained at the Hong Kong Polytechnic which covers medical laboratory science, nursing, optometry, radiography, physiotherapy and occupational therapy. In planning our curriculum we would need to be more selective, however, we would also need to think more carefully about the likely roles and functions of our students once they graduate as health care workers in their particular fields. It seems that as far as the pollution issue is concerned, it is here to stay for a long time so that health care workers can expect to have to address it in a number of different contexts. I find it helpful to think of the problem in curriculum terms by looking at it in two dimensions; the first is a dimension we can call Specialist versus Generalist, the second Training versus Education. I have made the assumption that only a small percentage of health care workers will ever need to become specialists in the area of pollution, further, that relatively few will need to receive intensive training as opposed to a more general education on the issues. This is not to denigrate the need for specialisms or intensive training, it simply recognises the fact that health care workers will do many other things besides engage with pollution. At the same time the battle to preserve the environment has to be fought across a broad front, both inside and outside daily working lives and we need to do something to ensure that the education of all health care workers does not omit these concerns. Health care workers are well qualified to engage with the public and the media on these issues since they have high face validity as people who have a concern for the health of the community. Yet, they may not wish to engage with public issues in this way unless they can see the relevance and be sensitised to them early on in their undergraduate career.

One way of bringing home to health care students their responsibilities for the environment is through the conduct of audits in their respective workplaces, in particular the clinical settings where they receive training. In these settings it is possible to begin to establish the real costs of existing work practices when compared against the damage such practices ultimately do to the environment. A recent article by Merrilyn Peach in the International Nursing Review showed how this was done at a large 900 bed hospital in Australia[3].

Table 3 shows that in one week, the following disposable items had been used:

Table 3: *Health care economics and technology costs to the environment*

Example: Peach (1991)

Weekly consumption of single use items in a 900 bed hospital

Combine dressings	4,190
Basic dressing packs	2,080
Urinary catheter packs	198
Needles (Jelco, butterfly & hypodermic)	40,384
Syringes (0.5 ml to 30 ml)	30,819

All these items have to be disposed of, either through burial or high intensity incineration; when the real costs of doing this are added to the purchase price, plus the costs of land use for such purposes and the effluent from the incineration, the notion that something which is disposable is also cost effective takes on a new meaning. Peach goes on to make the point that thinking your way out of these practices needs a fundamental change of mindset, away from the idea that Technology equals Progress towards Technology equals Cost. Going backwards is not always reactionary as has been seen in the move towards using terry towel diapers as an alternative to disposable diapers; paper diapers contain dioxins, a family of some 75 organochlorines, when disposed of these chlorines are released into the food chain and accumulate in the body at low concentrations for long periods of time.

Table 4: *International Council of nursing position Statement: The nurse's role in safeguarding the human environment*

The nurse's role is to:

1. Help detect ill effects of the environment on the health of man, and vice-versa.

2. Be informed and apply knowledge in daily work with individuals, families and/or community groups as to the data available on potential health hazards and ways to prevent and/or reduce them.

3. Be informed and teach preventive measures about health hazards due to environmental factors as well as about conservation of environmental resources to the individual, families and/or community groups.

4. Work with health authorities in pointing out health care aspects and health hazards in existing human settlements and in the planning of new settlements.

5. Assist communities in their action on environmental health problems.

6 Participate in research providing data for early warning and prevention of deleterious effects of the various environmental agents to which man is increasingly exposed; and research conductive to discovering ways and means of improving living and working conditions.

ICN Position Statement 1986

Another approach to sensitising health care workers to environmental issues in the workplace is through the preparation of case studies which show how a particular professional group makes a contribution at the present time. A start can be made by collecting relevant journal articles; for example, in nursing and medicine, international coalitions have been formed which have agreed and published agendas for change on environmental issues, workplace policies have been debated and implemented - Table 4 shows a position statement agreed by the International College of Nursing in 1986 which defines the nurse's role in safeguarding the environment. On the same theme but related to the medical responsibilities of physicians in an environment which is undergoing global change, McCally and Cassel[4] have recently set out the kinds of information relevant to this theme that physicians have available to them and which should be made more public as a contribution to preventive health care in the future.

To these case studies can be added a wealth of material which is currently being published which shows how coalitions working for change on environmental issues go about their business, in particular, the difficulties they face and how these can be overcome, when dealing with government departments and vested interests such as the all powerful international cartels and lobbies such as the tobacco industry. The recent book by Martin Raw and colleagues[5] called "Clearing the Air - a Guide for Action on Tobacco" published in 1991, takes an international look at how a number of pressure groups with limited funds have successfully organised themselves to bring about change. Another useful book I have recently read is John Ashton's summation of the Healthy Cities Project, another international review[6].

CONCLUSION

In the space of a short paper it is impossible to do justice to the wealth of approaches that can be adopted to sensitising and educating health care students on environmental issues. Clearly, a key to planning must be to determine at the outset whether one is in the business of training or education. Assuming that education is the primary purpose, in the hope that graduates will later contribute to change both at work and in the community, I would favour a broad treatment of the kind exemplified by the HKU approach though somewhat attenuated to take account of time. To this I would add case studies which bring the issue directly into the workplace of the student. Finally, I would try to build in some kind of participant observation in the community which introduces the student to issues of advocacy and lobbying for change as experienced by various pressure groups within the community such as Friends of the Earth.

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THE ROLE OF INSTITUTIONS OF HIGHER LEARNING IN COMBATING HEALTH HAZARDS OF ENVIRONMENTAL POLLUTION

KG Rampal and N Ismail
Universiti Kebangsaan Malaysia

INTRODUCTION

Much of contemporary environmental pollution has occurred as a result of attempts to improve our way of life. Environmental health-related damage has occurred as a result of attempts in pursuit of development and through the over-use or misuse of natural resources caused by a perceived necessity to meet basic human needs. Inappropriate (non-sustainable) development or a lack of development can also have negative effects on the environment in ways that may lead to detrimental impact on human health and welfare. While industrial pollution has been going on for many years, increased industrial activity and accelerated development of chemicals (about 200,000 new organic compounds synthesized annually and about 1000 put to use) pollution of air, water and earth has resulted in hazards to workers and the general public. Developing countries undergoing rapid industrialisation and urbanisation may be posed with the problem of indiscriminate use of chemicals and uncontrolled discharge of toxic wastes leading to contamination of water supplies. Atmospheric pollution from industry and traffic has also led to airborne particulate levels above permissible limits of concentration.

In Malaysia, although industrialization accompanied by urbanization began in the 1960's concern for the environment grew only in the 1970's, leading to the enactment of the Environmental Quality Act 1974 and the establishment of a Division and then a Department of Environment under the Ministry of Science, Technology and Environment. The Langkawi Declaration on Environment, signed in conjunction with the Commonwealth Heads of Government Meeting (CHOGM) in 1989 in Malaysia, heralded the acceptance of environmental issues as part of the social agenda for Malaysians. With this there has been increasing awareness and concern for health hazards of environmental pollution among policy makers, the general public and also institutions of higher learning.

PRESENT EXPERIENCE AND PRACTICE

Institutions of higher learning in Malaysia play an active role in combating health hazards of environmental pollution through education, research and service.

Education: Universities in Malaysia offer both formal and informal environmental health courses to students pursuing diverse educational programs. These include courses in Environmental Pollution and Environmental Management in the School of Biological Sciences, Chemistry and Environmental Pollution in the School of Chemical Sciences at the Universiti Sains Malaysia (USM). Courses in *sewerage and waste water treatment, water treatment and hydrology* are offered on a regular basis and on *solid waste management and environmental impact assessment* on an ad hoc basis at the Agriculture University of Malaysia (UPM). While environmental health related courses are offered at the Universiti Kebangsaan Malaysia (UKM) a new masters course in environmental management has been approved and will begin this year, 1992. Environmental health is also incorporated into the teaching of community health at all three medical schools in the country and in the Masters of Public Health course offered at the University of Malaya (UM). The Universiti Teknologi Malaysia (UTM) has developed a post graduate degree in environmental engineering while also offering environmental engineering programs at the undergraduate level. Short courses on environmental health-related subjects are offered periodically to the interested general public and industry. Hence it can be seen that universities in the country offer environmental health-related courses in both undergraduate and postgraduate programs while also opening its doors to the general public through its short courses.

Research: Funding for environmental health research is available under the "Intensified Research in Priority Areas" program of the Ministry of Science, Technology and Environment, through University funding and funds available from local and overseas agencies. Academics at the various universities have played and continue to play an active role in conducting research in various environmental health related subjects. These subject areas are diverse in their nature and offer considerable scope depending on the interests of the researcher and the needs of society. The scope has varied in studying problems close to the universities e.g. studies on air pollution (UPM, UM, UKM) and the haze in the Klang Valley (UM), industrial pollution affecting fishing communities of Prai Industrial estate (USM) and lead levels in breast milk in urban and rural mothers (UM). Managing hazardous waste has been of concern to researchers at UKM. Other types of studies have included studying vector borne diseases, effects of transport and traffic congestion (air pollution), effects of pesticides and residues on those working with chemicals and living in the areas exposed, and noise pollution in large cities. Researchers at the universities are also involved in National programs on monitoring for air and water quality. In the conduct of this research interdepartmental linkages have been forged while inter-university linkages are still few. Academics in the country continue to search for solutions in managing environmental health hazards and are attempting to formulate environmental conservation strategies that would suit and meet local needs and demands.

Service: Consultancy, advisory and laboratory services are being provided by universities in the country to the government, semi-government and private sector. Universities have developed mechanisms for these services to be provided e.g. Bureau of Research and Consultancy, through which both research and consultancy work to be performed by the academic staff is channelled. Academic staff at universities are actively involved with various government agencies providing their expertise through various committees and study panels. The necessity to have an environmental impact assessment for specific projects has increased the contribution of academic staff to the community and industry around it. This is in line with a vision to see closer cooperation between universities and industry. Environmental health specialists at universities are also becoming involved in work being carried out by non-governmental organisations. PEPAS, a WHO Collaborating Center at UPM has contributed tremendously towards promotion of environmental health.

ISSUES, PROBLEMS AND CONSTRAINTS

Slow development: Until recent years environmental issues were the domain of a few environmental groups. Those involved treaded carefully in this field. Few academics were actively involved in non-governmental organisations. However with the environment being accepted as an area of concern, greater involvement in environmental problems is being seen.

Unresolved issues: In spite of the advances made in recent years some common problems and issues remain unresolved. Information on environmental health-related problems is difficult to obtain or lacking. Baseline data on the magnitude of the effects of environmental pollution is lacking; this poses a problem, for example in studies conducted to determine acute effects of air pollution episodes. A concern among researchers has also been the difficulty in obtaining cooperation from industry groups in surveys or studies. Under the guise of "trade secret" information on chemicals and other substances is not available. It is suggested that closer linkages forged among university academicians and the employer groups e.g Federation of Malaysian Manufacturers and Malaysian Employer Federation may ease some of these problems.
There has been a suggestion among researchers that they sometimes have difficulty in convincing relevant agencies on the magnitude of the environmental health problem or the need to study environmental issues.

The concept of "Community right to know" is slow to arrive in Malaysia. However it must be acknowledged that new directions towards this end are already being seen both in the government and private sector. Established and enlightened multinationals are developing community right-to-know programs where their plants are located e.g. a pesticide plant in Shah Alam. The Government's effort in informing the community near Bukit Nanas of the proposal to develop a toxic waste management facility in their vicinity must be complimented.

The economics of environmental pollution is a subject which has not been well studied or understood by the different groups involved in decision making. Cost benefit analysis of environmental control strategies and training on environmental economics is lacking in most environmental health related training programs. More experts in this area are needed in the country as we head towards a balance between development and conservation of the environment.

FUTURE TREND, PROSPECTS AND PROPOSALS

Sustainable development: In line with Malaysia's commitment to the Langkawi Declaration on the Environment the country's policy is to arrest environmental degradation, promote conservation, environment and ecological balance within the context of sustainable development. All public sector and private institutions are cooperating and integrating environmental considerations in planning and implementation of their programs.

Setting priorities: Trends towards a more environmentally friendly society are already being seen. This is evident from the following changes. Academics and policy makers are working jointly in determining priority areas in environmental research. "Cradle to grave policies" particularly for hazardous waste are being enforced in the country. Consumer demand and pressure from the user groups e.g. in the building industry has led property developers to move towards the use of asbestos-free ceilings and has become a selling point for housing developers. Unleaded petrol has been introduced by most companies. Recycling campaigns by environmental groups, newspaper companies, governmental and non governmental organizations have become popular. Some have suggested zero waste strategies as the direction in which industry should be headed. Export of hazardous industries by the developed world is increasingly being questioned and there is increasing emergence of environmental groups.

Role of academic: The academic community can play a more active role in combating health hazards of environmental pollution in Malaysia. The role played in combating health hazards could be viewed in the context of primary, secondary and tertiary prevention strategies. For the purposes of primary prevention i.e those strategies targeted at "changing the social and physical environment in order to erect protective barriers between the agent and host", the academic community may play an active role in the following:

Primary Prevention

1. Undertake pre-market evaluation of toxicity of new chemical compounds, physical agents and industrial processes.

2. Collaborate with agencies in determining emission standards that would restrict the release of toxic materials into the environment. Interdisciplinary research e.g. epidemiological, toxicological and health policy research could be conducted and used as information for policy makers.

3. Collaborate with authorities on determining exposure standards so as to limit environmental exposures to these hazards.

4. Conduct research, develop and promote the use of less hazardous substances e.g. use of unleaded petrol, asbestos-free building materials.

5. Contribute to development of environment-friendly design specifications in new plants.

6. Contribute to development of formal and informal short and long duration courses; undergraduate and postgraduate courses in environmental health.

Secondary prevention

Professionals from medical faculties of institutions of higher learning have a distinct role in the development of tools for monitoring and conducting medical surveillance for effects of environmental pollutants. This may include biological monitoring for exposures which involves measurement of contaminants in blood, other body fluids and tissues e.g. lead and PCB's, as well as the effects on the different body systems e.g. lung function tests.

Tertiary Prevention

Strategies to limit the disability that occurs as a result of exposures to environmental pollutants have included changing the environment in which the individuals live. Rehabilitation programs have been advocated. However it must be realized that preventing exposures and hence the occurrence of environmentally induced disease is key to combating health hazards from environmental pollutants.

Universities can provide an avenue and facilities for developing innovative and sound environmental technologies and solutions. Malaysian universities are moving ahead with the development of different programs and institutes e.g. USM has an Environmental Research group, UM an Air Pollution studies group under the Institute of Higher Learning, an informal environmental research group at UKM, approval for the establishment of an Institute of Environmental Research in UPM under the 6th Malaysia Plan and UTM envisages the establishment of an Institute of Environmental Sciences. It is hoped that while universities develop their own programs inter-university linkages will be forged and strengthened.

At the ASAIHL level we propose to strengthen and promote existing ASEAN linkages in interdisciplinary research and training. Fellowships should be made available for intercountry exchanges for longer duration, including facilities for sabbaticals in ASEAN universities. Sharing of information and technology among ASAIHL universities could be fostered including the publishing of an ASAIHL environmental health news bulletin twice a year. ASAIHL could work towards developing a directory of experts in environmental health in the ASEAN region. To sustain interest among ASAIHL members an Environmental Health Seminar could be held every two years. The burden of organizing this seminar and publishing the newsletter could be reduced if member countries accept rotation of the secretariat. ASAIHL through its members could initiate projects to enhance environmental health awareness by promoting environmental education and voicing environmental concerns to the respective authorities in the communities around them.

CONCLUSION

Institutions of higher learning, with professionals in various areas of specialization e.g. geography, botany, zoology, and environmental health are in an ideal position to contribute to the alleviation of problems associated with environmental pollution. Hence institutions of higher learning can contribute positively towards development by assessing issues and developing techniques and equipment to combat hazards of environmental pollution.

With increasing interest locally and internationally in environmental health, it is expected that there will be greater need and demand for research, training and service from university academics. While these activities may be carried out by small groups of individuals there may be a need for a formal structure to be developed at the national level so as to foster coordination and reduce duplication of efforts. Interagency and inter-disciplinary linkages could be forged for systematic collection of environmental exposure and morbidity and mortality outcome data. With a vision to achieve developed country status by the year 2020 efforts need to be made to maintain and improve quality of life. The Malaysian public needs to be healthy and fit to increase productivity and fulfil their nation building role. Institutions of higher learning and individuals in these institutions could participate and face the challenges to make the Malaysian society more environmentally friendly in its efforts to combat health hazards of environmental pollution.

ASAIHL, through its members, could promote university communities which think "green" and facilitate educational, research and service activities that contribute towards combating health hazards of environmental pollution.

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EDUCATION PROGRAMMES FOR TRAINING OF AGRICHEMICAL USERS IN NEW ZEALAND

DR Penman
Department of Entomology, Lincoln University, Canterbury, New Zealand

INTRODUCTION

New Zealand is a country that is highly reliant on exporting agriculture products as a cornerstone to its economy. Its agriculture is generally considered to be highly efficient and produces many products of high quality that can fetch premium prices given excellent quality control and marketing. Recent marketing campaigns have begun to focus on the 'clean green' image, taking advantage of growing environmental awareness in many of our key markets. Such a marketing advantage is based on a perception of the New Zealand environment - as one of open spaces, isolation, ecological harmony and low input agriculture. Maintaining such advantages does, however, mean that we must pay increasing attention to agricultural practices to ensure they do minimise environmental impacts and do maximise our competitive advantages in food product marketing.

Environmental and health issues are likely to play an increasing role in international affairs. With the expectation that the current GATT negotiations succeed in liberalising some aspects of international agricultural trade we should expect increasing attention to non-tariff, or technical, limitations to trade. While GATT advocates harmonisation of environmental and health standards, we should expect national self-interests to become paramount and use such mechanisms to limit trade in some areas, particularly where other countries may hold competitive advantages[1].

New Zealand does, therefore, have a peculiar mix of concerns: maintaining the international perception of the 'clean green' image while endeavouring to internally minimise environmental and health hazards from our current production practices.

Attention has recently been focussed on the use of agrichemicals (pesticides) in agriculture and horticulture and the key issues provide a microcosm of the environmental issues likely to be increasingly important in agricultural trade. This paper examines some of the issues surrounding agrichemical use and describes an industry-developed initiative which aims to minimise environmental and health risks from agrichemical use.

THE ISSUES

A report 'Pesticides: Issues and Options for New Zealand'[2], commissioned by the Ministry for the Environment, identified areas of concern with respect to the administration and approval process for agrichemicals and highlighted the relative lack of information on possible environmental and health impacts from agrichemical use and consumption of residues on food.

The report was controversial and received widespread criticism from many interest groups. There were attempts to limit impacts on our international marketing campaigns and involve a wider group in formulating a response that might become the basis for new policy. The report became the focus for developing debate and since its release, there has been a growing awareness that some improvements were necessary in the ways we use agrichemicals and assess their impacts.

Residues of agrichemicals in food products provides an excellent mechanism for technical restrictions on trade and raises concerns about impacts on public health. New Zealand's export industries have a comprehensive system for compliance monitoring of agrichemical use prior to product export and this system can respond to rapid changes in international requirements. The same level of quality assurance could not be guaranteed for our domestic consumers. Likewise, we had little comprehensive monitoring of potential environmental impacts of agrichemical use.

It also became clear that training of agrichemical users was inadequate when less than 1% of all users had any formal training in the correct handling and application of these products[2].

THE RESPONSES

Government responded to regulatory issues by proposing legislative changes to encompass agrichemical regulation within an overall Hazards Control Commission. Legislation to implement this proposal is in development.

Concerns about residues in food were addressed by the planning and conduct of more appropriate compliance and surveillance residue monitoring programmes by the Department of Health and the Ministry of Agriculture and Fisheries. The recent release of their report[3] gives a base level of assurance of food safety from which future programmes can develop.

Questions of user responsibility could have been approached through regulation with all its attendant costs or by education. Despite initial rhetoric from some of the agriculture and horticulture production sectors there was a realisation that a continuation of the *status quo* would not necessarily be in their best interests with respect to retaining market access overseas and restrictions on current practices through domestic political pressures. Education, not regulation, became the preferred option, with preference for an industry-driven approach rather than one imposed by Government.

THE PROCESS

Primary producers could have faced the prospect of government-imposed regulation on their use of agrichemicals or begun a process of self-regulation. The current political climate favoured the latter so a group of key leaders from the main farmer and grower organisations, commissioned the preparation of an 'Agrichemical Users Code of Practice'[4] with the objective of 'providing practical and specific guidance for the safe, responsible and efficient use of agrichemicals'. The organisations represented in the joint Primary Industry Working Group were:

Federated Farmers of New Zealand
N.Z Fruitgrowers Federation
N.Z Vegetable and Potato Growers Federation
N.Z. Berryfruit Growers Federation
N.Z. Grape Growers Council

Consultants were employed to provide the technical input.

The Code is a succinct document covering the following topics:

1. Management of Agricultural Chemicals
2. User Training
3. Rural Transport of Agrichemicals by Road
4. Rural Storage of Agrichemicals
5. Application
6. On-Property Disposal of Unwanted Agrichemicals and Containers

plus Appendices providing further explanation.

While this constitutes a laudable initiative on the part of industry it became clear that publication of the Code was not enough. The Working Group had alluded to the problem with brief reference to User Training. The problem then became one of developing a programme for delivery of the Code to as wide an audience as possible. These requirements became more urgent when some sector and marketing organisations, e.g., N.Z. Apple and Pear Marketing Board, N.Z. Kiwifruit Marketing Board, intimated that passing a course in the safe use of agrichemicals would become a condition of supply of product for sale. These marketing organisations become the 'regulatory authority', rather than Government. In addition the forestry industry has requested that all their users of agrichemicals be trained within twelve months.

The development of an educational programme became urgent, consisting of a Core Programme and various Sector Programmes. The Core Programme had the aim of developing an understanding of:

- the role of agrichemicals in the management of pests;
- properties and mode of action of commonly used agrichemicals
- principles of agrichemical application;
- potential impacts of agrichemicals;
- obligations of agrichemical users to the wider community

The Sector Programmes aimed to develop a more detailed understanding of:

- particular requirements of a sector for using agrichemicals;
- appropriate agrichemical products and application methods.

The programme required a vehicle for developing the educational material and delivering training and certification. The Working Group did not have educational expertise so some means of developing a partnership was necessary for development, delivery and funding of the programme.

A Trust dedicated to funding research and education, relating to marketing of agricultural and horticultural products (AGMARDT), expressed interest in funding this programme so agreement was obtained between the Working Group members, the Forest Owners Association, Lincoln University (representing educational interests), and the Ministry of Agriculture and Fisheries (representing Government). This unique partnership approached AGMARDT for funding to establish an Agrichemical Education Trust (AET).

THE AGRICHEMICAL EDUCATION TRUST

AGMARDT agreed to fund the core operations of the Trust for three years and the Trust has now been constituted with the function of establishing programmes designed to:

* ensure that farmers and growers understand, and are prepared to act on, agreed standards for the use of agricultural chemicals;

* ensure that agrichemical usage safeguards the environment and physical health of New Zealand and New Zealanders;

* ensure agrichemical usage safeguards access for New Zealand produce to domestic and international markets;

* position the New Zealand Agrichemical Education Trust and its member organisations in a leadership role, managing a controversial issue professionally and in the interests of all New Zealanders;

* broaden New Zealanders' understanding of the necessity for the responsible and informed use of agrichemicals.

The Trust has been constituted with six members with the ability to coopt up to three members. Four trustees are appointed by farmer/grower groups, one represents educational interests and one government interests.

The Trust has now contracted out the task of preparing the educational materials. This consists of a manual for users, a training guide for approved trainers and other practical materials.

Under current educational reforms in New Zealand, any provider can apply to the N.Z. Qualifications Authority for accreditation to present an approved course. The Trust will seek accreditation of a national certificate for agrichemical use with the Trust maintaining its own quality standards through certification of approved Trainers. Once the core programme is developed, the Trust's main role will be in 'Training the Trainers' and making sure they remain up-to-date and provide quality courses. Courses will be delivered using a combination of distance-learning and classroom techniques. The key will be in the successful outcomes through farmers and growers demonstrating their competencies in the correct use of agrichemicals rather than a particular focus on methodology. Competency will be expected in both written and practical material. Once the basic material is prepared, it is expected that the Trust's activities will become self-funding through course fees.

CONCLUSION

This industry initiative may be unique in that it is a clear attempt at self-regulation. The challenge is enormous with the prospect of providing training to 30-40,000 users of agrichemicals in the primary production sector. The establishment of a Trust provides a non-governmental solution which may achieve the goal of education rather than regulation as a means of limiting environmental, health and market impacts from incorrect use of agrichemicals.

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THE ROLE OF PHILIPPINE ASAIHL INSTITUTIONS IN COMBATING THE HAZARDS OF ENVIRONMENTAL POLLUTION IN MANILA

TU Quirino
Technological Institute of the Philippines

INTRODUCTION

The Philippines: The Philippines is an archipelago of more than 7,000 islands scattered in blue tropical seas, blessed with pristine beaches, lofty mountains, jungles and verdant plains. The population of more than 63 million Filipinos, are praised by foreign visitors for their outgoing friendliness and gracious hospitality, their smiles and eagerness to make visitors feel at home. All these plus the prevalence of English, says the visitor, make the Philippines one of the most pleasant countries to live in and explore.

The City of Manila: Manila, the old capital, is one of the 17 municipalities (4 cities, 13 towns) of Metropolitan Manila, the national region of the Philippines. Metro Manila's population is about 8.5 million; 98 percent are literate in Filipino, English or both. Metro Manila spans a spectrum of extremes: between country and city, East and West, yesterday and today, tradition and modernity. Visitors see it as a shopping, recreational, cultural and educational haven.

Manila celebrated its 419th foundation year last June 24, 1991 and as of today is the world's most populated city. Manila's population density at 46,997 persons per sq km against Tokyo's 14,221, or a difference of 32,776 persons per sq km makes Manila the most populated metropolis. This is aggravated by the fact that the total land area of Manila is only 38.53 sq km.

The population densities of 11 districts of the 14 districts in Manila are compared in Table 1.

Table 1: *Districts, land area and population size in Manila*

District	Sq km	Population
Tondo	5.6	107,992
Pandacan	1.2	89,775
San Nicolas	0 6	84,507
Sampaloc	7.3	60,445
Sta Ana	3 9	50,345
Quiapo	0.6	50,083
Sta Cruz	3 7	45,330
Paco	2.2	42,678
Malate	2.8	40,773
Binondo	0.7	28,902
San Miguel	1.1	25,712

The city has a low stable growth rate, averaging below two percent per year. However, the influx of people from the provinces is huge and unrestrained as confirmed by the National Statistics Office. So the number of people who are not registered and come to Manila yearly cannot be assessed. With this influx of people comes the problem of slum growth areas and environmental pollution. Despite its limited land area, Manila's population has always exceeded those of the three other cities Quezon City, Pasay City and Caloocan City and other municipalities comprising the National Capital Region. The Manila Bulletin report of June 22, 1990 indicated:

- 30 to 35 percent of the population are living in slums or squatter dwellings.
- The city has a total of 83 squatter colonies.
- About 20 percent of the population is stricken with disease every year.
- The high population density creates corresponding demands on the economic, social, political and environmental systems which generate a number of serious concerns.

AIR POLLUTION

The major causes of air pollution in the city are road vehicles, private cars, trucks, buses and "jeepneys" which grow in number each year. The traffic congestion has not been alleviated by the construction of flyovers all over the city. Traffic congestion in Asia is the worst in the world and exhaust gases and particulates are an important source of air pollution. The study made by Poon of Asiaweek magazine shows the crawl-rate at peak-hours in kilometers per hour (Table 2).

Table 2: *Traffic "crawl rates" (Km/Hr) in Asian cities*

City	Crawl Rate Km/Hr
Bangkok	12
Tokyo	4
Kuala Lumpur	8
Singapore	8
Karachi	10
Manila	10
Hong Kong	10
Delhi	20

Manila now has a Light Rail Transit (LRT) system. However, these trains run only in certain directions, such as north to south. The LRT emits very little exhaust gas, only 45.2 grams per 100 persons per kilometer compared with bus emissions of 296 grams per 100 persons.

Table 3: *Exhaust emissions (G/100 persons/Km) for different types of transport*

Type of Transportation	Grams per 100 persons per Km	
Rapid Train	31 2	grams
Light Railway (LRT)	45 2	grams
Bus	296	grams
Mini-bus	196	grams
Private car with 4 persons	397	grams
Private car with 1 person	1,192	grams

Table 3 shows that transportation systems with the lowest exhaust pollution are the rapid train and the light railway. There are plans to extend the light railway system in Manila but the government has to seek funds for implementation. The present LRT in Manila was funded by the Japanese government.

Table 4: Efficiency of transportation systems in terms of passengers / hour

Type of Transportation	Number of Passengers Per Hour
Underground Subway	70,000
Rapid Train	50,000
Bus	30,000
Private Car	8,000
Airplane	500

Table 4 shows that to create less gas exhaust and achieve more passenger accommodation, Manila should expand its present train and light train system. The present light railway system running north/south of the city does not provide enough trains to service the public and covers few points of the city. The high frequency of "brown-outs" worsens the traffic situation because the trains stop running and traffic lights do not function.

Many cities of the world have subways and train networks to service the people. The thrust of the Aquino government was to build more flyovers which is not an appropriate solution. In fact, the government is now building a fly-over on our famous beachside, Roxas Boulevard which many of residents of Manila and Pasay Cities are trying to contest because it will destroy the view of the sea and the famous sunset over Manila Bay.

Manila should have more trains not fly-overs. The former transportation secretary, Oscar Orbos, tried to study and solve traffic problems. One solution was to use the Pasig river which runs from Sta Cruz in Manila to Guadalupe in Makati. He experimented with barges or river boats transporting passengers from Manila to Makati. This was tried for a certain period and proved effective but the boats were considered not to be safe and the river to be too polluted.

In 1970 in the United States, a Clean Air Act was passed and amended in 1977 to control the seven most common air pollutants - carbon monoxide, hydrocarbons, lead, NO_x, ozone, particulates and sulfur dioxide. The Act directed the Environmental Protection Agency (EPA) to determine maximum permissible concentrations of each of those pollutants.

In addition to determining national air quality standards for the seven analytes, EPA set maximum emission limits for plants and factories, called new source performance standards (NSPS). These were setup on an industry-by-industry basis for states to use as guidelines in imposing more specific emission restrictions on individual factories.

Another source of air pollutants are tall chimney stacks. Tall stacks help add to the long-range transport of pollutants; the taller the stack, the higher the gases rise into the atmosphere and the farther they may be carried. This is a source of pollutants of which the Department of Environment and National Resources (DENR) and the big cities in the Philippines are generally not aware.

SEWAGE POLLUTION

The sewage system in the City of Manila is antiquated. Despite the installation of new sewer lines, there have been no specific improvements either in flood control or in clogged lines. Most of the sewage waste of the City of Manila drains out to the Manila Bay area, the waters where fishermen in the area catch seafood for consumption of the city residents. Thus toxic waste becomes part of the sea food consumed by fish, shrimps, crabs, shellfish; before they are caught and sold in the market.

Water quality and drainage problems are often interrelated. Adequate control of potentially polluted water is recognized as an essential requirement for any long term plans for agricultural irrigation. Since the City of Manila always floods then the contaminated water from the rivers and the canals cascade down to nearby farms affecting our food supply.

AGENCIES FOR ENVIRONMENTAL PROTECTION

The Government National Environment Agencies: In the Philippines there is no single office concerned with environment alone. There is however the Department of Environment and National Resources (DENR) and the Environment Management Bureau (EMB). Other agencies include:

- Philippine Strategy for Sustainable Development (PSSD)
- Environment Impact Assessment (EIA)
- Environmental Sanitation (A Division of the Bureau of Health)

The City of Manila Environment Agency: In the City of Manila, the major environmental problems are left to the national agencies like the DENR and EMB or the Metro Manila Authority. The local government has an Environmental Sanitation Centre (ESC) whose main functions are to check on uncollected garbage, conduct water sampling and inspect the sanitary conditions of business establishments like restaurants, refreshment parlours, beauty parlours and hotels. The ESC is headed by an engineer Simon Cuevo who has a staff of only 57 inspectors for the whole city. Some of these inspectors are about to retire and there is no assurance of replacements.

Another group that helps the city is an arm of the Metro Manila Authority (MMA) called the Refuse Environmental Sanitation (RES) which at certain periods conducts cleanliness drives. The residents of Manila noticed that when the southeast Asian Games were held in Manila last year, the city authorities tried their best to give an impression that Manila was a clean city. The garbage trucks were making more than their usual rounds to pick up waste and spruce up the city. Why do we engage in such activities only when we have visitors? Is it not the duty of Government to service its constituents all the time?

In the City of Manila there are laws to protect us from environmental pollution. These ordinances prohibit the following: 1) throwing of refuse, covered by Ordinance 1965 and Presidential Decree 825, 2) smoking in public places, 3) spitting in public places, 4) vehicles with smoking exhaust pipes, 5) loud music played in public transportation (noise pollution), 6) urinating and defaecating in public places, and 7) scavenging as provided by Ordinance 7510. All these ordinances provide for fines to be made for infringements.

Non-Government Environment Agencies: One non-government organization involved with the environment, the Earth Savers Philippines, has other supporters for its movement; these include civic organizations like the Rotary International, and media organizations like the National Office of Mass Media, Filipino cost-oriented groups like the Renewable and Recyclable Resources Cooperative (RRRC) and it also collaborates with the Government agencies.

Most of the other non-government agencies are world-wide in scope; they include agencies of the United Nations:

- United Nations Development Program (UNDP)
- United Nations Food and Agriculture Organization (UNFAO)
- United Nations Environmental Program (UNEP)
- World Health Organization (WHO)

Other International Organizations concerned with the environment in the Philippines include:

- International Union for the Conservation of Nature and Natural Resources (IUCN)
- World Watch Institute (WWI)
- International Training Network for Water and Waste Management (ITN)
- The World Conservation Fund (WCF)
- Republic of the Phils-German Forests Resources
- United States Agency for International Aid (US-AID)
- World Bank (WB)
- Asian Development Bank (ADB)

The Role of Philippine ASAIHL Institutions in Combating Environmental Pollution:

The following strategies could be promoted and implemented by ASAIHL Universities:

1. Disseminate information about pollution and its causes.
2. Implement smoking bans and prevention programmes.
3. Encourage the recycling of paper.
4. Promote systems for the proper disposal of waste.
5. Encourage cleanliness drives through public education programmes.
6. Encourage the saving of gasoline to reduce pollutants.
7. Discourage the use of plastics.
8. Promote the saving of resources such as power for lighting and water.
9. Encourage the reporting of toxic waste pollution to the proper authorities.
10. Undertake research on pollution control and waste management

RECOMMENDATIONS

General Recommendations for the City of Manila:

1. Develop a master environmental plan for the city.

2. Network with ASAIHL institutions for the support and implementation of this master plan.

3. Use the results of recent environmental studies and their recommendations, such as the 1991 WHO study on chronic respiratory symptoms and illnesses due to vehicular emissions.

4. Setup a data-base to support an Environmental Assessment Plan from which information can be used to help the city monitor regularly its master plan.

Specific Recommendations:

1. Implement all existing city ordinances and national laws to protect the environment, with no exceptions.

2. Extend the Light Rail System to other points of the city to reduce gas emissions of the growing number of jeepneys, buses and cars.

3. Coordinate ASAIHL institutions, which should collaborate on the adoption and implementation of the ten strategies proposed to help the city reduce pollutants.

4. Use the "Ganda Linis" scheme which is to sort out first, the wet from dry waste and second, to further sort out dry waste, by separating bottles from paper for pick-up at doorsteps or gates. This would allow garbage scavengers to earn money and help keep the community clean from waste pollution without having to sift through rubbish. This will also reduce the scavengers in "Smokey Mountain" a garbage dump which is the source of income to hundreds of scavengers in Manila, but a place where diseases are bred and where the people residing

in the area are getting sick. The "Ganda Linis" scheme was conceived by Dr Melecio Palaypay and is implemented by community groups.

5. Develop new legislation with more protective environmental laws.

6. A reappraisal of engineering courses in ASAIHL institutions and of the role of institutions in environmental research and in promoting the ecology consciousness of its graduates.

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CHARACTERISTICS OF ACID RAIN IN MAINLAND CHINA

YT Hong
Institute of Geochemistry, Chinese Academy of Sciences

INTRODUCTION

In China systematic studies of acid rain and its influence on the environment began in 1982. The State Council of the People's Republic of China entrusted the Chinese Academy of Sciences to organize a group of scientists to conduct research on acid rain pollution in southwestern China. During 1985-1986 and the seventh five-year plan period 1986-1990, acid rain was placed on a list of key research projects by the state. Since then, research on acid rain has grown further in scale. The National Commission on Science and Technology and the National Environmental Protection Bureau organized and coordinated a comprehensive research programme for scientific workers with specialization in environmental geochemistry, atmospheric chemistry, atmospheric physics, environmental biology and environmental engineering. These scientists were from institutions of the Chinese Academy of Sciences and the China National Environmental Protection Bureau, together with post-secondary colleges and universities.

Comphrehensive and interdisciplinary investigations were carried out in problem areas including the provinces of Sichuan, Guizhou, Guangdong and Guangxi. A total of 189 observation stations were set up in 27 provinces, autonomous regions, and municipalities directly under the central government. Quality control was exercised by using the same sampling and analytical methods. This paper provides an account of the main research results obtained.

SPACIAL AND TEMPORAL CHARACTERISTICS OF ACID RAIN

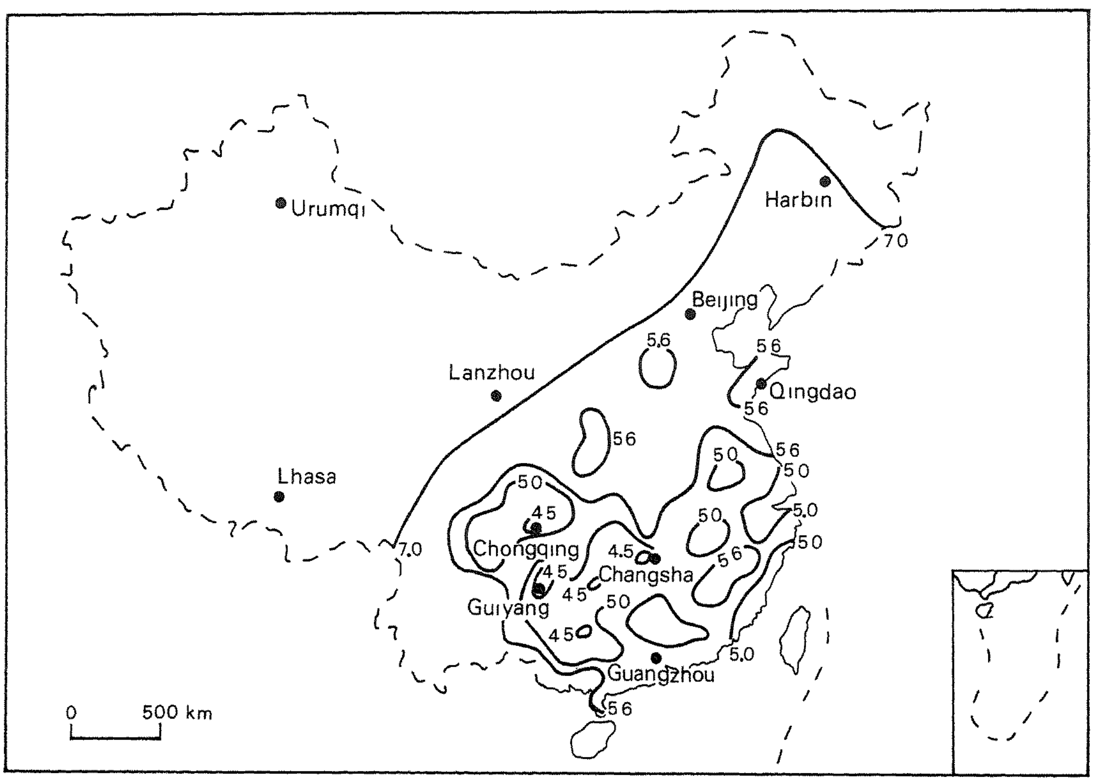

Figure 1: pH isogram of average annual precipitation in mainland China.

The pH isogram of average annual precipitation in mainland China is shown in Figure l. It can be seen that the acidity of rain water shows remarkable regional variations. The pH 7.0 line can be seen to run diagonally across the country dividing it into two halves. In a southeast direction away from the pH 7.0 line, the pH is more acidic. From north to south, the pH of rain water tends to more acidic. The regions with pH values less than 5.6 are located in the Sichuan, Guizhou, Hunan and Jiangxi provinces, where the frequency of acid rain exceeded 40%. The frequency of acid rain is as high as up to 80% in Chongqing, Sichuan Province and Zunyi, Guizhou Province.

The pH value of rain water in industrialised urban districts is, as expected, lower than that in rural areas. High altitute aircraft observations have provided confirmation of acidification of water in clouds above the urban districts of Chengdu, Chongqing and Guiyang below an altitude of 2400 m. In southwestern China the concentration of ions in the clouds tends to decrease with increasing altitude, while a reversed trend is observed in Guangdong and Guangxi provinces. This is indicative of contamination by local sources in southwestern China. Whereas for Guangdong and Guangxi provinces, the transfer of pollutants from other more distant areas is possible.

In mainland China, seasonal variations in the frequency of acid rain have been found. A maximum frequency of acid rain was recorded in the autumn and winter while minimum frequency was recorded in the summer time.

CHEMICAL COMPOSITION OF RAINFALL

Although there are obvious signs of acidification of rain water in southern China, it should not simply be attributed to the local sources of acidic matieral. The average annual concentration of SO_4 ions in non-acid rain precipitation is estimated at 212 ug/l. This value is in excess of that in southern China by a factor of 1.7 or 87 ug/l. In northern China, the average value of SO_4 and NO_3 ions is estimated at 241 ug/l as compared to 145 ug/l in southern China. The pollution caused by atmospheric SO_2 is more serious in the north than in the south. Furthermore, the total concentration of NH_4^+, Ca^{++} and Mg^{++} ions in rain water in the north is 2.9 times that of the south. The content of atmospheric particles is also about twice that in northern China. This indicates that in both northern and southern China, the rain water possesses almost the same amount of acidic pollutants. Nevertheless, no acid rain is reported in the north because of neutralization and buffering by alkaline substances which are relatively abundant in the atmospheric environment.

The ratio of SO_4^-:NO_3 ions in rain water is found to range from 4.1 to 15.1 with a contribution of 80-94% by sulphates to the pH of the rainfall. Therefore acid rain in mainland China is of the sulphate type.

THE SOURCES OF SULPHUR

The sulphate-type pollution characteristic of the rain water seems to be closely related with coal which is the principal source of fuel. In southwestern China, where acid rain pollution is serious, systematic measurements of the sulphur isotopic compositions of SO_4 ions in rain water, SO_2 released from burning coal and local atmospheric particulates have been made. Based on these results, the relative contributions of sulphur, from various sources, to acid rain can be estimated (Table l).

Table l: Sources of sulphur in the acid rain-affected areas of southwestern China estimated from isotopic fingerprinting

Source	Time interval	Range (%)	Average (%)
SO_2 released from burning coal	Year round	13-35	26
Local atmospheric particulates	Year round	46-57	50
Sulphur released from bacterial activity	May to October (annual average)	12-55	28 (13)
Long range transport aerosol	November to April (annual average)	7-32	19 (18)
Sulphur released from oceans	November to April (annual average)	1-4	2 (1)

It can be seen that the local atmospheric particulates released mainly from burning coal are the principal source of sulphur in rain water This is followed by SO_2 released from burning coal with an average annual contribution of 26%. It is worthy to note that sulphur-bearing compounds released as a result of activities of living organisms would make a significant contribution to sulphur in rain water with an average annual contribution of 13%. This contribution is even larger during the summer when bacterial activity is at a maximum (Figure 2).

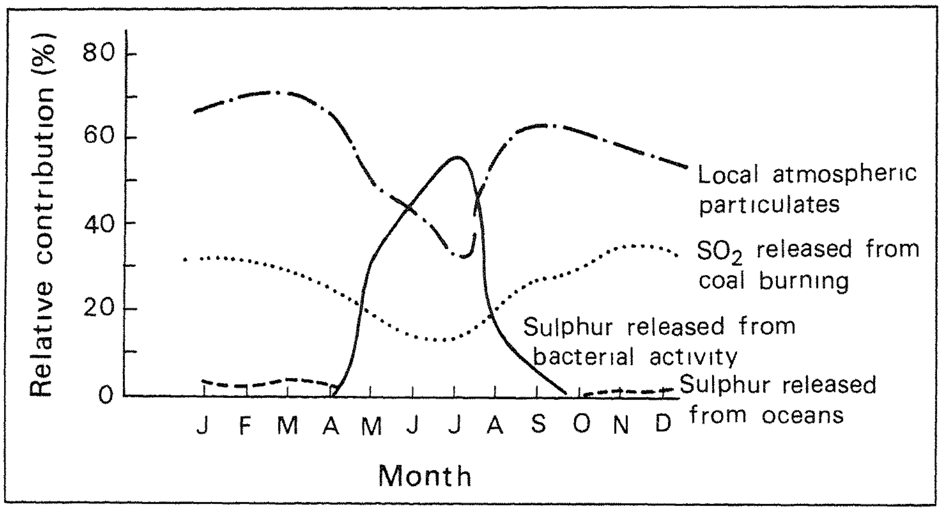

Figure 2: Relative monthly contribution of sulphur to rain water from various sources in southwestern China

INFLUENCE OF ACID RAIN ON THE ENVIRONMENT

Regional investigations have been undertaken on the sensitivity of soils and surface water bodies to acid rain Fortunately, in the acid rain-prone areas of China, especially in the provinces of Guizhou, Sichuan, Hunan and Guangxi, there are extensive outcrops of carbonate rocks or calcarcous argillaceous rocks. This has resulted in extensive cation exchange in the overlying soil. Consequently, the soils are capable of neutralizing and buffering acid rain. In the above-mentioned areas, the soils are mostly insensitive or slightly sensitive to acid rain

The areas sensitive to acid rain are located mainly along the coast of southeastern China (Figure 3). In these areas, the soils are developed on granitic rocks. Because of this, capacity for cation exchange of the soil is relatively low and there is much rain with a high acidity. In areas where economic development is rapid the acidification of water bodies is of concern and requires effective measures for control.

Observations and simulation experiments on the impact of acid rain on forests, agricultural crops and building materials have been carried out.

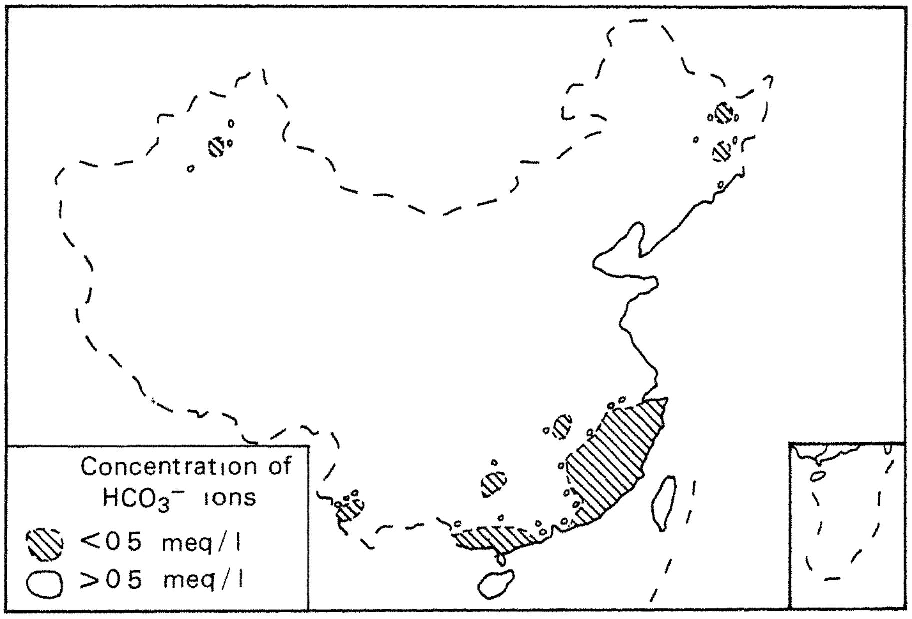

Figure 3: *Map showing the areas sensitive to acid rain in China based on the concentration of HCO_3 ions in surface water bodies*

DEALING WITH ACID RAIN

From the above discussion, it is clear that environmental legislation is needed for controlling sulphur releases from burning coal. Studies on engineering measures and on establishing standards which are applicable to the local environmental conditions are also needed. During the eighth five-year-plan period 1991-1995, research activities will be focused on the origin and environmental influence of acid rain in the eastern part of China, especially in the vicinity of Xiamen and Qingdao.

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IMPROVING THE TOTAL ENVIRONMENT OF SINGAPORE

TC Tan
Department of Community, Occupational & Family Medicine, National University of Singapore

INTRODUCTION

Progress in the past 25 years: Since Independence, the Island Republic and City State of Singapore under the Lee Government have made great progress in transforming a British dependent territory into a nation of excellence achieving the second highest standard of living in Asia with little environmental deterioration detrimental to the health and life of the population. The improvements, reflected in the social, economic and health indicators, and the general decline in incidence of communicable disease point to a healthy population with high quality lifestyle in an essentially urban environment.

Factors responsible for progress: The initial challenges of self-government were to ensure economic survival, national unity as well as to cater to the basic needs of the population. Singapore embarked on a national programme of development with rapid industrialisation and commerce, urbanisation and population resettlement; progress was made with the constant concern of minimising inevitable damage to the land- and resource-scarce environment. The Government took on a very pro-active role in improving the overall environment and the provision of massive low-cost public housing, clean air, wholesome water and hygienic food. Many key factors are identified as responsible for the improvement of the total environment. They include a strong and steady Government supported by an able civil service; sound national policies, enforced by appropriate legislation with well co-ordinated national efforts at redevelopment, industrial zoning and restructuring, high-density, high-rise housing, social amenities, environmental management, occupational health and industrial safety, public education, high literacy, easy access to modern health services and stringent health control measures.

Progress in the Next Lap: The successor Goh Government formed in 1990 has defined the next phase of further national development of Singapore and this was embodied in the policy document entitled the "Next Lap" which aims to ensure both continuity and change and to look beyond into the next century. Various Government ministries have come out with *Concept Plans* in support of the "Next Lap" with renewed emphasis on developing Singapore into a nation of four million people, with the status of a regional model centre of excellence and an international centre of growth and co-operation.

THE GEOGRAPHY

Singapore consists of a main island and 58 islets with a total land area of 663 sq km; one half of which (49.2%) comprises built-up areas and the rest being farms (1.7%), forests (4.5%), marshes (2.5%) and mixed areas of open spaces, quarries, gardens and military establishments (42.1%)[1 2]. The current population density is 4,200 persons per km^2. The 1990 Census revealed that the population was 3,002,800, with slightly more than 10% (312,700) foreigners. There were 1,324,700 employed persons aged 15 years and over in manufacturing (28.9%), commerce (22.8%), community, social and personal services (21.3%) and transport, storage and communications sectors (10.2%).

THE INDICES OF PROGRESS AND IMPROVEMENT

Population and socio-economic status: There has been tremendous improvement to the social, economic and health well-being of the nation. In the past 25 years, the population doubled from 1.45 million to 3.002 million, the urban area doubled, housing units trebled to 725,000, the manufacturing workforce quadrupled, the commercial space increased five-fold (from 1.8 to 8.2 million m^2), the industrial land sixfold (from 800 to 4,800 ha) and the per capita GNP increased from S$1,600 to S$19,500[3]. In the past decade, comparing 1980 to 1990 figures, literacy rate for aged 10 years and above rose from 84% to 90%, home ownership of HDB flats from 68% to 87%, motor vehicles registered from 371.3 to 542.4 thousands and the National Central Provident Fund Saving from $9,551 to $40,646 millions[1,2] (Table 1).

Table 1: *Singapore: Standards of living*

	1980	1986	1990
Persons per			
Television set	5	5	5
Public bus	305	299	285
Taxi	229	242	220
Population (in millions)	2 414	-	3.002
Literacy (% for aged 10 and above)	84	-	90
Percentage of total population in HDB hosuing (%)	68	85	87
Motor vehicle registered (in thousands)	371.3	473.7	542 4
CPF total amount due to members (in millions)	9,551	29,341	40,646

Source: Ministry of Information and the Arts

Land use and housing: Early in the national development of Singapore, economic and environmental survival were inseparable[3]. The rapid transformation of Singapore from the biosphere of the 1960s to the technosphere of the 1990's with major industrial developments, economic restructuring, urban renewal and population resettlement was achieved with minimal environmental deterioration[4,5]. Several key Ministries of the Government have been responsible for co-ordination of these national efforts[1].

The Ministry of National Development is responsible for the physical development of Singapore and covers public housing, urban development, public works, primary production, and parks recreational facilities and conservation. The Housing and Development Board (HDB) was established in 1960 to provide low-cost housing and by 1990 about 87% of the population were housed in public housing towns and estates[6]. A total of 725,000 flats have been built since 1960. At the same time the Central Area was revitalised and established as a centre for finance, information, communications, technology, tourism and commerce. The Urban Redevelopment Authority (URA) is the national planning and conservation authority, guided by a *Concept Plan*, to coordinate the long-term physical transformation of Singapore with integrated land use and transportation plans[3]. Lately its role has included the conservation of historical buildings and setting up of nature reserves in the urban environment in order to support and to attract a wide diversity of wildlife, thereby making a significant contribution to the improvement of the quality of life of residents[7].

Ecology and environment: The Ministry of the Environment, established in 1972, is responsible for the environmental health services such as sewerage, drainage, waste disposal systems, control of air and water pollution, and toxic chemicals and poisons. Efforts at improving the environment were made to keep it relatively pollution free[4]. The key in managing the environment was to prevent pollution via proper land use with planning controls and infrastructure development, effective legislation policies and strategies and public education. A five-pronged approach was adopted[3]. First, the removal of sources of existing pollution with the clearing of slums, squatters and the phasing out of animal farms and agriculture areas. Second, new pollution sources were prevented by an improved drainage scheme to alleviate localised flooding due to frequent tropical rainstorms. Third, an effective public health enforcement system was implemented to include anti-littering laws, anti-spitting laws, regulations on smoking and on unlicensed hawking and the creation of permanent hawker centres with some 25,000 stalls to ensure a high standard of hygiene and food handling. Fourth, the introduction of pollution control mechanisms to sustain and to improve standards of the water resources, air quality standards, siting of industrial developments, provision and maintenance of pollution control devices and use of noisy machines and construction piling near population centres. Fifth, to make the environment green and beautiful through enhancement, including preservation of the nature reserves, the beaches, the fauna and flora. An estimated one hundred millions dollars annually has been spent on planting and maintaining trees, shrubs and turf[8].

The Anti-pollution Unit was formed in 1970 and was incorporated into the Ministry of the Environment[9] to monitor outdoor air quality standards. Air quality levels on the island have been consistently found to be below WHO recommended levels. Concern about environmental lead has led to the gradual phasing out of the sale of leaded petrol and has resulted in a dramatic reduction in lead levels in air and in human blood[10]. Vehicular exhaust emissions are strictly enforced by the annual inspection of vehicles, spot checks of vehicles and the introduction of catalytic convertors for all new cars in the middle of 1992

The urban rivers used to be the city sewers with uncontrolled discharge of all forms of wastes and rubbish making the water black and foul smelling and devoid of fresh water life. In 1977, a 10 year cleaning up programme was initiated[11]. For the Singapore river and the Kallang basin, it was an arduous task involving the phasing out of some 21,000 unsewered premises as well as pig and duck farms, the relocation of some 5,000 hawkers, street vegetable wholesalers, pollutive marine and backyard industries, the resiting of the lighterage industry and the clearance of large squatter tracts. The latest results of analyses of concentrations of Pb, Cd, Cu, Zn, Fe and Hg in the water, sediment and biota of the Singapore river were found to be below safety limits[12] and showed no hazardous distribution of heavy metals in the water or sediment. Another study revealed that mercury levels in scalp hair of healthy Singapore residents were within safety limits and were similar to those in residents in rural and urban Malaysia. Mercury levels, attributed to fish consumption, were higher in male and Chinese (6.1ppm) than Malays (5.2ppm) and Indians (5.4ppm)[13].

Table 2: *Singapore. Provision of health personnel*

	1980	1986	1990
Persons per			
Doctor	1,010	930	753
Denist	5,324	4,917	4,003
Nurse	323	302	282
Hospital bed	261	254	274

Source: Ministry of Information and the Arts

Table 3: *Singapore's vital statistics*

Year	Rate of Growth (%)	Live-Births	Deaths	Infant Mortality	Maternal Mortality
1950	4 4	45 4	12 0	82 2	1 8
1960	3 5	37 5	6 2	34 9	0 4
1970	1 7	22 1	5 2	20 5	0 3
1980	1 2	17 1	5 2	11 7	0 0
1990	1 3	17 8	5 2	6 6	0 1

Source Ministry of Health, all rates per 1,000

Health: The provision of health workers and hospital beds has also improved in the past 10 years (Table 2). Crude death and infant mortality rates have declined since the 1950s[14-15] (Table 3). Infectious diseases have been brought under control by improved standards of living and by childhood immunisation programmes against diseases like tuberculosis, poliomyelitis, diphtheria, whooping cough, measles, mumps, rubella and hepatitis B[8] (Table 4 and Figures 1 and 2). Cancers and degenerative diseases like heart diseases, hypertension and diabetes have become the main health problems faced by the population[14]. Some further successes have been made in slowing down the death rate from cardiovascular diseases with effective preventive measures[16], and one prime measure was the reduction of tobacco consumption through increasing taxes, banning of advertisement, sport sponsorship, the restriction of smoking from public and selected private areas, and health education[14]. However, food-borne and vector-borne diseases like enteric fevers, non-B viral hepatitis, malaria and dengue fever continue to plague the population (Table 5 and Figure 3)[8,14].

Table 4: *Singapore: Proportionate mortality by broad disease groupings*

Cause of Death	1950	1960	1970	1988
Infective & parasitic diseases	21.5	8.8	6.8	3.0
Neoplasm	2.8	10.4	15.1	23.5
Endocrine, nutritional and metabolic diseases	2.8)	5.1	2.3	3.8
Diseases of blood and blood forming organs	0.7)		0.5	0.2
Diseases of nervous and sense organ	13.7	7 7	1.7	0.9
Diseases of circulatory system	6.2	10.6	27.0	34.8
Diseases of respiratory system	16.5	11 9	13.7	14.6
Diseases of digestive system	12.4	8 7	4.2	2 6
Diseases of genito-urinary system	2.0	3.0	2.2	2 6
Congenital anomalies	0.6	1.6	1 4	1 5
Certain causes of perinatal mortality	6.6	9 6	4 5	0 9
Accidents, poisoning and violence	4.0	5 0	8 0	7 3
Other causes	10 2	17 6	12 6	4 3

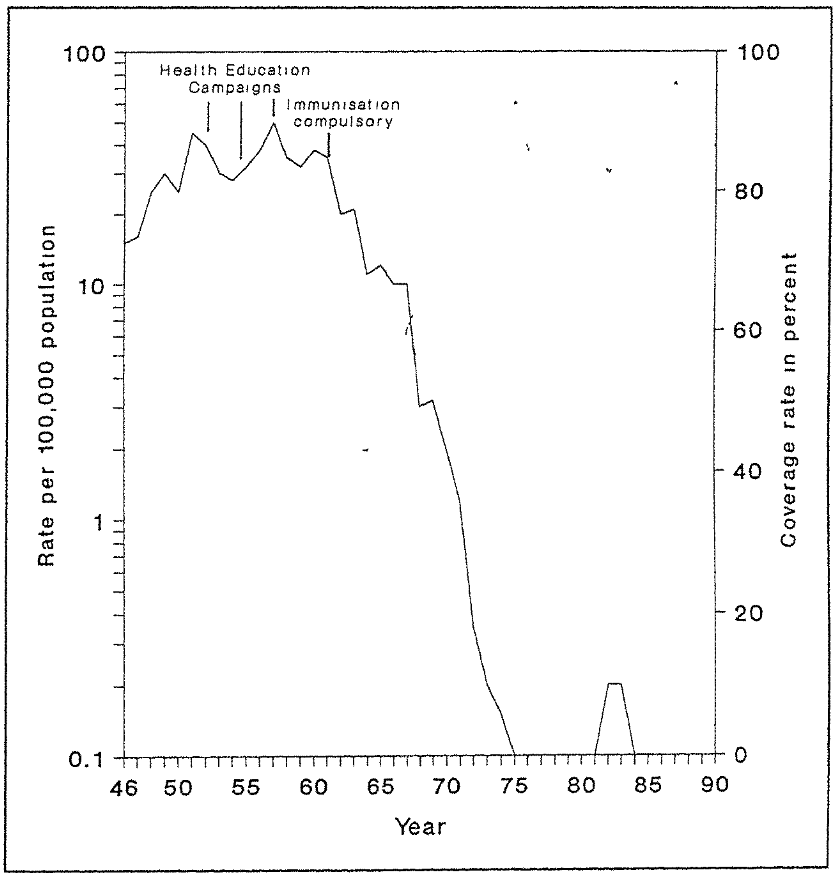

Figure 1: *Incidence per 100,000 population from diptheria and immunisation coverage rates in Singapore, 1946-1990.*
—— Incidence per 100,000 population, --- Immunisation coverage rate (infants); ·· Immunisation coverage rate (Primary school entrants)

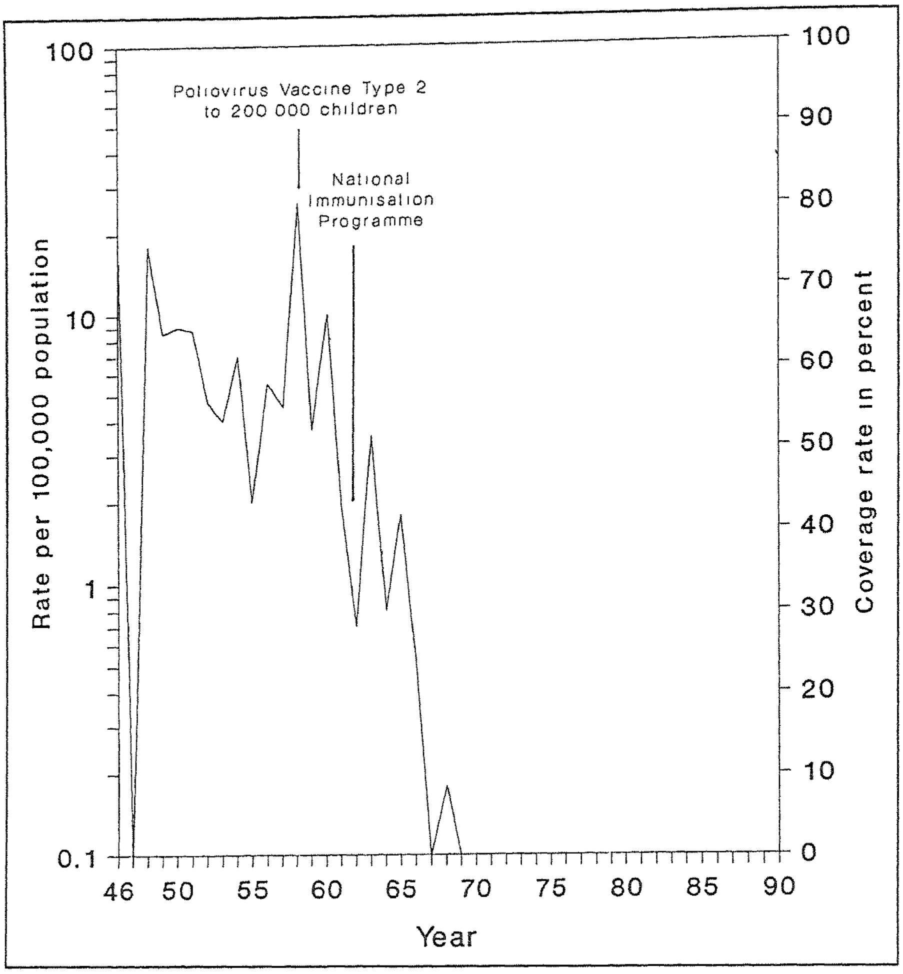

Figure 2: *Incidence per 100,000 population from poliomyelitis and immunisation coverage rates in Singapore, 1946-1990*
— Incidence per 100,000 population, --- Immunisation coverage rate (infants), Immunisation coverage rate (Primary school entrants)

Table 5: *Singapore Notifications of specific notifiable infectious diseases*

Notifiable Diseases	1980	1985	1989
Chicken pox	910	2,879	17,087
Cholera	18	27	39
Dengue/DHF	253	126	944
Diphtheria	-	-	1
Enteric fever	255	148	128
Leprosy	66	57	48
Malaria	200	166	203
Measles	490+	*136	146
Poliomyelitis	-	-	-
Tuberculosis	2,710	1,952	1,619
Viral hepatitis	1,001	610	439
Viral encephalitis	36	5	4

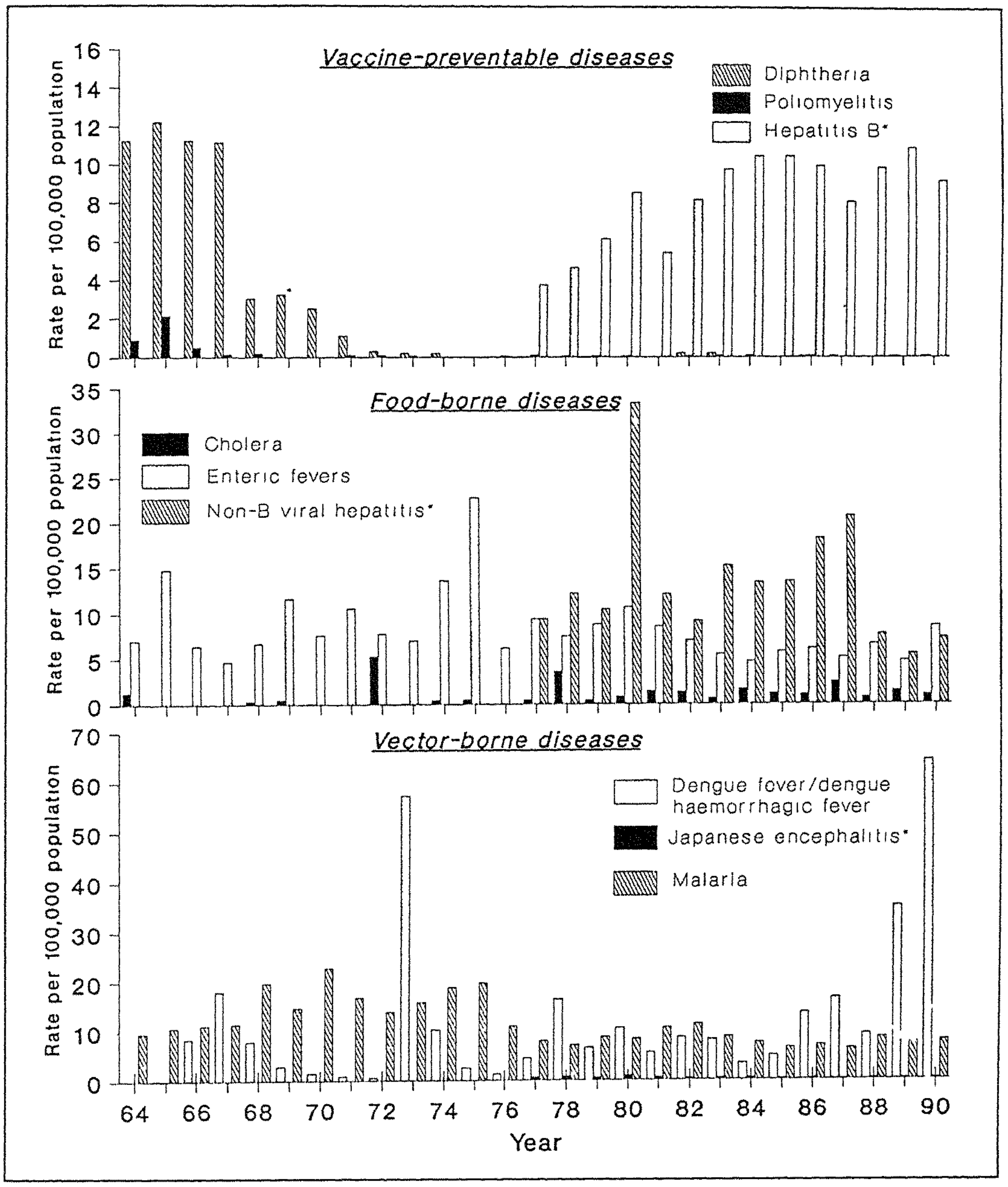

Figure 3: *Annual incidence rates of 8 notifiable infectious diseases in Singapore, 1964-1990*
** notifiable as from June 1976*

Singapore residents now enjoy a high standard of personal health. This improvement can be attributed to the general improvement in the standard of living, stringent public health control measures, good environmental management, and easy access to health services. Singapore has a dual system of health care; the public health system and a private health system[14]. The former provides for 30% of the primary health care and 80% of hospital care while the latter provides for 70% and 20% respectively. Health care in the public sector spans over three Ministries: namely the Ministries of Health, the Environment and Labour. The Ministry of Health is responsible for the preventive curative and rehabilitative health services and has overall responsibility for national health policies. It works closely with the Ministry of the Environment on the maintenance of environmental hygiene and food safety and control of communicable diseases. The Ministry of Labour is responsible for the industrial and occupational health of workers.

THIS, AND THE NEXT LAP

In the 70's and 80's, the development of environmental infrastructure was initiated with a comprehensive sewerage system and solid waste management system for all industrial, housing, commercial and hawker centre developments, with 1.7 billion invested for 2000km of sewers, 100 pumping stations and 6 sewage treatment works[3,4]. The main areas of concern were pollution control, sewage treatment, drainage, vector control, food safety, quarantine services and epidemiological surveillance, public cleansing and refuse collection and public health education. With rising affluence and international concern about the environmental issues that transcend national boundaries, the Strategic Planning and Research Department was formed in 1990 to map out strategies to develop Singapore into a model *environment city* within the next decade with emphasis on public education to inculcate an environmentally conscious and socially responsible people and to promote Singapore as a regional Centre of Environmental Technology, built on years of expertise, a successful record in managing environmental projects[5] and a focal point for regional and international environmental activities[4].

In 1990, Goh's Government mustered the people to go on to achieve a higher level of living in the "Next Lap"[17]. This led to a comprehensive master plan, called the *Concept Plan*[3], which carefully wove the natural green spaces, the hills, the sea, beaches and rivers into the urban landscape. Communicable diseases, related to environmental deterioration, have been largely eradicated and controlled. The URA was reorganised in 1989 into one national planning authority and empowered with the tasks of planning, monitoring and controlling the urban development of the island with a massive review and updating of the Island's 1971 *Concept Plan*. The new *Concept Plan* to be completed by the end of 1992 subdivides the island into 50 zones each with its Development Guide Plan with elaborate land use details, development control parameters and urban design guidelines. There are four main approaches in the latest *Concept Plan*[3]. First, to reorganise the urban structure of the Island, by decentralising into five regions, each an expanded town centre serving half a million people Second, to review the fabric of the Island, including the networks of roads, MRT, green belts and water bodies. Third, to examine the array of land use types targetted for a population of 4 million by the year 2030. Fourth, to find ways and means to upgrade the quality of the physical environment to achieve the creation of a tropical city of excellence

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THE ROLE OF THAI UNIVERSITIES IN COMBATING HEALTH HAZARDS OF ENVIRONMENTAL POLLUTION

V Wangsuphachart
Faculty of Tropical Medicine, Mahidol University

INTRODUCTION

Emerging Environmental Problems: Thailand, has undergone dramatic changes within the last few decades which are reflected in the nature and quality of life of the people, in the structure of communities and in the foundation of the economy. Thailand is moving rapidly from its past as a rural society, in which the local communities were so dependent on the natural resources which surrounded them, to a fast lane of industrial development and urbanization. The sustainable use of resources was a fundamental aspect of the rural life, where people perceived the inter-relationships between different components of their local environment. Their attitude and activities were then defined by the need to protect the surrounding resources of their motherland.

Within the past two decades, Thailand has gone through considerable industrial development and urbanization towards its status as a so-called Newly Industrialized Country (NIC) where economic growth has risen steeply and continues unabated. The Gross Domestic Product (GDP) has exceeded 10% in the last five years and it is expected to surpass more than 8% growth per annum by the year 1997.

Obviously, the economic growth and industrial development have been achieved at the expense of our environment and country's natural resources. This situation is associated with the migration of a large number of people to the cities and the growth in industrial activities followed by the rise in energy consumption and transportation which has resulted in air, noise and water pollution, health and occupational hazards and overcrowding in Bangkok and other major cities. These phenomena have become more apparent and intense so that the public's concern is now directed towards the environment. A philosophy of sustainable development, both economically and environmentally, is very challenging. Can economic growth generate financial resources which can be invested in projects to improve and protect the environment and ultimately to establish the policies and incentives to achieve the sustainable development for our society?

Environmental issues do not stop at national boundaries. The activities of individual countries can profoundly affect environmental conditions of others and eventually worldwide, for instance, the global climate change and the need for conservation of biological diversity. The need for cooperation between all nations to achieve environmental protection and prevent global environmental degradation is sufficiently important to link environmental with international trade. We are all looking for constructive and action-oriented commitment from all nations, to work towards this great task. Our joint contribution could make sustainable development a reality. All sectors of our society including government, business, non-governmental organizations, academics and the general public; have a great part to play.

The challenge to academics in combating health hazards of environmental pollution: The key role of academia, in this context, is not only to promote the teaching/learning process and produce qualified students in the area of environment and natural resources management, but also to create a profound consciousness about environmental concerns at national, regional and global levels.

There should be close bonds between academics and the community since the improvement and protection of our environment, through combating and alleviating current environmental problems, needs both intersectoral cooperation as well as technology. Universities and the higher educational institutions can share this great task through planned deployment of manpower, knowledge and appropriate resources.

ENVIRONMENTAL POLLUTION AND HEALTH HAZARDS IN THAILAND

Current situation in rural and urban areas: There is a wide spectrum of environmental problems in rural and urban areas of Thailand. Rural environmental problems include flooding, soil erosion, deforestation, poor water resources and a loss of biological diversity. Many of these relate to the decline in natural resources rather than to a reduction in environmental quality *per se*. Urban problems relate to a decline in environmental quality and the inability of the public infrastructure to meet the demands imposed by rapid population growth. Big cities are afflicted with air pollution from industrial exhausts, vehicle emissions and electricity generation using lignite; water pollution from untreated industrial and household waste water; other hazardous and toxic wastes from industries, hospitals and household refuse, noise pollution from traffic and industrial sites.

The general situation is worsening. The average level of particulate suspended matter (PSM), the most important pollutant in the air of Bangkok, was 198 ug/m^3 (range=87-389 ug/m^3) in 1989, which was 27% above the standard level. Sixty percent of the PSM is $<10\mu$. The other pollutants of concern, from combustion of fuels, CO_2, CO, HC, NOx, SO_2, O_3 and lead do not exceed the standard level. Domestic sewage effluents are a major cause of water pollution problems in Thailand and accounted for 75% of pollution in major rivers compared with 25% from industry Domestic effluent also accounted for 93% and 75% of the total BOD load in the Mae Klong River in 1990 and the lower Chao Phraya River in 1988, since less than 2% of Bangkok population is connected to the sewage treatment system. The number of industries producing moderate volumes of hazardous waste has increased from about 6,600 in 1979 to over 16,000 in 1989. The amount of industrial hazardous waste in 1991 was about 600,000 tons and is projected to reach 6 million tons/year by 2001. High residues of heavy metals, fertilizers, pesticides in water, soil and food have been reported.

Health impact and health hazards: Many aspects of the health impact and health hazards caused by environmental pollution are clearly described in the current literature. Air pollution largely affects humans through its effects on the respiratory system and can result in respiratory and cardiovascular disease. Inhaled gaseous pollutants can be absorbed in the alveoli; inhaled particulates can be deposited in the mucous layers on the surface of the respiratory tract. The risk of respiratory disease is aggravated by smoking or the presence of other irritants such as dust from construction sites in the lungs.

Consumption of contaminated water results in diseases of the gastro-intestinal system especially in infants.

A study of solid waste scavengers at a dump site showed that 45% of them were infected with Hepatitis B virus. Good environmental epidemiological research is needed to generate reliable statistics on morbidity and mortality related to environmental pollution, their magnitude and the incidence of disease.

Control systems and control measures: The Thai government is committed to promoting control measures to reduce environmental pollution as follows

Air pollution

- enforcement of national ambient air quality standards including regular vehicle inspections and emission tests
- control of diesel fuel quality
- use of low smoke motor oil and unleaded gasoline
- introduction of catalytic converters
- introduction of compressed natural gas buses
- improvement of road networks to maintain traffic flow

Water pollution

- enforcement of national ambient water quality standards
- fee collection for usage of surface water by industry and industrial effluent discharges
- municipal waste water treatment plants
- industrial waste water treatment plants
- sewerage systems in new development areas
- limiting the establishment of new water-polluting industries and the expansion of existing ones

Hazardous and toxic wastes

- enforcement of national industrial effluent and emission standards
- building centralized hazardous waste treatment plants such as Bang Khuntien treatment centre

Legislation and law enforcement: Legislation and law enforcement on pollution control of the environment was first enacted in 1977 in the case of the Mae Klong River pollution by sugar mill waste. The general legislative framework for the control and management of the environment is exhibited in the following acts which have a direct relevance to the industry

- **The Improvement and Conservation of National Environmental Quality Act 1975**, (NEQA) enacted the concept of environmental quality standards, the requirement for EIAs in the assessment of applications for industrial permits and the use of emergency powers

- **The Public Health Act 1941** (PHA), enacted for the prevention of diseases and the provision of national health care with legal authority for the prevention and abatement of water pollution

- **The Factory Act 1961** (FAC), provides the legal basis for setting up and controlling industrial plants and wastewater pollution control

Environmental control and law enforcement in Thailand involves the following key agencies:

Office of the National Environmental Board,
Department of Industrial Works,
Department of Health,
Industrial Estate Authority of Thailand,
Industrial Finance Corporation of Thailand,
Office of the Board of Investment,
Office of the National and Social Development Board

whose roles and duties overlap and need to be reorganized and restructured.

POSSIBLE ROLES OF ACADEMICS IN ENVIRONMENTAL PROTECTION

Educational Role: To ensure that environmental concern continues into the future, it is crucial that the educational system is involved in promoting knowledge and creating awareness about dangers to the environment and possible solutions in addition to producing qualified professionals in this area. Curricula at all levels of the educational system should include subjects geared towards environmental protection, particularly at university level. It is important that we consider introducing environmental protection issues in all activities of the university, since our graduates in many fields will become key decision-makers in the future.

Several Thai universities, both government funded and private, offer programs related to the environment in for example, faculties of public health, sciences, engineering, medicine (including occupational medicine) and in environmental resource studies. A wide spectrum of individual subjects have been covered in relation to environmental issues. They include

> *environmental / occupational health and safety, water resources, waste water, solid / toxic waste managment, environmental engineering, food sanitation, vector / rodent control, industrial hygiene and sanitation, toxicology, economic and ecological system management, system approach and cybernetics, economic analysis of the environment, environmental conservation and natural resource management, pollution problems and control, society and environment and appropriate technology utilization*

Knowledge and research generation: Education and training to develop human resources for effective environmental management and disposal of hazardous wastes from industries should be encouraged. There must be investments in and endorsement by the Government of research on environmental and industrial toxicology, biotechnology techniques to detoxify and treat industrial and hazardous wastes by appropriate and/or high technologies. Thai university staff have conducted several research projects and provided services which tackled environmental issues in the private, NGOs and governmental sectors.

Information dissemination: The academic institutions should act as centres for environmental information dissemination on crucial issues, problems, management, legislation and law enforcement by means of lectures, seminars, workshops, exhibitions, conferences, newsletters. They can also communicate through other media such as newspapers, videos, television, radio; musicians and perhaps popular song writers who are one of the most effective environmental communicators in the Thai society. The information released should explicitly establish the threats and magnitude of the problems within a situation together with effective solutions In many ways the Thai universities have successfully fulfilled this obligation.

Creating public awareness: Once the public is very well informed of the threats arising from environmental pollution, activities and programs to create public awareness on the key environmental issues, problems, management, consumer protection, health hazards, legislation and law enforcement should be consolidated by academics. Academics should facilitate greater involvement of the public, in the identification of environmental problems and their resolution, through cooperation and mediation rather than confrontation. Moreover, the enhancement of public campaigns on the preservation of natural resources identity and culture of the nation, historical places, arts, fine arts, Thai architectural buildings and other aspects of our inheritance should be encouraged. Several exhibits have been organized to promote environmental consciousness on the part of the public.

Policy advocation: One key role of the universities is to act as policy advocates for environmental protection, legislation and law enforcement on pollution control. With human resources in a pool of health sciences, pure sciences, social sciences and economics, anthropology and law, academics are well equipped to provide scientifically based sound recommendations and guidelines for policy formulation which reflect the concerns of the public. The universities must stand firm on issues of environmental protection.

Network and data base on environment: Universities can facilitate the creation of a networking system of collaboration between environmental agencies, other human resources and data bases on the environment, across various disciplines. This could be supported by computer technologies and local area networks. Access to data bases could then occur simultaneously and nationwide. Through our contribution, this could make sustainable development and environmental protection a reality in all the sectors of our society.

PLANNING UNIVERSITIES' APPROACHES TO SUSTAINABLE DEVELOPMENT

The philosophy of sustainable development: Thailand has potential to achieve sustainable development as its impressive and sustained economic performance over the last decade demonstrates. This economic growth could generate financial resources that can be invested in projects to improve and protect the environment and ultimately to establish the policies and incentives to achieve sustainable development.

Thailand has indicated its commitment and willingness to cooperate with the global community in environmental protection. Many organizations have expanded their roles to address international issues and show readiness to contribute to global solutions. The Chulabhorn Research Institution is a good example of excellence in human resource development and training in the area of the environmental protection. The Thai believe in building consensus in the approach to sustainable development; tolerance towards different ideas and opinions is a fundamental characteristic of Thai culture. To achieve this goal, the Thai people have to unite hearts and minds and fight for it.

Institutional and Manpower Strengthening: In order to make sustainable development and environmental protection a reality, universities must take action to invest in and support:

- personnel training for extension education on environmental issues
- research projects in both basic and applied fields
- the production of textbooks, technical reports, journals and other scientific publications, on natural resources, environmental problems and management

Reform of the environmental education system: The following changes would contribute to the development of educational programmes:

- the curriculum in schools and higher educational establishments should incorporate basic knowledge on environment, natural resources and ecology
- creating departments of natural resources and environmental management which cover technology, legislation and law enforcement, policy, planning and socio-cultural-economic aspects
- curricula at all levels of the educational system need to incorporate subjects geared towards environmental protection, particularly at the university level and consider introducing environmental protection in all activities of the universities

It is the duty of the universities to promote environmental consciousness, creating public awareness on environmental protection among their members and to the public, by means of generated activities and the network/media, which unite their personnel and the public with effective and practical strategies.

Coordination and consolidation of this approach within all sectors of our society, towards environmental protection and law enforcement is an important role and duty of the universities.

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HEALTH HAZARDS OF ENVIRONMENTAL POLLUTION

convenors:

A J HEDLEY
J PETERS

INTRODUCTION

The topic of this ASAIHL seminar, chosen by the University's Vice-Chancellor, reflects the high level of concern about environmental problems and trends in Hong Kong Since the seminar, the Government's commitment to intervene in these trends has been strengthened by the Governor's address to the Legislative Council on Wednesday October 7th 1992. Mr Christopher Patten's pronouncement, that the pouring of filth into our streams and rivers must stop, is an appropriate paradigm for all our pollution control efforts A clear indication that hardening public opinion may be reflected in community action was given by the Hong Kong Environmental Pollution Advisory Committee proposal, on Oct 19 1992, that heavy penalties including jail sentences should be imposed on polluters. The proposed amendment to the ordinance is due to go before the Legislative Council in 1993. Much of our current difficulty in achieving effective interventions in environmental pollution arises from a lack of awareness of the way in which our lifestyles and work contribute to the burden of pollution, and even perhaps inappropriate attitudes when we do have this knowledge. The key to change here is continuing education, a theme which Dr AR King picks up in his country report for Hong Kong medical and nursing students. He advocates that we sensitise students to environmental issues and include, in the mechanism of this process, some form of participant observation. The approach which he encourages would be a useful model for all disciplines in a tertiary education institution.

Professor Bhopal's keynote raises two important issues. First the problem of measuring the benefit gained by communities as a result of living and working with industrial and other processes which pollute. Second the need for applied research to measure risk. He identifies important problems in the attributing of causal relationships between environmental risks and adverse health effects and adjusting our observations for influences from other social and behavioural characteristics of the populations under study. Bhopal's report clearly indicates that research is an essential part of the political process of pollution control (politicians and legislators need to be convinced about the evidence for detriment to health) and in assuaging or supporting public opinion in relation to both risk and the effectiveness of interventions. Dr TH Lam concurs with Professor Bhopal in that he argues for the epidemiological approach to identify need and also determine the effectiveness of interventions. Many communities may believe that they can progress with environmental controls without epidemiology. Lam makes the point that if we neglect the epidemiological approach then our interpretation of possible causal relationships may be flawed The decisions which follow may then be inappropriate and lead to a waste of resources.

In Governor Patten's speech, October 1992, he acknowledged that Hong Kong's pollution is now affecting our health; many can testify to this including those who, by design or accident, have experienced immersion in the waters of the archipelago. Dr MV Boost and colleagues demonstrate, by using a sampling system of affordable and appropriate technology, based on a beer bottle, that our sea water is highly polluted with anaerobic bacteria The inference that the water is consistently oxygen depleted at a depth of only 3 metres is a signal for urgent action.

Hong Kong is increasingly characterised by its application of modern technology. Drs Burnett and Chan draw our attention to the potential conflict between the achievement of maximum benefits from building designs, in terms of energy efficiency on the one hand, and the creation of a healthy working environment on the other. In addition to the array of health risks in buildings raised by Burnett and Chan, we can also ensure that people do not smoke in other people's space within the built environment.

Dr Mukono's paper from Indonesia emphasises the need for research skills to be available and applied in the investigation of rural health risks in developing countries in the Asia-Pacific rim. Mukono's research approach could be adopted for monitoring the effectiveness of education programmes for farmers. However the protection of the public from both acute and chronic poisoning from pesticides is also now of critical importance. In Hong Kong, City Polytechnic doctors Tanner and Leung have applied a screening test for pesticide residues in vegetables (developed by C Lau of the Agricultural and Fisheries Department) and are comparing the results with chemical analyses of vegetables obtained from the wholesale market. An efficient screening test would allow rapid surveillance of produce to be carried out and rapid action on positive findings. Their studies have also shown that cleaning of contaminated vegetables by a variety of methods may be ineffective.

Most Hong Kong residents have stood within ear-shot and downwind from a percussion pile driver and observed the pollution from noise and exhaust fumes. Drs Tan and Wong deliver a comprehensive review of contemporary research on noise pollution. They conclude with recommendations for a better intersectoral approach, health education and strengthened legislation to promote hearing conservation. When it comes to the point where legislation is applied to penalise polluters the question of whether there has been detriment to health is often raised; in the past, lack of direct local evidence for detriment to health has probably led to the failure of prosecution or lenient judgements and penalties. The report by Peters and colleagues indicates how epidemiological research quantifies the health risks from air pollution; it also demonstrates the failure of planning strategies in that mixed residential and industrial development is an important factor in the creation of environmental risk to individuals. The serious inequity in this process is emphasised by the fact that those with the highest health risk profiles are living in areas with the highest environmental risk. Dr Kyle adds another dimension to the microenvironmental risks of urban conurbations in the form of heat stress. The question is raised as to whether thermal stress will be aggravated in an era of global warming and the case is argued for epidemiological studies of possible excess mortality in periods of extreme heat stress. The streets of Asian cities are now so heavily polluted that those who work *al fresco* are clearly at-risk and we should be able to measure the magnitude of the problem. Drs Bacon-Shone and Liao demonstrate how this field work can be done. They also show that energy consumption in this environment could be reduced in that most workers found their shops and offices were too cold.

Urban health development and the role of the universities, multisectoral cooperation and integrated planning is the theme of Dr RW Simpson's paper from Griffith University Australia and Australian studies on risk assessment and management are described by Professor J Spickett from Curtin University. With a classification of risk criteria and modelling of risks, this report shows how the risks from a particular hazard can be put in the context of background 'everyday' risks. The value of this in communicating the outcomes of risk assessment to the public is obvious, if not yet fully exploited.

Dr KY Lam reviews some factors relating to the cause of asbestosis and related diseases. A study of autopsies in a four year period revealed a prevalence of 1 in 609 cases. Although the disease is rare by any criterion, the survey does indicate that asbestosis is a cause of avoidable morbidity and mortality in Hong Kong and may not always be considered in the differential diagnosis. In Hong Kong the protection of the health of workers falls within the scope of the Factory and Industrial Undertaking Ordinance and its Subsidiary Legislation. In 1992 a new amendment to the bill extends the scope of the Air Pollution Control Ordinance to cover asbestos, in an environment, which currently does not come under the control of any legislation. The proposed control scheme will require owners to identify asbestos and implement management plans to manage the asbestos before conducting any work, including demolition. Unfortunately the removal of asbestos from relatively secure installations may be an even greater hazard than leaving it *in situ*. If the policy of stripping asbestos from buildings continues, it is to be hoped that the legislation will force contractors to apply proper control procedures to protect workers who are handling the material. The protection of workers is also the theme of Dr GLE Tan who reports on exposure to organic solvents in Malaysian industries. His studies clearly identify some weaknesses in control and ventilation systems and underline the need for, and the value of monitoring.

Overall, in this section, academia gives a good account of itself in demonstrating how the educational system, multidisciplinary collaboration and empirical research can make important contributions to the identification and control of environmental risks to the health of our populations.

THE IMPACT OF INDUSTRY ON THE HEALTH OF SURROUNDING COMMUNITIES: AN ANALYSIS OF EPIDEMIOLOGICAL AND PUBLIC HEALTH CHALLENGES

RS Bhopal
Department of Epidemiology and Public Health, University of Newcastle upon Tyne, England

INTRODUCTION: RELATIONSHIP OF INDUSTRY AND POPULATION

Five great changes are undermining the historical alliance between industry and local populations. Firstly, mechanisation in heavy industry has reduced drastically the number of people required to do the work making only a minority of local households dependent upon the industry. Secondly, improvement in the infrastructure required to support public and private transport and the much wider access to the motor car has permitted the workforce to live at a distance from the industry in which they work. Thirdly, both the readier availability of information on health hazards and mass literacy has permitted the public to absorb and act upon the information. Fourthly, the availability of unemployment benefit and other social security measures, which provide a safety net, have given a degree of independence from local industry to people. Finally, through national and international mass media, especially television, people have broadened their horizons, have raised their expectations and become less tolerant of factors which impair their quality of life.

However there are an increasing number of people who are not gaining any direct benefit from living close to industry but who are suffering the perceived disadvantages. These people are asking about the risks associated with living in close proximity to such industries. Furthermore, people may associate a host of problems as being attributable, directly, to the apparent source of hazards, often a local industry. Mostly, these concerns are articulated in terms of health problems, for in health the community finds a potent means of drawing the attention, interest and allegiance of its members and legitimising its claim to attention from the authorities, in a way which, for example, aesthetic problems fail to do.

The purpose of this paper is to analyse, using several recent studies, some of which are described in detail, the problems awaiting those ready to accept the mighty scientific, social and political challenges of research in this area.

CASE STUDIES

The first two case studies, which arose from observations unrelated to direct public concern, were largely driven by scientific curiosity about observed disease variation. The other three case-studies arose from public concern. The Monkton Coking Works Study is described in detail as one of the most comprehensive studies of its kind.

Health in an iron and steel town: Armadale, Scotland: Armadale was a rural hamlet in Scotland until iron and steel foundries were established in the 19th century[1]. Industrial and economic growth were accompanied by much poverty and environmental damage. Industrial closures followed in the 20th century, but one major plant, a steel factory remained open. Examination of the routine mortality statistics for Scotland (1969-1973) showed that the highest rates for respiratory cancer, as reflected in the standardised mortality ratios (SMR), were in Armadale and were not explained simply on the basis of occupation and smoking habits. Moreover, the SMR for respiratory cancer had been lower than the Scottish average until the late 1960's when there was a dramatic increase. The increase was not attributable to an artefact of data collection or errors in either the number of cases or estimates of population on which the rates were based. Air pollution in the district, particularly from the remaining steel foundry, was monitored[1,2].

Respiratory cancer case residences plotted on a map and clustering of cases east of the foundry was demonstrated. In addition, there was a cluster of cases in the north of the town. The sex ratio of births, normally about 1:1 was markedly altered in 1967 (more than 2:1), and moderately high in some other years. The area south west of the plant, where the cluster of lung cancer cases occurred, also had the highest sex ratio in the period 1967-1971. The area north of the town also had comparatively high sex ratios.

Environmental studies were done and the main findings were these:

- Armadale had higher SO_2 and smoke airborne particulate levels than comparable towns;
- the highest levels of smoke occurred on days when the winds were light or easterly;
- pollution with a range of substances (including nickel, chromium and arsenic) from the foundry was distributed north east and south west of the foundry;
- a wind tunnel simulation study showed that pollution from the foundry moved northwards into a small valley north of the town.

Lloyd and colleagues concluded that a casual link had been established with the high risk of lung cancer linked to environmental pollution from the foundry. Similar studies in Bathgate and Kirkintilloch demonstrated an association between exposure to steel foundry emissions and raised risk of respiratory cancer[3,4].

The residents of Armadale were aware of environmental pollution. Their health was shown by empirical methods (analysis of routinely collected mortality and birth statistics) to be affected, particularly in the late 1960's. Epidemiological data, together with observations on wind patterns and patterns of environmental pollution, led to an understanding of the likely cause of the excess mortality and disturbed sex-ratios.

Legionnaires' Disease: Glasgow, Scotland: Legionnaires' Disease is an environmentally acquired pneumonia which may follow the inhalation of aerosols contaminated with legionellae, the bacteria which cause the infection. Such contaminated aerosols are produced by a number of processes including the use of wet-type cooling towers and evaporative condensers. These are widespread in both industrial settings and in large buildings. Essentially, these systems eject a mixture of droplets, steam and aerosol into the atmosphere. The aerosol may contain legionella bacteria which may be transported moderate distances.

Outbreaks of Legionnaires' Disease have been associated with industrial plants and the disease is a hazard, albeit a rare one, for workers in industries where cooling towers are in use. The question is, however, whether Legionnaires' disease can arise in a community setting and if so, whether the source of infection can be traced either to cooling towers in general or to specified cooling towers. The answer, in the context of outbreak related disease, is yes[5]. In relation to sporadic, or more strictly non-outbreak disease, the question is controversial.

The source of aerosol causing sporadic Legionnaires' Disease has been, until recently, unknown. Bhopal and colleagues have recently shown that cooling towers are a source of community-acquired sporadic infection[6]. The approach they adopted was this. Firstly, the location of residence of all unknown cases of Legionnaires' Disease in Glasgow was mapped. The patterns of the geographical distribution of cases were studied for outbreak, non-travel, non-outbreak cases, and for travel related cases. Then, the geographical locations of premises with cooling towers were overlayed. There was, visually, a correspondence between the two patterns, a correspondence which when analysed statistically, showed that people living within 0.5 kilometers of any cooling tower were three times more likely to develop Legionnaires' Disease than those living more than one kilometer away. This observation could not be explained in terms of data error, artefact due to variation in diagnostic activity or as a result of host susceptibility. The best explanation was that people living near cooling towers were being infected in or near their homes after inhaling contaminated aerosol.

Laryngeal and lung cancer near incinerators of waste solvents and oils: England: In response to complaints about odours and nuisance from an incinerator of waste solvents and oils, a local authority commissioned a study of cancers, firstly at electoral ward level, then at a more local level. A possible cluster of 5 cases of laryngeal cancer, 4 of whom lived within 2 kilometres of the incinerator, was found[7]. Statistical analysis based on the Poisson Point Process Model found there to be a statistically significant excess of the cancer.

The Small Area Health Statistics Unit investigated this observation, and undertook an analysis of lung cancer and laryngeal cancer incidence around 9 other incinerators similar to the one above[8]. However, only three of these nine incinerators had been in operation for 10 years or more, and their capacity varied from 1-200 tonnes per month.

Rates were calculated using 1981 census data for the denominator, and postcoded Cancer Registry data for the numerator, and adjusted for age, sex, cancer registry and socio-economic status (using a composite index - Carstairs Index).

Essentially, this analysis showed no statistically significant excess around either the incriminated incinerator as discussed above, or the group of 10 incinerators when the results were pooled.

The authors emphasised that the observation of a cluster of laryngeal cancer cases was made after complaints by the public and after data for several cancers were analysed. In this circumstance the interpretation of statistical tests is difficult. The authors pointed to the limitations of their own study, principally:

- quality of numerator and denominator data;
- the problem of long incubation periods for some diseases;
- and lack of environmental data leading them to use a simple distance-effect model as a proxy for emission exposure.

These problems, they believed, might cause an underestimation of risk. However, they concluded that the apparent cluster of laryngeal cancer cases was unlikely to be due to the incinerator nearby.

Health around a gas refinery: Alberta, Canada: Robert Dales and colleagues investigated, in 1985, whether the concerns about ill-health of residents living downwind of natural gas refineries in Alberta, Canada, were corroborated by measures of health[9]. The gas refineries, in existence since 1957, emitted mainly sulphur dioxide (SO_2) and hydrogen sulphide. Two thousand, one hundred and fifty seven people (93% of those approached) living downwind of the refineries and two control groups of 839 and 632 (both 91% of those approached) were studied. People who had migrated in the previous 28 years were identified and sent questionnaires. Subjects were interviewed and respiratory function tested (FVC and FEV_1). Total sulphation levels in ambient air were mapped and, on the basis of location of residence, used to estimate the exposure status of study subjects. Thus two comparisons were possible: study area versus control area population, and, high and low exposure populations within the study area.

For children, reported respiratory symptoms were highest in the high exposure group, intermediate in the low exposure group, and lowest in the control group. However, lung function was no worse, indeed marginally better, in the two study area groups. Among adults, symptoms were most prevalent in the low exposure group, intermediate in the high exposure group and lowest in the control group. There was no difference in respiratory function.

The authors concluded that chronic exposure to gas refinery emissions have an effect large enough to cause symptoms among children, but not adults, and not enough to affect lung function. Their alternative explanation was that the difference reflected a recall or reporting bias. They recommended that future studies should incorporate methods of assessing psychological factors which might influence symptom reporting.

Worthy of note are: the emphasis on morbidity; the use of a geographically separate control group; the separation of children and adult smokers and non-smokers in the analysis, and the attempt to assess whether people had migrated for health reasons (only about 1% had done so). The crucial lesson from this work is the fact that the authors were unable to assess whether their observations were accounted for by a bias in reporting or a small but true biological effect of air pollution.

Health around a coking works: South Tyneside, England: In 1937 the Monkton Coking Works occupied a "green field" site. By 1967 it was surrounded by housing estates to the north, east and south east. The residents of these nearby housing estates became concerned about both the "nuisance" and health effects of living near an industrial plant which, in common with coking works elsewhere, emitted a complex mixture of airborne pollutants. In response to a lengthy and sometimes acrimonious debate between the residents, a representative of the Residents Action Group and the management of the coking works, the Local Authority funded a study to answer the question:

> Do people who live near Monkton Coking Works have greater ill-health than comparable populations; and, if so, is this related to the coking process?

This ambitious question required the collection of a rich data set[10]. Information was obtained on the following aspects of health or factors closely related to health:

- Socio-economic and lifestyle circumstances
- Causes of death (1981-1989) and causes of cancer (1986-1989)
- Birthweight and gender of newborn (1982-1989)
- Patterns of consultation with a general practitioner
- Long-standing ill-health, both self-reported and as reflected in general practice records
- Recent ill-health
- Perceptions of health
- Attitudes to industry
- Lung function

In addition, information was obtained on the following aspects of the environment:

- Weather patterns
- Smoke and sulphur dioxide (SO_2) emissions from the Monkton Coke Works as reported by the plant (to Her Majesty's Inspectorate of Pollution)
- Smoke and SO_2 as recorded at three monitoring sites near the Monkton Coke Works

Four hypotheses, set in advance of the analysis of the data, were tested:

i) That an effect on health would be specific rather than non-specific.
ii) That health effects of the emissions would vary with the likely degree of exposure.
iii) That for short duration health problems the risk would be greatest when the Monkton Coking Works was in production, and during weather conditions when dispersion of air pollution is difficult.
iv) That the clearest gradients in health problems would be observed in children.

Comparisons were made between one or more of the following:

* Housing estates;
* Areas composed of a number of housing estates closest to the Monkton Coking Works (inner study area) and housing estates a little further away (outer study area);

* Study areas and an area some 6 kilometres distant (control area);
* Study and control areas compared with South Tyneside as a whole, or the remainder of South Tyneside excluding the study and control areas.

The populations in the inner, outer and control areas were comparable with regard to a wide range of factors including housing; occupational exposure to dusts, fumes and chemicals; employment, and lifestyle. The exception was smoking, for which the proportion of current smokers was highest in the control area.

What then, was the answer to the central question of whether people living near the Monkton Coking Works have greater ill-health than comparable populations; and if so, whether this was related to the coking process?

In many respects the people living near the Monkton Coking Works (inner and outer areas) had more ill-health than a comparable population (the control area). This was most evident for self-reported respiratory health, as measured through the community survey. The findings of the self-reported data were bolstered by the analysis of GP records, and (with qualifications) by the lung function survey. In regard to upper respiratory and lower respiratory tract problems, therefore, there was no doubt that there was an excess of ill-health not readily explained.

The second part of the question was more complex. On the basis of the pattern of SO_2 and smoke emissions over several years, the Monkton Coking Works was identified as the principal surviving industrial source of these pollutants in the area. General principles, two models and empirical observation indicated that the concentrations of SO_2 and smoke emitted from the Coking Works would diminish rapidly with distance. As such, all four hypotheses set as the basis for demonstrating whether any excess of ill-health was related to the coking process, seemed reasonable.

The two hypotheses concerning the specificity of the effect on respiratory health, and the effect being most easily measured in children, were upheld. The third, that the effects would be greater for those living closest to the Monkton Coking Works was upheld for self-reported respiratory health. The hypothesis was not upheld in relation to adult mortality and cancer registration data. The fourth hypothesis, that there would be fewer consultations, particularly for respiratory problems, during periods when the Coking Works was closed was not upheld. But using daily air monitoring data, an association was found between the proportion of consultations with a GP for respiratory problems and levels of air pollution, as indicated by SO_2.

The interpretation of this complex data set is as follows: that the emissions from the Monkton Coking works had caused respiratory health problems of a subtle nature, which led to a marked excess of symptoms and a small excess of recognised and diagnosed respiratory disease. It was judged unlikely that emissions from the Monkton Coking Works had caused cancer or death.

DISCUSSION

For subject matter of this importance the scientific literature is scanty, and in particular the methodological approaches have been incompletely conceptualised. On the basis of the case studies seven fundamental questions are considered.

a) How do we identify unknown risks from industrial emissions to the health of the community?

First and foremost we need a change of attitude. The current view that health risk to the community from industrial emissions is small, possibly unmeasurable and probably unimportant, needs to be replaced with one which acknowledges the potential importance of such emissions and accepts as a scientific challenge the need for more sensitive methods for the detection of risk in these circumstances. We need to recall the prevention paradox - that a large population exposed to a small risk may account for more cases of disease and death than a small population exposed to a large risk.

Initially, the investigation should focus on routinely collected health data e.g. mortality statistics, or birth statistics. When problems are apparent more detailed studies may proceed, sometimes in new locations to test hypotheses. The work in Armadale is an excellent example of this approach[1,2,3,4]. The Small Area Health Statistics Unit has been established in the UK with this type of investigation in mind[8].

b) Given community concern what should be the response?

The instinct to ignore or deflect the concerns of communities, so evident in the past, should be resisted. Open dialogue between industry, the community, scientists and officials is essential. Reasoned discussion, with the objective of avoiding conflict, should prevail over assertion and counter-assertion. It is likely that the community has important reasons for concern which may be in terms of financial loss due to local property values declining, loss of amenity, nuisance, and anxiety or evidence of health damage. The funding of such studies poses a problem: the work is unlikely to be suitable for academic research grants and industry is unlikely to fund it for obvious reasons. The responsibility for funding is likely to rest with local authorities or health authorities, bodies which are usually short of funds.

The nature of the community's concern needs to be evaluated with care, and this should guide the investigation. Ideally, the community should both be informed about, and agreeable to, the investigation to be done.

c) What kind of study should be done?

The answer to this question depends on local circumstances. It is unlikely that environmental investigations alone will satisfy the community.

Symington and colleagues reported that even though the air pollution levels around the steel foundry they studied were demonstrably low, complaints continued, eventually leading to a health survey[11]. Where the underlying concern is about health, environmental studies, alone, cannot suffice. If the concern is about a single disease, or about a health state (death, cancer, respiratory health) then that should guide the investigation. Discussion with the community may be needed to agree on the prime concern, or focus of the study. Thus Dales and colleagues[9] concentrated on respiratory health, as did Symington and colleagues[11], presumably having agreed these priorities with the community. The Coking Works Study was deliberately comprehensive in its scope. Firstly, the dispute was at an advanced stage such that a definitive rather than preliminary answer was needed. Secondly, the community believed that the coke plant emissions were causing a wide range of health problems. Thirdly, Bhopal and colleagues were intent on exploring methodological issues so as to develop methods to guide future research[10].

d) What kind of health data need to be collected?

The data to be collected will depend on the nature of the studies but some general points can be made. Valid population denominator data for small geographical areas are essential for analyses of routinely collected denominator data. Thus, in the absence of population data for the geographical area to be studied, information about causes of death, cancer, hospitalisation etc. is of limited value because disease rates cannot be calculated. Numerator data require a geographical reference such as postcode or map grid reference number which can be used to define the number of cases in a geographical area of known population. The Coking Works Study[10] and the Legionnaires' Disease study[6] illustrate the use of existing administrative boundaries (enumeration districts) to build up either fixed geographical areas (housing estates, inner area etc. as in the Coking Works Study) or conceptual geographical areas (all enumeration districts within

0.25 km of any cooling tower etc. as in the Legionnaires' Disease study). The study of laryngeal cancer[8] around waste incinerators used enumeration district boundaries merely to permit the development of (near) circular areas around a point source. In the absence of such data investigators will be forced to undertake surveys afresh so as to gather both numerator and denominator data. As data on most causes of morbidity, and particularly on symptoms, are rarely available, such surveys may be necessary in any case. Data from community health surveys have the ability to discern subtle health effects. However, they present problems of interpretation posed by incomplete response, error and recall bias. Thus, Dales found that children, but not adults, living close to a gas refinery had more symptoms than expected. They were unsure as to whether this was due to recall or reporting bias or a true difference in morbidity[9]. Bhopal and colleagues deliberately asked questions on a wide range of health problems based on the idea that a recall or reporting bias would be non-specific while a true difference would be specific. They were convinced that recall bias was small by the striking specificity of the excesses reported. To counter criticism, most investigators would be wise to incorporate an objective indicator of health status. Dales and Bhopal and their colleagues did lung function tests[9,10] while Symington and colleagues had planned to follow-up their community questionnaire surveys with lung function tests, if there had been cause to do so[11].

The role of consultation-based information and other data from primary care health records requires more study. Here we have a relatively objective record of health events which are not of extreme severity and do not have a prolonged period between exposure and effect.

e) How do we infer cause and effect?

The problem of inference of cause and effect (exposure to emissions and disease) are great. To error and bias, which were discussed above, we can overlay the profound problem of confounding, whereby the apparent relation between cause and effect is mediated via another factor. For example, let us say that lung cancer is commoner in a population close to a dockyard than in a control population some 10 miles away. Is the excess due to proximity to the dockyard or due to other attributes of populations living close to dockyards? The most obvious explanation is that lung cancer is more common in older men and it may be that the population near the dockyard has more such people. We need, therefore, to adjust our analysis for age-sex differences. Other explanations are that the population near the dockyard is more likely to smoke, or more likely to work in occupations handling asbestos than the control population. In other words, the populations near the dockyard are different from those elsewhere.

No observational epidemiological study can adjust for all confounding variables, partly because the size of the required study would be too great and partly because we do not know all the confounding variables. How then do we solve the problem? The randomised control trial design overcomes the problem but in our context is not feasible or ethical. One partial solution is to adjust for important confounding variables or to match control groups with great care, or both. Elliot and colleagues adjusted their analysis of laryngeal lung cancer incidence not only for age and sex, as is usual, but also for socio-economic standing as indicated by a composite index, the Carstairs Index[8]. Dales and Bhopal and colleagues, used geographically distinct but comparable control groups[9,10]. Lloyd[1], Symington[10], Elliot[8] and Dales[9] and again Bhopal[10] and their colleagues compared areas within areas of interest, based on the concept that exposure is related to distance from the source.

The geographically distinct control population can be helpful in countering the confounding problem but doubts will remain about the true comparability of populations. It does not help with two other problems: the problem of selective migration into and out of the population and the problem that the health of people studied now has been influenced by exposure to emissions in the distant past; exposures which are likely to have changed and are not now measurable. Both these problems are, at present, nigh insurmountable. Dales and colleagues took unusual care in following up by postal questionnaire migrants from the areas under study[9]. Bhopal and colleagues asked about length of residence in the local area and were reassured to find most subjects had resided in the area for prolonged periods.

In their study of the Coking Works, Bhopal and colleagues were interested in acute health events, as reflected in general practice consultations, specifically to study the relation between exposure to ongoing pollution and also to solve the problem of confounding[10]. By comparing the health of individuals over time, and relating it to environmental events, we can infer that no person-related confounding factors are responsible for the association and that health effects of ongoing interest are being studied. The power of having both comparisons between populations at a point in time, and within populations over time, is apparent.

f) How should the release of data be handled?

The disclosure of the results is less a matter for science than for politics. Nonetheless scientists need to consider the impact of, and interpretation of, their results. Studies of the nature described here are likely to be highly controversial and of immediate and wide interest. They need, therefore, to be written so that, with a little help, the intelligent layperson can read them. The conclusions and the recommendations need to be particularly clear. Verbal presentation with ample time for questions is highly desirable. The distortion of the conclusions in the ensuing debate is inevitable but the role of the scientist is to write in such a way that distortion is minimised.

g) What needs to be done to make the response to public concern easier in future?

The debate on how this area of research and social relations should develop is ongoing. There is no clear consensus. However, it is clear that secrecy, hostility, or deflection of the public's concern by industry or professional agencies are likely to be increasingly counterproductive and ineffective tactics. Awareness, dialogue, information sharing and a readiness to undertake empirical studies are tactics which are likely to be beneficial for industry and public alike. The onus is on researchers to produce models for effective and efficient research and to build a bank of studies from which general lessons on both methodological issues and health effects from industrial emissions can be derived. While the thirst of populations living near industry for scientific studies is unlikely to be assuaged by bland reassurances or scientific extrapolations which are beyond their comprehension, it may be whetted by information from research in directly relevant circumstances. Thus, people concerned about gas refineries need to have access to the study by Dales and colleagues[9] and those concerned about incinerators of oils to that by Elliot and colleagues[8]. In the better acquisition, flow and application of scientific data on the health of people living near industry lies the basis of a successful response to public concern in the future.

ACKNOWLEDGEMENTS

I thank my co-authors Drs P Phillimore and S Moffat and Mr C Foy for permitting me to adapt the abstract of the Monkton Coking Works Report (Ref 11) for this paper Thanks also to Dr S Moffat and Dr S O'Brien for critical comments on the previous draft. My gratitude to Mrs Eileen Coope and Mrs Lorna Hutchinson for preparing the manuscript.

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EPIDEMIOLOGY AND ENVIRONMENTAL HEALTH: RELIABLE RISK MEASUREMENT IN WELL-POPULATIONS

TH Lam, AJ Hedley and J Peters
Department of Community Medicine, The University of Hong Kong

INTRODUCTION

The control of environmental and occupational exposure to health risks is an urgent priority world wide. In developed countries with a longer history of environmental control measures, there are increasing arguments for even greater control of environmental risks. In Asia, many communities are facing rapidly deteriorating environmental conditions as a result of urbanisation, new industries and pollution from neighbouring territories. The new health risks from environmental pollution are being superimposed on other trends in life styles (including the use of tobacco and alcohol and changing diets) and the background of other long standing morbidity patterns. Although the importance of environmental control and protection is increasingly recognised, there are marked differences in priorities for action.

Despite the differences in public perception and demand between developed and developing countries, arguments for control of environmental health risks have often been based on anecdotal and circumstantial evidence of risk to individuals or small groups, for example in a particular occupational setting. Episodes of acute poisoning resulting from pollution and causing a few deaths tend to attract wider media coverage and more public attention than chronic risks which can lead to gradual deterioration of the health of large populations.

Legislation and the establishment of regulatory agencies are usually the first steps in government involvement in environmental control. The focus of control measures is naturally directed at environmental pollutants and the setting of environmental exposure standards for various substances hazardous to health. This is followed by environmental monitoring to evaluate whether the standards are being exceeded or not. What is usually lacking in these processes, particularly in developing countries, is an epidemiological approach to the assessment of health risks.

DO WE NEED EPIDEMIOLOGY?

Our arguments for an epidemiological approach are based on the assertion that, as an empirical science of public health, epidemiology is the foundation of environmental health. It is needed to measure the distribution and determinants of health or ill health in populations. The role of epidemiology in setting exposure standards has been aptly emphasized in a review by McMichael[1]. Historically, the use of epidemiology has been mainly concerned with the identification of risk factors for serious diseases and mortality. In recent years, the advance of the discipline from qualitative to quantitative assessment of risks is exemplified by the fitting of exposure-response models to epidemiological data. Also historically, the evidence of causality at high exposure levels was clearcut but nowadays the range of exposures commonly of interest to regulatory authorities are low exposure levels for which there is little evidence about health consequences. McMichael has identified three problems for such model-fitting for low exposure ranges:

(1) There may be no reliable, precisely defined, measures of actual exposure of individual subjects;
(2) The health risks are small and difficult to detect with the desired level of statistical confidence; and
(3) Threshold exposures (a threshold dose is one below which ‘no response’ occurs) must be considered for setting exposure standards.

While the situation reviewed by McMichael must be true for developed countries with low levels of exposure and a high level of epidemiological data and expertise, in developing countries struggling between economic developments and environmental protection, the need for epidemiology may be less apparent or accepted. If a government regulatory agency has reached as far as the stage of setting environmental standards, will the regulatory agency feel any need for input from epidemiologists? If so, will such input be readily available locally and be relevant to the local situation?

When environmental exposure standards have to be set urgently in developing countries, there are many potential arguments which may be levelled against the call for such epidemiological input. First, there are already internationally recognised standards. These standards have usually been set after much effort by world experts including epidemiologists. They are readily available for use; the question as to whether the standards are too strict or unrealistic probably requires a political rather than a scientific decision. Second, there may be no local expertise and no local data. Third, because of a lack of resources, it may be argued that money should be spent on measures to improve the environment, rather than on epidemiological research which may be considered to be of only "academic" value.

EPU-EPA-EPD IN HONG KONG

The establishment and rapid expansion of the Environmental Protection Department (EPD) in Hong Kong reflects a strong commitment from the Hong Kong Government and is a major milestone in the history of environmental protection. The EPD began as a small Environmental Protection Unit (EPU) in 1977 which was strengthened to become the Environmental Protection Agency (EPA) in 1981. Further centralization and expansion of environmental control activities necessitated the establishment of the EPD in 1986.

During the early years of environmental control in Hong Kong, the role of epidemiology was uncertain and inconspicuous. The first milestone was laid only in 1987 when the EPD joined forces with the Departments of Community Medicine and Microbiology, Hong Kong University, in carrying out an epidemiological-microbiological study on swimming-associated illnesses. It was found that swimming at the "barely acceptable" beaches incurred higher risks of contracting skin, ear, respiratory and gastrointestinal illnesses than at "relatively unpolluted" beaches. Furthermore, a quantitative relationship between the densities of *Escherichia Coli (E. Coli)* in beach water and swimming-associated gastrointestinal and skin symptom rates was established[2]. Although the relationship could not explain more than about 50% of the variation in the illness rates, it was the first time local epidemiological data and modelling was used as a basis for setting exposure standards. It is noteworthy that the request for epidemiological input from the University was initiated by the EPD after an earlier phase of the study which was concerned only with the measurement of pollutants on the beaches. Another phase of the study will be carried out shortly by the EPD and the Chinese University of Hong Kong.

In contrast, the control of air pollution predated any local epidemiological input. In 1983, the Air Pollution Control Ordinance was enacted. Air control zones were named, the first two being Victoria Harbour and Tsuen Wan - Kwai Chung in 1986, followed by eight other zones covering the rest of the territory in 1989. Air quality objectives were set. These objectives comprise a list of levels of air pollutants which must not be exceeded. Environmental monitoring was carried out by a network of monitoring stations. It was found that the air quality objectives were often exceeded in many areas, one of the worst areas being Kwai Chung, a district with a considerable number of industrial outlets adjacent to large clusters of residential buildings.

THE RESPIRATORY HEALTH SURVEY

The second milestone originated in a very different way. As pointed out earlier, Kwai Chung was well-known for being the most polluted area in the territory with air quality objectives frequently being exceeded. Figure 1 shows the situation in 1988[3].

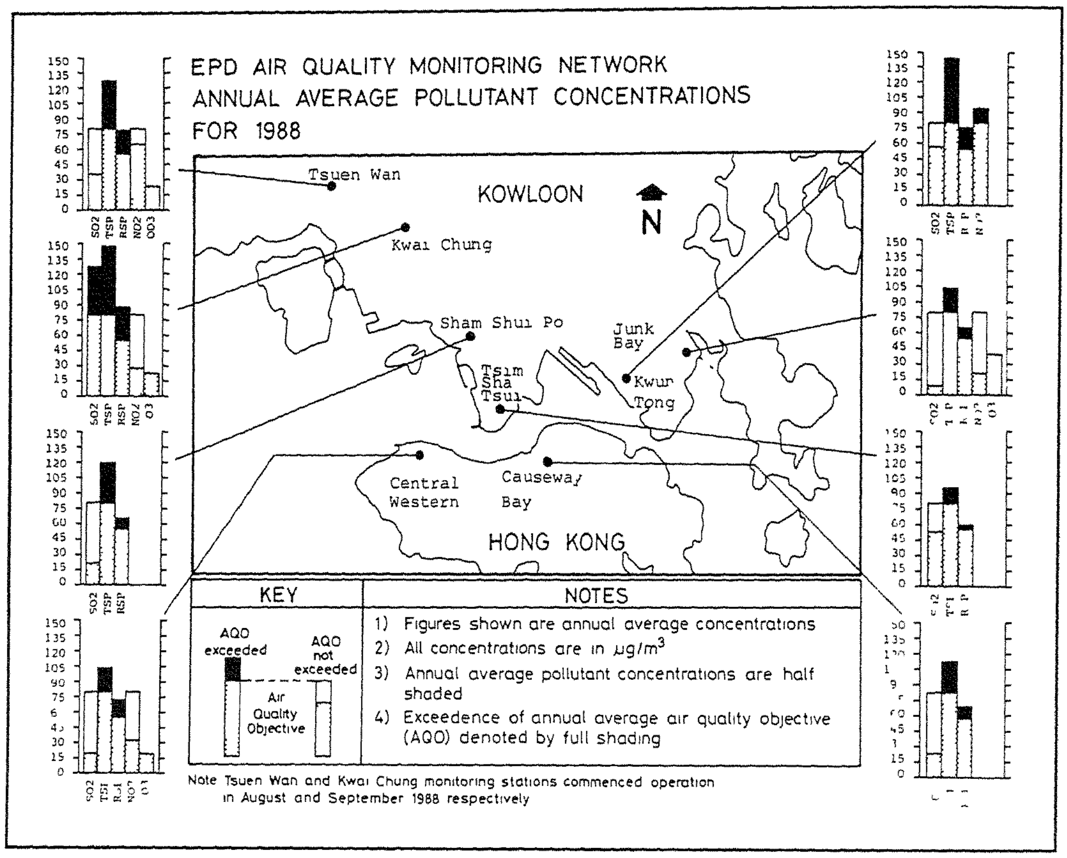

Figure 1: *Hong Kong's annual average pollutant concentrations recorded at air quality monitoring stations during 1988. (source: EPD 1989 [3])*

Kwai Chung, together with the adjacent island of Tsing Yi are constituencies of the Kwai Tsing District Board. In Kwai Tsing District (KT), there were about 8,000 industrial establishments mainly involved in garments, textiles, dyeing, enamel and electronics[4]. The district was also densely populated with large public housing estates and private residential buildings. For some years and on many occasions, the Kwai Tsing District Board had received an increasing number of complaints from its residents about the problems of air pollution and the alleged adverse effects on their health. The Environmental Affairs Committee of the District Board, having openly voiced their concerns repeatedly without much avail, decided that they should act on their own initiative. Their decision was that an investigation should be carried out to demonstrate whether or not air pollution did have an adverse effect on the health of Kwai Tsing residents. It was hoped that if the results confirmed the residents' views they would lead to the adoption of more stringent measures by the government to tackle the problem.

The Department of Community Medicine, Hong Kong University was approached for assistance to carry out the study in 1988. Realizing the importance of such a request, the Department decided to organise an epidemiological enquiry to determine whether there was any evidence of adverse health effects which could be attributed to residence in Kwai Tsing. Because of the very limited budget available to the District Board, the Department had to devote some of its own resources and to seek other sources of funding. The Department of Paediatrics was also invited to participate in the study. The first stage of a two year survey was carried out in 1989. Details of the Respiratory Health Study and the preliminary results have been reported elsewhere[5,6].

Nineteen hundred and seventy-nine children from Kwai Tsing were compared with 1477 children from Southern District where air pollution was considered to be satisfactory (with air quality objectives seldom exceeded). These children, the majority of them aged 8-10 years, were from primary 3 and 4 classes of schools selected in consultation with the District Board and the EPD. After adjusting for gender, age, socioeconomic factors, self smoking, exposure to passive smoking at home, the prevalence ratios of respiratory symptoms were found to be significantly higher in Kwai Tsing[6]. The excess risks ranged from 22% to 55%[5]. An assessment of the subjective perception of air quality confirmed the finding that fewer of the children and parents in Kwai Tsing (about 60%) compared with those in Southern District (about 90%) considered that the air quality of their district was good.

The field work of the second phase of the survey was completed in June 1990. In July of that year, new regulations, the Air Pollution Control (Fuel Restriction) Regulations, introduced by the EPD, which restricted the sulphur content of fuel oil in Hong Kong came into effect. This immediately led to great improvement in the air quality in Kwai Tsing. At one location in North Kwai Chung, a reduction of sulphur dioxide levels by 83%, total suspended particulates by 32%, and respirable suspended particulates by 27% was recorded[7].

In 1991, a consultancy was agreed between the EPD and the Department of Community Medicine for the academic department to continue the study which is now scheduled to be completed in mid 1993. The purpose of the consultancy is to assess the impact of the implementation of the new fuel restriction regulations on the health of primary school children in Kwai Tsing. Fieldwork in 1991 was extended to include approximately 4,700 and 4,900 children in Kwai Tsing and Southern District respectively. The final phase of the fieldwork in 1992 is in progress and on its completion the children first surveyed in 1989 will have been followed up for either 3 or 4 years.

EPIDEMIOLOGY IS NEEDED - SOONER OR LATER

Our experience in the Beach Survey and the Respiratory Health Study illustrates how an academic institution can contribute its epidemiological expertise in environmental health. In both surveys, an epidemiological approach was needed to produce reliable risk measurements in well-populations. The Beach Survey was initiated by the EPD in the early stage before control measures were implemented and the data were used to develop exposure standards. A new phase of the survey will provide more precise data relating the risks from specific pathogens other than E. Coli.

In contrast, the Respiratory Health Study was initiated by members of the community who were affected when exposure standards, which were already set, were exceeded. The control measure restricting the sulphur content in fuel oil was implemented in 1990, independent of the 1989/1990 survey results. However, the potential value of an epidemiological study as an evaluation measure was quickly recognised and this led to the extension and expansion of the survey with the aims of both evaluating the effectiveness of the control measures and predicting future risks.

We believe that these population based studies clearly indicate how a tertiary institution with epidemiological expertise can contribute to environmental control and protection. The experience reported so far suggests that effective collaboration between an academic institution and a regulatory body is both feasible and productive.

This kind of collaboration is important from the point of view of resource allocation. For example, in the Respiratory Health Study we encountered big problems because of insufficient resources in

This kind of collaboration is important from the point of view of resource allocation. For example, in the Respiratory Health Study we encountered big problems because of insufficient resources in 1989 and 1990. Resources from the Kwai Tsing District Board were very limited and soon became exhausted. Without the EPD consultancy, it would not have been possible for the study to continue to the present stage and the investment of time and effort in the first stage would not have been fully exploited.

When there is severe competition for resources, one can always hear arguments that epidemiology is not really needed. For example, in Kwai Tsing, one might argue that since the levels of pollutants were greatly reduced after the regulations were implemented, the problems of the Kwai Tsing residents should now be largely contained and the cause for complaints removed. However, one reason why epidemiological studies with objective measures are needed to assess the impact of environmental controls is that subjective complaints may not always reflect changing patterns of air pollution. According to anecdotal experience from our colleagues in the EPD, it appears that, for a while, there were fewer complaints after July 1990 but the level of complaints then seemed to pick up again, despite the fact that there had been no deterioration in air quality. Our EPD colleagues' impression can be confirmed by the results of the assessment of population perceptions of the air quality in the Respiratory Health Study. Figure 2 shows a general decreasing trend in the proportion of subjects who considered that the air quality of their living environment was good, with the possible exception of Kwai Tsing children in 1991. Such a trend, if supported by increasing health problems, would be unexpected and alarming in view of the reduction in the concentrations of air pollutants. Alternatively, another explanation is that the increasing complaints and dissatisfaction might actually reflect the increasing demands and expectations for an even better environment, after some initial improvements have been achieved.

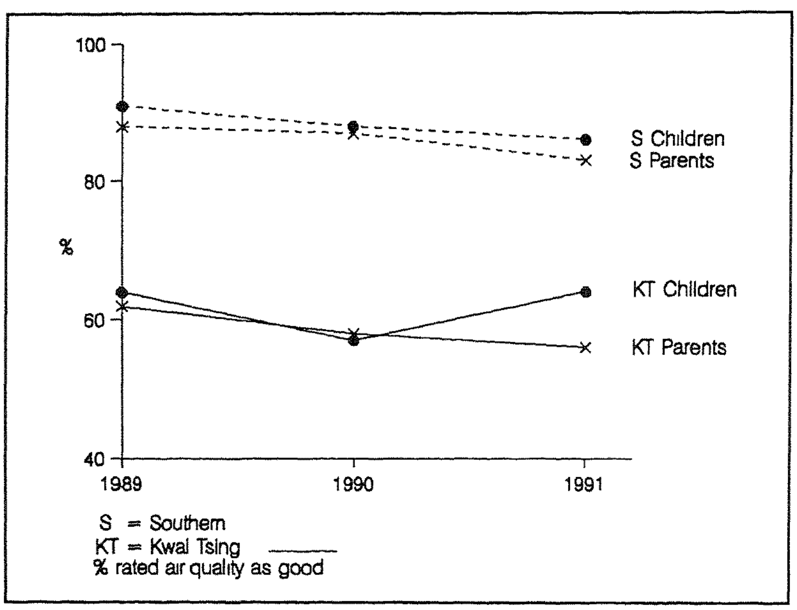

Figure 2: *Perception of air quality by Kwai Tsing and Southern parents and children, 1989-1991*

Figure 3 shows the preliminary results of crude prevalence ratios of three selected symptoms which showed statistically significant differences between Kwai Tsing and Southern children in 1989. The pattern of decreasing prevalence is not consistent with the increasing dissatisfaction of the subjects. The complaints of the residents seem to be prompted more by the visible emissions from the chimneys nearby than by increasing health problems. While it is premature to draw any definitive conclusions based on data from only three years, a clearer picture should emerge when the 1992 data are available.

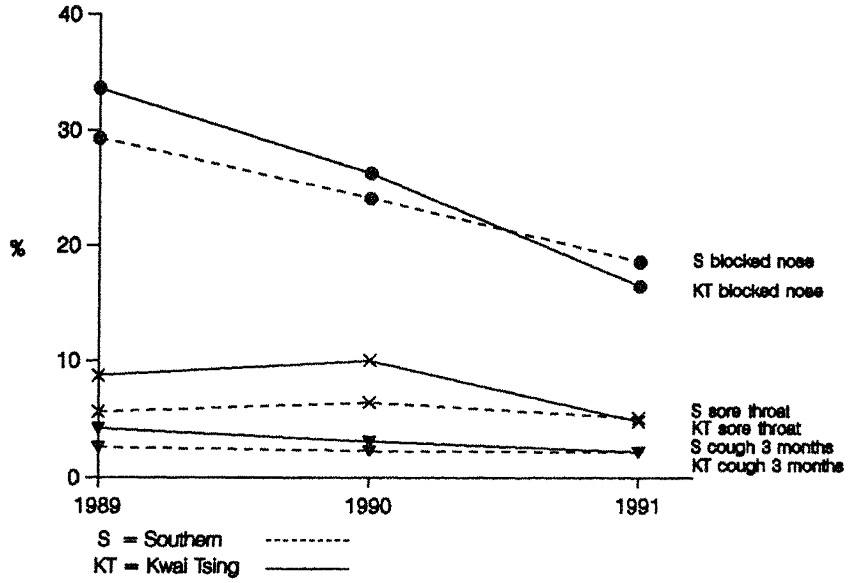

Figure 3: Prevalence of selected symptoms in Kwai Tsing and Southern children, 1989-1991

HAZARD, RISK AND PERCEPTION

Environmental pollutants with a high degree of visibility, such as dark smoke from factory chimneys, are readily recognised and often regarded as hazards to health, with or without evidence from epidemiological data. For the layman, the terms hazard and risk are often used synonymously resulting in much confusion. In epidemiology, hazard is defined as the potential of an agent or a factor to cause harm. Labelling something as hazardous to health does not carry much meaning unless the risk, i.e. the probability of the agent or factor to cause harm under specific conditions, is known. Risk is an epidemiological and statistical concept which is determined by measuring the incidence of disease or ill health in a defined population under specific conditions. Exposure standards are set in relation to exposure and health risk data, as well as other factors, such as technical or political considerations.

When exposure standards from developed countries are adopted by developing countries, the type of epidemiological data, the degree of risk and other considerations on which the exposure standards are based are often ignored and the specific conditions and limitations are not fully appreciated. The standards are sometimes treated as sacred and their relationships with health risks tend to be interpreted in a simplistic and absolute (or dichotomous, i.e. "yes" or "no") manner. If the standards are not exceeded, one then assumes that it is *safe* and there are no health risks, and vice versa. In this area, even environmental control professionals, with no special expertise in epidemiology, may confuse *risk* with *hazard* and *exposure* standards with *safety* standards.

It is well known that public perception of risks does not always correlate closely with the actual degree of risk. The reactions of the public are not always rational and do not necessarily vary proportionately with the magnitude of risk[8]. The role of epidemiologists, in addition to measuring health risks, should therefore include communication to other environmental control professionals, as well as the public, of the meaning and implications of the risks and the uses and limitations of exposure standards.

Furthermore, the methods of epidemiology can be used to measure the subjective perception of the public as well as other relevant factors which may be associated with perception and health. For example, the Respiratory Health Study findings on perception of air quality strongly suggest that the residents of Kwai Tsing are not satisfied with the conditions of their living environment. The findings on socio-economic variables also reveal that they belong to a disadvantaged sector and are more likely to have unhealthy habits such as smoking. The promotion of health for this population therefore involves much more than environmental control measures. Of course, whether environmental control would produce more health benefits than, for example, smoking control is a more fundamental question. It is interesting to note that results from the Respiratory Health Study show that self smoking by the children and exposure to passive smoking posed higher risks to the health of individual children than air pollution in Kwai Tsing.

CONCLUSION

It is sometimes argued that protection of the environment can, by itself, be an objective which is sufficient to justify control measures, even without reference to human health. We may even agree that the environment needs to be protected purely for its own sake. However, we must recognise that the ultimate objectives of environmental protection are to protect (and promote) the health of populations as well as their environment.

In terms of input, the relationship between ***"Environmental Control - Health - and - Epidemiological Assessment"***, is often markedly skew to the left. Obviously, more resources need to be devoted to environmental measures and these should involve government, industries and other sectors, as well as the general population. However, although the skewness to the left is not unjustified, what we must not forget is the crucial input on the right from epidemiology. Without epidemiology, environmental health cannot be built upon solid foundations. Even if control measures are accepted and implemented in the early phases of government involvement, further progress is likely to be hindered if detriment to the health of the population by certain environmental factors cannot be convincingly demonstrated. Conversely, the benefits in terms of reduction of adverse health effects after implementation of control measures must be evaluated by epidemiological data.

As we progress, the measurement of small but important health risks in the general population will be an increasing challenge to epidemiologists. In developing countries, for example in Asia, the beginning and development of epidemiology has been modest and we have to learn from our own experiences and those of our neighbouring countries with similar problems. Where epidemiology lags behind environmental measures, we must try to catch up to demonstrate the value of epidemiology in the evaluation of effectiveness of control measures. When control measures are not in place, epidemiologists should take the lead in demonstrating the adverse health effects and translate health data into action plans. No matter where we are now, there will be increasing calls upon epidemiology in environmental health issues. Teaching and research in epidemiology should therefore be strengthened in academic institutions which can and must play a major role.

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AN INVESTIGATION INTO THE PRESENCE OF ANAEROBIC BACTERIA IN COASTAL WATERS OF HONG KONG

MV Boost, LP Wong, PS Wong and KC Ma
Department of Health Sciences, Hong Kong Polytechnic

INTRODUCTION

The pollution of seawater is an increasing problem and one which requires monitoring. It is now evident that in spite of the vast volume of the sea that the large amount of waste material discharged into it is having a great impact. The types and sources of seawater pollutants include domestic sewage, sewage sludge, industrial wastes, solid wastes, shipboard wastes, pesticides, dredge spills, offshore oil exploration and production wastes, oil spills, radioactive wastes, heat, sediments from overland run-off and antifouling paint.

Causation of disease: The diseases transmitted by the water route include those with a faecal-oral route of transmission and are associated with the contamination of water by human faeces. Other problems include eye and skin complaints including cases of soft tissue infection of wounds contaminated with sea water. Monitoring of seawater has heavily relied on the enumeration of coliforms as indicators of pollution as these organisms are consistently found in human faeces[1]. This approach, whilst revealing the incidence of faecal contamination does not reveal longer term changes to the seawater[2].

Oxygen depletion: Most organic wastes entering the sea are biodegradable, but this aerobic degradation requires the use of dissolved oxygen. Since there is a finite amount of dissolved oxygen present in seawater, its concentration will be reduced to a very low content unless it is replenished by transfer of oxygen to the water by the atmosphere or other means. However, these rates of re-aeration are generally slow and the addition of large amounts of biodegradable organic matter to seawater will result in lowered dissolved oxygen levels and possibly in the development of septic conditions. Under these low levels of oxygen, anaerobic organisms can survive and their isolation reveals the effects of long term pollution. Anaerobes are present in high numbers in human faeces[3]. Under anaerobic conditions, the anaerobic bacteria may breakdown organic compounds resulting in the production of acids, alcohols, mercaptans (organic compounds with -SH radicals), and hydrogen sulphide. These materials are foul-smelling and are often toxic to aquatic organisms. Anaerobes may cause wound infection and may contaminate sea food[4]

Identification of anaerobes: This study attempted to isolate anaerobes from polluted areas of Hong Kong waters to determine if this pollution had resulted in severe oxygen depletion which would allow the survival and growth of these organisms.

As anaerobic organisms can only survive in low oxygen tension, the aim is to collect seawater samples from well below the water surface to increase the chance of isolation[5]. Also, the whole process of isolation must be rapid to prevent the death of anaerobic organisms by exposure to air. A variety of apparatus has been devised and described for the collection of seawater from the desired depth[5,6,7,8]. The type of apparatus to be used is determined by the sampling location and conditions[6] In general, the collecting apparatus should meet the following requirements: (i) be able to withstand the rough handling and high pressures to which it will be subjected; (ii) be capable of being sterilised and made of an inert material so as not to exert any bacteriostatic or bactericidal effect; (iii) hold a sufficient volume of material for microbiological analysis; (iv) be free from toxic substances e.g. disinfectants; and (v) be protected from light sources.

MATERIALS AND METHODS

Sampling Apparatus: As resources were limited, a simple sampling device was designed to collect seawater samples from a depth of about three metres. The sample bottle chosen was a beer bottle with a capacity of 550ml and made of brown glass, chosen because it would protect the sample from the light during transport to the laboratory. This sampler was derived from the 'Mouse-trap' bottle described by de la Roy[8]. The main difference being that the one used in this study was not resealed by a secondary closure cork. However, as the sample bottle had a long, narrow neck, this reduced the degree of contamination (Figure 1).

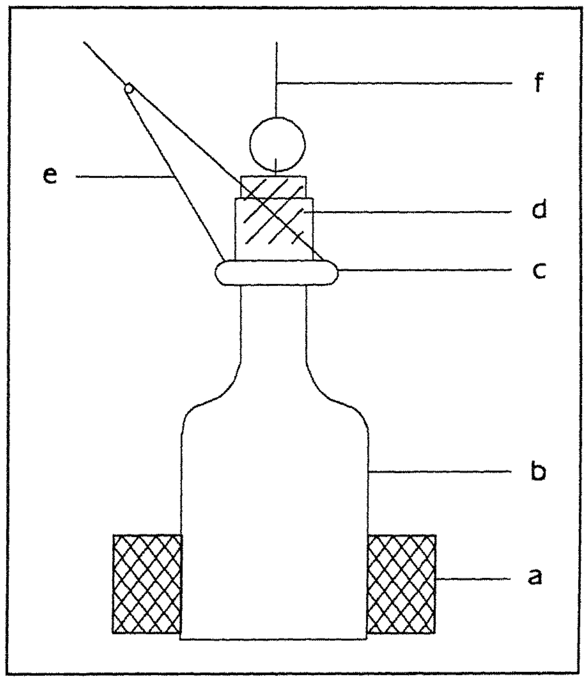

Figure 1: *Sampling bottle - a, weight (brick), b, brown glass bottle (beer bottle); c, metal ring (screwed), d, cork with a handle on the top, e, string connected to the metal ring; f, string connected to the handle of the cork*

Procedure for Sample Collection: Two brick weights were fixed to the bottom of the sample bottle using adhesive tape to ensure it remained in an upright position after it was dipped into the sea. The weighted bottle was tied with string to the metal ring (C). The apparatus was lowered into the sea. When the apparatus reached a depth of about 3 metres, the string connected to the handle of the cork was pulled. The bottle was allowed to remain in position for about 2 minutes to let the seawater fill it. The apparatus was then pulled up quickly and the bottle fitted with a cork to prevent contamination (Figure 1). Each sample was carefully labelled with the date and time of sampling and the location of the sampling point.

The sample was examined within six hours of collection, as the number of bacteria in seawater samples changes fairly rapidly after collection, an initial decrease in numbers being followed by a rapid increase[7]. To prevent exposure to sunlight and to keep the sample cool, it was transported in an insulated container to limit the changes to bacteriological content of the seawater.

Sampling Sites: Three sampling sites were chosen: Causeway Bay, Hung Hom Bay and Tolo Harbour. Water was collected from three different areas at each site. Four samples were collected from each area, each sample having a volume of 300ml.

Sample Preparation: Samples were shaken vigorously to break up bacterial clumps. As the number of organisms of interest was likely to be low, direct inoculation on solid media was not practicable and centrifugation and membrane filtration were used to allow a large volume to be examined. Two samples from each area were concentrated by means of centrifugation, whilst the remaining two were concentrated by membrane filtration.

Centrifugation: The sample was centrifuged at 8xg for 1 hour at 15°C. The supernatant was discarded and the sediment resuspended, inoculated to Schaedler agar with 5% horse blood and thio-glycollate broth and incubated anaerobically at 37°C for 48hrs.

Membrane filtration: The sample was filtered through a 0.22μm cellulose acetate filter and the filtrate discarded. The membrane was carefully removed and a portion of the membrane (about 1/4 sector of the membrane) was cut and inoculated to a bottle of thioglycollate broth[9]. The rest of the membrane filter was placed onto the surface of a neomycin Schaedler blood agar, taking care not to trap any air between the membrane and the agar. It was incubated together with the thioglycollate broth for 48 hours at 37°C anaerobically.

Isolation of bacteria. After 48 hours incubation in an anaerobic chamber, colonies were subcultured to two further blood agar plates: one to test for oxygen tolerance, the second to be used for identification tests A Gram stained smear was prepared The thioglycollate broth was subcultured after 48 hours onto further blood agar plates and to the following selective agar: arginine-glycerol-salt agar for isolation of actinomycetes[10]; kanamycin-aesculin agar for isolation of Gram positive anaerobic cocci[10], tomato juice agar for isolation of lactobacilli; thiosulphate-citrate-bile salt-sucrose agar for isolation of anaerobic Vibrio species.

Any obligate anaerobic organism isolated from seawater was identified by its biochemical reactions and other tests. Tests performed included sugar fermentation, urease, gelatin liquefaction, indole production, hydrogen sulphide production, litmus milk, nitrate reduction, aesculin, lecithinase production, bile tolerance and high potency antibiotic sensitivities as appropriate. These were all performed by standard methods.

RESULTS

Bacterial isolates: Species from five genera of anaerobic bacteria were isolated from the seawater samples: Clostridium, Lactobacillus, Bacteroides, Prevotella and Peptostreptococcus. The isolates included:
Clostridium subterminale, Bacteroides fragilis, Clostridium tetani, Prevotella melaninogenica, Clostridium novyi A, Prevotella oralis, Clostridium cochlearium, Peptostreptococcus magnus, Clostridium perfringens, Lactobacillus species, Clostridium species. Of the selective media used, only tomato juice agar yielded additional organisms.

There were some differences in the isolations from the different areas sampled.

Causeway Bay Typhoon Shelter: There were between three and six colony types isolated from each sample taken at this site. Twenty-six isolates were found to be anaerobic bacteria, these made up 59% of the bacteria isolated. The majority of the anaerobic bacteria were members of the genus Clostridium (57%). Other organisms found at this site were Bacteroides (29%), Peptostreptococcus (11%) and Lactobacillus (3%).

Tolo harbour: The organisms isolated from this site were mainly facultative anaerobes, only 35% of bacteria isolated were anaerobes. Clostridium (57%) and Bacteroides (43%) species were the only anaerobic genera isolated.

Hung Hom Bay: Anaerobic flora also predominated (53%) in these samples, and of these isolates, Clostridium species made up the majority (70%). The remainder of isolates at this site were Peptostreptococcus species (30%).

Among the anaerobic bacteria isolated, Clostridium species were the most common comprising 64% of the total number of anaerobic bacteria isolated. The species isolated most frequently was *Clostridium novyi A.* Fewer Gram negative anaerobes were isolated with representatives of the Bacteroides and Prevotella making up 24% of bacteria isolated. The Peptostreptococci (11%) and the Lactobacilli (1.5%) made up the remainder of the anaerobic isolates (Figure 2).

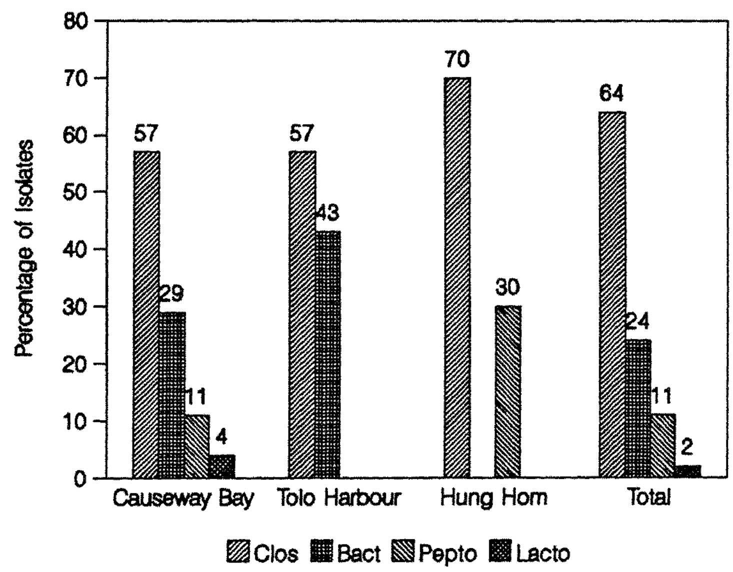

Figure 2: *Anaerobes isolated from sea water*

DISCUSSION

The sample bottle chosen appeared to be a suitable choice for the collection of specimens from a depth of about 3 metres. Membrane filtration enabled a large volume of seawater to be examined and it is an intrinsically more accurate method of enumerating the bacteria present than other methods such as most probable number methods. However, some practical problems were encountered in the processing of polluted seawater in that the membrane rapidly became clogged.

The number of anaerobic organisms isolated from the seawater samples indicates that the seawater was highly polluted. This conclusion can be drawn because in unpolluted waters the oxygen content is high even in the deeper areas. For the strict anaerobes to grow, the water must be highly contaminated with organic materials, which enhance the growth of aerobic bacteria and also algae, thus reducing the oxygen content of the seawater.

The ability of Clostridium species to form spores enables them to survive in seawater. They usually grow in the mud of the sea bed where the oxygen content is negligible. Bacteroides, which were also isolated in this study, are less able to tolerate oxygen and their isolation suggests that conditions are consistently anaerobic.

Peptostreptococcus species and anaerobic Lactobacilli were only found in small numbers. This may be due to the fact that these organisms have more fastidious nutritional requirements and therefore cannot survive well in seawater.

The source of the organisms isolated was considered to be faecal contamination as they are part of the normal flora of the intestinal tracts of domestic animals and humans. The presence of Clostridia may indicate faecal pollution at a time remote from the sampling as *E.coli* will die out in the aquatic environment, whereas the spore formers are able to survive for longer periods. The social and economic implications of these findings are important. There are many effects of highly polluted seawater on public health and on the quality and safety of seafood. In addition it creates a poor environment for people living near by. Bacterial contamination can result in the closure of fisheries, shellfisheries and recreational beaches.

This work was performed as a pilot study to determine the feasibility of isolating anaerobes from local waters and owing to the small number of sampling sites, the results cannot be said to be representative of Hong Kong waters in general. Further sampling sites may reveal a wider range of species and isolation rates. Other environmental factors effecting the survival of anaerobic bacteria in the sea, such as biological oxygen demand and the presence of heavy metal ions could also be determined.

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POLLUTION WITHIN THE BUILT ENVIRONMENT

J Burnett and DWT Chan
Department of Building Services Engineering, Hong Kong Polytechnic

INTRODUCTION

We would guess that when people come across articles in which the word *environment* appears in the title they tend to think of air, noise, waste and water pollution outside; in our streets, country parks, beaches and the sea. In Hong Kong many people spend much of their time in densely populated high rise buildings. It is surprising, therefore, that there appears to be relatively little public concern about the environment in which we live and work, notwithstanding the extremes of situations encountered in industry. However, some are slowly realising that the quality of the built environment is not what it could be and that this has an impact on our quality of life. This report addresses problems which are associated with air-conditioned commercial and public buildings.

Despite the fact that many such buildings originated as speculative developments there is increasing awareness that buildings should be regarded as an adjunct to the production processes they accommodate. That is to say, a building is a part of the plant and assets of the organisation housed within it. Judged in terms of business productivity the quality of the built environment may be defined in broad terms, i.e. health, safety and energy efficiency, and to some extent, intelligence. In the context of this seminar we deal here with the health and energy aspects of buildings.

Pollution within the built environment comes in a large variety of forms, resulting in a range of human responses from discomfort to disability, and even death. The consequences are diminished quality of life and loss of productivity. In addition, air-conditioned buildings are themselves a major polluting source on account of their heavy consumption of electrical energy.

HEALTH RISKS

Whilst it is recognised that the spread of many illnesses such as the common cold and influenza, is not exclusive to indoor environments, numerous studies clearly link a significant list of health problems with buildings, particularly air-conditioned buildings[1,2,3]. These vary from minor, troublesome and frustrating complaints to debilitating and even fatal illnesses.

Much has been written about Sick Building Syndrome (SBS), which is often erroneously linked to the issue of illnesses contracted from sources attributable to buildings, that is Building Related Illnesses (BRI). The term SBS is now applied to any building in which a significant portion of the occupants experience a set of symptoms that are alleviated when the affected persons leave the building. On the other hand BRI includes serious illnesses such as Legionnaires Disease.

Building related illnesses: The infection known as Legionnaires Disease is a serious pneumonia presenting with symptoms of high fever, dry cough, chills, headache and muscle pain with an incubation period of two to ten days[4]. The clinical spectrum of Legionellosis varies from asymptomatic or mild, flu-like illness to a devastating, fulminant pneumonia that can be fatal[5]. Pontiac Fever is a less severe, non-fatal fever of short duration also caused by legionella bacteria. This bacteria of which there are over 20 recognised species is now known to be widespread in the environment occurring in water and in the soil, where it can survive for relatively long periods of time[6]. The organisms are relatively non-pathogenic and for human infection to occur a large number must be inhaled.

The presence of sludge, algae, organic material and temperatures in the range 20 °C to 45 °C positively affect the proliferation of legionnella. Nearly all outbreaks so far have involved either improperly maintained air-conditioning plant or hot water systems. Contaminated aerosols may be generated by cooling towers, evaporative condensers and even bathroom showers and may be drawn through ducted air supply systems or spread beyond the immediate vicinity of source buildings[7].

Hypersensitivity Pneumonitis is an allergic reaction to dust particles breathed into the lungs also giving rise to flu-like respiratory symptoms. It occurs after repeated exposure to various organic dusts in susceptible people and may be difficult to diagnose in association with air-conditioned buildings. *Humidifier Fever* is also a flu-like allergy presenting with symptoms of cough, chest tightness, fever and malaise. Low levels of airborne material in aerosol form can produce episodes in susceptible individuals, the source of the contaminant being unclean, dusty and damp conditions in air-conditioning systems which produce an ideal environment for the growth of a range of micro-organisms including moulds, fungi, amoebae, bacteria and nematodes[8].

Many studies suggest that we should be more concerned about indoor radioactivity, in particular radon and its decay products which account for about 70% of the total radiation dose[9,10]. Radon is a radioactive gas which is produced by the natural breakdown of radium and thorium in soil and rocks. When radon and its decay products are inhaled they disintegrate and continue to be trapped inside the alveoli to emit alpha particles and gamma rays. The radiation emitted can cause tissue damage and increase the chance of developing lung cancer. It has been estimated that about 300 lung cancer deaths per year are attributable to radon exposure in Hong Kong, which is about 13% of all lung cancer cases and comparable to the death rate from traffic accidents. The average indoor radon concentration in Hong Kong has been reported as generally higher than that measured in other countries[11]. Granitic bed-rock is the main cause of elevated indoor radon levels. Another source of indoor radon is the radioactivity of the building materials. If ventilation is inadequate radon can accumulate to high concentrations in indoor air.

Sick building syndrome (SBS): The illnesses discussed thus far which are known to have specific causes are not to be confused with SBS for which the cause, if it is in fact a discrete entity, is complex and ill-defined, involving a mixture of contributing factors. SBS is however clearly associated with a group of defined symptoms, and numerous published studies indicate that its incidence is far higher among air-conditioned buildings than those which are not. Although symptoms are generally mild and the illness does not necessarily lead to absenteeism, they do appear to cause distress. Reports of the prevalence of sick building syndrome suggest that the total number of sufferers is great and that serious questions of worker efficiency exist [1,2,12].

Symptoms usually reported include sore eyes, stuffy nose, irritation of the upper respiratory tract, itchy skin, headaches, lethargy, fatigue, nausea and dizziness. Numerous possible causes have been suggested many of which include the toxic, pathogenic, irritant or allergenic affects of airborne contaminants such as formaldehyde emissions from building materials and furnishings, fumes from chemical cleaning agents, cigarette smoke, carbon dioxide and monoxide, fumes released by office equipment, polluted air drawn from outside, dusts and fibres and microbiological pollutants from carpets, the building occupants or the air-conditioning systems.

INDOOR AIR QUALITY (IAQ)

IAQ has become an issue of increasing attention in recent years mainly due to the increased frequency of problems being reported and increased awareness amongst occupants. This increase has been attributed to a large extent to buildings being operated with insufficient fresh air intake, a response to the drive to save air-conditioning energy in the wake of the oil crisis of the 70's. The increased building tightness has caused indoor air pollutants and CO_2 to build up, sometimes to harmful levels.

The problem is made more difficult by the relatively low levels of contamination found in commercial buildings and evidence that psychological influences and reactions may at least exacerbate the incidence of symptoms. The relative lack of control that individuals working in a 'sealed' environment are able to exercise over working conditions and resulting dissatisfaction have been cited. Odours, low relative humidity, a lack of negative ions, inadequate air movement, high temperatures, poor lighting, noise and vibration are cited as contributing factors.

Whilst indoor air quality is dependent upon a large number of variables acting together, current design criteria are concerned only with satisfying simple 'comfort zone' conditions; a target range for room temperature, relative humidity, air changes and flow rates. New work[13] is attempting to quantify more precisely the quality of the built environment but if present day design, installation and operating methods cannot satisfy existing criteria there seems little chance of meeting more sophisticated performance specifications.

LIGHTING

Light can be a pollutant which can have a negative impact on the quality of our environment. Outdoor pollution comes from installations such as neon signs and floodlighting. Indoors we often shut off or are unable to access natural light and resort to artificial illumination. Poor lighting reduces the efficiency and effectiveness with which people work, and can increase stress. It can decrease morale and increase absenteeism. It may also contribute to accidents.

Because humans respond differently to light it is not easy to establish good lighting design criteria. Current specifications dealing with illumination levels and glare index are inadequate. Recent research suggests we adopt new criteria to take account of visual comfort, visual satisfaction and visual performance[14]. The optimisation of design for general lighting, localized lighting and task lighting can improve conditions in today's technology-filled offices. New developments in lighting are providing more 'natural' light output from luminaires for less energy input. High frequency ballasts may provide major improvements by reducing eye strain and fatigue, as the 'flicker' from 50 Hz may be an annoyance. With lighting a major energy consumer (up to 40% of the electricity consumption in a commercial complex) and a significant contributor to heat gain it is an area where major advantages can be gained from retrofitting existing buildings.

NOISE AND VIBRATION

Noise (unwanted sound) is a problem of commercial environments world-wide. Noise irritates and creates stress, can reduce efficiency, may raise blood pressure and has even been linked to the aetiology of stomach ulcers.

The quality of sound as perceived by humans is a function of the relative intensities of sound levels in the audible spectrum. The goal for designers is to produce an indoor environment with a bland sound spectrum, balancing the effects of external noise (e.g. traffic and construction activities) occupational noise of people, noise from building sources (e.g. such as HVAC equipment and elevators) and equipment sources (e.g. faxes and photocopiers)[15]. There is a need to review the various criteria and guide-lines presently available. The traditional methods of reducing unwanted sound are based on attenuation and absorption (e.g. silencers, coverings, acoustic hoods). However such techniques may not deal with certain frequencies, especially low frequencies, and active noise control techniques continue to be of interest.

ELECTROMAGNETIC POLLUTION

The modern building is increasingly equipped with new technology. The problems with electromagnetic pollution of the environment appear to be relevant only to equipment, as the effects on humans, other than secondary effects causing failure of life safety equipment for example, are considered to be minimal[16]. Nonetheless, there is the possibility that low strength fields affect mood and performance and health concerns over equipment such as visual display terminals, remain.

PRODUCTIVITY AND QUALITY

We are concerned here mainly with white-collar workers engaged in a variety of tasks, increasingly using IT and hi-tech equipment. Although there seems to be no hard facts linking performance and productivity with the quality of the work environment there is enough evidence and experience to suggest a strong relationship. The U.S Environmental Protection Agency estimates that indoor air pollution will cost the country tens of billions of dollars annually in lost productivity, direct medical care, lost earnings, and employee sick days. Britain's House of Commons Committee on the Environment, after an exhaustive enquiry into the issue of indoor pollution estimated that the annual cost to the nation's economy in terms of time taken off and reduced effectiveness is likely to be in the order of hundreds of millions of pounds. The committee recommends that the Government should commission a wide-ranging review of indoor air quality policy that includes building design and construction, maintenance, leakage characteristics and ventilation rates for various types of buildings, in an attempt to gather information that would lead to a comprehensive indoor air quality policy for the UK.

It is interesting to look at matters from a cost perspective. Using some illustrative figures, the point can be easily made. A high powered financial operation may be paying monthly salaries and other costs of around $50-100k for each 10-20 m^2 occupied. The rent is likely to be a factor of 5-10 less, and the cost of maintaining the space, perhaps a further factor of 5-10 less again. Put another way, perhaps only 1-4% of the cost of running such a business is spent on maintaining the environment in which the business activities are carried out. If the maintenance of the environment including routine cleaning is given too little attention and resources then we may expect its quality to diminish. If the productivity of people in the work place is adversely affected, any supposed 'savings' resulting from reduced maintenance could be eliminated by a loss in productivity.

USE OF ENERGY IN BUILDINGS

Concerns over health hazards due to environmental pollution now extends to the problem of serious and permanent deterioration of the environment itself, particularly acid rain and the threat of global warming. The threat of global warming is real enough, but the prime cause is not the use of fossil fuels, but their inefficient use. Stabilising climatic deterioration will require cutting combustion by around half from current levels, however at the same time population size and affluence will grow. Greater energy efficiency is a significant way to reduce global warming[17]. The impetus should not come from the environmental lobby or legislation, but from the prospect of increased profits.

For each unit of electricity supplied, around 3.5 units of primary energy have been consumed at the power stations, which contribute about one-third of all CO_2 and NO_x emissions and about two-thirds of SO_x. The potential to reduce new generating plant is enormous, as for example in the USA when, during 1979-86, energy savings expanded energy availability by seven times as much as did nuclear power[18].

Electricity is the main form of energy delivered to buildings in Hong Kong. Despite ever increasing consumption the unit costs to consumers are lower in real terms than they were a decade ago, and much lower in comparison with building or rental costs. This is increasing Hong Kong's dependence on fossil fuels and contributing disproportionately to CO_2 production[19]. In the context of the world community Hong Kong is an energy glutton[20]. Much of this energy use is quite inappropriate; it is no exaggeration to say that parts of Hong Kong are at their coldest in summer. Consumers have little incentive to reduce their electricity consumption, have little idea of how efficiently they use it, or of the potential for adding to profits through energy saving. A recent study for the Arkansas Energy Office indicated potential savings from available technologies, excluding load management, of over 70% for the commercial sector[21].

Energy is used to condition the air, provide ventilation, lighting, transport goods and people, and to power business machines. Thermal, solar, equipment and human sensible and latent heat gains and/or losses need to be counterbalanced to achieve an acceptable working environment. Architectural solutions to reduce heat gains and provide energy saving include; optimum siting and orientation of the building, reducing thermal transmittance, providing solar shading and utilising thermal mass. Unfortunately, the desire to optimise saleable floor space leads to the extensive use of energy inefficient glass curtain walling.

The interactions between the external environment, the building envelope, people and the engineering systems are very complex and require better methods of analysis than those that are available today. Even those design aids that are available are not utilised by many and building envelopes are designed with only minimal attention to thermal and solar heat gains; as a result the engineering services are designed to cope with a worst case scenario. With conservatively designed systems set to cater for peak loads plant is often oversized and generally runs below optimum efficiency much of the time.

The design of energy efficient buildings which provide good quality environments requires close collaboration between members of the design team, all of whom understand the impact of any variable on the outcome. Similarly, to optimise the performance of engineering systems (primarily HVAC) it is necessary to solve the problem of whole building operation, where people, activities and external climate compound the complexity of the dynamic model. There must be clear direction in terms of the best system to use and strategies for effective control. Little has been done to evaluate the various installed systems.

A further consideration in respect of global warming is the use of CFC's in refrigeration plant. The Montreal Protocol and other initiatives call for the replacement of widely used refrigerants with less damaging new ones. However, it is noted that replacements may be less efficient in energy terms. Replacing ozone depleting refrigerants may be helpful, but can lead to more primary fuel being used in generating stations. However, recent studies[22] suggest that the losses of refrigerant to the atmosphere due to leaks and purging are more significant, indicating the need for initiatives to improve both awareness and management.

BUILDING OPERATION

Building maintenance is one of the less glamorous fields of engineering endeavour yet, as the complexities of operating a large modern building become more apparent, it is an increasingly important one. This needs to be understood by the maintenance workforce, the building owners and academia.

Two of the features of a number of studies of both large and medium size buildings[23] world-wide reveal:

- an alarming lack of basic understanding of the essential features of mechanical systems and the effect of system quality on occupant well-being and, ultimately, letability, among owners, estate agents and tenants.

- a lack of an appropriate building operations manual showing 'as-fitted' equipment, maintenance and operating procedures.

New buildings may benefit from improved documentation if ISO 9000 QA procedures are implemented in building production, but the vast stock of existing buildings needs building owners and operators to embrace QA in the management of their facilities. For the large, high-rise, air-conditioned complex, optimisation of the built environment in terms of air quality and energy use is not an easy task since our knowledge of the performance of whole buildings is somewhat patchy and primitive. The rapid advances in technology seen in other fields are expected to impact on building quality. Yet to date we have few good examples of "intelligent" buildings that are defined not in terms of the amount of electronics added, but rather in terms of the "intelligence" to respond to user needs.

CONCLUSIONS

Pollution in the built environment impairs our quality of life and productivity. Ultimately it has an impact on the competitiveness of businesses and centres such as Hong Kong as a whole. The cause is inefficient buildings and systems, produced through inefficient production methods and inadequate operation and maintenance. Deficient design, installation and operating skills are attributable to a large extent to inadequate education and training provided for building industry professionals.

It is argued here that the design, construction, commissioning and operation of large air-conditioned buildings is intellectually demanding if all influencing factors are taken into account with a view to optimising performance and costs. Research in this technologically based industry must direct itself to improving methodologies which lead to increased productivity, performance and profit.

To improve design we need sophisticated design algorithms, properly evaluated against real building, improved application of materials and production processes. The application of computing techniques to building production from inception to operation is worthy of a major study. Facility managers need real intelligence in their building management systems, to help deal with problems and optimise performance, and not simply generate volumes of unintelligible data.

This points to extensive studies of buildings in use, to optimise performance, identify investment opportunities for energy efficiency, and to feedback to the design and production processes. The ultimate goal is healthy 'green' buildings.

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THE EFFECTS OF PESTICIDE USE ON THE HEALTH OF FARMERS IN EAST JAVA, INDONESIA

J Mukono
Environmental Health Research Center, Research Institute, Airlanga University

INTRODUCTION

Indonesia's agro industry is an important a feature of the country's economy. Increasingly agricultural and forestry production are important contributors to food for domestic consumption and in the production of exportable materials. Increasing agricultural production has been associated with increasing pesticide use. Appropriate management is needed to decrease their negative effects and maximize their positive effects.

Previous study has demonstrated the unwillingness of farmers to use personal protection with consequent exposure to the risk of chronic toxic effects. The chronic toxicity of pesticides is associated with exposures to low doses over long periods of time. Organophosphate and organochloride pesticides can produce chronic toxicity features which include changes in cholinesterase enzyme activity and decreasing liver function.

The acute effects of organophosphate pesticides include neurological symptoms, muscarinic, and nicotinic effects. Neurologic symptoms may arise from both central and peripheral nervous systems and include headache, anorexia, hallucinations, insomnia and coma. Symptoms of muscarinic effects are anorexia, nausea, vomiting, abdominal cramp, diarrhoea, sweating, increasing mucous production, blurring of vision, oedema, and polyuria. Symptoms of nicotinic effects are convulsions, respiratory and circulatory disorders and coma.

The aims of this study were to assess the negative effects of pesticide use in general and to determine cholinesterase enzyme levels and liver function by measurement of total bilirubin, direct bilirubin, SGOT, SGPT, and alkaline phosphatase concentration.

METHODS AND MATERIALS

Study location: This study was based on cross-sectional surveys in two different locations. The study areas included desa Punten, kecamatan Batu and kabupaten Malang located 90 km south from the capitol of East Java, Surabaya, which have high levels of pesticide use, and desa Karangan and kecamatan Karangan and kabupaten Trenggalek, located 200 km south west, in which pesticide use is lower.

Sampling methods: The subjects in the two population samples were farmers from desa Punten and desa Karangan who used pesticides. The subjects were recruited by random sampling which yielded 63 farmers for desa Punten and 37 farmers for desa Karangan.

Collection of data: The data collectors included five physicians, two non physician lecturers and three personnel from the local Health Center. All farmers in the sample were checked for both physical diagnostic signs by a physician and health symptoms related to pesticides toxicity by the other interviewers.

Blood cholinesterase concentration was measured by a photometric technique based on the Merckotest kit reagent (25 centigrade). Total bilirubin, direct bilirubin, SGOT, SGPT, and alkaline phosphatase were measured by spectrophotometer.

Statistical analysis: Paired t-test was used to compare the laboratory test results for the two location samples.

RESULTS

The highest level of educational attainment for the majority (70%) of the farmers in the sample at the two locations is elementary school (70%).

Farmers used various types of pesticides including Hostathion, Nurdrin, Furadan, Dimecron, and Savin. During their work, their activities included mixing and spraying; the majority (58%) did not use personal protection such as masks and gloves.

The educational level of the farmers in this sample was related to their use of pesticides, including safety procedures. Subjects in the study sample had used pesticides in their agricultural activities over periods ranging from one to 25 years. Levels of blood cholinesterase enzyme activity showed decreasing levels with increasing periods of use by individual farmers.

According to the interviewed farmers, their health experience included symptoms of pesticides toxicity such as nausea, vomiting and diarrhoea. In addition some complained of other symptoms, such as visual disorders and muscle fasciculation.

The laboratory data are summarized in Table 1 and Figure 1.

Table 1: *Total and dırect bılırubın, SGOT, SGPT, Alkalıne-phosphatase, and ChE results, of farmers at desa Punten and desa Karangan*

Test		Normal values	Punten N = 63		Karangan N = 37	
Bilirubın:						
Total	(mg%)	< 1.00	0 673	0 230	0.821	0 197
Direct	(mg%)	< 0.25	0.181	0.073	0.179	0.092
SGOT	(μ/L)	F. 5-15 M: 5-17	11.059	4.320	13.022	6 395
SGPT	(μ/L)	F: 5-19 M: 5-23	17.835	7 056	15.327	7 472
Alk phos	(μ/L)	F: 40-190 M· 50-190	132 183	35 47	104.527	26 62
ChE	(kμ/L)	F: 2.0-6 7	6.33	1 78	6.04	1 52

Key Alk Phos = alkaline phosphatase ChE = Cholınesterase F = Female M = Male

DISCUSSION

In the present study of the two samples of farmers, the distribution of symptoms and laboratory results cannot be regarded as specific because of the wide range of pesticides used.

Although organophosphate pesticides are toxic to humans and aquatic life, their relatively short duration of action and persistence favours their use. Among all the groups of pesticides used in agriculture, organophosphate pesticides have the shortest persistence in soil under moderate climatic conditions. The acute poisoning effects of organophosphate pesticides are related to the anticholinesterase property of these chemicals. According to Yang[16], the acute intoxication of organochloride pesticides, particularly hexachlorobenzene (HCB), is mainly manifest as neurotoxic symptoms such as ataxia, trembling, and paralysis. Chronic intoxication by HCB may be associated with carcinogenicity, porphyria, and neurotoxicity.

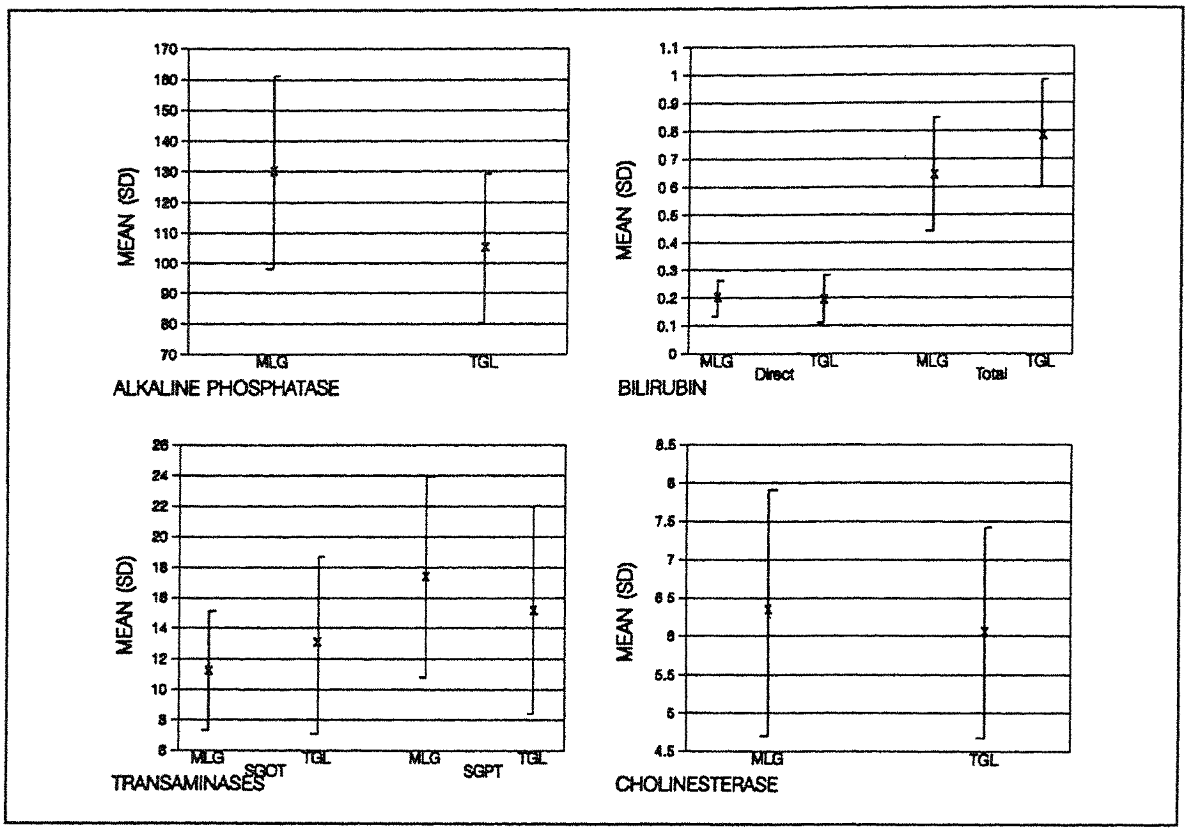

Figure 1: *Liver function tests and chE enzyme concentrations in Malang and Trenggalek*

All of the mean values for the analytes measured were within conventional normal ranges. However the dispersion of the individual observations was marked, with high values for cholinesterase concentrations in some subjects, especially in Malang. Mean alkaline phosphatase levels were significantly higher in Malang. Although the mean level of cholinesterase concentration was lower in desa Karangan than desa Punten the difference was not significant (p=0.187). The concentrations of direct bilirubin, SGOT and SGPT showed no significant differences between the two groups.

CONCLUSIONS AND RECOMMENDATIONS

1. The study indicates that there is considerable variation in both exposure to and effects of pesticides in each of the high and low use areas studied.

2. Biological monitoring and control of pesticides intoxication are indicated in occupational and agricultural settings.

3. Inappropriate handling of pesticides is a problem in both developed and developing countries. Thus, there is an urgent need for safe, practical, reliable and inexpensive methods and equipment for agricultural work, particularly in developing countries.

4. Safe handling and personal protection requires health education, and training, through the mass media and other approaches to improve individual knowledge and discipline, and ensure the use of equipment for protection, and proper management of pesticide wastes.

5. The technical aspects of pesticide formulation, application, and disposal are very important. A good understanding of these is needed for the control of hazards for occupationally and environmentally exposed people.

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NOISE AND HUMAN ACTIVITIES IN HONG KONG: A REVIEW

TC Tan* and LTL Wong+

- * **Department of Community, Occupational and Family Medicine, National University of Singapore**
- \+ **Occupational Safety Health Council, Hong Kong**

INTRODUCTION

Hong Kong is a noisy metropolis buzzing with a myriad of human and economic activities compounded by a huge population living and working together in a relatively small and crowded environment[1]. It has been generally recognised as one of the noisiest cities in the world[2]. Sound pollution confronts the average residents daily from vehicular traffic, airplanes, construction works, factories, Chinese restaurants, mahjong clubs, discotheques, karaoke clubs and pacinko or video game centres.

The detrimental effects of noise, both industrial and public health, has been progressively recognised in Hong Kong[3]. The development of legislation to contain sound pollution in Hong Kong is recent[4]. The first legislation enacted in the control of industrial noise was for noise in cartridge-operated fixing tools[5] in requiring proprietors to provide suitable ear protection. Following a special study by the United Nations Industrial Development Organisation (UNIDO) in 1979[3], more comprehensive legislation was introduced to provide for a wider coverage of control in all industrial undertakings[6]. To ensure better enforcement, the Noise Control Office within the Factory Inspectorate was established to oversee these regulations and a complementary Code of Practice[7] for the protection of hearing in industries was introduced for employers. The industrial activities identified for noise control included construction, electronics, metals, plastics, ship-building and repairing, and textiles for which industrial based subcommittees were formed under the Industrial Safety and Health Committee of the Labour Advisory Board[8]. These regulations are enforced by the Labour Department.

In 1989, the Noise Control Ordinance was introduced to provide statutory controls to restrict and reduce the nuisance caused by non-occupational environmental noise[9]. This Ordinance deals with noise emanating from domestic premises, public places, construction activities, industrial and commercial premises, and product noise from equipment and mechanical plant and was enforced by the newly established Environmental Protection Department. By 1989, the statutory provisions for control of sound pollution in Hong Kong included both industrial as well as environmental noise.

STUDIES ON NOISE AND HEARING

Noise and hearing studies in Hong Kong: Several new studies were conducted between 1987 and 1989 which revealed the ubiquitous nature of noise and the current efforts in dealing with noise control and hearing conservation. The measurement of noise level at work was quantified as the Leq(8h) which is in effect a measure equivalent to the personal dose caused by the same A-weighted sound energy received over a normal 8 hour working day. The local legislation for exposure to excessive noise was a Leq(8h) level exceeding 90 dBA and above. Sound Pressure Levels (SPL) were measurements of sound intensity for a specific work process measured over the whole octave frequency and was conducted when the ambient Leq(8h) reading for a subject exceeded 90 dBA and more. SPL measurements of selected work processes were made in order to assess the attenuation values and suitability of ear protectives worn by the workers at risk.

Public environmental noise: Noise and aging are the two main reasons for hearing loss and premature hearing loss may result from industrial and environmental noise. A study reported significant loss of hearing thresholds of about 10 dB throughout the octave frequency distribution of young normal Chinese subjects aged 18 to 30 years exposed to a daily average of Leq(8h) of 48.1 (4.23) dBA when compared with similar subjects who had about 1 dB loss in the West[2]. The young are especially susceptible to loud noise and provide a good measure of the overall effect of exposure to public and leisure noise. Adverse noise profiles have been reported in schools in urban areas[10]. Several possible sources of loud noise are postulated (Table 1).

Table 1: *Selected surveys of sound levels in Hong Kong 1987-89*

Survey	N	Measurement in dBA SPL		Leq (8h)		% of Leq >90 dBA
Discotheques	5	94.3	(1.9)	92.7	(1.0)	100
Road Works	15	107 4	(2 1)	104.8	(2.9)	100
Industrial buildings	10	84 9	(6 4)	83 7	(80.86)	0
Bore piling	3	91	(87-95)	85		0
H & sheet piling	6	100	(100-135)	96-105		100
Fire engine driver	10)	95 6	(1 8)	100 1	(93 8-103.7)	100
Hydraulic	10)			99 3	(94 6-103.9)	100
Bus engine						
Front engine	5	80 5	(4 3)	89 9	(88-92)	80
Rear engine	5			84 9	(76.6-82)	0

Noise from leisure activities like music, popular with the young, was potentially hazardous to both employees and regular clients in discotheques[11], karaoke lounges and video games centres. In addition the improper use of personal cassette players has been investigated. Wong et al[12] found that 81% of 394 youths aged 15-24 years used walkman players regularly but the mean ear canal sound level was 70.4 dBA, well below the hazardous level[12]. On the other hand a study of five discotheques in Tsimshatsui revealed that sound level, band frequency analysis and Leq(8h) measurements in all locations e.g. bar area, disc jockey, dancing areas except the main entrance exceeded the local threshold limit level (TLV) of 90 dBA[11] (Tables 2 and 3). Based on the International Standard (ISO)[13], the estimation of risk that discotheques workers will develop hearing impairment for conversational speech if they worked a 40 hour week and 50 weeks per year at 95 dBA is 17% after 10 year's exposure and 28% after 20 years.

Table 2: *Sound levels (dBA) in discotheques by selected locations (N=5)*

	Range	Mean (SD)
Number of employees	18-20	19 4 (0.9)
Sound level in dBA		
Main entrance	71 5-75.5	73 4 (1.8)
Bar area	91 5-96.6	94 3 (1.9)
Disc jockey	91.6-95.6	94 1 (1.6)
Dancing area	94.8-97.7	96 7 (1.8)

Table 3: Sound levels (dBA) and corresponding Leq level for 8 hour at bar area in discotheques (N=5)

Measurements in dBA	Bar areas in discotheques					
	A	B	C	D	E	Mean (SD)
Sound level	93.7	96.6	95.5	91.5	94.3	94.3 (1.9)
Leq(8h)	93.5	94	91.5	92	92.5	92.7 (1)

The cumulative exposure to the urban ambient noise is interspersed with intermittent hazardous noise from piling works[14] and road works[15], vehicular traffic such as fire engines[16], buses[17] and industrial buildings[18]. Measurements of sound levels of 15 road works using hand-held pneumatic drills[15] and 9 piling sites[14] exceeded the local statutory limit of 90 dBA. The average sound level was 107.4 dBA and the corresponding continuous equivalent level adjusted to 8 hours or Leq(8h) was 104.8 dBA (Table 4). The sound levels for the octave frequencies from 125 hertz to 8000 hertz were all in excess of 90 dBA. Estimates of the risk of developing hearing impairment for conversational speech among the operators were 18% and 42% after 5 and 10 years of exposure respectively. The intensity of the noise level was reduced with increasing distance from the source (Table 5). The noise generated by public buses and fire engines were well below the limit of 90 dBA except when the sirens of the fire engines were switched on and then only for very short durations.

Table 4: Sound levels (dBA) of hand-held pneumatic drills (N=15)

	Range	Mean (SD)
Average reading	104-112	107 4 (2 1)
Minimum reading	100-110	102 9 (2 5)
Maximum reading	106-113	109.4 (1.96)
Exposure time (in h)	2-7	4.67 (1.72)
Leq(8h)	100-111	104 (2.86)

Table 5: Sound surveys in construction piling

Type	N	Mean (range) in dBA Distance away from the source of piling (metres)			
		5	**10**	**20**	**30**
H piling	3	120 (115-135)	110 (107-123)	100 (97-112)	97 (93-105)
Sheet piling	3	100 (89-132)	69 5* (53-73)	92 5 (70-116)	86.5 (74-119)
Bore piling	3	91 (87-95)	83 (82-87)	77 (75-82)	74 (72-80)

* with concrete partition

Industrial noise: A 1982 study revealed that the relationship of industrial noise exposure and hearing loss was similar to studies made in the Western countries[1]. A three-fold increase of noise induced hearing loss was found in metal press operators exposed to sound levels in excess of Leq(8h) 90 dBA compared with matched controls[19]. A comprehensive study with tripartite participation of government, trade unions and university was conducted in 1988 of six major industries including construction, electronics, metals, plastics, shipbuilding and repairing and textiles. Twenty one out of 32 medium size factories were surveyed yielding 922 sound measurements and 1,062 out of 10,724 workers were examined[8]. More than one third (37.5%) of workers worked in locations where the noise level exceeded Leq(8h) 90 dBA (Table 6). Among examined subjects, 39.8% were exposed to Leq(8h) 90 dBA and above and 18.6% were found to have industrial hearing loss. Multiple logistic regression analyses adjusted for sex and age showed that for hearing loss, the important risk factors in excess of 1 were duration of noise exposure, noise intensity, floor vibration, and military experience (Tables 7 and 8).

Table 6: *The noise levels in Leq(8h) and workers*

Industry	No. of workers	No. of Leq(8h) measurements	Range*	% of Leq (dBA) measurements 90 dBA and above	% exposed to ≥90 dBA
Construction	365	121	80-110	56.2	44.4
Electronics	2341	156	65-93	7.7	2.3
Metals	1833	167	75-104	37 7	36.1
Plastics	1130	99	70-99	8.1	6
Ship B&R	1404	181	70-102	43.1	31.9
Textiles	3651	198	65-104	74.8	72.1
Total	10724	922	65-104	41.3	37.5

* denotes Leq measurements excluding those taken in the offices

Table 7: *Odds ratios (ORs) adjusted for age and sex and 95% confidence intervals (CI) for high tone hearing loss with selected variables*

Variable	OR (95% CI)	p
Noise exposure (per 10-year increase)	1.31 (1.06-1.66)	<0.05
Noise intensity (per 5 dB increase)	1.3 (1.13-1.49)	<0.001
Smoking (yes/no)	1.24 (0.84-1 83)	NS
Vibration (present/absent)	1.61 (1.16-2.24)	<0.01
Military experience (yes/no)	2.1 (0.98-4.51)	NS
Ototoxics (yes/no)	1.17 (0.70-1.96)	NS
History of hypertension (yes/no)	1.2 (1.00-1.48)	<0.05
Mahjong (per 5hrs/week increase)	1.24 (0.99-1.55)	NS
Noisy leisure time activity #	1.16 (0.61-1.24)	NS

including listening to hi-fi ≥5hrs/day or walkman ≥3hrs/day, or attending disco ≥5 hrs/week, or TV game centre ≥=5hrs/week.

Table 8: *Odds ratios (ORs) adjusted for all other variables in table by linear logistic regression for high tone loss*

Variable	OR (95% CI)	p
Age (per 10-year increase)	1 71 (1.14-1.99)	<0.001
Sex (male/female)	0 37 (0.24-0 56)	<0.001
Noise exposure (yes/no)	1 94 (1.25-2.91)	<0.01
Noise intensity (Leq >=90 dBA/<90 dBA)	1 39 (1.01-1.94)	<0.05
Vibration (yes/no)	1 63 (1.14-2.33)	<0.01
Military experience (yes/no)	2 2 (1.01-4 79)	<0.05
Hypertension (yes/no)	1 19 (0.69-1 03)	NS
Majhong (per 5hrs/week increase)	1 22 (0.97-1.54)	NS

Ear protection was provided by 17 of the 21 factories (76.2%) and was found appropriate and suitable in 15 of these 17 factories (88.2%) were found appropriate and suitable (Table 9). Only 6% of subjects worked with machinery fitted with noise reduction measures. About one in two subjects (43.3%) was provided with ear protectives. Amongst those provided with ear protection most wore ear plugs (88.4%). Supervision of the use of protectives varied greatly among the industries but was highest in construction (84%), textiles (78.5%), metals (34.9%) and low for plastics (25%) and electronics (15.8%). In locations where the Leq(8h) was 90 dB and more, statutory warning notices on noise were displayed to most subjects (90.6%) and the provision of ear protectives was high in all industries except in plastics (25%) and ship building and repairing (50%). The use of ear protectives was less satisfactory where only 26.2% of subjects used them all of the time at work and this poor compliance was found in electronics, plastics, shipbuilding and repairing, and construction. The most commonly used hearing protection was the Bilsom soft guard ear insert (5 out of 21 factories) and the Racal DBA earplug (4 out of 21 factories).

Table 9: *Sound pressure level measurements SPLM and ear protection*

Industry	SPLM	Mean SPL >90 dBA	Range	Establishments		
				N	% with Ear Protection	
					Provided	Found suitable
Construction	17	76 5	82-103	5	3/5	3/3
Electronics	17	17 6	68-93	3	2/3	2/2
Metals	20	50	82-101	4	4/4	2/4*
Plastics	14	42 9	73-104	2	1/2	1/1
Ship B&R	20	65	80-97	3	3/3	3/3
Textiles	24	45.8	73-103	4	4/4	4/4
Total	112	50	68-104	21	17/21	15/17

* 2 establishments had ear protection where the attenuation is unavailable

LEGISLATION AND HEARING CONSERVATION

Need for an intersectoral approach: It can be inferred that the ambient noise level in Hong Kong has contributed to the reduction of hearing sensitivity of the local residents. Noise induced hearing loss from noise in excess of Leq(8h) 90 dBA and above is the main health concern. Although the possible causes of hearing loss include degenerative effects on the auditory apparatus by the aging process, the polarisation of male workers to noisy work, other sources of non-industrial noise and medical illnesses, the presence of noise at work continues to be an important contributory factor of hearing loss in exposed workers. Hearing loss induced by noise at work is a progressive and permanent ailment and the only effective and economical measure is to reduce the exposure of workers to noise through the hearing conservation programme, which is a comprehensive approach in dealing with industrial noise involving the tripartite participation of Government, employers and employees. It aims to recognise, evaluate and control noise at source; to diminish noise transmission; and to encourage workers' participation and protection.

This review on the extent and the relationship of noise level and hearing loss and the existing local legislation emphasize the need to strengthen hearing conservation efforts directed at the amendment of relevant legislation, increasing supervision of use of personal ear protection, and strengthening health education and audiometric surveillance of high risk workers[8]. Industrial noise induced hearing loss should be enacted as a notifiable occupational disease in the existing Schedule of Prescribed Occupational Diseases (Second Schedule of Employees' Compensation Ordinance Chapter 282).

Audiometric services for workers: A mobile audiometric service for monitoring hearing levels of exposed workers should be established. This would allow the early detection of hearing loss and help to evaluate the effectiveness of personal protection. It would also support on-site education and surveillance to increase workers' knowledge and participation in hearing conservation at the personal level, in order to bring about attitudinal and behavioural change of exposed workers in using ear protection. The list of industrial work processes and exposed persons are constantly being identified by the on-going surveys of factories by the Noise Control Office. The establishment of a mobile audiometric monitoring programme, besides reducing premature hearing loss due to industrial noise at work, would be able to provide objective assessments of hearing loss in exposed workers and thus extend its support to any compensation scheme for hearing loss due to industrial noise by the definitive detection of hearing loss, its development, progression and residual damage, for which compensation claims are made.

Public education: Health education and consumer education on the use of musical and electro-acoustic appliances can be strengthened[12]. The current legislation deals with industrial undertakings and domestic premises but excludes all non-industrial entertainment activities such as discotheques, restaurants, night clubs, karaoke lounges and video games establishments. The current hazard-risk criteria for noise exposure should be extended to music and entertainment noise and provisions be made to include the coverage in the local laws. The hazard of noise emanating from piling and road works to the public is less predictable, and often regarded as a nuisance and inconvenience by the public The long term danger of premature hearing loss to the public is negligible as they would usually be exposed to the noise only for a short time. The details of the statutory control of noise from percussive piling work and general construction work such as road works are very well covered by the newly enacted Noise Control Ordinance in 1989. The provisions of this Ordinance are enforceable by the Environmental Protection Department and the Royal Hong Kong Police Force.

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ANALYSIS OF ORGANOPHOSPHORUS INSECTICIDES IN VEGETABLES

PA Tanner and KH Leung
Department of Applied Science, City Polytechnic of Hong Kong

INTRODUCTION

In Hong Kong (HK), there continue to be numerous outbreaks of pesticide poisoning from vegetables imported from China. The public is subjected to chronic poisoning by all pesticide residue, but the controlling authority is mainly concerned with acute poisoning. If an analytical result can be obtained from contaminated produce sold from Cheung Sha Wan Wholesale Vegetable Market within 3-4 h, then trade may be stopped and the sample source may be traced. This result is at present obtained from the screening of the green part of the leaf, a dangerous level being arbitrarily imposed. At City Polytechnic, we have begun to chemically analyse vegetable samples from the wholesale market and to correlate the results with the screening test. This paper documents the setting-up of this programme. We also describe an educational programme in which we are taking part, to develop the most appropriate pesticide removal method from vegetables and to communicate this to the end users of the produce. Organophosphate insecticides such as methamidophos, malathion and diazinon, exert their toxic action by inhibiting acetylcholinesterase, an enzyme of the nervous system.

METHODS AND MATERIALS

Screening test for pesticide residue in vegetables: This screening method for pesticide residues in vegetables was devised by Mr. Clive Lau of the Agriculture and Fisheries Department, and is based upon the inhibition of serum cholinesterase (ChE) extracted from chicken blood. The pesticide residue is extracted from the vegetable using a buffer solution (25 mmol, Sigma-7-9) and its presence is indicated by the slowing down, or complete inhibition of the ChE activity, as followed spectrophotometrically by the rate of formation of a yellow anion:

pesticide absence :

ChE + BTCI → thiocholine

thiocholine + DTNB → yellow complex (anion of 5-thio-2-nitrobenzoic acid)

pesticide presence :

ChE + pesticide → carbamylated/phosphorylated cholinesterase (c-ChE/p-ChE)

c-ChE/p-ChE + BTCI → no reaction

+ DTNB → no yellow complex

(DTNB = 5,5'- dithiobis - 1,2'- nitrobenzoic acid; BTCI = s-butyrylthiocholine iodide)

The activity (expressed in μmol min^{-1} cm^{-3}) of the cholinesterase, determined from a contaminated vegetable sample, is compared with that of a control, the chicken serum, and the percentage inhibition is calculated. Samples within the range of 70-100% inhibition are considered to be contaminated by pesticide. Those within the range 50-70% are arbitrarily considered as borderline cases, and those < 50% inhibition are considered to be uncontaminated. This method may be compared with the colorimetric[1], pH change[2,3] and immobilized enzyme[4,5,6] methods in the literature. Screening by TLC[7] and FIA[8] has also been employed. We note that some other residue screening tests for water, using enzyme impregnated tags, may give misleading results when used with vegetable extracts. The test described above may be used to screen organophosphates, carbamates and synthetic pyrethroids.

Chemical analysis of pesticide residues in vegetables: The main requirements of an analytical method for organophosphates in vegetables are that it is sensitive, selective, reproducible, rapid, accurate and precise. At City Polytechnic, we are using gas chromatography (gc) to achieve the required sensitivity[9]. Note that a pesticide residue concentration of 1-100 mg kg^{-1} in vegetables may give rise to an outbreak of poisoning. The selectivity of analysis is linked to different detection methods, using a nitrogen-phosphorus detector (npd) and a mass-selective detector (msd). Finally, we use an autosampler to automate the analyses since the number of samples may be appreciable. The use of hplc in analysing the more nonvolatile OP pesticides may also be evaluated[10].

STRATEGY OF ANALYSIS

Quantitative analysis of trace-level organophosphates is performed using gc-npd with a 10 m intermediate polarity column and by the use of external standards. Qualitative confirmation is provided by the use of a column of slightly different polarity. In many cases the peak shape may not be ideal for quantitation, overlap may occur, or the background may be high due to matrix effects. For these occasions, and whenever the sensitivity is adequate, we utilize gc-msd, with a narrow-bore crosslinked column, in the selected ion monitoring (SIM) mode. Our instrument, a Hewlett-Packard HP 5970 B msd coupled to a HP 5890 II gc utilizes electron impact (EI) ionization, which results in the highest amount of information about a compound, although it may exhibit lower detection sensitivity compared with pulsed positive ion - negative ion chemical ionization (PPNICI)[11]. Parameters including purge-on time, dwell time and injection temperature, oven temperature, programming rate and range have been optimized, based upon the chromatograms of 24 OP standards. The run time for analysis is 55 minutes, comprising an initial column temperature of 120°C, held for 5 min, a ramp of 5°C min^{-1}, and a final hold at 220°C for 30 min. We have also studied the limit of detection for OPs using the npd and msd detectors. This term was defined by IUPAC[12] and involves the measurement of the analytical sensitivity together with the standard deviation (sd) of the signal from a blank. Foley and Dorsey[13] have pointed out that concentration units are not to be employed when expressing LOD. Some assumptions enable the sd to be calculated from the maximum baseline noise[14].

Benfenati et al.[15] have published a procedure for the simultaneous analysis of 50 pesticides in water using gc-ms. We also utilize two ions of major abundance in the mass spectrum of each analyte for SIM. Quantitation is performed using the first ion SI chromatogram at the appropriate retention time (RT). Qualitative confirmation of the presence of the analyte is provided from the peak area ratio of ions 1 and 2 with that of the standard at the RT. When the sensitivity permits, we also utilize our mass spectral library search facilities for qualitative analysis, but the relative intensities of peaks vary according to the condition of the source and electron multiplier tube.

The autosampler utilizes a large diameter needle and we employ a septumless JADE injection system to avoid septum coring. We are aware of the poor long-term stability of injection techniques for pesticide residue analyses in complex matrices[15] but have not yet studied this in detail.

Clean-up procedures: We analyse the edible part of the vegetable after homogenizing or blending in a mixture of suitable solvents. The more elaborate clean-up procedures[16] have tended to be replaced by less time-consuming ones which minimize pesticide loss, and which employ selective detection[17]. Accumulated nonvolatile residues are removed by replacement of the insert and by cutting the top of the column. We will assess the use of XAD resin (Alltech Associates) in single-step solid-matrix cleanup of the vegetable extract[18].

EDUCATIONAL PROGRAMME

Ip[19] has documented an outbreak of methamidophos poisoning in Hong Kong resulting from levels of 5 mg kg^{-1} in cabbage. Professor C.P. Leung, Faculty of Medicine, CUHK, has initiated a programme to evaluate the effectiveness of various washing agents and procedures in the removal of pesticide residues from vegetables. The main aim of the programme is to communicate an effective washing procedure to the general public. We are taking part in this programme in the analysis of the residue. Preliminary results from Chinese Kale, sprayed with methamidophos, indicate that some patented reagents for residue removal are little more effective than water.

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HEALTH RISK AND ENVIRONMENTAL POLLUTION: THE HIDDEN FACTORS

HEALTH RISK AND ENVIRONMENTAL POLLUTION: THE HIDDEN FACTORS

J Peters, J Liu, CM Wong, AJ Hedley, TH Lam, SG Ong and AYC Tam*
Department of Community Medicine and * Department of Paediatrics, The University of Hong Kong

INTRODUCTION

Hong Kong is a small territory 1,070.12 km^2 in total with a population of 5,674,114 giving a population density of 5,302.32 people per km^2[1]. It is also fairly wealthy with a gross domestic product per capita in 1991 of US$14,102 such a figure being achieved in part through its extensive industrial base. With its small size, relatively large population and substantial industry it is inevitable that in a number of localities in Hong Kong urban residential and industrial areas are intermixed.

This has a number of disadvantages, one of which is that the exhaust emissions from some of the industrial outlets are high in sulphur dioxide, nitrous oxides and particulates. Coupled with the polluting exhaust gases produced by industrial premises are the suspended particulates produced by a buoyant construction industry as yet another building or road is developed, modified or removed. A third major polluter of the Hong Kong air is the motor vehicle with its emissions of carbon monoxide, sulphur oxides, nitrous oxides, hydrocarbons, and particulate matter. In addition to these three major sources of air pollution, there are other natural sources which contribute to the suspended particulate levels, such as soil blow off, saline aerosols, pollen and spores. With so many potential sources of ambient pollution over such a small area, levels of these chemicals in the local atmosphere, on occasions, exceed the air quality targets recommended by the Government's Environmental Protection Department on both annual and daily bases. Figure 1 shows the annual average air pollutant concentrations in four areas of Hong Kong; Kwai Chung and Kwun Tong on the mainland and Central and Southern on Hong Kong Island. Figure 2 shows the number of daily exceedences of the air quality targets by air pollutants in 1988 and 1989[2,3].

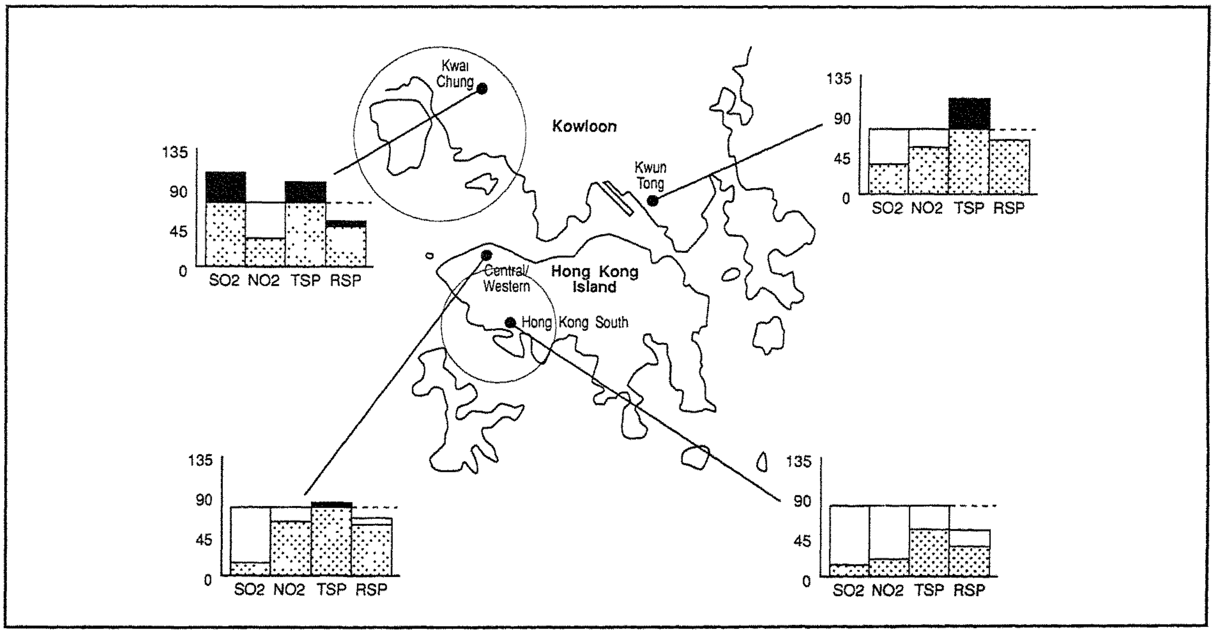

Figure 1: *Annual average pollutant concentration, in Hong Kong, 1989. All concentrations in μgm^{-3}; ---, air quality objective level; ■, exceedence of air quality objective; Hong Kong South 1990 data.*

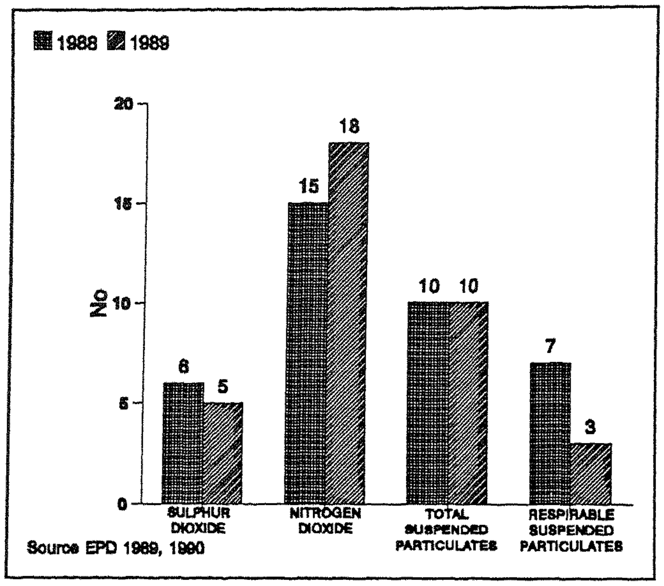

Figure 2: *Hong Kong air quality 1988 and 1989 daily exceedences: air pollutant levels.*

It is well documented that air pollutants, including respirable particulates, sulphur dioxide and nitrous oxides are associated with respiratory symptoms, reduced lung function, and impaired lung development in young children. In 1978 the World Health Organisation produced a working party report on the long-term effects on health of air pollution[4] and more recently other researchers have reported detrimental effects of air pollutants on the respiratory health of children[5,6,7], and subsequent improvement in lung function with a decrease in pollution levels[8].

STUDY BACKGROUND

In 1988, the Environmental Affairs Committee of Kwai Tsing District Board requested the assistance of the Department of Community Medicine, Hong Kong University, in determining whether there was any evidence of adverse effects on health related to residence in Kwai Tsing. Of the total number of complaints received by the EPD in 1988 (3121), over 10% of them originated in Kwai Tsing, and 65.6% of all complaints received related to air pollution[2].

Kwai Tsing is a district situated in the north west of the New Territories with considerable residential development, a residential population of 440,807 (8% of the total Hong Kong population) and approximately 8,000 industrial establishments, mainly involved in garment production, textiles, dyeing, enamel and electronics[9]. With the container port, with its eight cargo loading centres also situated in the district, the area also has a high density traffic flow, much of which consists of heavier vehicles such as goods vehicles and container lorries.

Discussions culminated in the Respiratory Health Study, set up in 1989, to measure levels of respiratory morbidity in primary 3 and 4 children and their parents living in Kwai Tsing, compared with a similar number of residents in Southern District, a residential area with less industrial development. Details of the methodology of the study and preliminary results, have been published elsewhere[10].

MATERIALS AND METHODS

In the first year of the study, 3456 primary 3 and 4 children, aged 8 to 11 years, from 18 schools, in the two districts of Hong Kong, Kwai Tsing and Southern, and their parents were studied.

Data collection was carried out using self-completed questionnaires, developed for both the children and their parents from international standard questionnaires. Information was collected on respiratory health, smoking in the home, perception of air quality, and, in addition for the parents, details of their child's respiratory health, and social and demographic data. All children were also given a health check which included the measurement of lung function.

Differences between the two districts were examined by chi square analysis for respiratory health of the children and their parents, smoking habits, social and demographic information and personal perception of air quality, using SPSS. Crude prevalence ratios were obtained for the respiratory symptoms and unadjusted odds ratios calculated. To adjust for the effects of co-existing but potentially independent risk factors, logistic regression was carried out using GLIM-3.

RESULTS

Demography: The distribution of children by age and gender in the two districts was quite similar (Table 1).

Table 1: *Population studied by district, age and gender*

AGE (yrs)	SOUTHERN (n) BOYS	SOUTHERN (n) GIRLS	KWAI TSING (n) BOYS	KWAI TSING (n) GIRLS	TOTAL
8	226	228	275	298	1027
9	399	282	470	420	1571
10	185	118	253	198	784
≥ 11	23	16	46	19	104
TOTALS	833	644	1044	935	
	1477		1979		3456
BETWEEN AGEBANDS: X^2=5.04; DF=3; P<0.17					
BETWEEN GENDERS: X^2=4.88; DF=1; P<0.03					

Respiratory health: Crude prevalence ratios for a number of respiratory symptoms in the children and their parents indicated significant differences between the two districts, being higher for the children and parents who lived in Kwai Tsing. This district effect continued to exist, even after the odds ratios were adjusted to take account of differences in a number of home environment factors. Table 2 shows the adjusted odds ratios for respiratory symptoms in the child for all cases where significant differences were found in the initial analyses. The excess risk to children, associated with living in Kwai Tsing ranged from 23% (nasal problems) to 55% (cough for three months).

Table 2: *Adjusted odds ratios for child's respiratory symptoms*

	SORE THROAT	COUGH am	COUGH pm	COUGH 3 mth	COUGH see Dr	PHLEGM am	PHLEGM 3 mth	WHEEZE	NASAL PROBLEMS
DISTRICT	1.42	1.27	1.32	1.55	1.30	1.29	1.37	1.36	1.23
GENDER	1.46							1.91	1.38
AGE		0.74	0.80				1.76		

KEY: am - symptoms in the morning or after waking up, 3 mth - problem for three consecutive months or more; see Dr -see a doctor in the past three months for named respiratory symptom

Socio-economic status: Significant differences were also found between districts with respect to the socio-economic information obtained from the parents' questionnaires. In terms of parental educational attainment, Kwai Tsing has a greater proportion of both mothers (64%) and fathers (49%) whose education ended at primary level compared with 49% of mothers and 36% of fathers in Southern District. Conversely, far fewer parents in Kwai Tsing went on to tertiary education, 1% of mothers and 3% of fathers compared with 4% and 9% in Southern District. The difference between districts is significant, for both fathers (X^2=157.27; df=4; p<0.00001) and mothers (X^2=173.48; df=4; p<0.00001).

In terms of housing, the Kwai Tsing families occupied more public (72% compared with 51%) and less private housing (26% compared with 46%) than the families from Southern District (X^2=150.06; df=5; p<0.001). With respect to the size of the housing occupied and the area per person available in the living quarters, there were also significant differences between the two districts (living quarter size, t=12.1; df=2631; p<0.001: area per person, t=12.23; df=2546; p<0.001). The mean value for living quarter size was 468ft^2 in Southern District compared with 354ft^2 in Kwai Tsing, and the mean area per person was 98ft^2/person and 71ft^2/person respectively, in the two districts.

Indoor air quality: With respect to indoor air quality in the living quarters, four factors were examined; cooking fuel, use of mosquito coils, incense and smoking. Differences were found between the families in the two districts for cooking fuel use (Table 3); more Kwai Tsing families used either kerosene or town gas whilst for the Southern families, liquid petroleum gas was the most popular. The differences in the numbers of families using specific types of fuels between the two districts were significant for all types of fuel used except firewood (Table 3). In terms of the use of mosquito coils and the burning of incense in the home, although slightly more families in Kwai Tsing used incense, these differences were not significant, but there were significant differences in the use of mosquito coils between the two districts, with more families in Southern burning mosquito coils (Table 3).

Table 3: *Cooking fuel, mosquito coil and incense use by district*

ITEM	SOUTHERN % (n)	KWAI TSING % (n)	X^2	P
TOWN GAS	42 1 (1394)	51 3 (1845)	26 39	0 0000
LP GAS	58 3 (1394)	44 7 (1845)	58 73	0 0000
KEROSENE	7 0 (1394)	24 0 (1845)	164 17	0 0000
FIREWOOD	0 2 (1394)	0 3 (1845)	0 35	0 55604
ELECTRICITY	7 2 (1394)	5 4 (1845)	4 24	0 03955
MOSQUITO COIL	25 0 (1314)	18 6 (1706)	18 02	0 00002
INCENSE	55 8 (1379)	57 7 (1810)	1 07	0 30031

df = 1 for all cases
Note the percentages do not add up to 100% because some households use more than one type of fuel for cooking

For family members smoking in the home, there were marked differences between the two districts, as shown in Table 4, with more Kwai Tsing (50%) compared with Southern District (41%) fathers stating that they were 'ever' smokers For the mothers, there were no statistical differences between the two districts. For current smokers, the figures were 40% and 33% for fathers and 5% and 3% for siblings in Kwai Tsing and Southern Districts, respectively.

Table 4: Smoking prevalence in the home

SMOKER	SOUTHERN %(n) CURRENT	SOUTHERN %(n) EVER	KWAI TSING %(n) CURRENT	KWAI TSING %(n) EVER	X^2;df	P
FATHER(PQ)	33.1 (1435)	40.7 (1435)	40.4 (1912)	50.2 (1912)	25.98;2	0.00001
MOTHER(PQ)	2 9 (1295)	3.2 (1295)	1.8 (1710)	2.7 (1710)	4.16,2	0.12521
CHILD(CQ)	0 1 (1468)	6.4 (1468)	0 4 (1967)	9.0 (1967)	9.91;2	0.0071
SIBS(PQ)	3.4 (1358)		5 3 (1798)		7.65;1	0.00568
OTHERS(PQ)	9.8 (1310)		11.7 (1752)		2.46;1	0.11658

SOURCE OF DATA: PQ - Parents' Questionnaire, CQ - Children's Questionnaire

In addition, more children themselves in Kwai Tsing claimed to be ever smokers (9% compared with 6%). The self smoking figures for children as current smokers, although small, differed by a factor of four between the two districts (Kwai Tsing 0.4%, Southern 0.1%). An 'ever' smoker is one who has smoked, any amount of tobacco, at some time in their life, but who may or may not be a current smoker.

The excess risks for respiratory symptoms in the children from living in a household where other family members smoke are shown in Table 5 and range from 30% (evening cough) to 137% (phlegm after waking up) and the excess risks associated with self smoking were also high (79% for nasal problems to 225% for sore throat).

Table 5: Excess risks for respiratory symptoms associated with others and self smoking

SYMPTOM	SELF SMOKING	FATHER CURRENT SMOKER	MOTHER CURRENT SMOKER	OTHERS SMOKING
SORE THROAT	225%			78%
EVENING COUGH		30%		58%
COUGH FOR 3 MTHS				120%
COUGH - SEE DR				49%
MORNING PHLEGM			137%	34%
PHLEGM FOR 3 MTHS		46%	118%	
WHEEZING	163%			
NASAL PROBLEM	79%			38%

Percentage of air quality: Finally, in terms of perception of air quality in the area in which the families lived and where the children went to school, only 54 to 69% of the Kwai Tsing parents and their children considered that the air quality was good compared with over 82% of Southern families. Table 6 gives the parental and child perception of air quality, by district.

Table 6: Perception on air quality as good by district

		SOUTHERN % (n)	KWAI TSING % (n)	X^2	P
PARENT	CHILD'S ROOM	89 (1400)	67 (1842)	224.43	0.00001
	HOME	85 (1402)	57 (1838)	297.37	0.00001
	SCHOOL	96 (1396)	69 (1816)	388.91	0.00001
	HOME AREA	87 (1379)	54 (1812)	387.34	0.00001
	PLAY AREA	82 (1361)	64 (1760)	121.04	0.00001
	TIME OUTSIDE	17 (1384)	18 (1831)	0.20	0.6578
CHILD	HOME	89 (1475)	68 (1974)	216.61	0.00001
	SCHOOL	92 (1474)	62 (1973)	412.22	0.00001
	TIME OUTSIDE	31 (1474)	30 (1976)	0.60	0.43919

DISCUSSION

Data from this study clearly demonstrate that socially and economically, the families in Kwai Tsing are disadvantaged when compared with those in Southern District. A lower level of education tends to result in employment in the semiskilled workforce sector. This can have financial repercussions which in turn reflect on the type and size of housing chosen (by default or otherwise) and the resultant level of crowding/overcrowding in the home, with its attendant links with ill health, including respiratory illnesses such as asthma[11,12]. Kwai Tsing District families live in more crowded conditions with, on average, only 76% of the floor area and 72% floor area/person available to Southern families.

Lower socio-economic status has been found to be a risk factor for cough, phlegm and persistent wheeze in children[13], and the varying prevalence of asthma in different racial and socioeconomic groups can be accounted for in terms of the social and environmental differences between the groups[14]. In this study, an increased number of respiratory symptoms in both children and parents in Kwai Tsing remained even after taking into account all other identifiable risk factors including smoking. The bronchial physiology of the children also appears to be compromised. These differences found in the children's reported respiratory symptoms were supported by later studies of responses to a histamine challenge test, which suggest that differences in bronchial physiology exist between the child populations of the two districts.

There is some evidence that the use of gas cookers and kerosene are associated with respiratory illness and/or reduced pulmonary function[15 16] although no relationship was found in some other studies[13,17,18]. In our study population, there is little difference between the districts when kerosene and gas use is combined, with only 6% of Kwai Tsing residents and 7% of Southern families using neither gas nor kerosene.

An association has also been found between exposure to mosquito coil smoke, when coils are used at least three nights a week, and asthma and persistent wheeze[18]. Unfortunately information on the frequency of use of mosquito coils, was not collected in this study.

Finally, one of the factors which has considerable impact upon indoor air quality and which is also the biggest single risk factor for respiratory disease is environmental tobacco smoke. These results are in agreement with a number of studies which have reported a link between parental smoking, reduced lung function and increased prevalence of respiratory symptoms, asthma, bronchitis, wheeze, colds and phlegm in children[19,20,21]. In this study, it was found that living in a household where other family members smoked or the children themselves smoked was associated with an excess risk of certain respiratory symptoms in children ranging from 30-225%. Forty percent of the Kwai Tsing children and 30% of the Southern children involved in this study are growing up in a home where at least one parent is a current smoker although this figure is low compared with some Western countries. One study of American children aged 0 to 19 years found that 62% of children had at least one parent who currently smoked[20]. However, given that approximately half of the child population studied is or has been exposed to environmental tobacco smoke, the public health impact of passive smoking could be substantial.

The fact that the air quality objectives in Hong Kong were exceeded, on average, once every ten days in 1988 and 1989 is endorsed by local public perception that the air quality in Kwai Tsing is not as good as it should be. The widespread problem in Kwai Tsing, as in some other urban areas of Hong Kong, of siting residential centres next to industrial outlets, due to oversight or inadequate planning, gives rise to environmental problems that can prove difficult to overcome.

Thus, the children who have higher risk health status and health behaviour are also the same children growing up with environmental pollution. This indicates important social inequalities in planning and environmental control and has profound implications for planners. Those at most risk tend to live in high risk environments. In the current economic climate, implementation of health policies and allocation of scarce financial resources should be targeted at such at-risk populations and the environment in which they live.

It is also to be noted that the above factors create special problems for epidemiological studies which aim to analyse health risks caused by pollution.

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RISK ASSESSMENT AND MANAGEMENT IN THE PREVENTION OF ADVERSE EFFECTS ON HUMAN HEALTH AND THE ENVIRONMENT

JT Spickett
Division of Health Sciences, Curtin University, Perth, Western Australia

INTRODUCTION

While the production of chemicals has been widely accepted as being of overall benefit and there is now substantial reliance on chemical products, there are still many uncertainties about the production, use and disposal of these chemical products. The widespread use of chemical products may be adversely affecting human health now and in the future. Alternatively it may be that the problems which currently exist are relatively minor and if addressed in the near future will not pose serious problems for human health or the environment.

By the 1970's it was becoming widely recognised that chemical industries together with other human activities had resulted in significant contamination of water, food and air. In Australia most states have established an agency of government to advise on matters concerning pollution of the environment and the future possibilities of danger to the environment. However, in the 1970's the major focus of concern was on the effects on the environment rather than the consequential effects on human health and safety. Since this time, the knowledge base in areas such as toxicology, hygiene, analytical chemistry and environmental control has increased dramatically. Although there is still a great deal of research required into many important aspects of environmental pollution, we are much better placed to assess the risks to health and safety than before. In more recent years these developments have been accompanied by an increase in public awareness of the health and safety implications of chemical industries and hence a focus on environmental health and safety aspects of new operations has developed. There seems, therefore, to have been a shift in emphasis from the 1970's, when the major area of concern was on the effects of human activities on the environment, to a concern about the effects on human health and safety in the late 1980's and early 1990's

RISK ASSESSMENT AND MANAGEMENT

Risk assessment can be generally described as the scientific evaluation of the human health and safety impacts of a particular activity and is, as far as is practicable, a scientific process where the potential hazards are identified and the extent of contamination and the likely levels of exposure are determined. From this information health and safety risks can be quantified. The second step, which is the risk management stage, uses the information from the risk assessment process to establish a policy and procedures to control the hazard. Risk management therefore involves many factors including feasibility, cost and public acceptability which must be separated from the risk assessment process.

Although there are a number of uncertainties in the assessment process the tendency is to take a conservative approach, but it is important that a realistic approach is taken at least in the early stages.

In developing countries it is important that consideration be given to environmental and occupational health and safety in the development of new industries. Economic development must include consideration of these matters otherwise there will be a continuation of the environmental contamination which is occurring elsewhere. Developing countries must be given assistance, as their economics develop to ensure that proper consideration is given to these matters.

ENVIRONMENTAL HEALTH AND SAFETY IMPACT OF NEW DEVELOPMENTS

There are a number of processes involved in the development of a new project eg. the development of a chemical plant in Western Australia. The initial proposal is screened by the Environmental Protection Authority and, if the development is likely to have a significant impact on the environment, it is subjected to a formal assessment procedure referred to as an environmental impact assessment. The assessment process is carried out by the proposers of the development.

There are three levels of assessment:

(a) Consultative Environmental Review (CER).
(b) Public Environmental Review (PER).
(c) Environmental Review and Management Program (ERMP)[1].

The Environmental Protection Authority (EPA) provides guidelines for preparing the documentation which must explain the project and outline its environmental impact and how this will be managed[1]. In addition to public meetings to discuss the proposal the EPA can also seek advice from people from within the EPA or independent consultants with experience on aspects of the project. The outcome of this process is a report which states whether the project is acceptable from an environmental point of view and the conditions necessary for the project to proceed in such a way as to have a minimal impact on the environment. Appeals by the proposers can be made to the Minister for Environment as the Minister will ultimately set the conditions under which the development can proceed. As part of the process the proposers of the development can be asked to prepare a management plan which will deal with any long term impact on the environment the project may have. This can include transport and disposal of waste and revegetation of any land which would be disturbed. If, in the opinion of the EPA, the project involves a significant level of risk, it will require a quantitative risk assessment to be carried out by an approved independent analyst.

The EPA has a guide for the assessment of the fatality risk of new industrial installations which is as follows:

> "A small level of risk which is acceptable to the EPA;
> A high level of risk which is unacceptable to the EPA and which warrants rejection, and
> A middle level of risk, which subject to further evaluation and appropriate actions may be considered to be acceptable to the EPA.

An individual risk level in residential zones of less than 1 in a million a year is considered to be so small as to be acceptable to the Environmental Protection Authority. An individual risk level in residential zones exceeding 10 in a million a year is so high as to be unacceptable to the Environmental Protection Authority"[1].

In the intermediate category (when the risk level is in the range 1 in 10^6 to 10 in 10^6 a year), a further evaluation of the risks will be required. At the design stage of the project, a ***hazard and operability study*** will be required, which will include an investigation of all methods of risk reduction. In addition to the assessment of individual risks, it is important to consider the cumulative risk in a region where a number of industries are located in order to ensure that any additional risk from a new development, combined with risk from an existing operation, does not exceed the established criteria. The assessment process described is effective in regard to the set criteria. However, the process does not consider in any detail potential secondary or indirect human health effects but is essentially concerned with mortality from major toxic releases. In addition the question of environmentally sustainable development is not addressed.

In order to illustrate how this process operates in the management of the development of new chemical manufacturing industries in Western Australia the paper now describes and discusses the development of chemical plants to manufacture cyanide for use in the gold refining industry.

After some initial investigation a full feasibility study for a cyanide plant was undertaken in 1985. Following this the proposers agreed to prepare a risk and hazard analysis which would also include the wider environmental and community issues.

The Public Environmental Report (PER)[2] which was prepared emphasised the environmental impacts as well as risks and hazards associated with both the construction and operation of the plant. The evaluation by other organisations was integrated with the approval process undertaken by the EPA. The initial part of the review outlined the benefits of having a local producer of cyanide including an assessment of the use of alternatives to cyanide for the extraction of gold.

The possible locations of the chemical plant were considered and a set of criteria were established which took into account the following[2]:

- availability of appropriate industrially zoned land
- availability of industrial infrastructure including workforce
- proximity to markets for the product and by products
- environmental considerations
- development costs
- proximity to other company operations.

Consideration was given to the most suitable manufacturing process and to the transportation requirements regarding the product. In this case, because of the limitation of the rail network, road transportation was proposed as being preferable.

Western Australia covers a large land mass (2.65 million square kilometres) with a population of about 1.5 million. Of this over 1 million live in the metropolitan area of Perth with a few other significant population Centres. South of the metropolitan area is an industrial area which was set aside for that purpose in the 1950's[3], Kwinana Industrial area located near Perth in Western Australia[4]. There was a small old residential area of less than 300 people near the preferred site but since 1975, when this area was designated "special industrial", the residents have been gradually relocated. The nearest significant residential area (over 30,000 people) is 2km inland from the proposed site and is separated from the industrial site by a vegetated ridge. In the surrounding industrial area there are about 10 major industries including an oil refinery, nickel refinery, and fertiliser manufacture, employing over 3,500 people.

Studies of the likely atmospheric emissions, liquid and and solid wastes indicated there would be no adverse effect under normal operating conditions, however the proposers were required to undertake a quantitative risk analysis to determine if there was any risk to people or property. This process involved the identification of the potential hazards, estimating the likely frequency of an event and the extent of damage.

The sequence is therefore: identification of potential hazards; the quantification of the likely occurrence of a hazard; and quantification of the consequences of a potential hazard. The quantification and consequence analysis enables a comparison to be made of alternatives and gives an indication as to the overall risks of the best option. The PER gives the general health and safety information on each of the main substances involved i.e. ammonia, natural gas, hydrogen cyanide, sodium cyanide, carbon monoxide and hydrogen. As mentioned earlier the EPA has established risk assessment criteria for industrial developments. The levels of risk criteria (individual risk of fatality) set for land uses other than residential are as follows:

- recreation
  - passive — up to 10 per million, per person, per year
  - active — up to 5 per million, per person, per year
- commercial — up to 5 per million, per person, per year
- public roads — up to 20 per million, per person, per year
- industrial — up to 50 per million, per person, per year[1]

The individual risk level for those in local industry was below 1 in 10^6 per year which is well below the level of 50 in 10^6 per year set by the EPA. In the assessment of the impacts the potentially adverse effects on the social environment were also covered to a limited extent including the impact of odour, noise, traffic, aesthetics and public amenity.

THE RISK ASSESSMENT PROCESS

The risk assessment for the project to manufacture liquid sodium cyanide was carried out by Cremer and Warner[5]. In the context of the assessment the term "hazard" was used to describe a set of conditions which could lead to an accident with harmful consequences and "risk" in terms of both the consequences and the likelihood of the hazard being realised. This final stage was to estimate the likelihood of a particular failure occurring.

Risk contours were derived for this plant[5] and are shown in Figure 1. The values for the total individual risk of the plant enabled the risks to be compared with the risk of death from accidents which occur as part of everyday life and can be regarded as "background risk".

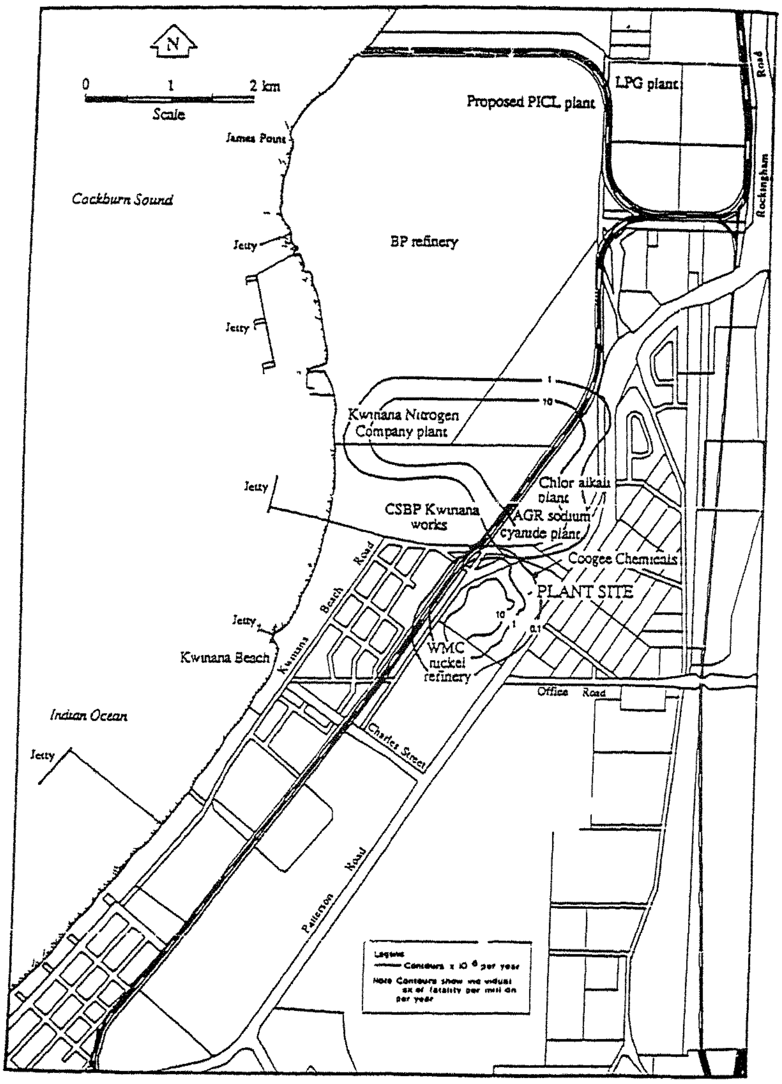

Figure 1: Individual risk contours (Modified from Cremer & Warner 1986 and Det Norske Veritas 1989). Present cyanide plant is shown - AGR sodium cyanide plant.

As could be expected there were a number of assumptions which have to be made for the risk assessment process to be carried out and hence there were a number of limitations associated with the results[5]. These can be summarised as follows:-

- Lack of recognition of a potential failure leading to release of hazardous material
- Limitations of failure rate data for various pieces of equipment
- Assumptions made regarding the effects of failure
- Assumption made regarding dispersion of hazardous material.

Given the limitations and assumptions, the risk assessment results are most useful in the comparison of alternative possibilities for a given proposal as many of the limitations and assumptions were the same for both assessments.

THE PERCEPTION OF THE RISK

One of the major difficulties in the risk assessment process is the communication of the risk to the general public, particularly those people living closest to the chemical plant. The risk can be seen as an involuntary risk whereby the people would not see themselves receiving any direct benefit from the plant. In this situation it is common for people to react adversely because they are being asked to accept a risk which although comparable to those which they accept as part of everyday life is one for which they see no benefit.

CONCLUSION

In recent years there has been an increasing concern regarding the environmental impact of chemical industries which has led to the development of a systematic review process. The proposers of the chemical industry must provide a detailed review of impact of the plant on the environment which has to include an analysis of the risk and hazards of the development on residential areas. This review process enables all parties including members of the general public to raise concerns regarding any aspect of the chemical plant.

Although this process is reasonably effective and is a vast improvement over the early procedures for establishing chemical plants there is relatively little consideration given to the potential secondary or indirect health effects resulting from the operation of the chemical plant. In the future the concept of environmentally sustainable development will also have to be included in the review process for the establishment of chemical industries.

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INDOOR AND OUTDOOR POLLUTION IN SHOPS AND OFFICES IN HONG KONG AND HEALTH EFFECTS

J Bacon-Shone and S Liao
Social Sciences Research Centre, The University of Hong Kong

INTRODUCTION

The aim of this study was to investigate the patterns of air pollution in open-fronted shops and offices in Hong Kong, both indoors and outdoors, and to look at the relationship between the pollution and the number of occupants, traffic flow and reported health complaints. Thirty-five shops and thirty-five offices were selected to be as representative as possible (although not a random sample, due to difficulty in obtaining permission) of conditions in Hong Kong. Outdoor measurements were taken directly outside premises, although that may not have been where the air-intake was. A detailed description of the distribution of the shops and offices and analytical details can be found in Liao et al (1991). All sampling took place during business hours between July and September 1990.

METHODS, ANALYSIS AND RESULTS

Table 1: *Parameters monitored inside and outside of street-level shops in Hong Kong*

	Inside Shops n = 35			Outside Shops n = 35		
	Median	Minimum	Maximum	Median	Minimum	Maximum
CO (ppm)	2 9	0 2	9 2	2 6	0 1	8 0
CO_2 (ppm)	530	360	860	480	345	630
NO_2 (μgm^{3})	59	29	142	69	39	161
RSP (μgm-3)	284	39	961	255	46	991
UV-RSP (μgm-3)	9	1	96	10	0	29
Nicotine (μgm-3)	0 6	0 2	3 9	0 6	0 1	206
Benzene (μgm-3)	179	ND	1236	382	ND	1181
Toluene (μgm-3)	81	ND	908	120	ND	969
Temperatures (°C)	27	22	35	32	27	39
Relative Humidity %	78 1	46 2	94 6	74 8	49 5	96 8
Bacteria/hr	61	6	226	NA	NA	NA
Fungi/hr	23	0	91	NA	NA	NA
Shop area (m^2)	60	10	180			
Total Employees	3	1	10			
% Smokers	20 0	0	100			
Cigarettes/Person (over 4-6 hours)	0	0	0 4			
Total Vehicles/hr				484	50	999

ND = below detection limits

Table 2: *Parameters monitored inside and outside of offices in Hong Kong*

	Inside Offices n = 35			Outside Offices n = 35		
	Median	Minimu	Maximum	Median	Minimum	Maximu
CO (ppm)	2.7	0.3	10.4	2.9	0.3	12.2
CO_2 (ppm)	760	435	2080	450	390	600
NO_2 (μgm^{-3})	16	5	94	84	14	1000
RSP (μgm-3)	67	14	205	170	39	503
UV-RSP (μgm-3)	10	2	93	9	2	26
Nicotine (μgm-3)	0.1	0	1.1	0.2	0	1.6
Benzene (μgm-3)	40	ND	487	35	ND	243
Toluene (μgm-3)	166	ND	11811	ND	ND	78765
Temperatures (°C)	25	20	30	33	22	38
Relative Humidity %	57.6	40.8	70.8	70.8	52.8	98.4
Bacteria/hr.	15	1	100			
Fungi/hr.	4	0	26			
Office area (m^2)	150	25	2000			
Total Occupation	11	2	157			
% Smokers	0	0	70			
Cigarettes/Person	0	0	0.5			
Total Vehicles/hr				592	0	2148

ND = below detection limits

Tables 1 and 2 summarize the analyte values and also the temperature, humidity, bacteria, fungi, shop/office areas, number of employees, proportion of smokers and cigarettes and vehicular traffic outside the shop/office. In addition, the room volume, ventilation type, floor number and employee activity were recorded and employees were interviewed regarding complaints about symptoms such as headache, drowsiness, dry eyes, respiratory irritation and temperature discomfort. The data are summarized using the median rather than mean as this removes the difficulty with values below detection limits, reduces sensitivity to extreme values, and avoids debate over whether the data follow a Normal or log-Normal distribution. Correspondingly, the Mann-Whitney U test is used for statistical tests of differences, rather than the Student's t test.

Table 3: *Principal component analysis*

Shops:

5 factors explain 71.0% of the variation

1) CO, CO_2 & Nicotine in & out
2) Temp (-ve), VOCs in & out
3) Bacteria and Fungi
4) NO_2 in & out, Temp & CO in
5) Humidity & RSP in & out

Offices:

6 factors explain 78.5% of the variation

1) Temp, humidity (-ve) & Benzene in & out
2) Nicotine in & out (both -ve), RSP out & Toluene in
3) Bacteria & Fungi
4) Temp & humidity(-ve) out, CO, RSP & UVRSP in
5) CO, CO_2, UVRSP & NO_2 out
6) Temp, CO_2 (-ve), NO_2 in

Table 3 shows the factor structure found when principal component analysis was done on the ranks of the indoor and outdoor levels of pollutants, separately for shops and offices.

DISCUSSION

As might be expected, given that the shops were open to the street, the indoor and outdoor measurements were similar, except for temperature, NO_2 and CO_2, the first two being lower indoors, while the latter being higher indoors ($p<.001$ for all). Conversely, given that the offices were all above ground-level and had some form of air-conditioning, it is not surprising that nearly all the indoor and outdoor measurements showed significant differences ($p<.001$), except UV-RSP and nicotine where the levels were very low, probably due to the small number of smokers.

Some comparison can be made with the air pollution in Hong Kong restaurants measured by Oldaker et al (1991). Their estimates of the geometric mean (which should be close to the median) were 8.4 μgm-3 for nicotine, 115 μgm-3 for RSP and 71 μgm-3 for UV-RSP indoors. They also give arithmetic means of 3.7 ppm indoors and 2.2 ppm outdoors for CO. With the exception of the RSP figures, these are all higher in Oldaker's sample than in our study, suggesting much higher levels of pollution due to cigarette smoke in restaurants.

The major association between health-related complaints and pollution was of 'sick-building' complaints typical of 'sick buildings' and with high indoor CO_2 levels ($p=.01$). It is interesting to note that nearly all the temperature complaints were in the offices and were mainly that the temperature was too cold (34% of offices) rather than too hot (6% of offices). The number of smokers in our sample was too small for the importance of tobacco smoke as a pollutant to be assessed.

The purpose of factor analysis (or more accurately in our case, principal component analysis) is to try and identify what is underlying the observed correlations in a set of variables. One hopes that a small number of new variables, which are linear combinations of the original variables, 'explain' most of the observed pattern of correlations. These ideas are very common in social science applications, but less so in other areas. In this data set, the pattern of correlation is complex and we have good reason to believe that there are a number of underlying causes of the pollution observed (e.g. petrol engines, diesel engines, cigarettes,). Sometimes the results of factor analysis are not easily interpretable and they are not always reliable, but the potential insights gained make it still useful.

In both analyses, bacteria and fungi separate out together, indicating their strong linkage together, and the lack of a link with any of the other measurements. For the shops, it is noticeable that for most of the pollutants, indoor and outdoor measurements load on the same factor, indicating the similarity of the indoor and outdoor air. For the offices, CO, CO_2, UV-RSP and NO_2 outdoors go together, as would be expected given vehicular pollution. Temperature and humidity link together, as do CO, RSP and UV-RSP indoors.

Thus the patterns found indicate that traffic flow is a likely major cause of pollution in the areas we studied, although direct measurement of traffic flow was not correlated with pollution. This, however, may reflect that slow or stationary traffic is more of a problem than fast-moving traffic, whereas in this study traffic flow was measured in vehicles per hour.

CONCLUSIONS

The indoor air environment in Hong Kong shops and offices would be greatly improved by better temperature control, lower CO_2 levels and better isolation from traffic exhaust pollution.

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CLIMATOLOGICAL ASSESSMENT OF POTENTIAL HEAT STRESS IN HONG KONG

WJ Kyle
Department of Geography & Geology, The University of Hong Kong, Hong Kong

INTRODUCTION

Today's world is an increasingly urbanized one where cities and metropolitan areas have grown into vast conurbations since the end of World War II. United Nations projections for tomorrow's world indicate that by the end of the twentieth century over 6.1 billion people will live on earth, about 50 percent of them crowded into urban areas. In the so-called "more developed" world the expectation is for 1.3 billion inhabitants with about 80 percent living in cities. This rapid increase in the size of metropolitan areas and the rising industrialization has kindled numerous studies in many parts of the world which attempt to gain insight into the multitude of man-made climate alterations which occur in cities and their impact on almost every facet of human activity.

One very important aspect of this change, is that increased thermal stresses are placed on those humans who are often least able to cope with them, the elderly. Clarke[1] and Ellis[2] have quoted the results of many studies which show that during heat waves in the United States the death rate from heat-related ailments is often much higher in cities than in outlying environs. The higher death rate in cities appears to be a result of climate modification due to urbanization so that during heat waves inhabitants of urban areas may experience sustained thermal stresses both day and night while those who live in outlying areas often obtain some relief from thermal stresses during nocturnal hours. Many studies also show that one group, the elderly, are at high risk during such times.

While there are many variables involved in such relationships it appears that there is unequivocal evidence that excess deaths in the elderly can be related to additional heat stress imposed on them in urban areas. A careful epidemiological study of death rates in New York City and Saint Louis during the heatwave of July 1966[3] indicated that cardiovascular incidents (CVAs), which include strokes, were considerably in excess of expectation. However, it also showed high contributions to the excess from arteriosclerotic heart disease, hypertension, diabetes and respiratory failure. It was also obvious that the elderly were most at risk in such events although there was considerable geographical and socioeconomic variation in both cities with the poorer and more crowded neighbourhoods having higher rates.

Heat-related deaths are not a unique experience to the United States with such incidents being related from many other parts of the world. While clearly there are differences due to social and cultural factors as well as acclimatization of the population there is no reason not to believe that such risks to the elderly also exist in a crowded urban environment such as Hong Kong. In the absence of detailed epidemiological studies of heat-related deaths in Hong Kong this study reports on an attempt at the climatological assessment of the hygrothermal environment with the aim of identifying those time periods when potential heat stress conditions are likely to occur. These might then be considered times when the elderly are most likely to be at risk.

The approach taken was to investigate the many potential ways of expressing heat stress which have been proposed in the literature and to select one which is readily calculated from available meteorological data in Hong Kong and which provides a rational scale against which to measure the magnitude of heat stress imposed on individuals by different combinations of the components of the thermal environment. Thus it is a compromise between simplicity of expression and detailed evaluation which is justified within the context of the objective, a preliminary identification of those time periods where heat stress conditions are most likely to occur.

PROCEDURE AND DATA SOURCES

Man is a very complex organism, and because of the need to have precise regulation of body temperature, is one in which it is difficult to isolate cause and effect, due to the many interrelationships and feedbacks involved. Table 1 shows a summary of human responses to heat stress as given by Lee[4] to illustrate some of the mechanisms involved.

Table 1: *Summary of human responses to heat stress (after Lee[4])*

Thermoregulatory responses
Dilation of skin blood vessels
Dilution of blood
Extension to increase exposed body surface
Decreased muscle tone
Sweating
Inclination to reduced activity
Consequential disturbances
Decreased urine volume
Thirst and dehydration
Difficulty in maintaining blood supply to brain leading to dizziness, nausea and exhaustion
Difficulty in maintaining chloride balance leading to heat cramps
Decreased appetite
Failure of regulation
Rising body temperature
Heat regulating centre impaired
Failure of nervous regulation centre ending in cessation of breathing

The meteorological variables determining thermal stress are thus linked to the energy exchange processes between the body and its surroundings and the resultant physiologic strain is a consequence of their interaction with the responses listed in Table 1. Hence the primary variables are air temperature, radiation load, vapour pressure and air motion. A complete assessment also requires analyses of such parameters as thermal conductivity of clothing, metabolic heat generation arising from activity, health, age, occupation and acclimatization to name some of many. In order to generalize it has been necessary to conduct experimental studies of climatic strain and derive various indices based on the average response of subjects under specified conditions. Many such indices are described in the literature[5,6].

One such index was devised by Belding and Hatch[7] as a rational approach to the evaluation of heat stress in terms of the thermal load imposed on a *standard man*, the capacity of the environment to accept the load, and the physiological capacity of the man to meet the demands over an eight hour period. Their heat strain index was defined as the ratio between the amount of perspiration which must be evaporated from the skin to maintain thermal equilibrium (absence of heat stress) and the maximum amount of evaporation which can occur under the specified conditions.

Lee and Henschel[8] modified this relationship to take account of the insulating effects of clothing and net radiation of heat to the body to devise a relative strain index (RSI) for *standard men* (25 years old, healthy and not acclimatized to heat). Table 2 lists a thermal discomfort scale based on Lee and Henschel's empirical studies for specified standard indoor conditions. These are: no solar radiation load, air movement of 1 metre per second, and metabolic heat generation due to sedentary activity of 100 kilocalories per square metre per hour. In this scale an RSI of 0.3 is taken as the critical point above which everyone is subject to stress.

Table 2: Relative strain index classification (after Lee and Henschel[8])

Relative Strain Index	*Percentage of persons unstressed/distressed*
0.10	100 unstressed
0.20	85 unstressed
0.30	0 unstressed
0.40	75 distressed
0.50	100 distressed

The RSI as formulated above has been used elsewhere in the sub-tropics for evaluating potential heat stress conditions[9]. It is expressed as:

$$RSI = (T-21)/(58-e)$$

where T is dry bulb temperature (°C) and e is actual vapour pressure (hPa). Note that in this form the reference person is equivalent to a healthy, sedentary young man dressed in a business suit indoors where air motion is negligible and no marked radiation load is imposed on the body.

The data on which the calculation of the RSI for Hong Kong is based are the mean hourly dry and wet bulb temperature data by month for the 30 year period, 1961 to 1990, recorded at the Royal Observatory. Actual vapour pressure was calculated from these data using the procedure described by Auliciems and Kalma[10] before using the equation above to compute the mean hourly RSI for each month.

RESULTS AND DISCUSSION

The 30-year normal diurnal distribution of average RSI for Hong Kong is presented in Figure 1. On this plot values of RSI under 0.2 can be interpreted as posing little or no potential heat stress threat. Values between 0.2 and 0.3 are transitional while those above 0.3 represent situations where there is increasing likelihood of heat stress. The RSI on a mean monthly hourly basis reaches a maximum in the late morning and afternoon hours of June to August with the value exceeding the distress threshold for ten hours between 0930 and 1830 in July. Quite clearly those midsummer daytime hours represent situations in which even healthy young men engaged in relatively light activity can be expected to feel some distress due to the body's difficulty in maintaining thermal equilibrium.

However, these periods are also those when even greater danger may be expected for those less able to withstand such heat loads due to decreased physiological capacity. Such reductions in ability are more common in the elderly and can be enhanced by pre-existing ill health. To some degree such reductions may be offset by the positive effects of heat acclimatization. It may be expected, however, that such subjects will not only suffer greater distress during those hours but will also be subject to such distress outside those hours in the "transitional period" identified in Figure 1. In this regard it is interesting to note that in the summer months the RSI threshold of 0.2 is exceeded throughout the whole 24 hour period so that those most susceptible do not even have the opportunity for some relief from thermal stresses during the nocturnal hours.

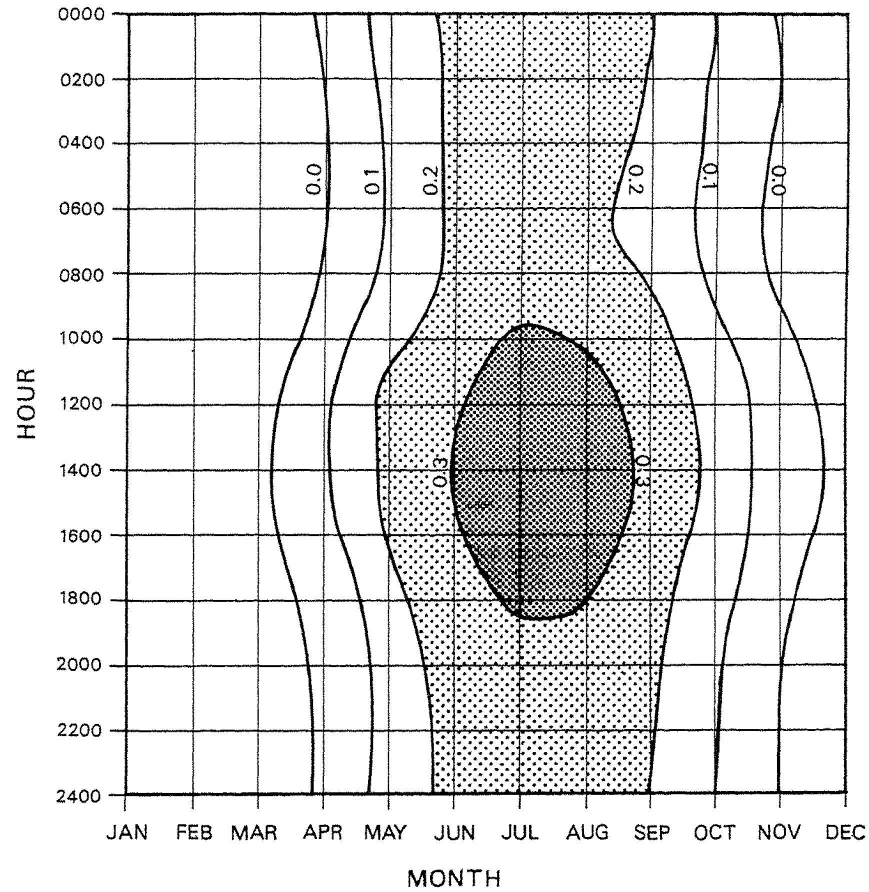

Figure 1: *30-year normal durnal distribution of RSI for Hong Kong.*

While the limited objectives of this study are thus met by the use of the RSI a number of improvements are clearly required to provide a more useful analysis of the potential hazard from heat stress posed in urban Hong Kong. These relate to three major areas where further information is necessary. First, a refinement in the RSI classification is needed to take into account the increased age and possible acclimatization to heat of the elderly in Hong Kong compared to the scheme of Lee and Henschel[8]. Such a refinement would ideally involve studies under controlled conditions in Hong Kong but could in the interim draw on experience from other parts of the world to provide more realistic thresholds. In any event it is to be anticipated that the period of hazard is likely to be longer in duration than that identified here. Second, it would be very useful to have a careful epidemiological study of excess deaths attributable to periods of extreme heat stress in Hong Kong. This would necessarily require the excess mortality figures for and identification of such periods. The third area involves refinement of the identification of potential hazard periods in more detail and is essentially a climatological analysis issue which is dependent on the results of the previous two.

Finally, in an era of potential global warming we may expect that urban areas such as Hong Kong will become even more thermally stressful for longer periods than at present. Clearly this poses inherently greater hazards for not only the elderly but for other susceptible groups in the population. A realistic appraisal of the hazard posed by such conditions is, in such circumstances, a worthwhile objective.

ACKNOWLEDGEMENTS

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ASBESTOS DUST - A SILENT ENEMY

KY Lam
Department of Pathology, The University of Hong Kong

INTRODUCTION

Asbestos is a general term embracing a number of complicated fibrous silicates of magnesium with differing chemical composition and morphology[1]. It has strong resistance to alkalis, neutral salts and organic solvents and the varieties used for building products have good resistance to acids. In addition, asbestos is non-combustible and able to withstand high temperature without changes[2]. Thus, it has become a common material used in building and industry.

Asbestos is a widespread air and water pollutant. Occupational exposure to asbestos may occur through direct handling or indirectly, by working in areas where asbestos is a component of building structures and other installations[3,4,5]. Non-occupational and non-industrial exposure may result from environmental or air pollution[3,5]. Also, there are reported cases of asbestosis acquired in the home due to inhalation of asbestos dust from contaminated work clothes[6].

The hazard of asbestos exposure has only received public attention in Hong Kong in recent years. This study was performed locally as an attempt to obtain a general picture about some aspects of the health hazards of this agent as an environmental polluter in Hong Kong.

MATERIAL AND METHODS

All the pathology records in Queen Mary Hospital from 1987 to 1991 were reviewed. The materials included all the tissues taken from surgical biopsies, cytological examination and the autopsies performed. The autopsies were either done for clinical interest (clinical cases) or required by law (forensic cases). Those cases with the histologic or cytologic evidence of asbestos exposure were analysed. The records were studied to detect the age, sex and mode of presentation of these patients and other associated diseases of these patients were also noted. The mode of death of those patients who underwent autopsy examination was also noted.

RESULTS

Prevalence of abestos lesions: Twelve patients with the histologic or cytologic evidence of asbestos exposure were found. All of them showed the presence of asbestos bodies in their tissue. Among them, seven cases were patients who had undergone bronchoscopic or sputum examination and the remaining five were from autopsy records (2 forensic and 3 clinical autopsies). In the study period, the staff in the Department of Pathology performed 3046 autopsies. Thus, the prevalence ratio at autopsy in recent years was 1 in 609 (0.16)%.

All except one of the patients were male. Their ages ranged from 39 to 90 with a mean of 70 (SD=5). The modal number was in the eighth decade.

Clinical presentation: Except for the two forensic cases, in which the victims died in traffic accidents, all of the other ten cases presented with signs or symptoms of chest disease. The clinical features included shortness of breath, cough, decreased exercise tolerance and suspicions of lesions in a chest x-ray.

Autopsy cases: In the autopsy cases in which the pathology of the whole body was thoroughly analysed, all of them showed the presence of diffuse fibrosis in addition to asbestos bodies. In addition, all except one patient showed the presence of pleural fibrous plaques. The disease contributed to the death of all three patients who had clinical autopsies performed on them. In this series, the diagnosis had been considered in all of them before death and occupational exposure to asbestos could be identified.

Other cases: In the patients who had undergone bronchoscopic or sputum examination the exposure to asbestosis was only considered clinically in one out of the seven patients (14%). Two cases of carcinoma of lung were found in this group.

DISCUSSION

Exposure to asbestos dust has been called "one of the worst industrial health tragedies in history[7]". In Hong Kong, although there is no mining of asbestos, the material was frequently used in the past for various construction projects like building houses and in shipyards where asbestos has been used in the ceilings and for insulation work[2]. The problem received little attention until recent years. Asbestos is now banned for use in buildings in Hong Kong[8]. However, because of the long history of use of this material in Hong Kong, a lot of asbestos products remain in our environment. This may pose serious risks especially during the demolition of buildings which contained asbestos materials.

Exposure to asbestos dust may be associated with the development of pleural fibrous plaques, pulmonary asbestosis, mesothelioma of the pleura or peritoneum, bronchogenic carcinoma and other forms of cancers[9,10].

The term asbestosis refers to fibrosis of lungs due to inhaled asbestos dust[3,5]. The most important factor in the development of asbestosis is the amount of dust inhaled[1]. Sometimes the asbestos fibres became coated with endogenous iron and protein to produce the characteristic asbestos bodies. The diagnosis of asbestosis depends on identifying asbestos bodies in lung tissue that also shows diffuse interstitial fibrosis[3,5]. These bodies were noted in all of our twelve patients. The disease was confirmed in all the five patients in the autopy series.

Pleural fibrous plaques were noted in 80% of the cases in autopsy series. Other asbestos related disease like bronchogenic carcinoma was found in two patients. It is well known in literature that there is no correlation between the severity of asbestosis and the development of malignancy and there is poor correlation between the intensity of exposure and the predisposition to cancer[11]. The fibrosis induced by asbestos may cause various symptoms, chest discomfort and abnormalities seen in chest films[11]. In this series, these clinical features were noted in all the patients except for the two victims who died in traffic accidents. However, exposure to asbestos was only considered clinically in one of the patients who had undergone bronchoscopic or sputum examination. Whilst in the clinical autopy series, the diagnosis had been considered in all of them before death.

CONCLUSIONS

Asbestos related disease, though not common is not rare in Hong Kong. It has a long latent period and the results of this study indicate that any exposure can have serious consequences. Emphasis should continue to be put on the prevention of exposure to asbestos dust and the early detection of asbestosis in potentially exposed groups.

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INTEGRATING ENVIRONMENTAL HEALTH PROBLEMS INTO URBAN PLANNING: PROBLEMS IN THE ASIAN-PACIFIC REGION AND THE CHALLENGES FOR UNIVERSITIES

RW Simpson
Faculty of Environmental Sciences, Griffith University, Australia

INTRODUCTION

The world population is expected to increase to approximately 8000 million people by the year 2025[1]. Most of this increase will be in urban areas especially in the developing countries. It is estimated that more than 70% of the increase in the developing countries in the 1925-2000 period will be in urban areas[1]. The increase in proportion of the population living in urban areas in the developing countries will change from 31% in 1985 to 56% by 2025. There are serious environmental health problems arising out of this rapid urban development.

URBAN HEALTH PROBLEMS

Urban areas do not necessarily imply severe health problems. Unfortunately lack of urban planning in areas where there are rapidly growing populations, expanding industrialisation and increasing traffic, can lead to widespread problems in air and water pollution, occupational hazards, traffic trauma, psychological stress, waste disposal problems, and risks from chemical and industrial accidents. Poor planning can also lead to some sections of the community having little access to services, adequate and safe housing, a good diet and hygiene, and adequate protection from exposure to environmental contaminants.

URBAN HEALTH DEVELOPMENT

Many environmental health problems are addressed in environmental management programmes. Of particular importance has been basic medical intervention, such as immunisation and diarrhoeal disease treatment. However WHO[2] notes that, except for water supply and sanitation activities in some developing countries, environmental health has not been strongly supported in most national and state health sectors. One reason is that the environmental management programmes have been controlled often by other sectors of government, such as environmental agencies. There are often exchanges of information regarding matters such as standards, monitoring, epidemiology, and toxicology. However those sectors in health departments associated with environmental health are often separated from "mainstream" health care units in low-status divisions. In particular the most serious component missing in health development programmes is intersectoral cooperation between health agencies and other key sectors, such as planning, transport, resources and industries, waste management, education, social welfare and water supply. One reason for this is the specialisation in disciplines such as medicine, hygiene, planning, architecture, social and natural sciences, and engineering, which often is reflected in sectoral planning.

KEY ISSUES

In 1991 WHO held a Regional Workshop to examine the problems of integrating environmental health into urban planning. A number of key issues emerged:

1. **Multi-sectoral cooperation and integrated planning:** Because of the link between health and a wide range of urban factors, there is a clear need for strategies which

coordinate government sectors involved in environmental health programmes with those involved in urban development planning activities.

2. **Public participation:** Health promotion and health education programmes will only succeed with active community involvement. Various approaches need to be implemented to address this problem.

3. **Information, monitoring and evaluation:** The complex and changing nature of urban environmental health problems requires continuing appraisal and evaluation of the information used to monitor public health and the ability of agencies to assemble the required information. The information required to address these needs, the training and skills, and the research required - all need to be identified within the context of integrated planning techniques.

THE ROLE OF UNIVERSITIES

The problems set out in the previous section pose a number of challenges for universities in the following areas:

- the range of postgraduate and undergraduate programmes necessary to train the required environmental professionals;
- the type of research necessary to provide the required information to government; and
- the form of the relationships needed to liaise with governments at both a national and international level.

In particular the extreme need for interdisciplinary and multidisciplinary programmes requires new forms of academic developments. At Griffith University an interdisciplinary environmental studies programme has been underway since 1975. The current structure of the Faculty of Environmental Sciences is shown in Figure 1. The programmes include the following:

- A new environmental engineering programme developed out of an existing environmental sciences programme, rather than just an adjustment of existing engineering programmes.
- A new combined law-environmental sciences degree programme over 5 years between the Faculties of Environmental Sciences and Law at Griffith University.
- A Masters of Public Health programme which comprises inputs from these universities in Brisbane - Medicine from the University of Queensland, Health Administration from Queensland University of Technology, and Environmental and Occupational Health from Griffith University.
- A joint Masters of Environmental Education programme between the Faculties of Environmental Sciences and Education at Griffith University.
- A joint Bachelors of Behavioural Sciences programme between the Faculties of Environmental Sciences (ENS) and Health at Griffith University with ENS providing the Occupational Health and Safety input.
- A Graduate School of Environmental Sciences and Engineering to coordinate all University research in these areas.

Plans for a Bachelors Degree in Environmental Planning building on the current Environmental Sciences programme rather than being an adaption of an existing planning department.

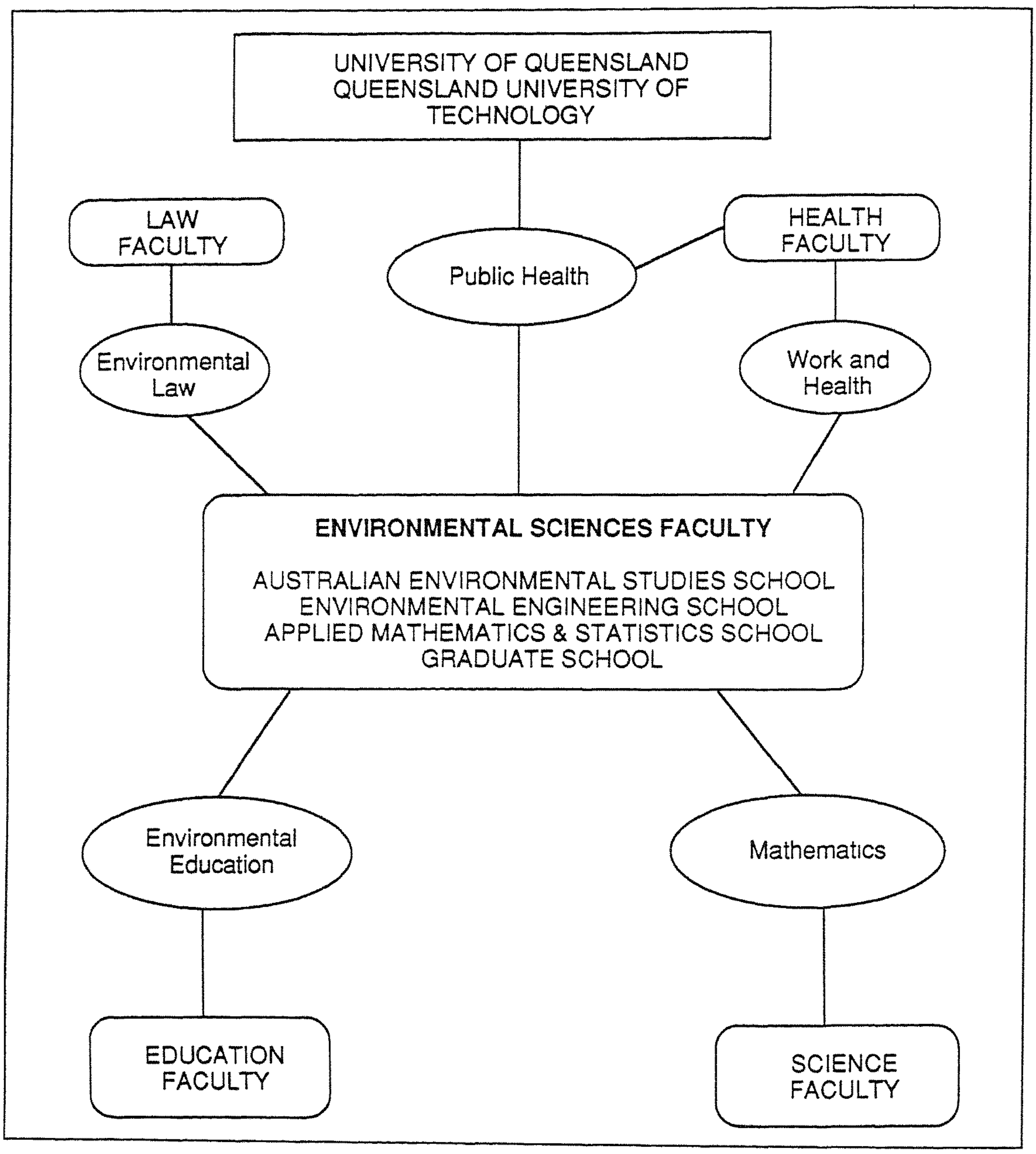

Figure 1: *Faculty of Environmental Sciences at Griffith University, Brisbane, Queensland, Australia*

Those developments are attempting to develop the range of programmes at a professional level (e.g. in law, health, engineering, planning, teaching) which can address the problems outlined in (1) and (2). The key element of the strategy has been to develop all programmes from the fundamental environmental sciences programme. Another has been to collect within one faculty a wide range of professionals in the social and natural sciences as well as engineering to develop the fundamental programme (approximately 50 in number). Finally key professionals in engineering, law, education and health have been recruited within the faculty to liaise with other faculties or universities.

However the third area is more difficult. Certainly university academics serve on government bodies. However it is clear that more government support is needed for more strategic based research. Until research funding is targeted to such areas rather than just to the existing traditional pure science based ones, then there is little inducement for academics to become involved in problems of interest to governments in the environmental health area. Universities need therefore to examine closely the way in which university research is funded to ensure they will be able to recruit academics to develop the programmes needed to meet the challenges posed by future environmental health problems.

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ORGANIC SOLVENT EXPOSURE IN SOME MANUFACTURING INDUSTRIES IN MALAYSIA

GLE Tan
Universiti Sains Malaysia, Penang, Malaysia

INTRODUCTION

Exposure to organic solvents is one of the major health hazards in today's work environment. Today there are hundreds of organic solvents that have widespread application in various industries of all sizes. The great increase in the number of organic solvents that are available, together with constant development of new processes that use them present many new occupational health problems. Most solvents can be toxic in varying degrees when used without proper and adequate controls.

Organic solvents have toxic effects on body organic systems such as the liver, kidneys, heart and lungs. But solvent poisoning is characterized mainly by the impairment of nervous system functions. There are narcotic effects and decreased vigilance even at low levels and at high levels unconsciousness and respiratory arrest may occur.

The main objective of this study was to identify the types of organic solvents used in selected industries in Malaysia, and to determine the levels of exposure in exposed workers. In addition, the neurotoxic and behavioural effects of organic solvent exposure were measured with the use of computerized psychometric testing. A third objective was to measure levels of biological exposure indices in the exposed workforce.

METHODOLOGY

The study was conducted in a number of different manufacturing industries viz. two electronics factories, one die cast metal and plastics factory, two plywood factories and two rubber based products factories in the northern Free Trade Zones of Malaysia. The types of organic solvents include freon 113 (1,1,2 trichloro 1,2,2 flouroethane); 1,1,1 trichloroethylene (TCA); acetone; trichloroethylene (TCE); methyl ethyl ketone (MEK); toluene and formaldehyde.

Environmental monitoring: For each factory, a representative sample of workers at maximum risk of exposure to solvents were selected for personal sampling. A total of 50 subjects were studied. In the work area of the exposed workers, area sampling was also carried out.

The equipment used was a James Hardie Pump or MSA Flowlite Sampling Pump, connected to a charcoal absorbent tube. For personal sampling, the charcoal tube was placed in a vertical position in the worker's breathing zone and the sampling pump was worn by the worker for a period of 5 to 8 hours[1,2]. For the area sampling, the sampling pump was placed in a fixed location at a height of 1.4 m on a tripod in the work area as close as possible to the worker's workstation.

The trapped organic solvent vapour in the charcoal tube was dissolved with carbon disulphide and separated by gas chromatography (GS) and analyzed with a flame ionization detector. The time-weighted average (TWA) concentrations for 8 hours were calculated and compared with threshold limit values - time weighted average (TLV-TWA)[3] exposure levels for each solvent.

RESULTS

Electronics factories: In the two factories manufacturing electronic components, transistors and integrated circuits, the solvents used are acetone, freon 113 and TCA. Both factories are well designed with equipment enclosures and modern ventilation systems. Table 1 summarizes the time-weighted average (TWA) for 8 hour solvent exposure levels in the two factories. The exposure levels of acetone showed large variations (2.71-27.89 ppm) in the two work areas of Factory 1 but were below the TLV-TWA of 750 ppm[3]. For exposure levels of freon 113 in work areas near automatic degreasing machines, concentrations in Factory 1 were low (11.17 and 15.17 ppm) but those in Factory 2 were higher (814.84 ppm), although in all cases exposures did not exceed the TLV-TWA for freon of 1000 ppm.

Personal samples of TCA exposure showed concentrations in Factory 1 ranging from 2.40 to 83.78 ppm, which are below the permissible TLV-TWA of 350 ppm. In Factory 2, TCA personal exposures in automatic degreasing machines showed large variations (14.37 to 191.4 ppm) between workers but were also below the recommended TLV-TWA of 350 ppm.

Table 1: *Acetone, freon 113 and TCA concentrations in electronics factories*

Work Area	Solvent	Personal/Area Sampling		TWA Range (ppm)	TWA Mean (ppm)	TLV-TWA (ppm)
Factory 1						
S4 Auto Casting	Acetone	3	-	8.73 - 16 71	12.75 ± 3.99	750
Epoxy Room	Acetone	4	-	5.25 - 27 89	16.70 ± 11.82	750
	Acetone	-	2	2.71 - 17 08	9 90 ± 10 16	
S4 Degreaser	Freon 113	1	-	15.17		1000
	Freon 113	-	1	68.42		
Visual Room	Freon 113	1	-	11.45		1000
	Freon 113	-	1	8.53		
Opto-Dispenser	TCA	8	-	2.40 - 83 78	16 12 ± 27 42	350
Factory 2						
IC Marking	TCA	2	-	20.22 - 191 40		350
Degreaser 1	TCA	-	2	2.43 - 14 43		
Transistor Marking	TCA	2	-	14.37 - 22 81		350
Degreaser 2	TCA	-	2	17.03 - 18.39		
Alkaline	Freon 113	1	-	814.84		1000
Degreaser	Freon 113	-	2	24 18 - 421 59		

Die cast metal and plastics factory: The factory studied assembles die cast and plastic toys and the organic solvents are methyl ethyl ketone (MEK) and trichloroethylene (TCE).

For personal exposures (Table 2), MEK concentrations showed considerable variation across subjects. In the hand spraying section, where an efficient local exhaust ventilation system exists, the mean personal exposures did not exceed the recommended TLV-TWA of 200 ppm with the exception of only one personal level of 289.98 ppm.

For the paint mixing and plate cleaning rooms, which are equipped with large wall extractor fans, the personal and area samples showed exposures below the recommended TLV-TWA.

For the recyclıng area, whıch ıs located outsıde the factory buıldıng under an open zınc shed, exposure levels on two occasıons (475.9 and 1208 5 ppm) were well above the TLV-TWA

In the electrostatıc mıxıng rooms of Omega I and II, MEK personal exposure levels ranged wıdely and on one occasion (1072 12 ppm) were above TLV-TWA

In the plate strıppıng area, TCE exposures ranged from 7 99 to 40 03 ppm, whıch are all below the TLV-TWA

Table 2: *MEK and TCE concentratıons ın dıe cast metal and plastıcs factory*

Work Area	Solvent	Subject	No of Sample	TWA Range (ppm)	TWA Mean (ppm)	TLV-TWA (ppm)
Hand spray	MEK	S1	6	3 44 - 66 99	23 56 ± 22 80	200
		S2	6	0 17 - 73 54	31 12 ± 27 01	200
		S3	5	25 76 - 289 98	84 23 ± 115 59	200
		S4	6	3 00 - 48 57	16 74 ± 17 02	200
		S5	6	9 06 - 111 41	30 57 ± 39 77	200
		Area	6	0 47 18 87	6 60 ± 6 53	200
Paınt Mıxıng Room 1	MEK	S6	4	0 71 - 23 92	18 91 ± 23 26	200
		S7	4	0 27 - 20 55	10 55 ± 9 26	200
		Area	5	0 96 - 17 33	5 11 ± 6 91	200
Room 2		S8	5	6 15 - 12 34	9 04 ± 2 47	200
		Area	5	0 65 - 16 10	10 42 ± 6 01	200
Plate Cleanıng	MEK	S9	1	3		200
		S10	1	159 77		200
		Area	5	5 01 - 182 96	64 90 ± 6 98	200
Recyclıng	MEK	S11	5	16 16 - 1208 50	360 47 ± 511 07	200
	MEK	Area	4	5 88 - 947 79	353 14 ± 421 09	200
Omega I Electrostatıc Mıxıng Room	MEK	S12	5	4 97 - 1072 12	230 88 ± 470 87	200
		Area	4	0 02 - 93 242	26 11 ± 45 02	200
Omega II Electrostatıc Mıxıng Room	MEK	S13	3	1 39 - 5 32	3 83 ± 2 13	200
		Area	2	1 18 - 3 01	2 10 ± 1 29	200
Work Area	**Solvent**	**Personal/Area Sample**		**TWA Range (ppm)**	**TWA Mean (ppm)**	**TLV-TWA (ppm)**
Paınt Strıppıng	TCE	4	-	7 99 - 40 03	30 12 ± 14 90	50
		-	1		27 68	50

Plywood factories: The adhesıves used ın the plywood factorıes contaın formaldehyde It can be seen (Table 3) that the concentratıons ın the hot press of both factorıes are below the recommended TLV-TWA of 1.00 ppm but concentratıons ın the glueıng sectıons are above TLV-TWA

Table 3: Formaldehyde exposure in plywood factories

Work Area	Solvent	Area Sample	TWA Range (ppm)	TWA Mean (ppm)	TLV-TWA (ppm)
Factory 1					
Hot Press	Formaldehyde	4	0 09 - 0 15	0 09 ± 0 05	1 00
Glueing	Formaldehyde	4	0 20 - 2 20	1 04 ± 0 86	1 00
Factory 2					
Hot Press	Formaldehyde	4	0 18 - 0 99	0 58 ± 0 34	1 00
Glueing	Formaldehyde	4	0 45 - 1 67	1 01 ± 0 51	1 00

Rubber based products factories: These two factories produce adhesive labels and masking tapes which use toluene-containing adhesives

For Factory 1, the toluene exposure concentrations (Table 4) in the coating and mixing areas (123 66 and 113 19 ppm respectively) were above the recommended TLV-TWA of 100 ppm.

For Factory 2, the toluene exposures in similar work areas of coating and mixing sections (50.59 and 62.22 ppm respectively) were below the TLV-TWA of 100 ppm.

Table 4: Toluene exposure in rubber based products factories

Work Area	Solvent	Personal/Area Sample		TWA Range (ppm)	TWA Mean (ppm)	TLV-TWA (ppm)
Factory 1						
Coating	Toluene	3	-	93 84 - 177 72	123 66 ± 46 90	100
	Toluene	-	1	311 40		
Mixing	Toluene	2	-	85 04 - 141 83	113 19 ± 39 80	100
	Toluene	-	1	98 83		
Factory 2						
Coating	Toluene	3	-	37 88 - 63 95	50 95 ± 13 03	100
	Toluene	-	1	46 24		
Mixing	Toluene	2	-	27 56 - 96 89	62 22 ± 49 02	100
	Toluene	-	1	111 62		

DISCUSSION

The environmental exposure samples, show large variations in exposure levels from day to day for the same subject as well as for different subjects in the same work area. The levels in the environment depend on whether there are proper or adequate controls or ventilation systems installed in the factories.

The organic solvent exposures in electronics factories are well below the recommended TLV-TWA values for acetone, freon and TCA. This is probably due to the more sophisticated engineering controls and equipment enclosures and local exhaust ventilation systems.

For the die cast factory, a local exhaust ventilation system is used in the hand spraying section and is efficient in keeping exposure levels to below TLV-TWA. In the paint mixing and plate cleaning rooms, there are adequate ventilation exhaust systems to remove solvents, thus keeping concentrations to below the recommended TLV-TWA. However, in the MEK recycling area, which is housed away from the factory itself and where natural ventilation is the only control method for dispersing solvent, the concentrations are above the TLV-TWA. In the electrostatic mixing room, ventilation is inefficient, and exposure levels are above the TLV-TWA.

In the cold press sections of the plywood factories, the concentration of formaldehyde is above the TLV-TWA of 1.00 ppm whereas in hot press areas, concentrations remain below the TLV-TWA.

For the adhesives and tape making factories, Factory 1 has poor ventilation systems and toluene solvent exposures in the coating and mixing areas are above the TLV-TWA, whereas in similar areas in Factory 2, the toluene concentrations are lower. This can be attributed to a more efficient and effective ventilation system in Factory 2.

It can be concluded that equipment enclosures, efficient ventilation systems, and other control methods can be implemented to maintain occupational exposures to below recommended levels.

It is intended that subsequent phases of this study will include biological monitoring of solvents and their metabolites in urine and expired air samples. The results from the chemical indices will be compared with the biological exposure indices (BEI) as reference values. All the biological monitoring will be conducted on the subjects who have been selected for personal monitoring in each of the factories.

For the assessment of the neurotoxic effects of organic solvent exposure, a computerized testing system, the Swedish Performance Evaluation System (SPES)[4], is currently being adapted and translated for use with the local population.

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MONITORING AND INSTRUMENTATION OF ENVIRONMENTAL POLLUTION

convenors:

N W M KO
W W-S YIM

INTRODUCTION

Session B, the most popular theme in terms of the number of papers received is comprised of two keynote papers, seven oral and nine poster papers.

The first keynote paper is on the monitoring and instrumentation of environmental pollution by Dr Hugh Tebbut, Director of Group Research of Biwater Limited. Analytical techniques for monitoring natural waters, drinking water and wastewaters are reviewed to examine their accuracy, sensitivity and speed. A number of examples of current practice in the water industry in the United Kingdom are presented. For future work, in place of biochemical oxygen demand as an indicator of organic content, it would be possible to use total organic carbon by automatic instrumental analysis or by ultra-violet absorption. In order to provide inputs to real-time environmental models, reliable on-line monitoring is needed.

The second keynote paper is on the air quality monitoring programme of the Hong Kong Environmental Protection Department by Raymond Leung, Principal Environmental Protection Officer (Air Services Group) of the Hong Kong Government. An overview on the air quality monitoring network which included sulphur dioxide, nitrogen oxides, ozone, carbon monoxide, suspended particulates, acidity of wet and dry deposition and meteorological parameters are described. This network is aimed at identifying key pollution problems and evaluating the effectiveness of control efforts.

Out of the orally presented papers, air and water quality, the latter including coastal and stream waters are included as topics. Low technology samplers transplanted in a Scottish town with high lung cancer mortality were used to study the dispersion of airborne metals by Lloyd and Gailey. The temporal patterns showed the influence of both meteorological factors and the output of the local steel foundry. The concentration of heavy metals in sea water, sediments and living tissues of macro-zoobenthic organisms off the north coast of central Java is described by Supriharyono. The results showed that the effluent of some industries may be heavily contaminated and that the concentration of heavy metals in sea water tends to be lower in the wet season and higher in the dry season. A thermal lens colorimetric system for the determination of phosphorous in natural water with a low detection limit of picogram amounts of phosphorous per ml is described by Wu, Siu, Chiu and Stokes. Phosphorous concentration was found to be the highest in stream water out of the tap, reservoir, stream and sea water samples collected and measured in Hong Kong. A survey on a drainage basin near Aberdeen on Hong Kong Island to evaluate the geographical approach to stream water quality monitoring is given by Peart. The spatial samples can be ordered such as to represent a temporal continuum which reflects changes consequent upon the human impact. A modular auto-enrichment subsystem for the preconcentration of phenols, heavy metals and polychromatic hydrocarbons prior to high pressure liquid chromatography analysis is presented by Chen, Chang and Wang. This system is capable of detecting ppb levels of the three groups of pollutants. The exposure to environmental pollution in the work environment in the case of a traffic toll booth in Malaysia is decribed by Yaziz. Carbon monoxide and temperature are strongly correlated with traffic flow and weakly correlated with ventilation rate, the latter indicating that the ventilation in the traffic booth is inadequate. A proposed air quality index for Hong Kong based on a review of the role, structure and use of air quality indices with reference to those from the USA, Canada, China and India is provided by Ng and Tanner.

The poster papers are wide-ranging in the coverage of topics. The results of 13 trace elements of environmental concern is described in a national programme in China by Chen, Tao and Deng. In general, the mean values of Cu, Cd, Pb, Zn, Hg, As, Cr, Ni, Co, V, Mn, F and Se in decreasing order according to soil types are lithisols, cold-highland soils, inceptisols, aridisols and mollisols, alfisols and oxisols. A gas chromatography thermal conductivity detector method is used by Cheung to monitor levels of nitrogen oxides in indoor air samples. A formation index is suggested to be useful as an environmental quality indicator. Research work on developing a piezo-electric crystal sorption detector for the continuous monitoring of organic vapours in the workplace is described by Fung. The detector is found to be suitable for the monitoring and control of organic vapours in the industrial environment. The effect of some standard fixatives on the morphology of fish gills which are used for interpreting pollution effects is provided by Shepherd and Ivantsoff. It is desirable to determine the osmotic pressure of the blood and tissue fluid of the fish to be studied so that the fixative can be buffered to be isotonic with the fish tissue. A study to simulate urban traffic noise in Singapore yielding a model which provides a significant improvement on the overall accuracy of traffic noise prediction is provided by Pamanikabud. An investigation on the haze episode of August 1990 in Kelang valley, Malaysia is presented by Samah. Because the sources of the haze are controversial, there is uncertainty on the application of control measures as well as possible effects of the haze on health and agriculture. A laser photoacoustic technique to analyse organic pollution gases in Hong Kong air samples is described by Shi, Siu and Chiu. The higher average of ethylene concentration in Hong Kong compared to Washington, D.C. is consistent with the higher density of cars in Hong Kong. A proton induced x-ray emission method for the study of respirable suspended particulates in Hong Kong is provided by Cai, Sze, Stokes and Young. The air quality of the three areas studied in decreasing order are Hong Kong South, Kwai Chung and Central-Western. The final paper by Yim, Ng and Thornton describes follow-up stream sediment geochemical reconnaissance surveys in the vicinity of Tai Mo Shan, New Territories, Hong Kong. These surveys were carried out to confirm the Cu, Zn and Pb bedrock mineralization, and to assess the possible environmental impacts on the catchment area of the Upper Jubilee Reservoir and the agricultural area of Shek Kong.

From the papers, it is evident that much attention is being devoted by scientists and medical practitioners to developing new methods for monitorıng health hazards of environmental pollution. Rapid advances are being made in many areas. Because of this, it is necessary to apply these new methods over a wide range of conditions in order that their performances may be fully evaluated. On the other hand, many reliable old methods should continue to be used in order to facilitate comparison between datasets obtained by the old and new methods.

MONITORING AND INSTRUMENTATION OF ENVIRONMENTAL POLLUTION

TMY Tebbutt
Director of Group Research, Biwater Limited, UK

INTRODUCTION

The proliferation of environmental pollutants throughout the world has been brought to light by the enhanced analytical skills which have become available in the last twenty years or so. However, it is one thing to be able to detect a particular contaminant under ideal laboratory conditions but quite another to be able to reliably and routinely achieve accurate measurements in a real situation. The nature of many environmental contaminants means that traditional analytical techniques are frequently unsuitable in relation to their accuracy, sensitivity and speed. It is often important to have access to real-time information about environmental quality so that rapid decisions can be made in order to safeguard both the environment and the public. The specific requirements for environmental monitoring and instrumentation are often closely related to the particular phase of the environment under consideration but many of the factors and concepts are of general application. The water cycle provides an appropriate framework for discussion of recent developments in monitoring and instrumentation which have resulted from the need to implement more effective control measures as part of new regulatory systems.

THE WATER ENVIRONMENT

The concept of pure water is strictly speaking incorrect since all natural waters contain varying amounts of constituents in addition to hydrogen and oxygen. All rain waters contain weak acids and salts due to the respiration of plants and animals, sea spray and other natural events. Human activities can add significant additional contaminants arising from combustion of fossil fuels and many other domestic and industrial processes. Surface runoff picks up further contaminants from rocks, soil and vegetation. Water which infiltrates into the ground collects additional constituents, the nature of which depends upon the strata. Water is an almost universal solvent so that most of the thousands of natural and synthetic chemical compounds with which it may come into contact are likely to be dissolved to some extent. Human bodily wastes as well as the consequences of human activities such as agriculture and most industries contribute further contaminants to surface and groundwaters. This water pollution can significantly affect the suitability of the water for specific uses and, in extreme cases, it can result in hazards to human health. Usually, however, the concentrations of individual chemical and microbiological contaminants are very low and thus difficult to detect. Routine monitoring in the water cycle is therefore usually restricted to a relatively small number of 'blanket' parameters which can help to provide an overall assessment of quality. In most cases these parameters are measured by more or less conventional laboratory-based analysis of discrete samples. For a limited number of parameters some form of continuous measurement is possible using in-situ sensors but the reliability of such instruments has not always been satisfactory. The increasing number of chemicals present in the environment coupled with, the sometimes conflicting, evidence of potential health hazards of some of them has placed a great deal of emphasis on the development of appropriate monitoring and instrumentation techniques.

MONITORING OF NATURAL WATERS AND WASTEWATERS

The chemical and microbiological content of most natural waters is so complex that it would not be practicable or cost effective to attempt to monitor all constituents. Traditional parameters like biochemical oxygen demand (BOD) and suspended solids (SS), together with dissolved oxygen (DO) and ammonia nitrogen are commonly used as routine measures of environmental quality for water pollution control purposes and for specifying the quality of effluents discharged into the water environment. Unfortunately, neither BOD or SS lend themselves to continuous monitoring since they both involve laboratory procedures and in the case of BOD a 5-day incubation period. The National Rivers Authority in England and Wales has indicated its wish to move to water pollution control parameters which can be monitored on a continuous basis. In place of BOD as an indicator of organic content it would be possible to use total organic carbon (TOC) by automated instrumental analysis or by ultra-violet absorption which is a property of some organics. The gravimetric determination of SS could be replaced by nephelometric measurement of turbidity. Whilst there are clear advantages in continuous monitoring for important environmental parameters it is vital that such monitoring is both accurate and reliable. A common problem with many remote monitoring systems is related to the invasive nature of the actual sensors. Natural waters and most wastewaters are likely to provide conditions which encourage biological growths so that fouling of sensor surfaces is common with consequent deterioration in the accuracy of the measurements. The actual insertion of a sensor into the liquid can affect the flow distribution in the vicinity which may introduce measurement errors.

In attempts to obtain more relevant data for water quality monitoring purposes a number of systems have been developed recently. A typical example is the National Rivers Authority's Merlin system, manufactured by Siemens Plessey, which enables continuous monitoring of pH, temperature, conductivity, turbidity, dissolved oxygen and ammonium. Merlin is housed in a floating stainless steel drum which can be anchored in a waterway. Readings from the sensors are stored in an internal logger and to conserve battery power the system is normally on stand-by. In the event of pre-set alarm levels being exceeded Merlin can collect water samples for later analysis and, by radio links, activate other monitors, human staff and a pollution control centre. This robust and transportable system can provide constant 24 hour surveillance on a local or area-wide basis. To satisfy the need for a compact hand-held water quality measurement instrument the NRA has encouraged development of a new unit by Grant Instruments and YSI. This instrument comprises a small data logging and control unit and an intelligent probe housing multiple sensors which can measure; depth, temperature, pH, conductivity, salinity, dissolved oxygen, turbidity, ammonium and ORP. For any monitoring system self contained power supplies are important as is the ability to log data over long periods. Low consumption electronics and long life batteries as exemplified in the Biwater Spectrascan Microlog range illustrate the use of state-of-the-art electronics technology in monitoring operations.

MONITORING OF DRINKING WATER

Drinking water quality in the UK has to comply with the relevant EC Directive and the Drinking Water Inspectorate has the responsibility for assessing the performance of water utilities in relation to some 60 quality parameters. These parameters cover a wide range of physical, chemical and microbiological characteristics the standards for which have to be met at all times and in all parts of the supply area. Returns for 1990 show that some 2.3M determinations were undertaken of which 98.8% were in compliance with the standards. Much of the analytical work is currently carried out on discrete samples which are subject to laboratory examination and there is clearly a need for more use of continuous monitoring systems. These would certainly provide a clearer picture of the levels of service achieved in relation to quality standards. Some parameters, such as colour and turbidity are easily monitored by continuous measurements but other parameters such as taste and odour, trace organics and microbiological indicators are much more difficult to monitor automatically. This may be because of the nature of the parameter or because of the very low allowable concentrations set by the standards. In any event it is clearly impossible at the present state of measurement technology to monitor all 60 parameters on a continuous basis. The concept of monitoring drinking water for all known contaminants is in any event unrealistic but attempts have been made to provide early warning devices for the presence of undesirable contaminants in water supplies. Such devices are normally installed at raw water intakes on lowland rivers which are prone to pollution. Biological monitors have had some success in this role on the basis that organisms living in the water often react rapidly to the presence of potentially harmful contaminants. Nitrifying bacteria are sensitive to many toxic substances so that nitrification rapidly stops in their presence. An ammonia sensor in the effluent from a small nitrifying column fed with raw water will detect an increase in ammonia due to pollutants affecting nitrification. Fish monitors have had some success because of the fact that the movement, respiratory activity and electrical signals generated by physiological activity are affected by the presence of small concentrations of potentially harmful contaminants in the water. Movement sensors or electrodes can detect these changes in fish behaviour and provide an early warning that something is wrong. Most fish monitors use species of trout but at Biwater's Bournemouth Water Company Nigerian elephant-nosed fish are used because of their high degree of electrical activity and tolerance of turbid waters. These biological sensors do not however identify the particular contaminant so that more detailed analysis is still essential in order to decide upon the appropriate actions.

PROCESS CONTROL

The efficiency and reliability of wastewater treatment processes can have a significant influence on the quality of the receiving water. In an analogous manner the ability of a water treatment plant to deal effectively with contaminants in the raw water is, in part, linked to the way in which the various processes can be controlled for optimum operation. Water and wastewater treatment plants are large scale complex process operations which offer potential benefits from a higher degree of automatic control than has historically been practised. In comparison with other process industries the water industry does, however, have the particular characteristics that it has little control over its raw materials and the product is of low value. These two characteristics have greatly influenced both the feasibility of automatic monitoring and control of treatment and also the economic viability of such measures. Wastewater treatment plants in general are subject to greater variabilities in both flow rate and composition of the input than with water treatment plants. To ensure compliance with effluent standards at least cost it is becoming increasingly important to control energy usage. For some years it has been common practice to utilise dissolved oxygen sensors in aeration tanks to control air supplies so that a suitable oxidation environment is maintained for biological stabilisation of the organic matter in the wastewater feed. More effective control of air supply could be achieved by the coupling of a sensor capable of measuring oxygen uptake requirements in the input wastewater (some form of real-time BOD or respirometry) to aerator output controls. The very nature of most wastewaters does however make it difficult to ensure the reliability of sensors which tend to become fouled with organic deposits or other material. Self cleaning systems using brushes or other mechanical devices are frequently employed but it is important that calibration of sensors is regularly checked. In this respect it is becoming common practice to install duplicate or triplicate sensors with an interrogation system to identify any anomalies and discount erroneous information.

FUTURE NEEDS

The pace of developments in environmental concerns is such that there will be increasing needs for more effective monitoring and measurement systems. Traditional wet-chemistry analytical techniques carried out on discrete samples are becoming increasingly costly and time consuming. In many circumstances there are needs to have information about environmental contaminants available on a virtually instantaneous basis so that control actions can be initiated. In river systems where discharges of hazardous chemicals could pose serious problems to water supply abstractions it has become necessary to install continuous monitors which can provide inputs to real-time environmental models. Such models can predict the fate of pollutants entering a river system, taking into account the effects of decay and dilution, so that concentrations at downstream locations can be predicted quickly enough to enable the appropriate actions to be taken. There are thus requirements for reliable on-line monitoring for characteristics such as; treatability, toxicity, trace organics and heavy metals. The problems associated with sensors which have to be immersed in the liquid being monitored are such as to encourage further developments in the area of non-invasive sensors. In the case of quality parameters the non-invasive concept is not always easy to envisage but already there are some applications of such techniques. Turbidity is an important parameter in water treatment which is commonly measured by the light scattering properties of the particles when exposed to a beam of light in a flow-through cell. The walls of flow-through cells tend to become less transparent with time due to the build up of slime on the surfaces. To obviate this problem a proprietary instrument detects light scattering in a free-falling stream of water so that no optical surfaces are involved. Satellite imagery is a rapidly developing science which already shows potential for environmental monitoring purposes. The use of such images to observe the destruction of rain forests is well known but the same techniques, aided by multi-spectral scanning of the images, can provide environmental information with a much more local focus. Satellite data has already been used to detect the early appearance of toxic blue-green algae in surface waters so that precautionary measures can be taken to deal with these growths. Satellite imagery has also been used to monitor the dispersion of cooling water and effluent discharges into estuaries and the open sea. Such satellite data can replace a great deal.of tedious and sometimes hazardous marine survey work. With the improvement in international relations it may well be that the higher definition capabilities of military satellites will become more generally available thus increasing the potential uses for environmental monitoring purposes.

Developments in spectrum analysis suggest that the time may not be far away when some form of laser scanning of a water sample could provide a great deal of information about its quality without the need for insertion of any sensor into the flow. Electro-optics and optical fibres seem likely to offer ways of transmitting information which are particularly relevant in hazardous or difficult access locations.

It would, however, be wrong to believe that non-invasive sensors will provide the answers to all monitoring requirements in the future. There will continue to be parameters which can only be measured by some type of contact or insertion sensor. Considerable research is being undertaken into the use of immobilised enzymes to provide biosensors for specific contaminants such as heavy metals and pesticides.

Consideration of environmental monitoring and measurement usually tend to be concerned with chemical pollutants, often in minute concentrations. It must, however, be remembered that in many parts of the world concerns about such micropollutants are irrelevant when water supplies often contain pathogenic microorganisms which can rapidly spread fatal and debilitating diseases. Bacteriological monitoring of raw water sources and water supplies is thus of primary importance and it is unfortunate that traditional forms of bacteriological monitoring involve time-consuming laboratory procedures. The need to incubate samples to produce visible colonies or observable biochemical effects means that continuous remote monitoring for bacteriological quality is not yet possible. Developments in biosensors and enzyme technology do, however, offer possibilities for more rapid detection systems which could perhaps offer real-time information about a whole range of important environmental parameters.

Environmental monitoring and measurement in the future will see more use of reliable remote sensors sometimes employing technologies transferred from other industrial sectors. Greater use of quality data in real-time modelling and control systems should produce both environmental and economic benefits for the public. Institutions of higher learning have an important role to play in the development of such techniques of environmental management.

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THE AIR QUALITY MONITORING PROGRAMME OF THE HONG KONG ENVIRONMENTAL PROTECTION DEPARTMENT

RPM Leung
Environmental Protection Department, Hong Kong Government, Hong Kong

INTRODUCTION

Environmental monitoring programmes have been among the major activities in the Environmental Protection Department (EPD) of Hong Kong. In the past decade, these monitoring activities have provided the objective basis for the development of new policies that are appropriate for Hong Kong, served to check on the effectiveness of existing policies and provided feedback on whether policies and control programmes are effective or need changing.

In air quality monitoring, a fixed network of 11 continuously operating air quality monitoring stations has been introduced. The department also operates a water quality monitoring scheme which now includes six automatic stream quality monitoring stations, 75 routinely sampled stations for inland waters, 123 stations in the seas around Hong Kong and 115 stations at Hong Kong's beaches.

The purpose of this paper is to provide a general overview of the extensive air quality monitoring network of Hong Kong, and then discuss how some air pollutants are measured. The study into a new generation of air monitoring instruments with high computational capability employing the differential optical absorption spectrometry principle will also be covered.

AIR QUALITY

Air quality is dependent on both contributions from numerous pollutants and pollutant varation according to strength of emission. Meteorology and topography also have a significant influence on air quality. Thus air quality can fluctuate by an order of magnitude with variations in time or space. This is particularly true of Hong Kong, given the hilly features of the terrain which divide the territory into many air sheds.

Air quality should be assessed against recognized criteria such as health objectives, standards or guidelines. Deterioration of air quality not only affects human health, but could also be a nuisance by damaging vegetation and animal matter, as well as being aesthetically displeasing. In Hong Kong, Air Quality Objectives (AQOs) have been adopted for sulphur dioxide, nitrogen dioxide, total suspended particulates, respirable suspended particulates carbon monoxide, photochemical oxidants such as ozone, and lead (Table 1). Most of these AQOs are set based on considerations of their health effects.

THE EPD AIR QUALITY MONITORING PROGRAMME

The nature and extent of a monitoring programme should be determined from the specific purposes for which the monitoring data are required.

The purposes of air monitoring programmes can be simple or complex, long term or short term. The major practical aims of the EPD network include air quality evaluation and air quality compliance check, planning and implementation of control strategy, land use planning and impact assessment as well as validation of air dispersion models, providing background and trend data, informing the public, and supporting pollutant effects studies.

Table 1: *Hong Kong air quality objectives*

Pollutant	Concentration in micrograms per cubic metre (i) Average Time					Health effects of pollutant at elevated ambient levels
	1 hr (ii)	8 hrs (iii)	24 hrs (iii)	3 mths (iv)	1 yr (iv)	
Sulphur Dioxide	800		350		80	Respiratory illness; reduced lung function, morbidity and mortality rates increase at higher levels.
Total Suspended Particulates			260		80	Respirable fraction has effects on health
Respirable Suspended Particulates (v)			180		55	Respiratory illness: reduced lung function; cancer risk for certain particles, morbidity and mortality rates increase at higher levels.
Nitrogen Dioxide	300		150		80	Respiratory irritation; increased susceptibility to respiratory infection; lung development impairment.
Carbon Monoxide	30000	10000				Impairment of co-ordination; deleterious to pregnant women and those with heart and circulatory conditions.
Photochemical Oxidants (as ozone) (vi)	240					Eye irritation; cough; reduced athletic performance; possible chromosome damage.
Lead				15		Effects cell and body processes; likely neuro-psychological effects, particularly in children; likely effects on rates of incidence of heart attacks, strokes and hypertension

(i) Measured at 298°K (25°C) and 101.325 kPa (one atmosphere).
(ii) Not to be exceeded more than three times per year
(iii) Not to be exceeded more than once per year.
(iv) Arithmetic means.
(v) Respirable suspended particulates means suspended particles in air with a nominal aerodynamic diameter of 10 micrometres and smaller.
(vi) Photochemical oxidants are determined by measurement of ozone only.

Air quality evaluation and AQO compliance check: A primary purpose in measuring air quality is to quantify population exposure to air pollutants of concern, in order to assess consequential risks to human health and amenities. The Hong Kong monitoring network targets densely populated areas, categorised as follows:

(a) Developed area at industrial interface
(b) Developed area with industrial development
(c) Developed area with commercial development; and
(d) Developed new towns.

For example, large areas around the industrial areas in Kwun Tong and Kwai Chung fall into category (a); Tsuen Wan typically falls into category (b); Sham Shui Po or Tsim Sha Tsui generally fall into category (c) and Yuen Long or Sha Tin, category (d).

Another important consideration is the fact that air pollution from motor vehicles impacts significantly on the air quality of Hong Kong particularly in areas close to roads, since a substantial proportion of the population live in such vicinities. A ground level station is therefore also included in the Hong Kong monitoring network.

According to the airsheds, Hong Kong is divided into 10 air control zones. These zones are at various stages of urbanization and development. Depending on the degree and complexity of development, one or more monitoring stations would need to be set up within a zone for its air quality to be satisfactorily assessed.

Planning and implementation of control strategy: The planning and implementation of specific control strategies or programmes requires reference to various basic considerations such as number and nature of pollution sources, topography and meteorology, and last but not the least, air quality data. For this purpose, air quality data have, in the past, notably supported development of the air quality management plan, the White Paper on Pollution in Hong Kong, and the new Air Pollution Control (Fuel Restriction) Regulations.

Land use planning and impact assessment, and validation of air dispersion models: Monitoring data can be used in assessing the impact of existing or proposed air pollutant sources on local or regional air quality, supporting validation of air dispersion models and providing input to land use planning.

Background and trend data: It is necessary to establish long term air quality trends and background air quality levels. There are sufficient stations in the Hong Kong network now to monitor air quality trend, but a background station has yet to be set up to provide long term background trend information.

Informing the public: A monthly air quality report is now issued for three fixed stations, to informing the public of the monitored monthly air quality. The three stations broadly represent air quality at locations close to road traffic in built-up areas, at commercial and residential districts, and at districts close to industrial areas respectively.

To indicate the state of air quality, embracing all the major pollutants an air pollution index system is being developed for the Hong Kong fixed network. The purpose is to provide the public with an indication of the state of air quality on a real time basis.

Pollutant effects studies: Pollutant effects studies require extensive use of air quality data, and involve coordination of many other factors such as number and distribution of receptors, suspected nature and severity of effect, time-dosage and presence of compounding factors. Data from the Hong Kong network have been used for specific local epidemiology studies.

THE EPD AIR QUALITY MONITORING NETWORK AND SHORT TERM MEASUREMENTS

Development of the air quality monitoring network started in 1983 with five monitoring stations, two on Hong Kong Island, two in Kowloon and one in Junk Bay. The present network consists of 11 stations, with plans for extending to 16 stations. The status of development of the network is given in Figure 1 and the pollutants and other parameters measured are given in Table 2.

A lot of the measurements are continuous and fully automated, and the data collected at these stations are transmitted back to the control centre at the EPD air quality laboratory through telephone links. The air quality data, after validation and suitable archives, are kept in the air quality data management database.

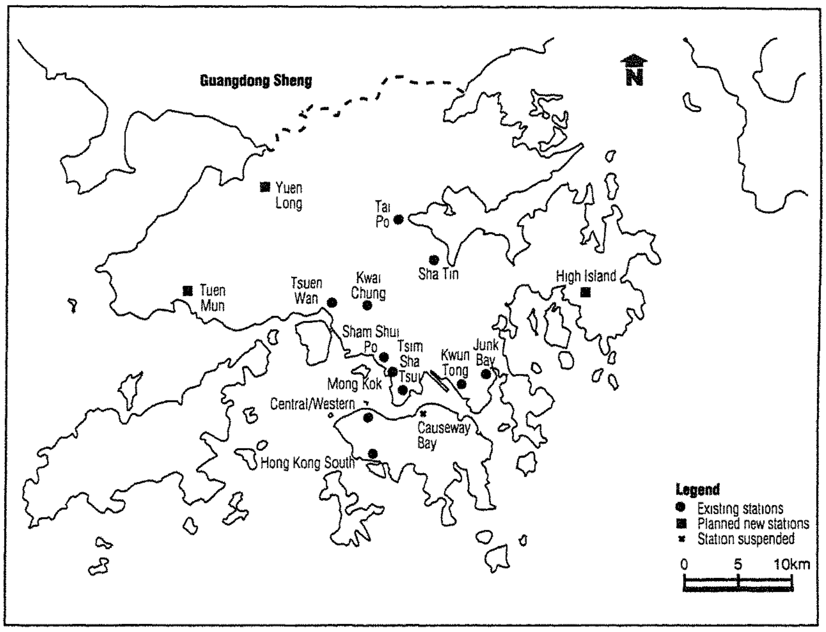

Figure 1: *Locations of existing and planned air quality monitoring stations*

Table 2: *Station analyser/sensor status*

Pollutant	Channel	KT	SSP	TST	C/W	JB	TW	KC	HKS	TP	MK	ST
SO2	0	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
NO	1	✓	✓		✓	✓	✓	✓	✓	✓	✓	
NO2	2	✓	✓		NOX	✓	✓	NOX	✓	✓	NOX	
O3	3				✓	✓	✓	✓		✓		
CO	4										✓	
WS	5	✓	✓	✓	✓					✓	✓	
WD	6	✓	✓	✓	✓					✓	✓	
TEM	7	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SR	8	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Calibration of the analysers are necessary to ensure acceptable quality of data. Automatic zero and span gas calibration by means of a permeation tube calibrator has been used for sulphur dioxide measurements. Nitrogen dioxide is also automatically calibrated by means of permeation tube calibrators. Only nitrogen oxide and ozone are manually calibrated at regular intervals. Monitored results are adjusted for zero and span drifts, if the drifts are within acceptable ranges. Otherwise, the results are invalidated.

Short term monitoring projects using a mobile laboratory or some temporary established stations are also routinely operated by the EPD. These projects are essential to provide air quality information supplementing data from the fixed stations. Some of these projects are also designed to meet specific purposes, for example to quantify the local impact of a cluster of chimneys on nearby buildings, or to identify the impact of vehicle emissions at some extremely polluted locations.

MONITORING AIR POLLUTANTS

The main air pollutants measured in the EPD network include sulphur dioxide, nitrogen oxides, ozone, and suspended particulates. Acid rain is monitored at some stations and carbon monoxide is also monitored at a road side station.

Sulphur dioxide: Automatic analysers employing the pulse fluorescence method are used for sulphur dioxide measurements. Inside the analyser, pulsating ultraviolet light is band pass filtered and focused into a fluorescence chamber. There it excites sulphur dioxide molecules contained in the air sample into high energy states. As these excited sulphur dioxide molecules go back to their initial states, a characteristic radiation is emitted. The concentration of sulphur dioxide in the air samples is then determined by measuring the intensity of the characteristic radiation.

The use of pulsation ultraviolet source, either generated by flash lamp or by chopper wheel, is for eliminating the dark current drift in the detecting and signal processing system.

This detection method can be compromised by automatic hydrocarbons, so these must be removed by a hydrocarbon filter fitted in the sampling line before the sample air is admitted into the detection chamber.

Nitrogen oxides: Nitrogen dioxide and nitric oxide are measured by dual-channel analysers using the gas-phase chemiluminescence method. The gas-phase reaction of nitric oxide (NO) and ozone (O3) produces a characteristic luminescence with an intensity proportional to the concentration of nitric oxide, as follows:

$$NO + O3 \longrightarrow NO2 + O2 + hv.$$

This reaction only takes place between NO and O3, and not NO2 in gas phase. Inside the analyser, the air sample is directed into two channels, one to measure NO and the other to measure both NO and NO2. In the NO channel, the concentration of NO can be determined simply and directly by the intensity of characteristic light emission. In the second channel, NO2 is first converted into NO by a molybdenum converter, and then the total NO is determined. The difference between the second channel reading and the NO reading in the first channel gives the concentration of NO2.

Ozone: An ultraviolet absorption method is used for ozone monitoring. The method is based on the direct gas-phase absorption of ultraviolet light over a narrow band. The sample air first passes through a selective removal system for ozone, then enters the absorption cell and absorbs a certain amount of the ultraviolet light, and this is stored as reference. Then in the next cycle sample air enters the cell bypassing the ozone selective scrubber and the ultraviolet absorption is again stored. The difference between the two values is proportional to the ozone concentration.

Carbon monoxide: Carbon monoxide is monitored using the gas filter correlation method. Radiation from an infra red source is chopped and then passed through a gas filter alternating between CO and nitrogen on a rotating filter wheel. The radiation then passes through a narrow band pass interference filter and enters a cell where absorption by the sample gas takes place, and is then measured by an infra red detector. The CO gas filter acts to produce a reference beam which cannot be further attenuated by CO in the sample cell. The nitrogen side of the filter wheel is transparent to the infra red radiation and therefore produces a measure beam which can be absorbed by CO in the cells. The chopped detector signal is modulated by the alternation between cells. Other gases do not cause modulation of the detector signal because they absorb the reference and measure beams equally.

Suspended particulates: Particulate samples are collected on a 6-day sampling cycle. Each sample collection lasts for one day. Both total suspended particulates and respirable suspended particulates are sampled. The equipment used are standard Hi-Volume TSP and 10 um Hi-Volume samplers. Weighing of filter paper and calculation of particulates concentration from the increase in weight of the sample filter paper is done in the EPD air laboratory, and the samples are then sent to the Government Chemist for elemental analysis.

Acidity of wet and dry deposition: Acid rain is monitored by wet/dry deposition samplers. The sampler collects wet and dry samples in separate 286mm diameter high-density polyethylene buckets. There is a conductive rain sensor which switches a motor-driven cover to seal the wet sample bucket on dry weather and cover the dry sample bucket during rainfall. Contents of the wet and dry buckets are collected at weekly intervals.

Meteorological parameters: Wind direction and wind speed data are collected at each fixed station to provide necessary information for interpretation of the air quality data measured. Meteorological equipment are usually installed on a mast 10 metres high above the monitoring stations.

FUTURE DEVELOPMENT OF THE EPD AIR MONITORING PROGRAMME

Development of the EPD air monitoring programme can be considered in several aspects. One is the further expansion of the network to cover the entire territory and provide background air quality information collected from the network in development of an air pollution index and forecast system. A third development is a study into a new generation of air monitoring instruments.

Network development: The development of the EPD monitoring network is almost complete. The last three urban stations at Tuen Mun, Yuen Long and Lantau will be established in the coming two to three years, and a baseline station is to be set up at High Island to provide information on the background air quality of Hong Kong.

Air pollution index and forecasting: An air pollution index and forecasting system is being developed for Hong Kong and it is expected to be completed by mid 1993. Air quality data collected on line from the monitoring stations will be processed and the state of air quality calculated and announced using a simple scale of pollution index. By making use of meteorology data and weather forecast information, an index for the next day could also be estimated. The purpose of the index system is to provide simple air quality information to the public so that they can be more aware of the air pollution levels to which they are exposed.

Study into new air monitoring instruments: Monitoring air quality on an automatic and real-time basis is very expensive, because of the high maintenance cost and the effort cost for quality assurance of the monitoring system. It is therefore extremely useful that the monitoring equipment should be as maintenance free as possible, and as reliable as possible.

A new generation of instruments for measuring air quality is emerging, using the differential optical absorption spectrometry method. It is a combination of simple measurement principle and high computing capability provided by a built in microcomputer. Usually, the transmitter unit of such a system is a high pressure xenon lamp that generates an intensive beam of light radiation from ultra violet to infra red. A receiver captures the light which has passed over a long path length, and focuses it to an optical cable, by which it is transmitted to the opto-analyser unit. The opto-analyser unit is the heart of the instrument, and it comprises a spectrophotometer, with electronics for acquiring processing measured data and a computer.

The computer compares the spectra for each wavelength with a pre-calibrated reference spectrum. It is then able to calculate the concentration of the pollutants measured. Gases that can be measured by this type of instrument include sulphur dioxide, nitrogen oxides, ammonia, hydrogen chloride, and some organic compounds such as toluene, benzene and formaldehyde.

The main advantage of this type of instrument is that it has a fast response, and no expensive gas calibration is required in routine operation. It is also a multi-parameter analyser thus reducing the number of pieces of equipment for measuring all the criteria pollutants. It has few moving parts and thus is likely to require very little maintenance, and it is cheaper and easier to operate.

There are some disadvantages One main drawback is that the measured pollution data is not directly comparable to any established air quality standards. Instead of giving the pollutant concentration at a point, measurement is made over a long path thus giving only an average pollutant concentration over the entire path length, which is fundamentally different from the conventional air quality standards.

The major immediate use of this type of instrument is therefore for providing a general picture of air quality over a district, and using the measured data to calculate a general air quality index. Two such instruments are to provide data for the development of the Hong Kong air pollution index system.

The two instruments will run side by side with the conventional analysers. It is hoped that some local correlation between the measured data can be established, and the prospect of complete replacement of the conventional analysers at some stations will be investigated. A few major air monitoring stations must still be maintained, where conventional analysers will be employed for the purpose of air quality standard measurements.

AIR QUALITY IN HONG KONG

So far air monitoring in Hong Kong has shown that the major pollutants of concern are sulphur dioxide, nitrogen dioxide, and suspended particulates. Sulphur dioxide is less of a problem now, as a result of the implementation of restriction on sulphur content on industrial fuel oil to 0.5% in mid 1990. The air monitoring results at locations close to industrial areas fell by over 80 percent after the restriction, and there has been a general improvement of about 40 percent throughout the territory. At present elevated levels of sulphur dioxide present a problem only at very localised areas.

The major problems are nitrogen dioxide and suspended particulates. The short term objectives of nitrogen dioxide are sometimes exceeded. The total suspended particulates and respirable suspended particulates are disturbingly high, and their annual objectives are frequently exceeded in some of the more urbanised districts, particularly those close to industrial development and heavy traffic.

CONCLUSION

Air quality monitoring in Hong Kong has in the past served to a various extent, the useful purposes mentioned above. Its major contributions, however, have been in identifying key pollution problems and monitoring the effectiveness of control efforts. Monitoring will need to be continued to provide information for development of new control initiatives, either to tackle the remaining major pollution problems or to prevent development of problems in future, and to provide feedback on effectiveness of environmental policies or control measures.

LOW TECHNOLOGY SAMPLING CAN SHOW SPATIAL AND TEMPORAL PATTERNS OF AIRBORNE METAL POLLUTION

OL Lloyd[*] and FAY Gailey[+]

[*] Department of Community and Family Medicine, Chinese University of Hong Kong
[+] Lothian Health Board, Deaconess Hospital, Edinburgh, UK

INTRODUCTION

During 1969-73, the town of Armadale showed the highest mortality from lung cancer of any community in Scotland[1]. To investigate the causes, detailed patterns of air pollution in the town were needed. Low technology samplers such as lichens, mosses and grasses have been used widely for ascertaining the geography of pollution from airborne metals[2,3]: they are inexpensive, robust, independent of power supplies, and not attractive to vandals. This paper summarizes some results of our use of in situ and transplanted samples in Armadale[4-10]. Our objectives were to ascertain firstly whether or not the spatial and temporal patterns of the concentrations of metals in the samplers indicated the source of these pollutants (the two main local industries in Armadale were a steel foundry and a brickworks), and secondly the effects of weather on the concentrations.

METHODS

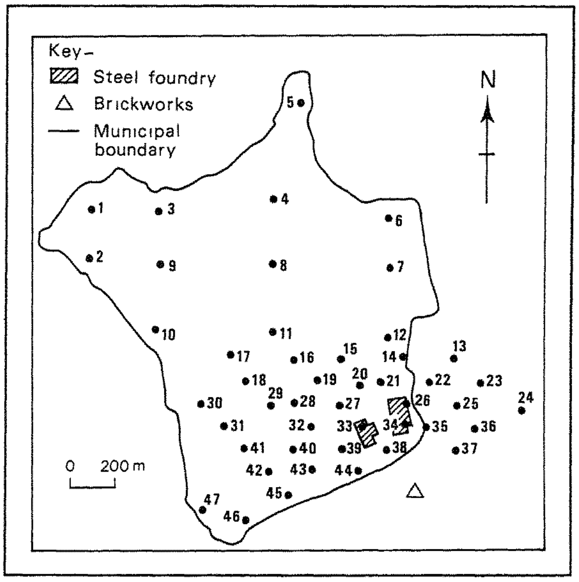

__Figure 1:__ Map showing the municipal boundary of Armadale, the location of the steel foundry, the brickworks and the 47 sites surveyed using low technology samplers.

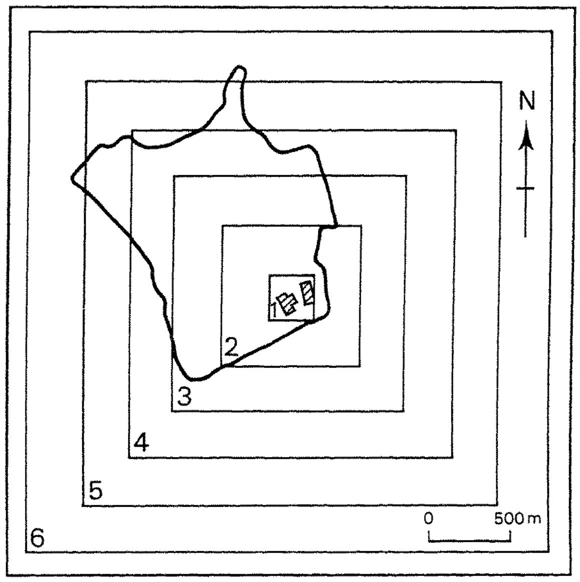

__Figure 2:__ Map showing the series of six concentric squares centred on the foundry used for the determination of mean concentration of metals.

Figure 1 shows the municipal boundary of Armadale, the location of the steel foundry, the brickworks and the 47 sites surveyed using ion technology samplers. The transplanted samplers were *Sphagnum* moss as spherical moss bags (SMBs), the lichen *Hypogymnia physodes* on its twig substrate, and a sticky fabric called "tak" wrapped around a hair curler. At each of the 47 sites, all three types of samplers were exposed for eight consecutive six-week periods. The indigenous samplers, collected once from the same sites, were specimens of the moss *Hypnum cupressiforme* and the lichen *Lecanora conizaeoides*. The metals measured were Fe, Mn, Zn, Pb, Cu, Cr, Ni, Cd and Co, selected for their links with the steel industry[11], previous studies of industrial pollution and health[12,13], or human disease. Further details on these studies in Armadale have been given elsewhere[4-10].

To quantify the foundry's pollution of the neighbourhood, square patterns (a series of concentric squares centred on the foundry) were superimposed on a map of the town (Figure 2). The mean metal concentrations in the in situ samplers at all sites within the peripheral area of each square (i.e. areas 1-6) were calculated; for the transplanted samplers, these concentrations were derived from the values for the eight exposure periods. Concentration ratios for each metal in each peripheral area were calculated from the concentrations in each of the peripheral areas 1-5 divided by the concentrations in the most distant area 6; a 2-way analysis of variance (ANOVA) was used to assess the differences between the values in those areas. The relationship between the pollution and proximity to the foundry was further examined by calculating Spearman's rank correlation coefficients for the distances of the sampling sites from the foundry and the concentrations of each metal in the various types of samplers.

The influence of Armadale's two industries and weather on metal concentrations were investigated. Pearson's correlation coefficients were calculated between the mean concentration of each metal for the three types of transplanted sampler for the entire town during each period and the following variables: the contemporaneous rates for the production of total steels, normal steels and special high Cr and Ni steels at the foundry; the rates of brick production; and meteorological parameters: total rainfall, average dry bulb temperatures, minimum and maximum temperatures, and the average wind speed. With only eight values of mean concentration for each metal, a significance level of $p<0.1$ was set for these coefficients.

RESULTS

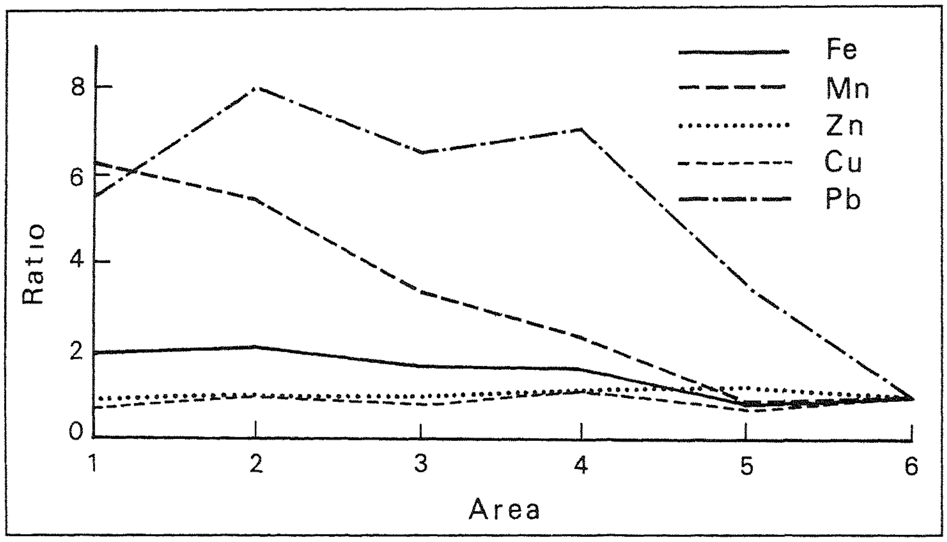

Figure 3: *Concentration ratio of various metals in tak samplers within the sequence of hollow squares 1 to 6 for Armadale, Scotland*

In the square pattern, the three areas nearest to the foundry showed the highest concentration ratios of most metals in all types of sampler; Figure 3 shows the ratios for tak. High ratios of over 4 were found for Cr in the SMBs and *Hypogymnia*, for Ni in the SMBs, for Cu and Cr in *Hypnum*, for Fe, Zn and Cd in *Lecanora*, and for Mn and Cu in tak. The concentration gradients generally declined outwards, but with some discontinuities, particularly between areas 1 and 2, and, areas 5 and 6. *Lecanora* was least useful in showing gradients. In most samplers, the gradients were comparatively smooth for Fe and Mn (Figure 4), and least evident for Pb and Cu[10]. The distances of the individual sampling sites from the foundry were negatively correlated with the values of each metal in all samplers except for Pb in *Hypnum* (Table 1) and Zn in tak; the correlation coefficients were significant for Fe and Mn in all samplers, and for Ni, Cu and Cr in many samplers. The negative association with distance was strongest for the values in the SMBs and weakest for those in *Lecanora*. The metal concentrations in the SMBs and *Hypogymnia* generally fluctuated together during the survey (Table 2); the pairs with negative correlation often included Zn, Pb or Cu.

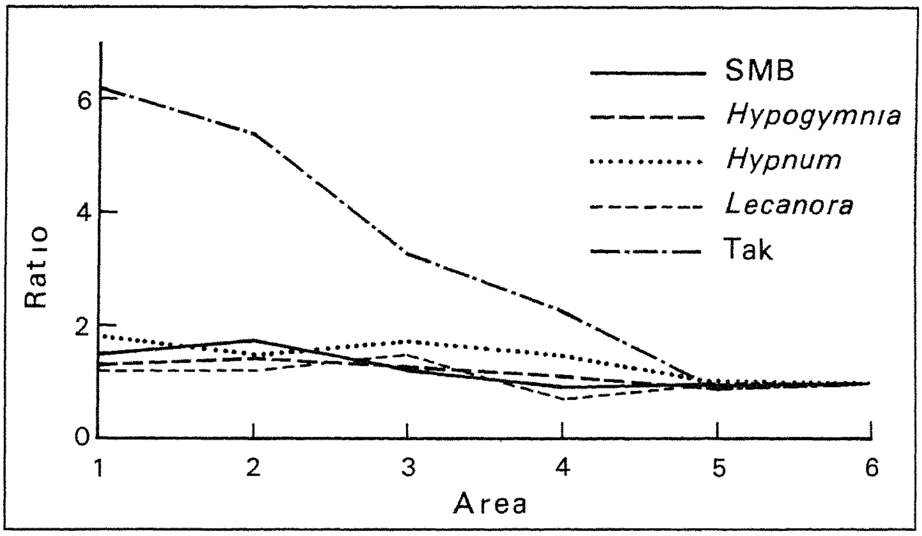

Figure 4: *Concentrations of manganese (Mn) in various low technology samplers within the sequence of hollow squares 1 to 6 for Armadale, Scotland*

Table 1: *Spearman correlation coefficients between the concentration of metals in biological low technology samplers and the proximity of their locations to the steel foundry*

Metals	Fe	Mn	Zn	Pb	Cu	Cr	Ni	Cd	Co
in spherical moss bags	-0.68**	-0 43**	-0 30*	-0.47**	-0 40**	-0 58**	-0.47**	-	-
in *Hypogymnia*	-0 63**	-0 42**	-0 32*	-0.16	-0 31*	-0 70**	-0.57**	-	-
in *Hypnum*	-0.87**	-0 29*	-0 21	0.05	-0 36*	-0 57**	-0.62**	-0 65**	-0 84**
in *Lecanora*	-0 40**	-0 29*	-0 05	-0.12	-0 10	-0 06	-0.52**	-0 69**	-

For tak, the statistical significance of the correlation coefficients were. Fe, Mn & Cu p<0 05; Pb & Cu not significant[9]; n = 47, * p<0 05; ** p<0.005

Table 2: *Summary of Spearman correlations for the concentration of metals in the eight exposure periods*

Metals	Fe	Mn	Zn	Pb	Cu	Cr	Ni
in spherical moss bags							
% correlations positive	100	96	86	71	68	93	34
% significant	86	68	32	25	7	27	25
in Hypogymnia							
% positive	82	86	61	64	61	86	93
% significant	32	21	29	14	18	33	33

n = 47; significance p<0.05[10].

The production rates of the various steels during the eight exposure periods showed positive associations with the mean concentration of the metals in the SMBs far more than in *Hypogymnia* or tak; in contrast, the correlation with the production rate of bricks were mostly negative in all three types of sampler (Table 3a). Of the meteorological parameters, rainfall was usually positively correlated with the mean metal concentrations for the whole town in SMBs but not in *Hypogymnia* or tak (Table 3b). The temperature data and the SMB values were mostly negatively correlated, some significantly; but this negative relationship was weak or absent for *Hypogymnia* and tak. Average wind speeds were mostly negatively correlated with the mean concentrations in both types of biological sampler.

Table 3: *Pearson correlation coefficients for the concentration of metals in the eight exposure periods and: (a) the rates of industrial production of types of steel and of bricks; (b) meteorological parameters*

Metals		Fe	Mn	Zn	Pb	Cu	Cr	Ni
(a)	in spherical moss bags							
Total steel		0.11	0.57	0.28	0.19	0.22	0.34	-0.03
Normal steel		0.09	0.60*	0.35	0.21	0.23	0.27	-0.22
Special steel		0.16	0.12	-0.21	-0.10	0.06	0.64*	0.79
Bricks		-0.30	-0.24	0.03	-0.42	0.03	-0.52	-0.55
	in *Hypogymnia*							
Total steel		-0.13	-0.16	-0.01	0.13	0.16	0.26	-0.55
Normal steel		-0.10	-0.10	0.06	0.15	0.23	0.23	-0.61*
Special steel		-0.10	-0.30	-0.31	0.07	-0.17	0.34	0.18
Bricks		-0.08	-0.14	-0.03	0.07	0.07	-0.60*	-0.15
(b)	in spherical moss bags							
Rainfall		0.21	0.10	-0.17	-0.01	0.08	0.26	0.57
Average dry T		-0.53*	-0.80*	-0 23	-0.59*	-0.04	-0.59	-0.11
Minimum T		-0.34	-0.63*	-0.09	-0.31	0.09	-0.63*	0.02
Maximum T		-0.11	-0.45	0.02	-0.42	-0.18	-0.25	-0.56
Mean wind speed		-0.21	-0.26	-0.38	-0.61*	0.06	-0.46	0.14
	in *Hypogymnia*							
Rainfall		-0.08	-0 27	-0.31	0.06	-0 18	-0.21	0.06
Average dry T		-0.02	-0 001	-0 01	-0.05	-0 02	-0.31	0.48
Minimum T		0.13	0.21	0 14	-0.07	0 06	-0.40	0.44
Maximum T		0.33	0.31	0.30	0.25	0 18	-0 10	0.61*
Mean wind speed		-0.46	-0.56*	-0 45	0 34	-0.18	-0.45	-0.37
	in tak							
Rainfall		-0.38	-0.60*	-0 72*				
Average dry T		0.25	-0.08	0.61*				
Minimum T		-0.06	-0.14	0 41				
Maximum T		0.01	0.09	0 56*				

T = temperature in °C; dry = dry bulb; no. of exposure periods = 8; significance p<0.1.

DISCUSSION

The use of low technology samplers, transplanted and in situ, demonstrated that the area of Armadale close to the foundry was most polluted by airborne metals because of the declining gradients of most metal pollutants away from it. However, discontinuity in gradient between areas 1 and 2 existed. This is possibly explained by a pollution plume sufficiently buoyant to provide an "umbrella effect" close to the foundry. The less consistent differences between the gradients of some metals may have resulted from differences of the samplers' surfaces or from differences of particle size (and hence transportability) of those metals. The pattern for Pb showed that this metal had a source other than the foundry. Although *Lecanora* was the least effective type of sampler for demonstrating the pollution gradient around the foundry apart from that of Cd, and unlike *Hypnum* was unable to collect Co, its ability to trap other metals was shown by the highest values for all metals except for Mn, Cu and Co which were exceeded by those found in *Hypnum*[5,6].

Weather factors were shown to disperse the air pollutants. The negative correlations between the metal values and the ambient temperatures may have resulted from conventional up-currents of air causing greater dispersion of the pollutants. On the other hand, the consistent difference between the three types of sampler in some of their associations such as with rainfall, minimum and maximum temperatures, may have resulted from differences in the physico-chemical qualities of their surfaces. The variation in the pattern of metal concentrations between the various types of sampler have been discussed previously[4-10,14].

The distribution of metals in the transplanted samplers found during the study[10] gave further evidence that the foundry was the main source of pollution: the positive correlations between Fe and Mn indicated again that these metals had a constant and stable source in Armadale; and the foundry was implicated by the generally positive correlations between the concentrations and the rates of steel production, together with their consistently negative correlations with brick production. The lack of significant correlation for other metals may have resulted from their relatively low concentrations, from variations of the input of those metals into the steelmaking processes or from the contribution of other sources as in the case of Pb. In general, the SMBs were shown to give results which were less variable and probably illustrated more accurately the local pollution pattern than those of *Hypogymnia*; tak was in an intermediate position. The strong correlation found between the values in *Hypnum* and those in the SMBs indicated that, as an indigenous sampler, *Hypnum* provided a more accurate picture of air pollution by metals than *Lecanora*. These findings supported the results of our earlier studies of the sampling methodology for low technology samplers[14].

In conclusion, therefore, the variations in space and time of the metal concentrations in Armadale provided evidence that the pollutants originated from the local foundry.

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HEAVY METAL CONTAMINATION IN COASTAL WATERS - A CASE STUDY ALONG THE NORTH COAST OF CENTRAL JAVA, INDONESIA

Supriharyono
Research Centre for Energy and Natural Resources, Diponegoro University, Central Java

INTRODUCTION

Development has resulted in an increase in the number of industries in many parts of Indonesia, including Central Java Province. According to a report of the Regional Industrial Office, Central Java, the number of industries in this area has increased by about 20,000 units over the last decade (Table 1). These industries are mainly, chemical, machine, metal and electronic, but also include various other industries (including agro-industries, textiles, processed chemicals, building materials and electrical industries) as well as small (asset) industries.

Table 1: *Industrial development in Central Java 1986-1990*

Type of Industry	Number				
	1986	1987	1988	1989	1990
Chemical	9	12	16	30	30
Machine, metals and electronics	33	42	53	91	94
Various other industries	719	752	832	935	1,082
Small asset industries	579,710	588,661	592,794	600,148	606,742
Total	580,471	589,467	593,695	601,204	607,948

Source: Regional Industrial Office, Semarang, Central Java

These industries are mostly located close to rivers, or the sea in coastal areas, alongside other activities, such as agriculture, fisheries, settlements, tourism, and shipping/harbours. This results in the coastal areas being the centre of human activities, and these, if not be controlled, will affect water quality or (coastal) marine organisms. One group of pollutants most dangerous to living organisms are heavy metals, and the effluents of some of the industries mentioned above are known to contain such heavy metals. Table 2 exhibits the possible heavy metal content in these effluents.

Table 2: *The possible heavy metal content of various effluents*

Industry	Heavy metal contain
Metal	Ni, Hg, Fe, Pb, Cd, Cr
Textile	Pb, Cd
Chemical	Hg
Paint	Cd, Hg, Pb
Pulp	Cr, Cu, Hg, Pb, Zn
Plastics	Cd
Ceramics	Pb, Cd

As these industries discharge their effluents into rivers and/or the sea, the coastal waters become contaminated with heavy metals. Water quality monitoring in the main river of Semarang (River Kali Garang), for example: in 1989, showed that the river received a total Pb and Fe load of 99.90 and 14.377 $kg.day^{-1}$ respectively, everyday, from at least 10 industries. These effluents resulted in an increasing concentration of Pb (about 0.0006 $mg.L^{-1}$) and Fe (0.168 $mg.L^{-1}$) in the water at the mouth of the River Kali Garang. Together with metals, other substances (biological and chemical) which consume dissolved oxygen were also drained into the river. For example, the loads of BOD and COD, to the River Kali Garang were recorded to be about 529.457 $kg.day^{-1}$. and 1606.754 $kg.day^{-1}$ respectively. These resulted in BOD and COD concentrations in the water reaching 7.0157 $mg.L^{-1}$ and 42.4602 $mg.L^{-1}$ respectively at the mouth of the river. Compared with the concentration upstream, these were increases of 6.3057 $mg.L^{-1}$ BOD and 18.2702 $mg.L^{-1}$ COD. Such levels may reduce the dissolved oxygen content in the coastal waters.

Heavy metals may have lethal and sub-lethal effects on marine organisms. Regarding this, since industrialism may introduce heavy metals into the marine environment, the heavy metal concentration in the aquatic (marine) environment should be monitored. This paper discusses the results of such monitoring in the coastal waters of North Central Java and the effects so far on marine organisms.

METHODS

Monitoring of heavy metal contamination has been carried out along the Semarang coast since 1987 and samples were collected from seven locations. Heavy metal contamination of the water was measured both in the dry (June/July) and the wet season (December/January). Heavy metals were also measured in the sediments and in the tissues of benthic organisms during 1989/90.

Water samples were collected using a "Van Dorn" Water Sampler and were composites of surface and bottom water. Sediment and macro-zoobenthic samples were collected using a grab (volume 0.025 m^3). Heavy metals contained in the samples (water, sediment, and living tissue) were analyzed using Atomic Absorption Spectrophotometry (AAS). Heavy metals dissolved in the water were extracted with Ammonium pyrrolidine-dithio carbonate (APDC) solution in chloroform before analysis. Heavy metals in the sediment and living tissue were extracted using concentrated nitric acid (HNO_3).

RESULTS AND DISCUSSION

Heavy metal contamination in the coastal environment: When heavy metals are introduced into the sea, they will be removed by marine organisms[1] through at least three processes, i.e. precipitation, adsorption and absorption. Some heavy metals, such as Fe, are very easily precipitated. Others are less easily precipitated but these are known to be very dangerous to marine organisms. The solubility of heavy metals in sea water depends on various factors, e.g. the presence of hydrogen sulphide (H_2S), organic material, and dissolved oxygen. The solubility of metals may be reduced in anoxic conditions or when H_2S and organic materials are high.

Several rivers drain into Semarang coastal waters and, since these rivers receive effluents which contain heavy metals from surrounding industries, it is suspected that the coastal waters will also be contaminated by heavy metals

Monitoring of the pollution load from several industries in the River Kali Garang proved that these increased concentrations of heavy metals occurred in the mouth of the river. Lead (Pb) and iron (Fe), for example, which were discharged into the River Kali Garang at levels of 99.9 mg and 14.377 kg per day respectively, have increased the concentration of these metals to about 0.0006 mg lead and 0.168 mg iron per litre in the water at the mouth of the river[2]. While oxygen consumption in the effluent (recorded as BOD and COD) was very high (529.457 kg and 1606.754

kg per day respectively), resulting in an increased concentration of BOD and COD (about 0.71mg and 24.19 mg per litre respectively) in the mouth of the river.

Monitoring of heavy metals in the coastal waters of Semarang revealed that the coastal environment has been contaminated by heavy metals and moreover that the concentrations of heavy metals fluctuated throughout the year. The concentrations tended to be higher in the dry season and lower in the wet season. In general it was found that the concentration of heavy metals especially cadmium and mercury, gradually increased (Table 3). However, in some cases (e.g. chromium, copper, lead and zinc) the concentrations were relatively high in 1987, decreased in 1988 and then increased again in the following years.

Table 3: *Heavy metal contamination in the coastal waters of Semarang*

Year	Concentration of heavy metals (ppm)					
	Cd	Cr	Hg	Cu	Pb	Zn
1987[3]	0.0009-0.0017	0.0260-0.3200	0.0008-0 0003	0 0015-0.0031	0.0082-0.0368	0.0012-0.0036
1988[4]	0 0001-0.0030	0.0007-0.0050	0.0001-0 0005	0 0009-0.0110	0.0030-0.0540	0 0030-0.0740
1989[5]	0 0015-0.0140	0.0140-0.0200	0 0000-0 0002	0 0030-0.0260	0 0310-0.0390	0.0095-0.0170
1990[6]	0 0130-0.0250	0.0090-0 0960	0.0020-0 0320	0 0090-0.0940	0 0100-0.0830	0 0690-0.1554

Heavy metals may be removed from the sea by adsorption onto particulate materials such as hydrated ferric oxide, hydrated manganese dioxide, clay minerals and organic substances. Forstner[7] considers that particle size affects the degree of adsorption and that smaller particle size (for example clays) will increase the removal of heavy metals. Measurement of heavy metal contamination of the sediments in Semarang coastal waters showed a significant level compared with their concentration in the water. Thus, these sediments, which are mostly (94%) silt and clay, contained 100-2800 times the concentration in the water. Heavy metal adsorption is suspected to be higher in organic substances, and this environment contains a large amount of organic substances (according to the BOD values). The heavy metal content of the sediments are shown in Table 4.

Table 4: *Heavy metal content (ppm) of sediments in the coastal waters of Semarang in 1989*

Heavy metal	Dry Season	Wet Season
Cd	3.57 $\pm$ 0.571	0.157 $\pm$ 0.050
Cr	14.48 $\pm$ 2.627	0.489 $\pm$ 0.255
Hg	0.046 $\pm$ 0 009	0.024 $\pm$ 0.013
Cu	72 65 $\pm$ 9.652	10.026 $\pm$ 8.113
Pb	26.94 $\pm$ 6.671	8.944 $\pm$ 1.500
Zn	424 $\pm$ 48	322 $\pm$ 68

Heavy metals can be absorbed by aquatic living organisms, either directly or indirectly and Table 5 shows the heavy metal concentrations in the tissues of several species of macro-zoobenthos collected in Semarang coastal waters. These organisms are known to be filter feeding, sediment feeding, and detritus feeding. Since sediment and organic materials are able to adsorb heavy metals, then the feeding habits of these species will indirectly support contamination of the living tissues with heavy metals together with direct absorption through the body or their food.

Table 5: Heavy metal content in the living tissues of zoobenthic species

Species	Heavy metals (ppm)				
	Cu	Cr	Zn	Pb	Hg
ECHINODERMATA					
Amphioplus	3.649	5.334	3.930	16.002	0.023
	6.319	2.323	5.204	20.631	0.052
MOLLUSCA					
Tellina	2.555	8.517	18 313	33.645	0 085
Solen	2.511	1 590	5.525	26.959	0.067
Tapes	10.627	16.447	11.133	51.619	0.121
POLYCHAETA					
Nereis	3.240	19.448	5.672	64.829	0.162

Effects of heavy metals on marine ecosystems: It is well known that heavy metals affect marine organisms[1 8], and Bryan[1] points out that although heavy metals (i.e. Mn, Fe, Cu and Pb) are essential for living organisms, in higher concentration they are dangerous. Copper, for example, is important for fish but this will have adverse effects in concentrations of 0.02 $mg.L^{-1}$ or more[9]. Moreover, this metal will be more toxic in the presence of zinc, since these metals (Cu and Zn) have synergistic effects. Chromium is also dangerous to marine organisms, especially to lower trophic level organisms such as planktonic and benthic organisms. Concentrations of 1.2 mg-$Cr.L^{-1}$ will be safe for fish, but are still dangerous for plankton[10].

Heavy metals may also have sub-lethal effects on living organisms. This sublethål effect includes obstruction of physiological processes (e.g. growth and reproduction), morphological changes and animal behaviour[11-14].

Measurement of sessile and benthic organisms at the study sites did not reveal any evidence of such heavy metal effects, despite the fact that benthic organisms were relatively abundant at these sites[4]. This may be because the concentration of inorganic (dissolved) heavy metals in the water are still lower than the lethal or sub-lethal doses for marine organisms (Table 6). However, the concentrations of heavy metals, both in the sediments and in the organisms themselves were very high. It is not yet known what the effects are likely to be on humans who eat these organisms. Therefore, this should be taken into account when considering environmental management or combating environmental health problems.

Table 6: Heavy metal concentrations in the water and the quality standards for marine organisms

Heavy metal	Concentration (mg/l)	Standard (mg/l)
Cd	0 0015 - 0 0140	$\leq$ 0 01
Cr	0 0140 - 0 0200	$\leq$ 0.01
Hg	0 0000 - 0 0002	$\leq$ 0 0006
Cu	0 0030 - 0 0260	$\leq$ 0.06
Pb	0 0310 - 0 0390	$\leq$ 0 05
Zn	0 0095 - 0 0170	$\leq$ 0 10

Government action concerning environmental quality: The issues of environmental quality in Indonesia, only started around the 1970's, when industrialism was beginning to develop. Anticipating this, the government established a law for environmental management in 1982

(Environmental Law number 4/1982). In order to manage the environment, this law was supported by a regulation (Government Regulation number 29/1986). This regulation suggests that any planned activity which it is suspected will have a bad environment impact, should have an EIA (Environmental Impact Assessment), or EIE (Environmental Impact Evaluation) for any activity that has already been running. This study should also be followed up by Environmental Management and Monitoring Plans.

Other than this law and regulation, there are several decrees (Ministerial Decrees), which combat environmental health problems. One of the Ministerial Decrees is the 'Environmental Minister Decree Number 3/MENKLH/11/1991 for Effluent Quality Standard', which deals especially with toxic effluents such as heavy metals. This legislation is implemented by the Clean Water Programme (PROKASIH) in several provinces of Indonesia, including Central Java. This programme is designed to ensure that river waters should be clean and free from industrial effluents known to have adverse effects.

According to the PROKASIH programme, the water quality of the River Kali Garang in Semarang is hopefully getting better. PROKASIH was established in August 1989, after the time by which any industry discharging toxic effluents should have installed waste water treatment facilities. The programme is still in progress.

CONCLUSIONS

Based on the results of monitoring, it can be concluded that Semarang coastal waters have been contaminated by heavy metals, in the water, in the sediments, and in the tissues of the organisms themselves. The concentration of heavy metals is usually lower in the wet season and higher in the dry season. Concentrations, especially in the water (dissolved heavy metals) were still lower than the water quality standard suggested by the government. Moreover, although the concentration of heavy metals in the sediments, and even in the tissues of benthic organisms, were slightly higher, no evidence of damage to the organisms was found.

The government of Indonesia is strongly combatting environmental problems and its current programme is the "Clean Water Programme".

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DETERMINATION OF PHOSPHORUS IN NATURAL WATER AT PARTS PER TRILLION LEVEL BY LASER THERMAL LENS EFFECT

L Wu+, GG Siu+, DS Chiu‡ and MJ Stokes+
+Department of Applied Science, ‡Faculty Laboratory Centre, City Polytechnic of Hong Kong

INTRODUCTION

In the environmental water system, the concentration of trace phosphorus necessary to induce eutrophication is sometimes less than that detectable by conventional techniques such as chemiluminescence, inductively coupled or direct current plasma emission-atomic absorption spectroscopy and AAS. Even the sub-part-per billion levels in phosphorus determination by the classic molybdenum blue colorimetry combined with solvent extraction is not sensitive enough. Most analysis techniques for inorganic phosphate determination are based on heteropolyacid formation such as molybdophosphate and vanadomolybdo phosphate in acid media. They usually depend on measurements of the sample absorption change from the reagent blank. However, direct absorption measurement has low sensitivity owing to stability limitations of the light source and detector, and the incident-power independence of the ratio of incident and transmitted powers. The laser thermal lens (LTL) effect, an indirect measuring method of absorption, provides a very sensitive way to measure trace chemical concentrations which could not be detected satisfactorily by other spectrometric methods. The application of LTL spectrometry to chemical analysis is well documented[1-16]. The detection limit of phosphorus reached the parts per trillion level [8] and is feasible for environmental analysis. In the present work we report LTL spectroscopic analysis of phosphorus in Hong Kong waters, from river, reservoir and sea, based on colour development by molybdate and malachite green aqueous solution and on solvent extraction using the 3:2 mixture of ethyl acetate (EA) and methyl iso butyl ketone (MIBK).

LTL spectrometry, first discovered by Leite et al[17], makes use of the high intensity of a laser beam to detect weak absorption of analyte. If a laser beam is tuned to the wavelength of the analyte absorption maximum, the deposition of heat by light and the resulting thermal effect will be most noticeable. The laser illuminated region is heated and a thermal refractive index gradient is produced owing to the Gaussian intensity distribution of the pumping beam and this affects the propagation of the laser beam itself, resulting in the self-defocusing or thermal blooming effect. This refractive index gradient can be monitored either by self-defocusing (single beam) or by probe-beam refraction (PBR, double beams). The absorbance information contained in the time-dependent intensities, the initial I_0 and the equilibrium or steady-state I_∞, can be extracted from the the relative change in intensity[1].

$$\Delta I/I_\infty = 2.303EA + 0.5(2.303EA)^2, \qquad (1)$$

where $\Delta I = I_0 - I_\infty$, A and E are the sample absorbance and enhancement factor respectively, $E=-P(dn/dT)/\lambda\kappa$, P, dn/dT, λ and κ are the laser power, temperature dependence of refractive index, wavelength and thermal conductivity respectively. I_0 and I_∞ are two intensities in LTL effect to be measured. This two intensity-point measurement, similar to an equilibrium determination, does not possess the high information input rate that a kinetic (time-resolved) measurement has, but it is enough for concentration determination.

EXPERIMENTAL TECHNIQUE

Reagents: Deionized water was used throughout the experiment. Aqueous solutions of 250 m*l* malachite green (MG) of 2×10^{-3}M, 250 m*l* molybdate of 0.68 M and 100 m*l* standard phosphate solution of 1.0 mg/m*l* were prepared by dissolving commercial grade MG, tetrahydrate ammonium molybdate (AG, 30 g, Adrich Chem.) and potassium dihydrogen phosphate (AG, 0.4387 g, Riedel-de

Haen) in deionized water separately. The standard phosphate solution was diluted to relevant concentrations for calibration. The reagent solution was prepared by mixing the solutions of 85 m*l* MG, 100 m*l* molybdate, 15.7 m*l* concentrated sulphuric acid and filtering after 30 min. with a membrane filter of pore size 0.45 μm.

Sample: The water for testing was filtered first, if necessary, and acidified with sulphuric acid to pH 2-3. About 20 m*l* acidified sample solution was transfered into a flask. 1 m*l* of 7.5 m sulphuric acid and 3 m*l* of reagent solution were added. This solution was extracted by 5 m*l* of a 3:2 mixture of EA and MIBK. The orthophosphate concentration in the sample solution was then determined by a LTL spectrometer.

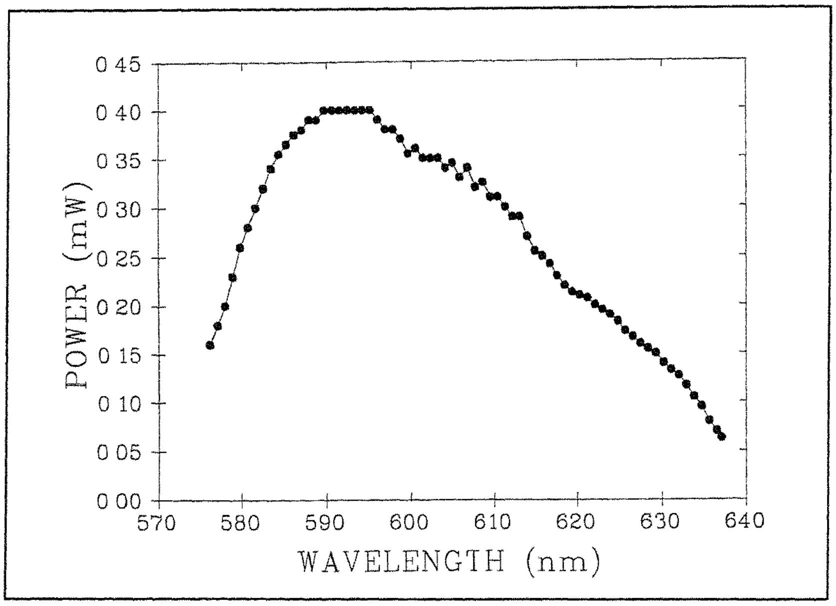

***Figure 1:** The spectral distribution of output power of the Ar^+ laser pumped dye laser (Coherent CR500) using Rhodamine 6G*

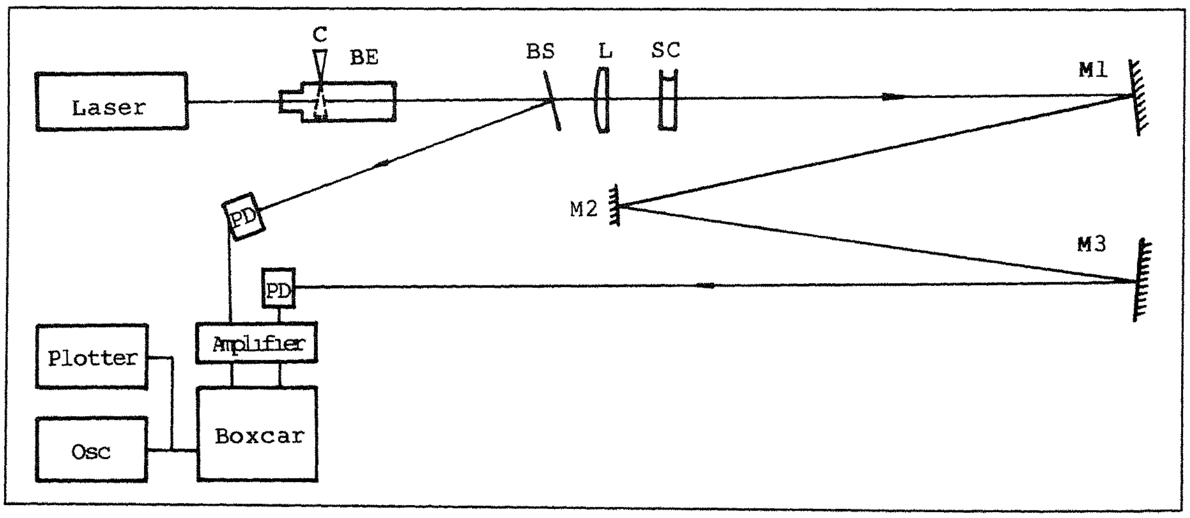

***Figure 2:** Schematic diagram of instrumental system C, shopper, BE, beam expander, BS, beam splitter, L, converging lens, SC, sample cell, M, mirror, PD, silicon photodiode, Osc, oscilloscope*

Apparatus: An Ar^+ laser (Coherent Innova 100) pumped dye laser (Coherent CR599, with rhodamine 6G dye) was used as the heating source and probe beam. Its output covered the wavelength range 570 nm to 640 nm with a power distribution shown in Figure 1. The single-beam self-defocusing method was adopted instead of PBR method in order to avoid the interference of the probe beam, usually a He-Ne laser (632.8 nm, close to the dye laser output used for maximum absorption, ~620 nm). A block diagram of the present experimental system is shown in Figure 2. The fluctuation of laser power was monitored by a power meter although a laser mode, 'light regulation', was selected to maintain a constant light power. The laser beam was chopped at a frequency of 2 Hz to provide an illumination duration of 250 ms on the sample and an interval of 250 ms between successive optical excitation. The sample cell of 1 cm light path was adjusted in position to achieve a maximum LTL effect (at about the confocal distance beyond the beam waist). A silicon photocell was used as the light detector in place of the pin-hole photomultiplier system. The linearity of the response of the photocell to radiation intensity was checked by using a set of neutral density filters.

Signal processing: The output of the photocell was amplified to the appropriate voltages with a dc amplifier. The signal was processed with a digital Boxcar integrator (NF BX531) by synchronous trigging as well as monitored by a CRO. The initial intensity I_0 (t=0) was measured at 200 s from trigging and the equilibrium or steady-state intensity I_∞ (t=∞) at 240 ms The value of each sample point took the average of 2^6 measurements and one set of I_0 and I_∞ took about 64s.

RESULTS AND DISCUSSION

Spectra of LTL effect: The molybdophosphate and MG complex has a wide absorption band. To determine the maximum absorption wavelength of the sample solutions, LTL spectra are studied. The LTL signal ($\Delta I/I_\infty$) versus wavelength λ of three sample solutions with the same concentration is shown in Figure 3 without power normalization The curves A, B and C are for the complex in solvents of acetone, dichloromethane (DCM), and the mixture of EA and MIBK (3:2) respectively. The wavelength for the maximum signal, which corresponds the maximum absorption, only shifts slightly from one solution to another.

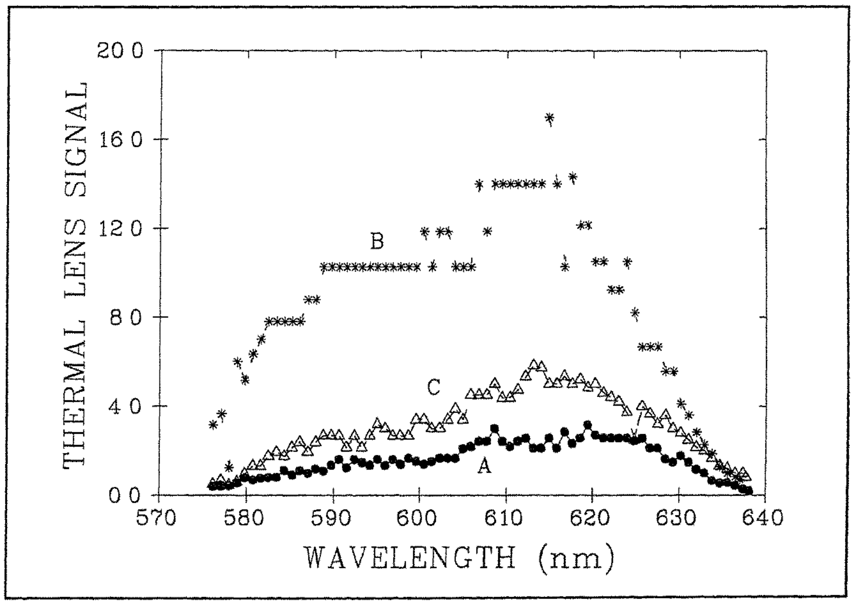

Figure 3: The LTL spectra of molybdophosphate-MG mixture, A, acetone solution, B, dichloromethane, C, EA-MIBK mixture Without power normalization

To obtain a power-normalized LTL signal which is proportional to the sample absorbance, Eq.(1) is solved for 2.303EA by the quadratic formula

$$2.303EA = (2\Delta I/I_{\infty} +1)^{1/2} -1. \qquad (2)$$

Then

$$(1/P)[(2\Delta I/I_{\infty} +1)^{1/2} -1] = 2.303(1/\kappa\lambda)(dn/dT)A. \qquad (3)$$

The LHS of Eq.(3) is the normalized LTL signal and Figure 4 shows the results obtained from Figure 3 by computer treatment. Similarity between three sample-solution spectra becomes apparent from 600 nm onwards. In order to keep the excitation wavelength away from the absorption peak of a molybdate-MG blank[18], 640 nm, we choose wavelength 613 nm as the excitation and probe source.

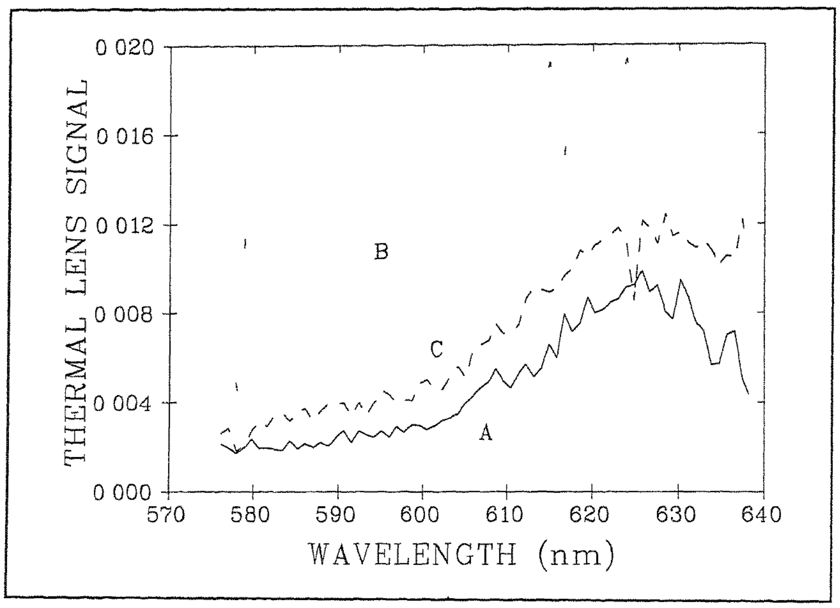

Figure 4: The LTL spectra of molybdophosphate-MG mixture with power normalization (A, B and C are the same as in Figure 3)

Enhancement effect of solvents: The phosphorus-concentration dependences of LTL signal of sample in various solvents are shown in Figure 5 All solutions are a mixture of the sample complex and solvent. At the high concentration (>0.10 ng/m*l*) region, the enhancement of acetone is strongest but its blank signal (at zero concentration) is negligibly weak. The linearity of DCM, alcohol and EA are better than that of acetone and the mixture of EA+MIBK but their enhancement and zero-point signals are not satisfactory. Acetone is suitable as a solvent of the sample complex for LTL effect.

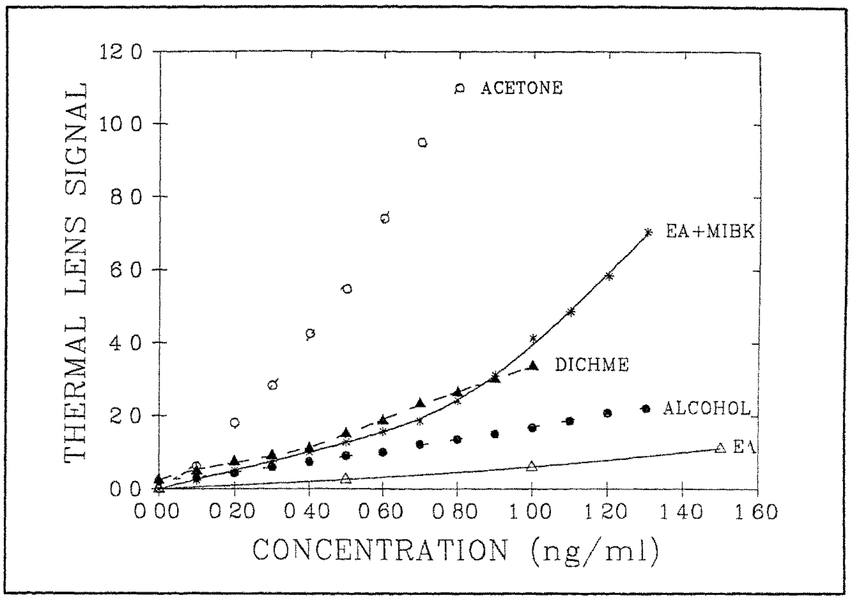

Figure 5: *The enhancement of solvents in phosphorus LTL signals*

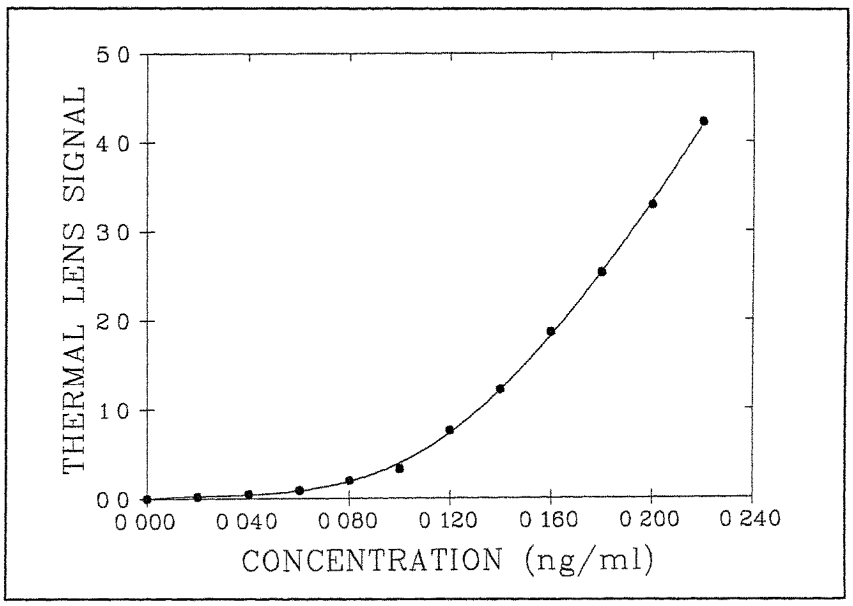

Figure 6: *Calibration curve for phosphorus (acetone solution). Laser power, 80 mW and wavelength, 613 nm*

Calibration: Figure 6 shows the calibration curve for the acetone solution of phosphorus (orthophophate) in a concentration range 0.02 to 0.22 ng/m*l*. The optimal working conditions of the dye laser are: power of 80 mW and wavelength of 613.0 nm. This is a working curve without power normalization based on two intensity measurements. For convenience in application, the concentration versus LTL signal [$x = (\Delta I/I_\infty)$] can be written as follows (Figure 7)

$$c = -0.00035 + 0.18\sqrt{x} \qquad x < 0.5$$
$$c = 0.046 + 0.085\sqrt{x} \qquad x \geq 0.5. \qquad (4)$$

The detection limit (twice the standard deviation of 12 sets of experimental data) is 3.6 pg/m*l* under these experimental conditions.

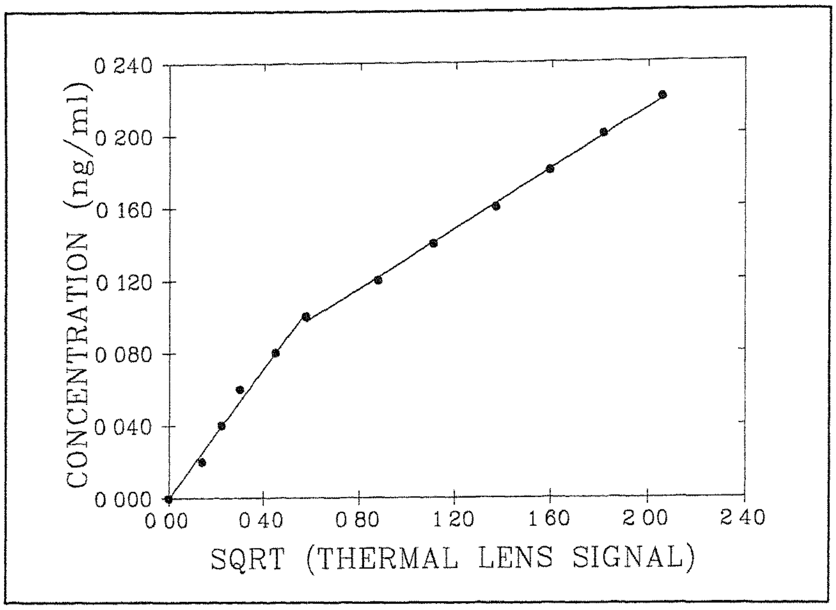

Figure 7: *Phosphorus concentration versus the square root of LTL signal*

Determination of phosphorus concentration in natural water: After filtering the pre-treated acidifying samples, the interference from other ions can be neglected in practical water testing[17]. Following the above-mentioned procedure, phosphorus (orthophosphate) concentration in waters from tap, sea and reservior (June 1991) was determined without dilution The results are shown in Table 1.

Table 1: *Results of phosphorus concentrations in tap, reservoir and sea waters*

Sample		Phosphorus Concentration (ng/ml)
1	Tap water	1 04 ± 0 11*
2	Water from the Kowloon	6 97 ± 0 96* (side)
	Reservoir	2 65 ± 0 55* (centre)
3	Seawater from	
	Yaumatei Pier	15 47 ± 2 08*
	Hebe Haven	12 56 ± 0 59**
4	Water from Shingmun River	31 42 ± 3 25**

* Average of six experiments
** Average of twelve experiments

While testing on the sea salt (hw-Marinemix) solution, a phosphorus concentration of 4.64 ng/ml is obtained by averaging over ten measurements, with standard deviation (SD) and related SD of 0.38 and 8.1% respectively.

Our results, though only from sampling on one day in June, are in the same order of magnitude as the statistical data (annual means of depth average data) of water quality of local sea[19]. The PO4-P results are similar to 0.01 (0.002-0.027) of Hebe Haven, lower than 0.056 (0.004-0.165) of the Harbour subzone of Tolo Harbour, all in units of mg/L.

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A GEOGRAPHICAL APPROACH TO EVALUATING THE HUMAN IMPACT UPON WATER QUALITY

MR Peart
Department of Geography and Geology, University of Hong Kong

INTRODUCTION

Long term records of water quality permit the evaluation of the human impact upon water quality[1]. However, long term records of water quality are not always available. In such cases, where it is desired to examine the human impact upon water quality, it may be possible to use the substitution of space for time. The ergodic approach has been applied to a range of researches. For example it has been used in geomorphology[2]. It would seem applicable to water quality studies. In the present study, a survey has been conducted in a small drainage basin at Wong Chuk Hang on Hong Kong Island to see if this approach can be used in the territory. This is because Hong Kong has no long term records of water quality which date back to times before significant human impact.

STUDY BASIN AND METHODS

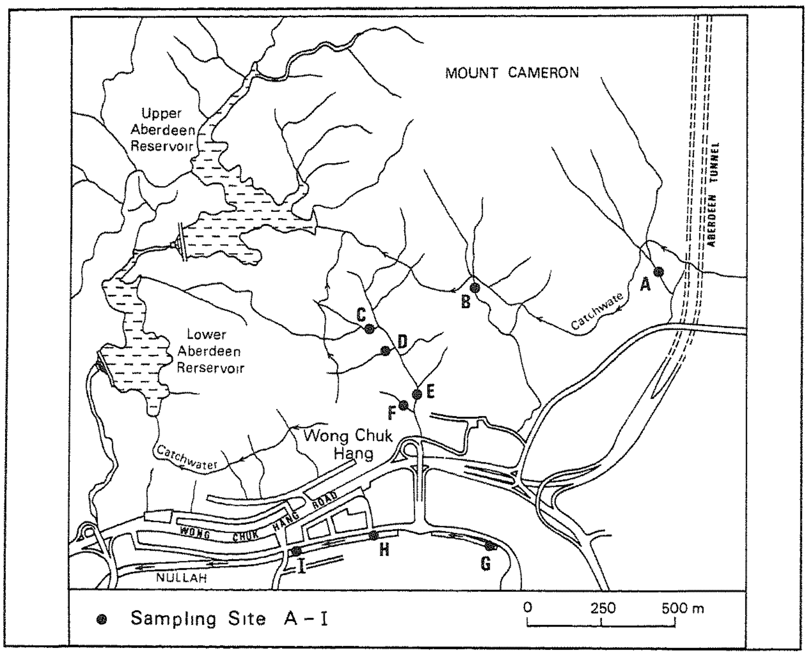

Figure 1: Map showing the location of the sampling sites.

The study basin is located at Wong Chuk Hang near Aberdeen on Hong Kong Island. It has an area of around 3 km^2 and the basin descends from a height of 439 m at Mount Cameron to sea level in the lower reaches. Bedrock geology is predominantly acid volcanics with sedimentary intercalations. Colluvium also occurs on the slopes which are steep, 30° to 40° in the upper areas. The upper reaches of the basin are well vegetated consisting of woodland, scrubland and rough grassland. The lower part of the basin has been urbanized and land use includes housing, factories and recreational areas. A small sub-basin on the margin of the urban area contained livestock farming in 1987. Pig and duck rearing were the most common types of livestock farming.

A series of water samples were collected for water quality analysis from the basin in July and August, 1987. A total of 5 samples were obtained from each site. Sampling was stratified to include four kinds of land use. Firstly, streams draining undisturbed well vegetated areas of the basin. These streams may provide a baseline for natural water quality before human impact. Secondly, a small stream in the lower reaches of the basin at a peri-urban location, which contained pig and duck farming. Thirdly, samples were collected in the nullah which drains not only the upper reaches but also the urban areas. Finally, a storm drain in the nullah was sampled. The location of the sample sites are shown in Figure 1 while their classification is given in Table 1. A repeat survey of selected sites (5 samples at each location) was conducted in January and June 1991. All water samples were collected under baseflow conditions.

Polyethylene bottles were used to collect the samples and prior to analysis they were kept in the dark and refrigerated as recommended by the American Public Health Association[3]. Before analysis the water samples were filtered using Whatman no. 40 filter papers. After filtration ammonia (NH_4^+), nitrate (NO_3^-) and urea (U-N) forms of nitrogen were determined along with phosphate (PO_4^{-3}). The antimony molybdate-ascorbic acid method based upon that for soil analysis was used to determine phosphate, and it may give absolute values that are too high. Nevetheless, for comparison between sites the results are valid. Acid hydrolysis, zinc powder and titrimetric methods were used to determine urea-N, nitrate-N and ammonia-N respectively. At the same time as water sample collection dissolved oxygen concentrations were measured in situ with a portable meter.

RESULTS

Table 1: *Water quality at the sampling sites shown in Figure 1. All results are in mg/l*

Site	Land-use		Ammonia-N	Nitrate-N	Urea-N	Phosphate	Dissolved Oxygen
A	Rural	Mean	0.46	0 22	0	0	6.98
		Range	0-0.96	0-0.56	-	-	6.4-7.6
B	Rural	Mean	0.51	0.50	0	2.33	6.76
		Range	0.28-0.84	0.28-0.84	-	0-11.64	6.0-7.4
C	Rural	Mean	0.42	0.56	0	5.08	7.06
		Range	0.12-0.84	0.28-0.84	-	0-14.85	6.2-7.9
D	Rural	Mean	0.64	0.45	0	0	7.30
		Range	0.28-0.96	0.28-0.80	-	-	6.9-7.8
E	Rural	Mean	0.37	0.45	0.50	3.16	7.52
		Range	0.12-0.56	0-0.76	0.28-0 84	0-8.83	7 1-8.0
F	Livestock keeping	Mean	22.51	7 74	12.25	120.6	3.18
		Range	8.68-45.48	2.24-13.64	2.45-18.20	13 5-216.2	2.8-3.5
G	Urban & rural	Mean	2.77	2.76	2.13	15.07	5.38
		Range	2.08-4.48	1.45-5.32	0.56-3.92	3.35-22.61	5.0-6.1
H	Urban, rural & livestock	Mean	1.16	0.64	0.67	15.79	5.02
		Range	0-1.96	0-0.84	0-1.68	10.17-24.62	4.0-5.8
I	Urban, rural & livestock	Mean	1.22	0.44	1.34	14.37	5.78
		Range	0.84-1.68	0.24-0.56	0.28-3.08	7.49-24.75	5.5-6.4
J	Urban storm drain	Mean	4.01	3.30	2.86	18.9	3.78
		Range	1.4-7.56	2.24-4.76	0.3-5.88	10.4-37.4	2.3-4.6

The results of the water quality survey are presented in Tables 1 and 2. Table 1 reveals a clear difference in water quality between the upper, rural, reaches of the basin and the lower areas. All forms of nitrogen and phosphate are absent or present in only small amounts in the upper reaches of the catchment. In contrast, the stream which drains the basin containing livestock farming adjacent to the urban area has the highest concentrations of ammonia-N, nitrate-N and urea-N along with phosphate. The other sites at the lower end of the basin in the nullah of the urban area have nitrogen and phosphate concentrations that are above those of the rural areas. However, phosphate, ammonia-N, nitrate-N and urea-N are all at levels well below those for site F.

There are considerable differences in dissolved oxygen levels in the streams. In the rural streams dissolved oxygen levels are high averaging around 7.0 mg/l. However, site F had a very low dissolved oxygen level with a mean of 3.2 mg/l. The lower reaches of the basin had dissolved oxygen levels that were below those of the upper reaches but considerably above those of the stream affected by livestock rearing and the urban storm drain.

Table 2 reports water quality observations at site F before and after the cessation of livestock farming. The concentrations of ammonia and nitrate nitrogen and phosphate are much reduced after animal rearing ceased. After livestock farming stopped urea-N was not detected in the stream.

Table 2: *Nutrient concentrations in the livestock affected stream (mg/l)*

		Ammonia-N	Nitrate-N	Urea-N	Phosphate
With livestock	Mean	22 51	7.74	12.25	120.6
	Range	8 68-45.48	2 24-13 64	2.45-18.20	13.5-216.2
Without livestock	Mean	0.47	0 57	0	2.38
	Range	0.34-0 59	0-1.17	-	0.16-4.01

DISCUSSION

In terms of nutrients measured in this study, Table 1 shows that livestock rearing in peri-urban areas may cause very high concentrations to occur. The ammonia-N, nitrate-N, urea-N and phosphate concentrations in the stream impacted by livestock rearing are much higher than for the rural streams (sites A-E). The data in Table 1 reveals that peri-urban agriculture can result in enhanced nutrient levels in watercourses. However, comparison of site F to sites H and I, which are downstream in the nullah, reveals that nutrient concentrations become well diluted due to mixing with less polluted waters draining from other areas of the basin. Therefore, in this basin the impact of the highly polluted stream on downstream water quality is less than might be expected.

In June 1988 the Hong Kong Government implemented a ten year livestock waste control scheme. Under this scheme livestock farming was banned in Prohibition Areas which covered the Urban Council Administrative Areas (Hong Kong Island, Kowloon and New Kowloon) and areas within the New Town boundaries. According to the Environmental Protection Department[4], the ban on livestock rearing was effective within six months. Table 2 offers a measure of it's effectiveness on water pollution in the urban areas of Hong Kong. It can be seen from Table 2 that the concentrations of all forms of nitrogen and that of phosphate are much reduced after cessation of livestock rearing in the basin. Moreover, urea-N, which is derived directly from animal waste, is not detectable in the basin following the banning of livestock. It is clear that Government legislation has led to a significant improvement in water quality in this peri-urban stream. Table 2 indicates that agriculture can have an impact upon water quality. It also confirms that spatial sampling can be used to evaluate the human impact for, after cessation of livestock keeping, determinant levels approach those of the rural areas.

In terms of monitoring strategies for water quality the data in Table 1 indicates that spatial sampling can be used to substitute for time in the evaluation of the human impact. Other studies[5,6] have also successfully adopted this approach. The method may be particularly valuable in basins where no long term records of water quality exist and may be valuable in other areas of Hong Kong. Investigations[7 9] provide further evidence that spatial sampling can be used to evaluate the human impact upon water quality in the Territory. The Environmental Protection Department sampling programme[10] also offers scope for this type of analysis.

There are problems with using spatial sampling as a substitute for time. For example, other controls upon water quality, such as soils and geology[11], may cause spatial variation in addition to the human impact. It is necessary to control for other potential causes of variation. Furthermore, if there is a change in quantity and quality of water entering the basin with time then current water quality levels in rural areas may not be the same as in pre-human impact times. That is to say water quality in rural areas may be non-stationary. Acid precipitation provides a good example of such a situation.

CONCLUSION

The data in Table 1 indicates that streams subjected to the human impact have poorer water quality than rural, natural streams in the same basin. The human impact is most marked in a stream impacted by agricultural waste and in urban storm drains.

The present study indicates that spatial sampling affords a means of evaluating the human impact upon water quality when no long term records exist. Rural streams may afford a baseline for water quality before the human impact. Some problems with the substitution of space for time in water quality monitoring are discussed. Geographers may have a valuable contribution to make to pollution studies in the selection and identification of suitable sampling points and data interpretation.

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MODULAR AUTO-ENRICHMENT SUBSYSTEM FOR USE IN ENVIRONMENTAL HIGH PRESSURE LIQUID CHROMATOGRAPHY ANALYSIS

SC Chen, JY Chang and RK Wang
Department of Chemistry, Fu Jen University, HsinChuang, Taiwan

INTRODUCTION

The complexities of pollutants present in the environment and the labour involved in formal analytical procedures has tended to direct environmentally concerned enquirers towards the use of screening methods such as spot tests or more simple methods, which are invariably much less informative, and sometimes even erroneous. Thus, the need for periodic, reliable monitoring of the environmental quality in a community often puts analytical chemists on the spot.

An automatic HPLC system with machine intelligence to speciate pollutants, based on microcomputer-interfaced and chemometrics-integrated conventional instruments, is feasible with existing technologies. Over the years, our laboratory has built a prototype of an automatic HPLC system with software commandability and intelligence for sophisticated applications as shown in Figure 1.

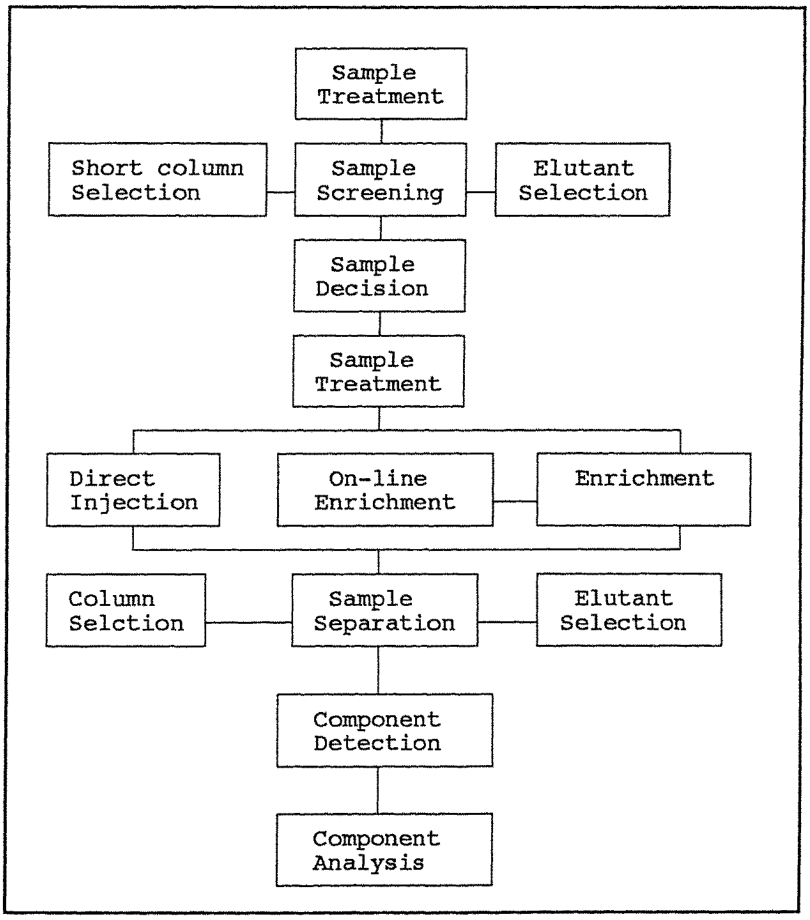

Figure 1: *Integrated automatic HPLC system.*

Though the utopia of total integrated automation is still a far-cry, our HPLC system integrates the functions of optional robotic automatic sampling or on-line sample enrichment, programmable solvent and column selection, expert systems - based troubleshooting, a user-friendly tutorial and chemometric speciation implemented by multivariate sensing via a home-made pulsed amperometric detector. The integration of AD/DA, digital signal processing, the 3-D chromatogram display, pulsed amperometric detection, dubbed Pseudo Multichannel Detector or PMD, and peripheral control is implemented by in-house developed software[1]. Further developments of the present system have also led to a laboratory information management system as shown in Figure 2.

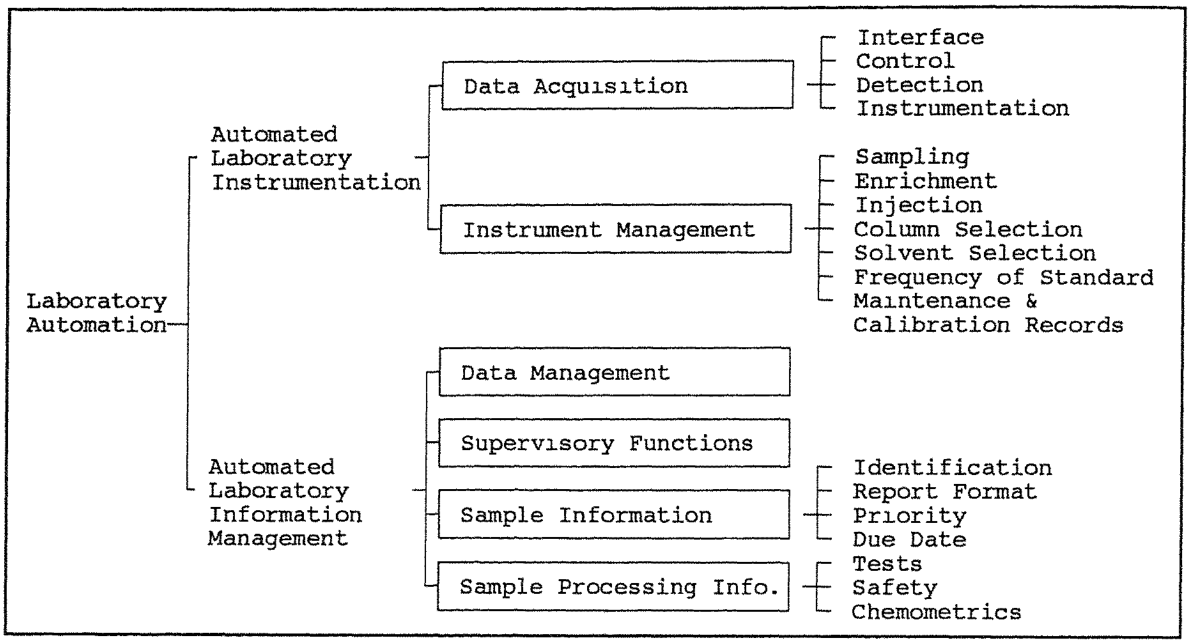

Figure 2: *Laboratory information management system for automatic HPLC system*

The presence of pollutants such as phenols, heavy metals and polyarometic hydrocarbons (PAH) in trace amounts necessitates pre-concentration steps prior to HPLC analysis. With the incorporation of an enriching function; the in-house developed automatic HPLC system has evolved into a modular HPLC auto-enrichment subsystem as shown in Figure 3.

RESULTS AND DISCUSSION

As shown in Figure 3, our system is capable of on-line sample enrichment, solvent and column selection, troubleshooting by a built-in expert system, a user-friendly tutorial, chemometric speciation, implementable via a home-made pseudo-multichannel amperometric detector and a commercial photodiode array detector. As an application example, a broad spectrum of pollutants from the polar phenols to the hydrophobic polyaromatic hydrocarbons can be separated in one injection and displayed on one chromatogram with heavy metals in the form of chelates emergent between the two, as shown in Figure 4.

As another application example, pollutants such as phenolics, heavy metals in the form of chelates and polycyclic aromatics, in the first phase, are enriched and subsequently eluted on a short ODS column and the presence of the pollutant group recognised by their retention information along with chemometric analysis of multivariate sensing data. In the second phase, after the speciation of pollutant type, a decision is made for metal analysis, for example, by the user to select a proper solvent for elution. This is assisted by the built-in expert system via programmable modules of solvent and column selection. The same sample containing metal ions can first be freed from its organic interferences by passing through a hydrophobic column and then enriched on a short ODS column followed by elution. Results indicate that detection limits of 25 ppb for metal ions, 2.5 ppb for phenols and 2.8 ppb for PAHs and good linear calibration curves, with the exception of metals, are possible.

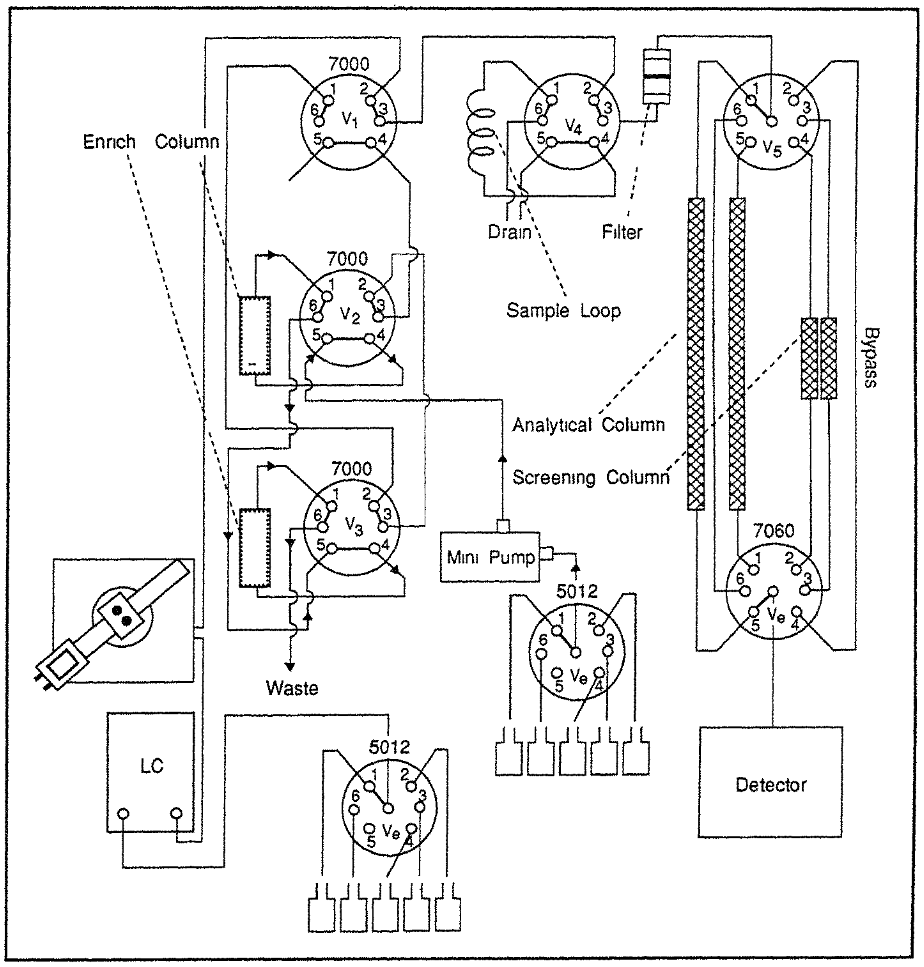

Figure 3: Modular auto-enrichment subsystem

CONCLUSION

The presence of pollutants such as phenols, heavy metals and PAH in trace amounts necessitates pre-concentration steps prior to HPLC analysis. Incorporating an enriching function into an in-house developed automatic HPLC system resulted in a modular HPLC auto-enrichment subsystem. This modular enrichment unit when integrated with the main intelligent system is quite powerful. PAH and phenols can be enriched on the first of two enrichment columns discretely connected in series, while metal ions are enriched as chelates on the second column. Subsequent elutions of these three groups of pollutants into respective analytical columns can be effected by tuning the elution strength of the moving phase and switching valves, all actions of which are computer commandable. The system is capable of detecting ppb levels of the three groups of pollutants. Though the utopia of total integrated automation is still a far-cry, this system is capable of auto-enrichment and separation of the three groups of pollutants.

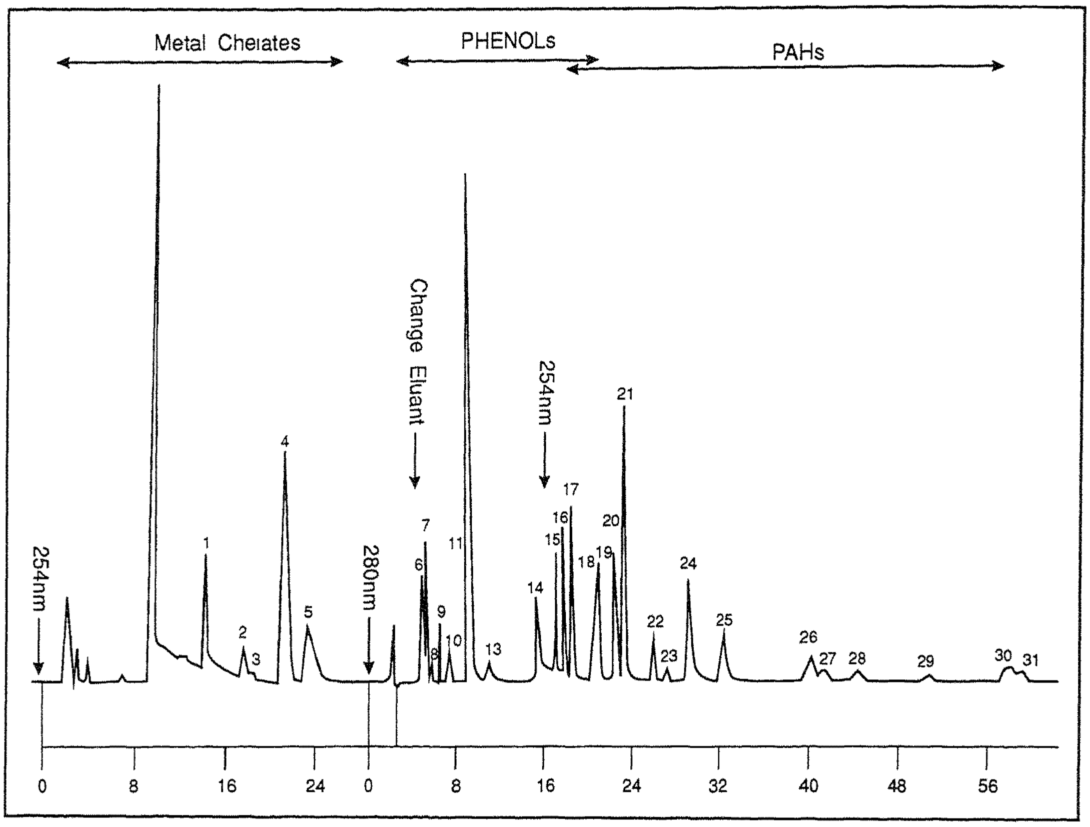

Figure 4: *Trace synthetic sample containing phenols, heavy metals and PHAs in low ppb's.*

1. Ni (DDTC) (0.1 ug Ni)
2. Co (DDTC) (0.1 ug Co)
3. Cr (DDTC) (0.1 ug Cr)
4. Cu (DDTC) (0.1 ug Cu)
5. Hg (DDTC) (0.2 ug Hg)
6 4-Nitrophenol (0.625 ug)
7 2, 4-Dinitrophenol (0 375 ug)
8. 2-Chlorophenol (0.125 ug)
9 2-Nitrophenol (0.125 ug)
10. 2, 4-Dimethylphenol (0 125 ug)
11. 4-Chloro-3-methylphenol (0.625 ug)
12 2-Methyl-4, 6-dinitrophenol (0.625 ug)
13. 2, 4-Dichlorophenol (0.125 ug)
14. 2,4,6-Trichlorophenol (0.375 ug)
15 Naphthalene (0.1 ug)
16 Fluorene (0.02 ug)
17. Acenaphthylene (0.2 ug)
18. Pentachlorophenol (0.625 ug)
19. Acenaphthene (0.1 ug)
20. Phenanthrene (0 01 ug)
21. Anthracene (0.01 ug)
22. Fluoranthene (0 02 ug)
23. Pyrene (0.01 ug)
24. Benzo[a] anthracene (0.01 ug)
25. Chrysene (93%) (0.01 ug)
26. Benzo[b] Fluoranthene (0 02 ug)
27. Benzo[k] Fluoranthene (0 01 ug)
28. Benzo[a] Pyrene (0.01 ug)
29. Dibenz[a,h] Anthracene (0.02 ug)
30. Benzo[ghi] Perylene (0.02 ug)
31. Indeno [1,2,3-cd] Pyrene (0 01 ug)

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EXPOSURE TO ENVIRONMENTAL POLLUTANTS IN THE WORK ENVIRONMENT - A CASE STUDY OF A TRAFFIC TOLL BOOTH IN MALAYSIA

MI Yaziz
Department of Environmental Sciences, Universiti Pertanian Malaysia, Selangor, Malaysia

INTRODUCTION

Industrial and social development is often accompanied by increased environmental pollution, more so in the less developed economies. To ascertain the health impact of deterioration in environmental quality, human exposure information is needed. For establishing the relationship between exposure and health both continuous and periodic assessments may be carried out.

Exposure estimation of pollutants in humans is a function of time and location. Certain population groups may be more susceptible. For a study on health effects, it is necessary to determine at what level a given exposure implies an unacceptable risk.

Air pollutants that have received wide attention include carbon monoxide (CO), nitrogen oxides (NO_x), sulphur oxides (SO_x), hydrocarbons, suspended particulate matter (SPM) and photochemical oxidants. Much effort has been spent in attempting to evaluate human exposure to air pollutants in both home and work environments. The present study is aimed at determining the exposure of workers in toll booths to air pollutants. This is carried out by quantifying the minimum, maximum and average concentrations of CO, SPM, NO_x, and lead (Pb) to which the workers are exposed during a normal work shift. The outcome of this study should contribute towards the establishment of baseline levels of specific air pollutants and at the same time generate data for a better understanding of air quality in relation to design, operation and maintenance of the booths and their ventilation systems.

MATERIALS AND METHODS

The study site is the outermost toll booth out of 15, for traffic heading south on a major interchange along the North-South Kuala Lumpur - Seremban highway. The lane of the selected booth caters for heavy traffic such as buses and lorries with some cars occasionally passing through during peak periods.

Table 1: *Average concentration of CO, SPM, Pb and NO_2 on different days based on three continuous measurements for each day*

Day	CO (ppm)	SPM (ug/m^3)	Pb (ug/m^3)	NO_2 (ppb)
Tuesday	9.94	156.57	1.26	39.44
Thursday	11.84	128.43	0.73	44.17
Saturday	13.27	158.73	0.35	38.35
Saturday (with fan)	11.45	191.35	1.13	40.41
Average	11.63	147.38	0.87	40.59

Air sampling was carried out inside and outside the booth. CO was measured using a direct reading CO detector. SPM was measured using a personal sampler fitted with a portable pump and a polyvinyl chloride membrane filter enclosed in a cassette. Airborne lead was determined by digesting the SPM filter in nitric acid and measuring the Pb concentration using an atomic absorption spectrophotometer. NO_x was measured using a sensitive filter badge[1]. The ventilation rate in the booth was determined using the number of air changes per hour with a Kurz model 491 anemometer and the volume of the booth excluding the volume of internal objects.

RESULTS

Large variation in CO concentrations observed diurnally (Table 2) were found to be positively correlated with peak traffic flows during the morning and evening rush hours. The lower CO levels in the afternoons were mainly caused by the lower traffic counts, stronger winds and higher ambient air temperatures which tended to disperse the pollutants thus reducing their likelihood to enter the toll booth. The relatively high CO concentrations during Saturdays reflected greater movement of vehicles during weekends which is confirmed by the greater numbers of buses, lorries and cars (Table 2). The average SPM concentration at 147 ug/m^3 is below that recorded on Saturdays. Lead levels were generally low with only 17% of the readings exceeding the Malaysian three month average guideline value of 1.5 ug/m^3.

Table 2: *Temporal variation of CO with traffic flow, temperature and ventilation rate on different days*

Time	Number of Vehicles				CO (ppm)	Temperature (°C)	Ventilation rate
	Cars	Lorries	Buses	Total			
(a) Tuesday							
0730-0800	202	30	4	236	20.0	24.0	0.08
0801-0830	153	35	15	203	13 2	25.0	0.08
0831-0900	105	50	7	162	12.3	26.0	0.07
0901-0930	91	56	12	159	4.5	26.5	0.10
0931-1000	99	89	13	201	8.0	27.0	0.10
1230-1300	119	53	5	177	6.5	32.0	0.07
1301-1330	64	58	5	127	5.7	33.0	0.05
1331-1400	49	48	8	105	3 5	33.0	0.05
1630-1700	102	62	11	175	5.3	30.0	0.10
1701-1730	146	66	12	224	7 7	26 0	0.10
1751-1800	127	89	9	225	17 5	26 0	0.07
1801-1830	148	53	8	209	7 0	26.0	0.08
Mean					9 3		0.08
Median					8 0		
(b) Thursday							
0730-0800	212	42	6	260	19 5	25 8	0.03
0801-0830	114	26	5	145	17 2	26.1	0 03
0831-0900	118	44	6	168	18 5	26 3	0 06
0901-0930	103	76	7	186	13.0	27.8	0.06
0931-1000	128	83	14	225	11 2	30 0	0.06
1230-1300	58	54	6	118	5.7	31.4	0.07
1301-1330	58	57	8	123	5 0	31 1	0.06
1331-1400	62	64	6	132	5 3	28.6	0.08
1630-1700	113	74	4	191	8 3	30.8	0.08
1701-1730	126	91	9	226	6 3	27.9	0.07
1751-1800	183	91	14	288	26.8	27.8	0.08
1801-1830	174	71	9	254	16.0	28.6	0.08
Mean					12.6		0.06
Median					9.0		

Table 2: *(contd.)*

Time	Number of Vehicles				CO (ppm)	Temperature (°C)	Ventilation rate
	Cars	Lorries	Buses	Total			
(c) Saturday							
0730-0800	164	52	11	227	19.7	24.6	0.08
0801-0830	133	57	15	205	15.2	24.6	0.08
0831-0900	121	66	17	204	10.5	25.2	0.07
0901-0930	96	69	19	184	5.5	27.8	0.07
0931-1000	86	83	12	181	5.0	28.3	0.07
1230-1300	151	83	8	242	15.7	28.4	0.03
1301-1330	190	52	9	251	20.2	28.9	0.05
1331-1400	216	70	15	301	18.0	28.9	0.05
1630-1700	168	72	14	254	13.5	32.8	0.08
1701-1730	161	70	10	241	15.8	32.2	0.08
1751-1800	192	57	9	258	10 5	31.6	0.08
1801-1830	211	49	10	270	14.8	30.8	0.08
Mean					13.4		0.07
Median					13.5		
(d) Saturday (with fan)							
0730-0800	199	51	6	256	21.0	25 0	0.68
0801-0830	113	46	7	166	12 0	25 0	0.78
0831-0900	88	52	14	154	9.8	25.5	0.68
0901-0930	105	61	11	177	13 5	26.0	0.67
0931-1000	88	65	13	166	9.8	26.5	0.67
1230-1300	106	65	5	176	8.7	30.0	0.78
1301-1330	136	55	6	197	7.8	31 5	0.78
1331-1400	134	62	7	203	10.0	32.0	0.49
1630-1700	138	56	11	205	15.3	31.5	0.69
1701-1730	115	81	15	211	11.2	30.5	0.67
1751-1800	128	62	11	201	13.7	29.0	0.68
1801-1830	129	48	8	185	12.5	28.0	0.78
Mean					12.1		0.70
Median					11.5		

The lower Pb levels in comparison with earlier data collected in 1985 may be partly attributable to the enactment of legislation to lower the Pb content in petrol from 0.8 mg/l to 0.1 mg/l in 1990 and the introduction of unleaded petrol in 1991. The 24-hour minimum and maximum average NO_2 readings are of 36.15 ppb and 47.90 ppb respectively. About 42% of the NO_2 data was found to exceed the Malaysian guideline value[2] (Table 3).

Table 3: *Recommended Malaysian Guidelines at 25°C and 101.13 Kpa*

Pollutant	Average duration	Limit		Target year for compliance
		ppm	ug/m^3	
CO	1 hour	30	35	1955
NO_2	1 hour	0.17	320	1990
SPM	24 hour		150	1995
Pb	3 month		1.5	1991

Statistical analysis indicated a weak correlation between CO, temperature and ventilation rate but a strong correlation between CO and traffic flow (r>0.5 at the 95% confidence level). The low correlation between CO and ventilation rate indicates that the latter was too slow for dispersion.

The results obtained in the present study showed that workers in the toll booths are continuously exposed to high levels of CO, SPM, Pb and NO_2 during an 8 hour work shift. A preliminary questionnaire survey of the workers indicated complaints of dizziness and headaches after work. Follow-up medically-related studies need to be carried out for example to examine the relationship between ambient CO and blood carboxyhaemoglobin levels over predetermined exposure periods. The air quality in the toll booths should be improved by improving the ventilation system. The results also showed a need to control the emission of CO and hydrocarbons from vehicles.

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A PROPOSED AIR QUALITY INDEX FOR HONG KONG

CN Ng and PA Tanner
Department of Applied Science, City Polytechnic of Hong Kong

INTRODUCTION

In Hong Kong (HK), the Environmental Protection Department (EPD) are now operating a network of 11 fixed stations to monitor ambient air quality. Results, in the form of bar charts depicting the concentrations of four pollutant variables in selected areas of HK, are published in the local press each month, and summarised in Environment HK[1]. In this paper, we review an alternative method of communicating the air quality monitoring data to the general public, in a generally intelligible, simple and concise form. It is also desirable that the success of regulatory programmes, such as those outlined in the HK Government's White Paper[2] may be evaluated, and that the air quality in different locations in HK may be compared. The methods described here, utilise an air quality index (AQI) to fulfil these requirements. More esoteric, analytical methods for displaying trends are not presented here[3,4]. In the following sections we describe the structure of AQI, and review their application in some other countries, before indicating their use in the HK context.

Pollutant variables and air quality objectives: Ott[5] defines the term pollutant variable (PV) to denote any physical, chemical or biological quantity intended as a measure of environmental pollution. In this paper we are concerned with the measurement of environmental quality PVs, reflecting actual ambient conditions, rather than with source PVs[5]. Furthermore, monitoring is carried out over a short time period and the PVs are associated with acute effects of air pollution such as impairment of heart function, respiratory irritation and visual perception. In HK, the PVs selected by the EPD for real time monitoring and storing 1-hour average concentrations are sulphur dioxide (SO_2), nitrogen dioxide (NO_2), and at 5 sites, ozone (O_3). Carbon monoxide (CO) is also monitored at a road-side site. The ambient aerosol concentration, expressed as total suspended particulates (TSP), is measured over a 24-hour period using a high-volume air sampler fitted with a suitable filter. The smaller particles which can penetrate deeply into the lungs, less than or equal to 10μm nominal aerodynamic diameter are termed respirable suspended particulates (RSP) and are similarly measured after size selection by an impactor. This terminology differs from that used in the USA, where the particles <10μm in diameter (measured by the same method) are called PM_{10}[3]. The term suspended particles (SP) is employed in Canada to denote fine suspended particulate matter (diameter <10μm) in conjunction with its method of monitoring, involving the opacity produced on a moving tape[6].

Governments have established National Ambient Air Quality Standards (NAAQS), or Air Quality Objectives (AQO), which state the PV concentrations giving rise to non-desirable or harmful effects upon the general population. In the USA, the primary NAAQS are set at levels to protect public health, whereas the sometimes more rigid secondary NAAQS are set to protect against other non-health related effects of air pollution such as damage to plants and soiling. The primary NAAQS are summarised in Table 1 and are compared with the AQO used by the EPD of HK. Some objectives specify concentrations for both short and long averaging periods, (and also include limits for number of exceedences) intending to protect against the occurrence of both acute and chronic effects. The USA EPA has developed additional standards (episode criteria) under short averaging periods, indicating alert, warning and emergency levels for the control of air pollution episodes. Significant harm levels, which should never be attained in an air quality control region, have also been promulgated. The Clean Air Act of the Government of Canada provides AQO, stating maximum desirable, acceptable and tolerable levels of PVs for various averaging periods. The former constitute a basis of measure for an anti-degradation policy whilst the latter two provide an indication of effect upon personal comfort and health. The air quality guidelines in Table 1 are by no means the most stringent in the world[7].

Table 1: *Comparison of NAAQS and AQO for selected pollutants*[†]

Pollutant	Averaging Time Period	USA EPA Primary NAAQS	HK EPD AQO	Government of Canada AQO Desirable	Acceptable	Tolerable
SO_2	1 hour	-	800 (i)	439	877	-
	24 hours	365 (ii)	350 (ii)	155	284	800
	1 year	80 (iii)	80 (iii)	26	52	-
NO_2	1 hour	-	300 (i)	-	395	997
	24 hours	-	150 (ii)	-	207	301
	1 year	100 (iii)	80 (iii)	-	-	-
CO	1 hour	40000 (ii)	30000 (i)	14881	34341	-
	8 hours	10000 (ii)	10000 (ii)	5724	14881	-
O_3	1 hour	235 (iv),(ii)	240 (i)	100	161	300
	24 hours	-	-	29	49	-
	1 year	-	-	-	29	-
PM_{10}/RSP/SP*	24 hours	150 (ii)	180 (ii)	-	-	-
	1 year	50 (iii)	55 (iii)	-	-	-

[†]Concentrations are expressed in $\mu g\ m^{-3}$ at 298 K and 1 atm. Some conversions of units have been made Dashes indicate the absence of objectives

*See the text for definitions of these parameters
(i) not to be exceeded more than three times per year
(ii) not to be exceeded more than once per year
(iii) arithmetic mean
(iv) maximum daily 1-hour average

Subindices and aggregation: Each PV, X_i , is transformed into a dimensionless quantity, I_i , called a subindex:

$$I_i = f_i (X_i)$$

Various linear and nonlinear relationships have been employed[5], the most widely used being segmented linear functions. For example, for the Pollutant Standards Index (PSI), the subindex for carbon monoxide is set at 100 or 500 for concentrations corresponding to the primary NAAQS or the significant harm level, respectively. Other breakpoints correspond to 50% of the NAAQS and to the episode criteria. These separate the descriptor categories of the subindex for health and environmental impacts. The overall AQI, I, is obtained by aggregation of all subindices:

$$I = g (I_1, I_2, ..., I_n)$$

through a suitable operation such as summation, multiplication, or taking the maximum. For the latter, the index is said to be due to the PV with the largest subindex, and assumes its numerical value Once the AQI has been computed, it is communicated to the general public, with an appropriate health descriptor category.

Pollutant standards index (PSI): During the 1970's, air quality conditions were reported to the USA public by diverse, inconsistent AQI[8]. Thom and Ott[9] proposed the PSI in 1975 and it has been adopted with little change by the USA Federal Government since that time. Some characteristics of PSI are:

- it includes five PVs, measured over short averaging times (in parentheses): CO (8h), PM_{10}(24h), SO_2(24h), O_3(1h) and NO_2(1h).

- subindices are calculated from PVs using linear segmented functions, with the primary NAAQS and/or Federal Episode Criteria, and Significant Harm Levels as breakpoints.

- the overall PSI is calculated from the subindices by selecting the maximum value of all subindices.

- four health effect descriptions are employed:- good, moderate, unhealthful, very unhealthful, and hazardous and these are related to cautionary statements.

- the PSI value is reported daily and the critical pollutant is reported along with the index (together with other pollutants, if they violate NAAQS).

The long-term adoption of PSI in the USA has enabled a clear examination of urban area trends in air quality to be made[3]. When used with meteorological data, some understanding of the occurrences of unhealthful days is possible.

The Ontario Air Quality Index System (OAQI System): Critical reviews of AQI in Canada have been given[10,11]. The principal objective of the OAQI system, implemented in 1988[12,13] is to inform the public on the quality of the air in 27 cities, in real time. Its characteristics are:

- it includes 8 parameters from 6 pollutants, the sub-indices for NO_2, O_3, SO_2, CO, SP and total reduced sulphur (TRS) being based upon the respective 1-hour average level. The sub-index value for CO(8) is calculated based on the running 8-hour average level of CO. The final subindex, the Air Pollution Index (API), is calculated every hour from a combination of the running 24-hour average concentration levels of each of SO_2 and SP[14]. The API forms a basis for the control and regulation of air contaminant emissions.

- Except for API, the subindices are calculated from PVs using linear segmented functions. The breakpoints correspond to the descriptor categories:- very good, good, moderate, poor and very poor - and appear to be based, in part, upon both the Government of Canada AQO and the Government of Ontario Air Quality Criteria.

- The AQI is available by telephone and is released to the media and to the public 8 times daily, or hourly if the air quality is in the moderate category at any site. For a given hour, the AQI is said to be due to the parameter with the highest subindex and assumes its numerical value.

- The AQI descriptor categories are those of the subindices, and each carries a general description of possible health and environmental impacts.

- The public can access site-specific air quality forecasts, based upon the probability of occurrence of certain meteorological conditions.

AQI in China and India: The Chinese ambient air quality standards have been discussed[15]. The AQI in use in Shanghai, China[16], is derived from composite AQI and a standard-exceeding index of air pollution[17], based upon the PVs SO_2, NO_2, particulates and Pb. Mudri[18] has described an AQI in use in South India, based upon the geometric mean of subindices derived from the PVs dust fall rate, TSP, NO_2, SO_2 and sulphation rate.

Application of AQI to the HK context: In order to compare the descriptor categories for the ambient air in HK, and to evaluate the use of PSI and OAQI indices, these have been calculated, and are shown in Table 2, for a typical 24-hour period at Mongkok. We have omitted the PVs, O_3 and TRS and have assumed a conversion factor[5] between COH and $\mu g\ m^{-3}$ units for particulates.

Table 2: Ambient air conditions at the Mongkok air sampling site, 16 January 1992

Ambient Conditions	Daily mean windspeed and direction 0.8 ms^{-1}; 95 degrees Daily mean temperature 14.6 degrees Celsius		
Overall PSI index	51	Overall OAQI index	14
Descriptor category	Moderate	Descriptor category	Very good
Critical pollutant	SO_2	Cautionary statement	no effects
Cautionary statement	none issued		

Limitations to the AQI approach: If we employ an AQI then we should be aware of the limitations of its use. Although it is useful for daily public reporting and for following air quality trends and control strategies, the index only reflects the few acute air pollutants being monitored. Furthermore, the overall index may mask trends in component pollutants.

In HK, people spend much of their time indoors in an airconditioned environment and the ambient air quality differs from that outside. Also we note that most of the EPD air sampling sites in HK are at rooftop level and may not reflect acute air pollution in street canyons. Hunt[3] has described a relative risk model with which to assess chronic air pollution from carcinogens, which do not have AQO. We would need to include other factors such as sick building syndrome and the risk model for indoor radon to get a more comprehensive picture of air pollution.

CONCLUSIONS

1. It appears worthwhile to report air sampling data in HK in the form of an AQI. However, the general public should also be informed of the limitations of such an approach.

2. The PVs encompassed by the PSI appear to be more appropriate in the HK context than those of the OAQI, especially with reference to particulate matter and TRS. Since this index has been in use since 1975 in the USA, the comparison with HK data is of interest.

3. It appears reasonable to base the breakpoints of the index upon the USA EPA NAAQS, rather than substituting slightly different values from the HK AQO. The USA EPA air quality standards provide a complete range of breakpoints for the descriptor categories, except for NO_2.

4. We recommend that these PVs are sampled at each site by the HK EPD (with averaging times in parentheses): CO(8h), RSP(24h), SO_2(24h), O_3(1h) and NO_2(1h). There appears to be little point in sampling TSP since the health hazard effects are reflected by RSP measurements. We note that most indices in USA metropolitan areas are dominated by O_3 and CO[3].

5. A study of variation of AQI with the meteorological factors at selected sites should be undertaken, with a view to explain and forecast ambient air quality.

ACKNOWLEDGMENT

We thank Mr. R. Leung of the Air Services Group, HK EPD, for providing us with air sampling data.

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BACKGROUND LEVEL OF TRACE ELEMENTS IN SOILS OF MAINLAND CHINA

JS Chen, S Tao, BS Deng and XJ Wang
Department of Geography, Peking University, PRC

INTRODUCTION

Studies on the distribution of trace elements in soils are important for the assessment of environmental pollution. In response to the lack of reliable data, a national programme was carried out during 1986-90 to investigate the background level of trace elements in soils of mainland China. Soil samples were collected from 4,130 localities and the fraction finer than 2 mm was used for the chemical determination of 62 elements In this paper, the results of 13 trace elements of environmental concern Cu, Cd, Pb, Zn, Hg, As, Cr, Ni, Co, V, Mn, F, and Se are presented

MATERIALS AND METHODS

Sample collection: The sampling density used is variable according to the region ranging from 1 sample/415 km^2 in the eastern coastal provinces to 1 sample/6261 km^2 in the western provinces. In the Tibetan Highlands and the desert basins of Xinjiang, the samples were located close to vehicular routes. Table 1 shows the number of samples collected from each of the administrative regions of mainland China excluding 589 samples from municipalities including Beijing, Tianjin, Shanghai, Shenzhen, Xiamen, Ningpo, Wenzhou and Dalian

The 4,130 samples included both residual and transported soils The latter included desert sands, loess deposits, beach deposits and alluvial deposits

Table 1: *Summary of the number of samples collected from each of the administrative regions of mainland China excluding 589 samples from municipalities including Beijing, Tianjin, Shanghai, Shenzhen, Xiamen, Ningpo, Wenzhou and Dalian*

Administrative region	Number of samples	Administrative region	Number of samples	Administrative region	Number of samples
Hebei	148	Fujian	87	Guizhou	50
Shanxi	89	Jiangxi	73	Yunnan	73
Inner Mongolia	339	Shandong	117	Tibet	202
Liaoning	116	Henan	86	Shaanxi	60
Jilin	112	Hubei	92	Gansu	76
Heilongjiang	246	Hunan	507	Qinghai	115
Jiangsu	83	Guangdong	167	Ningxia	29
Zhejiang	76	Guangxi	150	Xinjiang	260
Anhui	70	Sichuan	118	Total	3541

Localities identified to be influenced by pollution and/or mining activity, and those within 200 m of roads were avoided.

Chemical analysis: Chemical analysis was conducted by 34 laboratories in universities and national research institutes. The selection of laboratories was based on an analytical quality control examination organized by a working group of analytical chemists.

The samples were dried at ambient temperature and pulverized to pass through a 200-mesh sieve prior to analysis. A summary of the analytical methods used for trace element determination and their detection limits are given in Table 2.

Table 2: *Summary of the analytical methods used for trace element determination and their detection limits*

Elements*	Digestion	Analytical method
Co (2), Ni (2), Cu (1), Mn (5), Zn (1), Cr (2 5), V (5)	HNO_3-HF-$HClO_4$	Flame atomic absorption spectrometry
Cd (0 002), Pb (1)	HNO_3-HF-$HClO_4$	Graphite furnace atomic absorption spectrometry
Se (0 002)	HNO_3-HF-$HClO_4$	Hydride generation atomic absorption spectrometry
As (0 5)	-	Spectrophotometry
Hg (0 002)	HNO_3-V_2O_5	Flameless atomic absorption spectrometry
F (5)	-	Selective ion electrode

* Values in parentheses are detection limits in mg/kg

Data analysis: Only geometric and arithmetic means are presented here because they are more readily comparable with data reported in the literature The arithmetic mean was used to estimate geochemical abundance using the technique of Miesch[1]. However, geometric means are better "maximum likelihood estimators" because of the tendency for elemental concentration in natural materials to be positively skewed[1] Because of this, the geochemical results obtained were logarithmically transformed The geometric mean is preferred as the best estimator of central tendency.

RESULTS AND DISCUSSION

Table 3: *Comparison between the geometric and arithmetic means of trace elements in soils of mainland China and the United States Values are in mg/kg*

Element	Mainland China			United States[2]		
	Number of samples	Geometric mean	Arithmetic mean	Number of samples	Geometric mean	Arithmetic mean
Cu	3938	20	23	1301	17	25
Cd	3947	0 074	0 097	-	-	-
Pb	3989	24	26	1134	16	19
Zn	3937	67	74	1239	48	60
Hg	4041	0 04	0 065	1263	0 058	0 089
As	3982	9 2	11	1249	5 2	7.2
Cr	3981	54	61	1310	37	54
Ni	3591	23	26	1190	13	19
Co	3293	11	13	1101	6 7	9 4
V	3874	76	82	1294	58	80
Mn	3990	432	582	1314	333	600
F	3987	440	478	998	210	430
Se	2904	0.22	0 29	1039	0 26	0 39

Mean concentration of trace elements in soils: Table 3 provides a comparison between the geometric mean and arithmetic mean of selected trace elements in soils of mainland China and the United States. Data for the United States are from a study of 1,319 samples from the United States[2]. The geochemical data of soils in mainland China are comparable to those of the United States since both countries are similar in size, latitude, climate and soil distribution. Both countries possess extreme climatic conditions, with deserts in the western part and a warmer, more humid climate in the southeastern part.

Both the geometric and arithmetic means for the selected trace elements in mainland China and the United States are found to be in close agreement. The relative error of the geometric mean for the majority of the 13 trace elements between the two countries varies from 8 to 25%. Only F is up to 35%. Cu, Pb, Zn, As, Cr, Ni, Co, V, Mn and As, are slightly higher in Chinese soils while Hg is slightly higher in the soils of the United States. These differences may have arisen from sampling and analytical variations between the two studies.

Regional variation in abundance of trace elements in soils: The results have revealed regional variation in trace elements in the soils of mainland China The transitional metals are found to be sensitive to differences in parent materials and climatic regimes under which the soils developed.

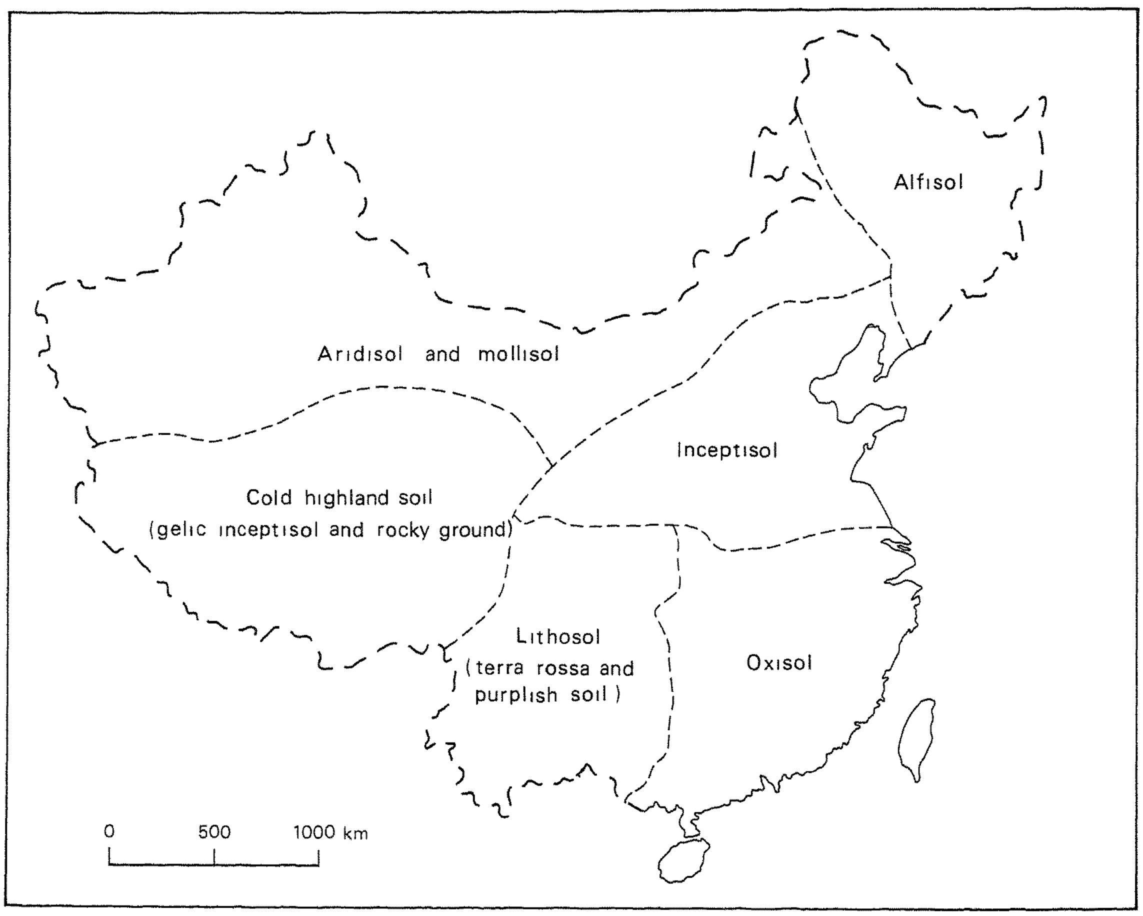

Figure 1: Distribution of soil orders in mainland China

Figure 1 shows the distribution of soil orders in mainland China. The geometric means of selected trace elements in soil orders of mainland China and the United States are given in Table 4. The means for the majority of the 13 elements in oxisols are the lowest, except for Hg, Pb and Se. The means of most elements in alfisols are the next lowest; while lithosols (terra rossa soils and purplish soils) have the highest mean values for all elements except Se. The cold highland soils (gelic inceptisol and rocky ground) have the second highest mean values for most elements. With the exception of Hg, the mean values of trace elements in mollisols and aridisols are about equal and are somewhat intermediate among the soil orders; all 13 elements for inceptisols are slightly higher than those for mollisols and aridisols. In general, the sequence of mean values according to soil order are: lithosol > cold-highland soils > inceptisol > aridisol > mollisol > alfisol > oxisol (Table 4). Correspondingly, the sequence in terms of regional division is: Southwestern China > Tibetan Highland > Xinjiang-Mongolia > Northern China > Northeastern China > Southeastern China (Figure 1).

Table 4: *Geometric mean of selected trace elements in soil orders of mainland China Values are in mg/kg*

Soil order	Number of samples	Cu	Pb	Zn	Cd	Ni	Cr	Hg	As	Co	Mn	F	Se	V
Lithosol	205	27	30	95	0.240	36	76	0.084	16	17	577	589	0.05	113
Cold-highland soil	196	24	26	79	0.098	31	70	0.021	16	12	619	490	0.19	78
Mollisol	240	10	18	60	0.070	22	46	0.022	9	11	563	378	0.14	67
Aridisol	108	22	19	60	0.087	24	48	0.011	8	12	582	394	0.11	69
Inceptisol	508	22	20	71	0.080	28	56	0.009	10	14	613	446	0.19	82
Alfisol	186	15	20	75	0.090	18	47	0.055	5	11	1127	366	0.16	69
Oxisol	262	11	26	34	0.030	10	34	0.040	6	6	197	281	0.33	56

The distribution of trace elements in the soil orders of mainland China is attributed mainly to the effect of climate and soil development. The high values of lithosols are caused by the indigenous elemental concentrations of the parent rock from which the soil originated For example, the purplish soils in the Sichuan Basin were developed from the purple shales which are characterized by high concentrations of trace elements. The high mean values in terra rossa soils may have been caused by the weathering properties and processes of the parent limestone. This is explained by the dissolution and leaching of the alkaline elements during the weathering of limestone with the residual clay accumulating some of the trace elements as a sink. Certain elements, such as Hg and Pb, are difficult to relate to climatic or soil formation factors because these elements are likely to be introduced into the environment through agricultural and industrial input.

ACKNOWLEDGEMENTS

This study would not have been possible without the cooperation of several hundreds of people from universities and national institutes Funding is provided by the Environmental Protection Agency of China We thank all persons who collected the samples and the chemists from the 34 laboratories who carried out the analytical work Computer programming of the data was carried out by the National Environmental Monitoring Centre We are also grateful to the scientists at the United States Geological Survey in Denver and the Savannah River Ecology Laboratory of the University of Georgia for hosting our travel in 1987 and for beneficial discussions

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INDOOR MONITORING OF NITROGEN OXIDES

MT Cheung
Chemistry Department, Hong Kong Baptist College

INTRODUCTION

Our project studied levels of NO_x, i.e. NO, N_2O, and NO_2 at various indoor habitats locally. The nitrous oxide, N_2O, which is mostly produced naturally via bacterial action on soil[1] and from upper atmospheric reactions, is an essential chemical constituent in tear-bombs; whereas NO and NO_2 are usually formed from the combustion of fossil fuels and other anthrogenic sources. The distribution of these toxic gases depend on the location, size, occupancy density and elevation of habitats from ground level together with weather conditions, and general habits of the residents[2].

Levels of these three gases were monitored weekly between 3-6 p.m. and 8-11 p.m. from February to April, 1989 at four selected sites, Kwun Tong (KT), Mongkok (MK), Homantin (HMT), and Yuen Long (YL).

EXPERIMENTAL TECHNIQUE

Sampling: The NO_x gases were adsorbed by drawing air at a flow rate of $0.25m^3hr^{-1}$ with a Dupont sampling pump through an orbo tube packed with two sections of activated silica gel, mesh 70-230. Simultaneously, temperature, relative humidity, and oxygen level were recorded on site. The trap system was set at a height of 3-m above ground in a bedroom, sitting room and dining room, away from any direct emission sources. Immediately after sampling, the orbe tubes were stored in air-tight bottles.

Sampling treatment: The silica gel was transferred into a sample vial, silicon rubber sealed, inside a glove box, constantly flushed with dry N_2. With the sample vial in a multi-block heater, NO_x was thermally desorbed at 90°C with a Hamilton syringe previously maintained at 90°C also and analysed with a HP 5890 GC coupled with a TCD. These conditions were observed throughout; molecular sieves column, 8', ⅛" O.D. No. 5A, 80/100 mesh; temperature programming, 35°C-170°C at 20°C min^{-1}; carrier gas, Helium, flow rate 30 ml min^{-1}; injector temperature, 110°C; detector temperature, 180°C and calibaration with Scotty-analysed standard NO_x gases.

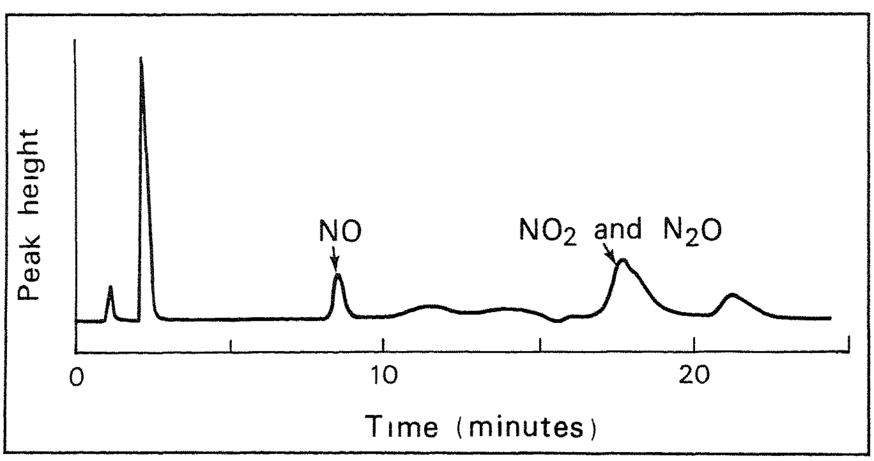

Figure 1: *The typical chromatogran of a sample* (simplified diagram).

Sampling analysis: From Figure 1, NO and N_2O could not be resolved and estimation of the relative concentrations of these species can be achieved by solving the following two equations:

$$\text{At} \quad R_T \text{ of } 17.93 \text{ min.} \qquad H_1 = E_1C_1 + E_2C_2 \qquad (1)$$
$$R_T \text{ of } 18.13 \text{ min.} \qquad H_2 = E_2'C_1 + E_2'C_2, \qquad (2)$$

where H_1 and H_2 are peak heights at the two retention times R_T's and the E's were evaluated from separate calibrations. The three NO_x were monitored and their levels are recorded in Figure 2.

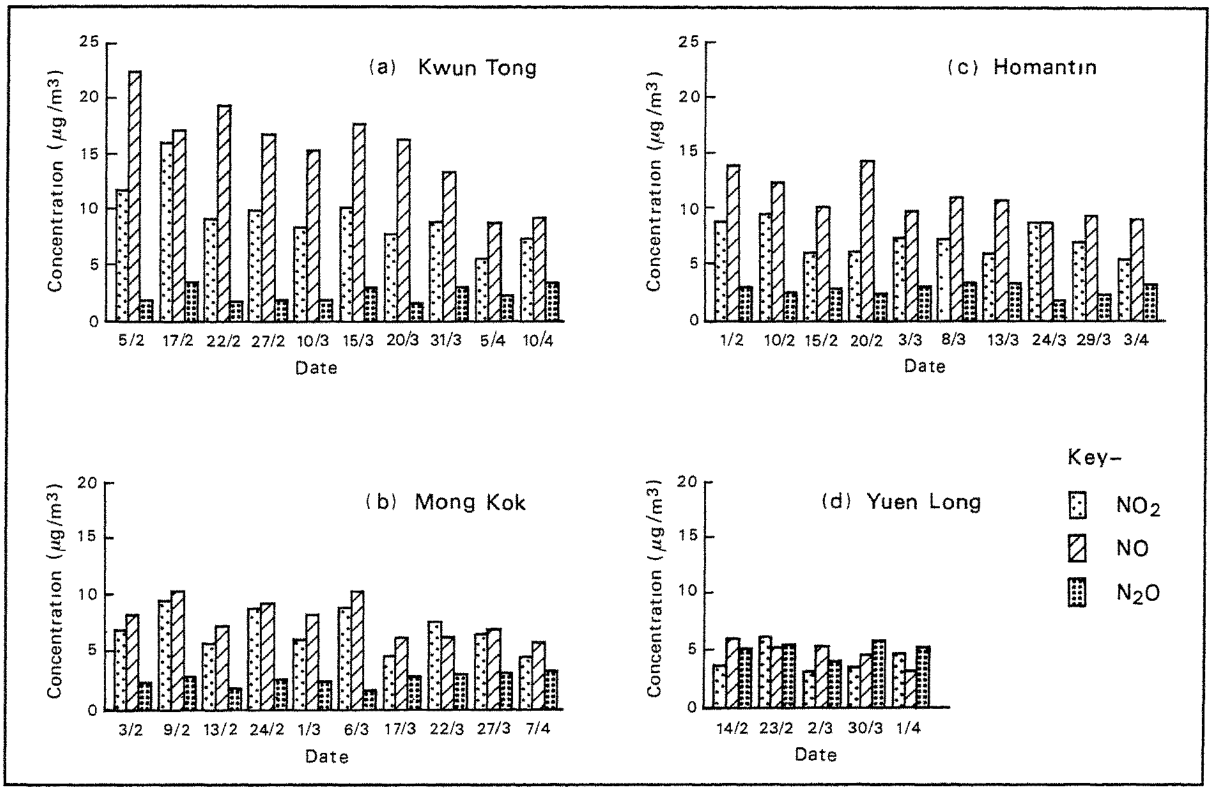

Figure 2: The graphical representations of the nitrogen oxides level at the sampling sites from February to mid April.

DISCUSSION

Complete adsorption of all the NO_x could be facilitated with the front section of the silica gel since analysis of the latter portion yielded negligibly small concentrations of all the NO_x's.

The N_2O, with a 0.25 ppm, is the most abundant species in the natural environment as compared with 0.0002-0.002 ppm and 0.0005-0.004 ppm reported for NO and NO_2 respectively[3] with a ratio of 125:1:2. However, the trend $NO>NO_2>N_2O$ has been demonstrated for all indoor residences except that at Yuen Long where the three oxides did not exhibit any significant discrepancies from each other. This upset is mostly due to anthropogenic sources in the urban districts. The NO_2, with a life time of three days, can be converted to NO via these routes:

$$3\,NO_2 + H_2O = 3\,HN_3 + NO \qquad (3)$$
$$N_2O + NO_2 = 3\,NO. \qquad (4)$$

Nitric oxide, NO, playing the role of a catalyst, is being regenerated; hence, the relative ratio is a good indicator of the extent of urbanization.

From our findings, Kwun Tong reported a maximum of 15.6 ugm^{-3} NO as compared with 10.9, 8.0, 5.1 ugm^{-3} for HMT, MK and YL respectively and the corresponding NO_2 values were 9.47, 7.2, 7.0, and 4.5 ugm^{-3} for KT, HMT, MK and YL respectively. In Hong Kong, with relatively high humidity and a fairly oily atmosphere, the N_2O levels were 9.40, 2.8, 2.6 and 5.4 ugm^{-3} for these four regions, which was about 3-4 times lower than those for NO and NO_2. There is one exception, YL, which is surrounded by trees and shrubs and is distant from industrial and commercial influences.

The four sampling sites differed from one another in building area, number of residents, geographic location, cooking and cleaning habits and elevation from ground level. The area source index can be evaluated for these sites as a means of comparison. Table 1 is a summary of the results.

Table 1: *Area sources and formation index of NO*

Sources	Measurement	District			
Si		KT	HMT	MK	YL
Human Occ.	# Res. x Occ. Time/day	1.583	2.29	1.082	1.75
Infil. of ext. air	A of window/ Total A of wall x ext. poll /ht.	0.303	0.117	0.167	0.187
Other emission sources	# Cooking & vent. equip. x ult. factor/d	0.1875	0.1875	0.125	0.058
Pot-plants	# of pot-plants	1	1	2	0
$S_i/A = S_T$	$S_1S_2S_3/S_4$, ppm m^3	(37.16)* $2\ 42{*}10^3$	(27.87) $1.8{*}10^3$	(74.32) $3.04{*}10^4$	(139.35) $1.36{*}10^4$
$\log \bar{k}$		(2201)** $\pm$ 1056 3 343	(860.4) $\pm$ 85 2.934	(360 2) $\pm$ 110 2.56	(73.4) $\pm$ 22 1.87

** $\bar{k}$ values, M, average value of k
** Area of residence, m

Reaction 5 resulted in the formation of nitric oxide, an intermediate oxide of NO_2 and N_2O, mainly due to anthropogenic origin. In the presence of oxidents, it is converted to NO_2 which in turn is retransformed back to NO when any reducing material is encountered.

$$NO_2 + M \rightarrow NO + MO \qquad (5)$$

The formation index of NO has been estimated and reported in Table 1.

$$k = [NO]^3 / [N_2O][NO_2] \qquad (6)$$

= formation index of NO. Temperature dependence has been neglected due to low temperature fluctuation within the monitoring period.

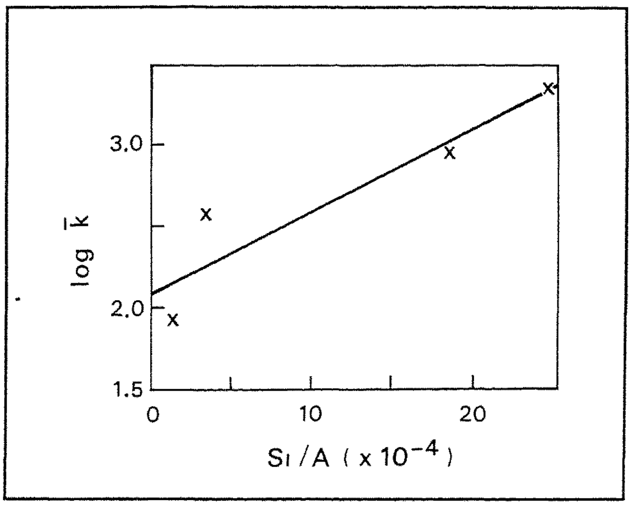

Figure 3: *Plot of log $\bar{k}$ vs. area sources.*

Figure 3 illustrates the plot of S_T and log $\bar{k}$ and shows a linear correlation between the two variables. The build-up of this acidic gas fluctuates according to the spatial design of the flat, human population, resident time, ventilating equipment and cooking devices together with the frequency of utilization of any generators, hence the formation index can serve as a good environmental quality indicator.

The fugacity of a gas both real and ideal can be defined as:

$$\ln f = G/RT + \lim_{f^o \to 0} (\ln f^o\ G^o/RT),$$

since the second term on the right is a constant at constant temperature. Therefore,

$$\ln f = G/RT \text{ and } d \ln f = dG/RT$$

Also, $dG = -RT \ln k$, and hence $d \ln f = -RT \ln k/RT = - \ln k$

On integration,

$$1/f = -f \ln k \pm f k'$$
$$1/f^2 = - \ln k \pm k'$$

From Henry's Law relationship, $f = KS$, where S represents the magnitude of emission sources; therefore,

$$(1/KS)^2 = - \ln k \pm k'$$

On generalization, $K\ S_1S_2S_3....S = \ln k \pm k''$ (4a)

with variable temp.[5], $K\ S_1S_2.....S = (\ln k \pm k')T,$ (8)

since $d\ln k/d(1/T) = -0$ where K = Henry's Law Constant f = fugacity of a gas

k = formation constant of a chemical reaction; k" and

k' = the integration constants

G = Gibbs free energy

T = absolute temperature, °K

f^o = fugacity at the standard states

R = gas law constant.

On plotting ln k versus $S_1S_2...S_n$, a linear correlation is obtained with an intercept k" and slope K which can explain the distribution of our NO gas in the local residences.

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DEVELOPMENT OF A PIEZOELECTRIC CRYSTAL SORPTION DETECTOR FOR CONTINUOUS MONITORING OF ORGANIC VAPOURS AT THE WORKPLACE

YS Fung
Department of Chemistry, University of Hong Kong

INTRODUCTION

Concern for workers exposed to organic vapours has led to the establishment of guidelines and threshold limit values (TLV) for regulating organic vapours of known health hazards at the workplace. As TLV values of most organic vapours which affect health are in ppb to ppm levels, very sensitive analytical methods are needed for monitoring. Continuous monitoring at such ion ppm levels requires the use of expensive and delicate equipment and this creates problems due to high capital and operating costs of such instruments, in addition to the fact that most of this equipment requires a special environment for its operation.

The development of the piezoelectric crystal sorption detector provides a suitable sensor for such application as it is relatively cheap, portable, sensitive and can be linked up with any alarm system installed[1 5]. It measures the change in frequency of the piezoelectric crystal upon adsorption of organic vapours in air according to the following Sauerbrey equation:

$$F = kF\,W/TA,$$

where
- F = change in resonance frequency of crystal system in MHz
- W = change in mass at piezoelectric crystal in µg
- T = thickness of crystal plate in cm
- A = area of the electrode in cm^2
- k = constant for a specific crystal depending on its dielectric, elastic and piezoelectric constants and on its density

As all the other terms are constant, the change in frequency is directly proportional to the change in weight. The equation can be simplified as follows:

$$F = k'w$$

The typical k' value is 0.4×10^6. For a 9 MHz detector constructed from a quartz disc of a typical dimension of 8 mm diameter and 0.15 mm thickness, a mass sensitivity of 500 Hz/µg is expected. Thus, with a frequency counter that can measure accurately up to 0.1 Hz, the detector is an extremely sensitive microbalance with a detection limit in the pg region. The above calculation is based on the establishment of equilibrium at the crystal surface. However, the dynamic flow injection method can offer comparable, if not better, sensitivity as compared to the equilibrium method. Moreover, as the method only requires a crystal with suitable sorbent, it is inexpensive and capable of automation and operation in an industrial environment.

This paper describes the development of the piezoelectric sorption detector for the monitoring of halogenated organic vapours used as solvents in industrial applications.

MATERIALS AND METHODS

Chemicals and materials: Most of the chemicals were of an analytical reagent grade and they were used without further purification. For coating materials, they were either synthesized in the laboratory (organometallic compounds) or obtained by gas chromatography. Most of the solvents studied were of technical grade in order to represent the actual industrial operation.

Apparatus: The 9 MHz AT-cut quartz crystals were supplied by the International Piezo Co. (HK) Ltd. and the frequency counter used was a Health Kit model IM 4120. The crystal oscillator circuit and the detector cell were home-made. A permanent record of the transient signal was obtained using the Tektronix storage oscilloscope model 5441.

Operational Procedures: The flow system for studying the piezoelectric crystal sensor is shown in Figure 1. For reducing the signal drift, the temperature for the piezoelectric detector was maintained at ±0.5°C and the variation of the gas flow rate for the blank and sample was adjusted by using two independent needle valves in two separate gas streams. The samples were introduced either by diffusion across a capillary diffusion tube at P1 or by direct injection at sample injection valve P4. Gases flowed through the two lines continuously with proper settings of the two teflon-glass three-way stopcocks at T1 and T2 so as to ensure continuous flow at P1 and P2. The two procedures investigated, were by continuous flow and flow injection.

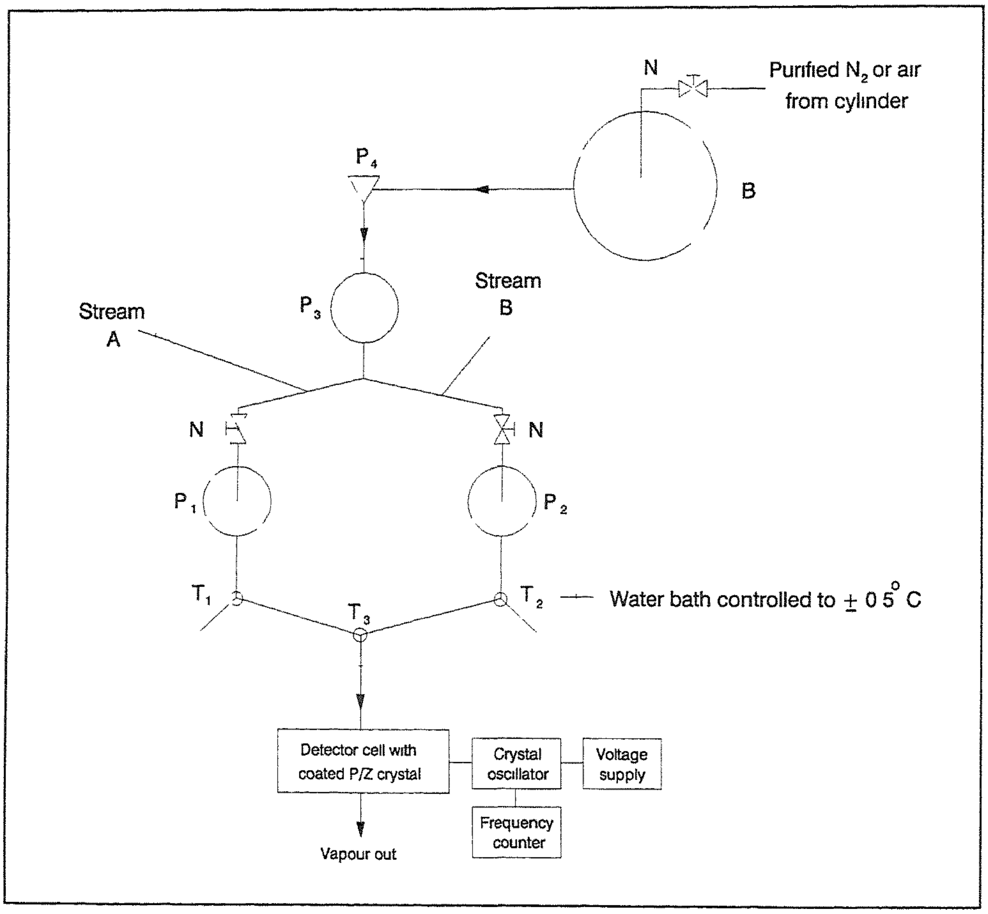

Figure 1: A schematic diagram of the experimental set-up for the study of piezoelectric sensor[5].
N, needle valve; B, round bottom flask 2 litre volume; $T_{1,2}$, teflon-glass 3-way stopcock, P_1, impinger containing the sample diffusion tube; P_2-P_3 empty impingers, P_4, sample injection valve

RESULTS AND DISCUSSION

Organic vapours studied: This study focussed on the development of a sensor for monitoring solvent vapours in workplace air. Particular attention was given to chlorinated hydrocarbon solvents such as 1,1,1 trichloroethane and trichloroethylene which are used widely in the metal-finishing and electronic industry for grease removal. These uses are of concern in Hong Kong due to the proximity of industrial and residential areas.

For any sensor developed to monitor organic solvents at the workplace, experimental error should be within ±0.1 TLV values. Other factors such as interference by other compounds, response time and recovery time are also considered in the selection of suitable coating materials.

Selection of suitable sorbent material for piezoelectric crystal detector: The success of the piezoelectric crystal detector depends on the sensitivity and selectivity of the coating material towards the analyte vapours. Both are strengthened by a suitable interaction between the sorbent and the vapour of interest. A strong interaction would lead to slow recovery time and signal drifting. However a weak interaction could lower the sensitivity of the method. Thus, traditionally, gas chromatography coating materials are frequently used as the sorbent due to a suitable interaction between the coating and the organic vapour. The problem is that there is a limited variety of suitable material which can be tested as sorbent coating.

The availability of organometallic compounds in recent years provides a large variety of potentially sorbent materials for use in piezoelectric crystal detectors. The interaction between organometallic compounds and organic vapours is well known and is used in homogeneous catalysis[6]. A suitable coating material using organometallic compounds with metal centres selected from Group VIII metals from the periodical table is appropriate. These metals are known to be reactive in the oxidative addition reactions. The reaction of selected organometallic complexes towards given compounds are shown in Figure 2. Differential interaction towards given vapours is clearly exhibited by different groups of organometallic compounds which is utilized for selectivity purposes. The sensitivity is considered sufficient for the majority of the organic vapours studied.

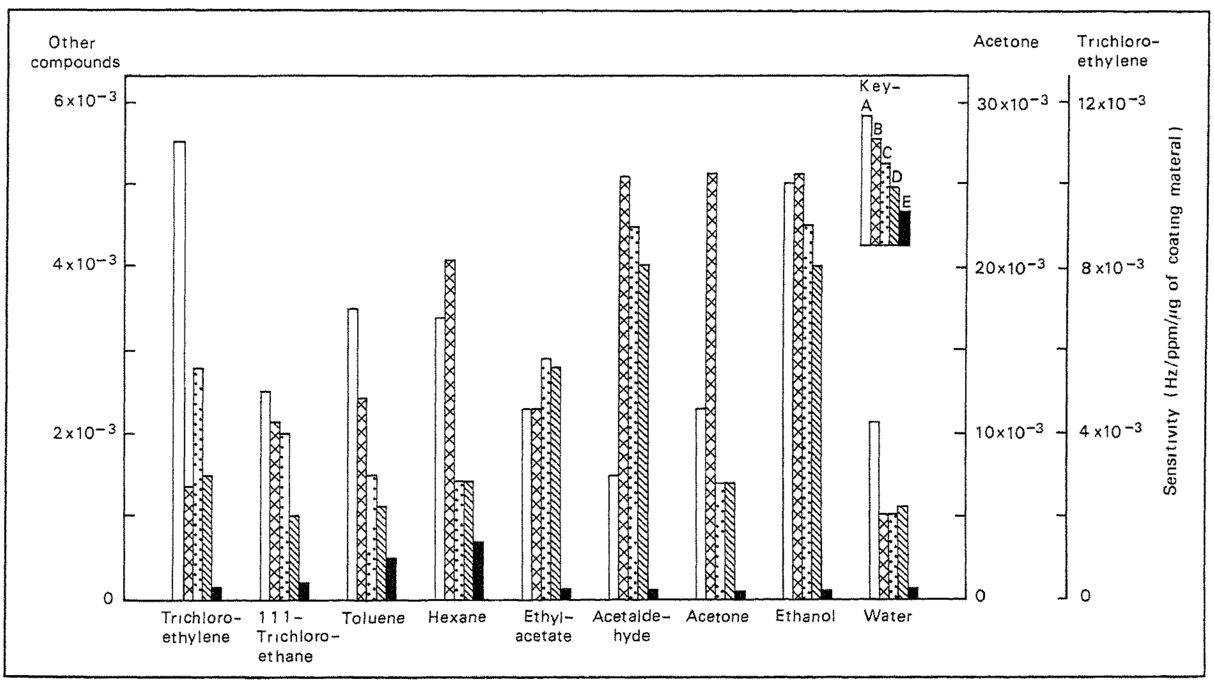

Figure 2: *Sensitivity of organometallic complexes towards various types of analyte vapours.*
A, $Rh(C_4H_9NC)_4Cl$; B, $Rh_2(TMB)_4Cl_2$, C, $Rh_2(DMB)_4Cl_2$, D, $Rh_2(TMB)_2(dppm)_2Cl_2$, E, $RhClCO(pph_3)_2$.

Optimisation of analytical parameters: The variation in the flow rate can affect the response of the piezoelectric crystal sorption detector. For continuous flow, the flow rate must be kept constant to avoid frequency drifting and to obtain good reading stability. The flow injection method was investigated, because the sample was introduced to the gas stream over a short period of time. The instrumentation for automatic injection is more complicated and the results obtained are in cycles within a specified time period. Thus, both the continuous flow and the flow injection methods are used under different conditions. In general, the response and recovery times are shorter and the detector response higher with a high flow rate (Figure 3). Both the response and recovery times were calculated as the time taken for the analytical signal to reach 98% of the equilibrium values when the sample was introduced or withdrawn from the system. Therefore a high and stable flow rate is employed with the use of the piezoelectric crystal sorption detector.

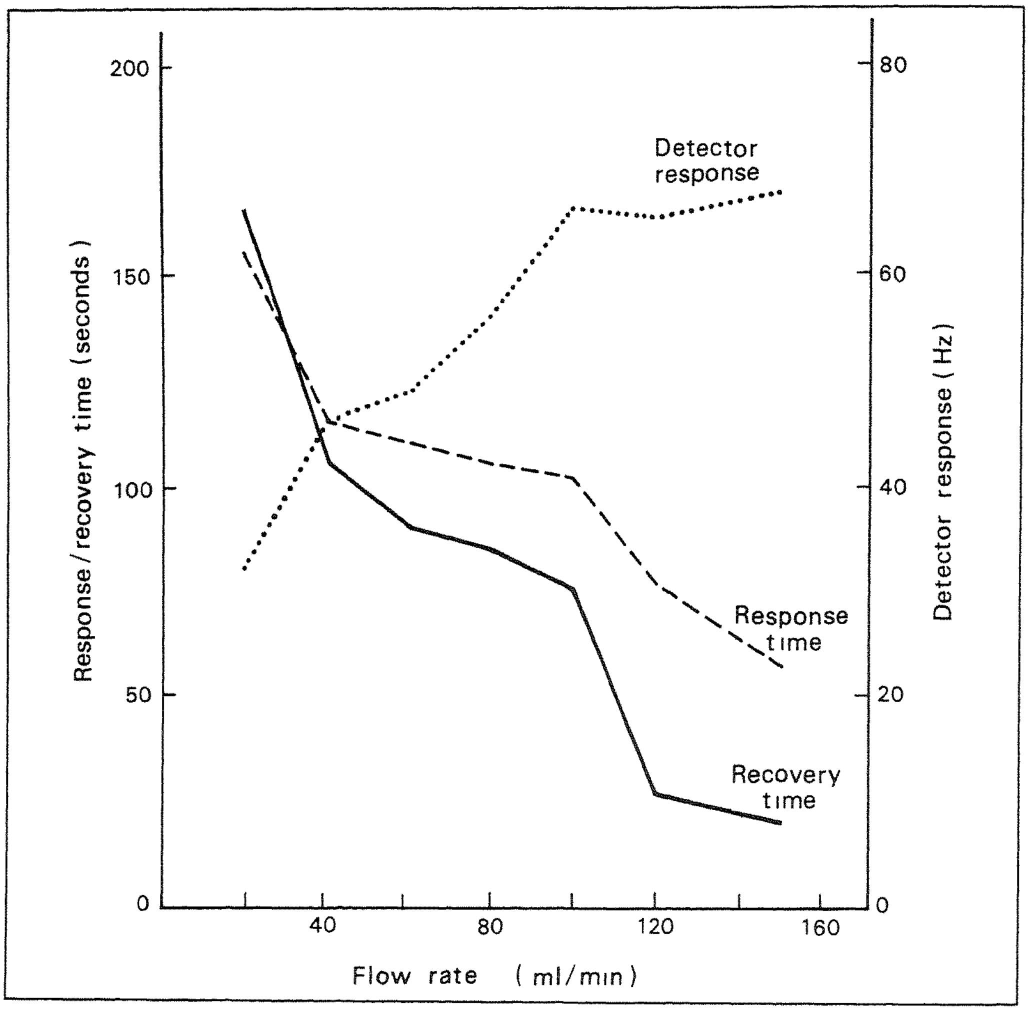

Figure 3: *The effect of flow rate on the detector response, response time and recovery time under experimental conditions of cyclohexanone at 125 ppm and tritolyl phosphate at 26 μg)*

Table 1: *Analytical parameters of the piezoelectric crystal sorption detector for organic vapours and water*

Analytical parameters	Analyte				
	Formaldehyde	1,1,1-trichloroethane	Trichloroethylene	Cyclohexanone	Water
Working Range	2 ppb - 2 ppm	13.5 - 1200 ppm	3 - 700 ppm	1 8 - 140 ppm	7 5 x 2000 ppm
Sensitivity (Hz/μm/ppm)	16	1 9 x 10^3	6 x 10^3	2.3 x 10^2	4 x 10^2
Response time	2 5 min	< 10 sec	1 min	100 sec	6 min
Recovery time	3 min	40 sec	1 min	75 sec	7 min
Sorbent	Chromotropic acid	d-n-decylphthalate	$[Rh_2(DMB)_4]Cl_2$	Tritolyl phosphate	gelatin
TLV (ppm)	1	350	50	25	

Table 1 shows the results of the application of the piezoelectric crystal sorption detector for monitoring organic vapours. In comparison the results with the TLV values specified for these compounds in the workplace, the working range is at least 10% of the TLV values at the lower detection limit and much higher at the upper end. The sensitivity is satisfactory and the response and recovery times are reasonable for monitoring the change in concentration during operation.

Industrial application of piezoelectric crystal sorption detector: The piezoelectric crystal sorption detector can be used for monitoring in two industrial areas. Firstly at the workplace to monitor continuously specified TLV values of halogenated organic solvents commonly used in factories in Hong Kong. Secondly to monitor the exit of exhaust ducts after the vapours are specified process such as clearing with activated carbon. After removal of organic vapour, air may be recycled in the factory to ensure reduce the cost of air conditioning. The detector is useful for monitoring the quality of the recycled air.

The cost of the equipment is low because only air pumps, flow regulating devices, a frequency counter and a piezo-electric crystal costing about US$10 each are required. All the components are readily available and no expensive or sophisticated instruments are needed. The lifetime of the piezoelectric crystal is long and is in the order of months. No special operator skill is required except for regular calibration using standard organic vapours.

In summary, the piezoelectric crystal sorption detector is found to provide a suitable sensor for the monitoring and control of organic vapours as it is relatively cheap, sensitive and useful in the industrial environment. Suitable detectors were developed for the monitoring of halogenated hydrocarbon, formaldehyde and cyclohexanone in the workplace air. The analytical parameters obtained for the piezoelectric crystal sorption detectors developed are capable of meeting demand for industrial application.

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EFFECTS OF SOME STANDARD FIXATIVES ON FISH GILL MORPHOLOGY

M Shepherd and W Ivantsoff
School of Biological Sciences, Macquarie University, Australia

INTRODUCTION

The initial aim of the study was to determine the most appropriate fixative for gills of some Australian native fishes. Four standard fixatives were chosen with some variations to buffering and concentrations. It was found that many of the gills had altered morphology that has previously been reported to be induced by toxicants and other aquatic pollutants. Gill pathology is commonly used as an indicator of pollution. The types of lesions induced by toxicants and other irritants from 130 studies have been summarised[1], but fixation procedures for gill tissue varied considerably between authors. In this study, it appears that the fixatives themselves induced artefacts that have previously been attributed to pathogenicity.

MATERIALS AND METHODS

The site of collection, Smith's Lake (32° 24'S, 152° 22'E) is situated 130 km north of Newcastle, N.S.W., Australia, with an area of 10 km^2. There are no industrial sites and only about six private residences in the catchment area. A minimal amount of tourist activity is present at the eastern end, where the lake is separated from the sea by sand barriers. For these reasons it is considered that the lake is relatively pristine. Fish including mullets, silversides and whitings were captured by beach seine from identical environmental conditions e.g., salinity, water temperature etc. After capture, fish were held for a maximum of 10 minutes in lake water, removed one at a time and killed by severing the spinal cord behind the head. The second gill arch on the left side of each fish was removed, cut into small pieces and immediately placed in the fixatives consisting of 10% formalin, Bouin's solution, 1:1 3% paraformaldehyde : 3% glutaraldehyde, 3% or 2% glutaraldehyde in 0.1M sodium cacodylate buffer either with 3% or 2% sucrose or without. Gills were fixed for two hours at 4°C, preserved until returned to the laboratory for approximately 2 days and then dehydrated and embedded in Spurr's resin. 3μm thick sections were cut using a glass knife, mounted and then stained with 1% toluidine blue.

RESULTS

Some of the lesions reported to have been toxicant or irritant-induced, can also be induced by the fixatives themselves. The effect of a particular fixative varied between species. Under the same conditions of capture and fixation the gills of *Atherinomorus ogilbyi* (Figures 1a,b) had gross epithelial lifting, whilst those of *Myxus elongatus* (Figures 2a,b) had a crenated epithelium and loss of structural integrity. This indicates that there is a different reaction of gill tissue to 10% formalin between species. In Figures 5a,b and 8a,b the same initial fixation using 3% glutaraldehyde in 0.1M cacodylate buffer with and without 3% sucrose, produced good fixation with only slight epithelial shrinkage in *Myxus elongatus*, whereas terminal channel aneurism and mucous secretion were produced in *Sillago ciliata* (Figures 4a,b). Terminal channel aneurism has been associated with the methods of euthanasia by stunning, decapitation and cervical spine severance[2]. However, all species in this study were killed by severing the spinal cord behind the head, but only one species had terminal channel aneurism. Slight variations to concentration of the fixative, glutaraldehyde in 0.1M cacodylate buffer with sucrose, produced a crenated epithelium in one fish (2% solution, Figures 6a,b) but only slight shrinkage in another of the same species (3% solution, Figures 5a,b). When the 3% solution was used with paraformaldehyde for the same species, the epithelium was again crenated, (Figures 7a,b). All species showed some degree of epithelial lifting with Bouin's solution (Figures 3a,b). Other types of changes such as mucous cell proliferation (Figures 6a,b) and lamellar fusion (Figures 7a,b), which are not fixation artefacts, were also found in the same group of fishes from the unpolluted lake.

DISCUSSION

Some of the gill lesions (Figures 1 - 8) have been reported as being toxicant or irritant induced[1]. Epithelial crenation and shrinkage, although not specifically known to be toxicant induced, leads to a decrease in the water-blood barrier distance, a measurement that is frequently used in morphometric studies of toxicant induced change[3]. The results of this study indicate that several types of lesions can be induced by the fixatives themselves. On the other hand, formalin fixed gill tissue had a significant increase in percentage of epithelial lifting when compared with Bouin's solution (49.7 versus 26.6%)[4]. While this was found generally to be true in this study, it did not apply to all species studied. *Myxus elongatus* showed a crenated epithelium and loss of structural integrity when fixed with 10% formalin.

It is known that the osmotic pressure of tissue fluid and blood can not only vary between species, but also within a species when under differing conditions, such as salinity. The reported lesions of lamellar aneurism, epithelial lifting, shrinkage and crenation are probably due to a difference in osmotic pressure between the fixative and the blood and tissue fluid in the gills. Therefore, a fixative that is hypertonic relative to the gill tissue could produce epithelial shrinkage and crenation and terminal channel aneurism, whilst a hypotonic fixative would produce epithelial lifting.

The site of collection was considered to be pristine, yet two further types of lesions, lamellar fusion and mucous cell proliferation, were found in fish from the same area. Specialised cells in the primary and secondary lamellae, i.e. chloride and mucous cells, arise from existing basal cells, needing approximately 24-48 hours to differentiate and move out to the secondary lamellae [5 7]. Therefore these lesions are not fixative induced and this then poses the question of how common these lesions are in a normal population of fish.

CONCLUSIONS

When using altered morphology as an indicator of polluted habitats, the most suitable fixative for a particular species and for tissue type must first be investigated. It would be advantageous to determine the osmotic pressure of the blood and tissue fluid of the fish to be studied so that the fixative can be buffered to be isotonic with the fish tissue, thereby eliminating this class of artefact. Large sample sizes must be used to evaluate the abundance of naturally occurring lesions within a normal population.

ACKNOWLEDGEMENTS

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FIGURE LEGENDS

Figures 1a & 1b: *Gross epithelial lifting* Species - *Atherinomorus ogilbyi* - Atherinidae Fixative - 10% formalin

Figures 2a & 2b: *Crenated epithelium with loss of structural integrity* Species - *Myxus elongatus* - Mugilidae Fixative - 10% formalin
Note the different effects between species using the same fixative (Figures 1a, b and 2a, b)

Figures 3a & 3b: *Moderate epithelial lifting* Species - *Atherinomorus ogilbyi* - Atherinidae Fixative - Bouin's solution
All species showed some degree of epithelial lifting with Bouin's solution

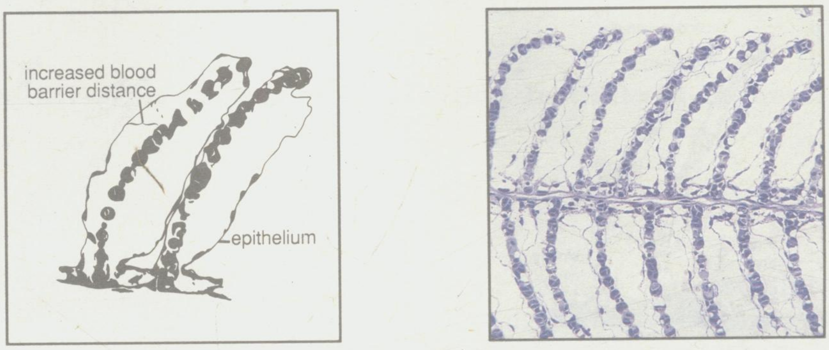
Figures 4a & 4b: *Terminal channel aneurism, mucous secretion Species - Sillago ciliata - Sillaginidae Fixative - 3% glutaraldehyde in 0 1M sodium cacodylate buffer with 3% sucrose, post-fixed in osmium tetroxide*

Figures 5a & 5b: *Slight epithelial shrinkage* Species - *Myxus elongatus* - Mugilidae Fixative - 3% glutaraldehyde in 0 1M sodium cacodylate buffer with 3% sucrose, no post-fixation
This is considered the best fixative of those used for this species, although it is still not ideal Note the difference between species using the same initial fixative (Figures 4a,b and 5a,b)

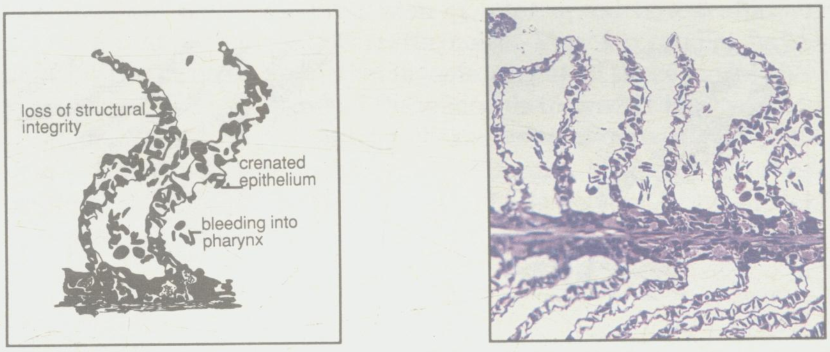
Figures 6a & 6b: *Crenated epithelium, mucous cell proliferation* Species - *Myxus elongatus* - Mugilidae Fixative - 2% glutaraldehyde in 0 1M sodium cacodylate buffer with 2% sucrose, no post-fixation
Note that the 2% solution of the fixative produced a crenated epithelium, whereas the 3% solution of the same fixative (Figures 5a & 5b) produced shrinkage of the epithelium in the same species These gills also show proliferation of mucous cells along the secondary lamellae which is not attributable to fixation, but usually to toxicant induced change

Figures 7a & 7b: *Crenated epithelium* Species - *Myxus elongatus* - Mugilidae Fixative 1 1 3% paraformaldehyde 3% glutaraldehyde
These gills also show fusion of secondary lamellae, usually associated with toxicant induced change, and is not attributable to the fixation process

Figures 8a & 8b: *Shrinkage of epithelium* Species - *Myxus elongatus* - Mugilidae
Fixative - 3% glutaraldehyde in 0 1M sodium cacodylate - no sucrose
Shrinkage of the epithelium leads to a decrease of the water-blood barrier distance, a measurement that is often used in toxicity studies



Figures 1a & 1b



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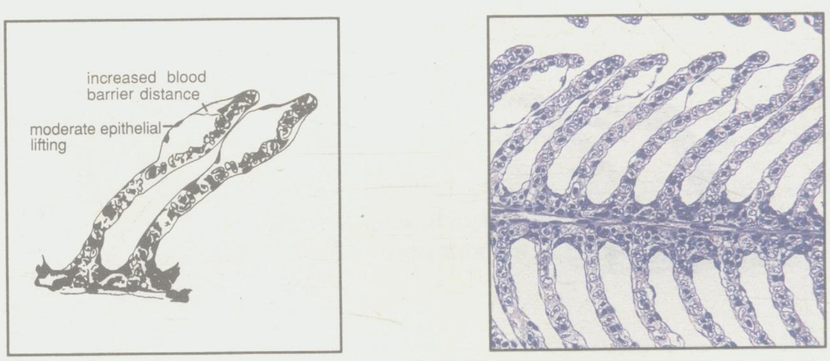
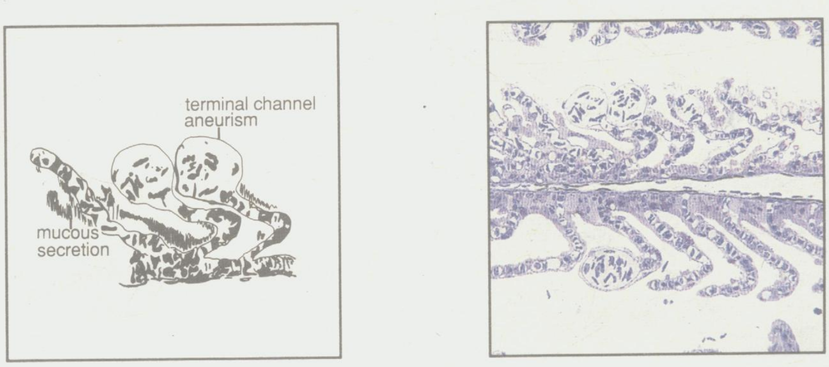


Figures 3a & 3b



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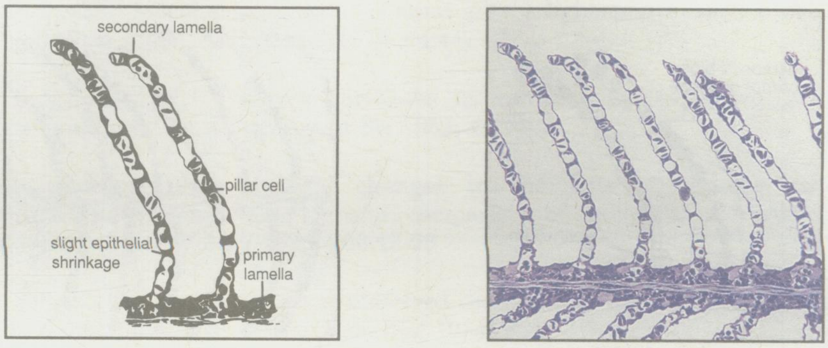
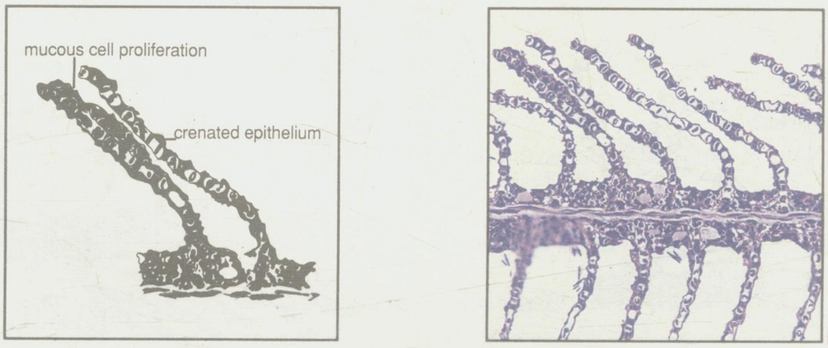
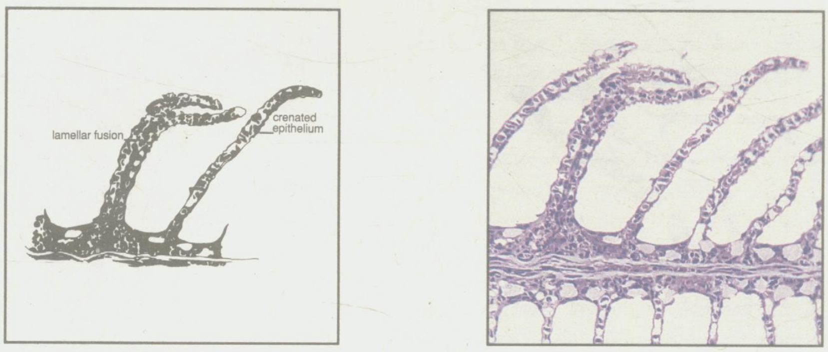


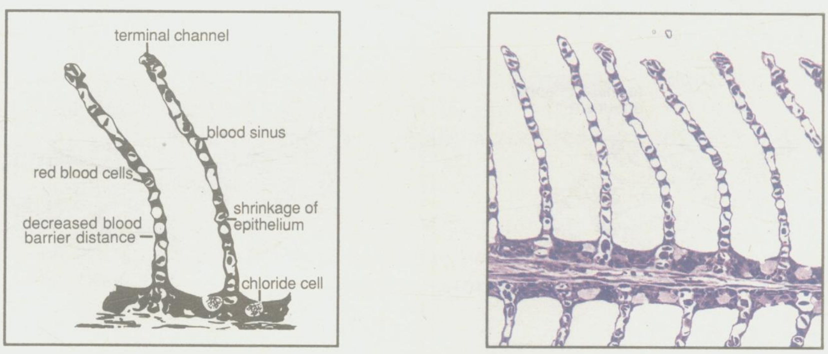
Figures 5a & 5b



Figures 6a & 6b



Figures 7a & 7b



Figures 8a & 8b

SIMULATION OF URBAN TRAFFIC NOISE ON THE ENVIRONMENT

P Pamanikabud
Department of Civil Engineering, King Mongkut Institute of Technology, Thonburi, Bangkok

INTRODUCTION

Traffic noise in urban area[5], especially the central business district (CBD), has different characteristics to traffic noise generated by freely flowing traffic on a highway on. CBD roads a stop/go pattern traffic flow is the norm whereas in contrast, traffic on a highway has a continuous flow pattern. In addition, different surroundings between CBD roads and highways such as carriage width, road side buildings, and road intersections in the vicinity contribute to the differences. The simulation model for prediction of interrupted flow traffic noise is, therefore, different in nature from that of the free flow traffic noise. Very few studies have been done in the area of interrupted flow traffic noise prediction models, and all of these models have been built and tested in western countries. The efficiency of these models to predict interrupted flow traffic noise in an urban area of an Asian city, where the characteristics of vehicle types and composition together with surrounding conditions are generally different, is worthy of investigation together with the building of an effective interrupted flow traffic noise simulation model for Asian urban traffic.

SCOPE OF THE STUDY

This study project was aimed at the development of an interrupted flow traffic noise model that could be used efficiently for the prediction of traffic noise in the central business district of Singapore.

THE EXISTING MODELS

The three existing models, which were developed to predict interrupted flow traffic noise in the United Kingdom, were used in the early stages of investigation and model development of this study. The mathematical formulae of these three models is presented as follows:

Edinburgh Model:

$$L_{10} = 55.2 + 9.18 \log Q(1 + 0.09\ PH) - 4.2 \log Vy + 2.3\ T,$$

where L_{10} = traffic noise level in dBA that exceeds 10% of the measuring time period (1 hour)
Q = traffic volume (veh/h)
PH = proportion of vehicles exceeding 1.5 tons (%)
T = index of dispersion (ratio of variance to the mean number of vehicles arriving over a 10 second interval)
V = mean speed of traffic (km/h)
y = carriage width (metres).

Sheffield Model:

$$L_{10} = 51.51 + 10.5 \log Q(1 + 0.04\ PH) - 5.71 \log (d_k + 0.5\ y) + 2.38 \log G,$$

where d_k = distance from noise meter to edge of kerb (metres)
G = 1, or percentage gradient, whichever is larger.

Gilbert et al. Model:

$$L_{10} = 43.3 + 11.02 \log (L + 9M + 13H) - 0.43\, y + 2.42/d_f,$$

where d_f = distance from nearside kerb to nearside facade (metres) and $d_f > 1$

L = number of light vehicles (< 1525 kg) (veh/h)

M = number of medium goods vehicles (1525 - 4500 kg) (veh/h)

H = number of heavy goods vehicles (> 4500 kg) (veh/h)

MATERIALS AND METHODS

Data for this study were collected from 20 signalised intersection sites in Singapore CBD which constituted about 15% of the total CBD'S signalised intersections. The CBD area and locations for data collection are shown in Figure 1. Noise levels, traffic speeds, traffic volumes, and composition of traffic flow were collected. Various measurements of the road geometry and surrounding conditions such as road widths, distances from kerbside to noise receiver, distances from receiver to facade, accelerations and decelerations of traffic flow were also taken. A one-hour period traffic noise level and its corresponding volume and composition were taken during the morning peak, and off-peak hours of the day at these 20 designated sites, hence a total of 60 noise level measurements were taken for this study project.

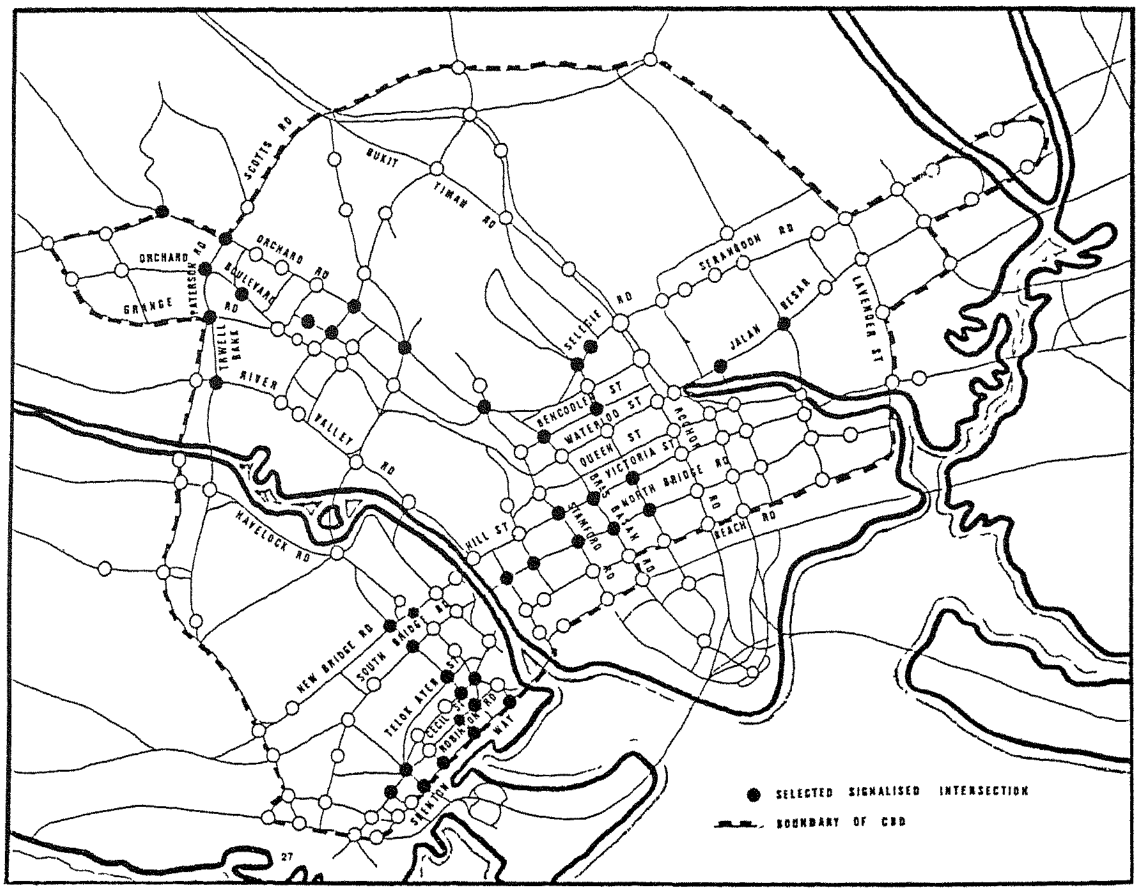


__Figure 1:__ Central business district of Singapore and locations of data collection.

RESULTS

Collected data were used to calculate the predicted noise level in L_{10} (1-hour) using the 3 existing models. Goodness of fit was examined between the predicted L_{10} and measured L_{10} from the field data. Two approaches were used to examine this relationship, namely, a graphical method and paired t-test. For the graphical method, predicted noise values were plotted against measured values and the results examined for goodness of fit against a 45 degree or equivalent line. This graphical test showed that all of these 3 models over-estimated values of L_{10} in comparison with the field measurement values. The model which produced the smallest deviation in predicted L_{10} from measured data was that of Gilbert et al. model, in which 97% of the data points fell within the 95% confidence interval band compared with 62% for the Edinburgh model and 2% for the Sheffield model, respectively.

A paired t-test was also carried out on the differences between the predicted results from the model and the measured results from the field data. The null hypothesis was μ_o = o, that is, the mean value of the difference between pairs of measured noise and predicted noise measurements was equal to zero. The results from the paired t-test at a significance level of 5% and 59 degrees of freedom showed that the null hypotheses for these 3 models were rejected. Therefore, all of these 3 existing models could not be considered a good representation of the actual measured noise values from Singapore CBD. The Gilbert et al model had the lowest t-value at 9.58 in comparison with 40.9 and 42.0 for the Edinburgh and Sheffield models respectively. The statistical results on these 3 models were similar to those of the graphical tests. These results are shown in Table 1.

Table 1: *Comparison of three existing models*

	Model		
Statistical Functions	Edinburgh	Sheffield	Gilbert
Mean	3.69	5.53	1.27
Standard Deviation	0.70	1.02	1.02
t-Value	40.9	42.0	9.58
R	0.75	0.76	0.73
R^2	0.56	0.58	0.53

THE DEVELOPMENT OF A NEW MODEL

Improvement of Existing Models: Improvement was made to the 3 models using statistical modification. Each parameter and group of parameters used in these models was investigated using a correlation test against measured noise level. Several additional parameters were also tested for goodness of fit when included in the model. A stepwise multiple regression was performed on the three modified models, and the results showed that an additional parameter, inverse distance from kerb edge to facade ($1/d_f$) should be added into modified Edinburgh and modified Sheffield models in order to improve their performance. No change was found in the parameters of the modified Gilbert et al. model. The coefficient of multiple determination R^2 of these modified models was improved substantially to about 0.80. Comparison of the details of the existing and modified models are shown in Table 2.

Table 2: Comparison of existing models and modified models for predicted L_{10} (1-hour) values

Model	Existing Model	Modified Model
Edinburgh	55 2 + 9.18 log Q(1 + 0 09 PH) - 4.2 log Vy + 2 3 T	54.8 + 8.13 log Q(1 + 0.09 PH) - 3 09 log Vy + 4.66/d_f
Sheffield	51 51 + 10 5 log Q(1 + 0 04 PH) - 5.71 log (1 + 0.5 y)	52.7 + 8 12 log Q(1 + 0.04 PH) - 3 81 log (1 + 0 5 y) + 3.24/d_f
Gilbert et al	43 3 + 11.02 log (L + 9M + 13H) - 0.43 y + 2 42/d_f	49 6 + 7.67 log (L + 9M + 13H) - 0 07 y + 4.22/d_f

Modification of Selected Model: The Modified Gilbert et al. model was selected for further development in an attempt to improve its prediction efficiency, since it had the highest $R^2 = 0.82$ and also because of the model's simplicity. The plot of measured L_{10} and predicted L_{10} of the Modified Gilbert et al. model from the graphical test is shown in Figure 2. The Modified Gilbert et al. model was further modified by the application of proportional weighting values from the Illinois Department of Transportation study of light, medium, and heavy vehicle parameters together with a change in the parameter $1/d_f$ to $\log(d_f)$ which provided a higher correlation to the L_{10} noise level.

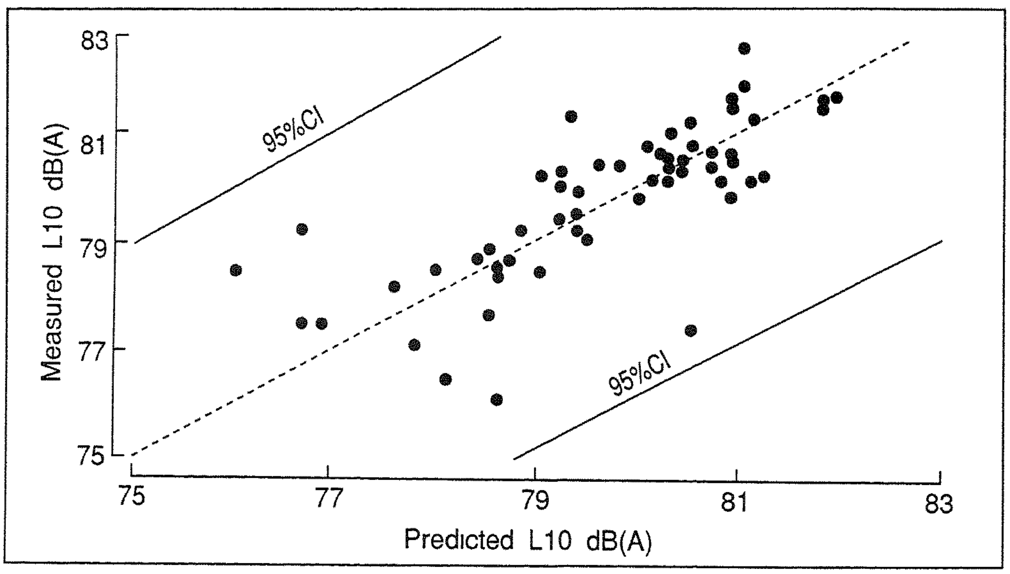


Figure 2: Plot of measured L_{10} and predicted L_{10} from the modified Gilbert et al model
$L_{10} = 49\ 6 + 7\ 67 \log (L + 9M + 13H) - 0\ 07\,y + 4\ 22 / d_f$

Statistical Analysis of the New Model: Stepwise regression using linear multiple regression analysis was applied to this new set of parameters, and the results of this "new" modified model are as follows:

$$L_{10} = 51.5 + 8.51 \log(L + M + 3H) - 0.081\,y - 0.421 \log(d_f)$$

where L_{10} = predicted traffic noise level in L_{10} (1-hour)
L = volume of light vehicles (< 1525 kg) (veh/h)
M = volume of medium goods vehicles (1525 - 4500 kg) (veh/h)
H = volume of heavy goods vehicles (> 4500 kg) (veh/h)
y = carriage width of road (metres)
d_f = distance from kerb edge to facade (metres).

This new modified model gave the highest R^2 value of 0.84 when tested by ANOVA. Results of the ANOVA test are given in Table 3.

Table 3: *Results of the ANOVA Test for the 'New Modified' Model*

R^2	R	SE	F-Statistic	Prob > F
0.84	0.92	0 6	2 21	0 1429

Graphical tests and paired t-tests for these 4 modified models were also carried out and the results showed that the new modified model fitted best the 45 degree equivalent line in the graphical test, gave the smallest standard deviation of 0.57 and a t-value of 0.10 in the paired t-test. Results of the graphical test and paired t-test for the new modified model are shown in Figure 3 and Table 4 respectively.

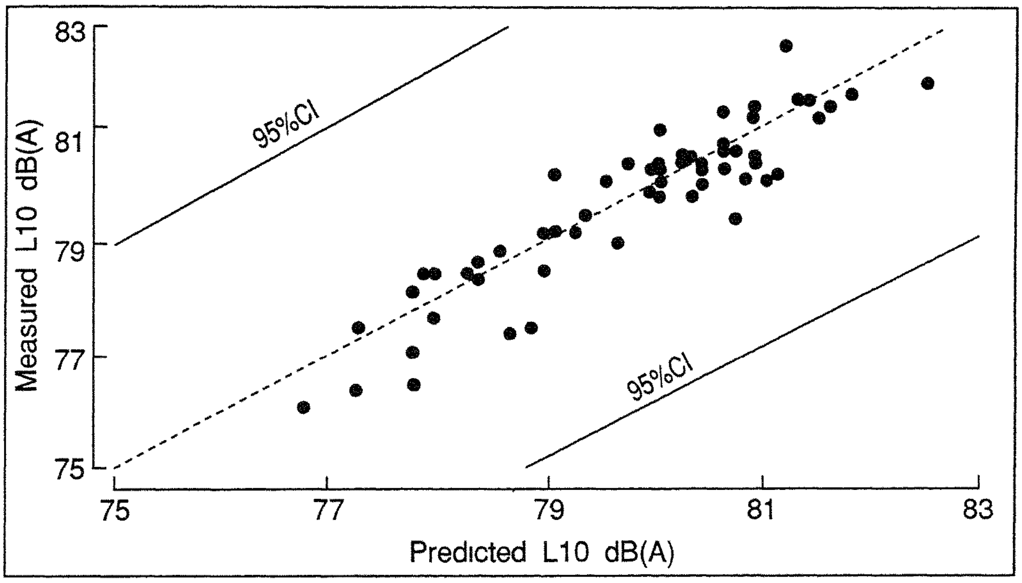


Figure 3: *Plot of measured L_{10} and predicted L_{10} from the 'new modified' Model*
$L_{10} = 51\ 5 + 8\ 51 \log (L + M + 3H) - 0\ 081\ y + 0\ 421 \log (d_f)$

Table 4: *Results of the Paired t-test of the 'New Modified' Model*

	Modified 'Gilbert et al' Model	'New' Modified Model
Mean	-0 02	0 007
SD	0 76	0 57
t-Value	0 20	0 10

CONCLUSION

From the results of this study, the "new" model which was developed proved to be the most suitable interrupted flow traffic noise forecasting model for traffic in the central business district of Singapore. This model also improved the overall accuracy of interrupted flow traffic noise prediction in comparison with the performance of existing models.

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INVESTIGATION INTO THE HAZE EPISODES IN THE KELANG VALLEY, MALAYSIA

AA Samah
Department of Geography, University of Malaya

INTRODUCTION

The severe haze episodes of August 1990 and September-October 1991 have increased awareness of air pollution and the need for pollution control in Malaysia. In all cases where severe haze occurred the synoptic situation observed was that of a prolonged dry period. The haze dissipated in the region as the weather was influenced by convectional instabilities accompanied by thunderstorms. During this dry period, the insolation induced land sea breeze circulation and, as shown by Samah and Lim[1], the diurnal variation of air pollutants in the west coast of Peninsular Malaysia can be simulated by inculcating the surface land-sea breeze circulation into the Air Resources Atmospheric Turbulence and Diffusion Laboratory (ATDL) model[2]. If the ATDL model had a pollution sink of 50% of the daily emission, the rate of daily build up would exceed the level observed during the haze episode of August 1990[1]. This is due to the lack of explicit representation of vertical advection. Based on the continuity relationship[3], and incorporating the land sea breeze circulation it was seen that the daily build up predicted was of the same order of magnitude as that observed (Figure 1). The simulation showed the importance of land sea breeze circulation in the transport of air pollution in this region.

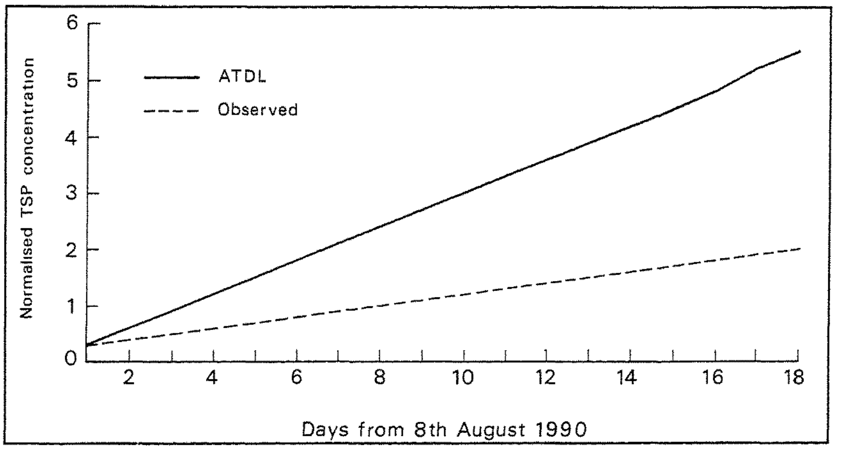

Figure 1: *Comparison of the observed daily build up of haze with that predicted by the ATDL model.*

SOURCES OF THE HAZE

A Landsat imagery of the haze over the Kelang Valley clearly illustrated the sources of the haze in August 1990. The haze was observed to be located in the vicinity of the major highways around the Kelang Valley. A plume from agricultural burning was also observed originating in the northeast sector. The effects of the land breeze could be deduced from the seaward advection of the plume. The main sources of this haze were vehicular emissions and agricultural burning.

Haze usually occurs due to the scattering and absorption of sunlight by fine suspended particulates in the atmosphere. Figure 2 depicts the daily build up of total suspended particulates (TSP) in the Kelang Valley during the haze episode of August 1990. It shows a build up rate of approximately 13% per day with the particulate concentration doubling from an initial concentration of 120μg/m^3 on the 16th of August to over 400 μg/m^3 on the 27th of August. From 28-30th August there was rapid abatement of the haze associated with the onset of convective instabilities.

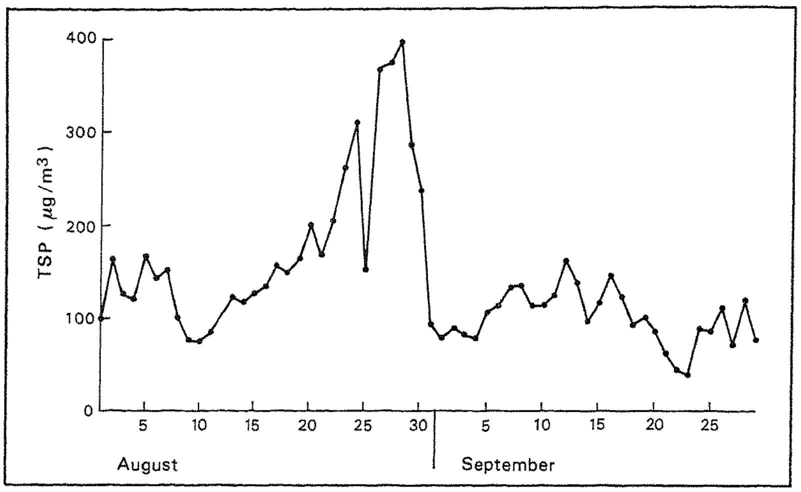

Figure 2: The observed variation of total suspended particulates in the Kelang Valley, Petaling Jaya from 1st August-September 1990
Source. Sham et al[4]

Vehicular emissions account for more than 75% of the air pollutants in the Kelang Valley. It is estimated that 53.1% of the air pollutants are due to hydrocarbons associated with fuel combustion and agricultural burning. The second major source, SO_x contribute 26.5%, followed by NO_x which account for 10.5%. Others such as particulates and CO contribute about 5% each to the total air pollutants[4,5].

In the Kelang Valley a number of stationary sources also contribute to the air pollutant levels. In this region there are about 210 factories registered with the Department of Environment. Most of the boilers in these factories use oil. There are four power stations, with two powered by coal and the other two by oil. In the case of the boilers fired by coal or oil, the most significant pollutants are SO_x and NO_x. However the concentration of SO_x in the tropics tends to be low due to formation of sulphate. This sulphate however could add to the level of particulates and further worsen the haze.

Due to rapid development in the Kelang Valley the land use pattern has been dramatically transformed. Oil palm estates and rubber plantations have now been transformed into large housing estates to accommodate the growing population The clearing by developers of vegetation leads to soil exposure creating a very dusty environment especially during the dry season.

THE CHEMICAL COMPOSITION OF THE HAZE

The metal content of the total suspended particulates during the haze episode in October 1991 is shown in Table 1. A time series of daily variation of the normalised concentration of TSP and some metallic elements is also depicted in Figures 3 and 4. The time series indicates that during the haze on the 6th of October 1991 there was a good correlation between the peaks of Al, Na and Ca and TSP (Figure 3). However in the case of Pb there is a negative correlation with TSP (Figure 4). This could either imply that vehicular emissions did not contribute to the haze or that the haze was due to the production of secondary pollutants from photochemical reactions with primary hydrocarbons from vehicular emissions. Further investigation into the organic composition of the haze is needed to confirm this hypothesis. In the case of Al, Na and Ca, these elements are usually associated with soil and sea salt particulates. The positive correlation between these elements and TSP implies that soil particulates and possibly sea spray contributed to the haze. These elements may also play some role in the photochemical reaction associated with the haze. Clearly more research must be undertaken to study photochemical reactions that could occur in a haze episode.

Table 1: *Mean and range of daily concentration of heavy metals in the TSP during the haze episode from 13th September to 27th October, 1991*

	Pb	Fe	Cu	Cr	Cd	Na	Ca	Al	Ni
Range	0.06- 0.67	<0.01- 1.25	<0.01- 0.79	<0 01- 0.02	<0.01- 0 01	<0.01- 28.29	<0.01- 18.40	<0.01- 6.76	<0.01- 0.03
Mean	0.32	0.46	0.11	<0 01	<0.01	4.30	1.68	1.66	0.01

Source: Department of Chemistry, Malaysian Ministry of Science, Technology and Environment

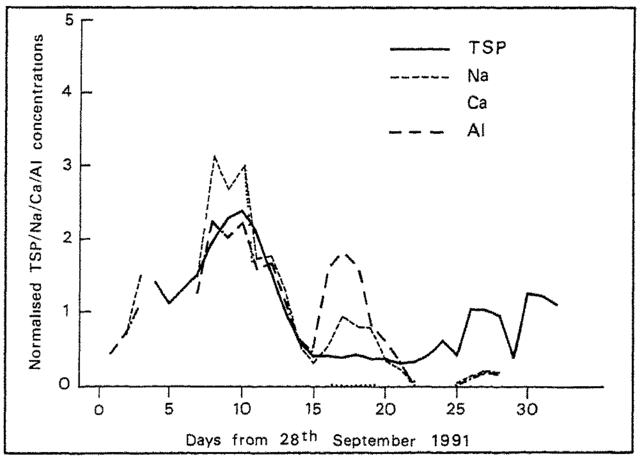

Figure 3: *Normalised TSP, Na, Ca and Al concentrations during the haze episode of September-October 1991*

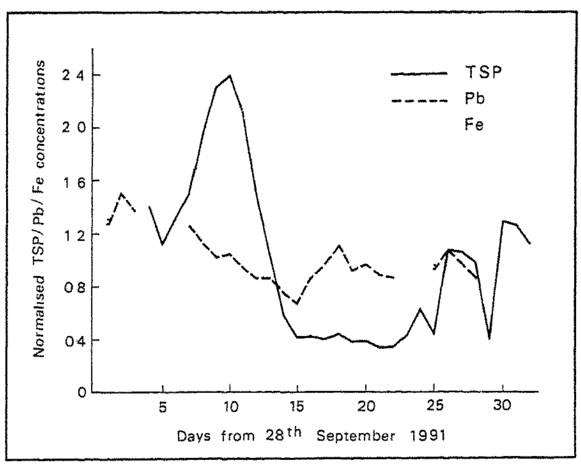

Figure 4: *Normalised TSP, Pb and Fe concentrations during the haze episode of September-October 1991*

Knowledge on the organic nature of the haze was limited to analysis of those organic compounds which were soluble in benzene (Figure 5). In this analysis, a good correlation between TSP and the organic soluble compounds was observed. On average, the percentage of organic compounds in TSP ranged from 10%-30% of the total concentration. It is known that among hydrocarbons released during fossil fuel combustion, benzo(a)pyrene is known to cause skin cancer in mice. Therefore, an analysis of the organic compounds in haze should be made. Postulations can then be made on a photochemical reaction pathway that accounts for the various organic compounds observed.

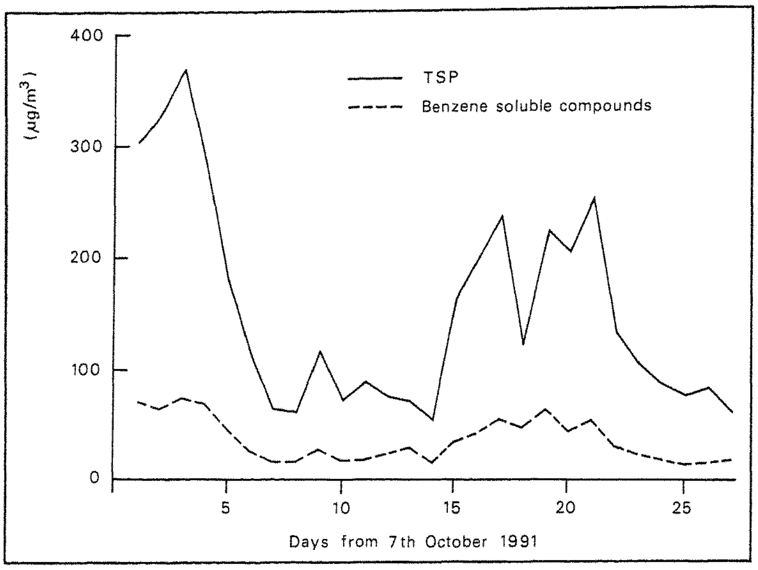

Figure 5: *Comparison of TSP and benzene soluble compounds in TSP.*
Source: Department of Chemistry, Malaysian Ministry of Science, Technology and Environment.

Gaseous monitoring of the haze on 9th of October 1991 showed that SO_2 was nearly constant with a low concentration of 5-10ppb (Figure 6). In the case of CO, the variation averaged around 6 ppm with a maximum of 9 ppm during the morning peak hour traffic. NO and NO_2 concentrations averaged 15 ppb with a maximum of 25 ppb, also associated with the morning peak hour traffic. Ozone production was observed to peak at 50 ppb at 1500 hours local time (Figure 7). In terms of gaseous concentration during the haze episode, the maximum concentrations were close to or less than the threshold limit values recognised by the American Conference of Government Industrial Hygienists[6]. Therefore at present the gaseous concentrations of the haze pose no immediate danger.

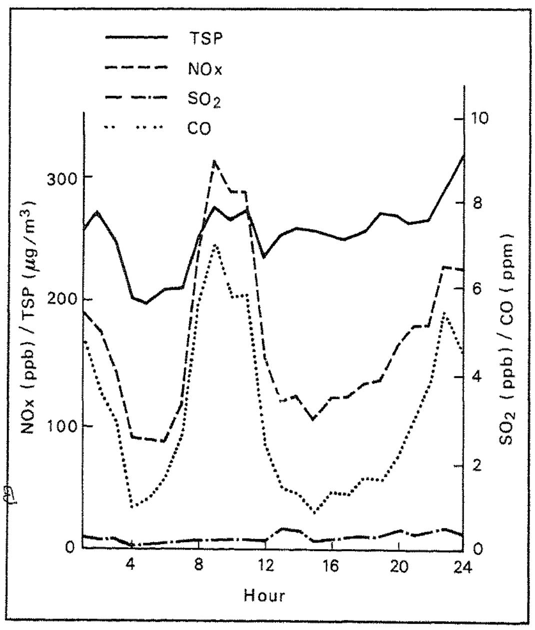

Figure 6: *Hourly variation of TSP, CO, SO_2 and NO_x concentrations in Kuala Lumpur on the 9th of October 1991 when TSP concentration was maximum.*
Source: Department of Chemistry, Malaysian Ministry of Science

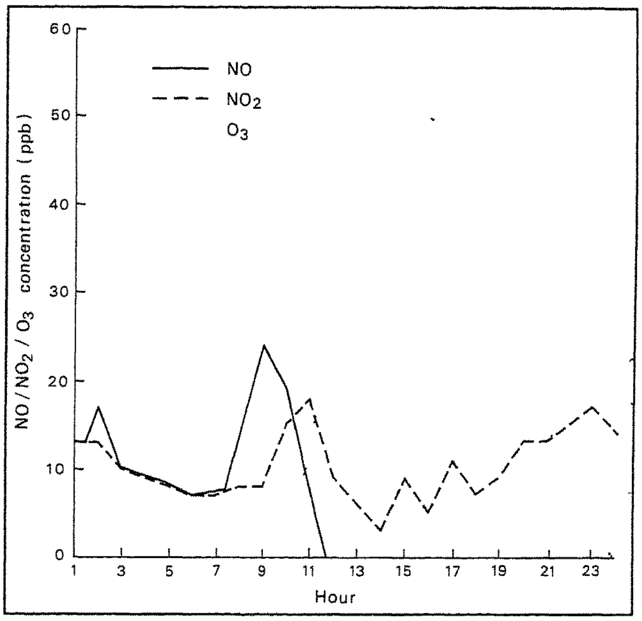

Figure 7: *Hourly variation in NO, NO_2 and O_3 at Universiti Pertanian on 9th of October 1991.*

THE METEOROLOGICAL CONDITIONS ASSOCIATED WITH HAZE EPISODES

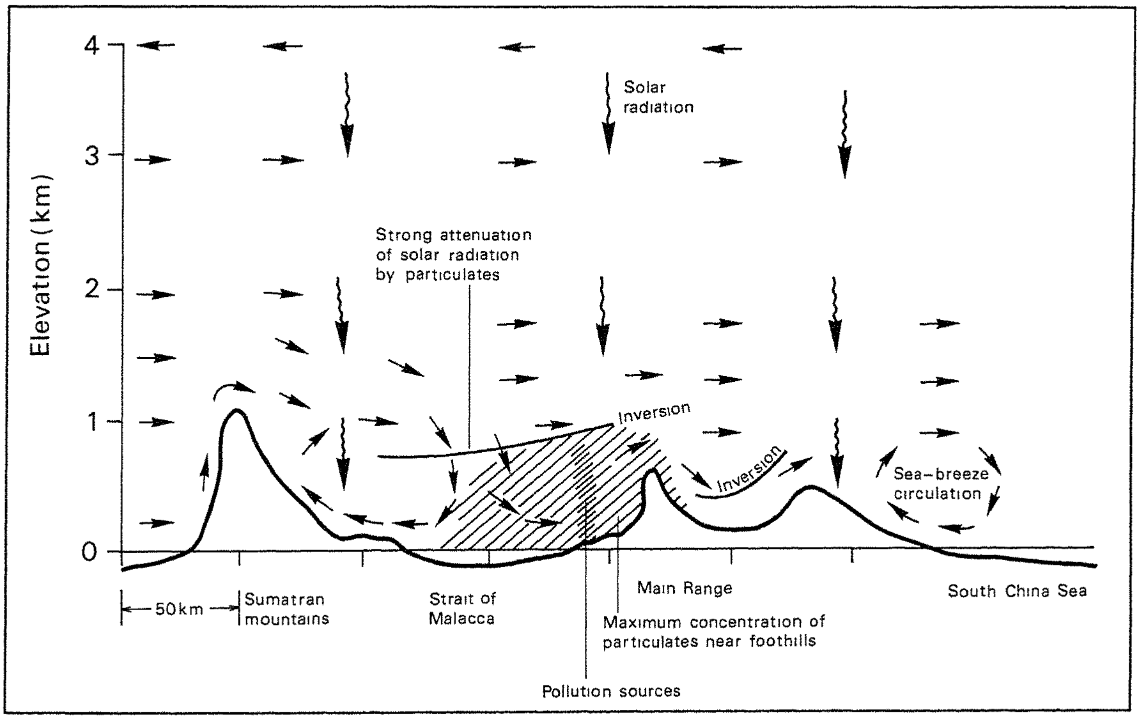

Figure 8: *Conceptual model of the meteorological condition that is conducive to the occurrence of haze during the summer monsoon period.*

On all occasions when haze episodes have been observed in Peninsular Malaysia the meteorological condition was dry and stable. Analysis of the distribution of haze episodes[7] showed a maximum in the month of August which is usually associated with the summer monsoon dry season, and most haze episodes tend to occur during this period. An exception to this rule was the haze of April, 1983 which was associated with a strong ENSO event and resulted in severe drought in this region. Figure 8 is a conceptual model of the meteorological conditions that could give rise to stable atmospheric conditions conducive to TSP built up. In August, the summer monsoon circulation is fully established in the region and the southwesterly flow over the mountain ranges of Sumatra tends to create a rainshadow area in the west coast of Peninsular Malaysia. The rainshadow effect is due to the subsidence of the southwesterly flow as it crosses the mountain ranges. The subsidence tends to create a midlevel inversion due to adiabatic warming of the air. This inversion then forms a lid, to trap the air pollutants emitted, causing the observed build-up. Analysis of the build-up of TSP in the August 1990 haze episode showed that over the whole region the TSP level started to increase on the same day. This supports the assumption that this build-up was due to locally emitted pollutants.

The onset of thunderstorm activities has been observed to clear haze as shown in the case of the haze of August 1990 (Figure 9). Similarly in the case of the haze of 1991, the onset of the winter monsoon, which brought extensive rainfall and a change in wind direction from southeasterly to easterly, was able to disperse the haze.

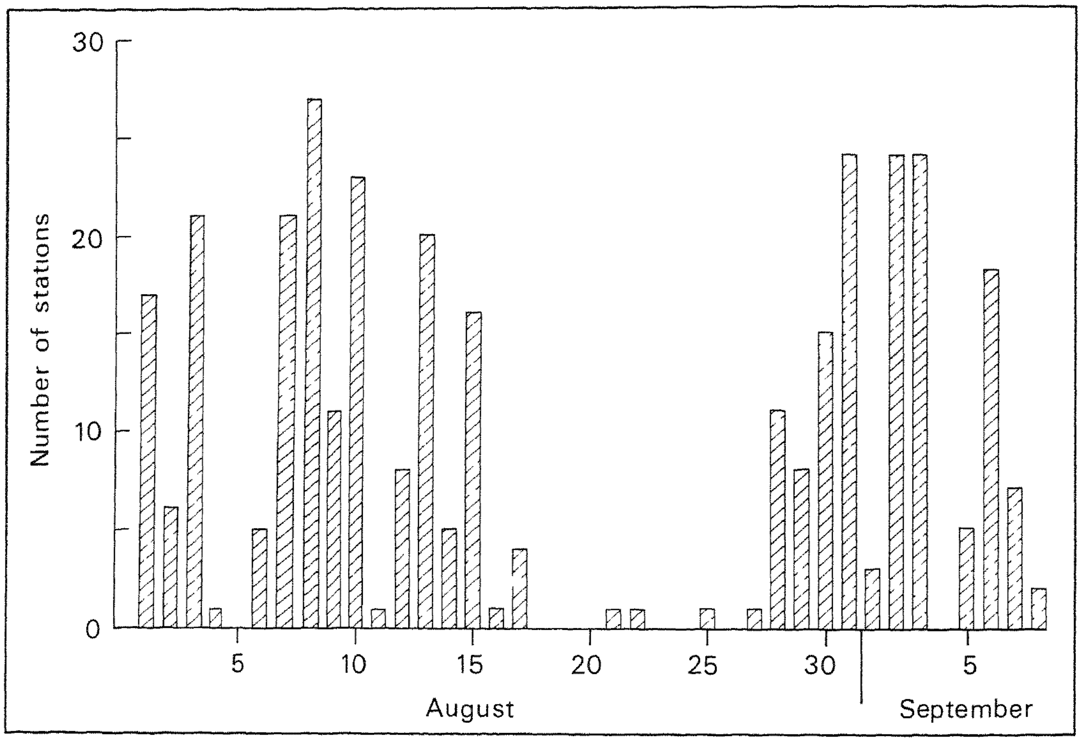

Figure 9: Total number of stations reporting rain during August and early September 1990

HEALTH HAZARDS OF THE HAZE

The main health complaints about the haze episodes in August 1990 and September-October 1991 were related to respiratory and eye problems. Newspaper reports claimed that conjunctivitis incidence increased during this period. However, a preliminary epidemiological study conducted by the Malaysian Department of Health showed an inconclusive relationship which may be explained by the poor reporting technique of the general practitioners concerned. A careful epidemiological study should be designed to gauge the short and long term effects of the haze on the populace.

During the haze episode, through the media, people prone to respiratory problems, such as the infirm, infants and asthma sufferers, among others, were advised by the Health Department to stay indoors. The population was also advised to wash their faces and throats as often as possible. Motorcyclists were also advised to wear dust filters or wet handkerchiefs over their faces.

CONCLUSION

Rapid industrialisation in the Kelang Valley has increased the sources of air pollution. During the dry season when the atmosphere is stable, this region is prone to haze formation. Vehicular emissions, agricultural burning and forest fires are possible sources of the haze. One of the major components produced by these sources is hydrocarbon. However, the photochemical reactions between the hydrocarbon compounds and the radicals present in the atmosphere such as hydroxyl are still unknown. Under such circumstances an air pollution research unit in a local university could assist the current understanding on meteorological conditions and the photochemistry of haze. A realistic model can then be designed to predict the formation of haze in the Kelang Valley. Tests on the effectiveness of proposed mitigating factors, such as reduced traffic flow, could be incorporated into this model.

Finally, the chemical components of haze and their respective concentrations, will allow epidemiological studies to be carried out on the effects on the acute and chronic health effects of haze.

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PHOTOACOUSTIC DETERMINATION OF TRACE POLLUTANT GASES IN HONG KONG AIR

B Shi*, GG Siu‡ and DS Chiu*
***Faculty Laboratory Centre, ‡Department of Applied Science, City Polytechnic of Hong Kong**

INTRODUCTION

Sensitive detection of specific air pollutants is a prerequisite for understanding the complex physical and chemical processes that take place in the atmosphere leading to the production of smog and acid rain. A variety of conventional techniques such as chemiluminescence and flame ionization detection have been applied to air-pollutant monitoring but they do not meet the requirements for continuous and simultaneous recording either in situ or remote and therefore new techniques need to be developed. Following Kreuzer's pioneering work[1], photoacoustic spectroscopy (PAS), which possesses the advantages of simplicity, high sensitivity and speed compared with conventional methods, has been developed for trace analysis.

The primary objective of the PAS technique is to measure infrared absorption in gas samples and to identify a spectral signature at key wave-lengths. Almost all of the known air pollutants have their fundamental absorption bands from about 2 to 15 μm in the infrared portion of the spectrum. For example, in the wavelength range of a carbon monoxide laser (~ 5-6 μm), pollutants like nitric oxide (NO), peroxy-acetylnitrate ($CH_3CO_3NO_2$), formaldehyde (H_2CO), phosgene ($COCl_2$), ethylene (C_2H_4), 1,3-bu-tadiene (C_4H_6), prohylene (C_3H_4), ammonia (NH_3) are absorbing and in that of a carbon dioxide laser, ethylene, 1,3-butadiene, ammonia, trichloroethylene (C_2HCl_3), perchloroehtylene (C_2Cl_4), ozone (O_3), toluene (C_7H_8) and benzene (C_6H_6) etc. are doing the same. The high intensity of the laser beam is used to enhance the sensitivity of absorbance measurement due to the fact that the acoustic signal transformed from the absorbed optical energy is proportional to not only the absorption coefficient of gas but also to the beam intensity. The PAS signal, following theoretical studies on direct PA generation[2], is

$$S = R(1- e^{A})I_0 = RAI_0$$

for small absorbance A, where R and I_0 are the PA response rate of the system (or the enhancement factor) and the radiation intensity respectively, $A=\alpha lC$ (α, l and C are the absorptivity of the absorbing gas at the specific wavelength, the PA cell pathlength and the concentration of the gas). Although CO and CO_2 lasers are only step-wise tunable (discrete wavelength emission), they are the most widely applied infrared laser sources in PAS and reach the same sensitivity as a continuously tunable laser (e.g. spin flip Raman laser).

PAS detection of trace gases is well documented[3 12]. The present work aims to apply the PAS technique to the practical detection of trace pollutant gases in the Hong Kong atmosphere and to test the practicability of the PAS technique for monitoring air pollution in Hong Kong.

EXPERIMENTATION

The experimental arrangement is represented in Figure 1. Infrared absorption in the gas sample is measured through a photoacoustic effect. The infrared beam is chopped and passes through the gas sample enclosed in the PA cell to provide periodic heating. If the wavelength of the excitation beam is tuned to an absorption line of a gas component, energy deposition and the resulting thermal effect will be most noticeable. The energy periodically absorbed by the gas causes a periodic rise in its temperature and pressure. These pressure variations are detected with a microphone whose output is further amplified by a lock-in amplifier. The absorption spectrum is obtained by scanning through the whole range of the laser infrared wavelength. A minimum αl of 10^{9} is achieved in PAS meaurements[12].

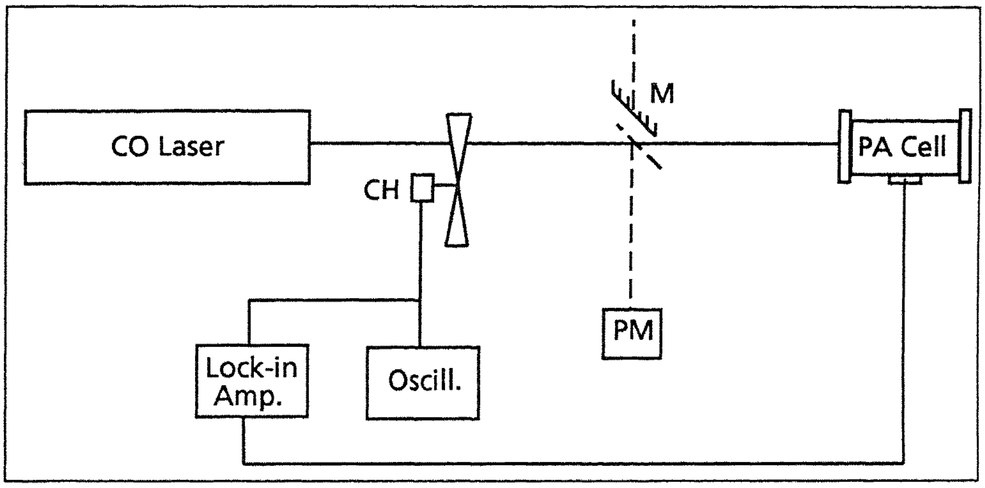

Figure 1: *Schematic diagram of the instrument system: CH, chopper, PM, power meter, M, mirror movable to-and-fro.*

A step-tunable infrared CO laser (PL3, Edinburgh) with about 60 lines between 5.2 and 6.2 μm output powers between 5 mW and 1.5 kW at an operation temperature of -10°C was used for PAS experiments. The laser power entering the PA cell was measured by a power meter (Coherent 210) and the wavelength tuning was monitored by an infrared spectra analyser (Edinburgh). A conventional glass PA cell of size ø15.2xL120 mm^2 was used for qualitative detection of pollutant gases and a Helmholtz resonance cell, with a sample chamber of ø12.0xL104 mm^2 and a resonance chamber of ø60.0xL48.3 mm^2 connected by a tube of 4.8xL52.0 mm^2, for quantitative measurement of ethylene in the atmosphere. At the resonance frequency of 284 Hz, the signal of the Helmholtz resonator was increased to 16.4 times that of the conventional stainless PA cell and to 145 times that of the glass cell. The signal-to-noise ratio was enhanced by more than four times. A microphone (CZN-15E, Shanghai Feile) was fitted in a lateral tube perpendicular to the inner wall of the sample chamber. The PA signal was monitored and measured by a lock-in amplifier (NF5600) and an oscilloscope (Tektronix 2465A). Optical transmissive components were all made of ZnSe with a flat spectral response (~69% transmittance) for $\lambda < 25$ μm and without the disadvantage of deliquescence. All reflective components were gold-plated mirrors with ~99% reflectance.

The humidity during the sampling period was very high (max. 92-97%). The interference absorption by water vapour over the CO laser spectrum dominated and suppressed almost all other weak absorption signals from trace pollutant gases. This particular difficulty of water-vapour interference was overcome by removing water vapour using a liquid nitrogen trap and desiccation. In addition, the PA cell was dehydrated by continuous evacuation each time before replenishing the gas sample. The spectrum of water vapour which was used for water-vapour corrections of other samples collected during the same period, was obtained by computer differentiation of the before and after thorough desiccation states. The background spectrum was investigated using a desiccated nitrogen gas sample, in which line intensity was almost independent of wavelength at a level of 4.0-4.5 μV/mW.

Characteristic absorption lines for particular gases were identified for determination of gas components in air. Uniqueness prevented mutual interference but for other cases the rejection ratio[4] or the method of solving linear equations was applied for unambiguous detection. The standard infrared spectra of gases[13] provided a sound basis for investigation. If the spectrum of an interfering gas was known, e.g water vapour in the range from 5 15 to 5.45 μm, as shown quantitatively in Figure 2, wavelengths of the absorption lines there should be avoided for identifying other gases unless water correction had been completed first.

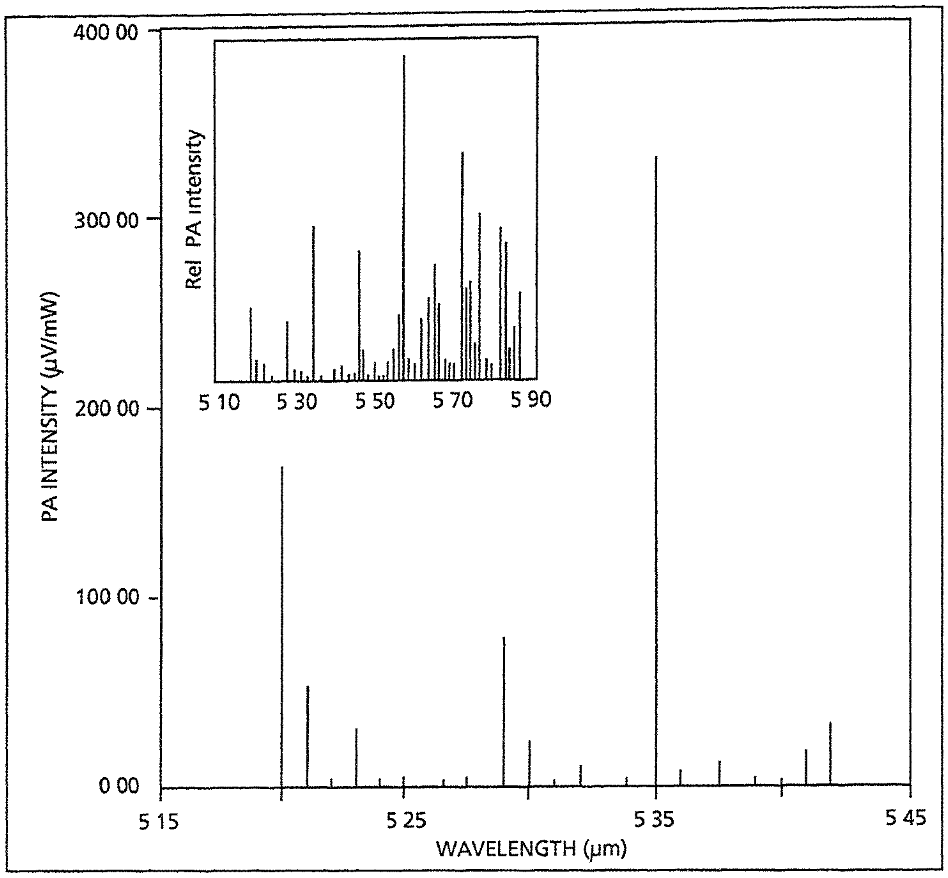

Figure 2: PA absorption spectrum of water vapour at CO laser transition from 5 15 to 5 45 μm The inset shows a wider wavelength range

Comparative sampling was adopted in qualitative PA investigation A reference sample was first collected in a nearby relatively 'clean' spot, e g. a park Its spectrum was then subtracted from that of a gas sample by a road by computer differentiation so as to eliminate the interference from water vapour and highlight the pollutant gases. For quantitative analysis, the background deduction and water vapour correction were essential.

QUALITATIVE MEASUREMENTS OF AMBIENT URBAN AIR

Figures 3-6 are absorption spectra of air from the Bio-chemical Laboratory, City Polytechnic of Hong Kong (CPHK), the Nathan-Jordan road junction[1], the front of Kowloon Tong Station (KTS) and inside the Lion Rock Tunnel (LRT) respectively PAS measurments show that the air quality varies markedly.

The three major absorption lines in Figure 3 are identified as benzene (5.47 μm), acetaldehyde (5.73 μm) and formaldehyde (5.82 μm), components of frequently used anaesthetics and preservatives, reflecting unsatisfactory laboratory ventilation. The pollutant gases in Figures 4-6 are essentially produced by auto emission: ethylene (5.29 μm), acrolein (5.46 μm, 5.76 μm and 5.82 μm), propene (5.57 μm), acetaldehyde (5.63 μm), formaldehyde (5.81 μm) and cycloheptatrine (5.86

μm). However their relative intensities vary in different emission situations or degrees of accumulation. The traffic flow during sample collection was 85 and 50 vehicles/min. in NJ and KTS respectively and there were traffic jams in KTS. Figures 4 and 5 show that the concentrations of the emitted pollutant gases are different, and appear to be more excessive with idling and starting engines. The intensities of the absorption in Figure 6 reflects the accumulation of pollutant gases inside the tunnel.

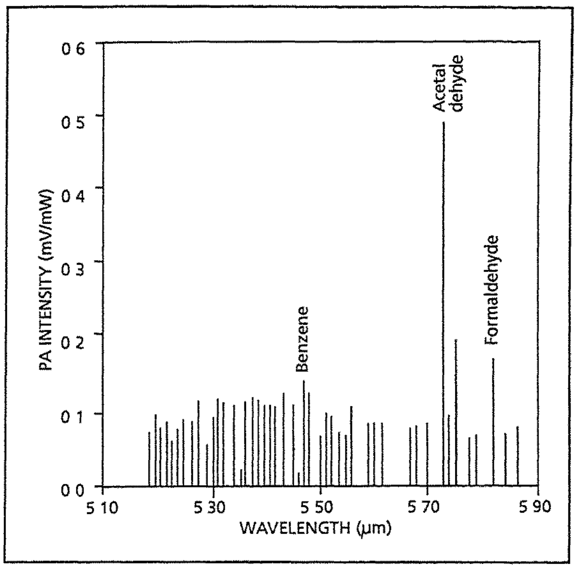

Figure 3: *PA absorption spectrum of CPHK air.*

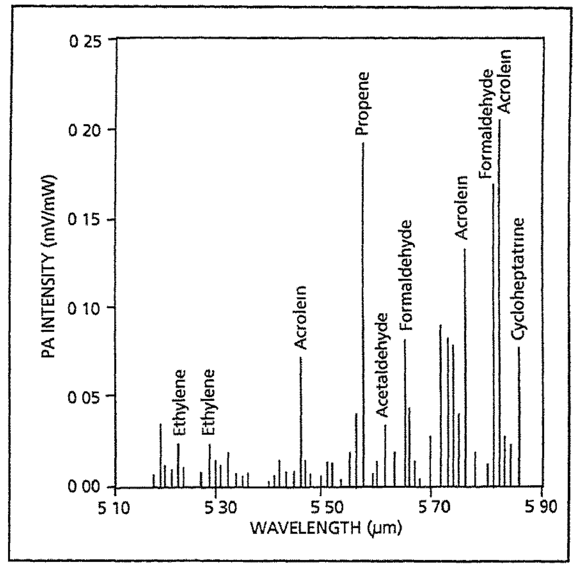

Figure 4: *PA absorption spectrum of air from the Nathan-Jordan road junction*

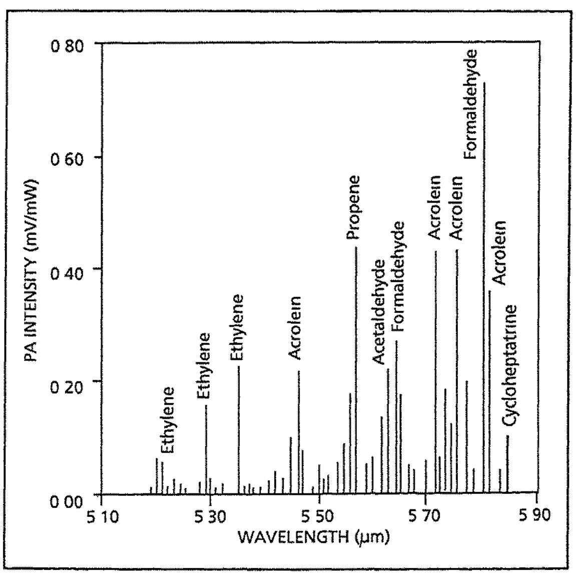

Figure 5: *PA absorption spectrum of the air from Kowloon Tong Station*

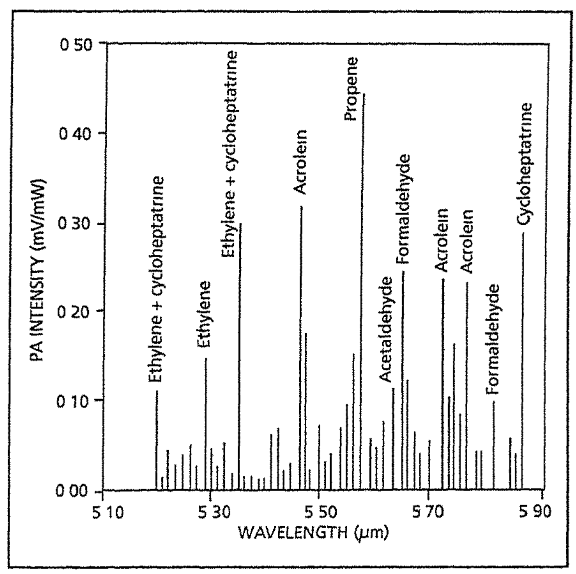

Figure 6: *PA absorption spectrum of air inside the Lion Rock Tunnel*

QUANTITATIVE MEASUREMENTS OF ETHYLENE CONCENTRATION

Ethylene is an urban air pollutant which is produced mainly by auto emission (about 19.0% of exhausted auto hydrocarbons[14]). It is both a toxicant to plants, a ripening agent for fruits, and plays a role in the formation of photochemical smog (about 17.6% of the photochemical reactivity of these emissions[4]). It can hence serve as an environmental index and has been investigated widely[4,8,15].

For ethylene analysis, three lines of wavelengths 5.31 μm, 5.34 μm and 5.385 μm have been chosen to avoid the interference from water vapour and other gases (c.f. Figure 2). The performance parameters of the PAS system are shown as follows:

Laser line (μm)	Typical output power (mW)	PA signal [nV/(mW.ppm)]	Background [equiv. C_2H_4conc.(ppm)]
5.31	160	98.34	45
5.34	240	448.50	10
5.385	220	96.65	42

The calibration was completed by a standard 20 ppm ethylene gas sample, prepared by diluting pure ethylene gas with buffer nitrogen gas, whose spectrum is shown in Figure 7. Owing to measurement discrepancies between ethylene absorption coefficients at different wavelengths and with different magnitude[8], the ethylene concentration in our experiments is taken as the mean value obtained from these three lines so as to reduce the influence of water vapour, background and sample preparation and to increase its reliability.

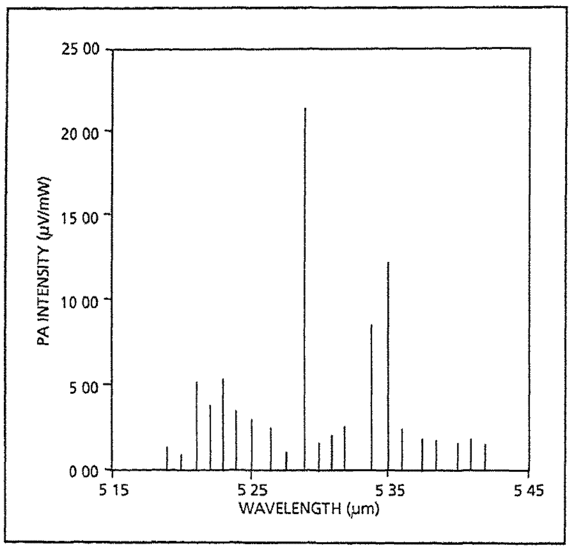

Figure 7: PA absorption spectrum of a standard ethylene gas sample (20 ppm).

Air samples from seven spots in Hong Kong and Kowloon have been investigated: (i) the Chinese University of Hong Kong, at the gate near a car park (CUHK); (ii) in the Lion Rock Tunnel (LR); (iii) the Kowloon Tong Station, at the front (KTS); (iv) Boundary Street, near Tai Hang Tung Road (BS); (v) Wei Yi Street, Kwung Tong (KT); (vi) Kwai Chung Road, Tuen Wan (CW) and (vii) Queens Road (near Lane Crowford) in Central (HKC). Results of the analyses of the air samples collected on the morning of 17th December 1991 are shown as follows:

	CUHK	LR	KTS	BS	KT	CW	HKC
Conc.(ppm)	243	1664	379	548	1273	625	659

The typical fractional error of individual line measurement is 8%. They are comparable with the average daytime concentrations of ethylene in Washington, D.C. during July and August 1972[15], sampled in open areas as far away as possible from any streets. Ethylene concentrations reached 700 and 600 ppb at the Monument and Capitol respectively but were lower in areas of light auto traffic: e.g. Arlington 172 ppb. Our results show that the ethylene concentrations are higher than the Washington data due to the fact that there are few open areas in the urban districts of Hong Kong, the density of auto traffic is higher and more diesel engines are operating. The data confirm that auto traffic (CW, BS, HKC), exhaust accumulation (LR) and industrial consumption of hydrocarbonate-based fuel (KT) are decisive factors for the ethylene concentration level in air.

SUMMARY

The PAS technique is shown to be effective in monitoring pollutant gases in the atmosphere but the interference from water vapour absorption over the CO spectrum slows its speed. An effective and fast desiccation method is also required.

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APPLICATION OF THE PROTON INDUCED X-RAY EMISSION (PIXE) TECHNIQUE FOR THE STUDY OF RESPIRABLE SUSPENDED PARTICULATES (RSP) IN HONG KONG

ZX Cai, PYK Sze, MJ Stokes and ECM Young
Department of Applied Science, City Polytechnic of Hong Kong

INTRODUCTION

RSP's are particles with diameters equal to or less than 10 μm. Particles of these sizes can be inhaled into the lungs and can therefore inflict adverse health effects on human-beings. The intensity of these effects depends on the extent of penetration into the respiratory system and also on the particulate toxicity. The extent of penetration depends on the particulate size. The toxicity of the particulates, to a large extent, is due to the intrinsic toxicity of the elements present in the particulates. A number of trace metals, such as nickel, cadmium, lead and mercury are of specific concern[1,2].

***Table 1:** Atmospheric concentration (ng/m^3) of elements in the coarse and fine fractions of RSP's in the three areas studied**

Element	Coarse fraction				Fine fraction			
	Hong Kong South	Kwai Chung	Central-Western	C.W./K.C. ratio	Hong Kong South	Kwai Chung	Central-Western	C.-W./K.C. ratio
Ca	(78.8)	258.9	208.1	0.8	(224.7)	635.8	752.6	1.2
Cu	31.6	41.7	25.8	0.6	296.4	220.7	34.3	0.2
Fe	23.2	157.9	87.8	0.6	67.6	206.0	456.8	2.2
Cd	(4.2)	(4.1)	(2.5)	0.6	80.7	(101.4)	38.5	0.4
Cl	26.9	N.D.	N.D.	-	(26.8)	(35.7)	75.0	2.1
K	12.8	17.1	15.4	0.9	45.4	65.4	237.8	3.6
S	(6.6)	(1.7)	(1.1)	0.6	(8.9)	(33.8)	(42.9)	1.3
Zn	(1.0)	13.5	8.4	0.6	(11.1)	86.2	150.4	1.7
Ti	(0.4)	8.8	5.3	0.6	9.6	50.9	46.8	0.9
Pb	N.D.**	N.D.	N.D.	-	(4.1)	4.0	51.2	13.0
Mn	1.1	3.3	2.0	0.6	2.1	3.4	19.0	5.6
Co	1.0	1.3	0 8	0.6	2.0	0.9	(1.7)	1.9
Br	(0.1)	N.D.	N.D.	-	2.9	3.7	4.5	1.2
Ni	(0.4)	1.1	0.7	0.6	(2.1)	(3.2)	4.9	1.5
As	0.3	0.6	0.4	0.7	(1.0)	2.2	12.5	5.7
Sr	(0.9)	(1.2)	N.D.	-	N.D.	(3.2	(4.8)	1.5
Cr	N.D.	1.2	0.7	0.6	(0.5)	(0.4)	3.1	7.8
Hg	(0.2)	N D.	N.D.	-	(0.3)	N.D.	1.7	-
Ba	N.D.	N.D.	N.D.	-	(0.2)	N.D.	N.D.	-
Se	(0.1)	N.D.	N.D.	-	N.D.	N.D.	N.D.	-
Total	189.6	512 4	359.0	0.7	786.4	1456.9	1938.5	1.33

* Concentrations in parentheses are statistically with higher uncertainty and are included for reference purpose only

** Not detectable; detection limit was estimated to be 0.1 ng/m^3.

The atmospheric concentrations of most elements in the RSP's are typically of the order of ng per m^3 of air, so that effective monitoring requires techniques of extreme sensitivity. In this study, we used a PIXE technique to monitor a total of twenty elements (Table 1), some of which are well-known for their toxicity. The PIXE technique is a high-speed, high-sensitivity and non-destructive analytical technique which only requires samples of microgram sizes. Sampling was performed in three areas in Hong Kong; Hong Kong South, Kwai Chung and Central-Western, typifying the three characteristic environments: residential, industrial and high-traffic-density, respectively.

METHODOLOGY

A high-volume Andersen air sampler model SAUV-2 was used to collect the RSP's. This air sampler was equipped with a cascade impactor for separation of the RSP's into the following six equivalent aerodynamic diameter (EAD) ranges:

Stage	1	2	3	4	5	6
EAD (μm)	7.2-10	3.0-7.2	1.5-3.0	0.95-1.5	0.49-0.95	<0.49

The sampling period was from 13 May to 13 June, 1991.

The samples were directly analyzed without any treatment by PIXE with yttrium as the internal standard. The PIXE technique used 2.2 MeV protons with a 15 nA beam current produced by a 1.6 MeV tandem accelerator. The low proton beam current was used to minimize the loss of volatile elements. The released characteristic x-rays were detected with a Si(Li) detector having a resolution power of $^{55}Fe_{FWHM}$ = 170 eV.

The pulse output from the detector was analyzed with a multichannel pulse amplitude analyzer model S88 connected to a PDP 11/23^{+} computer for on-line analysis. The error due to target thickness was corrected and the analysis system was calibrated with several standard materials to ensure reliability. Each concentration reported in this study is the result of two analyses of two targets of the same sample.

RESULTS AND DISCUSSION

In Figure 1, the atmospheric concentrations (in ng/m^3 of the air containing the RSP's) of the twenty elements sampled are compared for the three areas. The elements are arranged in the order of decreasing concentrations for Hong Kong South. The figure shows that, with few exceptions, the elemental concentrations were highest for Central-Western and lowest for Hong Kong South. The sum of the concentrations of the twenty elements are 976, 1969 and 2298 ng/m^3, for Hong Kong South, Kwai Chung and Central-Western, respectively. The RSP problem in Central-Western is aggravated by the operation of the Kennedy Town Incineration Plant which incidentally was near our sampling site.

To help in the assessment of health effects due to RSP's, two fractions are chosen: the fraction of the element present in coarse RSP's, defined as those with EAD's larger than 3 μm; and the fraction of the element present in fine RSP's, defined as those with EAD's smaller than 3 μm. The results are presented in Table 1.

Particulates in the fine fraction are well-known to exert more serious effects on humans than those in the coarse fraction because they may escape the defense mechanisms of the upper respiratory tract and enter the lungs[1]. The smaller the particulates, the deeper they may be deposited in the lungs and the more damage they can do to the human body. Data on the fine fraction are therefore considered to be a better reflection of effective pollution.

Table 1 indicates that the elemental concentrations were much higher in the fine fraction than in the coarse fraction for all three areas. For the coarse fraction, the sum of the concentrations of the twenty elements in Central-Western was lower than that in Kwai Chung by a factor of 0.70.

Whilst for the fine fraction, which has a more significant effect on health, the sum of the concentrations of the twenty elements in Central-Western was higher than that in Kwai Chung by a factor of 1.33.

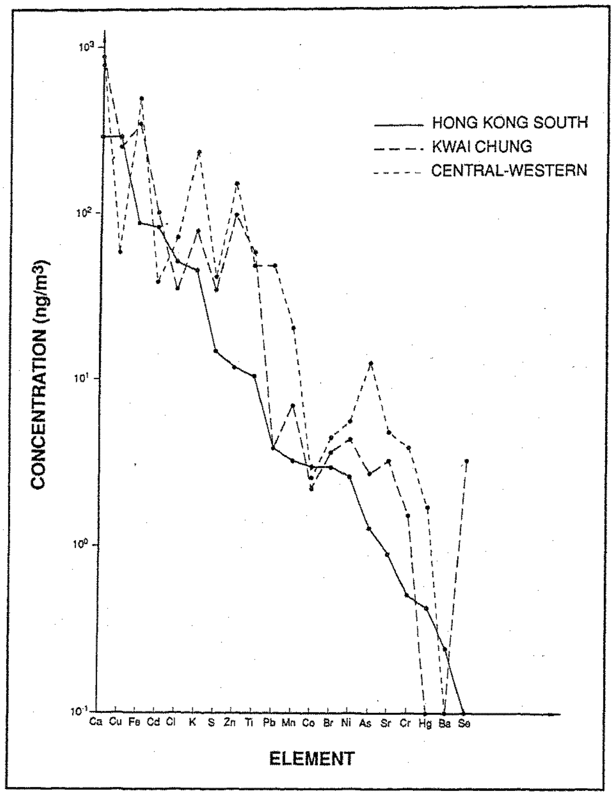

Figure 1: *Atmospheric concentration of elements in RSP's in the three areas studied.*

For Hong Kong South, the sum of the elemental concentrations in both fractions were significantly lower than for the other two areas.

The particulates which enter the lungs inflict adverse health effects in the following ways: interference with clearance mechanisms in the respiratory tract thus preventing or slowing the removal of other more harmful particulates; transport of adsorbed or absorbed irritating gas molecules to sensitive areas of the lungs; and intrinsic toxicity directly affecting the body[1]. In view of this last point, the PIXE technique is particularly useful in that it identifies the elements which are present in the particulates and can thus provide information on the toxic effects of the particulates.

An examination of the more toxic elements listed in Table 1 indicates that in the fine fraction the concentrations of Ni, Mn, As, Cr and Pb are 1.5, 5.6, 5.7, 7.8 and 13 times, respectively, higher in Central-Western than those in Kwai Chung. Hg was below the detection limit (0.1 ng/m^3) in Kwai Chung, but was 1.7 ng/m^3 in Central-Western. Only the concentration of Cd was higher in Kwai Chung. The above analysis thus indicates that the health effects due to RSP's in Central-Western were more serious than would be indicated by consideration of the mass of the RSP's alone.

In both the coarse and fine fractions, the concentrations of elements, toxic or non-toxic, were generally much lower in Hong Kong South than the other two areas studied. This is a reflection of the better air quality in Hong Kong South in terms of RSP's.

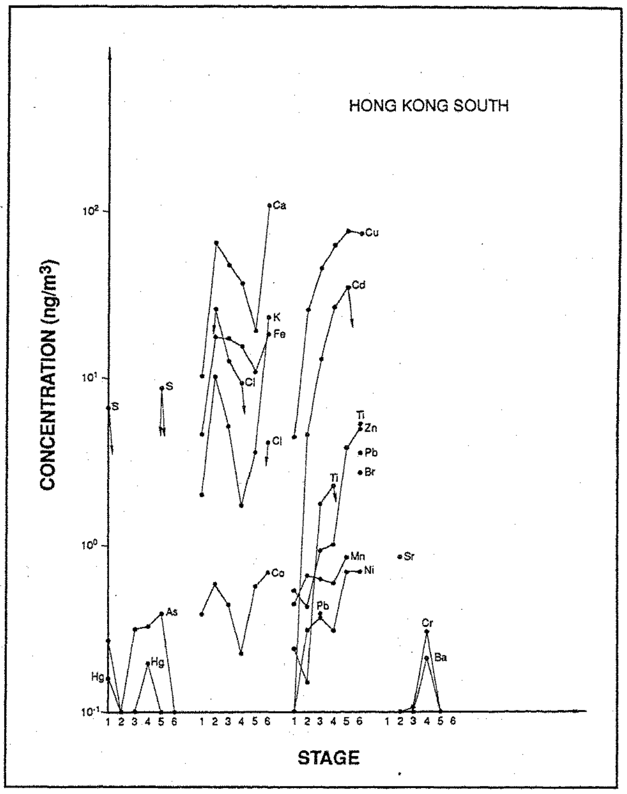

Figure 2: *Size distribution of elements in terms of the 6-stage classification for RSP's in Hong Kong South South.*

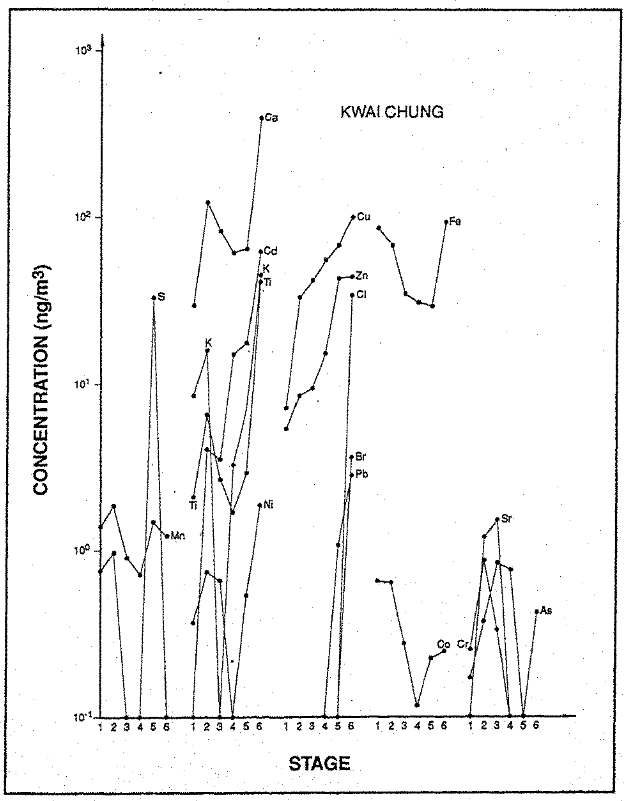

Figure 3: *Size distribution of elements in terms of the 6-stage classification for RSP's in Kwai Chung.*

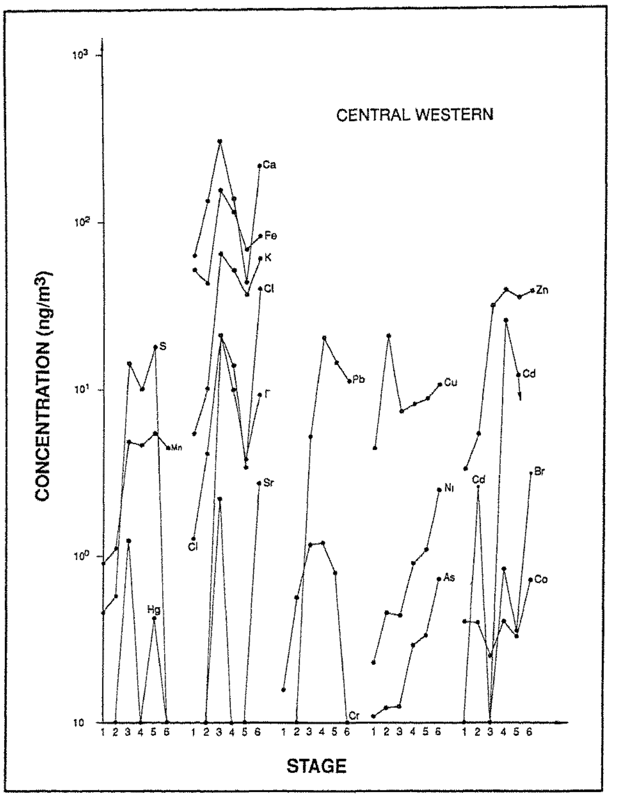

Figure 4: *Size distribution of elements in terms of the 6-stage classification for RSP's in Central-Western.*

Figures 2, 3 and 4 show the size distributions for the elements in the three areas in terms of the 6-stage classification. Elements of similar distribution characteristics are grouped together. Some features which are common to all the figures are noticeable. For example, elements such as Ca and K exhibit similar size distribution patterns indicating a probable common source which is not area dependent. There are also features which are specific to the individual figures and are characteristic of pollution in the areas under study.

The majority of the elements exhibit peak values at stage 6, if not at stage 5. A number of these elements also exhibit a second peak. This peak occurs at stage 2 for Hong Kong South and Kwai Chung, and at stage 3 for Central-Western This general shift is responsible for the much higher concentration of the fine fraction (which includes stages 3, 4, 5 and 6) with respect to the coarse fraction in Central Western.

The following elements were present in high concentrations (using 10 ng/m^3 in any one or more stages) in all three areas: Ca, Fe, Cl, K, Cu, and Cd. Among these, Ca, Fe, Cl and K are generated by dispersion processes, such as soil dust dispersal or bubble bursting at the sea surface[3,4,5]. Cu and Cd are expected to originate from various anthropogenic pollution sources[6].

In Kwai Chung, Ti, S and Zn were also present in high concentrations. Ti is mainly soil-derived[4]. S and Zn are more noteworthy as they are related to fossil fuel combustion[6].

In Central-Western, in addition to the nine elements discussed above, Pb was also an element of high concentration. Pb is a typical reference element from leaded-gasoline combustion in automobile engines[1,6]. The considerably higher concentration of this element in Central-Western indicates a more significant contribution from this pollution source.

CONCLUSIONS

RSP's were more concentrated in the fine fraction in all three areas studied. In fact, a large number of elements showed maxima in the range of < 0.49 μm in size distributions. This is of considerable concern as particulates of these sizes may penetrate deeply into the lungs and stay for a significant period of time.

In terms of the health effects of the RSP's, the air quality of the three areas decreased in the following order: Hong Kong South, Kwai Chung and Central Western. Our RSP data also indicate that each area had its own pollution characteristics.

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FOLLOW-UP STREAM SEDIMENT GEOCHEMICAL RECONNAISSANCE SURVEYS IN THE VICINITY OF TAI MO SHAN, NEW TERRITORIES, HONG KONG

WWS Yim[+], CY Ng[x] and I Thornton[•]
[+] Department of Geography and Geology, The University of Hong Kong
[x] Tannabo Limited
[•] Global Environment Research Centre, Imperial College of Science, Technology and Medicine

INTRODUCTION

Stream sediment geochemical reconnaissance surveys which have been developed primarily for mineral exploration have found numerous applications in environmental pollution. For example, the Wolfson Geochemical Atlas of England and Wales by the Applied Geochemistry Research Group of the University of London[1] is perhaps the finest example of this type of survey. This atlas has not only provided baseline information on the distribution of chemical elements but has also found applications in pollution studies including water quality assessment, public health, agriculture and inshore fisheries Since both natural and anthropogenic inputs of chemical elements into streams are possible, the geochemical maps produced from stream sediment geochemical reconnaissance surveys would be useful to highlight problem areas with high concentration of toxic metals of concern to human health.

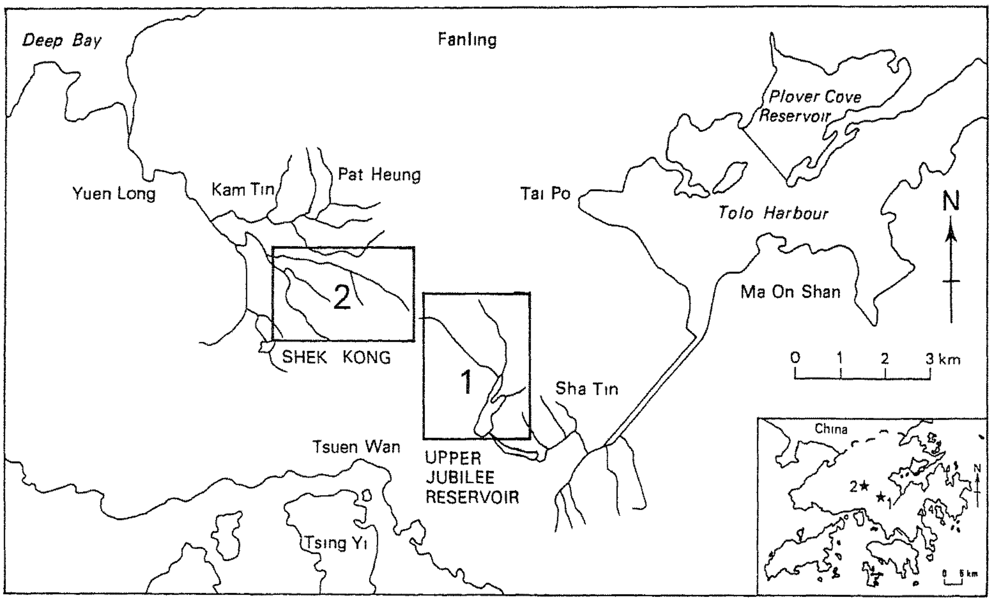

Figure 1: Location map of the Upper Jubilee Reservoir and Shek Kong areas

In the late 1960s, a stream sediment geochemical reconnaissance survey in Hong Kong involving more than one thousand sampling stations was carried out by the Institute of Geological Sciences[2] on the behalf of the Hong Kong Government. Possible bedrock mineralization indicated by Cu, Zn and Pb anomalies centred on Tai Mo Shan in the New Territories was subsequently confirmed[3] and the fieldwork undertaken by the authors. Due mainly to the radial drainage pattern of Tai Mo Shan, there is a potential for these chemical elements which are of concern to human health to disperse downstream. Because of this, for the present study, two areas near Tai Mo Shan were selected for follow-up stream sediment geochemical reconnaissance surveys. They are the Upper Jubilee Reservoir and Shek Kong areas located in Figure 1. These areas were chosen for two reasons. Firstly, the streams discharge into the Upper Jubilee Reservoir and downstream to affect groundwater reservoirs which are used for domestic and/or agricultural consumption. Secondly, the streams drain through the important agricultural areas of Shek Kong, Kam Tin and Yuen Long before entering Deep Bay where extensive oyster farming is carried out. There is therefore a possibility that the natural input of Cu, Zn and Pb originating from bedrock mineralization to create a health hazard in addition to those deriving from anthropogenic sources. The present study has two main objectives. Firstly, to confirm the Cu, Zn and Pb mineralization, and secondly, to assess the possible environmental impact of 23 selected chemical elements on the catchment areas downstream of Tai Mo Shan. This is carried out by means of a rapid multi-element method of chemical analysis with simultaneous ICPAES.

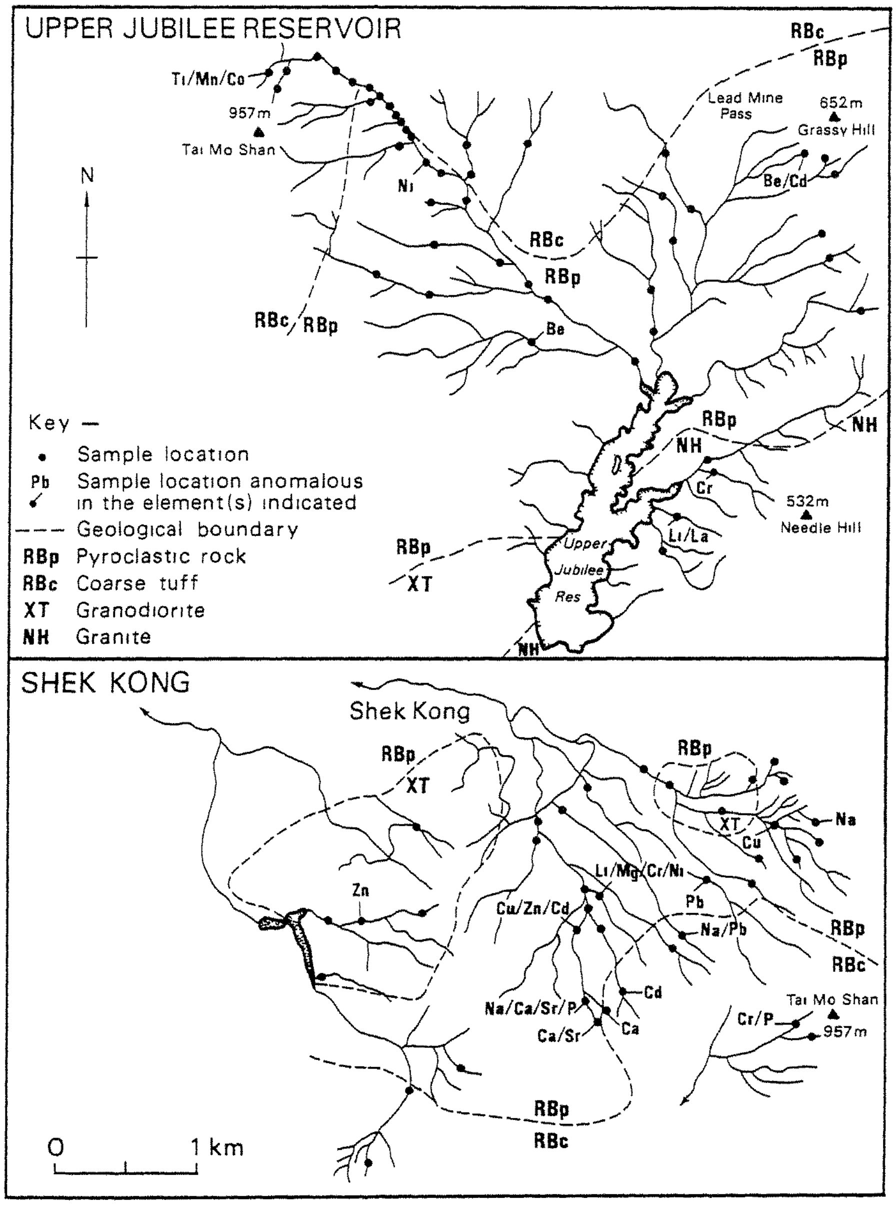

Figure 2: Map showing the simplified geology, the distribution of stream sediment sampling stations and anomalous sampling stations in the Upper Jubilee Reservoir and Shek Kong areas. The geology shown is based on Allen and Stephen[2].

SAMPLING AND CHEMICAL ANALYSIS

Active stream sediments were collected along the locations shown in Figure 2. The two areas, Upper Jubilee Reservoir and Shek Kong are 11.7 km^2 and 8.8 km^2 respectively. A total of 84 samples were collected giving an average sampling density of just over 4 per km^2. However, because of the absence of sediment along the fast flowing stream sections, it is not possible to distribute the sampling stations evenly throughout the two areas studied.

In the laboratory, the samples were treated in the manner shown in the flow chart (Figure 3). Each sample was placed in a ceramic mortar for drying at 100°C prior to disaggregation with a ceramic pestle. The sediment fraction passing through a 170-micron (approximately British Standard Sieve No. 90) nylon sieve was used for chemical analysis. After a digestion using 2:1:5 nitric acid/perchloric acid/hydrofluoric acid on a 0.1 g sample weight, 23 elements - Li, Be, Na, Mg, Al, P, K, Ca, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Rb, Sr, Cd, Ba, La and Pb were selected for determination by ICPAES using a direct reading Applied Research Laboratories 34000 C equipped for the simultaneous determination of more than 30 elements.

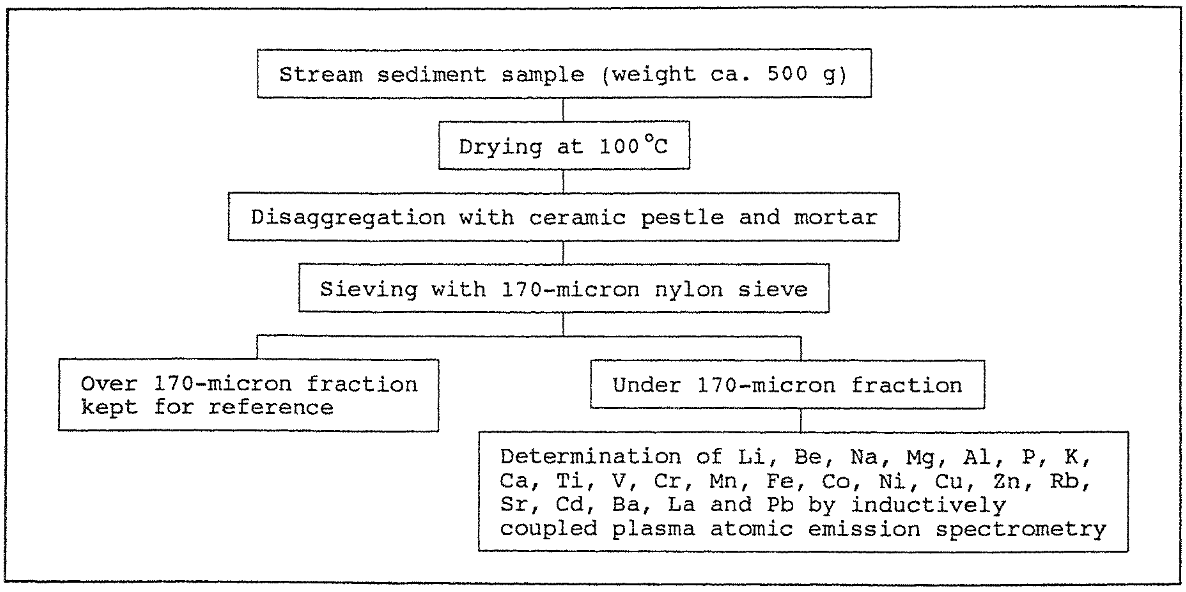

Figure 3: *Flow chart of sample treatment.*

Analytical control was maintained by comparing observed values of duplicates using the method of Thompson and Howarth[4]. The sample batch for analysis was made up of about 10% duplicates and the overall precision of the results was estimated to be generally better than $\pm$ 15% at the 95% confidence level. For the majority of the chemical elements determined, the precision was comparable if not superior to those obtained by the atomic absorption method. However, the simultaneous ICPAES method has numerous advantages because of its low chemical interferences, excellent detection limits, efficient excitation, speed and savings on labour.

Geochemical data for all samples were computed to determine, for each chemical element, the arithmetic mean, standard deviation, range, coefficient of variation and correlation coefficient between elements. Statistical limits recommended by Hawkes and Webb[5] were adopted for the data interpretation. The background was taken as the mean concentration plus 1 standard deviation, the threshold as the mean concentration plus 2 standard deviations and an anomaly was taken as the mean value plus 3 standard deviations.

RESULTS

A summary of the geochemical results and the crustal average of the chemical elements studied is presented in Table 1. Out of the 23 elements, only 8 - Rb, Be, La, Ti, Mn, Zn, Cd and Pb show mean concentrations exceeding that of the crustal average. No anomalous samples were found for 6 elements - K, Rb, Ba, Al, V and Mn. The 5 largest and smallest coefficients of variation found were Na, Ca, Cd, Pb and Be, and, Al, La, Rb, Li and Fe respectively. Cu, Zn and Pb enrichments also associated with Cd all of which are related to bedrock mineralization are identified in the two areas studied.

Table 1: *Crustal average of chemical elements studied and summary of geochemical results. In parts per million unless stated*

Element	Crustal average*	Mean $\bar{x}$	Range	Standard deviation σ	Anomaly $\bar{x} + \sigma$	No. of samples	Coefficient of variation $\frac{100\,\sigma}{\bar{x}}$ %
Li	30	25.2	14.6 - 50	7.4	47.4	2	29.4
Na	25,000	2,643	380 - 12,400	2,403	9,852	3	90.9
K	25,000	17,811	7,000 - 30,000	5,805	35,226	-	32.6
Rb	150	188	77 - 320	54	350	-	28.7
Be	2	6.3	1.7 - 25	4	18.3	2	63.5
Mg	17,000	2,980	530 - 9,800	1,483	7,429	1	49.8
Ca	33,000	4,904	350 - 20,000	3,941	16,727	3	80.4
Sr	300	48.4	10.1 - 121	21.6	113.2	2	44.6
Ba	580	355	62 - 550	123	724	-	34.6
Al	81,000	71,510	46,000 - 101,000	12,430	108,800	-	17.4
La	25	44.2	27 - 78	9.7	73.3	1	21.9
Ti	4,400	5,036	660 - 17,500	2,670	13,046	1	53.0
V	150	72.6	13.5 - 129	25.8	150	-	35.5
Cr	100	15.7	6.3 - 69	9.5	44.2	3	60.5
Mn	1,000	1,251	530 - 4,600	493	2,730	1	39.4
Fe	46,500	30,485	13,300 - 50,000	9,228	58,169	-	30.3
Co	25	19	4.5 - 65	8	43	1	42.1
Ni	75	11.3	5 - 62	7.1	32.6	2	62.8
Cu	50	20.3	5.3 - 73	11.9	56	2	58.6
Zn	80	236	62 - 630	117	587	2	49.6
Cd	0.1	1.3	0.5 - 6.1	1	4.3	3	76.9
Pb	10	182	62 - 960	133	581	2	73.1
P	900	369	59 - 870	147	801	2	39.8

* Source - Green[6], Taylor[7] and Wedepohl[8]

Figure 2 shows the distribution of the anomalous sampling stations in the two areas studied. No clear cut pattern is discernible probably because the total sample population of 84 examined was too small. Nevertheless, all of the Cu (2), Zn (2) and Pb (2) anomalous samples are located in the Shek Kong area indicating that this area may be more intensely mineralized. In the case of Pb, both anomalous samples are located within 1.5 km northwest of the peak of Tai Mo Shan (Figure 2). Cu and Zn and Cd are all present in anomalous concentrations. The distribution of the Cu, Zn and Pb anomalous samples found is consistent with a mineral zonation pattern resulting from hydrothermal activity controlled by temperature. The lower temperature Pb zone is located above the higher temperature Cu and Zn zone.

Table 2 provides a comparison between selected geochemical characteristics of the two areas studied. The range of concentration and provenance of Cu, Zn, Cd and Pb are indicated by the coefficients of variation and the correlation coefficients respectively. Both the highest and lowest coefficients of variation are found in the Shek Kong area with Cd (85.7%) and Zn (38.2%) respectively. Pb (84.8%) also shows a high coefficient of variation in the same area. In terms of correlation coefficients, the strongest positive correlation in both areas studied is between Zn and Cd, followed by Zn and Pb. These results are thought to reflect the nature of bedrock mineralization with mineral veins sporadically intersecting the stream courses. In the Shek Kong area, the area immediately to the northwest of the Tai Mo Shan peak is found to be the main anomalous area for Cu, Cd and Pb (Figure 2). Bedrock mineralization is therefore confirmed in both areas studied although the present results also indicated that its extent is rather localised being restricted to narrow mineral veins.

Table 2: *Comparison of area size, number of samples, coefficients of variation and correlation coefficients of selected chemical elements in the two areas studied*

Area		Upper Jubilee Reservoir	Shek Kong
Area size in km^2		11 7	8.8
Number of samples		8 8	38
Coefficient of variation	Cu	41 6	57.1
	Zn	44.4	38.2
	Cd	66 7	85.7
	Pb	50 6	84.8
Correlation Coefficient	Cu/Zn	-0 05	0.30
	Cu/Cd	-0 41*	0.28
	Cu/Pb	0.13	0.14
	Zn/Cd	0 67	0 56
	Zn/Pb	0 39	0.43
	Cd/Pb	0 29	0.19

DISCUSSION OF ENVIRONMENTAL IMPLICATIONS

Based on the concentrations of Cu, Zn, Cd and Pb in stream sediments found in the vicinity of Tai Mo Shan, elevated concentrations of these metals are expected to occur downstream through natural dispersion. It is therefore essential to distinguish between natural input and industrial input in water and sediment pollution impact studies. The identification of inputs through the examination of coefficients of variation and correlation coefficients of chemical elements obtained from stream sediment geochemical reconnaissance surveys should be possible.

Cd, a metal of environmental concern is found to be associated with bedrock mineralization in both areas studied. Because of the geochemical association of Cd with Zn, these two metals are usually strongly positively correlated with each other in earth materials. An example of environmental concern is the concentration of Cd and other heavy metals present in oysters cultured in the inshore waters of Deep Bay (Figure 1). It is necessary to determine whether the metal concentrations are the consequence of natural input and/or industrial input. If both types of input are involved, it is desirable to quantify their individual contribution. The present study is in support of the findings of Yim[9] and Yim and Leung[10] that the concentrations of Cu, Zn and Pb in marine sediments in Tolo Harbour is at least partially related to natural input from mineralized rocks around Tai Mo Shan.

The high concentrations of Pb found is of the greatest environmental concern because of the toxicity of the metal to human health. The threat of Pb of water supply through reservoirs and groundwater reservoirs is a possibility that should be further investigated. However, since other sources of environmental Pb such as leaded fuel and lead paints are possible, it is necessary to adopt a fingerprinting method to identify the different sources.

CONCLUSIONS

Stream sediment geochemical reconnaissance surveys based on the use of simultaneous ICPAES is an inexpensive and efficient method for obtaining information on the distribution of a wide range of chemical elements for identifying problem areas. The coefficients of variation and correlation coefficients between the chemical elements would provide a means of identifying their provenance in addition to elemental concentrations. In the present study, bedrock mineralization in Cu, Zn, Cd and Pb is confirmed by the follow-up surveys in the Upper Jubilee Reservoir and Shek Kong areas. The transportation of these elements downstream is therefore of environmental concern.

Follow-up work using Pb isotopes to fingerprint the Pb content in stream and reservoir waters of the Upper Jubilee Reservoir is reported separately by Dr BL Gulson[11] at this seminar (see country report for Australia). The result of this work indicated that other sources of environmental Pb such as from leaded fuel and leaded paints may be more important in accounting for the Pb concentration found in human blood and urine. Follow-up work on the pathways of Pb into human beings using Pb isotopes for fingerprinting would be an important environmental topic worthy of investigation.

ACKNOWLEDGEMENTS

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LEGAL CONTROLS OF ENVIRONMENTAL POLLUTION

convenors:

TL MOTTERSHEAD
JH COTTRELL

INTRODUCTION

The papers presented in this session emphasise two things:

1. that legal controls of environmental pollution cannot be considered independently of economic, cultural/social and political factors in each country in the Asian region; and
2. that the need, relevance and effect of such controls concerns and requires the expertise and co-operation of lawyers, economists, scientists, educators, other professionals, non government organisations, government, business and the general public.

The papers show that control of pollution in Asia and other countries has been implemented by legislation. This legislation has been enacted without extensive consultation by the governments with interested parties and without research being done as to the best method of controlling pollution. The legislation has therefore been reactive rather than proactive. The reaction has all too often been after severe tragedies e.g. death or gross deformation of life forms from exposure to pollution or consumption of contaminated food (Allen). There was a call to reverse this trend from the speakers and the audience by considering what each interested organisation can do to be proactive.

To be proactive requires a consideration of how effective existing control mechanisms have been and then to consider how they can be improved. A detailed analysis of legislative controls and comparisons with other countries was made and their success in reducing pollution by air, land or water was undertaken e.g.:

1. prosecutions under the water pollution legislation in Hong Kong (Baillie);
2. an overview of all types of pollution legislation in Hong Kong (Skrine);
3. decrease in pollution (or otherwise) since the introduction of unleaded petrol into Hong Kong (Au, Chou, Wong);
4. how controls through health laws have affected pollution in Malaysia (Utama);
5. the affects of the legal requirements for environmental impact assessments for developments in Malayasia (Idris, Fuad).

One paper queried whether legislative control was the most appropriate method of controlling pollution. It urged that alternative methods of control be considered especially after careful analysis of the mechanism of environmental control that exists in nature itself (Kaine, Reeve, Musgrave).

It was concluded that since control has been effected through legislation in most countries and considering that the control has not had overwhelming success in drastically decreasing pollution (Allen) it has to be objectively reviewed to see what more can be done and more specifically what ASAIHL can do. The following suggestions were made for ASAIHL to consider (Barcelona):

1. more conferences to be held for ASAIHL particularly encouraging participation of other interested groups as this will act as an information exchange and encourage all parties to remain committed;
2. environmental consciousness should be raised by incorporating environmental issues into all curricula at all levels of education i.e. primary, secondary and tertiary;
3. corroborative research into the environment between universities should be encouraged;
4. ASAIHL should take a leading role in suggesting curricula that incorporates environmental issues, promote competitions, contests, prizes and presentations in environmental issues;
5. ASAIHL should start a journal about environmental issues;
6. a policy should be formulated that educating the teachers in environmental issues is compulsory;
7. ASAIHL universities should canvas what they can do to offer the use of each institution's collective expertise in environmental areas e.g. EIA (Idris, Fuad);

8. ASAIHL should try to be involved in and access experiences from other countries e.g. through participating in regional training centres for EIA (Idris, Fuad);
9. law schools could act as a body willing to pursue citizen suits on behalf of individuals or groups, particularly where these individuals or groups would otherwise be unable to bring actions e.g.due to lack of funds (Axline).

The Session concluded with much for all of us to consider and with much more for us to do particularly as it was agreed that time is running out and real action is required today!

ENVIRONMENTAL POLLUTION, HIGHER EDUCATION, AND THE RULE OF LAW

M Axline
University of Oregon, School of Law, Eugene, Oregon, USA

INTRODUCTION

"Ultimately, enforcement of the laws is what really counts."[1]

The thesis of this paper is that there is a need to narrow the gap between the ideals of environmental laws and the reality of environmental pollution. In the paper I propose, as I have suggested in other forums[2], that partial privatization of environmental law enforcement is the optimum way to narrow the gap between environmental ideal and polluting reality.

Although many countries have adopted environmental laws that are intended to protect the environment, those laws are meaningless in the absence of effective enforcement. As a rule, agency enforcement is inadequate. Regulatory agencies are chronically understaffed, subject to political pressure, and often have agendas quite different from legislative agendas. Consequently, despite strong environmental laws and the best legislative intentions, environmental pollution continues to threaten public health in virtually every part of the world. Only through fundamental changes in the methods by which we regulate environmentally destructive activities can we have any hope that our children will inherit a liveable planet.

Institutions of higher education have a unique role to play in promoting the changes that will be necessary if we are to achieve meaningful environmental protection. Colleges and universities have both the ability and the responsibility to educate students about shortcomings in regulatory processes that lead to increased harm to the environment. Institutions of higher education must investigate, document, and teach about the economic, social, and political factors contributing to lax enforcement or nonenforcement of environmental laws. It is worse than useless to simply teach what laws say. It is deceptive. It creates the illusion that problems have been solved, when in fact they have not. It allows people to feel comfortable when they should be concerned. We must not only teach students about the aspirations of the law — we must also teach them about its fallibility[3]. Then we must work with them to create solutions.

Students of course are taught that legislatures create laws and bureaucracies implement those laws. What students are *not* generally taught is that there is a serious dichotomy in society's view of the administrative state. On one hand, governments are founded on the assumption that bureaucratic agencies are institutionally capable of implementing laws adopted by elected officials in a roughly neutral way. It is assumed that laws, once adopted, will be enforced. That fundamental assumption is seldom questioned. On the other hand, few people believe that agencies are effective at regulating polluting industries, and sociological and legal literature is filled with explanations of why agencies fail to fulfill their missions.

These explanations for the failure of agencies for the most part make perfect sense. So why do we continue to act as if bureaucracies are capable of carrying out their regulatory missions? The answer is that bureaucracies have become so central to the operation of modern governments that to abolish bureaucracies would be to do away with government altogether, and no one wants to go that far, including me. But if eliminating bureaucracy isn't the solution, how do we establish a system that insures aggressive enforcement of environmental laws? Before describing what I see as the building blocks of a meaningful environmental law enforcement system, I want to examine in slightly more detail the reasons that regulatory agencies cannot be expected to do the job themselves.

THE NEED TO SUPPLEMENT AGENCY ENFORCEMENT

We are all familiar with bureaucracies. Administrative agencies are present in nearly every aspect of modern life, from administering education for our children to enforcing criminal laws to collecting taxes to regulating polluting activities. We have all been frustrated with the paperwork and red tape that seems to inevitably arise when dealing with agencies, and we have all seen agencies do things that seem directly contrary to what they were established to do. These shortcomings are due, I believe, primarily to four fundamental aspects of agency structure.

Inadequate resources: Regulatory programs are never adequately funded. In the environmental arena, there is simply no way that agencies, in *any* society, no matter *how* well funded, can do more than put a band-aid on the overwhelming number of activities that threaten the environment. There are too many sources of pollution, too much pressure for natural resources, too many laws to enforce, and too many other demands for scarce public dollars. In the United States, the Environmental Protection Agency (EPA) has known for years that virtually every pesticide contains secret ingredients that are unregulated and potentially very dangerous. But EPA has been unable to do anything about it because it does not have the resources to keep up with the literature on even the *known* ingredients. Only the highest profile environmental problems receive serious attention, as scarce agency resources are used up in running from one emergency to the next. Chronic, long term environmental problems don't receive attention until they become full blown crises, because agencies only have enough resources to respond to crises.

Capture: The second reason that we cannot rely on regulatory agencies alone to enforce environmental laws is that agencies tend to become captured over time by the sectors they are charged with regulating. This tendency to be captured by, and begin to serve, regulated entities is not a recent development[4]. As two prominent authors wrote in 1971:[5] "[T]he federal bureaucracy is, with dismaying frequency, overly deferential to the business interests they are obligated to control." Given time, virtually any agency will become captured by the entities it is charged with regulating[6].

While there is "widespread recognition"[7] of the problem of agency capture, little has been done to solve the problem. Agency capture results from preferred access by regulated entities to agency proceedings, agency reliance on information provided by regulated entities, the inherent difficulty in maintaining an adversary relationship in the face of continuous contacts, and the relative economic and managerial benefits to agencies of cooperative, rather than adversarial, relationships[8].

There have been a number of proposals over the years for solving the problem of agency capture, most of them having to do with empowering citizens to play a role in the administrative process roughly equal to the role played by regulated entities. Such participation is not realistic, however, because over time even publicly funded citizen participants cannot provide the continuity and determination that is assured from regulated industries. Even if it were possible to create a strong and ongoing citizen presence in the regulatory process, such an arrangement would pose the risk that citizen representatives would themselves be captured over time, for many of the same reasons that agencies are captured.

Self-Interested decisionmaking: A third problem contributing to the gap between legislative goals and environmental reality is the self-interested nature of decisionmaking within agencies. The benevolent assumption underlying most teaching about the relationship between legislative bodies and bureaucracies is that agency decisionmakers are engaged in a good faith effort to implement legislation in the manner intended by the legislature. Fidelity to legislative direction, however, is often one of the least important considerations in agency decisionmaking. Individual and agency self-interest often play more of a role in agency decisionmaking than legislative intent[9].

A. Individual self-interest: Individual decisionmakers within agencies are subject to a variety of pressures other than direct pressure from industry interest groups. Promotion within an agency, for example, may depend upon factors other than performance in implementing the legislation under the agency's jurisdiction. Within the United States Forest Service, for example, promotion frequently depends upon the amount of timber sold, although the environmental laws governing the national forests specifically provide that protection of the environment shall be given a higher priority than sales of timber. And it may be more difficult to decide to close a polluting factory when the decisionmaker's children go to school with the children of factory workers.
B. Agency self-interest: Collective decisionmaking within an agency may also be driven by factors other than a desire to aggressively implement relevant legislation. A desire to increase the budget, for example, may lead an agency to develop unnecessary programs, which spawn additional self-interested decisionmaking by individuals. A classic example may again be found in the United States Forest Service, where the agency's budget is enlarged if it sells more timber, but shrinks if it provides more environmental protection.

Inherent tension between agencies and legislatures: In addition to the problems of inadequate resources, agency capture, and self-interested decisionmaking, many systems of government correctly assume an inherent tension between centers of power within government. Thus, certain roles are defined for legislatures, certain roles are defined for agencies, and certain roles are defined for the courts. There would be no need for such definitional line drawing if government were simply one big happy family, all seeking to achieve the same ends. Yet when laws are adopted, it is assumed that the best method for enforcing those laws is to rely on a bureaucracy that is *institutionally* distinct from, and therefore likely to have a different agenda than, the body that wrote the law.

CITIZEN SUITS AND THE RULE OF LAW

Few realistic solutions have been offered to address the intractable problems with relying exclusively on administrative agencies to enforce environmental laws. As I suggested at the beginning of this paper, however, recent efforts to partially privatize the enforcement of environmental laws through "citizen suits" have achieved remarkable success in the United States. Empowering citizens most affected by pollution to enforce laws regulating that pollution addresses each of the problems that contribute to agency inertia. Empowering citizens to enforce the laws addresses the problem of limited agency resources by greatly increasing the personnel available to monitor polluting activities and to force polluters to stop violating the law. This population-wide increase in enforcement resources is accomplished with little or no tax dollars.

Empowering citizens to enforce environmental laws addresses the problem of agency capture because individual citizens who are harmed by pollution or resource destruction will not be lobbied over time by industries. Rather, such citizens act in response to single, localized, and specific problems.

Empowering citizens affected by environmental pollution to enforce environmental laws also addresses the problem of self-interested agency decisionmaking because citizens do not have to worry about their careers within a regulatory agency when deciding whether to enforce laws. Rather than worrying about advancement within the agency, they act out of the same concern as the legislature that adopted the laws initially – a concern for health, a clean environment, and a higher quality of life.

In short, empowering citizens to enforce environmental laws insures aggressive enforcement and helps to close the gap between legislative ideals and environmental realities. An important additional benefit to citizen suits is that when citizens are empowered to enforce environmental laws, that contributes to a strengthening of the rule of law and a shared sense of community.

How citizen suits work: Although almost every environmental law that has been adopted in the United States in the last twenty years has included a provision authorizing citizen enforcement, the model legislation in the United States for citizen environmental law enforcement is in the Clean Water Act. The citizen suit provisions of the Clean Water Act work in the following way. Under the Clean Water Act, no person can discharge any pollutant unless she first obtains a permit to do so from EPA. EPA reviews all permits to insure that the total discharges to a body of water will not exceed acceptable water quality standards. A condition to receiving a discharge permit from EPA is that the discharger must regularly monitor discharges and self report those discharges, including any violations of permit conditions, to EPA. These reports, called discharge monitoring reports, are available for review by citizens. They are for the most part accurate, since criminal penalties can be imposed upon anyone who falsifies a report. Substantial civil penalties may be imposed for violating pollution restrictions established in discharge permits.

If a citizen reviews the discharge monitoring reports for a polluter and finds that the polluter has been violating the terms of a permit, the Clean Water Act authorizes the citizen to file suit against the polluter and seek civil penalties, injunctive relief, and attorney fees. Discharge monitoring reports are presumptive proof that violations indicated in the reports did in fact occur. This presumption prevents unusual and exotic defenses from being offered after the fact, and makes prosecution of such cases much simpler.

A common feature of most citizen suits under the Clean Water Act is that after the suit is filed and the polluter realizes that it may have to pay substantial civil penalties (penalties can run as high as $25,000 per day per violation), the polluter seeks to settle the case with the citizen plaintiffs. Settlement typically includes the polluter agreeing to purchase better pollution control equipment or cut back on emissions, paying some amount of money to an environmental organization working to improve the environment, and paying the attorney and expert witness fees for the citizen plaintiffs. So long as the aggregate cost of such a settlement is less than the estimated costs of civil penalties, the polluter has an economic incentive to accept such a settlement. And citizen plaintiffs are satisfied because they achieve immediate improvements in the environment, without having to wait for whatever delayed effects might occur if civil penalties were imposed by the courts.

Why citizen suits work: Although providing citizens with the right to enforce environmental laws might conjure up the spectra of overzealous citizens filing suit at the drop of an organochlorine molecule, there are a number of self-limiting factors that insure that citizen suits will likely be filed only in serious cases. The first is that such suits are time consuming and somewhat costly to prosecute and therefore are not initiated lightly. The second is that citizens typically do not act until confronted with a real problem (although their action threshold is lower than that of regulatory agencies). Finally, there is an emotional cost to prosecuting a lawsuit that citizens will not likely assume. Such lawsuits are time consuming and citizens do not undertake them lightly.

Any legislation authorizing citizen suits should, of course, attempt to strike a balance between providing incentives for citizens to file serious cases and avoiding the problem of overzealous environmental prosecutors. The factors that go into such an equation will vary from country to country, but it does seem to me that at a minimum such legislation must insure that citizens' legal fees will be paid if they prevail, and sanctions against losing polluters must be sufficiently high to encourage serious settlement efforts on the part of the polluter.

CONCLUSION

In simpler times, it was each citizen's obligation to participate in enforcing the rules that govern society. The complexity of modern society, and the lack of accountability in bureaucracies, has stripped many of us of our sense of community, and made us feel powerless to stop violations of the laws by which we have collectively agreed to live. Citizen enforcement of environmental laws is not only a way to provide more meaningful protection for the environment — it is a way to reestablish a sense of purpose in the communities in which we live. When citizens are given a meaningful voice in enforcing legal rules, they feel more a part of the social contract, and lend their energies more easily to shared efforts to improve the condition of the world. In the long run, that is what we will need to survive together on this blue planet.

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8 The mechanics of agency capture have been delineated in a number of articles. See e.g., Stewart R. The Reformation of American Administrative Law. Harv L Rev 1975; 88:1669, 1713; Chambers. Increasing Citizen Participation Case W L Rev 30 at 34.

9 An old but accurate saying is that agencies pay attention to authority in the following order of priority. (1) the unspoken word; (2) the spoken word; (3) the memorandum; (4) the agency manual, (5) the agency's regulations; (6) statutes; and (7) the Constitution.

LEGAL CONTROLS OF ENVIRONMENTAL POLLUTION IN ASIA: HOW EFFECTIVE ARE THEY?

J Allen
Business International Asia/Pacific Ltd, Hong Kong

INTRODUCTION

The enforcement of anti-pollution laws has, as would be expected, a shorter history in Asia than in Europe and North America. The first laws, and the first effective laws, belong to Japan and Singapore and were enacted a little over 20 years ago. Some laws existed before in both these countries and elsewhere in the region, but they were either not effective or they were only designed to deal with simple types of pollution, such as black smoke.

The most recent laws belong to countries which have been late entries into the world trading system, such as China. In South and South-East Asia, laws were passed in the early 1970s, soon after the landmark Stockholm Conference on the Human Environment in 1972. With a few exceptions, these laws were not enforced with much vigour during the following decade and a half. The late 1980s brought renewed emphasis on pollution control in South-East Asia, a result of the mounting piles of waste from fast growing economies and the emergence of global problems, such as ozone depletion.

The theme of this paper is that legal controls have yet to make a significant impact on pollution in most parts of Asia. This conclusion in itself is hardly startling: the negative effects of economic growth on the environment can be seen in every Asian city. If controls were working, problems of air, water, noise and waste pollution would not exist to such a serious extent. The causes of these problems, however, run deeply through many levels of politics, economics and society. They include the primacy of economic growth in public policy, the very low level of resources devoted to pollution control, and a lack of public pressure on governments. Deeper and more contentious reasons derive from the autocratic structure of many governments, the closed way in which natural resource exploitation licences are allocated, the barriers to public input into decision-making, and strong economic vested interests. The conclusion to be drawn is that solving environmental problems may require far-reaching political as well as economic changes.

It would be unfair to say there have been no successes. Japan has brought visible industrial pollution under control, such as smokey chimneys, and has a good record on energy efficiency. Singapore has kept fairly tight control on both industrial waste and domestic wastewater; it has the highest rate of treatment for household sewage in Asia. However, the story does not end here. Both countries have paid less attention to "invisible" forms of waste, such as soil contamination from chemicals. Both have a growing garbage problem. They are also discovering that pollution does not go away after 20 years of enforcing laws against it. Old types of pollution must be constantly monitored and treated, while new ones are appearing. Traffic-related air pollution in Japan is on the rise.

The paper begins with a historical overview of pollution and environmental degradation during the colonial period in Asia, then moves on to consider the forces obstructing environmental policy. Positive developments around the region are examined in the third part of the paper.

HISTORICAL BACKGROUND

In their national reports to the recent United Nation's Conference on Environment and Development, several governments in Asia blame pollution on the "rapid industrialisation and urbanisation" their economies have undergone during the past three decades. There is much truth to this - the variety, volume and complexity of pollution has increased markedly as a result of the development of export-oriented industrialisation. Human sewage has become more difficult to dispose of with population growth and the migration of people into cities. Rubbish volumes have paralleled rises in GDP and space is running out for landfills. Incinerators, meanwhile, are highly unpopular. New forms of high-tech industry and agriculture have introduced thousands of strangely-named toxic chemicals, like organo-chlorines, or ones which do not damage humans, but do destroy the ecosystem, like chlorofluorocarbons (CFCs).

But the foundation for modern pollution in Asia did not start with post-War industrialisation. Its origins stretch further back, to the 19th century, when European powers were busily extending their colonial rule across the predominantly agricultural map of South and South-East Asia, and expanding trade links with North-Asia. A summary of the main developments will show that pollution, and general environmental degradation, has resulted from the deepening interdependence of the Asian and European/North American economies.

The driving force behind this process was the need by the "West" for Asia's raw materials - wood, minerals, rubber and other crops - and for further markets to whom it could sell. James Rush, an American academic specialising in Asian history, gives a succinct description of these events in his recent book[1]. To quote, selectively, from his book[2]:

> "For the most part ..... the impact of Western-driven international trade upon the resources of Asia was light until the 19th century. In India, Britain consolidated its power at the end of the 18th century. By that time its own forests were already exhausted and it was badly in need of new sources, especially for seaship-worthy hardwoods like teak. The quest for teak drove British officials to lay claim to India's natural resources and generated huge profits for private businessmen who opened the forests and brought the wood out...
>
> The next and final stage of imperial consolidation in India occurred after the war of 1857, known to many Westerners as the Indian Mutiny. By this time the engines of Europe's nascent industrial revolution had begun to alter Asia's economy and landscape. Among its noticeable modern manifestations in India was the beginning, in the 1850s, of a great web of railway lines - rails along which the colony's valuable raw materials could be efficiently withdrawn and new products 'made in Britain' brought in."

Rush goes on the to describe similar changes occurring in many other parts of South and South-East Asia - the Philippines, Malaya, Java and Sumatra, Burma and Vietnam - and the institutional and infrastructural developments which went hand in hand with economic change and expansion[3].

> "Everywhere it was the same. As the land filled, it was changed: trees were felled, marshlands filled, streams and creeks diverted to water the crops. Vast strands of forest became vast expanses of paddy field, plantations, tea and rubber gardens. Those who changed the land also changed the biosphere, altering the subtle interactions of land, water, and air that control the pattern of rainfall and other features of the ecosystem.....
>
> The role of government also grew, as colonial administrations (and the kings of Thailand) introduced new bureaucratic departments to rationalize commerce, revenue collection, and public works. Public works, in fact, were among the most visible elements of change; by the 1920s, new modern roads and bridges, railroads, telegraph and telephone lines, and harbour works had become the boast of every colonial regime....
>
> And it meant the growth of large capital cities that were seats of government, gathering places of elites, and statewide centres of banking and credit, exporting

and information. Cities like Rangoon, Bangkok, Manila, and Batavia (Jakarta) dominated entire colonies and states; others, like Medan, Surabaya, Cebu, and Saigon became powerful regional commercial centers."

Adding to the strain on the environment - and the volume of pollution produced - was the alarming population growth. Between 1870 and 1940 the population of South-East Asia increased from 55 million to 145 million, causing widespread encroachment on "open land"[4].

The main thrust of Rush's argument is that the economic changes introduced by the colonial governments unbalanced a certain ecological equilibrium that had existed before in the predominantly agricultural communities of South-East Asia. This began the systematic exploitation of the region's rich natural resources and laid the basis for the greatly intensified economic development - and environmental degradation - which occurred after the Second World War. Although Rush does not write in detail about pollution, the development of transport links, new towns and cities, and the establishment of plantations would have given rise to a larger variety and volume of pollutants than previously experienced - smoke, sewage, noise and waste.

The existence of a problem is reflected in early anti-pollution laws passed in some colonies. In India the Bengal Smoke Nuisances Act was passed in 1905. Bombay copied this in 1912. The country passed a Motor Vehicles Act in 1939, which gave states the right to control exhaust emissions. In 1913, the Thai Government passed the Navigation in Thai Waters Act, which includes a provision forbidding the discharge of oil into navigable waters. While the object of this law was not oil pollution control, but rather prevention of fire, it indicates oil dumping was a problem even then.

Other, non colonial states, had also begun to suffer industry-induced pollution in the early years of this century. The most notable was Japan. Michio Hashimoto, a veteran environmental official (now retired) and observer, has written that early pollution problems in Japan drove community groups and trade associations to protest against the government. One such group was the farmers' unions, who "fought against the hazards from mining smelters, demanding control measures of air and water pollution in order to avoid agricultural damage"[5]. Mining regulations existed, but the government did not enforce them effectively. Hashimoto writes[6]:

> "Since industrial pollution was relatively unaffected by government regulatory measures, villagers, farmers and fishermen organised themselves against the pollutors, gaining some compensation by either direct confrontation or legal action. In 1904, a strong confrontation by farmers and residents living near cement factories resulted in the installation of electric precipitators, thus ending the air pollution which had caused heavy deposits around the immediate and surrounding areas. Finally, in 1939, the National Government, aiming at unifying the nation for war, enacted a strict liability act against the mining industry."

While the process of widespread environmental degradation/pollution was initiated by colonial powers, it intensified under the governance of the region's newly-independent nation states. Determined to build export-oriented industrial economies in only a few decades, the pace of deforestation, commercial farming, mining, hydro-electricity production and manufacturing increased and, with new technology, became more systematic and, as a consequence, more destructive.

This process was particularly pronounced in GDP terms during the 1980s. According to the Economic and Social Commission for Asia and the Pacific (ESCAP), average growth in the past decade in the Asia/Pacific region stood at 6.8% compared to a world average of 3%. Growth levels in many newly industrializing countries of North and South-East Asia during this period were higher than the Asia/Pacific average and are expected to remain well above world averages through the 1990s.

These policies suited Western powers and were, accordingly, done with the intellectual and financial encouragement of the World Bank/IMF and Asian Development Bank. They were also legitimised by the noble cause of eradicating poverty, creating jobs and strengthening national security. But poverty has not been beaten and pollution has often been severe in the industrial areas of several countries over the past 40 years. Infamous public health tragedies include Minamata in Japan (1956), Bhopal in India (1984) and Bukit Merah in Malaysia (1980s). More recent cases in South Korea and Taiwan, although not as serious as those above, indicate that public health is still at risk from industrial accidents.

ENVIRONMENTAL PROTECTION VERSUS ECONOMIC GROWTH

Pitted against the economic momentum generated by the colonial and then newly independent nations of Asia, it is hardly surprising that an ostensibly "anti-development" philosophy such as environmental protection has had few allies at any level of society until recently. A lack of capital for investment in "non-productive" social infrastructure (sewerage, parks) and the imperative of creating jobs, housing and food put the environment out of mind. The minority who was conscious of the problem and tried to raise it as an issue faced political pressure, especially in the more authoritarian countries.

In communist China, pollution was considered ideologically impossible. Said Qu Geping, head of its National Environmental Protection Agency (NEPA) in a recent book:[7] "About a decade ago some people (in China) held that environmental pollution was unique to the capitalist world and socialist countries had no pollution problem. This unrealistic view hid the truth from us." In conservative and determinedly capitalistic South Korea, complaining about the state of the environment was seen as subversive and, ironically in regard to China's old position, communist-inspired[8]. In Malaysia, a member of the Environmental Protection Society of Malaysia was put in jail during the internal security crackdown of 1987, while lawyers and activists working on behalf of the Bukit Merah villagers were also arrested in the same year[9]. Even in Hong Kong, one of the more liberal political enclaves in Asia, green groups were afraid to come out too strongly against the Chek Lap Kok airport when it announced in 1989 for fear of being branded "anti-development".

A battle of opposites: An underlying reason for viewing environmental activists as subversive was the belief of governments and business leaders that economic growth and environmental protection were diametrically opposed: an economy could have one but not the other. Putting it another way, governments have traditionally talked about "totals" - total development as against total environmental protection. In economic terms it implies that the only question which needs to be asked is: "Are the total benefits of economic growth worth more than the total costs of environmental degradation?"[10]

The flaw in this approach is that decision makers did not question whether the high environmental price their country paid for economic growth was really worth it. In other words, could some newly industrializing countries have achieved a high rate of growth and maintained a healthier environment by going a bit slower in economic growth? Instead of "totals", developing governments should be talking about "how much development versus how much environmental protection"[11].

The answer to this question is likely to be different for each country, depending on its level of development, population, education system, and so on. The living example that this theory is not pie-in-the-sky idealism is Singapore.

Evidence from the most developed economy in the region, Japan, goes even further - expenditure on environmental protection may do little harm to GDP. A paper published in July 1991 by the Study Group for Global Environment and Economics[12], a think-tank of EA personnel, stated that capital spending on pollution equipment helped to produce a slightly higher GDP in Japan in 1975 than could have otherwise been expected[13] almost 1% higher, in fact. (1975 was the year when investment in pollution treatment equipment peaked in Japan during that decade).

While it may appear that such a group has a vested interest in publishing a favorable conclusion, the fact that the information is drawn from the 1977 White Paper on the Environment indicates that it is an official statistic. The report also provided a reason for the positive outcome:[14] The reason there were no adverse effects on the macro economy resulting from these strict pollution control measures was that the economic cooling brought about by a rise in prices from pollution control measures was cancelled out by the buying effect of an increased demand for pollution prevention-related facilities[15].

Although the evidence and theory suggests that economic and environmental policy could be better integrated, managing the environment in Asia in the 1980s, and also in the 1990s, suffers from one major pressure which in other parts of the world is less serious: the sheer pace of economic activity and population growth which brings a higher rate of pollution growth and environmental degradation. Environmental management in this situation is often crisis management - a government has to work very hard just to maintain present environmental quality, no matter how bad it already is. Putting longer-term plans in place which will result in quantifiable improvements requires steely determination.

Weakness of government environment agencies: A third general reason for the weakness of pollution control in Asia is the low status accorded most government environment agencies. Many of these agencies were established around the time governments began their first phase of legislative activity on behalf of the environment in the early 1970s, around the time of the United Nations Conference on the Human Environment in Stockholm in 1972. Some were established in response to this conference (Malaysia, Thailand). Others were set up in reaction to local pollution problems (Japan, Singapore).

Although some have been in existence for 20 years, a common pattern throughout the region is that they are under-funded, under-staffed, and lacking in political and legal clout. Even today many have only a few hundred staff compared to several thousand in the economic and industrial ministries of governments. Furthermore, it is often said the dullest civil servants in any bureaucracy are assigned to environmental work; the smarter ones work in economic/political ministries. This is obviously very unfair to many capable and dedicated environmental officials in the region. Yet the fact that this slight is repeated so often suggests there are indeed pressures drawing most capable government staff into the "pro-growth" agencies.

Sharing enforcement, and sometimes policymaking, powers with more powerful "pro-growth" ministries of finance or industry also limits the effectiveness of environment agencies. Since environment agencies develop laws and policies which seek to control industry and natural resource exploitation more stringently, it is not surprising that other ministries try to undermine or ignore them. In Japan, for example, the Ministry of Construction is building a dam across the Nagara River without having done an environmental impact assessment. A former director-general of the country's Environment Agency who criticized this situation was later removed from his post.

Complementing this is the fact that environment agencies have little control over how land is used and most countries lack adequate town planning laws. The evidence of bad siting of industrial, commercial and, even residential, developments is spread throughout the region. In Bangkok, dense condominium development is allowed in areas without adequate access roads. The result is constant traffic jams along the city's "soi" or lanes. In Hong Kong, residential skyscrapers and terraces were allowed to be built next to beaches. Since most had no adequate sewage treatment plant and were not connected to sewers, the result was very high pollution at beaches. (This problem has been partially resolved).

Vested Business Interests: Vested business interests also reinforce, and depend upon, the traditional "economic growth first" policy. A large part of the problem is the short-term investment horizons which most local and foreign companies around the region follow. Long-term development models, which sustainable development is calling for, are not in the interest of sectors which rely on quick profits, such as the "old-style" clear-fell logging companies, or companies which want to erect plants in ecologically sensitive areas.

Secondly, resources such as forests have become a vital source of wealth for politicians and play a central part in the political patronage system which binds politicians and business interests in parts of South-East Asia. As Green Forum, a leading environmental group in the Philippines, said in its December 1991 newsletter:[16] "The Philippine Constitution mandates state ownership of our natural resources. State ownership works out as expropriation by politicians for themselves and in exchange for patronage of their political and business supporters. In the case of logging in the Philippines.... (these) concessions have become the centerpiece of the politics of patronage."

In such a system, environmental management is virtually impossible. A recent book, called "Saving the Earth", from the Philippine Center for Investigative Journalism[17], documents the links between logging companies and political power in the Philippine provinces many politicians own stakes in these firms and shows how the logging companies use physical and psychological force to stop environment officials from enforcing the law. The book also details widespread illegal logging outside concession areas a practice that the government is aware of, but seems powerless to stop.

Other factors: Other factors which have inhibited the effective enforcement of environmental laws include corruption, federal government systems, and the lack of integrated conservation and pollution policies.

Corruption can take several forms: the using of influence or money to secure sites for industrial/commercial development in ecologically sensitive areas; or the bribery of low-level enforcement officials to register as acceptable a factory which is transgressing pollution limits. Bribery is also a problem in the enforcement of laws pertaining to illegal logging activities and golf courses around the region. In South Korea, two officials were arrested in 1991 for accepting bribes in relation to golf course developments.

Federal government structures can undermine the efforts of a central environment agency to implement its laws. In India and Malaysia, the role of enforcement of laws is given to state governments to look after. Since state environment agencies have even fewer resources than the central agency, their ability to do an effective job is proportionately lower. Furthermore, economic competition between states drives them to permit projects which probably would not be allowed if proper environmental impact assessments were done. According to Shyam Chainani, honorary secretary of the Bombay Environmental Action Group, all the state pollution control boards in India are under pressure from their own governments to clear new development projects quickly and the central Ministry of Environment and Forests is the only body which sometimes applies the brakes:[18] "If a state pollution board does not clear [a project], they [the state government] are afraid it would go to another state."

Finally, the very low priority accorded the conservation of flora and fauna in almost every country results in the encroachment of urban areas and leisure resorts into habitats that contain endangered species. This can not only damage species; it also brings man-made pollution to areas which previously had little or none. The construction of golf courses in water catchments, forest areas and farmland - a growing issue in South-East and North Asia - is one of the best examples.

POSITIVE DEVELOPMENTS

Balanced against the fairly bleak picture drawn above are a number of developments which hold out promise for a cleaner and safer future. In the interest of saving space, these will be dealt with in point form:

* Government interest in the environment has increased in the last few years. There are several reasons for this: environmental problems have become too difficult to ignore; public pressure, protest and knowledge has increased; the environment has become an issue of international importance and Asian nations have become signatories to international treaties, such as on the ozone layer and wildlife trade; international pressure has increased on Asian nations to address their environmental problems; and countries have wanted to improve their records in light of the Earth Summit held in Brazil earlier this month.

In concrete terms this means:

* Many anti-pollution laws have been made more stringent and new ones enacted in the past two years. In 1990, South Korea introduced a set of six new laws which completely revamped its environmental legal regime. More laws have been enacted since. In 1991/2, both Thailand and Malaysia amended their basic environment laws. Taiwan continues bringing out new regulations, as has Hong Kong and India.

* Attempts are being made to introduce the "polluter pays principle" and waste recycling policies. Thailand has set up an Environment Fund. South Korea has introduced a deposit scheme on certain categories of industrial and consumer goods. Japan introduced two laws on recycling in 1991.

* Greater emphasis is being put on environmental impact assessment procedures (EIAs). The EIA process gets a bad press around the region, deservedly so because it is often seen by developers as another official hurdle to jump rather than a useful tool for improving a project. A common complaint of engineering consultants is that developers never give them enough money or time to do a proper job. Nevertheless, with public pressure for a cleaner environment increasing, it is likely EIAs will get better, rather than worse, in future. One example is the second EIA done for a controversial resort project in Penang, Malaysia. It was rejected in January 1992.

A point worth stressing here is that as environmental controls become stricter, different sections of society will benefit or lose to varying degrees. Tougher pollution laws will bring about a cleaner and healthier environment for most of society, but certain sectors of the business sector will lose out. The worst affected will be companies in highly polluting industries or who operate on very tight margins: they may find it too expensive to invest in the required pollution treatment. This applies particulary to the small-scale industrial sector, which is responsible for a large proportion of all industrial waste. (Note· In several countries this sector is shielded from tougher environmental laws by governments who do not want to drive them out of business and create unemployment).

Other positive developments include:

* Some governments are willing to listen to the views of environmental groups. In India and Malaysia, environmentalists have been invited to sit on panels which review the environmental impact assessments of major projects.

* Expenditure on environmental infrastructure is increasing. Thailand, Hong Kong, South Korea and Japan are all planning significant investments in sewage treatment and waste disposal. The question that needs to be asked, however, is will these be built in the form that is envisaged now, or will they be scaled back? The picture is patchy.

* Conservation issues, though still low on the agenda, are edging up it gently. This has as much to do with local as international pressure.

CONCLUSION

Legal controls on environmental pollution have, with a few exceptions, not been very effective in Asia over the past 20 years. The priority accorded to economic growth to the exclusion of the environment has resulted in a high ecological price paid for that growth. Laws and institutions to promote environmental protection, which were set up as long as 20 years ago in parts of North and South-East Asia, have been given little chance to work. Some government systems in the past actively discouraged environmental activism among the public, while the extent of public input into government policy even today (although growing) is still extremely limited. In certain countries, where exploitation of natural resources plays an important part in the economy, the power wielded by politicians over the use of those resources is often abused for personal gain; and makes environmental management extremely difficult. The short-term investment horizon of business intensifies the unsustainability of development.

In the past two years all governments in the region have placed greater emphasis on the environment: laws have been made more stringent, environment agencies have been strengthened and a few governments appear to be taking more account of public attitudes to their environment policies. However, without more fundamental changes in political and economic structures these policies may not bring about the improvements needed. The continuing high level of economic growth during the 1990s, and the increasing environmental strain which will accompany it, demands that government move faster towards integrating the two areas than they are at present.

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HONG KONG'S WATER POLLUTION CONTROLS - ARE WE SERIOUS?

B Baillie
Department of Professional Legal Education, Faculty of Law, The University of Hong Kong

INTRODUCTION

Hong Kong has seen a rapid expansion of its population and industrial capacity over the last 20 years or so, particularly with the relatively recent liberalization of economic policies in the People's Republic of China (PRC). It has also grown dramatically in structure as a banking and financial centre of international importance.

There is no doubt that, correspondingly, the statistical average income of Hong Kongers has increased significantly due to the economic development here. Indeed, the Territory could be described as affluent, forgetting for the moment the fact of an inequitable distribution of its wealth.

However, it's rise to a position of relative economic strength as one of the "economic dragons" of the Asian region has been achieved only at a very heavy environmental cost.

As in other parts of the world, the leaders of Hong Kong during this period have been all too willing to sacrifice the Territory's environment for the sake of short term economic development.

The legacy of that philosophy, which seems to be one of the people at large, not just the government, is only now being fully realised and the cost of its correction calculated.

In particular, there has been an across-the-board diminution in Hong Kong's water quality, particularly its harbours and beaches, which is the area I want to focus on.

POLLUTION SOURCES - GENERAL OVERVIEW

The main classification of water pollutants: According to the Environmental Protection Department ("EPD") Hong Kong discharges 2 million tonnes of waste water each day. Its polluting impact is said to be the same "as if 8419 dead pigs were put into Victoria Harbour each day"[1]!

The waste water comprises two main kinds of pollutants, industrial waste and domestic sewage. The other principal sources of waster pollution are:

- livestock waste
- fish farming
- construction waste
- maritime industry waste

Industrial waste: The average biochemical oxygen demand (BOD) strength of Hong Kong's industrial effluent is more than 300/mg L-BOD[2]. There are more than 6000 factories in Hong Kong producing effluent above 250 mg/L BOD[3], which is the government's design standard maximum for non toxic effluent[4]. There is also the problem of factories discharging their wastes, of whatever composition, illegally. In 1990 of the 550 formal complaints received by the EPD concerning water pollution, over 90% related to the illegal discharge of industrial liquid waste e.g. effluent into surface drains[5].

It is not simply a matter of the enormous volume of non-toxic industrial waste which reaches Hong Kong's waters; there are several predominant industries whose wastes are extremely lethal.

For example, Hong Kong's electronic industries produce dissolved metals wastes, particularly copper[6]. The seriousness of the problem is reflected by a recent estimate that each day "toxic metals weighing as much as a double - decker bus were dumped into Hong Kong waters; the copper alone is sufficient to plate the outside of the Bank of China building three times a week." The EPD predicts that if all factories which produce such wastes were made to comply with the 1990 Technical Memorandum, which sets out effluent standards by which the EPD will assess discharge licences in the future, dissolved metal loads in industrial waste would be reduced by 94%[7].

A very high profile polluter in Hong Kong in the past has been the textile dyeing industry, which is a major Hong Kong industry, (although the trend is towards establishing or using factories in the PRC where the labour costs are lower and environmental controls far less stringent).

For decades it has been common for textile dye factories illegally to connect their waste disposal pipes to the common storm drain system, or simply to run them into the nearest gutter or "nullah" (open drain). A recent article in the SCMP (5/4/92) described the sad plight of the Tuen Mun River (N.T.) resulting from extensive pollution over many years by such unscrupulous or ignorant factory owners. The Tuen Mun is now so polluted the colour of the water has changed dramatically; and that is not an isolated example[8].

Domestic waste: By any standards Hong Kong is an urbanised society. It is one of the world's great cities, (or collection of cities), notwithstanding that there is a surprisingly high percentage of the Territory not yet built on.

The problems of environmentally sound disposal of a city's every day waste are not peculiar to Hong Kong, but are certainly magnified here, perhaps because of the increasing pressure of domestic and industrial expansion combined with a very limited supply of accessible land.

Household refuse and the like is normally disposed of in landfills established in the New Territories. No doubt those landfills contribute to the overall degradation of Hong Kong's rivers[9].

However, by far the single most serious domestic pollutant is sewage. This is a well documented aspect of Hong Kong's environmental woes, particularly as until recently the government planned to spend billions of dollars on a Master Sewerage Disposal Scheme - now shelved, unfortunately[10].

In short, half of all domestic sewage from Hong Kong's main urban areas finds its way into the harbours, such as Victoria and Tolo Harbours, untreated[11].

The seriousness of the problem of safe disposal of Hong Kong's domestic sewage may be appreciated from the fact that single source accounts for more than half of Hong Kong's water pollution[12].

Livestock waste: Hong Kong was once a significant agricultural producer. In the New Territories various forms of farming - particularly pig and duck breeding - take place, although gradually the rural areas are being given over to urban settlements or "container dormitories".

The waste generated by the farms has long been a significant source of pollution. For example, in a study carried out in the Pt. Shelter region of the Tolo Harbour the EPD identified three main sources of pollution as[13]:

a) domestic commercial and recreational use/waste - 500 kg. nitrogen (produced per day);
b) livestock waste - 205 kg.
c) fish-farmers - 560 kg.

A ten year livestock waste control scheme was introduced in 1988 and has been credited with bringing about some improvement in water quality in specific areas, such as Silvermine Bay Beach and Anglers' Beach[14]. However, there remain areas where livestock waste remains the main pollutant source; e.g. Yuen Long and Tseung Kwan O[15].

In general, agricultural activities are estimated by the EPD to account for 10% of Hong Kong's organic pollution load[16].

Fish farming: Hong Kong has a long tradition of mariculture. Fish farms can be seen in many areas of the near coastal waters, particularly the bays of Lamma Island. Although fish farms have often been the victims of the algae blooms which are in turn linked to pollution of the water[17], fish farming also is a source of pollution in that approximately 30% of the food they are given falls to the sea bed where it builds up and releases toxic ammonia and hydrogen sulphide into the water which destroys the natural ecosystem of that part of the sea[18].

Construction waste: The construction industry in Hong Kong has enjoyed a boom in recent years. With the demolition of many buildings to make way for new ones, the industry produces an increasing volume of hard waste, much of which is dumped at sea including Victoria Harbour. The EPD estimates the volume of construction waste in 1990 at 8,446 tonnes per day, and likely to rise; (it has increased 600% between 1986 and 1990)[19].

Maritime industry waste: As one of the world's busiest ports Hong Kong has vast numbers of ships using its harbours and territorial waters daily.

Inevitably this maritime traffic has been a source of marine pollution over the years. Hong Kong is signatory to the main international covenants controlling the discharge of wastes at sea, and enforces strict criteria for all ships to meet with respect to discharge; e.g. to discharge used oil the ship's master is required to ensure that the oil is separated from other liquid wastes on board ship and the oil is then pumped to a land based disposal facility.

Nevertheless, the Marine Department, which operates an oil pollution control vessel, had to deal with 57 separate incidents of significant oil spills in 1990, one of which involved the sinking of an oil transport barge in the enclosed waters of the Yau Ma Tei typhoon shelter[20].

Anyone walking the foreshore of Victoria Harbour and the Lamma Channel, (to name but two areas), will observe the more obvious signs of maritime pollution - masses of polystyrene containers and other debris of all kinds littering the surface waters and beaches.

Other: Hong Kong's coastal waters in recent years have also suffered ecologically due to increased silting from the Pearl River, (which carries enormous loads of China's precious top-soils), and sand dredging carried out for land reclamation works. The effects of dredging, in particular, are likely to worsen with the construction of the new airport and ancillary infrastructure. Such projects have an immediate, direct effect on coastal ecology.

LEGISLATIVE POLLUTION CONTROLS

General - Legislative and common law:

A. **Common law:** The Hong Kong authorities have always had common law remedies available to them to prevent private polluters from continuing their polluting activities.

The principal remedy lies in an action for public nuisance the ingredients of which are the use of private land to the detriment of the public. The Attorney General is entitled to bring an action seeking injunctive relief on behalf of Hong Kong's citizens.

Indeed, if a person is acting illegally - such as pouring industrial waste into a common storm drain - the Attorney General may seek an injunction to prevent continuation of the illegal activity, regardless of whether that activity creates a public nuisance.

For some reason the Hong Kong government historically has been reluctant to avail itself of such common law remedies. Perhaps there is a good reason - political or otherwise - but if so it is not immediately apparent to me.

I referred earlier to a newspaper article concerning the drastic pollution of the Tuen Mun River due to the illegal discharging of industrial wastes over many years. It was reported that the E.P.D's attitude was that until given regulatory powers, (which occurred recently), it could do nothing "except watch the growing menace and observe the darkening water"[21]. However, I have little doubt a court would have granted an injunction to restrain the illegal discharges had the EPD (via the Attorney General) sought it on the public nuisance (or illegal activity per se), basis.

B. **Legislation:** Over recent years the Hong Kong government has enacted various ordinances and regulations designed to empower the EPD (and some other agencies), to monitor, control and punish polluters. The most significant of this new body of legislation is the Water Pollution Control Ordinance (Cap. 358) (WPCO) and regulations thereunder, which I wish to deal with subsequently. Some examples of other anti-pollution legislation are:

(i) Dumping at Sea Act (Overseas Territories) Order 1975 designed to control the quantity, quality and place of marine dumping and enforced by the EPD

(ii) Waste Disposal Ordinance (Cap. 354) (and Waste Disposal (livestock Waste) and Regulations) - relates to the method and place of various waste materials; the regulations deal with livestock waste.

(iii) Building Ordinance (Cap. 123) - gives to the Building Authority certain relevant powers such as control of the design of waste treatment facilities in new buildings.

(iv) Public Health and Municipal Service Ord. (Cap 123) - relates to the control of discharge of toxic or hazardous effluent in sewers

(v) Merchant Shipping (Prevention of Oil Pollution) Regulations 1984 - relates to pollution by oil discharges from ships.

There are other pieces of relevant legislation; these are a sample of the more important legislative controls.

As a "last-resort" control the Hong Kong government may require any land holder to refrain from specified activities on his land by inserting a covenant to that effect in the land holder's lease, as all land tenure in Hong Kong is leasehold, with the Crown as the landlord[22].

Water Pollution Control Ord.(Cap 358) 1980 (WPCO) (and regulations and/or subsidiary legislation):

A. **The broad framework:** The WPCO provides the general framework of the scheme of control of water pollution and for improvement/maintenance of specified water quality standards.

It is supported by fairly extensive regulations, in the form of the Water Pollution Control (General) Regulations and various site specific or zonal regulations, too numerous to specify.

The WPCO establishes the following broad scheme aimed at improving Hong Kong's water quality: -

(i) Water Control Zones (WCZ) and Water Quality Objectives (WQO) are created by Part II of the ordinance.

(ii) A system of licensing of waste discharges is provided for by Part V, with a system of appeals to an Appeal Board created by Part VI.

(iii) The "action-forcing" or default provisions, are found in Part III.

(iv) Enforcement of the prohibitions and quality standards mandated by the WPCO (and regulations) is entrusted to the Director of the EPD who becomes the "Authority" for the purpose of the ordinance: (S.4(3)). Part VII sets out the Authority's powers of enforcement.

(v) Part VIII contains miscellaneous provisions which I need not refer to except to mention that s47 applies the WPCO to the Crown and s49 provides that the issue of a licence under the WPCO is not "a dispensation from the requirements of any other Ordinance except where that other Ordinance so provides."

This paper is not a detailed examination of the machinery of the WPCO (or regulations). What follows is comments on some of the more important provisions.

B. **Water control zones and water quality objectives:** The WPCO has wide application. It applies, in effect, to all waters of Hong Kong, be they marine or inland waters. "Inland waters" are defined as including (inter alia), rivers, streams, lakes, pools, ponds, workers in water works (as defined in the Waterworks Ordinance) and ground waters: S2. The WPCO applies also to public drains and sewers: S.2

The definition of 'discharge' or 'discharging' is also extremely wide, and in effect covers any direct or indirect release of any substance in circumstances where the substance is likely to reach Hong Kong's water, or a public drain or sewer. "within a reasonably foreseeable time": s2.

The Secretary for Planning, Environment and Lands, (S.2), is empowered to set-up an Environmental Pollution Advisory Committee (EPAC) for the purpose of consulting with the Governor, the Secretary or the Authority on the implementation of the WPCO: (s4, 5, 46 and 48). Under s.5 the Secretary has the power (after consultation with EPAC), to "establish" WQO's for each WCZ. s5(2) requires the WQO to be the quality level which "in the opinion of the Secretary, should be achieved and maintained in order to promote the conservation and best use of those waters in the public interest".

Once gazetted the WQO becomes part of the WPCO legislative framework; (s. 5(4)), after which the Secretary notifies relevant agencies, such as the EPD, of the new WQO and each agency, (although normally it is the EPD as the Authority, but regulatory powers may be delegated to other agencies), must exercise all his powers and functions with the aim of achieving that WQO: (s6(3))

Of course, the Secretary may declare a variety of different WQO's for the one WCZ: s.(11).

The WCZ's are fixed by the Governor in Council, after consultation with EPAC: (s4(1))

There are now seven declared WCF's, the most recent being the North Western Water Control Zone which was declared on the 25th Feb 1992. No doubt the EPD - which is committed to improving drastically Hong Kong's water quality - will be strengthened in its anti-pollution role as all of Hong Kong is gradually divided into WCZ's.

C. **Licensing discharges:** Sections 14, 15 and 16 allow for licensing of existing or exempt discharges and deposits, (which are deposits or discharges "of matter" made - whether regularly or continuously" - in the WCZ within a period of 12 months preceding the Governor's declaration of a reference date for the purposes of classifying an existing discharge or deposit; (s7(2)).

Sections 19 and 20 concern applications for new discharge licences. Prior to 1990 amendments to the WPCO the Authority had a discretion "to grant or refuse to grant a licence": (s20(3) old WPCO). However, the amended s20(3) makes it mandatory that the Authority "shall not grant" a licence if he considers that "even by imposing terms or conditions under sub-section (4))" the proposed deposit or discharge is likely to endanger public health.

With respect to an application under Section 15, (by a previously exempt discharger), the Authority is required to grant the transitional licence unless he considers that the discharge is likely to endanger public health etc: S.15 (1)

The licences may restrict the amount or composition of the discharge or deposit. The Authority has power to grant the licences but must have regard to a published set of technical standards when fixing discharge limits.

The WPCO was amended in December 1990 to toughen the licensing provisions. For example, under the previous legislation a discharger of polluting waste could be exempted from the provisions of the WPCO, and could even increase the annual volume of his discharge by up to 30% Now there is no exemption. Those previously exempted are deemed granted a transitional licence and have two years within which to apply to renew that licence when they must comply with the published effluent standards required of a "new discharge": S.16(1) & (3) The amendment is a step in the right direction, but is it necessary to give a 2 years grace period? [Note: the Authority may cancel a transitional licence if he considers the discharge is likely to endanger public health etc: S.16(2)].

There is a right of appeal to an Appeal Board should an applicant feel aggrieved by a decision of the Authority or Secretary made under any of a long list of sections set out in S.29(1).

The time for appealing is 21 days from the date of notification of the decision: s29(3).

The Regulations provide much more detail as to the manner of applying for a licence, the right of third parties to object to the grant of a licence, (reg 11), registration of existing discharges and deposits and such matters as the methods of calculating quantities, rates and temperatures of discharges, or increases thereof: Regs 3 and 4.

The 1990 amendments to the WPCO introduced the technical memorandum, or published guidelines, referred to above: (s21). I do not propose referring to the technical data, except to say that the aim of such guidelines is to achieve the purpose of the WPCO, (i.e. enhancement or maintenance of Hong Kong's water quality). Whether, if applied, the standards would achieve that is difficult to say. However, the EPD has observed that if fully applied, the standards set for effluents "would reduce effluent loads to levels that would meet the water quality objectives". Subject, of course, to otherwise applicable land or contractual law factors.

D. "**Action-forcing**" **provisions:** Under Section 8 a person who discharges "any waste or polluting matter" into a WCZ, (inter alia), commits an offence: s8(1).

If the discharge emanates from a vessel or premises the master of the vessel or owner of the premises, as well as the person who caused the discharge, is guilty of an offence: s8(2).

Various exceptions, such as a discharge incidental to the normal operation of a vessel, are set forth in Section 8(3).

Section 9 makes it an offence to discharge any matter, other than domestic sewage or unpolluted water, into a public drain or sewer in a WCZ: s9(1); "unpolluted water" is defined as rain-water or water which does not contain any noxious or polluting matter.

By virtue of section 10 an offence under Sections 8 or 9 is one of strict liability, (although modified to a limited extent by section 12).

Interestingly, in 1990 Section 10A was added, whereby company officers may be found personally guilty of an offence by their company under Sections 8 or 9.

Penalties for offences under Sections 8 and 9 were recently increased to:

HK$100,000 - first offence
HK$200,000 - subsequent offences
HK$5000 - per day of a continuing offence

In addition, an offender may be required "to restore" waters damaged as a result of his offence: s.13(1).

E. **Enforcement:** By virtue of Part VII particularly, the Authority has broad powers of enforcement of the provisions of the WPCO.

For example, Section 35(1) empowers the Authority to serve a notice in writing on "any person" requiring him or her to furnish the information specified, within the stipulated time. The kind of information which may be required to be provided is prescribed by Regulation 17A, which in turn refers to Form A. Matters covered by Form A include particulars of the identify of owners or users of premises, the nature of the use, the composition of discharges/despite, their BOD and the like. In other words, the Authority is able to ask anyone for any information relating to any potential or actual water pollution point source, in effect.

Failure to comply with such a notice is an offence the penalty for which is a fine of up to HK$10,000.

Authorized environmental protection officers may be appointed, (S.36). They have relatively wide powers of search of premises or vessels from which they have "reason to suspect" a discharge is occurring contrary to section 8(1) or 9(1): s37(1).

An authorized officer is entitled to require of any person in charge of a place certain documents, samples or information relating to possible illegal discharges: S38. Obstructing an authorized officer in the course of his duty is also an offence for which the penalty is a fine of up to HK$10,000: S.40.

It is also an offence for a person to tamper with a sampling device used by the Authority. The penalty is the same: s40A.

WATER CONTROL ZONES AND WATER QUALITY STANDARDS

Establishing zones and standards: Earlier, the paper dealt with this aspect of the WPCO framework, and will not therefore go over it again.

An apparently important role is envisaged for the Environmental Pollution Advisory Committee (EPAC).

The Secretary is required to consult EPAC when formulating his proposals for the creation of both the zones of water control, (S4(1)), and the standards of water quality required in each zone or part thereof, (S.5(1)). In making regulations concerning matters specified in section 46 the governor also is required to consult EPAC.

It is not clear how members of EPAC are appointed, although by implication, as I have said, it is the Secretary who appoints the members. In any event, the WPCO provides that if at any time there is confusion as to who are, for the time being, EPAC members, the Secretary is empowered to "determine the question by certificate under his hand": (S. 48).

Two examples of water control zones and their required water quality standards:

A. **Southern Water Control Zone (SWCZ):** This zone was established by the Water Pollution Control (Southern Water Control Zone) Order, 29/7/88.

It covers an area which includes many of Hong Kong's most popular swimming beaches, such as the beaches of the south coast of Hong Kong Island and those of Lantau Island.

The EPD identifies domestic sewage as the single worst pollution source in this zone[23].

Since the SWCZ came into existence there has been a marked improvement in water quality mainly through improvement to domestic sewerage treatment plants and/or septic tanks (of which there are more than 60 and 6000 respectively in the zone)[24]. A 'high profile' example of that improvement is the re-opening, in 1990, of Silvermine Bay beach for swimming; (it was too polluted to allow safe swimming during the three previous years)[25]. (Nevertheless as at May 1992 only 14 of Hong Kong's 45 monitored beaches were rated "good" quality; the rest were rated, "fair" (12), "poor" (14) or 'closed' entirely (3), (with the remaining 2 unknown); Urban Planning and Environmental Law Report, May 1992).

B. **Tolo Harbour and Channel Water Control Zone:** This zone and its original water quality standards were originally declared in February 1982. The zone is different in composition to the SWCZ. It has both large residential and industrial areas. According to the EPD, Tolo Harbour "is an example of failure to implement a comprehensive plan for water quality"[26]. It has suffered, and continues to suffer, massive pollution problems resulting from the cumulative impact of the establishment of two large cities - Sha Tin and Tai Po - plus the establishment of a large industrial area and other specific polluting uses; eg: a water treatment plant. Domestic sewage and industrial effluent have been major causes of pollution in this zone[27]. More specific WQO's relating to sewage treatment came into force in 1987. These have resulted in an improvement in industrial and domestic effluents[28].

PROSECUTIONS AND PENALTIES

Generally: Prosecutions concerning water pollution offences do in fact occur, although a trip on the Star Ferry may cause you to wonder.

There are various agencies which may institute prosecutions, but the EPD is the agency mainly concerned. It appears to be taking a generally tougher stand with polluters, after years of preferring education, publicity and 'persuasion' to try to effect a change in the community's attitude to the problem of water pollution.

Recently the Assistant Director of EPD's Waste and Water Control stated that only one successful prosecution under the Dumping at Sea Act (Overseas Territories) Order 1975 was brought prior to 1986, when EPD took over responsibility for enforcement of that Act, but that since 1986 115 successful prosecutions have been brought, 82 of which were in 1991. There are a further 20 current prosecutions[29].

The Water Pollution Control Ordinance: The EPD has very kindly supplied me with a computer print-out of details of all prosecutions brought under the WPCO since 22nd December 1988, (to 24th February 1992).

Virtually all prosecutions are related to illegal liquid discharges, although there is power under the WPO to prosecute illegal solid matter deposits, of course. It seems liquid discharges are by far the more prevalent.

In all, there were 89 successful prosecutions in this period; (their success was guaranteed as all but one of the defendants pleaded guilty).

A. **Areas:** Prosecutions related to 5 WCZ's -

- Tolo Harbour (46)
- Port Shelter (24)
- Deep Bay (7)
- South Water (9)
- Junk Bay (3)

B. **Sources of pollution:** There were 3 broad categories of point source pollution:

- Industrial effluent (I) (60)
- Sewerage Treatment Plant (STP) (17)
- Commercial (C) (12)

C. **Repeating offenders:**

- First offences (65)
- Second offences (15)
- Third offences (5)
- Fourth offences (3)
- Fifth offences (1)

D. **Penalties:** Fines imposed ranged from HK$1000 (for a 1st offence) to HK$140,000 (for a 2nd offence); but this was recently reduced on appeal to HK$70,000 on the ground that it was not technically a second offence[30].

The empirical data does not, of course, provide information as to the circumstances of each offence, which would vary in their degree of seriousness and this would affect the penalty imposed. Nevertheless, it is interesting to note that one frequent offender received the same fine, (HK$20,000), for each of 3rd, 4th and 5th offences committed in a short period, 14 November 1990 - 3 December 1990 in relation to the same premises. It could be that the court treated the offences as "one transaction", which would be reflected in the penalty imposed. Prima facie, at least, it suggests the court did not view that defendant's continuing transgressions seriously. Such an attitude, (not that I suggest for a moment you can from these data alone ascribe that attitude to all the judiciary), would lend support to the perception that in Hong Kong many industrialists or business people find it cheaper to run the risk of prosecutions under the WPCO rather than spending the money necessary to correct the source of the polluting effluent.

Irrespective of attitudes of the courts, the EPD should perhaps consider giving more 'bite' to the enforcement of the WPCO by using its powers under s.13(1) (i.e. direct the polluter to restore damaged waters), or even by seeking injunctions to restrain the continued existence of the effluent source.

WHY WORRY ABOUT HONG KONG'S WATER QUALITY?

Poisoning the food chain: A recent advertisement put out by the Hong Kong Marine Conservation Society and the World Worldlife Fund highlighted in dramatic, but factual, fashion the seriousness of the problem of pollution of Hong Kong's marine waterways; (the advertisement referred to a study quoted by the Environmental Protection Department, in which mussels taken from Tai Tam Bay were found to have a toxic level of 20,000 units/kg, a level high enough to be fatal if you ate five of the mussels[31].)

The simple fact is that toxins in the waters of Hong Kong - whatever their nature - will enter the food chain in one form or another and thus pose a direct threat to human consumers.

So from our own selfish point of view of water reserves we should be greatly concerned that Hong Kong improves the quality of both its sea and fresh water reserves (irrespective of your views on the right of <u>all</u> members of our ecosystem to be protected from the poisoning effects of human generated and distributed pollution)

Red tides: One mechanism whereby pollution links with toxins entering the human food chain is the 'red tide', (noctiluca scintillan).

A red tide "is the visible result of a population explosion, or bloom, of one or more of about 120 species of microscopic plant life called dino-flagellate algae"[32].

Red tides may occur in unpolluted waters, but pollution is a likely cause of the occurrence of red tides in that pollution, such as livestock and domestic effluent, increases the nutrient load of the coastal waters thereby creating ideal conditions for a "population explosion" of algae <u>pollution</u>[33].

The effects of red tides are varied, but include an increase in the toxicity of ammonia in the water and the production of various toxins, which can be, for example, accumulated in shell fish growing in the area affected by the red tide. Hence the warning of the Marine Conservation Society!

Regrettably, red tides have occurred frequently in the waters of Hong Kong[34]. When they do occur nothing can be done to remove them[35]. The area affected simply has to be "closed down".

According to of the EPD: "The ultimate solution is of course to minimise the chances of red tide occurrence by reducing the input of nutrient pollution. The government's long term pollution control strategy aims to do this"

It is to be hoped the government is serious in pursuing such a strategy and that it will provide the EPD with meaningful support to implement it.

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6 (ECCO, Issue No. 7, April 1992).

7 EHK 59, 3.46.

8 The EPD reports that one dyeing factory on the Ho Chung River was the biggest single source of pollution in the entire river. Its closure (after 15 years of polluting - you may well ask why it could take 15 years to close it down) resulted in a "great improvement" in water quality. (EHK 62, 3.67)

9 45% of Hong Kong's rivers and streams were assessed as of bad to very bad water quality in 1990 - EHK Fig 3.12, 57.

10 However, the government is spending many millions on individual projects in the perceived worst polluted areas, such as Tolo Harbour, Yuen Long and Shau Kei Wan (Hong Kong Island) (EHK 67 - 70), but, regrettably, of the HK $10.44b. needed for the extensive sewage works to clean up, particularly, Victoria Harbour, only HK $82 m had been released as at 1st April 1992 and the target date for the works has been shifted from 1994 to 1997; (Urban Planning and Environmental Law Report, May 1992, 5).

11 EHK 70, 3.107.

12 EHK 59, Fig. 3.14.

13 EHK 69, 3.104

14 EHK 73, 4.5.

15 EHK 62, 3.68 and 57, 3.35.

16 EHK 59, Fig 3.14.

17 "Interflow", Issue 63, Feb 1992, 8.

18 EHK 57, 3.38.

19 EHK 74, 4.13 and Fig. 4.3.

20 EHK 64, 3.75.

21 Controls to Clamp Down on Persistent Offenders. South China Morning Post 1992 April 5.

22 EHK 59, 3.46.

23 EHK 61, 3.63.

24 EHK 61. 3.64.

25 EHK 61, 3.64.

26 EHK 66, 3.86.

27 EHK 66, 3 88, 3 90.

28 EHK 60, 3.59

29 Letter to South China Morning Post, 13 May 1992, and on the 19th June 1992 it was reported in the press that an offender had been fined a total of HK$200,000 for few offences under this Act

30 R. v Shaw Bros Studio (Gall J , March 1992)

31 EHK 54, 3 23

32 EPD internal "Briefing Note on Red Tide", 1

33 Ibid.

34 EPD noted widespread red-tides built up along Hong Kong's eastern coast, encouraged by heavy rainfall and rising temperatures, in April 1992; (Urban Planning and Environmental Law Report,5)

35 EPD internal "Briefing Note on Red Tide", 2

ENVIRONMENTAL LAW IN HONG KONG – A LEGAL PRACTITIONER'S POINT OF VIEW

R Skrine
Denton Hall, Burgin and Warrens, Solicitors, Hong Kong

INTRODUCTION

This paper will give a brief summary of Environmental Law in Hong Kong from a Legal Practitioner's point of view.

HONG KONG ENVIRONMENTAL PROTECTION ORDINANCES

Generally: The Ordinances referred to below provide a basic framework for pollution control in Hong Kong. A licence system is used in many cases to regulate the amount of pollution created. When compared with the U.K., Europe and the U.S.A., Hong Kong environmental legislation is in its infancy. The emphasis of legislation in Hong Kong is to attempt to prevent pollution (rather than dealing with the very considerable pollution which has already occurred following years of neglect and rapid economic growth). The legislation usually results in criminal, rather than any civil action being taken.

Air Pollution Control Ordinance 1987: Provision for control of air pollution from stationary sources. The Government can notify the owner of a plant to abate the amount of pollutant nuisance when in the opinion of the Government, the emission of the air pollutant is prejudicial to health or is likely to imperil the safety of aircraft. Pollutant nuisance is not defined in the Ordinance; accordingly there is a wide discretion.

Under Part 4 of the Ordinance the owners of specified premises are required to use "the best practical means for preventing the emission of noxious or offensive emissions from such premises...". Further, a license is required to operate any "specified process". Specified processes are defined in the third schedule and include "aluminium works, chlorine works, gas works, sulphuric acid works and chemical incineration works (any many others).

The penalty for failing to comply with any abatement notice, for failing to use "best practical means" or for failure to obtain a license is a fine of up to HK$50,000 together with a daily fine of HK$5,000 for each day the offence continues.

Noise Control Ordinance (1988): This provides statutory control to restrict and reduce the annoyance caused by environmental noise. Since 17th August 1989, a permit must be obtained from the Environmental Protection Department ("EPD") to carry out construction work by using powered mechanical equipment at night (7 p.m. to 7 a.m.) and on public holidays including Sundays. Since the 17th November 1989, percussive piling at all other times requires a similar construction noise permit. The Ordinance also provides powers to control noise from the operation of industrial and commercial premises through the issue of abatement notices.

From 1st March 1992, traders and businessmen importing, manufacturing or supplying products intended for use in Hong Kong must ensure that such products comply with noise standards set down by the EPD. The Noise Control Authority may test or inspect or give directions as to the manner of using any such products. It is an offence for any person to use any "non-conforming" products.

Penalty for breach of the Ordinance: On first conviction fine of HK$50,000; on second or subsequent conviction a fine of HK$100,000. In any case, up to a fine of HK$10,000 for each day during which the offence continues.

Water Pollution Control Ordinance 1980: This provides for the designation of various water control zones. Each zone will have separate restrictions on the nature and quantity of effluents which may be discharged. Discharge of effluent other than domestic sewage into a foul sewer must be licensed. Note that the Victoria Harbour Zone (No.6) which includes Tsing Yi Island has been designated but will not come under legislative control until 1995.

Under the Ordinance, a person cannot discharge any poisonous, noxious or polluted water into the waters of Hong Kong in a water control zone or any matter into any inland waters in a water control zone which tends to impede the proper flow of water in a manner leading or likely to lead to a substantial aggravation of pollution.

No person can discharge any matter into a public sewer or sewer drain in a water control zone other than domestic sewage or unpolluted water.

N.B. a person can obtain a licence for an exemption from the above provision.

Penalty: for a first offence a fine of HK$50,000; for a second or subsequent offence a fine of HK$100,000 and in addition if the offence is continuing, a fine of HK$500 for each additional day.

Waste Disposal Ordinance 1987: This provides for the licensing of waste collection services and disposal facilities.

It orders the prohibition of livestock in urban areas, controls the discharge or deposit of (livestock) waste in defined control areas and provides for the establishment of a system whereby specified waste must be notified to the relevant authority who may give directions as to the method of disposal. N.B., the Ordinance does not give an indication of specified waste.

Penalty: for a first offence a fine of HK$50,000; for a second or subsequent offence a fine of HK$100,000 and in addition if the offence is continuing, a fine of HK$500 for each additional day.

New regulations known as the Waste Disposal (Chemical Wastes) (General) Regulations made under this Ordinance have now been prepared; came into force on 1st May 1992.

Waste Disposal (Chemical Wastes) (General) Regulations 1992: These are aimed at improving control over the standard of transportation, treatment and disposal of certain difficult wastes, such as chemical and clinical waste. They are intended to provide a "cradle to grave" control of chemical substances.

From 18th May 1992, all producers of chemical waste are required to register with the EPD. Failure to do so can result in a penalty of HK$200,000 and/or a 6 months imprisonment. However, there is a grace period of 6 months to comply.

Any chemical waste producer must deliver the chemical waste to either a reception point or a licenced site for disposal. The Tsing Yi Waste Disposal Plant, which is supposed to come into operation early next year, is being built for such purpose. In the interim, however, waste producers can, by way of permit, deliver their chemical waste to the landfill in Tseung Kwann O for disposal. In cases where the chemical waste is not suitable for disposal in this way, the EPD recommends that chemical waste producers store their chemical waste pending completion of the Tsing Yi Waste Disposal Plant. Certain types of chemical waste, such as asbestos and products containing chromium which are not suitable for disposal at the Tsing Yi Waste Disposal Plant; must be delivered to the landfills for disposal.

Alternatively, chemical waste producers may dispose of chemical waste by themselves or by using other companies and facilities provided an appropriate licence has been granted.

Penalty: HK$100,000 or imprisonment for 6 months Re: trip tickets
HK$50,000 or imprisonment of 6 months Re: having over trip tickets

The Dumping At Sea Act 1974 (Overseas Territories) Order 1975: This provides that no dumping of any matter can be done *in* territorial waters by any ship or *outside* territorial waters from any British ship. Further, loading of materials on a ship in the territories to be dumped at sea is prohibited.

Dumping can only be done with a license and in strict accordance with the conditions set out in such license.

Penalty: Fine of HK$5,000

Ozone Layer Protection Ordinance 1989: This prohibits the manufacture of chemicals which deplete the ozone layer and imposes controls on the import and export of the substances.

Penalty: Fine up to HK$1,000,000 on first offence. A fine of HK$100,000 for each day on which the offence continues.

PROSECUTIONS

Generally: Prosecution against anyone contravening Rules and Regulations made under the Ordinances referred to above are brought either by the Environmental Protection Department or the Police. At least in relation to noise pollution cases, the level of fines imposed can be affected by who prosecutes the case. Fines tend to be much higher if the EPD prosecutes, rather than the Police who may not have the time or the facilities to test noise level or indeed the enthusiasm to prosecute. As an example, a Hong Kong company received a fine of only HK$600 in June 1991 for its 9 offences prosecuted by the Police. The same company's highest fine of HK$50,000 for each of 4 offences was when prosecuted by the EPD. Although the judiciary is independent and cannot be influenced, it seems clear that some magistrates are handing out fines on the low side which do not deter offenders.

For many companies, paying fines is simply a business expense to be incorporated into their financial budget. There are various examples of companies which offend again and again, as an example, one company has been fined on no less than 9 separate occasions for offences against the Noise Control Ordinance; another, a dyeing factory, has been fined 10 times for smoke emissions and yet another, a barge operator, has been convicted on 8 fines, rather than correct the pollution problems themselves. The highest fine to date is HK$210,000 for discharging excessive amounts of cyanide.

Do penalties represent a deterrent?: You will see from the examples above, that fines often do not deter polluters. However, the Government does have more control when a licence system exists (for example under the Dumping At Sea Act 1974). In those circumstances, continued contravention of licence provisions can result in the issuing authority either revoking or refusing to re-issue such licence. Such revocation may lead the licencee (e.g. a construction company or its sub-contractor) to breach its obligations under building contract if it can no longer dump waste material.

The role of a legal practitioner: From what I have said above, it can be seen that potential clients will not frequently be seeking the advice of their lawyers in relation to environmental matters. Indeed all but the most conscientious companies will probably simply appear in Court and pay their fines. However, clients may well require assistance with the following matters:

- Criminal proceedings which have been brought against them, which may result in the revocation of a licence (of whatever type). Any claim for breach of contract made following the revocation of a licence.

- Companies which are bidding for or who have been awarded contracts in relation to the Port and Airport Development Scheme ("PADS") will require advice about the impact of the environmental clauses inserted into the bid documentation and contracts. Many of the consortia bidding for the PADS contracts, especially a foreign consortium with little knowledge on Hong Kong law, will need to know the effect of such clauses.

- Liaison role with overseas offices/firms to advise clients investing in or doing business with e.g. the U.S.A., Europe and U.K.

- Contravention of the Waste Disposal (Chemical Wastes) (General) Regulations.

However, the extensive civil litigation which emerges overseas in relation to environmental clean up costs (for example Superfund in the U.S. - see below) simply does not exist in Hong Kong at this time. We can expect this to change gradually as Hong Kong's environmental legislation becomes more sophisticated.

COMPARISON WITH THE U.S.A.

By contrast to Hong Kong legislation, the U.S.A. has very stringent environmental protection laws resulting in significant civil and criminal liability for those in contravention.

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 ("CERCLA") - also known as the "Superfund legislation" imposes strict (i.e. no defence) joint and several and retroactive liability in connection with the clean up of hazardous waste sites in the U.S.A. Under CERCLA, the Environmental Protection Agency (EPA) utilises congressionally appropriated funds to "remediate" (i.e. clean up) a hazardous waste site. The EPA can then seek to recover the clean up costs of such site (which in 1991 amounted on average to US$47.5 million) from any responsible party it can locate or it can order such responsible party to clean up the site. A potentially Responsible Party ("PRP") is defined in extremely wide terms and includes past and present owners and operators of the site. In view of the retroactive and strict nature of liability, the EPA has successfully through the Court identified the following PRPs:-

> Careful and environmental conscientious current owners; past owners who disposed of their interest over 50 years ago (there is no time limit); off-site landlords; purchasers of stock in a vendor company.

The defences under Superfund liability are extremely limited and it is doubtful whether the PRP will be able to claim cover under insurance policies; the standard Comprehensive General Liability policies are now specifically excluding cover for environmental impairment and so liability will be self-insured.

The US Oil Pollution Act 1990: This provides for <u>un</u>limited liability in case of accident-related oil spill claims in U.S. waters. Potential claims (including clean up costs) could run to several US$ millions which will probably be uninsurable.

US practitioner: As a result of U.S. legal position there is a great deal of legal work to be undertaken particularly in relation to:-

- defending claims from the EPA (both criminal and civil); claiming and defending claims for contributions from other PRPs and;

advising on and preparing environmental audits for companies/individuals buying land and/or companies owning land.

COMPARISON WITH THE U.K.

In the U.K., Environmental Protection legislation is much more complex and legal advice is more often required. The Environmental Protection Act 1990 controls pollution of the environment including emissions from operations which are "capable", because of their quantity or concentration, of causing "harm" to men or any other living organisms. The key words "capable" and "harm" invite extensive interpretation, the definitions given in the Act being unhelpful.

Other areas of importance:

- There are discussions about the setting up a contaminated land register.

- Environmental management/auditing

NOTE: Highest fine to date; Shell UK were fined £1,000,000 in the Crown Court for pollution of the Mersey Estuary.

HAS THE USE OF UNLEADED PETROL PROVIDED A LEAD-FREE ENVIRONMENT IN HONG KONG?

CT Au[*], KM Chau[+] and KY Wong[+]
[*] Department of Chemistry, Hong Kong Baptist College, Hong Kong
[+] Final Year Project Students, Department of Chemistry, Hong Kong Baptist College

INTRODUCTION

In order to improve the environment in Hong Kong, the lead content in petrol has been decreasing steadily in the past decade or so:[1] In 1981, it was reduced from 0.84 to 0.60 g 1^{1} and in 1985, to 0.25 g 1^{1}. In 1990, the lead level in petrol was 0.15 g 1^{1}. In April, 1991, unleaded petrol (with lead content less than 0.013 g 1^{1}) was introduced to the public. Since then, over 50% of the petrol used has been unleaded. In order to monitor the effect of the use of unleaded petrol on the environment, dust, soil, water as well as urine and hair samples from four persons were collected and tested for lead content.

METHODOLOGY

Survey on the use of unleaded petrol: Information on the percentage sale of unleaded petrol was obtained from Shell Company of Hong Kong Limited and the station managers of petrol stations at Waterloo Road (near Pui Ching Road) and at Lion Rock Tunnel Road, Kowloon Tong. Additional surveys were conducted at three more stations on the percentage use of unleaded petrol by motorists.

Annual average daily traffic (AADT) data: The data in the Annual Traffic Census (6/1991) published by the Transport Department, Hong Kong Government were adopted.

Sampling location and method: Dust, soil and water samples were collected at spots located in Hong Kong Island, Kowloon as well as in Shatin areas.

Dust: Roadside dust samples were collected by hanging polystyrene bowls which were under shelter by the roadside. Household dust was collected from filters of air conditioners. One air-conditioner was at ground level, the other was on the 4th floor.

Soil: About 10 g of surface soil was collected per sample with a plastic trowel, usually 2 m from the edge of the road.

Water: Sea and sewage water samples were collected about 25 cm below the water surface. Domestic water samples were collected directly from the tap.

Urine and hair: Samples were collected regularly from four persons, two adults and two children. One of the adults was male, lived in Chai Wan and did office work in Wan Chai. The other adult was female lived in Shatin and attended college in Kowloon. The children were both boys, one of whom lived and went to school in Chai Wan and the other lived and went to school in Shatin.

EXPERIMENTAL

Sample treatments

A. **Dust and soil:** Dust samples were air dried before weighing. Soil samples were first dried in an oven at 100°C for 24 hours and then ground and sieved (hole size: 0.25 mm in diameter) before being weighed for chemical analysis. Each sample was digested with 10 ml conc. HNO_3 for 1.5 hours and then, with the addition of 10 ml $HO10_4$, for another 1.5 hours with gentle heating. The resulting solution was filtered and diluted to 50 ml before lead content was determined by flame AAS.

B. **Water and urine:** All samples were acidified by conc. HNO_3 and then analysed by flame AAS.

C. **Hair:** 1.5 g of hair was cut from the nape of the neck region by stainless steel scissors washed in a sequence of acetone, water, water and acetone, with one minute shaking and 10 minutes of soaking with each solvent. The washed sample was dried and 1 g of the hair was digested in conc. nitric acid at a temperature of 80°C. After that, the digested sample was evaporated to dryness and the hair residue was dissolved in water containing 0.1% nitric acid, made up to 50 ml. Later the lead content in the analyte solution was determined by flame AAS.

Analytical techniques: In this project, a Perkin Elmer (Spectra AA-20) absorption spectrophotometer with GTA 96 Graphite Tube Atomizer was used to test the lead content in sample solutions. Inductively coupled plasma spectrometer (Plasma 300) as well as photoelectron spectrometer (Leybold Heraeus - Shenyang) were employed for the elemental analysis of the dust samples. Morphology monitoring was done by a Joel Model T330 scanning electron microscope

RESULT AND DISCUSSION

Percentage use of leaded petrol: Figure 1 shows the variation in use of leaded petrol. It is clear that since the introduction of unleaded petrol, the use of leaded petrol dropped to about 60% and further decreased to 45% after high-octane unleaded petrol was made available on 15th October, 1991.

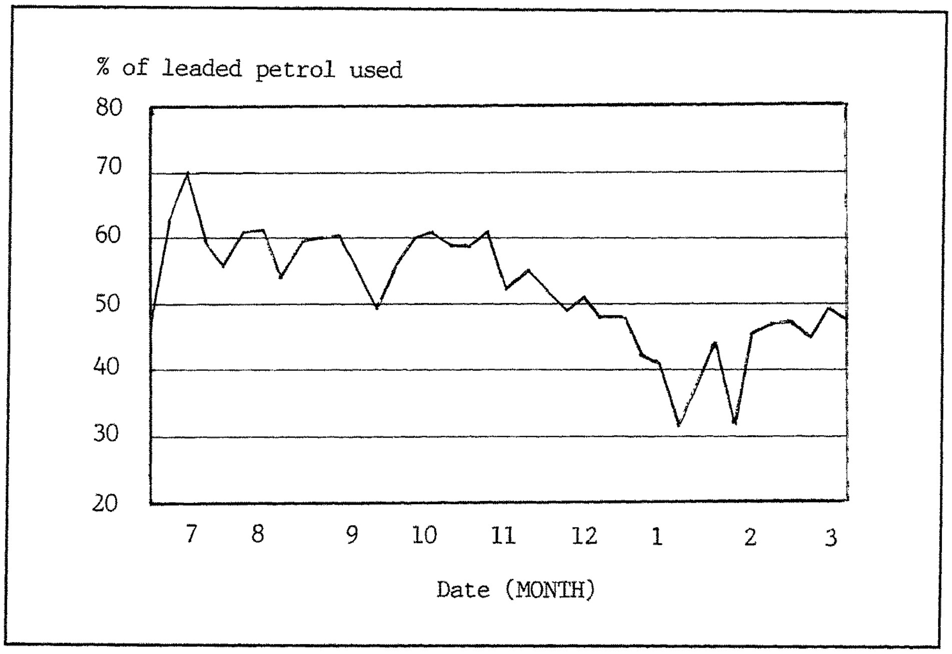

Figure 1: *Use of leaded petrol in Hong Kong*

Dust: Table 1 summarizes the lead content in the dust sampled at various spots. The lead content of the dust from an air-conditioner in a 4th floor flat had a mean value of 156 ppm. At ground level, a value of 1053 ppm was recorded. From the rest of the data in table 1, there is no correlation between the lead content in dust and the AADT value of the sampling location. This may be because about 70% of the vehicles in Hong Kong are run by diesel engines and do not use petrol. The AADT values can only serve as an indication of the traffic conditions but do not reflect the actual figure of vehicles run by petrol.

***Table 1:** Lead content in dust sampled at various sites*

Location	Mean Pb content/ppm	Range/ppm	Standard derivation	AADT
Air conditioner, 4th floor, Chai Wan	156	97 - 215	40	not available
Aberdeen	777	258 - 1,211	281	55,970
Wan Chai school dust	948	185 - 1,745	397	22,780
Air conditioner, ground level, Shatin	1,053	686 - 1,891	327	not available
Primary School, Shatin	1,961	948 - 2,766	452	not available
Waterloo Road	1,986	519 - 4,051	889	40,700
Cross Harbour Tunnel Entry, Wan Chai	2,030	729 - 3,680	633	118,380
Yuen Wo Road, Shatin	2,140	641 - 3,028	627	28,590
Wo Che Street, Shatin	2,702	1,389 - 5,294	744	14,400

Only dust collected at two of the spots monitored showed a gradual decline in lead content over the past eight months. One of the spots was at Waterloo Road, outside the Hong Kong Baptist College and the other was in Shatin, outside the Sheng Kung Hui Holy Spirit Primary School in Lek Yuen Estate, Shatin. Data from these two sites are shown in figure 2 with the ground floor air-conditioner data in Shatin plotted for comparison.

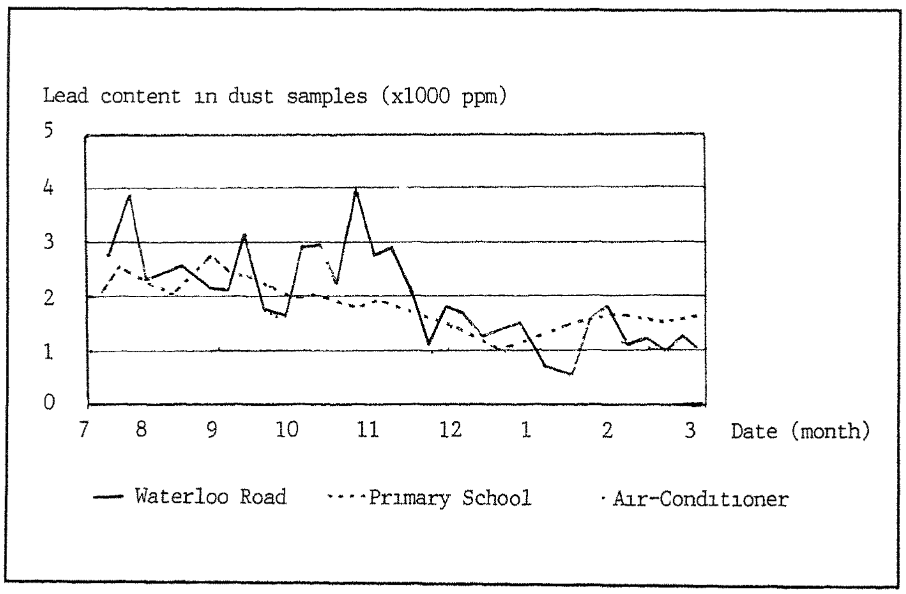

***Figure 2:** Variation of lead content in dust samples from Waterloo Road, primary school and an air-conditioner.*

Figure 3 shows the data collected at the entry of the Cross Harbour Tunnel in Wan Chai. No clear indication of a decrease in dust lead content could be found. With an AADT value of 118,380, lead content in the dust there was found to have a mean value of 2030 ppm.

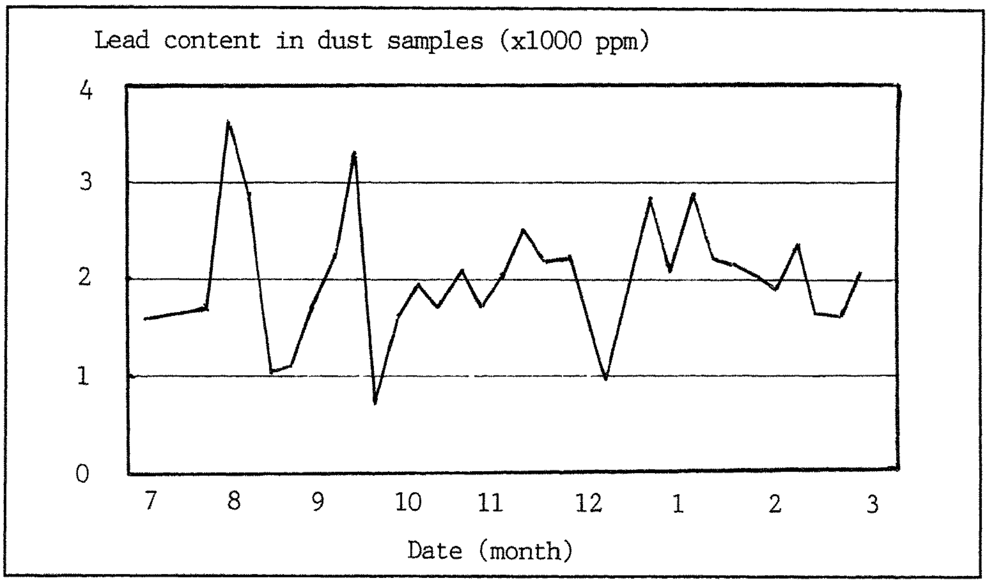

Figure 3: *Lead content in dust sample collected from the Cross Harbour Tunnel, Wan Chai.*

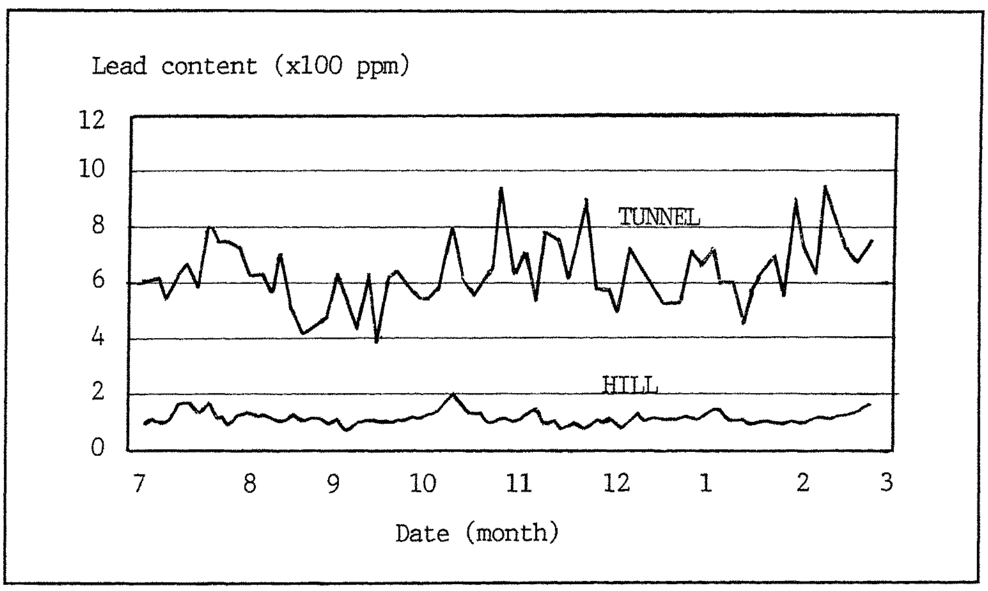

Figure 4: *The lead content in soil samples collected at Cross Harbour Tunnel and Chai Wan.*

Soil: Figure 4 shows the data of the soil sampled at the entry of the Cross Harbour Tunnel in Wan Chai and by the hill side in Chai Wan. No clear indication of decline in the lead content in soil collected in the Hong Kong Island could be claimed. The data collected in Shatin, New Territories, are shown in figure 5. The soil by the side of Yuen Wo Road with heavy traffic gave a lead content of around 600 ppm while away from the traffic in a park, the lead content in the soil there was below 100 ppm. It appears that there was a gradual decline in lead content in the soil collected in the park.

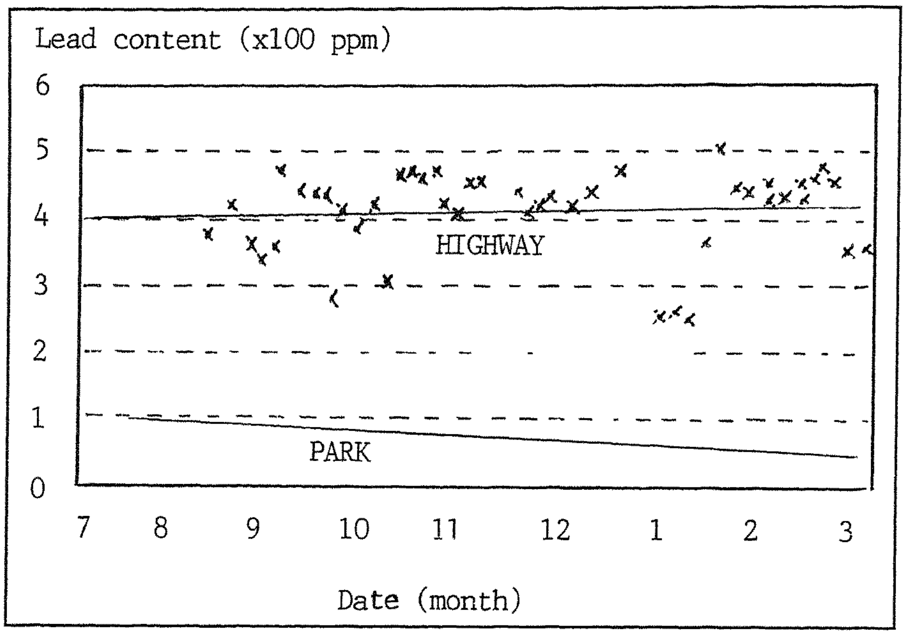

Figure 5: *Variation of lead content in soil samples from the highway and the park in Shatin.*

Tap water, sewage water and sea water: The detection limit of the flame AAS used was 0.11 ppm. All the samples concerned had a lead content below the detection limit of the flame AAS employed.

Urine and hair: All the urine samples were had a lead content below the detection limit of the flame AAS employed. For the hair samples, the hair of the adult who lived in Shatin and went to college in Kowloon was found to have a lead content of 3.1 ppm. The other three persons had hair with lead contents below the detection limit of the flame AAS employed. The lead level in the hair analysed is low compared with values of 9.7 ppm as reported by Ahmed and co-workers[2].

Elemental analysis of dust sample: For the dust collected in Waterloo Road, the top seven metals as indicated by inductively coupled plasma spectrometry were Al, Zn, Mn, Fe, Mg, Cu and Pb. The X-Ray photoelectron spectrum of the same dust showed that the elements detected were Al, Fe, Mg, Pb, Ca, Si, S, Cl, O and C. The XPS is a very surface sensitive technique, and only surface elements within the top 20 A are detected.

Morphology of outdoor and indoor dust: Indoor dust, was found to be composed of very fine particles and pieces of fibre whereas outdoor dust, consisted of bigger opaque irregular particles which were coarser in appearance.

CONCLUSION

Since the introduction of unleaded petrol in April, 1991, a decline in lead content, as measured by roadside dust samples has been demonstrated in the Hong Kong environment. Although no such decline was detected in the surveys of soil, water and human urine and hair samples, it is considered a positive start and one which can be expected to continue in the future.

We wish to express our gratitude to the Shell Company of Hong Kong Limited and the station managers of the petrol stations at Waterloo Road and Lion Rock Tunnel Road, Kowloon Tong for providing the sales information for unleaded petrol.

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THE INFLUENCE OF THE HEALTH ACT ON PRESENT ENVIRONMENTAL PROBLEMS

SH Prabawa Utama
Faculty of Law, Sedelas Maret University, Surakarta, Indonesia

INTRODUCTION

Almost all countries in South-east Asia face major dilemmas. On the one hand, national interests demand the acceleration of the process of industrialization; on the other hand, the developing industries have created various problems of urbanization and pollution. The problems of pollution very often cause hazards to public health. The Health Act, which is aimed at preventing pollution caused by industrial plants, is therefore of extreme importance.

For the theoretical basis of this paper, I have used the ideas of Purnadi Purbacaraka and Soerjono Soekanto on "The Systematic Science of Law".

1. The Society of Law is the system of regular relations between society and the law (relations refer to two kinds, abstract and concrete relations of communication).

2. The Subject of Law is the system of regulating another in a system, for example "natuurlijk persoon" (the individual person), "recht persoon" (the public person), and "ambtenaar" (the bureaucrat).

3. The Parts of Law are rights and obligations: rights are facultative, whereas obligations are imperative.

4. The Phenomenon of Law is the aspect of attitudes and actions in law, for example incidents of law and conditions of law.

5. The Relationship of Law is every process of relationships which causes an effect of law.

6. The Object of Law is the interest of the subjects of law which consists of material or immaterial aspects.

The above systematic science of law controls all kinds of laws, including health laws as well as environment laws. The characteristics of law (either health or environment laws) must, therefore, be able to be controlled by the systematic science of law. If we talk about the systematic science of law, we must also talk about the discipline of law. The problem now is, "Can the legal system control the pollution problem?" and, if it can, "How can it control the problem of pollution?"

QUESTIONS

The problems discussed in this paper include:

1. Can the legal system control environmental pollution?
2. What is the present relationship between the Health Act and the Environment Act, and how can these two acts control pollution resulting from industries?

METHODOLOGY

The methods used in presenting the problems in this paper are the prescriptive and evaluative methods, that is, giving input to solve the problems and making an evaluation of the rules of law on health and the environment.

AIM

The aim of this discussion is to find problems and then, at the same time, to solve the problems. In law enforcement, why do the subjects of law (victims) often find difficulties in prosecuting other subjects of law (the accused) in criminal law and to accuse other subjects (defendants) in civil law by using Health Acts or Environmental Acts?

CONCEPTUAL FRAMEWORK

The independent variables of this discussion consist of two principles:

1. The principle in criminal law is Nullum Deliccum Nulla Poena Sine Praevia Legi Poenalle (No one can be imprisoned unless there is law).

2. The principle in civil law is onrechtmatige daad (misdemeanour), i.e. "liability based on fault principle" or "risk liability on fault principle."

The dependent variables of this discussion are the Health Act and the Environment Act.

In order to understand the relationship between the independent variables and the dependent variables, we must first understand the discipline of law (Figure 1).

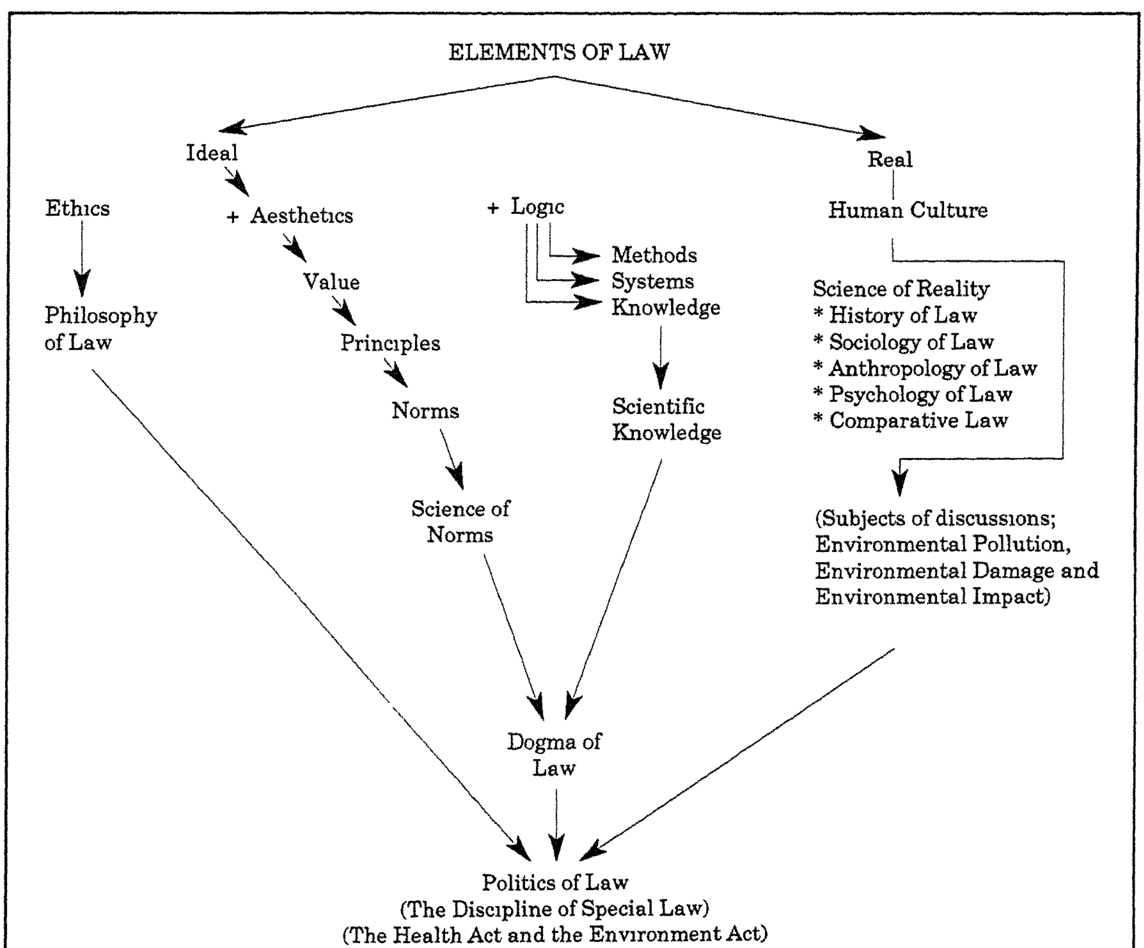

Figure 1: The discipline of general law.

The sub-systems of health and the environment are located in the elements of reality (human culture). The Politics of Law is usually called the Discipline of Special Law (see Figure 2).

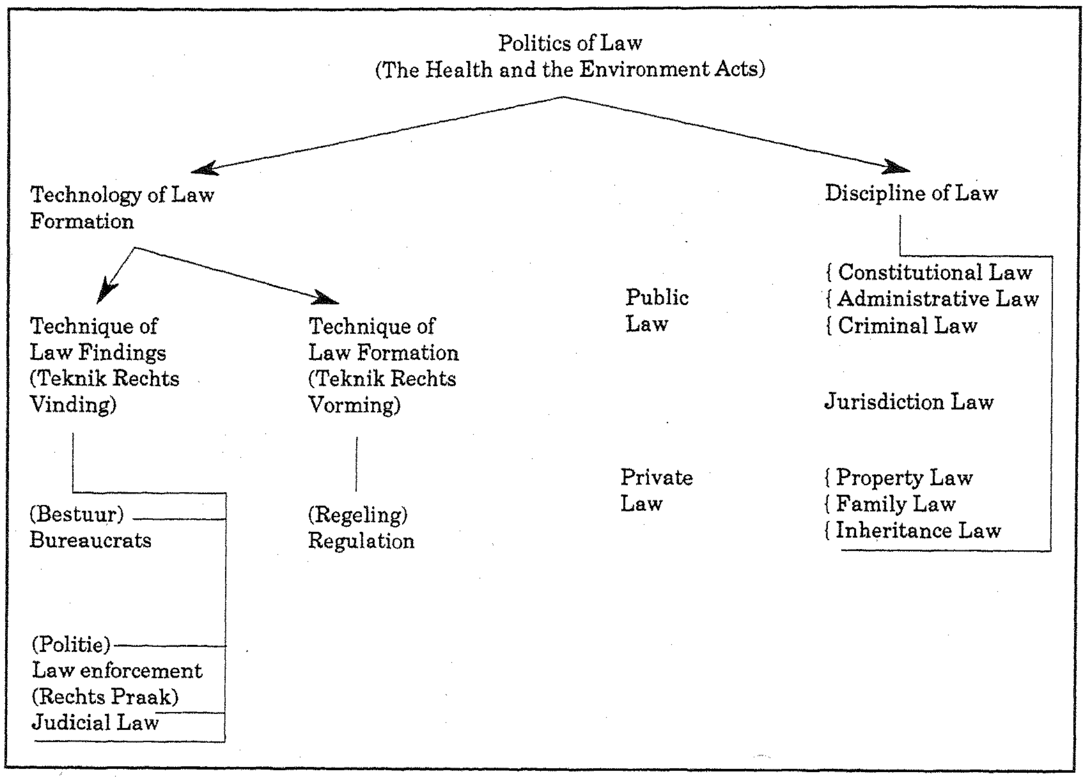

Figure 2: *The discipline of special law.*

In the above chart, the sub-system of health and the environment is related to the technology of law which can be law findings (Rechts vinding) or law formation (Rechts vorming). Because both the Health Act and the Environment Act can mean public law (criminal law) or private law (civil law), these two acts, therefore, can control environmental pollution.

The execution of the two acts to control environmental pollution, including health hazards, is law enforcement. Law enforcement is always guided by the systematic science of law, so that all elements in the systematic science of law must become elements for forming the technology of law. In order to enforce law we must use positive law (normative law). The positive law can be seen in the technology of law (see Figure 3).

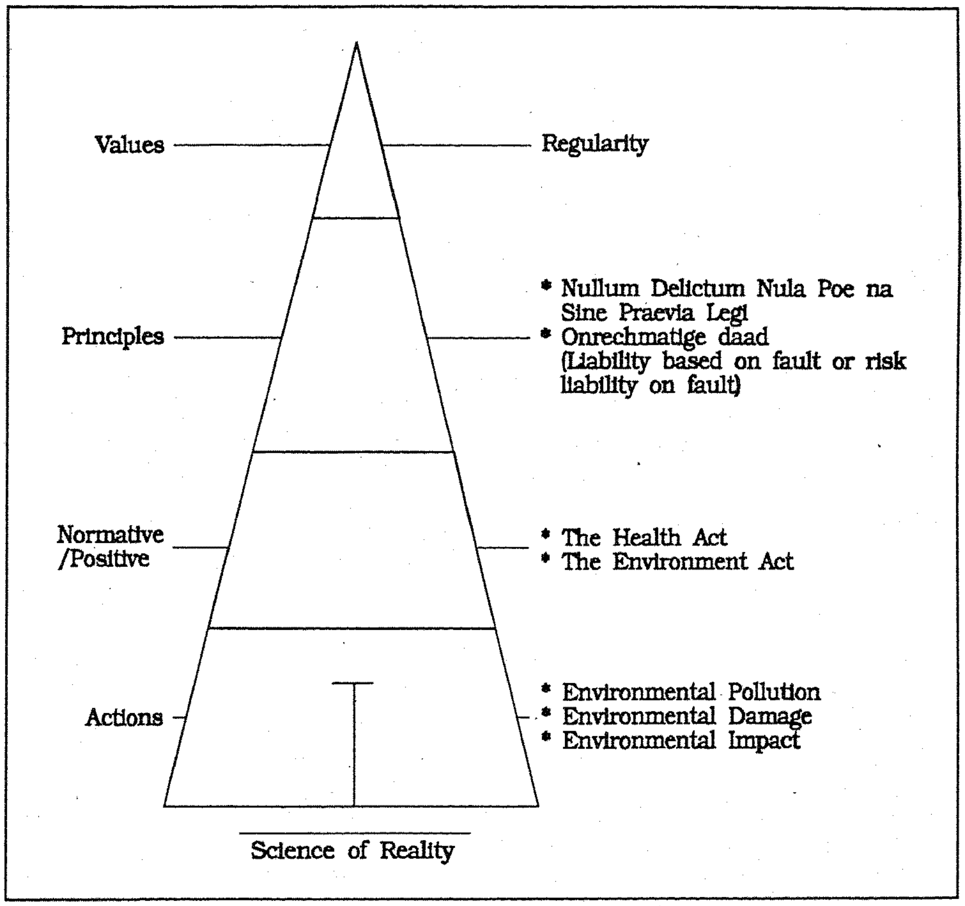

Figure 3: *Science of reality.*

From the above chart we can draw the conclusion that, theoretically, acts for controlling environmental pollution and health hazards can obviously be implemented.

CAN THE HEALTH ACT AND THE ENVIRONMENT ACT CONTROL POLLUTION? AND HOW DO THEY RELATE TO ONE ANOTHER?

In answering the above questions, we must keep in mind the methodology, the aim and the conceptual framework because we have already clarified how the independent variables (the principle of law) and the dependent variables (the Health Act and the Environment Act) relate to each other. In the Philippines, Thailand, Malaysia, Singapore and Indonesia we find that most acts deal with administrative problems, especially administrative problems related to formal licences. For example, if an industry does not have a complete valid licence, the government will make "conciliation". "Conciliation" means that an industry in a certain area which cannot solve certain problems of employment and which does not have a complete valid licence is ordered to apply for the licence. If it does not take part in solving the problems of the government, the operation of this industry will be closed down by the government.

So, the subjects of law (victims) still find difficulties, not only in prosecuting in criminal law, but also in accusing in civil law by using the Health Act and the Environment Act. It is still difficult to carry out these laws in ASEAN countries because:

1. ASEAN countries are still in the process of developing and the major investments for development come from industries.

2. The industries in ASEAN have created not only environmental pollution, but also environmental impact and environmental damage.

3. Most victims of both criminal and civil laws are not aware that they are hurt due to environmental pollution, environmental impacts and environmental damage.

4. A criminal act usually uses material evidence in which the victims become the witnesses; but, on the other hand, important witnesses, i.e. victims, often refuse to give their testimony because of work contracts with the factories which have created pollution.

5. In criminal law, a criminal act (starfbar feit) or misdemeanour (onrechmatige daad) is difficult to formulate. In the case of pollution, a misdemeanour must use formal evidence, but often there is no formal evidence because a legal relationship between the victims and the party who has made pollution does not occur. For example, if there is environmental pollution made by an industry, the victims of this criminal act will have difficulty in prosecuting the industry, the reason being that the subject of law (the party who does the criminal act), such as the top manager, the chief of security, the chief of engineering or the chief of personnel, etc. (corporate crime) does not intentionally do the criminal act or misdemeanour, although technically the impact has caused environmental pollution.

6. Formal evidence for these performing misdemeanours often cannot be found because there is no legal relationship between the victims and the subjects of law who have done the criminal act (environmental pollution). Consequently, compensation and restoration are difficult to obtain because it will be difficult to evaluate the nominal losses of the victims.

7. In the theory of law[1] used in problems of civil law there is the factor of "fault" which is raised as a result of the existence of the causality principle. In order to prove this in civil law, we usually use "liability based on fault principle", that is, the burden of proving lies with the victims. If the victims cannot prove the fault, they will not get any compensation. But, in environmental pollution problems, we can not use the "liability based on fault principle," but we must use "the risk liability on fault principle"[2]. Hence, the burden of disproving the fault lies on the side of the person who commits the misdemeanour (usually industry), because in the countries of South-east Asia, most victims are usually illiterate in law and their economic status is very low. "Risk liability on fault principle" is ideal, but the person who commits the misdemeanour can usually hide the evidence, making authentic evidence impossible.

   Victims, most of whom are poor and illiterate in law, often have difficulty in proving their cases by themselves due to the expensive costs of laboratory proof, and they do not have enough money to hire lawyers. One exception is if there is a Bureau of Law Consultation which is willing to give law guidance, but this is often not possible.

8. Environmental pollution, such from health aspects, is in fact very dangerous for the victims, either directly or indirectly. It is still difficult to prove whether or not there is a correlation among pollution and the industries which produce environmental pollution and the victims. Research must be carried out to formulate and draw conclusions about the pollution made by certain industries that cause environmental damages.

9. The relationship between the Environment Act and the Health Act is in fact quite close if it is viewed from the sub-system of law because a criminal act in the form of environmental pollution causes not only pollution or damage to the ecology, but also more serious damages to individuals.

10. The Health Act and the Environment Act have a very close relationship due to the fact that the victims of the Environment Act are the subjects of law of the Health Act. Victims of the Environment Act who become the main subjects must be given special attention in

order to get protection and compensation. They are the subjects of law who are in fact also the victims of environmental pollution, environmental impact and environmental damage. If environmental pollution, for example, occurs in a certain ecology, the impact of this environmental pollution will affect the victims who become the subjects of law of the Health Act.

11. Nowadays, Environment Acts just protect the ecology, not the victims who become the subject of law. Protecting ecology means not to cause environmental damage which affects people or individuals.

SUMMARY

1. Theoretically it can be proved that legal controls of environmental pollution can really control the problems of pollution.

2. Empirically, legal controls of environmental pollution cannot be carried out by the law enforcement agencies.

3. Environmental pollution, environmental impact, and environmental damage are caused not only by industries but also by household waste and garbage.

4. In the law enforcement of environmental pollution cases, prosecution or accusation in the field of both criminal law and civil law are difficult to realize because the legal definitions in the Health Act and Environment Act have not been formulated clearly.

5. The Health Act and the Environment Act are closely related because the subjects of the Health Act are also the subjects of the Environment Act and both subjects become victims in the Health Act and the Environment Act.

IMPLICATIONS

Suggestions for "The Role of the Association of Southeast Asian Institutions of Higher Learning in combating the health hazards of environmental pollution" are:

1. ASAIHL must first delineate the subjects of law who can be accused or prosecuted in either criminal law or civil law in cases of law enforcement of corporate crime.

2. ASAIHL must delineate and define the victims of environmental pollution, environmental impact, and environmental damage so that this definition can be used for compensation and restoration through the Health Act.

3. ASAIHL also must pay closer attention to the fact that the problems of environmental pollution are not only caused by industries, but also by household waste. This means that any one who causes waste pollution is subject to fine.

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ENVIRONMENTAL IMPACT ASSESSMENT AND THE ROLE OF LEGISLATION IN ENVIRONMENTAL CONTROL - THE CASE OF MALAYSIA

A Idris and A Fuad
Faculty of Engineering, Universiti Pertanian Malaysia, Malaysia

INTRODUCTION

Concern for the environment is mounting in Malaysia as in any other developing nation of this region. A significant step towards preserving the environment was made when the Malaysian Parliament passed the Environmental Quality Act 1974 on 16th March 1974. This act covers a wide range of environmental management activities, but emphasis is on corrective rather than preventive measures. Furthermore, the act has several drawbacks, such as having little jurisdiction over non-point sources of pollution and non-localised activities such as land clearing and jungle operations. Wherever the act lacks enforceable power, non-statutory control measures are promoted, such as the issuance of guidelines for various activities to be enforced by relevant responsible agencies.

In 1985, the Environmental Quality Act of 1974 was amended. A section was introduced which requires any person intending to carry out any prescribed activity to submit a report on the impact on the environment to the Director General, Department of Environment (DOE) for approval[1]. Thus, environmental impact assessment was introduced as a planning tool for preventing adverse effects on the environment. In this manner, EIA is used as a means of integrating environmental considerations in project planning.

ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

In Malaysia, the EIA procedure adopted consists of three major steps:

a) Preliminary assessment
b) Detailed assessment
c) Review of EIA reports.

A complete diagrammatic representation of the procedure is shown in Figure 1. The organisational structure for scrutinising and approving EIA reports are summarised in Figure 2.

In order to assist and facilitate the smooth integration of EIA in project planning, the procedure is designed to have the following features:

a) the need to conduct EIA is decided at the outset of project identification.

b) if preliminary assessment is necessary, it is carried out simultaneously with the project pre-feasibility study.

c) if detailed assessment is required, it is conducted together with the project feasibility study.

d) the assessment in (b) and (c) are reviewed simultaneously with the respective feasibility reports prior to decision making on the project proposal.

e) environmental monitoring is carried out during the project construction and operation.

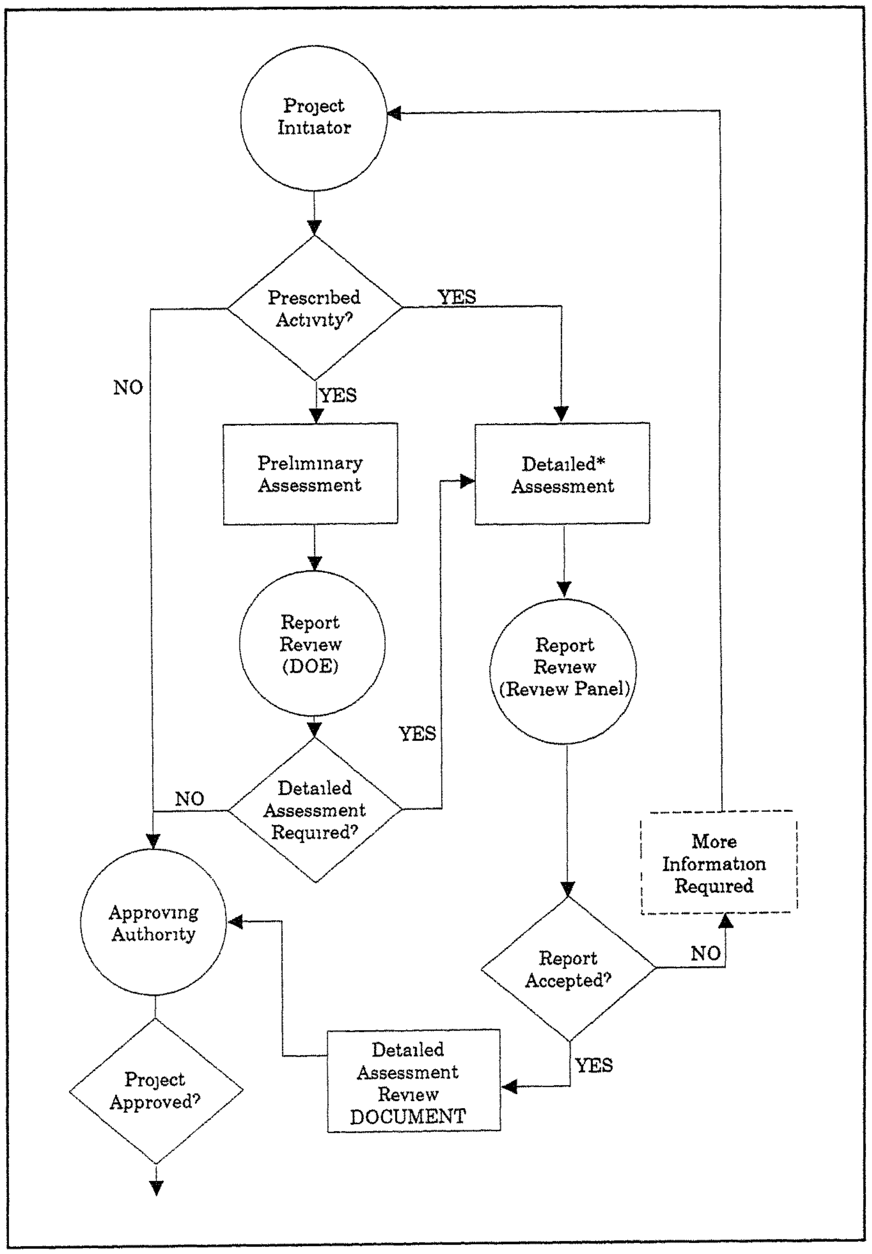

Figure 1: *Outline of environmental impact assessment procedure in Malaysia*
** Consultation with DOE on Terms of Reference*

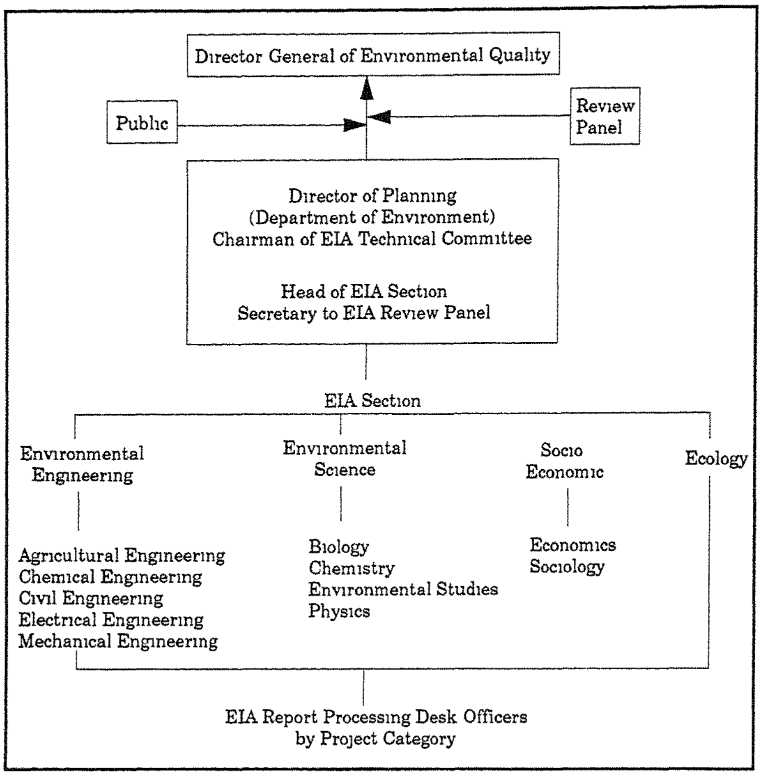

Figure 2: *Organisational structure of EIA report processing and approval procedure*

A diagrammatic summary of the concept is shown in Figure 3

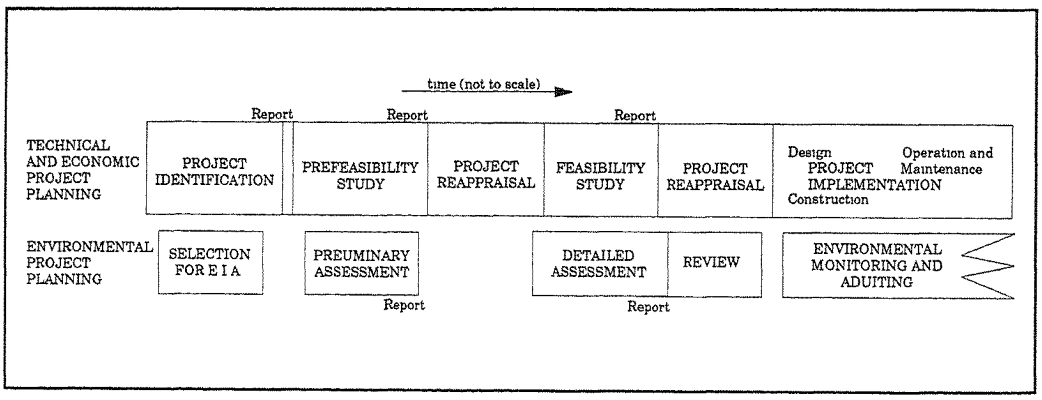

Figure 3: *Integrated project planning concept*

EIA - CURRENT PRACTICE

Undoubtedly, the EIA process in Malaysia is a powerful instrument used for planning, management and protection of the environment It has been years since EIA became legally mandatory and a short review of the current progress and practice would be beneficial to us.

From 1st April 1988 to 31st August 1991, a total of 509 projects were identified and subjected to approval by the DOE (Table 1)[2]. Most of the projects were related to quarrying, infrastructure, industries and resort development. Out of this, only 269 EIA reports had been received by the

DOE, 266 of which related to 17 of the 19 categories of activities specified by the EIA legislation. Table 2 shows the top three categories of EIA reports which are related to development of infrastructure (16%), industries (14%) and resorts (13%). The next group of activities are petroleum and gas development (11%), quarries (10%) and housing development (9%). No reports on the development of airports and transportation have been submitted, but it will not be long because some massive transportation projects and airport development are being planned. Out of these EIA reports submitted, only 5 are detailed EIAs and 16 are risk assessment. Hence, in most cases, the environmental impacts are not considered serious enough to warrant a detailed EIA submission.

Table 1: *Projects subjected to EIA Notified and Monitored by DOE (1 April 1988 - 31 August 1991)*

No	Activity[a]	1988	1989	1990	1991	Total
1	Agriculture	2	7	4	3	16
2	Airport	0	0	2	0	2
3	Drainage and Irrigation	2	3	0	2	7
4	Land Reclamation	0	5	6	3	14
5	Fishery	0	4	4	1	9
6	Forestry	1	7	18	9	35
7	Housing	3	5	15	7	30
8	Industry	7	10	14	11	42
9	Infrastructure	3	18	46	14	81
10	Port	1	2	1	0	4
11	Mining	9	1	15	2	27
12	Petroleum	9	5	12	4	30
13	Power Generation	6	2	3	2	13
14	Quarry	3	18	47	19	87
15	Railway	0	0	3	0	3
16	Transportation	0	0	0	0	0
17	Resort/Recreational Development	2	9	31	26	68
18	Waste Treatment	6	7	12	6	31
19	Water Supply	2	2	2	0	6
20	EEZ[b]	1	1	0	2	4
	Total	57	106	235	111	509

a, Category of Projects as in EIA Order, 1987, b, Petroleum Development Projects in the Exclusive Economic Zone Act, 1984

Table 2: Number of EIA reports received/reviewed by DOE (1 April 1988 - 31 August 1991)

No	Activity[a]	1988			1989			1990			1991			Total
		PA	DA	RA	PA	DA	RA	PA	DA	RA	PA	DA	RA	
1	Agriculture				1						2			3
2	Airport													0
3	Drainage and Irrigation	1			1						3			5
4	Land Reclamation				3			3			1			7
5	Fishery										1			1
6	Forestry							2			6		1	9
7	Housing	1			3			9			11			24
8	Industry			1	7	1	1	13	1	2	9		3	38
9	Infrastructure				1			17			23	1		42
10	Port				1			2						3
11	Mining	1			1			7						9
12	Petroleum	4			3		2	11		3	4		3	30
13	Power Generation	2			3			1			3			9
14	Quarry				3			13			11			27
15	Railway							1						1
16	Transportation													0
17	Resort/Recreational Development							15			21	1		37
18	Waste Treatment	1			3			10			1			15
19	Water Supply				1			2	1		2			6
20	EEZ[b]				1		1				2			3
	Total	10		1	32	1	3	106	2	5	100	2	7	269

PA· Preliminary Assessment; DA; Detailed Assessment, RA; Risk Analysis, a, Activity of Projects according to the EIA Order, 1987; b; Petroleum Development Projects in the Exclusive Economic Zone (Section 21(1) and 22(1) of the Exclusive Economic Zone Act, 1984)

In the majority of cases, the proposed projects consisted of routine development such as construction of infrastructure. They are generally non-controversial and their environmental impacts are well known where mitigating measures to safeguard the adverse impacts are guided by existing government legislation. Such projects do not require public participation and likewise the public also have very little interest in such projects or their EIAs. The public appears quite content to let DOE deal with the developers. However, some projects have aroused great public interest and the EIAs have been heavily scrutinised because they involved the development of public properties or the project site is near to environmentally sensitive areas such as water catchment area, historic places or marine national parks. Cases such as a golf course development in Pulau Redang, which is a marine national park area and a housing development near a zoological garden in Kuala Lumpur have created lots of opposition from public.

The rapid economic growth which Malaysia experiences will naturally lead to more development projects. With increasing activities, more EIAs are expected to be carried out. Although there is no provision that requires project proponent to notify the DOE of projects subject to EIA, the DOE has found it useful to maintain a 'proactive' register of projects most likely to require EIA. In this way guidance can be given to the project proponent on preparation of EIA report.

It is only in 1990 that DOE[3] began checking the projects that were approved to see whether they comply with the conditions of approval. However, the outcome was not very good due to DOE's shortage of manpower and also the response from project proponent to furnish detail monitoring programmes was slow.

PROBLEMS RELATED TO IMPLEMENTATION OF EIA

There has been a number of problems related to the implementation of EIA which can be listed as follows:

Lack of awareness: There has been lack of awareness among some approving authorities and project initiators on the usefulness of EIA as an effective tool during planning stage. To many developers, EIA is seen as a "stumbling block" to development. As such, EIA is the last thing the developers will consider doing and only if they are compelled to do so. Projects are always judged mainly on their financial viability and attractiveness and never on environmental consideration. Therefore, developers attitude toward environment is generally very low and as a consequence the public has to suffer due to the devastating adverse impacts from some developments. Some cases of river pollution due to industrial effluent, high sediments in water courses and flood problems testify to the facts very clearly.

Timing of submission of reports: The EIA process has been designed to follow an integrated project planning concept as mentioned previously, where EIA is to be carried out at feasibility stage. In most cases, feasibility studies are not carried out and EIA report comes last during project implementation. Any EIA that is presented towards the end of project cycle is not meaningful and it is reduced to a mere formality. The practices in 1989 showed that only 50% of EIA reports were submitted in the feasibility stage[2].

Delayed submission of EIA reports is also attributed to lack of understanding and attitude of the project proponents on the EIA process as mentioned previously. The EIA consultants are normally given a short time frame to carry out the study and sometimes there are budget constraints because no fund is allocated for EIA studies. An EIA report which is done in a rush and at unrealistic budgets actually reduces the quality of work and also the depth of study. Subsequently the DOE and the public are the ones criticizing the project proponent and EIA consultants for not doing a good job.

Professional input in EIA: The implementation of EIA in Malaysia is only about 4 years old. There has been a general lack of expertise for the proper conduct of EIA and also the review of EIA reports. EIA requires many different kinds of expertise, as an EIA exercise is multidisciplinary. Most of the 269 EIA reports conducted and submitted to DOE had been carried out by people with no formal training in EIA. Most are probably undertaken by consultant engineers but certain specialist inputs come from research organisations and the universities. Others engage in EIA studies on strictly business or profit making terms and lack the true professionalism required. This is because there has been a lot of EIAs carried out within a short time scale and untrained people are tempted or persuaded to undertake EIAs. The consequences is that their reports are rejected by the DOE on some weakness that had been highlighted such as:

- poor description of project concept
- insufficient baseline data on existing environment
- lack in quantitative and qualitative prediction of impacts
- insufficient proposal to mitigate adverse impact
- lack of option for siting, technologies and control for pollution[2].

CONCLUDING REMARKS

The use of environmental impact assessment as a tool in the planning stage of a development has been demonstrated to have some success. Although the effectiveness of implementation has suffered due to several factors mentioned above, the usefulness of EIA will continue to benefit us in the long term towards achieving a sustainable development. Various authorities that are involved with project planning and implementation should be better educated to have greater concern for EIA. Also, a good assessment of projects will need trained specialists. Therefore, the role of universities is important in providing the necessary expertise to help in the EIA exercise. Experiences from other countries in the region may also be beneficial and can be shared by ASAIHL Universities through some form of a regional training centre for EIA.

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SOCIAL RESPONSIBILITY AWARENESS ASSESSMENT OF SELECTED UNIVERSITY RESPONDENTS IN COMBATING ENVIRONMENTAL POLLUTION

A C Barcelona
School of Management, Universiti Utara Malaysia

INTRODUCTION

Background: We all live in an environment, and we all depend on the environmental resources for life and production (food, energy, air, water, materials); and through the process of technological development and innovation, we also inherit the waste products or the residue of living in an environment.

The ever frightening ozone depletion detected by a British Antarctic survey scientist, Joe Farman in 1985[1] and the US$125 Billion a year budget[2] needed to save our environment are only minor proofs that environmental pollution is a man-made problem.

If mankind is responsible for creating environmental pollution, then we should all be aware of our social responsibility of reducing if not totally eradicating its harmful effects to mankind.

It has been stated[3] that if a community's needs are clear and explicit, social responsibility is scarcely an issue; this is a well-understood fact.

For man to continue the propagation of his species; for any organization, (public, private) to perpetuate, each one must be willing to assume social responsibility in the environment in which we live. Everyone must safeguard the health and quality of life of community members.

Significance of the study: The primary purpose of this exploratory study is to determine whether the sampled groups are aware of their social responsibility in combating environmental pollution.

It is hoped that this paper will serve as an impetus or the starting point for a macro study intended to uncover the social responsibility awareness of other groups of university respondents.

It is felt that proper environmental education should start with the assessment of subjects' awareness of their responsibility towards the environment.

The citizenry can only exercise their social responsibility towards eradicating environmental pollution if they are aware of such actions or reactions that are deemed to affect the environment positively or negatively.

Problem statement: The present work is envisaged to answer the following:

1. What is the degree of social responsibility awareness (SRA) of the selected respondents in eradicating environmental pollution?

2. What is the respondents' level of SRA in combating environmental pollution in terms of knowledge, and attitudes (verbal, behavioral, emotional)?

3. Are there significant differences between the:
   degree of SRA of the sampled groups
   level of SRA in terms of attitude and knowledge?

Hypothesis: There are no significant differences between the degree of SRA of the sampled groups.

Definition of terms: The following terms are defined as used in the study:

Environment may be defined as the total of all social, technological, biological, physical, and chemical elements which compose the surroundings of man[4].

Environment can be classified into socio-cultural environment, which consists of the media, the social structure, the political system and the values of the people; the socio-economic environment, which refers to the development level, employment, markets, technology, labour relations, and the physical environment, which provides the resources necessary for man's survival[5].

Pollution is defined in Act 127 Environmental Quality Act, 1974 (Laws of Malaysia) as any direct or indirect alteration of the physical, thermal, chemical, biological, or radioactive properties of any part of the environment by discharging, emitting or depositing wastes so as to effect any beneficial use adversely, to cause a condition which is hazardous or potentially hazardous to public health, safety, or welfare, or to animals, birds, wildlife, fish or aquatic life, or to plants or to cause a contravention of any condition, limitation, or restriction to which a license under the Act is subject.

Social Responsibility refers to one's duties towards the society. Social Responsibility is a function of the identified needs of the community or the society in general.

SRA Awareness refers to the consciousness of the selected groups of respondents of their duties towards a defined need of the community or society.

SRA Awareness Assessment is a means to determine/judge how informed/conscious are the selected groups regarding their responsibilities towards the identified need of the community or society.

Degree of SRA refers to the extent of respondents social responsibility awareness towards combating environmental pollution.

Scope and Limitations

The limited time to conduct the research, constrained the researcher to confine the subjects of the study to just one university, hence, the results of the study apply only to the chosen university.

An English version of the instrument was used for the present study. There is no need to translate the instrument, considering that the subjects are senior students, lecturers and administrators.

METHODOLOGY

Research method: The descriptive research method will be used in this exploratory work.

Sampling and instrumentation

Stratified sampling criteria were established such as position title, academic rank, active involvement in campus activities.

From the records of UUM, Department of Academic Affairs, from the total population of 774, which consists of 260 Category A Lecturers, 69 Senior Administrators, 445 Senior Students, the subjects for the present study were taken.

The sampling frame consists of 53 males, and 28 females randomly selected, making a total of 81 respondents (29 students; 23 lecturers; and 29 administrators of Universiti Utara Malaysia) who were asked to answer the modified Social Responsibility Scale adapted from the work of Berkowitz and Lutterman, (1968), and the Ecological Instrument used by Maloney and Ward[6]. (Alpha 723).

To further validate the findings, another set of 121 senior students and 31 senior lecturers from the same institution were randomly selected (from the population frame of 774) and were asked to answer the simplified Ecological Instrument[6].

Scoring scheme: The 30-item questionnaire is designed to measure the degree of awareness of the respondents regarding his/her social responsibility in combating environmentally pollution. In the first survey of 80 respondents, the lower the scores obtained the more environmental aware the respondent. The scores include Highly Responsible/Highly Aware Group who scored 30; the Responsible/Aware Group who obtained 31 to 61; the Less Responsible/Less Aware Individuals who gained 61 to 92; and the Least Responsible or Least Aware Group, who scored 93 and above.

In its simplified form the 30-item questionnaire further included the assessment of respondents' knowledge of environmental issues, and attitude (behavioral, verbal and emotional) regarding ecology.

The higher the scores obtained the better the standing of the respondent in terms of environmental attitude and knowledge about environmental issues.

Data treatment: Descriptive statistics, mean, frequency, and percentage distribution, were computed and t and z test carried out using Microstate Statistical Package.

IMPLICATIONS OF THE FINDINGS

The two small-scale surveys showed that the degree of awareness of the selected respondents with respect to their social responsibility towards eradicating environmental pollution did not differ significantly. The majority of the sampled groups of subjects, regardless of their occupational status (academicians, administrators, students) obtained a SRA score which classified them as a less responsible, less aware group.

The results indicate that definite action must be taken to enhance the degree of awareness of the very people who are supposed to teach the future hopes of the country, as well as those who are to direct, or manage an educational institution.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions: If we are to ask ourselves, is there really a need for small-scale surveys such as the present study, or should it be done on a larger scale?

The present work is limited, but presents concrete proof that people are not especially concerned about the environment; we may express it verbally, but we do not have the knowledge, nor the commitment; as in the case of the majority of the sampled respondents in the second investigation.

Some would say that the result might be different if the entire population were considered. But if all of us have been responsible care takers of these gifts of nature, there would be no ozone layer problems, pollution and/or greenhouse effects.

We can simply point one finger and accuse the government for failure to enforce effectively environmental acts, but the other four fingers are pointing back to us!

We just continue living, for as long as we can survive, we pursue our respective vocations, but simply shrug our shoulders to our worsening environmental conditions. Let those who can survive, survive, until such time that nature will take its course, and mankind cannot do anything anymore but pray!

Specifically the selected respondents, administrators, academicians, students; being essential components of an institution of higher learning, it is expected that they should be more aware of their responsibility towards the society in eradicating environmental pollution. And this is true of all institutions of higher learning, ASAHIL members.

We can only expect the students to be aware of their social responsibility in solving environmental pollution problems, if the mentors themselves are adept as to what is happening in the environment.

It is a challenge for university administrators to contribute solutions to environmental issues; to instill social responsiveness to the academic staff, who are engrossed with a voluminous teaching load, research activities and paper work.

Awareness itself will not solve environmental pollution, but the seed must be sown/planted for our future survival. Once we are aware, then we can perform our responsibility in abetting environmental pollution.

Recommendations: In the light of the findings from the present study, the following recommendations are put forward:

1. More conferences, seminars, workshops such as this being done by ASAHIL should be applauded and encouraged, among universities, private companies, public organizations.

   All we need is to light one little candle, all we need is a tiny spark, to enkindle the enthusiasm, knowledge, instill social responsibility awareness, regardless of one's status in life. We should all be concerned about our own environment; and the time is now.

2. A policy should be promulgated incorporating
   Environmental Consciousness in the curriculum; better as a separate subject for all university students, in all the fields of study/programs.

   Basic concepts and theories about the environment could be discussed, and issues and cases studied related to particular fields of specialization or studies should be covered.

   Students will inherit the present ecosystem. They should, therefore, be provided with the working knowledge on how to protect the environment from pollution and defilement.

3. In the lower levels of education, say Form Schools, there is a need to upgrade knowledge. The topic of the environment should be covered and discussed in the law subjects that the university students are taking.

   Ignorance of the law is not an excuse, an area of environmental education should incorporate study of environmental laws, standards.

   As of now emphasis to make college students academically prepared, less emphasis is placed on the behaviour towards the society, (specifically social responsibility towards environmental issues like pollution).

5. Carry out sponsored/funded research work projects linking the field or area of expertise to environmental consciousness or environmental issues; should be encouraged among academicians, (among ASAHIL members)

6. Collaboration among ASAHIL members

   6.1 . ASAHIL could serve as a catalyst in order to institute a formal curricula on environmental education., in both the lower levels as well as in university education and in carrying out funded/sponsored research activities related to environmental issues.

6.2 Competition/Contest among ASAHIL members such as an essay writing contest, painting contest, debates are suggested.

The theme should be geared towards developing environmental awareness and consciousness among participating academicians, students/delegates.

Prizes could be in the form of a cash amount, free travel to any ASAHIL member country, scholarships.

6.3 Research competition and presentations are also recommended.

Prizes may vary from cash to scholarships or sponsored trips.

This will motivate academicians to write and/or conduct environmental studies and at the same time fulfil their career requirements.

6.4 An ASAHIL Journal on Environmental Issues is suggested.

Contributions will be solicited from among the members, either empirical or theoretical articles/studies.

Such publication will represent the continuing effort of institutions of higher learning to help educate members and readers on environmental issues.

6.5 A policy should be formulated that requires university administrators, academicians to either organize or attend seminars about environmental concerns.

NOTE FROM THE EDITOR

This paper has been edited for publication purposes. Those readers wanting more details (e.g. the data from the study and references used) should contact the author directly.

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ALTERNATIVES TO LEGAL CONTROLS ON ENVIRONMENTAL POLLUTION

G Kaine*, I Reeve* and W Musgrave+
* **The Rural Development Centre, University of New England, New South Wales, Australia**
+ **Faculty of Economic Studies; Centre for Water Policy Research, University of New England**

INTRODUCTION

The central issue addressed in this paper, and one which lies at the heart of the debate about the management of the environment, is the development of a practical but conceptually sound framework for the management of complex but poorly understood systems. In the paper an attempt is made to sketch the outlines of such a framework, drawing on hierarchy theory and systems theory as reflected in industrial organisation theory.

The linking of these two quite different approaches to systems analysis provides a framework within which changes in the environment provoked by economic activity may be interpreted in terms of the dynamics of ecosystems. Further, the appropriateness of legislative, market or other mechanisms as a means of containing those changes can be evaluated.

ECOSYSTEMS AS HIERARCHICAL SYSTEMS

The biosphere, and any local part of it, is a thermodynamically open or dissipative system[1]. An important property of dissipative systems is their spontaneous tendency to hierarchically structured self-organisation[2]. In such hierarchies the dynamic behaviour of systems which constitute one level of the hierarchy are only weakly linked to the dynamic behaviours of systems at levels above and below it, resulting in 'stratified stability'[3]. This means that the systems at any one level in the hierarchy must be sufficiently stable to provide the basis for the organisation of the next highest level. Hence, ecosystems may be conceptualised as being composed of 'nearly decomposable' hierarchies of systems[4].

Levels in the hierarchy are distinguished from each other on the basis of the rates at which processes occur. It is possible to choose a time scale for observing a complex system such that the frequency of motion of some processes within the complex will be so rapid that they appear to be in 'equilibrium' and only the 'average' values of these processes will be observable. The detailed dynamic behaviour of these processes will not be apparent at the chosen time scale. These processes comprise the lower levels of the hierarchy. For the same scale of observation the motion of other processes will appear to be so slow that they will appear to be fixed and these processes comprise the higher order levels of the hierarchy. Only those processes with a frequency of motion corresponding to the time scale selected will exhibit observable dynamic behaviours. Note that these observable dynamics will be nearly independent of the detailed behaviours of the processes lower in the hierarchy. Consequently, a theory of the dynamic behaviour of the processes that can be observed can be constructed in ignorance of the detailed structure at the next level down and the very slow interactions at the next level up[4].

In a nested hierarchical ordering of systems the dynamic behaviour of processes or systems at any one level depends, by first order approximation, on the behaviour of the other systems at that level, the nearly fixed values of the slow moving interactions between systems (which constitute the higher order systems at the next level up), and the average or equilibrium values of the fast moving lower order systems below. This vertical decomposition of systems permits stable assemblies of systems to be constructed whose dynamic behaviour is irrelevant to the construction of larger structures. Only the average or equilibrium values of these stable assemblies influences the behaviour of larger structures.

In addition to the vertical segregation of systems on the basis of the frequencies that characterise their dynamic behaviour, systems at the same hierarchic level may also be differentiated. At a particular level in the hierarchy, it is possible to define boundaries around sets of lower order components such that the interactions between components take place more frequently within boundaries rather than across them. These groups of frequently interacting components, each of which may be regarded as a system, are referred to as 'holons'[5]. The holons at a particular level in the hierarchy, can be regarded as being only 'loosely coupled' to the neighbouring systems or holons at that level[6].

This loose horizontal coupling permits the internal dynamics of each holon or system to operate independently of the detail of the internal behaviour of the other holons or systems at that level[7]. Given then that the internal dynamics of a system may be treated as virtually independent of other systems, then the internal dynamics of a system can be changed without affecting the higher order aspects of the hierarchy. This is provided that, in the longer term, the altered holon or system requires similar inputs from lower order systems and provides similar outputs to the higher order systems. Hence, while the internal dynamics of a particular system may be changed, provided the system continues to generate similar outputs and requires no change in the inputs from lower order systems, then the dynamic behaviour of the system is 'functionally equivalent' from a hierarchical perspective[7]

The characterisation of ecosystems in terms of hierarchies that has been reviewed here provides a convenient conceptual framework which, while only partly developed, can be employed to address some aspects of the management of economic intervention in ecosystems. Consider the consequences of altering the internal dynamics of a system such that the equilibrium outputs of it are altered. While this may have no direct impact on the internal dynamics of the other loosely coupled systems at the same level in the hierarchy, the change in equilibrium will alter the interactions between these systems at the next higher level in the hierarchy leading to novel emergent properties.

Grobstein[8] characterises an emergent property as a property arising from the transformation of a relationship by the action of context. Prior to the transformation the property is not present. Following the transformation, which is initiated by a specific context, the emergent property appears. For example,the appearance of algal blooms in river systems may be interpreted as a new emergent property resulting from a change in the context, viz phosphorus availability, within which the population dynamics of algae operate[9]. Note that the appearance of the emergent property is context dependent, different emergent properties may arise when the relationship of interest is placed within different contexts.

Hence, changes in the equilibrium values or properties of lower order systems may generate changes in the observed dynamic behaviour of higher order systems and provoke new emergent properties. Eventually these changes will be transmitted to systems throughout the hierarchy and, ultimately, the behaviour of systems throughout the hierarchy may be changed. If at least some of the relationships within systems are non-linear and hysteretic then dynamic behaviours which are catastrophic and chaotic may emerge.

This brief description of the way in which a change in one part of the structure of a hierarchy of systems may introduce complex changes throughout the hierarchy captures the flavour of the potential for economic activity to alter the behaviour of ecosystems and, in doing so, to provoke novel emergent properties which are not apparent in the initial state of the hierarchy. Given limited knowledge about the dynamics of systems at each level in the hierarchy, and the hierarchy itself for that matter, then the impact of economic activity on the dynamic behaviour of systems in the hierarchy and the emergent properties associated with changes in the equilibria of systems will be unpredictable. Consequently there will be extreme or gross uncertainty as to the impacts of large scale economic activity on ecosystems. In essence, economic organisations will be operating in a 'turbulent field'[10].

ECOSYSTEMS AS TURBULENT FIELDS

Emery and Trist[10] describe a causal typology of organisational environments and infer principles governing appropriate organisational behaviour in each of these environments. One of the environments they describe is termed the 'turbulent field'. This environment is characterised by extreme uncertainty as to the consequences of actions that organisations might contemplate. In the turbulent field, actions taken by organisations trigger events that lead off in ways that are increasingly unpredictable. The impacts of actions do not necessarily decline with distance, but may be amplified beyond all expectations at some point[10].

The extreme unpredictability that characterises the turbulent field, as conceptualised by Emery and Trist, is the product of the increasing scale, complexity and degree of interaction of organisations. Actions of these organisations can initiate unintended changes in the relationship between organisations, and between organisations and their environment by unwittingly provoking changes in relationships within the environment itself.

The parallels in the nature of the relationships between organisations in this type of environment and between organisations and the physical environment as portrayed above is apparent. The increasing scale and complexity of the interactions between groups of organisations and ecosystems disturbs the behaviour of systems throughout the hierarchy of systems that make up the latter, provoking changes within the hierarchy and the unanticipated appearance of emergent properties. These newly emergent properties may well, in turn, introduce interactions between organisations which previously appeared to be unconnected.

An organisation in a turbulent field cannot successfully adapt simply through its own actions. The inherent unpredictability of the outcomes arising from the actions of an organisation implies that 'set' beliefs cannot be formulated and consequently 'chance' beliefs cannot be formulated with respect to the set of outcomes[15]. Emery and Trist[10] argue that, to cope with persistent areas of uncertainty, 'values that have overriding significance for all members of the field' must emerge. These commonly shared social values, which may take the form of ethical codes, socially sanctioned rights or claims, or categorical rules, simplify the environment from the perspective of individual organisations. These shared values raise the predictability of the environment by limiting the range of actions available to organisations. The effectiveness of these shared values will depend on the degree to which they adequately represent the environmental requirements of organisations and the extent to which they encapsulate goals which will lead to the convergence of the interests of all parties. That is, shared values need to be formulated which enable areas of gross uncertainty concerning the ecosystem to be avoided, and that define a set of socially sanctioned actions which relieve organisations of responsibility for the unintended consequences of that set of actions. If such values are to be effective they must, of course, be formulated with due regard to the hierarchical structure of ecosystems.

Returning to the characterisation of ecosystems as hierarchical structures of systems, a shared value which may provide an effective means of promoting the avoidance, or more precisely, the creation of areas of gross uncertainty would concern establishing mechanisms which generate functional equivalence in altered systems. As described earlier, when the dynamic behaviour of a system in the hierarchy is altered such that the equilibria of the system are changed, the change in the equilibria provokes changes in the behaviour of other systems in the hierarchy generating new emergent properties. If the behaviour of the system which was initially altered can be suitably modified such that the original equilibria are restored, then the original behaviour of other systems in the hierarchy may also be restored and the new emergent properties may, in time, be eliminated.

ESTABLISHING FUNCTIONAL EQUIVALENCE

To the degree that novel emergent properties introduce interactions between organisations which previously appeared to be unrelated, in the sense that an emergent property entails a diminution of the rights of others, then that emergent property is an externality. In such circumstances, the exercise of rights to appropriate resources effectively includes the right to alter the emergent properties of the ecosystem. If the characterisation of the hierarchical system as a turbulent field is correct, then the consequences of sanctioning such rights is unpredictable. Hence, the exercise of rights to appropriate the resources of ecosystems need to be limited in such a way that systems in the hierarchy remain functionally equivalent. By constraining rights such that systems in the hierarchy are functionally equivalent, the consequences of the economic behaviour of individuals and organisations will be contained within boundaries that are, at least relatively speaking, well understood and reasonably predictable. In effect, the exercise of claims to resources is restricted to that which can be accommodated within the apparent dynamics of the ecosystem.

Just as the rationale for attempting to establish functional equivalence in systems is provided by the uncertainty concerning the nature of the interactions between holons and the emergent properties of these interactions, this uncertainty also provides a justification for attempting to establish functional equivalence by restricting appropriation rights. The informational requirements for identifying the restrictions on rights that are necessary are likely to be small, relatively speaking. Detailed knowledge of the other holons in the hierarchy is unnecessary. Only information as to the resource appropriations that are relevant to the emergent property is required. Clearly, this information entails the accumulation of some knowledge regarding the relationship between the emergent behaviour and the relevant appropriations. However, given that the functional impairment of the holon is probably diagnosed on the basis of the appearance of novel emergent properties, then the task of identifying the relevant appropriations becomes somewhat simpler. Particularly detailed knowledge concerning the nature of the relationship between appropriations and the emergent property may be unnecessary if adaptive mechanisms are used to limit appropriations[12 14]. A substantially greater body of knowledge may be required to reconfigure or modify the relationships within the holon in order to achieve functional equivalence.

DISCUSSION

If the preservation of ecosystems is a widely accepted social goal, and the conceptualisation of ecosystems presented here is correct, then the need arises to identify the appropriate instruments or mechanisms which are to be used to establish functional equivalence. To begin with, the restriction of rights to resources clearly entails a form of licencing which is supported by legislation. However, as the behaviour of the ecosystem of interest is dynamic, then the restriction on rights must be responsive to that dynamic. In other words, the proscription of rights should, ideally, be sufficiently flexible to allow changes in the degree to which rights are restricted as the capacity of the ecosystem to withstand intervention varies over time. This entails a mechanism for routinely redistributing rights. Another concern is that the distribution of the rights that are available at a particular point in time reflect variations in demand between different uses and users. The crucial issue is to maintain flexibility in terms of access to the resource while ensuring efficient utilisation of the resource and avoiding costly disputes over access.

This might be achieved by employing 'ecosystem-coupled markets'[14]. This approach involves an integration of market mechanisms and legislative controls, the legislative controls defining the boundaries of the market while the market mechanism routinely resolves the allocation of resources between users. Legislation is employed to grant or sanction rights of access to resources in terms of licences, permits or entitlements. These entitlements define rights of access relative to environmental standards which are set at a level which is intended to ensure functional equivalence. The entitlements themselves are transferable between users and uses. While the entitlements define the maximal access the holder has to the resource, the actual access in any particular period is contingent on the state of the ecosystem at that time, relative to the approved environmental standards. A similar system of entitlements which are subject to periodic variation has been employed in Australia for some time to manage irrigators access to water resources. Kaine et al[14] have extended this concept with regard to the broader riverine system.

The right to appropriate resources is, given the conceptualisation presented here, always contingent and not absolute. As noted earlier, the functional impairment of a holon may not be apparent until a novel emergent property appears, and the implications for the behaviour of the remainder of the ecosystem hierarchy of this new property are probably unpredictable. Consequently, the right to appropriate resources must be regarded as contingent upon the absence of novel emergent properties. Clearly, the exercise of rights to resources may, over time, generate a number of novel emergent properties. Hence, a succession of restrictions may come to govern these rights. This adaptive and evolutionary view of rights accords with Murphy's observations regarding the formalisation of rights within legal systems[15].

The role of legislation in combating environmental pollution is, in the framework presented here, largely strategic. Legislation provides, through licencing and the setting of standards, the means for the resolution of the strategic problem of implementing functional equivalence. Markets in those licences, on the other hand, provide the means for routinely resolving conflicts between potential users of resources. The market mechanism provides, we believe, an efficient and effective alternative to litigation. Moreover, markets provide an alternative that is both more responsive to changes in demand for resources and more likely to encourage, through price incentives, the search for substitutes.

CONCLUSION

In this paper an attempt has been made to outline a conceptual framework within which the management of ecosystems might be analysed. Ecosystems were characterised as complex hierarchical structures composed of progressively higher order interactions. The disruption of the stable behaviour of a system at one level in the hierarchy disturbs higher order interactions between systems resulting in novel emergent properties. Such properties may be eliminated by modifying the disrupted system such that functional equivalence is obtained. The inherent unpredictability of the consequences of disrupting the stability of a system at some level in the hierarchy leads to the view that the relationship between economic activity and ecosystems could be described as a turbulent field. The management of such a field requires the formulation of shared values by the individuals and organisations that form part of the field. The purpose of these shared values is to impose limits on behaviour such that actions which entail gross uncertainties are avoided.

To be effective these values must reflect the requirements of the environment. In the context considered here, these requirements were interpreted as establishing functional equivalence so as to avoid provoking unpredictable changes in ecosystems. Meeting this requirement involved restricting rights to resources by linking property rights in those resources to the appearance of novel emergent properties. This enables markets in those rights to function as allocative mechanisms while limiting access to the resources to a level that can be accommodated within the apparent dynamics of the ecosystem.

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TREATMENT AND PREVENTION OF ENVIRONMENTAL POLLUTION

convenors:

IJ HODGKISS
YB HO

INTRODUCTION

The major role that the ASAIHL can play in the treatment and prevention of environmental pollution is to produce environmentally aware graduates, particularly in engineering and science. Some of these will meet the requirements of industry, but a greater proportion will simply be better informed citizens. A subsidiary role, in terms of the numbers involved, is the production of environmentally trained science, law, engineering and environmental management graduates to enter the government pollution control infrastructure and, hopefully, a growing pollution control industry in Asia.

There are, undoubtedly, institutions in the ASAIHL which are able to go further than this and have their academic staff involved as consultants in, or advisers on, environmental control at the government and commercial level. Others support advanced research projects dealing with pollution technology which is applicable also to local pollution problems. This serves two functions - it helps the academics involved keep up with the rest of the world so that they are in a better position to evaluate local problems, and it provides a source of expert advice to organizations (governmental or in the private sector) involved in the treatment and prevention of environmental pollution.

In his opening address, the Vice-Chancellor of The University of Hong Kong described the most important role of the institutions within ASAIHL as offering leadership by enlightening and informing the community through soundly based rational exposition.

The 13 papers in this session clearly illustrate the range of contributions made by the ASAIHL, encompassing three areas - monitoring; research into prevention and treatment; and education. Dealing with the first area are papers relating to bacterial reduction during sewage treatment and with microbiological contamination of shellfish in Hong Kong. In the second area papers deal with the 'polluter pays principle' in Malaysia, the prevention and treatment of pollution (particularly by industrial wastes) in the Philippines using various disposal methods; industrial wastewater treatment in Malaysia; the control of motor vehicle emissions using methanol as an alternative fuel; the treatment of air pollution in Hong Kong; attempts to control environmental deterioration in Bangkok; and a keynote address on the move to low-waste technology in the United Kingdom. In the final area (education) are papers dealing with environmental education in the Philippines and a keynote address dealing with the theme of the seminar, that is, the role of the ASAIHL in combating environmental pollution, particularly in terms of environmental education and the expertise the ASAIHL can contribute to the prevention and treatment of environmental pollution.

One area on which the lively discussion at the end of this session concentrated was the relationship between governments and tertiary institutions in relation to environmental consultancy. In many industrial countries, academics are an integral part of environmental research and planning efforts. Because they have the knowledge (and often, research results also), government environmental agencies in these industrialized countries are willing to involve them. In many Asian countries, academics are still not a part of this big environmental effort since the governments of these countries appear to believe that their tertiary institutions do not have the necessary practical capabilities and experience. Overseas consultants are all-to-often brought in and these lack the relevant local experience. As a result they sub-contract or 'squeeze' local academics to gain their experience! An unfortunate offshoot of this policy is that little earmarked funding for environmental projects reaches the tertiary institutions. Another area discussed dealt with the importance of exchange of ideas and information between the ASAIHL countries. The forthcoming new journal at The University of Hong Kong (the 'Asian Journal of Environmental Management') was identified as a potential vehicle for expanding such exchanges.

If one conclusion had to be drawn from this session, it would be the widely held belief that the primary goal of the ASAIHL in relation to the treatment and prevention of environmental pollution must be through even greater efforts in environmental education. And this, not merely for students at the institutions but for all levels of society - schoolchildren, students, workers, the unemployed and the aged; and for all sectors - industry, the commercial sector, government and the general public. That is, anyone and everyone!

TOWARDS LOW-WASTE TECHNOLOGY

J Diaper
Department of Environmental Science, The University of Bradford, UK

In the past many pollution abaters and regulators have relied too often on empirical developments of existing conventional solutions to solve new and more complex waste problems of an increasingly industrialising society as distinct from standing back, re-appraising the problems and using the mass of scientific data which is available to provide appropriate solutions. Many pollution control manuals use the concept that if it's an organic waste a biological plant is the answer (and an aerobic plant at that), and if it's an inorganic waste then use conversion to insoluble material and its subsequent sedimentation; in both cases the solid waste produced goes to landfill. However the message is beginning to get across that the solutions to our pollution problems need a combination of both scientific knowledge and engineering judgment.

SEEKING APPROPRIATE SOLUTIONS

As an example, the author recently visited a paper mill where the technical staff related that it was only when the correct amount of nutrients were added to the biological treatment plant that the plant started to work effectively (three months after commissioning). This suggests the basic science behind the biological processes involved had not been appreciated. Over the last two decades the concept of the stoichiometry of biologically mediated reactions has developed, particularly from the concept that an approximate formula for the organic fraction of bacteria is $C_5H_7O_2N$ or, when phosphorus is also considered, $C_{60}H_{97}O_{23}N_{12}P$[1,2,3]. The implication of this is that just as chemical reactions have to be balanced, so do the reactions which occur in biological treatment plants and as far as the above example goes, that if one has a carbohydrate waste to treat biologically, the addition of nutrients in the form of nitrogen and phosphorus is essential and, to at least a first approximation, calculable.

Other concepts from theoretical chemistry similarly can be adapted to these reactions. The concepts of reaction kinetics have been used by Monod[4] to describe the variation of the rates of bacterial reactions and adapted by waste-water engineers to good effect in the design of waste-water reclamation plants. In addition the application of chemical thermodynamics has indicated the narrow window for the production of methane in anaerobic digestion[5].

These concepts taken one step further, provide a perspective in materials processing, which underlines all our activities in pollution control.

Firstly, taking the chemical industry and taking the global view, all our ultimate raw materials are impure, inasmuch as they are obtained from the atmospheric environment, the aqueous environment, or the terrestrial environment. The wanted components of these resources are separated from the unwanted materials which are then discarded as wastes. Secondly, whereas it is implicit, particularly in the early stages of our academic disciplines, that reactions are assumed to go to completion, from the concept of thermodynamics, reactions only proceed to their position of equilibrium. The reactions which proceed to 99.9%, can still leave reactant concentrations of 100 $mg.L^{-1}$, to be discarded as wastes. Thirdly, in terms of efficient use of capital equipment, reactions which proceed at a finite rate are not allowed to reach their equilibrium position, since the rate of production falls rapidly with the extent of the reaction. Again, raw materials are not completely consumed and are wasted. Thus, - wastes are inevitable. Our objective must be to reduce these wastes to the absolute minimum.

There are two strands to waste management, the first, that of the prevention of the production of wastes is the concept of "Clean Technology"[6], in which new processes are designed which result in less waste being produced; and the second, for existing production processes, that of reducing the quantity of wastes to be disposed of outside the factory, by recycling and the conversion of wastes into useful products, which can be described as "Low-Waste Technology". There is some overlap between the two.

Low waste technology has in fact a long history, especially in the chemical industry, but it tends to be a hidden history. Whilst the basic production processes are well known the by-products and recycling activities tend to be forgotten. A classical example is the lead chamber process for sulphuric acid; the reclamation and re-use of the catalytical nitrogen oxides and the spent oxide from gasworks providing a secondary source of sulphur are other examples of low waste technology. Again little attention is paid to the conversion of the hydrochloric acid gas, liberated in the Leblanc alkali process, to chlorine by manganese dioxide, producing manganese(II), which needed reoxidising back to manganese(IV), to conserve stocks of that material[7]. Whilst the basic processes are well remembered in the history of chemical history, the re-use and recycling processes which accompanied them often lie in obscurity. This paper aims therefore to put forward the proposition that during the twentieth century we have made such progress in understanding the science of materials that we have a much larger set of tools and techniques to tackle pollution problems than we might have imagined.

EXAMPLES OF POLLUTION PREVENTION AT SOURCE

The U.K. booklet on "Clean Technology"[6] illustrates this point with a set of processes which highlight new approaches to pollution and waste problems, to which have been added other examples.

1. **Copper recovery:** In printed circuit board manufacturing, an acid solution of cupric chloride is used to etch away the unwanted copper foil. In doing so the copper(II) ions are reduced to copper(I) and the efficiency of the etching solution decreases In the conventional process, to reactivate the solution, hydrogen peroxide is used to oxidise the copper(I) back to copper(II). Obviously, the addition of this reagent increases the volume which has to be bled off. This surplus solution was treated with alkali, and the resulting copper oxide disposed to landfill. The new process is to re-oxidise the copper(I) in the anodic compartment of an electrochemical cell, which is separated from the cathodic compartment by a semi-permeable membrane which blocks the normal passage of the copper ions to the cathode As the etchant solution increases in copper concentration a small amount of the copper enriched solution is bled off to the cathode to be plated out and collected as pure copper. Disposal costs are virtually eliminated.

2. **Phenol elimination:** A second example involves one of the more contentious substances -phenol. This substance can taint water especially when chlorinated; about 0.001 ppm of chlorinated phenol is detectable by taste, and at concentrations greater than 1-5 ppm phenol can be toxic to fish. In ICI Chemicals and Polymers, Wilton, U.K , the production of diphenyl oxide produces an aqueous effluent containing 10% phenol. However, in a nearby plant a waste hydrocarbon "heavy ends" stream is produced, which is used as a fuel to raise process steam. By using the "heavy ends" from the higher alcohols plant to solvent extract the phenol from the diphenyl oxide effluent stream, 95% of the phenol could be removed, and completely destroyed in the furnace normally used to burn the "heavy ends", thus reducing the polluting potential of the original aqueous effluent.

3. **Butanol recycling:** The following case study illustrates a particular problem in pollution control in a wider context. A local district council in the U.K. wished to expand, both industrially and domestically Expansion would result in an increase in wastewater discharged to the local sewage works, whose design loading was 6333 kg of oxygen demand per day. It was already overloaded at 7200 kg per day, resulting in the sewage works discharging an effluent in excess of its consent and thus causing increased costs of purification at an abstraction point further downstream as well as depleted fish stocks in the river. The company was one of only two industrial concerns in the town. It kept within its volume consent but its average contribution of

1500 kg O_2 demand was well above its consent value of 1088 kg O_2 demand. A flow and material balance as described by Eckenfelder[8] revealed two sources of highly concentrated effluent, one with a high solids content which could be tankered away, and a second source, that of distillates containing the excess alcohols from esterification processes, for example, involving butan-1-ol and stearic acid.

In this instance the distillate separates into two liquid layers on condensation, a butanol rich layer, (approx. 80% butanol), which can be recycled, and a water rich layer (7.3% butanol) which went to drain. The phase diagram for the system[9, 10] is shown as Figure 1. For each batch of ester produced, 1500 kg of the water rich layer were produced, with an oxygen demand of 284 kg, i.e. 25% of the daily consent. The perceived problem here was that although textbooks on theoretical chemistry address the problem of distillation they do so from the point of view of near ideal mixtures of two liquids. When binary azeotropic mixtures are discussed, the emphasis is on the fact that the two components will distil over together as an azeotropic mixture so long as both components are present. The point that is not made is that when one of the components is exhausted, what is left must be the other component, a fact used in the classical determination of ethanol in water[11].

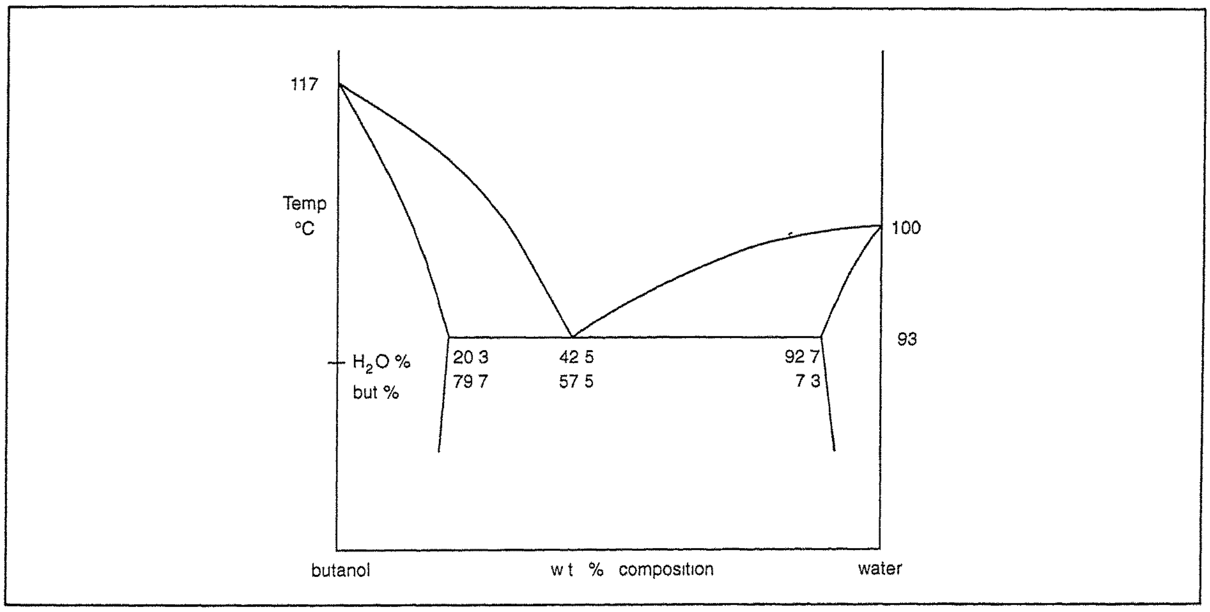

Figure 1: *Boiling point diagram butan-1-ol/water, a heteroazeotropic system with 2 liquid layers over a limited range below 93°C*

The 1500 kg water rich layer (7.3% butanol) can itself be redistilled. The azeotropic mixture (57.5% butanol) distils over, carrying all the butanol and the requisite quantity of water to produce on condensation a further 132 kg of butanol rich liquor and 59 kg of water rich liquor, leaving behind in the distillation pot 1309 kg of water. The water rich layer has an oxygen demand of 12 kg and can go to drain as can the remaining water, whilst the butanol layer is recycled. Figure 2 shows the outcome. The result is a reduction in the oxygen demand equivalent to approximately 25% of the daily consent and a saving on a raw material, butanol. Coupled with the disposal to land of solids, the total oxygen demand dropped to approx 300 kg per day, well within the consent, and the financial savings gave a payback period on the required capital investment of less than 3 years. Even at this point a representative of the regulatory authority was still insisting on the installation of a biological treatment plant which would have had severe financial repercussions for the firm.

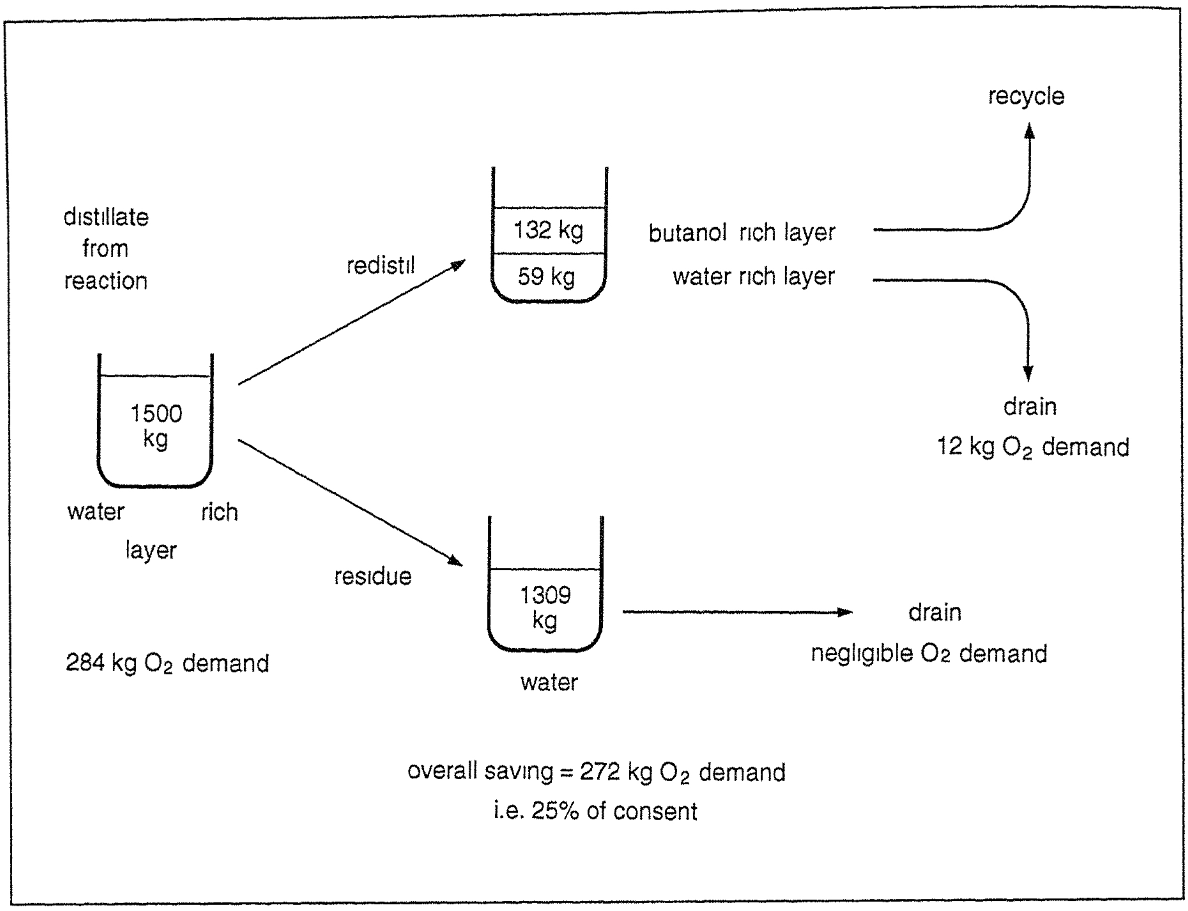

Figure 2: *Heteroazeotropic distillation for the butan-1-o1/water system.*

4. **Electroplating:** To return to electroplating industries, but in a different location, in 1991, a final year Bradford Environmental Science student from Hong Kong, Wan-choi Lam, undertook a project[12] on the pollution problems associated with the small electroplating establishments to be found in the multistory industrial buildings in Hong Kong. These establishments[13] sometimes have a floor space as little as 20 m^2, a large plant having a floor space of up to 300 m^2. Because of high property prices, little space is available for waste storage or treatment. Current recommendations[14] favour treatment methods for the electroplating wastes based on conventional chemical precipitation of divalent and trivalent metal ions by caustic soda. However the toxic sludges produced would require disposal to landfill with implications for leachates. Treatment facilities can take up to 30% of the factory area. In addition floor to ceiling heights in the multistorey factory flats can be as little as 3m,as distinct from conventional sedimentation tanks needing an overall height of 5m to be available.

The compactness of ion exchange methods of concentrating the effluent resulting from drag out and rinsing operations and the possibility of recycling the treated water and the recovered metals seemed an attractive proposition. Lam[12] used non-selective ion exchange resins [Amberlite IR-120H, IRA-140(Cl) and IRA-93(OH)] in the laboratory to treat solutions of copper, nickel and chromium at a concentration of 500 $mg.L^{-1}$. The effluent from the ion exchange units was of the order of 1 $mg.L^{-1}$. Lam concluded that it should be possible to adopt the method of ion exchange in the treatment of plating rinsewaters for small electroplating undertakings. Resin bed volumes of 30-120 litres in each column may be sufficient for a flow of 5 m^3 per day. This would occupy a much smaller area, and require much less height, (resin bed height of 1.5 m.). On regeneration, concentration factors ranged from 50 for copper, 138 for chromate, to 3.5 for nickel. The pH values for the regenerated solutions were however at the extremes of the pH range. Whilst it would therefore seem possible to devise a recycling scheme for both the recovered water and the metals, the development of a centralised chemical treatment facility in Hong Kong and integrated waste collection scheme[13] may provide an alternative route for the highly concentrated low volume regenerates. Lam suggested a system as in Figure 3 incorporating a filter and activated carbon cartridge to remove suspended solids and organic contaminants.

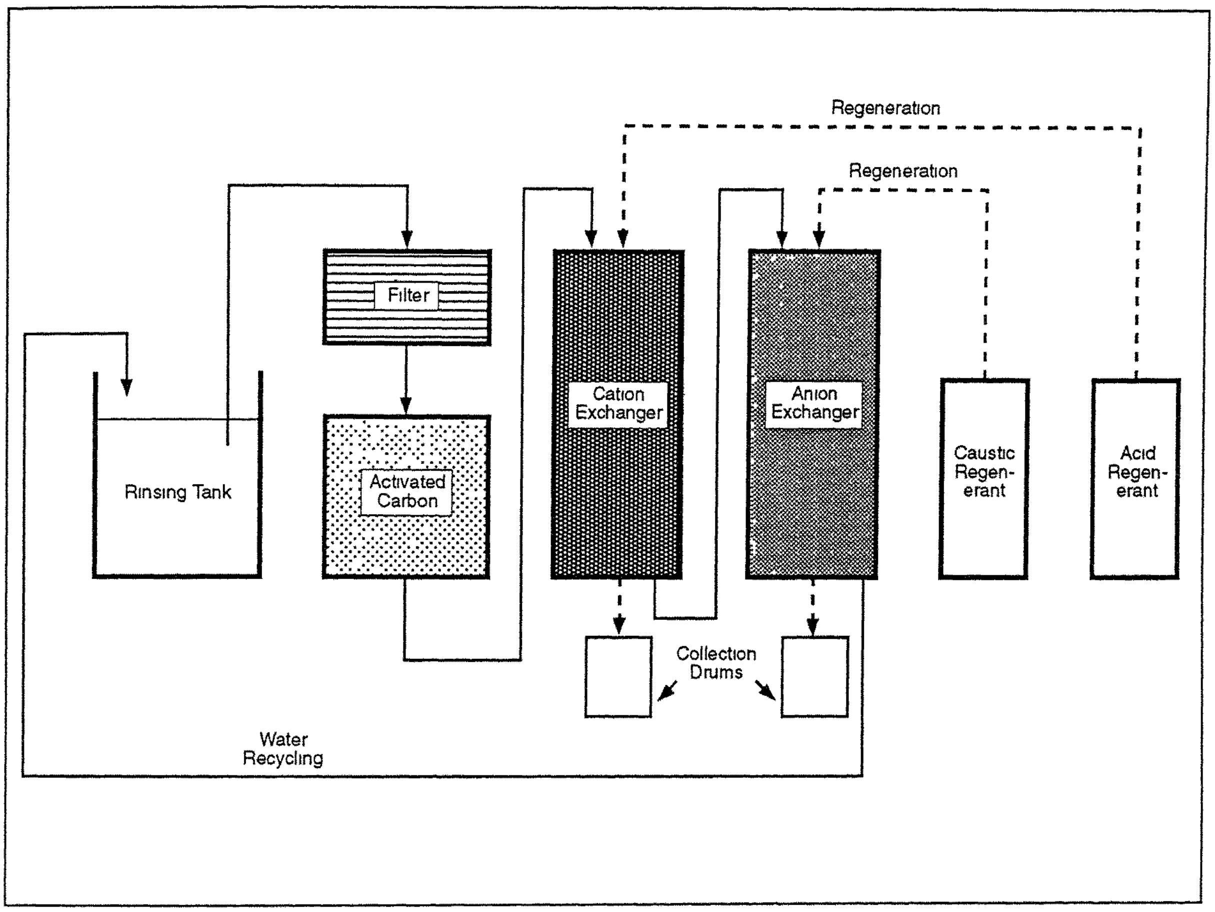

Figure 3: *Possible ion-exchange treatment system for small electroplaters.*

5. **Woolwashing:** Wool, as it arrives at the start of the processes to convert it into textiles, contains up to 10% grease together with dust, dirt and other materials accumulated by sheep. The conventional wool scouring or washing process yields a wastewater containing these materials plus detergent. The chemical oxygen demand of such wastewaters can be as high as 100,000 $mg.L^{-1}$, when typical consents to discharge to the water companies treatment plant are of the order of 5,000 - 10,000 $mg.L^{-1}$. In addition the grease can interfere with operation of wastewater treatment systems. The traditional way of approaching this problem in the Bradford area was to treat the effluent with concentrated sulphuric acid to de-emulsify the grease, neutralise it with lime, separate, filter and refine the crude lanolin into e.g. cosmetic grade lanolin. The process generated odours and significant quantities of gypsum. An alternative process, that of solvent extraction, has been described[15] which uses less hazardous chemicals.

The more modern separation process of ultra-filtration has now been used and is reported in "Clean Technology"[6]. The firm involved, a carpet manufacturer and a specialist firm concerned with ultra-filtration devised a successful system, in which the filtrate can be recycled, and the slurry produced can be disposed to agricultural land with the beneficial effect of the potassium and nitrogen content. The result of lower water charges, no gypsum for disposal and no charges for landfilling wet solids has achieved a payback period on the investment of less than two years.

6. **Anaerobic digestion:** Industrial effluents containing organic chemicals are more problematical than domestic effluents in that they have a higher organic loading. Traditionally such effluents are dealt with by aerobic treatment plants. But the biodegradabilities of organic compounds vary greatly[8]. Generally speaking anaerobic digestion has been used as a sludge digestion process and is only useful, particularly with respect to methane produced, when the C.O.D. available is high. But this is exactly the situation with many industrial effluents.

The anaerobic digestion process is characterised by the conversion of organic materials to biogas (methane and carbon dioxide) not biomass, by being contained in a sealed unit which does not allow the escape of odours, by producing a very small quantity of sludge and consequently low nutrient requirements, and by its operation at 30-35 °C.

This last characteristic is not the handicap it may seem since most factories will generate warm effluents. It does not however produce as low a final effluent concentration as aerobic systems, because of the lower values of the kinetic constants[3]. However it can cope with large sudden influent concentrations (e.g. 20,000 mg.L^{-1} COD) since the process is not limited by oxygen transfer considerations, and yet the micro-organisms can be left unfed for long times without any apparent deterioration. Anaerobic seed is stored regularly in the author's laboratory at 5 °C for periods of three months and yet responds in less than 24 hours when brought back to 35 °C and fed.

It is however a complex process, comprising at least three stages -that of hydrolysis, acidogenesis/acetogenesis and methonogenesis. Should the last process get out of step with the other two then the result is a stuck digester with a malodorous material that is difficult to dispose of in an acceptable manner. Hence its reputation. Table 1 compares aerobic and anaerobic digestion.

Table 1: *Anaerobic versus aerobic treatment*

For Effluent Containing 1 Tonne Per Day Organics	
Aerobic Route Activated Sludge	
Electrical input	50 kw
Nutrients	10 - 40 kg
Sludge	0 2 - 0 8 te (As Wet Sludge)
Effluent	5% Residue
Anaerobic Route	
Electrical input	2 kw
Nutrients	1 kg
Sludge	0 02 te (As Wet Sludge)
Effluent	5% Residue
Plus 130 kw Useful Engergy - Gas	
Completely Sealed System - No Smell	

Big improvements are being made in the technology of anaerobic digestion especially when one compares the payback period quoted in the example of the sugar beet factory in "Clean Technology" (12 years) and that of a brewery (18 months)[16]. Coupled with the green concept of producing useful fuel (0.4 $m^3.kg^{-1}$ COD applied), in effect from low grade heat (an effluent temperature of 30-40 °C), anaerobic digestion of industrial organic effluents has an interesting future.

SPECIALISED TREATMENT PROCESSES

All the examples quoted above are small firms or single plants or single production lines which have moved from conventional aerobic treatment or precipitation and landfill disposal to more technical and specialised solutions to industry's waste problems, in each case obtaining some benefit from the treatment process in some form of recycling. Each has used technology which is readily recognisable as having its roots in the sciences. Table 2 summarises this. In addition each has proved to be economic since the payback period is less than three years in all cases. Clearly, there is an important question here. Why are the wastes arising from the separate processes normally consolidated for treatment in one treatment plant which has to cope with everything?

Table 2: *Summary of process treatments*

Process - Copper Recovery	
	Conventional Treatment - Precipitation
	Recommended Treatment - Electrolysis
Process - Phenol Reduction	
	Conventional Treatment - (not disclosed)
	Recommended Treatment - Solvent Extraction
Process - Butyl Stearate	
	Conventional Treatment - Biological
	Recommended Treatment - Distillation
Process - Plating Waste	
	Conventional Treatment - Precipitation
	Recommended Treatment - Ion Exchange
Process - Wool Washing	
	Conventional Treatment - Acid Cracking
	Recommended Treatment - Ultrafiltration
Process - Biological Treatment	
	Conventional Treatment - Aerobic
	Alternative Treatment - Anaerobic

One result of such consolidation is that different compounds of different biodegradabilities- different rates of biodegradation- are treated in the same plant. Because the physical dimensions of the plant have to be fixed, and as a result the residence time is fixed, then the more easily treated materials are adequately dealt with whilst the more intractable materials pass through virtually unchanged. One reason for this state of affairs may well be the concept of economies of scale. Yet all the evidence points in the direction of specialised treatment processes for individual plants. Another reason may be that the greening of industry image may be better served by one large and costly plant, but by the fact that it has to cope with many different wastes may be more susceptible to the problems generated when mishaps occur in the factory or when spillages of toxic materials occur.

In returning to the opening remarks, the problem of standing back and re-appraising the problems of wastes and their disposal means taking a broader perspective. The concepts of "Clean Technology" and "Low-Waste Technology" have highlighted one aspect in particular -that of the advantages of single production lines with an integrated and appropriate waste treatment system. It cannot be over-emphasised that the majority of the examples quoted are the small firms and not the giant corporations.

However other points that need attention are that the scientific information is not packaged for the pollution controllers. Taking the specialised aspect one stage further, the separation of domestic wastewaters from industrial wastewaters is imperative since from a treatment point of view they can be incompatible. The domestic wastewater reclamation plants are efficient in doing what they were intended to do, that is treating domestic wastewaters.

Low-Waste Technology implies therefore specialised waste-water reclamation systems for each production unit, each being operated at its optimum, and each being cost-effective, particularly in view of the advantages to be gained by the company -savings through recycling, and discharging less wastes into the environment. A better image for industry and cheaper products for the consumer.

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CHANGING ENVIRONMENTAL VALUES AND INSTITUTION BUILDING: THE ROLE OF ASAIHL

P Hills
Centre of Urban Planning and Environmental Management, The University of Hong Kong

INTRODUCTION

This paper focuses on the role of ASAIHL in shaping environmental values in the region and its contribution to the task of building those institutions which determine the environmental agenda and assist in the formulation and implementation of policy. I shall not be devoting much attention to the technical aspects of pollution prevention and control as these matters will be dealt with elsewhere in the programme. Rather, my intention is to direct attention to the fundamental role that institutes of higher learning can and should play in stimulating debate about environmental issues, extending and strengthening the environmental research base and evaluating environmental policy initiatives.

Collectively, our institutions represent a significant repository of environmental expertise that has much to contribute to the task of tackling environmental problems throughout the region. The extent to which we are encouraged and, indeed, allowed to make such a contribution depends both on the way in which we perceive our own role and the receptiveness of those responsible for designing policy interventions. In this context we must inevitably address concerns of a "softer" (i.e., less technical nature) which involve asking basic questions about the ways in which environmental values are changing across the region and the suitability and effectiveness of those institutions through which values are ultimately translated into policy.

VALUES AND THE MYTHS OF ENVIRONMENTAL MANAGEMENT

Clearly, the priority which a society attaches to the environment is dependent on a range of subjective value judgements[1]. In any society there will co-exist a variety of different perceptions of what the environment is, what it should be and how it should be manipulated and exploited. For example, some see problems of resource depletion where others see a world of abundant resources[2]. We work in a context, therefore, where there exist numerous "environmental rationalities", reflecting the ways in which the world is perceived by different groups in society[3]. These perceptions will remain divergent so long as groups have different interests and different sources of information and knowledge[2]. Clearly, this does not mean that environmental quality cannot be measured in some empirical form: indeed, many of the papers presented at this meeting have reported on the methods and techniques that can be used to achieve this objective. What we are concerned with here is the extent to which there are variations in perceptions as to what constitutes an acceptable or, indeed, desirable level of environmental quality. These perceptions vary because of the existence of different environmental rationalities and one important implication of this is that acceptable or desirable environmental quality levels are difficult to prescribe, particularly in policy terms. Whose values arè to be used? Those of particular national interest groups, be they environmentalists or industrialists? Or those reflecting practice elsewhere in the world, usually the industrialized nations?

This last question leads us conveniently into an area that both influences and reflects environmental values in Asia but which is still not tackled with a great deal of analytical rigour: namely, what have been termed "myths of environmental management". In his recently published paper, Lee[4] sets out a number of such myths, some of which I propose to summarize briefly. I should point out that Lee's paper is primarily concerned with the environmental problems confronting the urban poor in the developing countries of the region but his observations do have a wider applicability which extends beyond the urban environment.

Firstly, there is the myth that global environmental concerns are a First World (i.e., industrialized nation) problem and not a Third World issue. The latter part of the 1980's saw the industrialized nations become increasingly concerned with problems of the "global commons" (e.g., ozone depletion and the greenhouse effect) and this preoccupation has been carried over into the way in which these predominantly Western countries view the environmental problems of the Third World (e.g., loss of the rainforests). Even local environmental groups in developing countries may become preoccupied with the problems of habitat and species loss, while at the same time ignoring the acute and life-threatening environmental problems existing in their nations' urban areas, problems which in global terms are no less significant than the fate of the rainforests. As Lee (p.8-9)[4] comments: "In immediate human terms they may be the most urgent of all worldwide environmental problems.......It is time to recognize that the plight of the urban poor is a global environmental problem".

One of the most powerful myths surrounding environmental management in developing countries is that it can be ignored in the early stages of development. In the past, this argument was often strongly associated with the view that industrialized nations were tending to "push" Third World countries into environmental management practices that were not so much intended to improve environmental quality but to blunt the competitive edge of newly emerging economies. While one suspects that the latter view is now a good deal less prevalent, there is no doubt that the so-called Japanese Model of getting dirty, getting rich and then cleaning up the mess later has had a powerful effect on shaping both public and political values and opinion on the relationship between environment and development throughout much of Asia. A key question here is, of course, whether the Japanese Model is tenable in the 1990s and beyond, and specifically whether countries can get rich enough quickly enough (and possess the political will) to tackle the environmental problems created during the drive for economic growth and modernization.

Despite the overriding concern with economic growth across much of the region, we have witnessed very extensive attempts at environmental institution building since the mid-1970s. Indeed, as a recent overview paper indicates[5], a great deal of sectoral and general environmental legislation has been implemented over the past 15 years, most countries now have specialized environmental agencies or ministries and most require that new development projects are subject to some form of environment impact assessment procedure. Nonetheless, environmental quality in many countries is continuing to deteriorate, certainly in major urban areas, and this suggests that there may be significant shortcomings in both the legislative frameworks that have evolved so far and in the institutions charged with the responsibility for formulating and implementing environmental policy.

A third myth, which in part relates to the second, concerns the cost of environmental management measures. Put simply, it is widely assumed in developing countries that environmental management is expensive and cannot therefore be afforded, or rather, implies trade offs in public (and personal) expenditure terms that may be politically unacceptable. This is an area in which there has been considerable debate in recent years but there does seem to be a consensus emerging which suggests that a growing number of low cost pollution abatement options do exist and that these can be effective in reducing overall pollution burdens. Similarly, there is considerable potential for recycling in many industrial processes, the financial benefits of which could be used to offset investment in pollution abatement measures and improve profitability.

Among the many important issues raised in this context is that of the suitability or appropriateness of the technologies "imported" into developing countries. As Lee points out, developing countries employ the same basic technologies in infrastructure development and services that are used in the industrialized nations (e.g., with regard to piped water, water-borne sewerage). The key difference between developing and industrialized nations is that access to "high quality" services in the former is typically limited to those sectors of the population with income levels that approach or match income levels in the latter.

There has also been much debate about the role of foreign consultants and international and bilateral aid agencies specifically with regard to the importation of high cost equipment and services (usually from their own countries) which result in unnecessarily high standards in infrastructure provision. Some commentators (for example, Gakenheimer and Brando[6]) have however argued that pressures for such high standards may also arise in developing countries themselves where engineers often favour "modern" options and where politicians do not wish to be accused of "down-modernizing" basic environmental services.

Interesting though these debates may be, the fact remains that potential solutions to many of the problems confronting the region's major urban centres, and indeed its rural areas, are already well-known. They do not require technological advances and they need not be reliant on high-cost imported equipment. What they do require for their successful implementation is more effective planning and project management, a better match between resource availability and the identification of possible solutions and, finally, a more robust political commitment to follow through on the necessary policy measures.

The final myth that merits consideration in the present paper concerns the mechanisms that are employed to manage the urban environment. Increasingly, these mechanisms have been viewed in terms of a dichotomous choice between the market and state, a view reinforced by the international trend towards decentralization of government functions and privatization of public sector services and organizations. As Lee suggests, however, "participatory management" involving both NGOs (non-government organizations) and CBOs (community-based organizations) has much to contribute, particularly in urban areas but its full potential is rarely realized[7]. Although market-based mechanisms have become increasingly attractive as policy instruments for tackling specific types of pollution problems (e.g., through pollution charges and tradable permits) there are very real limits on the extent to which the market itself can be used to rectify many of the broader environmental problems confronting major cities of the region. The private sector is typically unwilling to address the environmental servicing requirements of low income communities. Furthermore, government often faces serious difficulties in regulating privatized natural monopolies.

Decentralization of government functions is often less than effective because necessary management skills remain concentrated at the central government level and because local agencies are not permitted to raise any, or enough, revenue to ensure that they are adequately resourced to undertake the tasks assigned to them.

Although much has been written about the role of community participation in the development process and, indeed, many well-intentioned efforts have been made to secure enhanced participation in planning for a variety of sectors, the overall effectiveness of these efforts falls far short of what might be achieved. That participation is often ineffective is a reflection of a number of powerful constraining factors, not the least of which are bureaucratic suspicion and a failure to develop appropriate institutions through which community participation can be effectively harnessed to assist in the task of managing the environment, both in a general sense and with regard to specific policy concerns.

These contrasting views on the manner in which environmental issues and responses to them can and should be perceived constitute a significant part of the general frame of reference within which our own potential contributions to the field must be formulated and evaluated. Clearly, we must also accept that environmental values or rationalities are not static but are constantly changing and evolving as public and political attitudes towards the environment mature and as expectations are adjusted in light of such factors as improved living standards and greater awareness of the causes and possible solutions to the problems that we face. Professional academics obviously have much to contribute in fostering and sustaining the debates that stimulate changes in environmental values. This can be achieved through a variety of mechanisms: research, publications, involvement in both governmental and community-based organizations and through the academic programmes with which we are associated. The effectiveness of our contribution will be influenced however by the nature of the institutions that emerge nationally and internationally to address environmental problems.

ENVIRONMENTAL INSTITUTIONS

There is an understandable tendency to view institutional developments in the environmental field primarily in terms of those advisory and policy making bodies that are directly related to government. Such bodies may take the form of government ministries or specialist environmental agencies, advisory committees or boards (often comprising a mix of representatives of key sectors and industries supplemented by academics and, in some cases, by members of environmental groups) and, depending on the legislative measures enacted, assessment and appeal boards such as those which exist in Malaysia for the appraisal of environmental impact assessments submitted to government and those in Hong Kong for dealing with cases associated with air and water pollution ordinances.

These institutions, though often influential, possess certain characteristics which, it can be argued, are likely to inhibit their longer term effectiveness in providing a forum for extensive debate on environmental issues and how they should be tackled. Membership is often limited to representatives of an (urban) elite whose appointment may reflect a desire to ensure that powerful interest groups are included in the composition of the body rather than to ensure that the most representative and qualified are indeed in a position to make a positive contribution. Inevitably, there tends to be an emphasis on maintaining the status quo, which means that government policy may not be subject to a great deal of scrutiny. Many environmental institutions in the region do not function in an open manner. The public is denied access to meetings, deliberations remain confidential and the case for particular policy initiatives or decisions is not justified publicly. Institutions often tend to be reactive rather than proactive. In other words, they function only in response to particular issues, policy initiatives or legal cases and cannot necessarily initiate studies in their own right or encourage government to make policy or decisions in areas which are not currently on the environmental agenda but which may soon become matters of considerable importance.

Many environmental institutions also remain relatively detached from the process of implementing policy. This has a number of important implications. Firstly, it may result in insufficient attention being given to the implementation process itself and mechanisms by which the intent of policy can actually be translated in practice. Secondly, it may result in too much emphasis being placed on inputs into the policy making process and not enough placed on the quality and effectiveness of outputs of that process. Thirdly, it may lead to a preoccupation with formal approaches to environmental management, that is to say, with legislation and regulation, which may also be associated with an inability or unwillingness to consider other options. Fourthly, it may encourage the development of a fragmented and partial perspective on the environment in which the linkages between key components are ignored because they do not fit easily into the prevailing organizational structures of the institutions themselves. This may make it very difficult to deal with complex, multi-dimensional environmental problems (e.g., global climate change) in a synoptic manner. Clearly, these difficulties are by no means confined to the environmental field but reflect some of the general problems that arise in the development of institutional structures in many policy areas.

Although we ourselves may be preoccupied with the role played by the types of institutions referred to above, we cannot ignore the growing importance of the non-government and community-based organizations discussed in the previous section of the paper. Such organizations are playing an increasingly significant role in environmental policy making at various levels for a variety of reasons. Firstly, they are not by their nature status quo oriented organizations and typically show a far greater willingness to question existing values and the conventional wisdom regarding both the nature of environmental problems and possible solutions. Secondly, the larger and better organized NGOs are showing themselves to be adept at mobilizing resources and at political lobbying. Thirdly, these organizations now often have access to the technical expertise which they previously lacked and which greatly strengthens their position in debates surrounding more complex environmental concerns. Fourthly, membership of such organizations has grown substantially over the past ten years and even very localized groups that have emerged to contest particular environmental controversies are often well supported at the grass roots level. Clearly, this is in part a reflection of the process by which the environment has become politicized and suggests a recognition on the part of the community at large that environmental issues, like many other areas of public policy, must be addressed through the political system. Finally, the environmental movement has itself become globalized in much the same way that the problems with which it is concerned are now recognized as being international rather than purely national in character.

THE ROLE OF ASAIHL

The discussion above has attempted to set out a general framework within which we can debate a variety of issues concerning the role of academics and their parent institutions, not only with regard to combating the health hazards of environmental pollution but also in the context of the design and implementation of environmental policy in its broadest sense.

As regards the role of ASAIHL, this should be considered at two levels· national and international. It should also be considered in the context of the particular role that institutions of higher learning play in society, specifically with regard to their research and teaching functions. Let me deal with the latter point first.

As I suggested in the introduction to this paper, our institutions are a major repository of environmental expertise in the region. Although the situation varies from country to country, our institutions do for the most part function independently of key interest groups in the environmental arena. This places us in a particularly influential position to stimulate and sustain debates on a wide range of environmental issues, supporting our contributions to these debates through the research that we undertake and the findings that we publish. In this context, I should like to stress the importance of bringing research findings to the attention of both national and international audiences. It is clear that a considerable amount of valuable and high quality environmental research is being conducted in institutions throughout the region but all too often the output of this research effort fails to reach a wider audience, either nationally or internationally. It is frequently the case that one finds out about such research only through direct contact with the researchers involved, usually at conferences such as this. In many cases, the papers on key regional environmental issues that appear in international journals are authored by academics from outside the region. I would suggest, therefore, that we need to make a determined effort to increase awareness of the research that is being undertaken in the region and that more outlets to facilitate this should be developed in the years ahead.

The comments above relate primarily to conventional academic research but many of our institutions are also actively involved in research projects commissioned by government departments, other public or private sector agencies and international bodies such as the United Nations. This work is also extremely important, not least because it can help academic institutions forge closer links with the key centres of environmental decision making at the national level and assists academics in gaining a better appreciation of the manner in which environmental policy evolves and is implemented.

Our institutions are also well placed to provide training in the field of environmental planning and management, building upon the research base that already exists. The University of Hong Kong, for example, offers a wide range of environmental courses at both undergraduate and postgraduate levels, drawing upon expertise in the natural, engineering, medical and social sciences. Demand for our various programmes is high and it clear that such courses have a strong appeal for a growing number of students in a number of disciplines. Designing such programmes is, however, no easy task and those taught at the postgraduate level impose particular intellectual demands requiring the effective integration of a wide range of disciplinary inputs. Our Master of Science in Environmental Management draws on inputs from ten different departments in seven faculties and is an especially challenging mix of science and engineering coupled with economic, political, social and legal perspectives on environmental issues.

At the national and international levels, ASAIHL has an especially important role to play as a forum for discussion of environmental issues. Through such discussion, the conventional wisdom can and should be challenged and prevailing environmental values subjected to scrutiny. In this way, ASAIHL can function as an important channel for communication at both the national and international levels, bringing together academics to exchange opinions and to bring their research findings to a much wider audience. As a body of academic institutions ASAIHL should also be helping to shape and change environmental values in the region and is well placed to do so because member institutions should be fully aware of the particular national contexts (political, economic and social) within which environmental rationalities emerge. At present, there is clearly considerable tension between many of the Western models of environmental management and the actual environmental practices of many countries of the region. While political sovereignty has gained wide acceptance in the post-colonial era it seems that environmental sovereignty has now become a major potential source of conflict between industrialized and developing countries. This is perhaps inevitable given the growing recognition that many environmental problems can only be effectively tackled through global cooperation. There is, however, a need for more informed and rigorous debate in many countries of the region concerning the appropriateness of these Western models and the trade offs they imply. Similarly, all countries, whether industrialized or developing, must be aware of the trade offs associated with prevailing environmental practices and particularly the time stream of environmental costs and benefits of what we loosely label development. ASAIHL and its member institutions have much to contribute in these areas.

CONCLUSION

The Earth Summit in Rio provides a graphic illustration of the manner in which the environmental agenda has changed since the last great global environmental conference held in Stockholm in 1972. It also shows us how much more important the developing countries of the world, and especially those of the Asia-Pacific region, have become in the new global context for environmental decision making. The environmental problems that now dominate the political arena and impinge ever more strongly on international diplomacy are extremely complex and long-term. It is unlikely that they will be solved, partly because of their very complexity but also because it may never become entirely clear what actually constitutes an effective solution. Furthermore, solutions must be framed with respect to particular problem definitions and this is also an area in which there are still considerable differences of opinion (as, for example, with regard to the causes, extent and implications of global climate change). Irrespective of these differences, our role as academics is an especially important one in view of our potential contributions through research, teaching and involvement in public debate. We should therefore be aware of our responsibility to present an independent but constructive assessment of the nature of the environmental problems confronting our respective societies.

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PREVENTION AND TREATMENT OF ENVIRONMENTAL POLLUTION

MM Mena
College of Engineering, University of the Philippines

INTRODUCTION

Republic Act No. 6969 declares as a state policy action "to regulate, restrict or prohibit the importation, manufacture, processing, sale, distribution, use and disposal of chemical substances and mixtures that present unreasonable risk and/or injury to health or the environment; to prohibit the entry, even in transit, of hazardous and nuclear wastes and their disposal into philippine territorial limits for whatever purpose; and to provide advancement and facilitate research and studies on toxic chemicals". One of the objectives of this Act is to inform and educate the population regarding the hazards and risks attendant to the manufacture, handling, storage, transportation, processing, distribution, use and disposal of toxic chemicals and other substances and mixtures. The Association of Southeast Asian Institutions of Higher Learning (ASAIHL) can play a major role in the shaping of our environment by promoting cooperation among its members in an effort to demonstrate a strong environmental responsibility in various educational curricula. Everyone muse recognize that the Environment is one of the basic resources for development and that the damage from pollution will cost us much more in the long term. There are ways and means of incorporating environmental dimensions into higher education and training. ASAIHL can be an effective group in assessing these ways and means.

PREVENTION OF ENVIRONMENTAL POLLUTION

The prevention of pollution is a relatively new field: The strategy of the past was more to clear up pollution rather than to prevent it, whereas today, the emerging strategy is more to prevent pollution. This modification of approach results from the fact that wastewater treatment, as a means of controlling environmental pollution, does not provide a complete solution to the pollution problem because the pollutants in most cases are just being transferred from one medium (water) to another medium (air or land). The ultimate solutions, therefore, lie more in prevention. This is particularly true for hazardous wastes because in the context of hazardous waste management, it is necessary to eliminate the potential hazard to the environment and human health. Thus, while a hazardous substance can be removed from an environmental medium by physical, chemical and/or biological treatment methods, the disposal or elimination of the hazard potential could still be a problem.

Hazardous wastes are by-products of industrial development and economic growth. These wastes are generated from many sources including industrial wastes, agricultural residues, municipal sewage sludge, and everyday household trash. Wastes are considered hazardous if, because of their quantity, concentration, or physical or chemical properties, they:

> cause or significantly contribute to an increase in human mortality or serious illness, or pose substantial present (or potential) hazards to human health or the environment when improperly managed.

Alternative solutions for reducing polluting emissions from industry are shown in Figure 1.

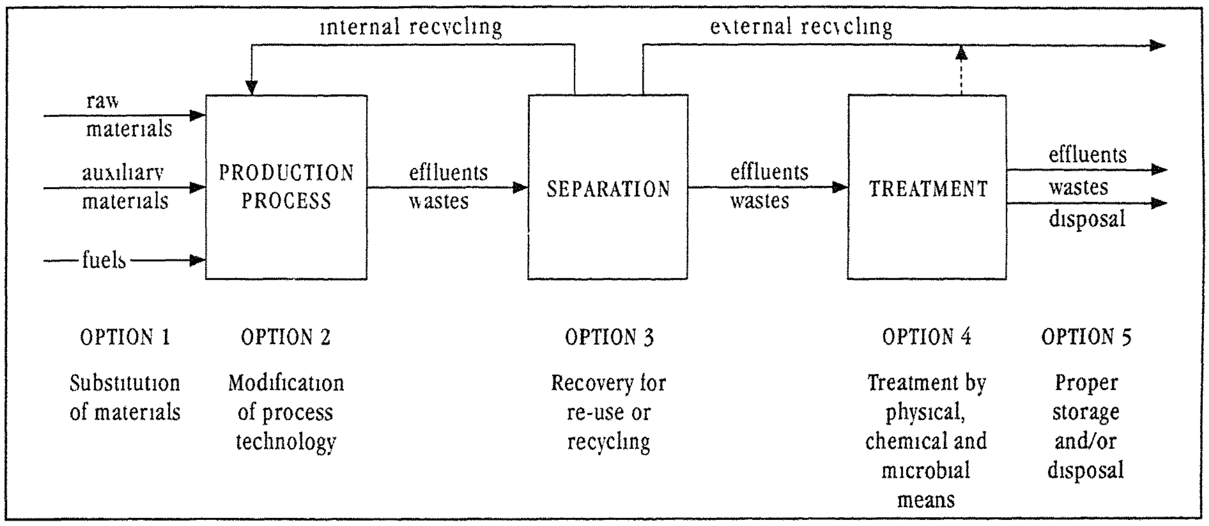

Figure 1: *Alternative solutions for reducing polluting emissions from industry.*

One has to recognize that each hazardous waste management scheme is unique as it is designed to meet the specific needs of the manufacturing process that is used and the wastes that are generated. In general, however, the development of a hazardous waste management strategy requires consideration of the following options arranged in the order of hierarchy:

Option 1 prevention of hazardous waste generation by changing the product line, substituting safer materials, or increasing the efficiency of the process.

Option 2 Minimization of hazardous waste generation by extending the product lifetime, modifying a process or acquiring more efficient technology.

Option 3 Recovery of hazardous wastes for re-use or recycling either on-site or off-site.

Option 4 Detoxification of hazardous waste through a chemical, physical, thermal, or microbial treatment process.

Option 5 Proper storage of hazardous waste to be used for a new product or to be detoxified when the appropriate technology becomes available in the future. Proper disposal by burial or deep-well injection.

TREATMENT TECHNOLOGIES

Several treatment processes are promising for hazardous wastes. However, it is unlikely that any single unit process will be adequate for the high degrees of control necessary for specific toxic-waste components. For both aqueous and concentrated hazardous wastes, design and operation of treatment plants are waste specific. Each unit process train is engineered to meet the site specific requirements. Below is a summary of treatment technologies and their objectives.

Chemical treatment: Modifies the chemical structure of the hazardous waste constituents. The modifications render the material less hazardous. However, the problems of discarding the modified materials still remain. Some commonly used processes include:

1. Precipitation;
2. Neutralization;
3. Ion Exchange;
4. Oxidation/Reduction.

Physical treatment: Involves separation and concentration of the components within a waste stream. This segregation may include:

1. Solid/Liquid Separation;
2. Membrane Separation;
3. Distillation;
4. Evaporation.

Biological treatment: Uses microorganisms to decompose waste. The microorganisms use the waste constituents as food sources, thus detoxifying the material as their digestive processes break down complex organic molecules into simpler, less toxic molecules (for example, water, carbon dioxide, acids). Some conventional biological treatment methods include:

1. Activated Sludge Processes;
2. Aerated Lagoons;
3. Stabilization Ponds;
4. Anaerobic Digestion;
5. Composting.

Thermal treatment: Designed to destroy wastes by subjecting materials to high temperatures. Some thermal treatment technologies include:

1. Incineration;
2. Pyrolysis;
3 Stabilization/Solidification.

CONCLUSION

There is clear evidence that the increasing demands of modern society for a better environment have implications for our education and training programs. In the case of the engineering profession, for example, there is need for the profession to recognize that development is "more and more a compromise between that which is technically possible, that which is considered economically attractive, and that which is acceptable on environmental grounds". Furthermore, there is need to recognize the international and interdisciplinary nature of environmental pollution control. ASAIHL can be an effective group in breaching the walls between academic disciplines.

THE NATURE AND CONTROL OF MOTOR VEHICLE EMISSIONS - METHANOL AS A ALTERNATIVE FUEL

CS Cheung, YB Lui and TP Leung
Hong Kong Polytechnic

NATURE AND HEALTH HAZARDS OF EMISSIONS

The major emission pollutants from motor vehicles are carbon monoxide, hydrocarbons, oxides of nitrogen and particulate matter. The USA Environmental Protection Agency found that petrol trucks emit 4-13 times more hydrocarbons and 10-40 times more carbon monoxide than diesel trucks, while diesel trucks emit 0-50% more oxides of nitrogen and 2-9 times more particulate matter than petrol trucks[1].

Some unburnt or partially burnt hydrocarbons are always present in engine exhaust. The quantity is small but objectionable due to the odour of some species, their contribution to photochemical smog, and their potential toxic and carcinogenic effects. Carbon monoxide, an intermediate product in the combustion of hydrocarbons, is found in engine exhaust if combustion is incomplete. At elevated level, carbon monoxide can cause impairment of coordination, and be deleterious to pregnant women and to those with heart and circulatory conditions. Operating near to the stoichiometric air-fuel ratio, petrol engines are more liable to emit unburnt hydrocarbons and carbon monoxide, especially when the fuel-air mixture becomes rich in fuel.

Nitric oxide is formed during combustion due to the reaction between oxygen and nitrogen at high temperature. The concentration of nitric oxide formed is related to oxygen concentration and the temperature level, both of which are higher in diesel engines. Upon contacting air, nitric oxide is oxidized to nitrogen dioxide (NO_2). NO_2 can cause respiratory irritation, increased susceptibility to repiratory infection and lung development impairment.

The health effects of particulates include respiratory illness, reduced lung function and cancer risk in the case of certain particles; morbidity and mortality rates increase at higher levels. The main constituents in particulate matter are soot, a soluble organic fraction (SOF) and oxides. The soot is carbonaceous material, which results from incomplete combustion of fuel and lube oil. The SOF is basically unburned hydrocarbons from the lube oil and fuel. The major portion of the oxides is derived from the sulphur in the fuel. The higher sulphur and aromatic content, plus incomplete fuel air mixing, accounts for higher particulate concentration in diesel exhaust[2]. The SOF contains polycyclic aromatic hydrocarbons (PAH), including Benzo[a]pyrene (BaP), which are known to be carcinogenic. There is strong experimental evidence that diesel emissions produce cancer in experimental animals but the carcinogenic role on human beings is still controversial[3].

AIR QUALITY IN HONG KONG

The Environmental Protection Department in Hong Kong has set up air quality objectives for seven wide-spread air pollutants, namely, sulphur dioxide, total suspended particulates (TSP), respirable suspended particulates (RSP), nitrogen dioxide (NO_2), carbon monoxide (CO), photochemical oxidants (as ozone) and lead[4,5]. Five of these pollutants partially come from motor vehicles: TSP, RSP, NO_2, CO and lead.

In their annual reports, the EPD reported that the measured NO_2 concentrations in Kwun Tong, Central/Western District and Causeway Bay areas are often higher than the one-hour and 24-hour objectives. Maximum short-term levels are sometimes more than twice the objective. The levels of TSP and RSP concentrations are also higher than the objectives with the highest readings exceeding the objective by more than 50%. The levels of CO and lead are on the other hand below their respective objective concentrations. In 1988, the three-month average concentration of airborne lead was reported by the EPD to be in the range of 0.16 to 0.22 microgrammes per cubic metre, while the objective is 1.5 microgrammes per cubic metre. Motor vehicles are the main emitters of the nitrogen oxides and the particulates, emitting about 75% and 45% respectively of these pollutants. The EPD also operates a Toxic Air Contaminants Programme. One of the toxic contaminants monitored is BaP which is also a constituent in diesel engine emissions. In 1988, a maximum concentration of 2.6 $ng.m^{-3}$ was recorded in Kennedy Town, which is considered high when compared with the 24 hour USSR standard of 1 $ng.m^{-3}$ or the maximum concentration of 0.23 $ng.m^{-3}$ recorded in New Jersey. Diesel engines are blamed for generating the high level of BaP, NO_2 and particulates in Hong Kong.

LOCAL LEGISLATION ON EMISSIONS

In Hong Kong, the law governing vehicle emissions is the "Road Traffic (Construction and Maintenance of Vehicles) Regulations", which specifies emission standards for vehicle engines and smoke levels for in-service vehicles. Every in service motor vehicle shall be so constructed and maintained that the smoke or visible vapour emitted shall not exceed 60 Hartridge Smoke units when measured with a Hartridge MK3 Smokemeter. Petrol vehicles manufactured after 1 October 1978 must conform to one of the foreign emission standards stipulated therein. The stipulated emission standards are those of the 1970's. In fact some of them were revised/amended in the 1980's[6] but such revisions or amendments have not been immediately adopted in Hong Kong.

Another law which came into effect on 1 January 1992 is the "Air Pollution Control (Vehicle Design Standards) (Emission) Regulations 1991". The new legislation introduces to Hong Kong current emission control standards from the USA and Japan and imposes them on private cars, taxis, light goods vehicles and light buses, registered on or after 1 January 1992. These standards are not new in the USA; the emission standards for light duty petrol cars have been commissioned since 1981, those for light duty diesel cars have been commissioned since 1985, while those for light duty trucks (petrol and diesel) have been commissioned since 1988. These standards are still current in the States. Despite the introduction of this new legislation, motor vehicle emission pollution will not improve in the next few years because for all existing motor vehicles and for all heavy duty motor vehicles, the new standards do not apply. For these motor vehicles, the very old standards still apply.

Service and maintenance practices can have a major effect on engine emissions. A regulation in Santiago, Chile, requiring that buses undergo a smoke opacity check every three months has effectively reduced air pollution. Such a regulation is also needed in Hong Kong to reduce emissions from diesel vehicles.

ALTERNATIVE FUEL FOR VEHICLES

In the next decade, more stringent emission standards are anticipated especially for heavy duty vehicles[7]. Alternative fuels, especially methanol, which have been studied in the last two decades primarily for meeting the energy crisis, offer potential for meeting the future demanding emission standards. Methanol is a clean fuel, which can be burned in spark-ignition or compression-ignition engines, and it is a viable fuel for commercial vehicles. In fact, the US Federal Registry has included an emission standard of not exceeding 0.26 grams of OMHCE (organic material hydrocarbon equivalent) per vehicle kilometer for 1990 and later model year methanol fueled light duty vehicles.

SPARK-IGNITION METHANOL FUELED ENGINE

Relative to petrol, methanol has a higher octane number, higher latent heat of vaporization and lower flame temperature. Thus it permits operation at a compression ratio as high as 13:1, resulting in an improvement by about 10% in thermal efficiency, less unburnt hydrocarbon and lower NOx concentration in the exhaust. However, there are several problems associated with methanol fuel: (a) 3-4 times more formaldehyde emission; (b) difficult to start in cold weather; (c) safety (explosive mixture in fuel tank and invisible flame); (d) corrosion wear of engine and fuel system materials; and (e) relatively short driving range due to the low energy content of the fuel on a volume basis (half of that of petrol).

A technology program[8] using modified petrol vehicles was conducted by the US Army in the late 1980's to determine the feasibility of using methanol as an alternative fuel. Over 1,651,190 hours were accumulated using 64 sedan and pickup vehicles. Using M85 fuel (a fuel containing 85% methanol and 15% petrol), with suitable modification to the engine/vehicle fuel systems, no abnormal operation, maintenance or safety problems were encountered. The fuel economy, in miles per gallon, of using M85 fuel was shown to be one half that of petrol vehicles. In an US EPA program[9], the fuel economy of using M100 fuel (100% methanol) was found to be 39%-47% higher than petrol cars. Also using resistively heated catalyst, emissions of OMHCE, methanol and formaldehyde were much reduced. Using M85 fuel instead of M100 will produce less formaldehyde and unburnt methanol emissions, cause less component wear and improve cold startability.

Another popular research topic is the FFV (flexible fuel vehicle). Nissan[10] has designed an engine system to burn a wide variety of fuels ranging from M85 to M0 (petrol). The use of M85 as the fuel results in an increase in aldehyde emissions to 14 mg per mile compared with 4 mg per mile when using M0 fuel (The California Air Resources Board has enacted a 15 mg per mile formaldehyde emission standard for methanol fueled vehicles commencing 1993). Cold startability is good down to -20°C.

It can be concluded that the technology for spark-ignition methanol vehicles has been well developed and is marketable subject to the availability of fueling stations and support of customers and governments.

COMPRESSION-IGNITION METHANOL FUELED ENGINE

Compared with diesel fuel, methanol is essentially free of particulates and contains much less oxides of nitrogen. However, it has a low cetane rating which means a poor autoignition property. It needs a higher temperature than diesel fuel to obtain autoignition. It is difficult to use methanol in a conventional diesel engine without some additional ignition equipment. Compared with the spark-ignited counterpart, its technology is less well developed.

Daimler-Benz AG of Germany[11] reported the operation of methanol in a modified commercial vehicle diesel engine after adding a sufficient quantity of ignition and lubricity improver and a corrosion inhibitor. The performance was as good as or even better than those of the conventional diesel engine. Using a spark assisted system, the Ford Motor Company[12] carried out an experiment on a direct injection methanol engine with performance equal to or better than a diesel engine, about 10% at full load. In Japan, Hino Motors Limited[13] tried with sucess to improve the autoignition capability by using a higher compression ratio, a heat insulated piston and an exhaust gas recirculation system. Caterpillar Inc.[14] also developed a glow plug ignition assist neat methanol engine with equal or better performance than the diesel engine. The Detroit Diesel Corp.[15] operates a methanol urban bus demonstration program. In 1990, DDC had 54 urban buses and 5 trucks operating with methanol engines. They found that a durable solution to the effective control of hydrocarbon emissions has been an especially challenging area. Recently DDC has developed an engine meeting the 1991 US Federal emission standards.

The technical problems associated with methanol fueled diesel engines have largely been tackled but further improvements to the performance and emission levels are possible.

DEVELOPMENTS IN MAINLAND CHINA

In China, significant research activities on methanol fueled engines has been carried out in the universities since the early 1980's. Their research has been reported mainly in the journal 'Chinese Internal Combustion Engine Engineering' (CICEE) and the 'Transactions of the Chinese Society for Internal Combustion Engines' (CSICE).

At Xian Jiaotung University effort has been concentrated on the following research work on methanol fueled diesel engines: (a) Investigation of the performance of a methanol fueled multi-spark assisted diesel engine; (b) investigation of the performance of a spark and glow plug assisted methanol fueled diesel engine; and (c) investigation of the working stability and combustion characteristics of a spark assisted methanol fueled diesel engine. Their contribution to the field is highly commended both inside and outside China.

Shandong Polytechnic University has reported the following research activities: (a) Successful application of a methanol-petrol blended fuel with up to 20% methanol to petrol vehicles - the only reported problem was cold startability; (b) successful application of up to 100% methanol fuel to a turbocharged petrol engine on a test bed; (c) application of a two tank system to a methanol-petrol blended fuel engine to avoid the problem of phase separation and cold starting; and (d) application of a methanol vaporizer in a diesel engine, which has resulted in an improvement of thermal efficiency by 7-17%.

Jilin University of Technology staff have carried out the following research in recent years: (a) Efficiency improvement of the spark ignition methanol fueled engine; (b) the effect of methanol on the performance of a petrol engine, using a methanol-petrol dual fuel carburetor; (c) efficiency of the neat methanol spark ignition engine and analysis of its exhaust emissions; and (d) petrol-methanol dual fuel system.

Staff at Yunnan Institute of Technology, besides cooperating with the Jinlin University of Technology in the dual fuel system, have also worked on the characteristics of methanol-petrol blended fuel. Institute of Engineering Thermophysics, China Academy of Science staff investigated the application of M100 as a fuel for 4- and 2- stroke automotive spark ignition engines, while those at Zhejiang University applied M100 as fuel to a pre-chamber stratified charge spark ignition engine. Tianjian University workers investigated the burning of neat methanol in a swirl chamber diesel engine with glow plug ignition. By coating the combustion chamber wall with an heat insulating material and by other modifications, operation stability and thermal efficiency was further improved.

JOINT RESEARCH OPPORTUNITIES WITH CHINESE UNIVERSITIES

The authors have established contact with some universities in China for joint research. A joint project with the Internal Combustion Engine Division at the Xian Jiaotung University to improve the performance of the methanol fueled diesel engine has been proposed. The topics to be investigated include: (a) Working stability and combustion characteristics; (b) application of insulation coating to improve performance at low load; (c) heat transfer problems and heat release characteristics; (d) optimization of performance by adjusting compression ratio, spray angle, position of spark plug, spark energy, etc.; and (e) exhaust emissions.

CONCLUSION

The air quality in Hong Kong is quite unsatisfactory due to motor vehicle emissions, especially those from diesel vehicles: Legal legislation is insufficient to control such emissions. In the 1990's, tighter emission standards to protect our environment can be anticipated, such that further technological improvement to the petrol/diesel vehicles will reach their limits. Burning methanol is a viable alternative for our consideration.

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TREATMENT AND DISPOSAL OF HEAVY METAL WASTE USING CEMENTITIOUS SOLIDIFICATION

GL Peralta*, FC Ballesteros Jr.+ and ML Cepeda+
*** College of Engineering, University of the Philippines**
+ National Engineering Centre, University of the Philippines

INTRODUCTION

The theoretical bases of this investigation can be described briefly as follows:

Leaching test procedure: A fundamental measure of the potential hazard of waste is its ability to generate leachate wherein its toxic constituents are present. There are over 60 worldwide test procedures which seek to determine the likely concentration of contaminants in the leachate that may be generated.

The many test procedures developed by different institutions indicate that there is still no uniform test procedure which is adopted internationally. However, in a number of countries, there has been a general trend towards the adoption of the procedure developed in 1980 by the US Environmental Protection Agency's (USEPA) office of Solid Waste which is presently known as Toxicity Characteristic Leaching Procedure (TCLP). Agitation for 18 hours in an acidic medium will simulate water seepage through the solidified waste.

Standards for heavy metals: Maximum permissible concentrations in leachate from toxic wastes have been set at 100 times the drinking water standards. This factor takes into account attenuating processes such as dilution and adsorption occurring underground that will reduce the leachate concentration from the point of leachate generation to the point of human or environmental exposure. Some regulatory agencies are less conservative and have reduced the factor to a tenfold increase above the drinking water standards. These standards are listed below:

Table 1: *Leachate standards (mg L^{-1})*

Element	Arsenic	Cadmium	Chromium	Lead	Mercury	Silver
Standard	5 0	1 0	5 0	5 0	0 2	5 0

Instrumental assessment of the binding mechanism: When cement reacts with water, at the onset of solidification it forms needle-like structures consisting of Calcium Sulphoaluminates (ettringite, $3CaO.Al_2O_3.3CaSO_4.30\text{-}32H_2O$), and its derivative monosulphage, $3CaO.Al_2O_3.CaSO_4.12H_2O$. Bensted and Verna[1] as cited by Kujala[2] claimed that Fe^{3+}, Mn^{3+}, Cr^{3+} and Ti^{3+} can replace the Al^{3+} ion in both ettringite and monosulphate.

Every crystalline substance produces its own intensity peaks in XRD charts which, depending on the internal structure, are characteristic of that substance. Microanalysis of the solidified product could therefore help establish whether immobilization is due to chemical binding of the metals in the sludge with the cement or simply microencapsulation.

METHODS

The experimental procedure for this study is presented in flowchart form in Figure 1.

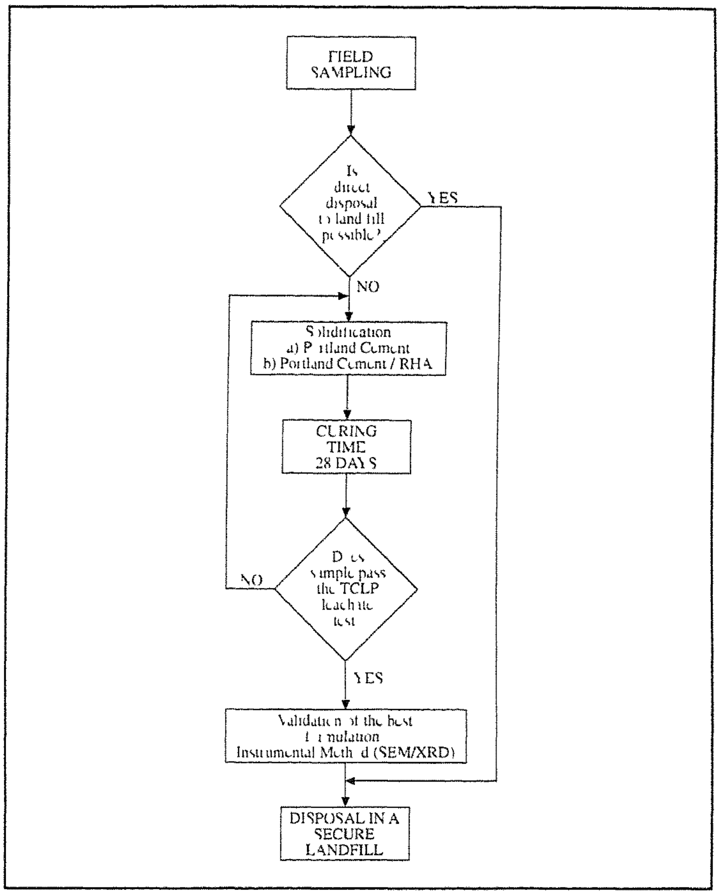

Figure 1: *Project methodology. Treatment and disposal of cooling tower sludge*

Two samples known as samples A and B were collected for this study. The concentrations of the contaminants are shown in Table 2.

Table 2: *Sludge characteristics in terms of heavy metal concentrations*

Element	Standard ppm	Sample A			Sample B		
		Total Assay mg kg^{1}	100%* Mobility mg L^{1}	Remarks	Total Assay mg kg^{1}	100% Mobility mg L^{1}	Remarks
Ag	5 0	126	6 3	F	32	1 60	P
As	5 0	2200	110	F	2600	130	F
Cd	1 0	1 05	0 053	P	0 28	0 014	P
Cr	5 0	1560	78	F	2400	120	F
Hg	0 2	16	0 800	F	165	8 25	F
Pb	5 0	150	7 50	F	150	7 50	F

Legend P - Passed Standard, F - Failed Standards; * - 100 g sample dissolved in 2 litres of extraction fluid

Two types of binders were used in the solidification process. The first consisted of pure portland cement, the other a mixture of 50% rice husk ash (RHA) and 50% portland cement. RHA was prepared by continuous open burning of rice husk ash for 24 hours, followed by pulverization to 325 microns to obtain a greater surface area.

Cement requirement: Hiraoka and Takeda[3] published a study proposing a fixation requirement for various hazardous substances as shown in Table 3.

Table 3: *Fixation capacity of cement*

Hazardous Substance	Arsenic	Cadmium	Chromium (VI)	Lead	Mercury	Cyanide
Portland Cement (mg haz. subs./kg cement)	30	3000	300	500	50	10

Using these values, the initial formulations (sludge : cement) necessary are:

Mercury : 1:3
Cadmium : 1:0.00035
Lead : 1:0.3
Chromium : 1:8
Arsenic : 1:87

It is clear that arsenic has a high cement requirement (87 times the weight of the sludge). The cost of solidification would be highly prohibitive should this formulation be employed as the starting point. At the other extreme, the cement requirements of Cd and Pb are insufficient to immobilize mercury and chromium. To demonstrate the economic viability of the solidification process without compromising its technical feasibility, the 1:3 sludge to cement ratio was adopted as the starting point. Around this value, the other formulations were made ranging from 1:1 to 1:5.

RESULTS AND DISCUSSION

The results of this study indicate successful immobilization by cement of the heavy metals in the sludge. The instrumental assessment of the immobilization mechanism confirmed physical entrapment of the heavy metals within the silica matrix of the hardened cement and sludge.

TCLP: The survey of the sludge characteristics presented above (Table 2) reveals that almost all elements except cadmium are above the standards. Arsenic and chromium have the highest amounts ranging from some 300 - 500 times the standards.

Table 4 shows that for the leachate from Sample A to pass the standards, one part of the sludge should be mixed with 2 parts of portland cement. However, this formulation is apparently insufficient to successfully immobilize all the contaminants in Sample B (mercury being the exception) (Table 5). Both 1·1 and 1:3 sludge to cement ratios failed to properly contain the contaminants at environmentally safe levels.

Table 4: *Leachate analysis of treated sample A (binder: portland cement)*

Element	Standard ($mg.L^{-1}$)	1 2 ($mg L^{-1}$)	Remarks	1:3 ($mg.L^{-1}$)	Remarks	1:4 ($mg L^{-1}$)	Remarks
Ag	5.0	0.060	P	0.050	P	0 50	P
As	5.0	0.020	P	0.009	P	<0.001	P
Cd	1.0	<0.01	P	<0.01	P	<0.01	P
Cr	5.0	0.012	P	0.110	P	0.017	P
Hg	0.2	0.058	P	0.0595	P	0.0275	P
Pb	5.0	<0.20	P	<0.2	P	<0.20	P

Table 5: Leachate analysis of treated sample B (binder: portland cement)

Element	Standard (mg.L^{-1})	1:1 (mg.L^{-1})	Remarks	1:3 (mg.L^{-1})	Remarks	1:5 (mg.L^{-1})	Remarks
Ag	5.0	0.450	P	0.060	P	0.30	P
As	5.0	0.015	P	0.025	P	0.046	P
Cd	1.0	<0.01	P	<0.01	P	<0.01	P
Cr	5.0	0.094	P	0.560	P	0.015	P
Hg	0.2	1.485	F	0.315	F	0.047	P
Pb	5.0	<0.20	P	<0.2	P	<0.20	P

Legend: P = passed standards; F = failed standards

The immobilization potential of the alternative binder, i.e. a one to one ratio of rice husk ash and portland cement, was also evaluated as in the case of Sample A. Table 6 shows that rice husk ash if used in combination with portland cement can be a better binder for some of the target contaminants. This may be attributed to the higher silica content of the rice husk ash binder and its greater surface area, an advantage in the solidification process.

Table 6: Comparison of various immobilization potentials (sample A, mg.L^{-1})

Element	Standard (mg/L^{-1})	1:2		1:4		1:5	
		PC	PR	PC	PR	PC	PR
Ag	5.0	0.060	0.020	0.050	<0.02	<0 02	<0 20
As	5 0	0.002	0.008	0.001	0.008	0.004	0.004
Cd	1.0	<0.01	<0.01	<0.01	<0.01	<0 01	<0 01
Cr	5.0	0.120	0 055	0.170	0 018	0 016	0.011
Hg	0.2	0 058	0.003	0.028	0.037	0.029	0.021
Pb	5.0	<0 20	<0.20	<0.20	<0 20	<0 20	<0 20

Legend: PC - portland cement binder, PR - portland cement RHA binder

Instrumental assessment: Inspection of the micrographs of the treated samples shown in Figure 2 and 3 shows the formation of needle-like structures characteristic of ettringites, which are one of the principal products of cement hydration. No monosulfate compounds were detected in significant quantities. Note the absence of ettringite structures in the untreated samples. Bensted and Verna[1] theorized that in both ettringite and monosulfate Fe^{3+}, Mn^{3+}, Cr^{3+} and Ti^{3+} ions may take the place of Al^{3+}. However, in this experiment, when these same needle-like structures were subjected to X-ray diffraction for qualitative analysis, it was discovered that they were composed purely of ettringite (Figure 4). Had the heavy metals been chemically bonded to the ettringite matrix forming a different chemical compound, the XRD analysis would have yielded different intensity peaks which would not have corresponded to that of ettringite. Furthermore, for this ion exchange to take place, the participating ions should have approximately the same ionic radii to displace Al^{3+}, or Ca^{2+} in the ettringite. The values shown in Table 7 do not support the ion-exchange theory.

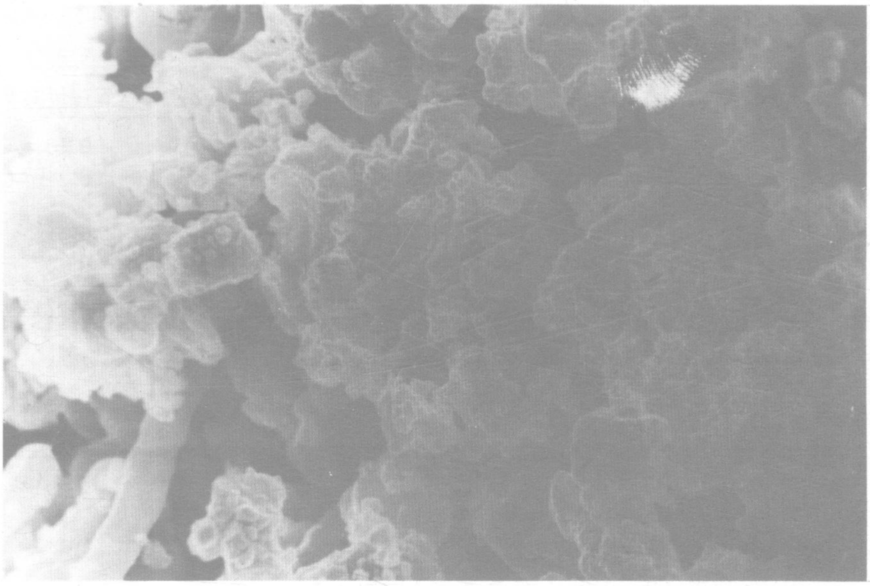

Figure 2: Microstructure of untreated sample A. Magnification: 25 KV x 3000

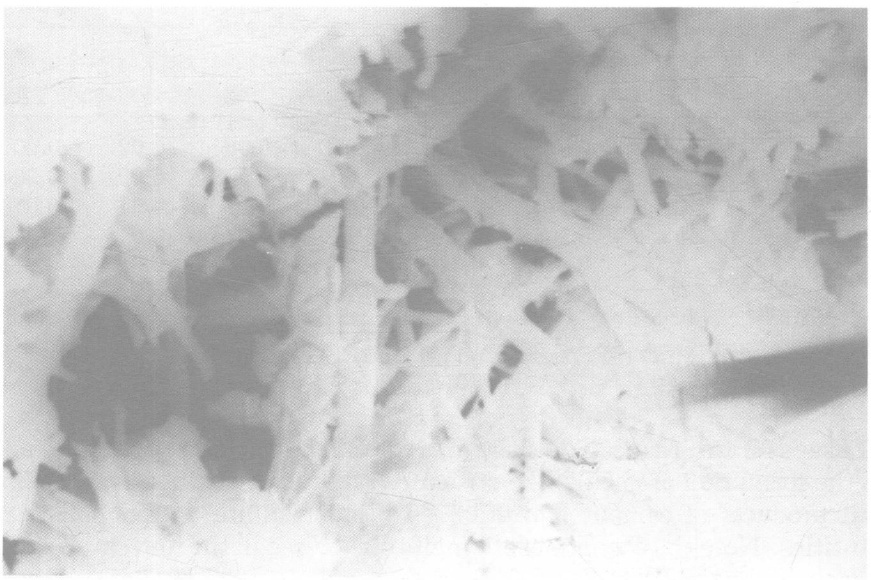

Figure 3: Microstructure of treated sample A. (Binder: Portland Cement). Magnification: 25 KV x 6000

Table 7: Ionic radii of selected ions (Nanometers)

Calcium	Aluminum	Silver	Arsenic	Cadmium	Chromium (3+)	Mercury (2+)	Lead
0.099	0.051	.0.126	0.058	0.097	0.063	0.110	0.120

The ionic radii of Ag, As, Cd, Cr, Hg, and Pb are relatively larger than Al and Ca making ion-exchange difficult if at all possible. The findings of the XRD analysis showing that the structures formed are purely ettringites substantiate these findings.

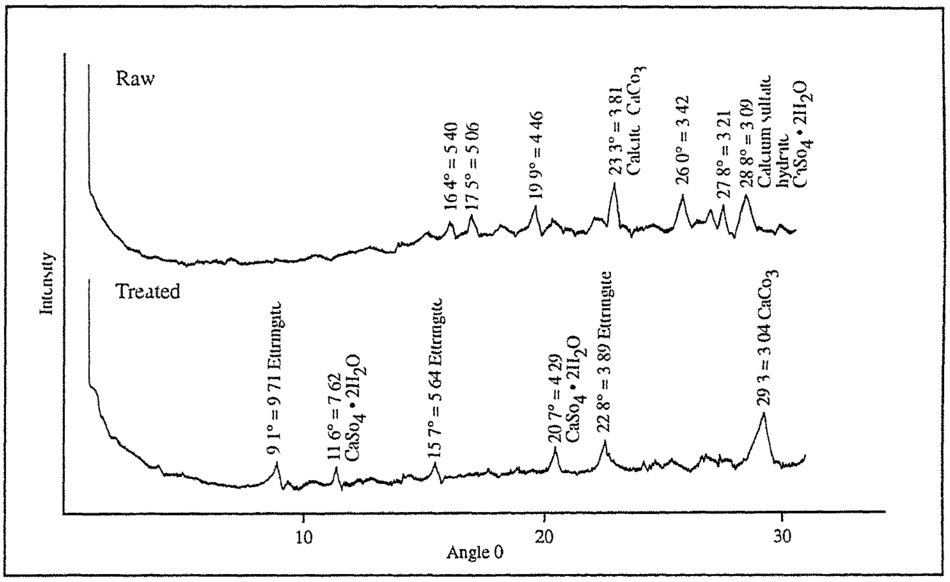

Figure 4: *XRD chart of raw and treated samples*

CONCLUSIONS

The results of the study clearly show that the mobility of heavy metals can be effectively reduced by the solidification/stabilization (S/S) process using cement and RHA as silicate sources. Although the immobilization mechanism was mainly physical and not chemical, the substantial reduction in mobility qualifies the S/S process as a feasible treatment technology for the immobilization of hazardous wastes particularly heavy metal wastes. The specific conclusions drawn are as follows:

1. Leaching of heavy metals can be minimized or retarded to meet standards by blending the waste with portland cement. The present findings show that immobilization is more effective when silica is available at higher amounts using either portland cement in higher formulations or an alternative siliceous source with higher silica content such as rice husk ash.

2. In the investigation of the bonding mechanism of cement on heavy metals, crystal capture or physical entrapment of the metal contaminant in the ettringite/silicate matrix is the main mechanism responsible for the immobilization process: Chemical bonding is thus ruled out. The leaching of heavy metals into the extraction fluid was the result of the destruction of the entrapping silicate structure.

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A MEMBRANE ANAEROBIC SYSTEM FOR WASTEWATER TREATMENT

A Fakhru'l-Razi
Department of Civil and Environmental Engineering, Universiti Pertanian Malaysia

INTRODUCTION

Membrane Filtration Technology has been used for over 30 years for the practical separation of impurities or valuable constituents from solutions. Membrane separation techniques have been applied for biomass recycling in biotechnology[1] and wastewater treatment[2]. The combination of biological treatment by activated sludge with ultrafiltration was first reported by Smith et al[3]. To predict membrane flux, Fane et al[1] developed a computer model of a combined ultrafiltration and activated sludge wastewater treatment system. The major resistance to flux is provided by the suspended solids. Substances smaller than the pore size of the membrane filter are driven through with the solvent while larger solutes are retained. Various membrane technologies such as reverse osmosis (RO), ultrafiltration (UF) and microfiltration (MF) have been used successfully for various water and wastewater treatment applications These technologies require no phase change, little energy and are cost effective

A major difficulty in the anaerobic digestion process is the need to retain a sufficient quantity of active biomass in the reactor. By preventing bacteria from escaping in the effluent, the digestion process becomes eventually independent of growth rate. This way it becomes possible to attain high populations of bacteria leading to high rates of digestion in spite of very low growth rates. A new membrane anaerobic system for industrial wastewater treatment was tested and its performance is presented.

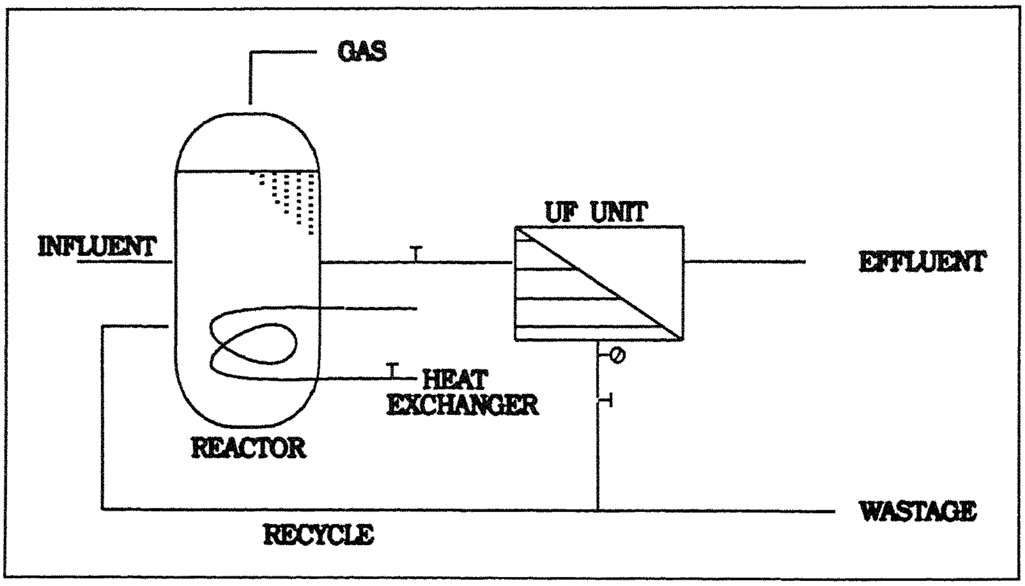


Figure 1: *Schemetic diagram of the UF membrane anaerobic reactor system*

METHODS

The system consists of a crossflow UF membrane unit and an anaerobic reactor (capacity 120 litres) treating high strength wastewater as shown in Figure 1. A positive displacement pump was used to provide the feed to the UF module. The feed velocity and operating pressure were controlled by adjusting the flow and pressure regulators. A heat exchanger in the reactor provided the temperature control. The UF module was equipped with PCI UF membranes which have a molecular weight cut-off of 10,000 and can be operated at a pressure range of 2-15 bar, pH range of 2-12 and temperatures of up to 70°C. The study was conducted at a temperature of 35°C and with minimal pH control. The reactor was operated over a range of solid retention times (SRT) and organic loading rates (OLR) in order to evaluate its treatment efficiency. Six steady states were attained over a mixed liquor suspended solids (MLSS) range of about 10,000 to 15,000 mg/L^{-1}. This was achieved by varying the OLR and the deliberate wastage of digester sludge from the system.

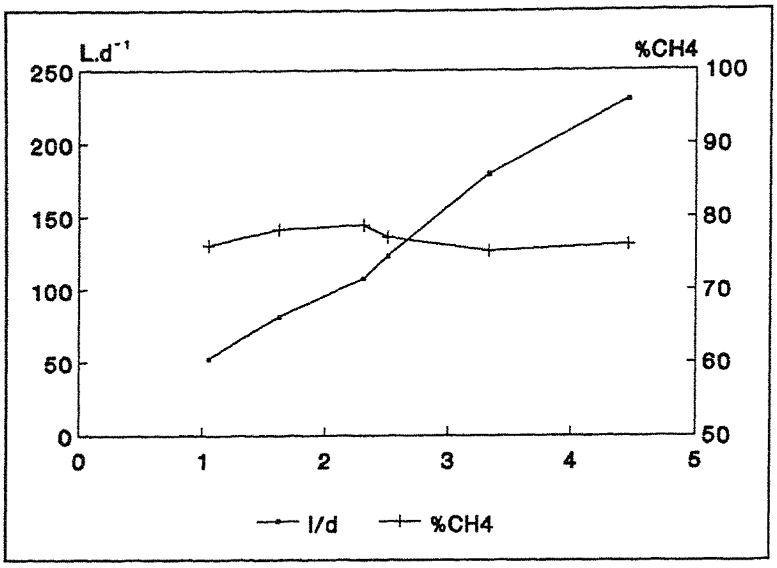
RESULTS AND DISCUSSION

The reactor was seeded with sludge from an active anaerobic digester. The initial mixed liquor suspended solids concentration was about 10,000 mg.L^{-1}. The reactor was allowed to reach its first steady state. This was achieved after about 20 days of operation. The feed COD and sludge wastage rate was then increased and the system was allowed to achieve a new steady state. About 15 days were needed to achieve a new steady state after each new operating condition. A total of six steady states were achieved. Table 1 summarizes the results obtained during the study. The maximum OLR applied was 4.46 COD.m^{-3}.d^{-1}. The feed COD at this loading rate was 19,110 mg.L^{-1}. and the HRT was controlled at between 3.2 to 3.7 days which were largely determined by the membrane flux rate. The total volatile acids concentration in the effluent were below 100 mg.L^{-1} throughout the study. Increase in total volatile acid concentration and reduction in gas production were taken as indicators of any impending failure.

Table 1: *Summary of results*

Parameter	Steady State 1	Steady State 2	Steady State 3	Steady State 4	Steady State 5	Steady State 6
COD in, mg L^{-1}	3510	5710	8620	9990	13720	19110
COD out, mg L^{-1}	60	80	110	155	180	220
Vol acids, mg.L^{-1}	40	45	60	70	90	95
Gas prod., L/d^{-1}	52.4	81 4	107.6	123 1	179.1	229 8
%CH_4	76 1	78 3	78.9	77 2	75.3	76 2
L CH_4 g^{-1}COD	0.32	0 33	0.31	0 32	0.34	0.33
MLSS, mg.L^{-1}	11600	12200	13000	14200	14700	16200
MLVSS, mg L^{-1}	10100	10600	11400	12200	13100	14700
Wastage, L d^{-1}	0.22	0 37	0.56	0 71	0.81	1.08
Feed (Q), L d^{-1}	36.1	34 3	32 2	30 2	29.3	28 1
HRT, d	3.23	3 34	3 48	3 67	3 68	3.69
SRT, d	555	323	213	169	149	111
OLR						
KgCOD m^{-3}.d^{-1}	1.05	1 62	2 30	2 50	3.32	4.46
BLR						
KgCOD kg^{-1}VSS d^{-1}	0.104	0 153	0 202	0 205	0.253	0.303
Subst util rate						
KgCOD.m^{-3}.d^{-1}	1.04	1.61	2 28	2 48	3.31	4.42
Sp sub ut rate	0.102	0 151	0 199	0 202	0.250	0.299
KgCOD.kg^{-1}VSS.d^{-1}						
COD removal, %	98.3	98.6	98.7	98.4	98.7	98.8

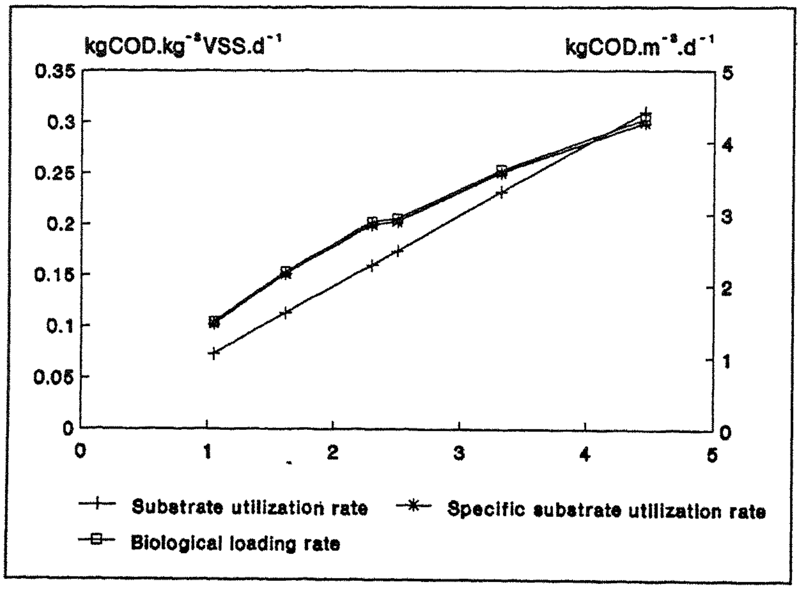
Figure 2 shows the variation in gas production and methane percentage of the digester gas at different OLRs.



OLR (kgCOD m-3.d-1)

Figure 2: *Gas production*

The rate of gas production increases with increasing OLR while the methane content of the gas ranged from 76.1-78.9%. The methane yield ranged from 0.31-0.34 L $CH_4.g^{-1}$COD utilised, at standard temperature (273K) and pressure (1 atmosphere). There was no sudden increase in volatile acids with increasing OLR confirming that the digester was performing very well. As shown in Figure 3, the substrate utilisation rate, the specific substrate utilisation rate and the biological loading rate (BLR) all increased proportionally with increasing OLR with a corresponding increase in biomass concentration. This indicates that the loading rate applied is probably the limiting factor for biomass production. In Figure 4 the treatment efficiency of the system shows a consistent COD removal of above 98%. The mixed liquor volatile suspended solids (MLVSS) load increases with increasing OLR indicating that the bacterial population had increased with higher COD inputs.



OLR (kgCOD.m-3 d-1)

Figure 3: *Membrane reactor performance.*

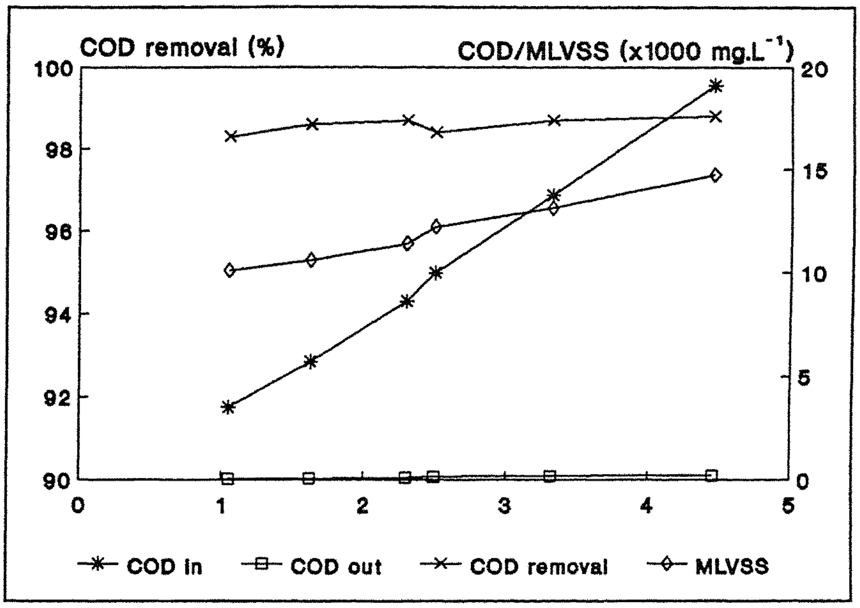


Figure 4: Treatment efficiency.

The results obtained so far were most encouraging with respect to biomass retention and the treatment efficiency of new anaerobic system. Clearly the system was capable of higher loading rates and had not reached its maximum treatment capability. This had been achieved without any membrane cleaning and with good control of biomass concentration in the digester.

CONCLUSIONS

The results of the study have demonstrated that the new anaerobic digestion system incorporating a crossflow UF membrane unit resulted in a sound technique for retaining a high concentration of biomass as indicated in an earlier study[2]. The treatment efficiency of the system indicates its potential use for treating high strength wastewaters. The study has shown that the UF membranes are capable of efficient biomass/effluent separation and producing a clear effluent. The UF membranes have practically prevented any biomass loss through the effluent or permeate resulting in very high operating SRTs, thus making the system quite tolerant to variations in influent characteristics. The system was subjected to a maximum loading rate of 4.46 kg $COD.m^{-3}.d^{-1}$ and a hydraulic retention time (HRT) of 3.69 days. At this loading rate the system was capable of achieving an overall COD removal of 98.8%.

The system has demonstrated its ability to positively control SRT and HRT which has always been one of the major difficulties in anaerobic digestion practice. In anaerobic systems, the microorganisms' growth rates are slower than in aerobic systems thus, requiring a longer SRT in order to accommodate the slower net growth rate.

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PREVENTION AND TREATMENT OF AIR POLLUTION IN HONG KONG

JC Lam
Department of Building and Construction, City Polytechnic of Hong Kong

INTRODUCTION

Air pollution is a part of many problems and a problem of many parts, an important feature of urban design and environmental management. It is a problem that is concomitant with industrial growth and economic development, complicated by an ever-changing technology, the economic situation and social and political constraints. Pollution of the air imposes risks and costs on the community due to its adverse effects on public health. The direct physiological effects of air pollution range from nuisances such as eye irritation, bad smells and allergies, to causing or aggravating respiratory and cardiovascular diseases.

ENERGY USE AND AIR POLLUTION

As the economy expands and living standards improve, so energy consumption, particularly electricity grows. It can be seen from Figure 1 that there was an 85% increase in the gross domestic product (GDP)[1] and a rise of 105% in total primary energy requirement[2] in Hong Kong during the 10-year period from 1980 to 1989. Growth in energy consumption was bigger than in GDP. This implies that by the end of the 10-year period, Hong Kong consumed more energy to produce the same amount of goods and provide the same services.

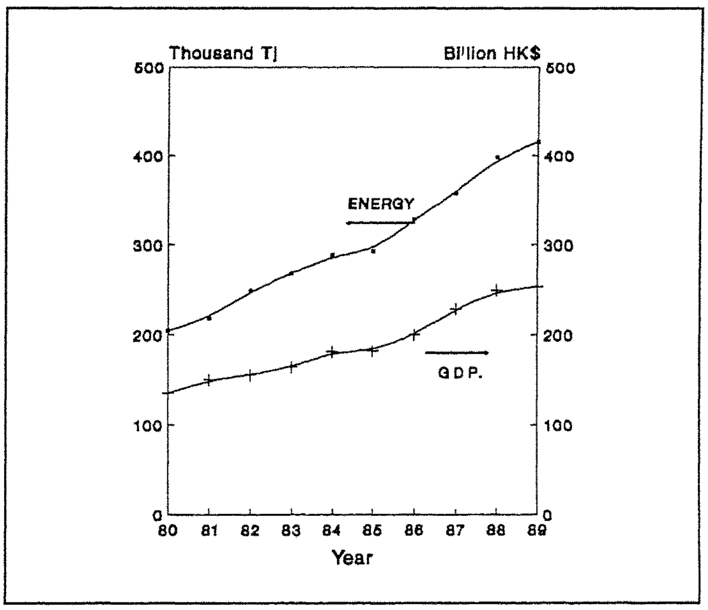

Figure 1: *Total primary energy requirement and GDP in Hong Kong (1980-1989).*
(GDP at constant (1980) market prices)

Total primary energy requirement per unit of GDP, sometimes called energy intensity, is often used to compare improvements in energy efficiency in different countries. Figure 2 shows the energy intensities for Hong Kong, Japan, the USA and the UK. It can be seen that, by the end of the period 1980-1989, Japan, the USA and the UK consumed, respectively, 19%, 18% and 18% less energy to produce the same amount of goods and provide the same services[3,4]; whereas Hong

Kong needed 11% more. It is worth noting that these figures can only give a general indication to improvements in energy efficiency. They do not show how energy performance can vary greatly from one sector to another, nor do they mean that one country is uniformly more energy-efficient than another. Nevertheless, it is not unreasonable to suggest that there is a need for improvement in energy efficiency in Hong Kong.

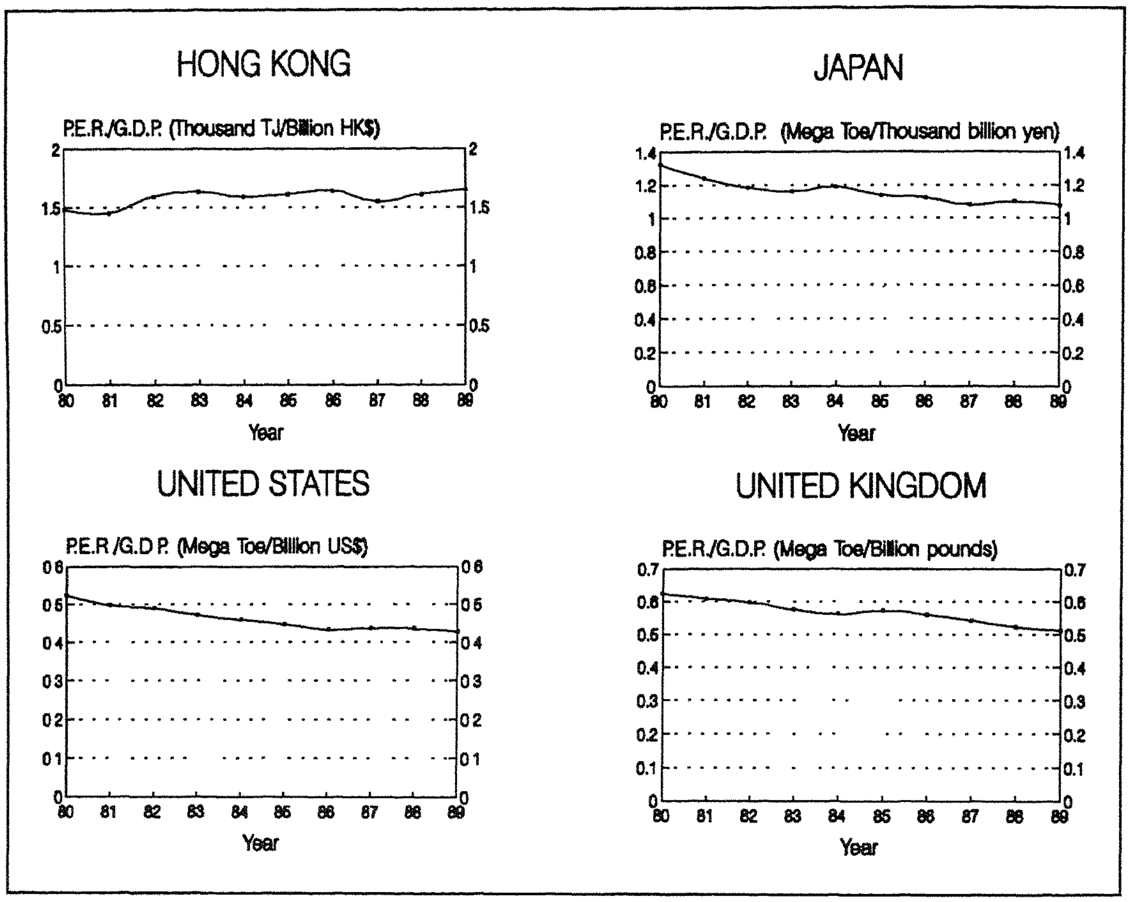

Figure 2: Energy intensities (1980-1989) (GDP at constant (1980) market prices) (1 Thousand TJ = 0.2388 Mega Toe (Ton of Oil Equivalent)).

In 1990, more than 9,000,000 tonnes of solid fuel (mainly coal), 35 kilolitres of liquid fuel (mainly diesel) and 200,000 tonnes of gaseous fuel (LPG) were consumed in Hong Kong[5]. This represented a total potential energy of about 436,622 TJ. Pollutants emitted from the burning of these imported fuels are substantial.

There are four major air pollutants which affect human health and cause economic damages in Hong Kong. Table 1 provides rough estimates[6] of the total tonnage of air pollutants emitted from various sources in Hong Kong in 1990. The data indicate that nitrogen oxides alone represent approximately 42% of the total pollutant emissions, and carbon monoxide and sulphur oxides together contribute approximately 56% more. These three gases, largely combustion-oriented, compose more than 95% of the total emissions of major air pollutants.

Table 1: Estimated air pollutants emitted in Hong Kong[6] in 1990

Pollutants	Tonnes per year	Potential Adverse Effect
Carbon monoxide	83,000	Toxic, impairment of co-ordination, deleterious to people with heart and circulatory problem
Sulphur dioxide	147,000	Adverse effects on the lung
Nitrogen oxides	174,000	Acid rain, vegetation damage, visibity, degradation of materials
Particulates	9,000	Visibility, respirable fraction has effects on health - reduced lung function, cancer risk for certain particles
Selenium, vanadium, radon, etc.	Trace quantities	Various

Besides this, there were 34 million tonnes of carbon dioxide emissions which contributed a part to global warming. All these indicate that fuel combustion is the single largest source of air pollution in Hong Kong.

PREVENTION OF AIR POLLUTION

In the Hong Kong context, the obvious solution to prevent air pollution is to use less energy. This can be accomplished by generating electricity more efficiently (supply side management) or by consuming electricity more efficiently (demand side management). There are various means to achieve these ends:

Supply-side management[7]:

(a) Cleaner Fuels - The overall conversion efficiency of our coal-fired power plants, including system losses, is about 32%. However, options are open for repowering some of the existing plants with diesel oil or even natural gas with which the conversion efficiency can be 40% or more under optimal load conditions.
(b) More Efficient Technologies - For new power stations to be built in Hong Kong, serious considerations should be given to the construction of combustion turbine-based combined-cycle plants with overall conversion efficiency up to 50%.
(c) Total Heat and Power - Another alternative is to adopt a cogeneration (or combined heat and power) system where heat otherwise wasted is used to produce steam or hot water for other industrial processes.

Demand-side management[8]:

(a) Peak Clipping - this is to reduce the electricity demand during the peak hours through supervisory load control.
(b) Valley Filling - this is to increase the electricity demand during the off-peak hours through thermal storage, thus putting unused capacity to work.
(c) Load Shifting - this is to shift existing load from peak to off-peak hours through rescheduling of load pattern.
(d) Strategic Conservation - this is to lower energy in selected applications so as to reduce the total system demand. Building audits and replacement of incandescent lamps with fluorescent tubes are examples.
(e) Flexible Load Shaping - load is adjusted according to operating needs, thereby gaining more flexibility in supply planning. This can take the form of interrupted service, in return for various incentives to consumers.

TREATMENT OF AIR POLLUTION

No matter how efficient we are in using energy, we still need to consume a certain amount of fuels and therefore produce air pollutants. It is imperative that these unavoidable emissions are properly treated and dispersed, otherwise they would cause harmful effects to people's health and to the economy. Treatment of air pollution mainly takes the form of add-on technologies such as:

(a) Electrostatic precipitators and fabric filters for controlling dust emissions.
(b) Flue-gas desulphurisation systems for controlling sulphur oxides emissions.
(c) Selective catalytic reduction for controlling nitrogen oxides emissions.
(d) Off-stoichiometric combustion for controlling carbon monoxide emissions.
(e) Floating roofs for controlling hydrocarbon emissions from oil tanks.
(f) Vapour recovery systems for controlling emissions from petroleum distribution activities.
(g) Chimneys of adequate height for the proper dispersion of flue gases from stationary sources.
(h) Three-way catalysts for NOx, HC and CO emissions from gasoline-fuelled vehicles.
(i) Trap oxidizer systems for controlling particulate emissions from diesel-fuelled vehicles.

All these technologies are in fact quite well established. However, they are provided at a cost and the key questions are who should pay the cost and what the socio-economic implications will be.

SOCIO-ECONOMIC IMPLICATIONS OF AIR POLLUTION CONTROL

Alfred Marshal[9] well over a half century ago suggested a "fresh air levy" on all property owners to be spent by local authorities on air pollution control. He voiced the opinion that the owner would recoup much of this by increased valuation of his property. In 1952 J.E. Meade[10] suggested that a proper tax on the negative externality (air pollution) would yield proper revenue to subsidise the damaged party. In 1960 R.H. Coase[11] discussed transferrable rights (eg. a right to clean air) and said that when property rights were well defined and easily traded, their initial ownership by either the polluter and the polluted (damaged party) would lead to the same ultimate resource allocation. These three proposals have very important bearings on the present-day philosophies of air pollution control. The first proposal is embodied in the "User Pays Principle". The second proposal is embodied in the "Polluter Pays Principle" which is so widely adopted in Hong Kong as exemplified in the Air Pollution Control Ordinance and Regulations. The third one on "Transferrable Emission Rights" is the origin of such concepts as emission offset, emission banking and emission trading now practised in the USA.

Responses by the industry to the increase of air pollution control costs are price adjustment, cost cutting and functional improvement so as to maintain an acceptable profit margin. However, not all costs can be passed onto the consumers. There is a difference between large firms and small firms. Large firms are usually price-searchers because of their monopolistic positions. They can always pass part or whole of their air pollution control costs to the end users. Such is the case of local electric companies operated under the "Scheme of Control" and the "Fuel Clause Adjustment Formula". The small firms which characterise the Hong Kong industry are in a less fortunate position. They are usually price-takers and have to absorb the increased costs through cost cutting elsewhere or functional improvement in their operations. If these measures fail to restore their competitiveness, they have to diversify their products, services or markets. Failing all these, they have to shift their operations elsewhere. In other words, some of the industries or operations will become obsolete and vanish while other new industries will appear and expand and the whole economic structure will need some adjustment.

ENERGY CONSERVATION IN BUILDINGS

In 1989, energy required for electricity generation accounted for 67% of the total consumption in Hong Kong. There are three main electricity end users - industrial, commercial and residential. From Figure 3, it can be seen that as the Hong Kong economy shifted from industry to more services-oriented in the 80s, the commercial sector became the major electricity consumer. In 1989, the commercial sector accounted for about 44% of the total electricity consumption in Hong Kong, while residential consumption remained steady at about 20%. Electricity consumption in commercial and residential buildings therefore, accounted for 43% of the total energy consumed in Hong Kong in 1989. A significant proportion of the electricity is for air-conditioning and lighting, especially during the long, hot and humid summer. One way to alleviate environmental pollution would be to conserve energy use in buildings through more energy-efficient design and more effective operation and maintenance of buildings.

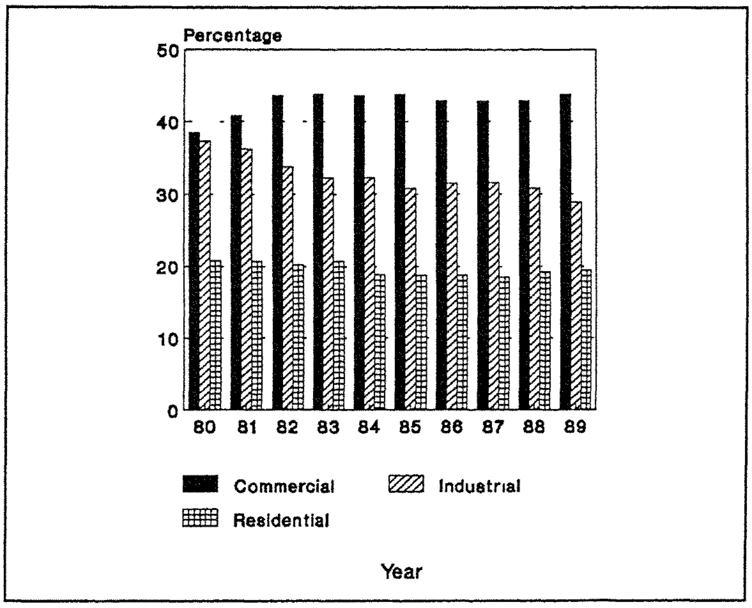

Figure 3: Percentage of electricity consumption in commercial, industrial and residential sectors.

In response to this, a research group called the Building Energy Conservation Unit was set up in early 1990 to carry out research and consultancy work on issues related to energy-efficient design, operation and the environment. More emphasis has been put on energy efficiency and environmental implications in teaching subjects such as environmental and building science and building services. Seminars have been organised for students and practising building professionals to raise their awareness of energy conservation and environment protection. It is hoped that these activities would help create a more energy conscious environment among the design professions.

CONCLUSION

With an expanding economy and improvement in living standards in Hong Kong, there has been a substantial growth in economic activities as well as energy consumption and the concomitant air pollutant emissions. The problem of air pollution in Hong Kong is therefore not only a technical one, but also an economic and social one. More research work on policy issues, especially the interactions between environmental, social and economic aspects, is needed in order to arrive at an optimal balance for a sustainable development in Hong Kong.

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ENVIRONMENTAL EDUCATION - A STRATEGY FOR THE TREATMENT AND PREVENTION OF ENVIRONMENTAL POLLUTION

JA Manalo, VM Segovia and TR Hocson
Institute of Education and Management for Environment and Habitat, The Philippine Women's University

The Philippines is beset by all types of problems - deforestation, pollution, degradation, depletion of resources, urban congestion and consumer exploitation. Local environmental agencies are however constrained to cope with these environmental problems due to inadequately trained technical manpower and a general public without environmental awareness.

Education has been identified as one of the ten Philippine strategies for sustainable development, but all the other strategies require some form of environmental education - whether they involve basic ecological environmental management concepts or the highly specialized training for development of skills in pollution control, clean technology or impact assessment.

Environmental Sciences, later changed to Environmental Education, has been prescribed to be integrated into the curriculum at all levels of education by the Department of Education, Culture and Sports. This has been hampered by problems of lack of trained teachers and teaching materials and more importantly, by the lack of concern and commitment on the part of the teachers and the students.

To correct these teacher inadequacies, in-service training for teachers has been initiated by the Philippine Women's University and the Philippine Association of Chemistry Teachers with financial assistance from Funds for Assistance to Private Education and the Department of Science and Technology. The last such course was held in 1991 and the Biological Teachers Association has in the last two years started their own environmental education training for Biology teachers.

The training of teachers involves a holistic approach which includes not only the acquisition of knowledge on basic ecological concepts and skills on the use of teaching methodologies and approaches but also the development of values and environmental strategies to achieve the long term goal of environmental stability.

The present trend of measuring man's success through his wealth, power, and prestige instead of human dignity has caused diminution or even loss of personal and social responsibilities. These materialistic attitudes and lifestyles have enticed people to become indifferent to objective moral standards, ultimately leading to instability of our environmental balance.

Again, one solution to these problems and ills of society is a strong education program which develops values including environmental concern and commitment to sustainable development.

In the seminars, environmental values are integrated and a values clarification exercise is incorporated, which provides the participants with the opportunity to synthesize their value priorities and a chance to exercise a decision-making process through consensus amongst themselves.

Since 1977, the PWU Institute of Education and Management for Environment and Habitat has offered an M.S. in Environmental Management which prepares students for the needed specialization in such areas as Solid Waste Management, Resource Management, Environmental Education or in the broad spectrum of Environmental Management. Special training on Environmental Impact Assessment, Land Use Planning, Pollution Control, Energy, Consumerism, Environmental Monitoring and Legislation are prescribed for all students.

PWU also pioneered Environmental Management Education for industry, bankers, local officials, and government and community leaders in cooperation with the International Centre for Management in Geneva, Switzerland, the National Environmental Protection Council, and the National Pollution Control Commission, with funding from UNEP, the British Council and the Ministry of Human Settlements.

Seminar-workshops on Environmental Impact Assessment, Pollution Control and Social Responsibility for Industry were sponsored for various participants in the three major regions of the Philippines with foreign experts serving as resource speakers. These went on regularly until 1984 and were resumed in 1988 in collaboration with the San Miguel Corporation.

The last seminar on Environmental Impact Assessment was held in July 1991 with funds from the Australian government and in collaboration with the Department of Environment and Natural Resources (DENR).

Attention has recently been directed towards women, who compose 50% of the nation's population, to make them equally environmentally aware and to develop their skills in planning, advocacy, monitoring, and networking with other environmental agencies and NGOs to help protect the environment.

With funds from the Australian government, women leaders of civic and religious organizations together with academe are the recipients of this environmental training. They are drilled on environmental management with emphasis on solid waste management. Various strategies of solid waste disposal are introduced, with waste recycling for fertilizer, fuel, feed and factory materials taking the lead. The strategy is to reduce pollution to almost zero. For the development of skills on monitoring and community resource surveillance, they are exposed to tactics using simple indicators to warn them of impending pollution or environmental degradation - then through advocacy and networking, they can report these problems to the nearest responsible agency for speedy action, possibly through the Regional DENR Woman Officer who attends the seminar with them.

Discussions on risk assessment and consumerism include issues of hazardous and toxic products, fertilizers, pesticides, CFCs, and their relationships with pollution, global warming, and thinning of the ozone layer. Reminders on preparedness and careful handling will hopefully reduce pollution and potential illnesses and disasters.

Women are believed to make things happen due to their influence on their families - their husbands and children - who may be motivated to lend a hand in protecting the environment. This family movement initiated by the wife, mother and sister can easily infect the whole community and lead to preservation of the environment.

More than 1,000 participants have attended the seminars and, applying the principle of multiplier effect in these environmental education projects, the number influenced would be more than doubled. Outputs of the seminars for women are individual commitments to protect the environment and group action plans they would implement, which range from information dissemination to recycling and solid waste management.

Apathy, lack of concern and lack of environmental awareness have allowed environmental destruction to go unchecked. Suddenly the forests are gone, minerals and the seas are exploited, and pollution is widespread. Metro Manila is enveloped with smog, there is a scarcity of fuel, power, and water; streets are filled with garbage; children and slums are everywhere. These gigantic environmental problems, coupled with overpopulation and poverty, seem almost beyond solution.

However, a possible solution, both immediate and longrange, is environmental education. A vigorous campaign to protect the environment is now being mounted throughout the country. Recently-sprouted environmental NGOs are now bonding, federating, networking with academic institutions and civic organizations to organize programs for environmental protection. Environmental seminars are being organized for the media, businessmen, professionals and the general public.

Funding agencies, foundations, foreign embassies and lately the Asian Development Bank have started to fund projects on environmental education - including the preparation of materials, conduct of non-formal education, improvement of teachers and the integration of environment into the three levels of education - activities all aimed at reversing the trend of environmental degradation.

An effective environmental education covers techniques to cure pollution, prevent resource degradation and exploitation but, more importantly, develop values of equity, social responsibility together with a commitment and concern to protect the environment for sustainable development. This may be the only hope for our salvation.

BACTERIAL REDUCTION DURING SEWAGE TREATMENT - THE HONG KONG EXPERIENCE

IJ Hodgkiss* and SHC Chiu+
*** Department of Botany, The University of Hong Kong**
+ School of Public Health, University of Massachusetts

INTRODUCTION

Because the accepted function of sewage treatment is to remove organic matter and produce an effluent which satisfies a physical and chemical standard, little attention has been placed on the reduction of the microbial content of the sewage. This is despite the fact that the greatest part of the organic matter in human faeces is present in the form of the bacteria which inhabit the human gut[1].

The bacterial content of the final effluent depends on the type of treatment and its efficiency at each plant but, in general, primary treatment (which separates settleable solids from the liquid phase of the sewage) has little effect on bacterial removal[2]. Secondary treatment is, however, more effective in achieving a good reduction[3] and 90-99% removal of faecal coliforms and other pathogens is common in the activated sludge process[4].

Shatin Sewage Treatment Plant, in the New Territories of Hong Kong, receives waste input from residential, industrial and clinical sources and the treatment process involves primary settling and an activated sludge process but no tertiary treatment. The final effluent is discharged into Tolo Harbour via thin 2500 mm diameter, 1 km long submarine outfalls at an average flow rate of 111500 m^3 per day. This paper looks at the bacterial reduction in this plant in comparison to similar plants elsewhere, using a range of bacterial indicators.

MATERIALS AND METHODS

Three sampling points were chosen to represent stages in the treatment process: STP1 represents the raw sewage after screening and passing through grit channels; STP2 represents primary treated effluent after passage through the primary sedimentation tanks; and STP3 represents secondary treated effluent after passage through activated sludge aeration tanks and final settling tanks and just before final discharge. Samples were collected on five occasions (seasonally determined) during the year in sterile 250 mL sampling bottles and maintained at 4°C for return to the laboratory. All analyses were completed within 6 hours of sampling. Total coliforms (TC), faecal coliforms (FC), *Escherichia coli* (EC), faecal streptococci (FS) and faecal clostridia (FCL) were isolated on 47 mm diameter, 0.45 μm membrane filters[5] and then standard incubation temperatures and media were used to culture them. Ten fold dilutions of the sewage effluents were used. Colony counts were made and the geometric means of 3 replicate samples calculated as the mean CFU count per 100 mL for later statistical analysis.

Salmonella spp. (SAL), however, were isolated using MPN procedures[6] whereby 10, 1 and 0.1 mL sample volumes were used as inocula. Confirmation of the salmonellas involved the slide agglutination test and the MPN of salmonellas per 100 mL was obtained from probability tables.

RESULTS

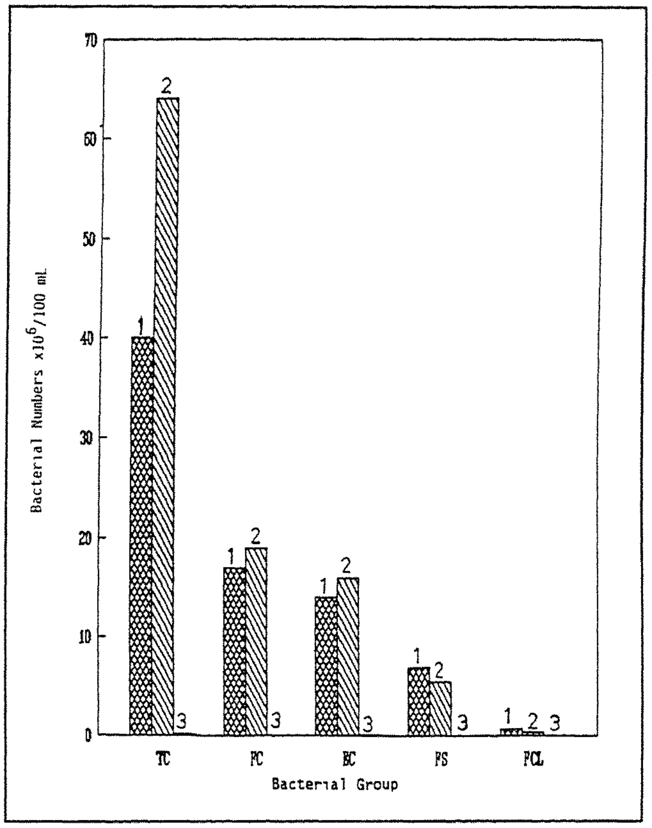

Figure 1: *Variations in various mean bacterial counts at the three stations in Shatin Sewage Treatment Plant.*

Table 1: *Summary of the total coliform (TC), faecal coliform (FC), Escherichia coli (EC), faecal streptococci (FS) and faecal clostridia (FCL) numbers per 100 mL in effluent samples from Shatin Sewage Treatment Plant.*

Parameter		GM*	Log SD**	Minimum	Maximum
STP 1	TC	4.0×10^7	1.4	3.1×10^7	$7 2 \times 10^7$
	FC	1.7×10^7	2.3	4.9×10^6	5.0×10^7
	EC	1.4×10^7	2.6	3.5×10^6	4.4×10^7
	FS	7.0×10^6	2.1	2.9×10^6	1.6×10^7
	FCL	7.1×10^5	3.3	2.3×10^5	6.1×10^6
STP 2	TC	6.4×10^7	5.8	2.7×10^6	4.3×10^8
	FC	1.9×10^7	4.7	2.0×10^6	1.1×10^8
	EC	1.6×10^7	4.5	1.8×10^6	8.5×10^7
	FS	5.5×10^6	3.4	5.8×10^5	2.3×10^7
	FCL	2.9×10^5	2.1	1.7×10^5	1.2×10^6
STP 3	TC	2.0×10^5	2.4	5.8×10^4	5.2×10^5
	FC	9.5×10^4	2.6	3.1×10^4	3.7×10^5
	EC	6.3×10^4	1.9	3.0×10^4	1.3×10^5
	FS	2.2×10^4	6.6	3.3×10^3	3.2×10^5
	FCL	1.0×10^4	2.5	2.0×10^3	3.1×10^4

* Geometric mean; ** Logarithmic standard deviation

Table 2: Reduction percentages for the various bacterial groups at Shatin Sewage Treatment Plant

Parameter	Primary	Secondary	Overall
TC	(60.0)*	99.7	99.5
FC	(11.8)	99.5	99.4
EC	(14.3)	99.6	99.5
FS	21.4	99.6	99.7
FCL	59.1	96.5	98.6
SAL	94.0	55.0	96.7

* Bracketed figures represent % increases.

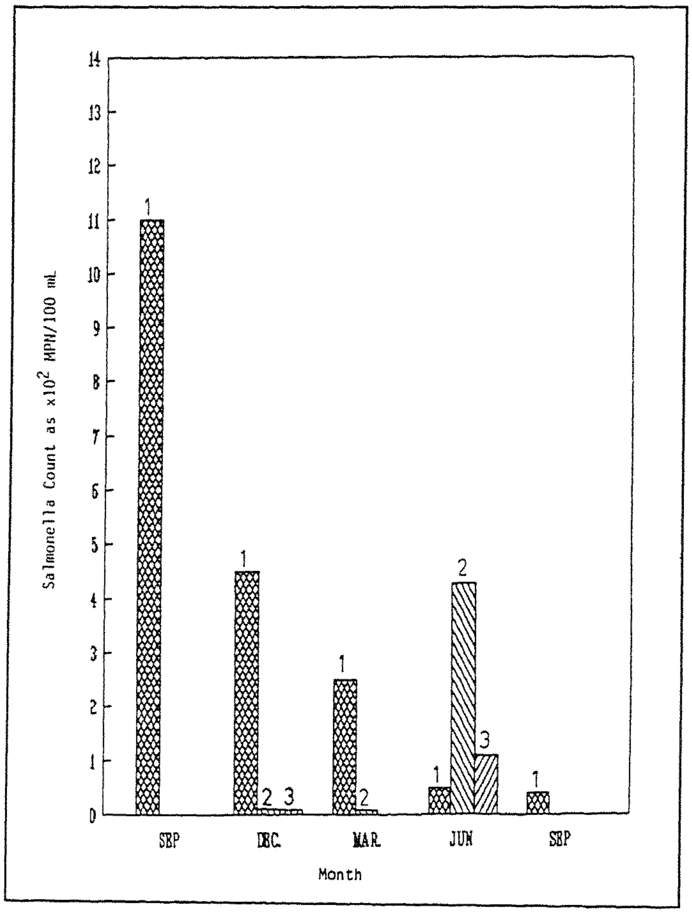

Figure 2: Seasonal variations in the density of Salmonella spp. at the three stations in Shatin Sewage Treatment Plant

Figure 1 shows the variation in the geometric mean bacterial counts for TC, FC, EC, FS and FCL in the 3 types of sewage sample, Table 1 shows these geometric means together with the ranges obtained and Table 2 shows the reduction percentages for these bacterial counts from STP1 to STP2, STP2 to STP3 and STP1 to STP3. Figure 2 shows the seasonal variation in *Salmonella* spp. density in the 3 sample types over the same 1 year period. Thus, unlike the other groups, which were present on all occasions, whereas *Salmonella* spp. were recovered on all 5 sampling visits at STP1; they only occurred on 3 occasions at STP2 and on 2 occasions at STP3. Levels varied from 1100 to 40 with a mean value of 181 per 100 mL at STP1; from 430 to 9 with a mean of 10.9 per 100 mL at STP 2; and from 110 to 9 with a mean of 6.0 per 100 mL at STP3.

Table 3 presents data concerning the percentage reduction of various physical and chemical parameters during the treatment process to allow comparison with the appropriate bacterial reductions. The data used to calculate these percentage reductions were provided by the staff of the Shatin Sewage Treatment Plant from their regular monitoring programme. BOD_5, COD, TSS and organic N showed a decrease throughout the treatment process, whereas NH_3-N and total P increased during primary treatment but fell during secondary treatment. Orthophosphate P was the factor which stood out, in that its levels were higher in the final effluent than in the incoming effluent.

Table 3: *Mean values of, and reduction percentages for, various chemical and physical parameters at Shatin Sewage Treatment Plant*

Parameter	Mean Values (mg L^{-1})			Reduction Percentages		
	STP1	STP2	STP3	Primary Treatment	Secondary Treatment	Overall
BOD_5	233.6	162 0	8 0	30 6	95 0	96 6
COD	511 4	350 0	64 4	31.6	81 6	87 4
TSS	213 6	101 4	17 4	52 5	82 8	91 8
NH_3-N	26.7	30 5	2 0	(14 2)*	93 4	92.5
Org-N	12 1	10.4	2 5	14 0	76 0	79 3
Ortho-P	3 7	4.2	4 1	(13 5)	2 4	(10 8)
Total P	5.7	6 0	4 9	(5 3)	18 3	14.0

* Bracketed figures represent % increases

DISCUSSION

During treatment, the overall percentage reduction in BOD_5 levels was 96.58%, in TSS it was 91.85% and in NH_3-N it was 92.51%. Reductions in these factors indicate that the process was working quite well during the period of this study. In passing, it is worthy of note that neither orthophosphate nor total phosphate show significant reduction at the Shatin Sewage Treatment Plant.

TC, FC and EC means were higher at STP2 than at STP1 before decreasing again at STP3, whereas FS, FCL and SAL means decreased from STP1 to STP2 to STP3. Thus, in the case of the first group, reduction percentages were negative for primary treatment, that is, numbers actually increased during primary treatment Even in the latter group, FS reduction was only 21.4% and FCL only 59.1% during primary treatment. Only in the case of SAL was primary treatment really effective (94%). This is an even higher value than the 73 and 79% observed in two treatment plants during primary settlement[7]. These authors noted that the removal of salmonellas during primary settling was highly correlated ($r = 0.65$, $P < 0\ 001$) with the removal of suspended solids. However, in the present study, salmonella reduction was 94% whereas TSS reduction was only 52.5%.

Although large variations can be expected in microbial densities during sewage treatment[1] and more samples are necessary to ensure representative results, it can be seen that primary treatment is not particularly effective in removing most bacteria. This agrees with the findings of previous workers[4,8,9,10]. Miescier & Cabelli[10] suggest that TC, FC and EC are capable of multiplying during the primary sedimentation process and this explains their increase during this stage.

Secondary treatment (in this case the activated sludge process) is more promising in terms of microbial reduction, except in the case of *Salmonella*. For the latter, it was only 55% (but, primary reduction in this case was by far the highest at 94%), whereas for the other 5 bacterial groups it ranged between 96.5% (FCL) and 99.7% (TC). Again, this agrees with results obtained elsewhere, in that values of 92% reduction for TC and 99% reduction for TC and FC have been obtained in activated sludge plants in Japan[11] and Bahrain[12] respectively.

The overall reduction of TC, FC, EC, FS and FCL at this treatment plant ranged from 99.4% for FC to 99.7% for FS. Again, these results are comparable to those of similar studies elsewhere[10,11,12] as well as to results obtained in another treatment plant in Hong Kong[13]. The value of 96.7% for reduction of salmonellas is again comparable to the result of Yaziz and Lloyd[7], which varied between 93 and 99%, and slightly higher than the value of 90% obtained by Kayser and Muller[14] in a one step activated sludge plant.

This result seems to be excellent, particularly bearing in mind the fact that this type of sewage treatment facility is aimed at meeting chemical and physical standards rather than reduced microbial density. On several occasions, 100% reduction was obtained for some bacterial groups. However, a closer look at the data reveals certain public health concerns with the bacteriological quality of the final effluent. Although some 96.7 to 99.7% bacterial reduction is achieved, the final effluent still contains a considerable number of faecal bacteria. Thus, some $6x10^4$ *E. coli* and $2.2x10^4$ faecal streptococii are still present in each 100 mL of final effluent and the pathogenic bacteria *Salmonella* spp. were recovered from 2 of the 5 final effluent samples.

These bacterial levels in the final effluent may be considered as low, since they will be diluted after discharge into the aquatic environment. However, bearing in mind the total volume of discharge involved (about 111500 m^3 per day), the fact that it does not meet the bacteriological water quality objective for effluent discharge into Tolo Harbour (*E. coli* < 1000/100 mL), and the fact that Tolo Harbour is already grossly polluted[15-19], there is cause for concern.

Disinfection of final sewage effluent is not a common practice in Hong Kong, despite the fact that studies have shown how effective disinfection can be in reducing much of the bacterial load. In view of the deteriorating conditions in Hong Kong's marine water quality, it has been suggested that such action should be considered. However, the National Rivers Authority in the United Kingdom has just announced strict curbs on the use of chemical disinfections in sewage treatment plants because, although they kill coliform bacteria, they do not kill salmonellas and viruses. Conversely, they are seen as adding to the cocktail of chemicals already present in sewage. Thus, before disinfection is used, disinfectants have to be found which are active against salmonellas and viruses but harmless to plants and animals, and which do not accumulate in the bodies of marine organisms.

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TREATMENT AND PREVENTION OF ENVIRONMENTAL POLLUTION IN THE PHILIPPINES

EM De Jesus
Polytechnic University of the Philippines

BACKGROUND

Pollution control has been one of the primary concerns of governments throughout the world. In the Philippines, various measures have been implemented to ensure a safe and pollution-free environment but results have yet to be seen. As more calamities, both natural and man-made, continue to wreak havoc on the human population, the need to take steps to minimize threats to human life becomes all the more urgent.

In the Philippines, as in many other countries, the issue of environmental pollution is an issue of policies. Despite government's attempts to raise consciousness on environmental pollution matters, control has been difficult to implement because other related issues remain unresolved.

THE KEY ISSUES

One major problem is overpopulation. According to the population Institute of the Philippines, the country's population was about 62 million in 1990, and is growing at a rate of 2.4% annually: At this rate, the Philippines population is expected to double by the year 2019. The situation has strained the government's capability to provide the people basic services such as food, clothing and shelter, education and health care. The critical issue therefore is to balance population size with available resources or, more precisely, the rate of population growth in relation to the capacity of the economy to provide the basic needs of the populace.

The key issue involves the need to curb rapid population growth which leads to a decline in the quality of life for the majority. In relation to this, the government must also address the problem of slums, since congestion in the urban areas has resulted in environmental degradation.

Current efforts to stem the high rate of population growth centre around the integration of population education into school curricula at all levels. More significant is the effort to conduct family planning services in order to increase awareness concerning the importance of population control.

Another key issue in pollution control revolves around the country's forest reserves. According to the Department of Environment and Natural Resources Secretary Fulgencio Factoran, about 75% of the country's land area of about 30 million hectares was forested in 1945. In 1976, only half of these forests remained. In 1991, less than a million hectares of old growth forest remained in the country. The Philippines is losing an average of 100,000 hectares a year due to illegal logging, burn agriculture and forest fires

The fast eradication of forest reserves has resulted in severe soil erosion. Degradation of forest lands due to logging and poor enforcement of forest protection have cost the country much in terms of loss of property and life during typhoons and floods.

The present program to replenish loss of forest reserves includes an intensified campaign to plant trees and protect existing resources.

DISPOSAL OF INDUSTRIAL WASTES AND HOUSEHOLD WASTES

In 1990, about 25 million or nearly half of the national population was residing in urban areas. By the year 2000, this is expected to increase by 40%. In Metro Manila, 7 million of the total population crowd on 636 km^2 of land. With a population that is increasing at a rate of 3.6% annually, Metro Manila will soon be one of the mega cities of the world with a population of 11 million. Solid wastes and garbage find their way into the river system through open canals. Metro Manila generates about 3,600 tons of garbage per day and this is expected to reach more than 5,000 tons per day by the year 2000. In Metro Manila, 69% of the country's 15,000 industrial firms are located. Most of them emit toxic substances and their waste water is also discharged into rivers, lakes or estuaries. These wastes account for 30% of the organic pollutants that have killed Metro Manila's water systems.

POLLUTION CONTROL IN THE PHILIPPINES

The country is now facing the dilemma of how to manage and rehabilitate the environment, specifically on how to maximize the utilization of its natural resources. The government is always seeking new techniques which can be applied to increase production while simultaneously conserving and preserving the natural environment in order to maintain a balanced ecosystem. The Department of Environment and Natural Resources (DENR) is specifically given the task of integrating environmental considerations with decision-making.

In the Philippines, the most commonly applied instrument for pollution control is called the "end-of-pipe" control system. This attempts to limit waste products through setting standards for permissible emission rates. Residual management looks at the pollution problem within a framework of materials policy which includes resource recovery, recycling, and appropriate by-product design that saves on materials and energy.

Recently, several measures have been adopted to integrate into industrial process designs the reduction of waste and restrictions on waste disposal. More firms are now reformulating products, developing saleable by-products from residuals and redesigning or combining processes aimed at cutting costs as well as reducing wastes. One firm, for example, was able to reduce wastes by 66% by cutting back water use by 33%. Moreover, the technique of resource recovery has proven to be economical due to the increasing costs of new materials and energy. Paper, glass, metals and other materials are recovered from waste streams and recycled by networks of workers.

The government has also strengthened the laws of pollution control: Republic Act No. 6969 was passed to control toxic substances and hazardous nuclear wastes and provides penalties for violations. Other policy instruments such as the use of economic incentives to encourage pollutive firms to install pollution control facilities, and collective action such as the installation of central collection and treatment facilities for waste-waters are needed to supplement current enforcement efforts.

The DENR has taken into consideration several key issues in relation to pollution control:

a. pollution from industrial effluents;
b. solid waste disposal by domestic, commercial and industrial establishments;
c. air pollution from gasoline/diesel-fuelled vehicles and industrial establishments; and
d. population migration to urban areas.

The DENR in cooperation with other government agencies and the private sector (including non-governmental organizations) is currently undertaking a river revival program called the "Irog ko, Irog ko" project. This is aimed at lowering the pollution load of the Navotas-Malabon-Tenejeros-Tullahan river system. By 1992, the DENR is committed to lowering the industrial pollution load by 60%. The National Housing Authority (NHA) is also committed to the removal of all the squatter shanties along the 26 kilometer waterway and to the relocation of the population outside the basin, thus lowering the pollution load in 1992 by 50%. This is through the installation of sewerage collection and a marine outfall at a total cost of US$238.8 million.

The current efforts for air quality management in urban regions are particularly addressed to Metro Manila. Other urban growth centers, however, have already started (and, in some cases, are stepping up) their air pollution control programs. At present vehicle exhaust emission is the most pressing air pollution problem. Activities being implemented to alleviate the situation are stepped-up efforts to enforce the anti smoke-belching law and educational campaigns to raise the level of awareness of motorists and the general public to the air pollution problem.

In general, research is continuously being done to establish or update environmental quality standards and to provide supportive laboratory services and assistance to industry to aid them in complying with pollution control requirements.

More important is the recent call for the planting of hundreds of millions of trees to increase the capacity of the ecosystem to absorb carbon dioxide and the other greenhouse gases being discharged into the atmosphere everyday by fossil burning motor vehicles and industrial facilities.

The government has encouraged the population to participate in the drive - not only to reduce risks to health - but also to ensure that the next generation can enjoy nature's bounties.

SUMMARY

The current pollution problem is a product of several root causes - foremost amongst which are the rapid population growth and the fast depletion of forest resources. The government has been addressing both problems, although these efforts seem to have had little effect. The question remains as to how the country can cope with the problem of the disposal of industrial wastes and household wastes.

The country is now facing the dilemma of how to manage and rehabilitate the environment, specifically of how to maximize the use of its natural resources. Techniques have been applied to increase production while conserving and preserving the natural environment in order to maintain a balanced ecosystem.

Several measures were adopted to integrate into industrial process designs the reduction of waste and restrictions on its disposal. More firms are now adopting the technique of resource recovery which has proven to be economical due to the increasing costs of new materials and energy. The government has also strengthened the laws of pollution control and, through the DENR, has continued to impose strict compliance with these laws. It has also embarked on efforts to restore safety and assure the minimization of pollutants in, and hazards to, the environment.

MICROBIOLOGICAL STUDIES OF SHELLFISH AND WATER QUALITY IN DEEP BAY, HONG KONG

CSW Kueh
Environmental Protection Department, Government of Hong Kong

INTRODUCTION

Bivalve shellfish have been implicated in a number of human infections many of which are related to pollution of shellfish-growing waters. These include viral hepatitis, gastroenteritis, systemic illnesses and septicemia[1]. The aetiological agents are those derived from human and animal wastes, such as *Salmonella, Shigella, Campylobacter* species, hepatitis A and Norwalk viruses, or those growing in natural waters including *Vibrio parahaemolyticus, Vibrio cholerae, Aeromonas* spp. and the recently discovered *Vibrio vulnificus* which results in a mortality as high as 50% of affected individuals.

Hong Kong's inshore waters are subject to various degrees of pollution, and enteric pathogens have been found in local oysters and clams[2,3]. Vibrios, including the pathogenic species, occur frequently and often in large numbers in seawater and seafood sold in the market[4,5].

Bacteriological analysis of marine water quality, including shellfish-harvesting areas, is mostly based on coliform indices which do not adequately reflect the level of pathogens in the shellfish. A microbiological study is being undertaken to monitor faecal and aquatic pathogens in the water and shellfish of Deep Bay, an oyster-culture area in Hong Kong. The study includes identifying Deep Bay's major pollution sources and conducting laboratory depuration experiments to reduce the level of pathogens in shellfish. This paper reports the preliminary findings of the first phase of the study.

MATERIALS AND METHODS

Water quality sampling: This comprises monthly monitoring of surface water quality at four stations (DM1-DM4) in Deep Bay (Figure 1). In addition, bottom water samples from stations DM3 and DM4 (oyster-culture areas) were collected for analysis. Turbidity was measured with a Hach 16800 turbidimeter, salinity with a Seacat SBE-19-03, and faecal coliforms and *E. coli* were analysed using an Environmental Protection Department devised method[6].

Pathogen sampling: Water samples collected monthly from DM1 and DM3 were tested for 6 pathogenic bacteria, namely *Salmonella* spp., *Shigella sonnei*, *Shigella* spp., *V. parahaemolyticus, V. cholerae* and *V. vulnificus*. Oysters and sediments from DM3 were also analysed for the same 6 pathogens.

Pathogen analyses: Water samples were first filtered through 0.45 μm pore size Millipore membranes. Eighteen to twenty oysters (without shell liquor) were pooled and homogenized and sediment samples were thoroughly mixed in phosphate buffer saline before analyses were carried out. Bacteria were enumerated using the MPN method with standard media and identification was done using the Vitek System and other biochemical and serological tests[7-10].

Oyster depuration experiments: Oysters were placed in 1.82 m x 0.76 m x 0.15 m tanks with filtered water flowing through a 20 watt UV unit at a rate of 4.5 $L.min^{-1}$. Water temperature was maintained at 17-20°C, salinity 17-22‰ and dissolved O_2 above 60% saturation. Eighteen to twenty oysters were removed each day for bacteriological analysis.

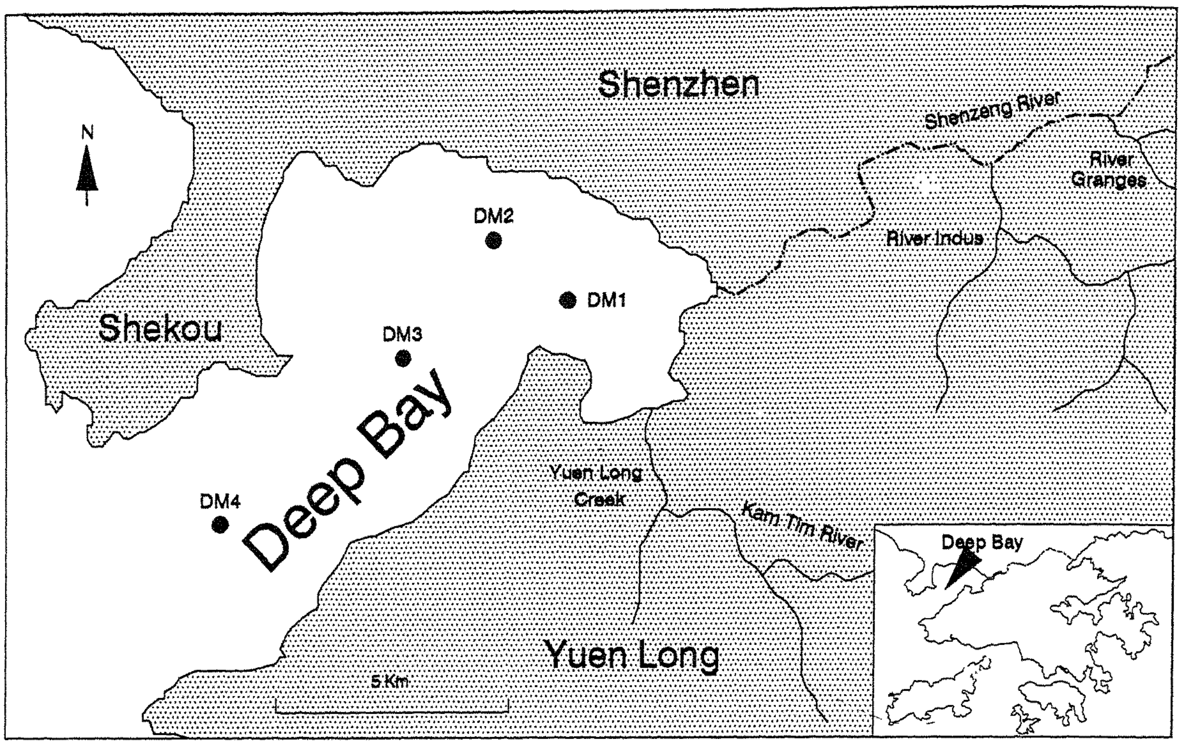

Figure 1: Map of Deep Bay showing sampling stations and major river tributaries.

RESULTS AND DISCUSSION

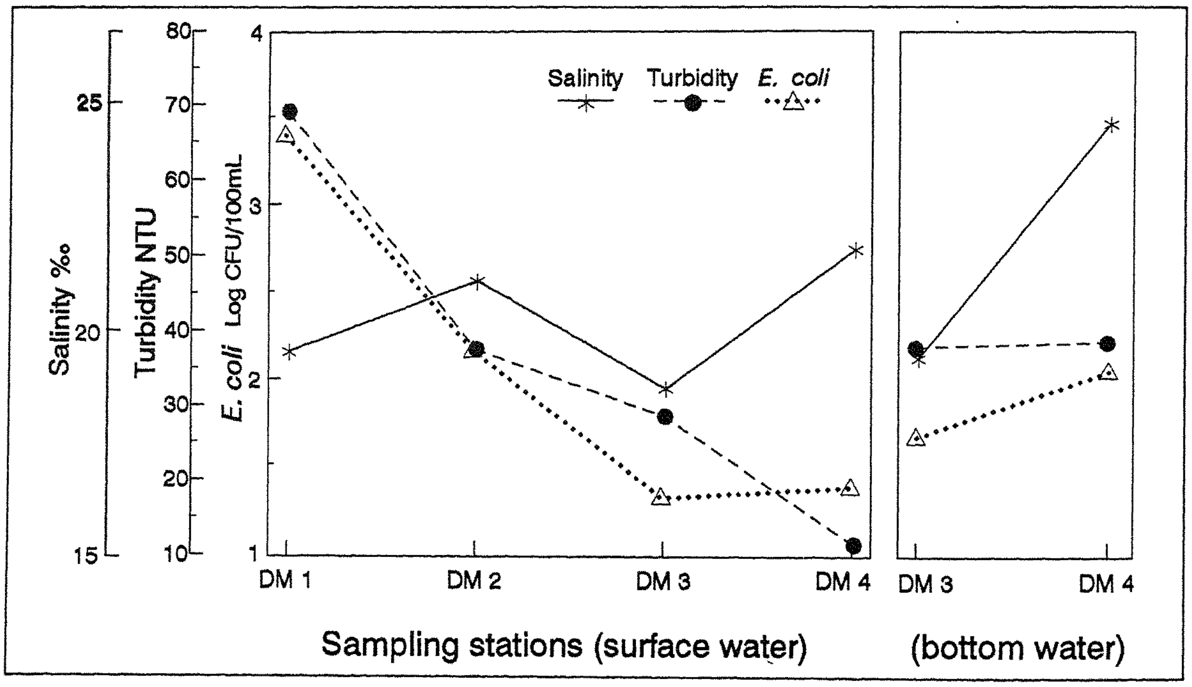

Figure 2: Water quality of Deep Bay (Jan 1990 - Dec 1991).

Deep Bay water quality: The water quality profile of Deep Bay for 1990-91 indicates that surface water at station DM1, where the Yuen Long Creek and Shenzhen River enter Deep Bay, was slightly less saline but more turbid and contained a higher concentration of *E. coli* than that at stations DM3 and DM4 (Figure 2). Pathogenic bacteria including *V. parahaemolyticus*, non-01 *V. cholerae*, *Salmonella* spp. and *V. vulnificus* at station DM1 were also more numerous than at station DM3 (Figure 3). Slow tidal exchange and input from the rivers possibly contributed to the poor bacteriological water quality at the inner end of Deep bay.

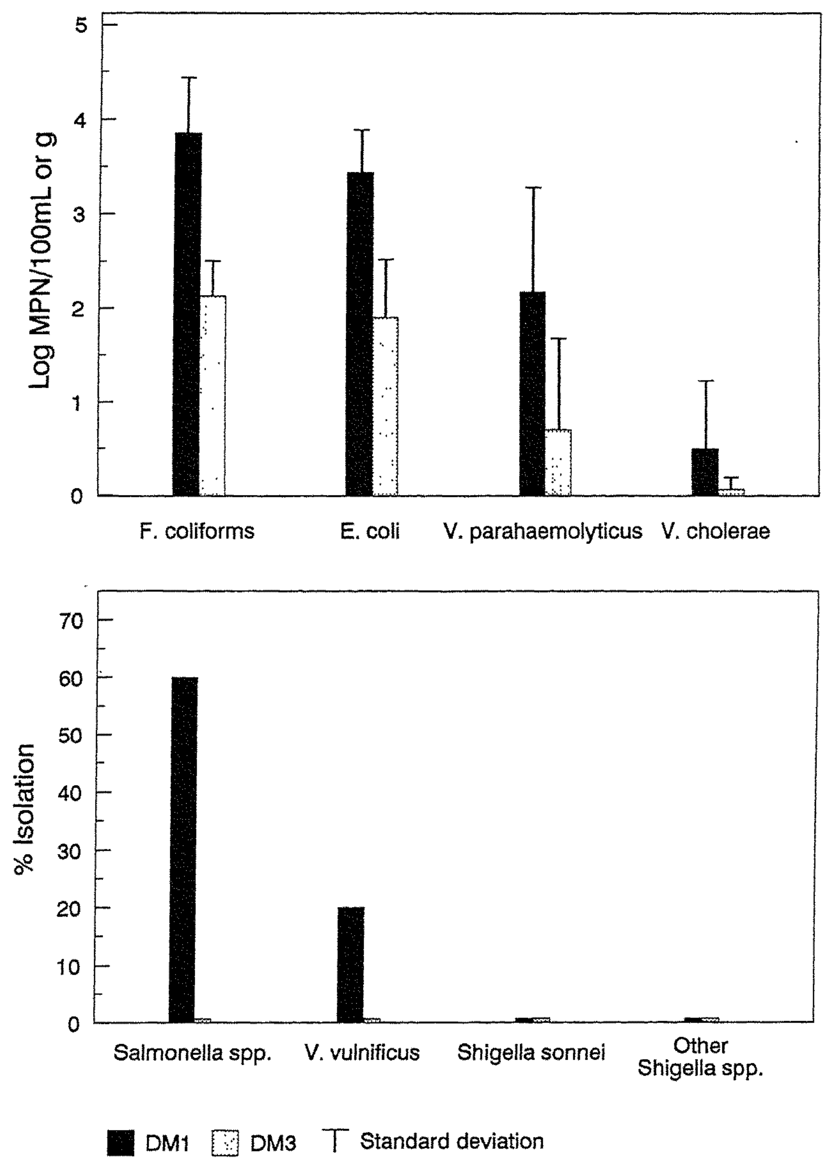

Figure 3: *Bacterial content of water at stations DM1 and DM3 in Deep Bay (Oct 1991 - Feb 1992).*

Routine river monitoring data[11] reveal that the water quality of the Ganges and Indus, which join the upper Shenzhen River, is poor due to pollution by livestock waste, domestic sewage and agricultural runoff. Suspended solids of the two rivers were around 40 $mg.L^{-1}$ and *E. coli* was 10^5-10^6 per 100 mL. Yuen Long Creek receives flows from the Kam Tim River, and passes through Yuen Long town and a number of villages and housing developments. Its flow is large and the bacterial content is also comparable to the other two rivers.

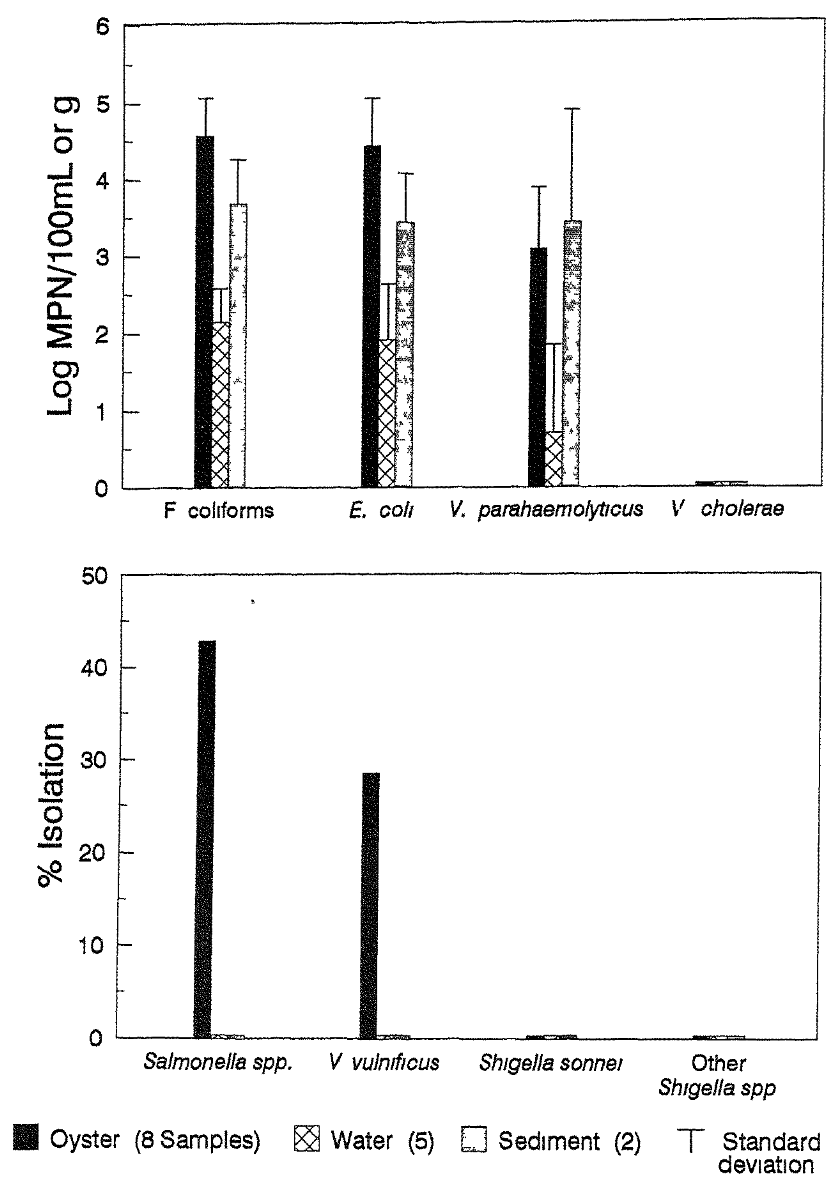

Figure 4: Bacterial content of oysters, water and sediments at station DM3 in Deep Bay (Sept 1991 - Feb 1992)

Effect of sediments: Bottom sediments may be an important source of bacterial contamination in Deep Bay. The study shows that bottom water at stations DM3 and DM4 contained more *E. coli* and suspended solids than surface water (Figure 1) Salinity near the bottom, however, was higher, suggesting that water at these stations was stratified Faecal coliform, *E. coli* and *V. parahaemolyticus* numbers in the sediments of DM 3 were high (Figure 4). Resuspension of fine particles from the muddy bottom is likely to occur readily in Deep Bay due to wind, current and tidal flushing and so pathogenic bacteria present in the sediments may reenter the water column and be taken up by oysters hanging from the culture rafts

Shellfish quality: The faecal coliform and *E. coli* contents of Deep Bay oysters were around 10^4 per 100 gram of flesh, that is, above the World Health Organization and United Nations Environmental Programme Interim Criteria for the sale of shellfish[12].

Pathogenic bacterial numbers in the oysters were 1-3 orders of magnitude higher than those in the water. The species detected included *Salmonella* spp., *V parahaemolyticus, V. cholerae* and *V. vulnificus* (Figure 4). No *Shigella* has been isolated from the oysters, water or sediment in Deep Bay so far. *Salmonella* is a common cause of gastroenteritis in Hong Kong, and it is frequently found in the faeces of man and a variety of animals. The number of *V. parahaemolyticus* in oysters in high, approaching that which can induce illnesses in healthy individuals[1]. None of the *V. cholerae* isolated were the epidemic 01 strains responsible for the classic cases of cholera; however, the non-01 strains may also cause gastroenteritis and wound infections *V vulnificus* was detected in as many as 20% of the samples. As infections caused by *V. vulnificus* can often be fatal, its presence, even in small numbers, signifies a health risk to consumers, particularly the elderly, the immunocompromised and those with diabetes and underlying liver diseases[13].

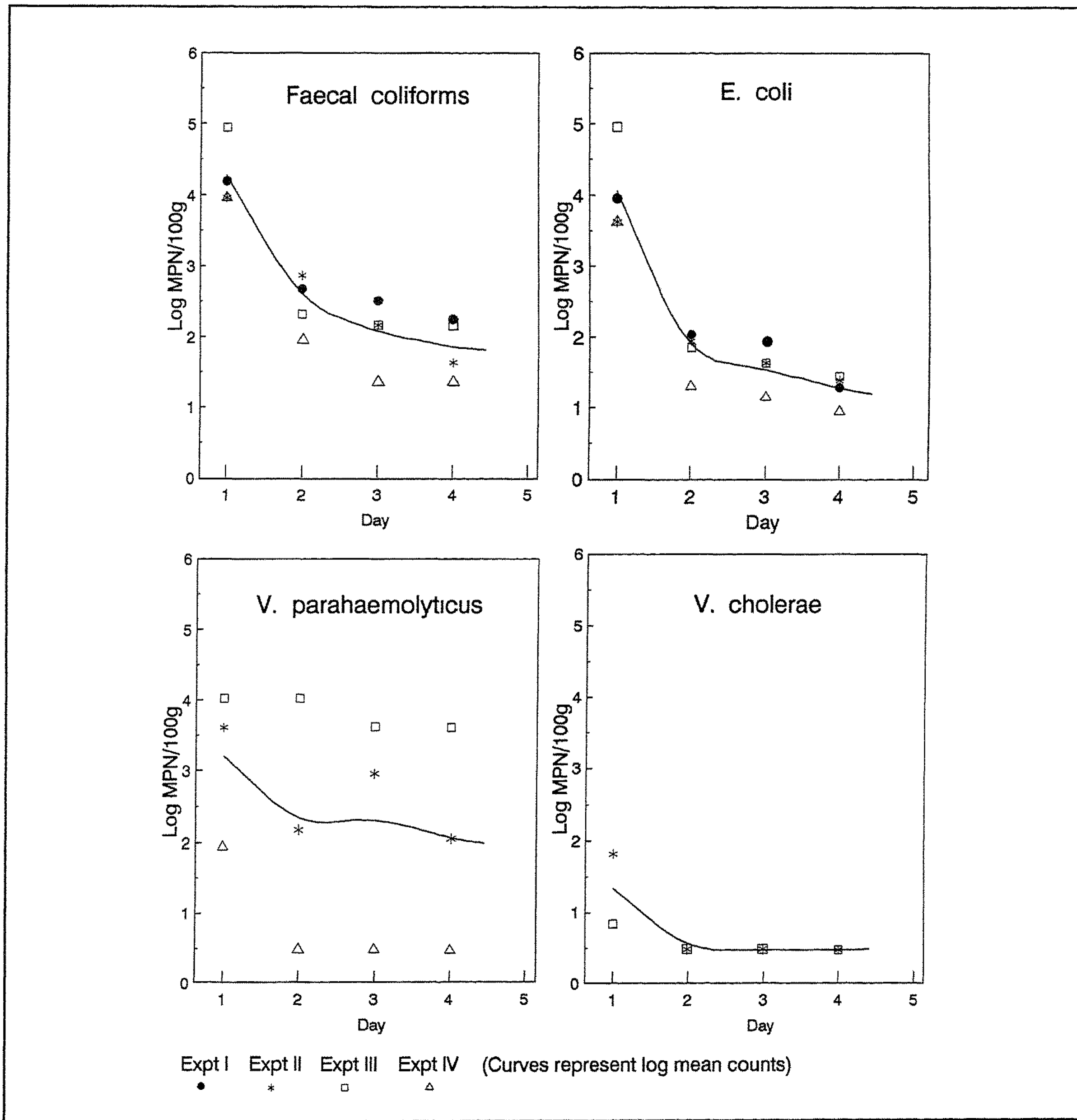

Figure 5: *Removal of bacteria from Deep Bay oysters using the UV depuration system (temperature 18°C, salinity 20‰).*

Shellfish depuration Relaying contaminated shellfish in clean natural seawater would not be a viable depuration option in Hong Kong because of the lack of suitable "unpolluted" and accessible estuarine sites However, preliminary results from laboratory depuration studies using UV-disinfected water offer some promise Faecal coliforms and *E coli* were reduced by about 10^2 per 100 g and *V cholerae* to a minimum level in 2 days (Figure 5) *V vulnificus* and *Salmonella* spp were also undetectable after the treatment

By comparison, the elimination of *V parahaemolyticus* was less satisfactory and the microorganism sometimes persisted in the oysters after 3 consecutive days of depuration It is possible that as an estuarine species, *V parahaemolyticus* might have multiplied within the depuration tank and became a constant source of inoculum for the oysters The problem may be more acute at higher temperatures where the microorganism are known to proliferate more rapidly Chan et al[5] observed that nearly 30% of the *V parahaemolyticus* found in local seafood possess haemolytic toxins. It is not known whether those strains present in depuration tanks were as toxic as those in oysters harvested from the field

The present work is continuing and data from the next phase of the study should reveal the variability, seasonal effects and impact of major pollution sources on the pathogen content of the oysters and water in Deep Bay The depuration system will need to be tested under a variety of operating conditions Regrowth of bacteria such as the vibrios in the depuration water will have to be controlled in order for the system to work effectively

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ENVIRONMENTAL DETERIORATION IN GREATER BANGKOK, THAILAND

Y Paraken
Faculty of Engineering, The University of the Thai Chamber of Commerce

INTRODUCTION

At the end of World War II (1945) the population of Thailand was only 18 million. People enjoyed living the old Thai life style, with both good physical and mental health. The most well known insecticide was DDT and this was quite popular among well to do families, who were not aware of the long term effects.

At this time, the land was fertile, the sea and sky were blue and Thailand's waters were rich in fish. People enjoyed hunting wildlife and the forests remained thick and green. Every water source could be used for fishing, swimming, cooking and drinking.

Over the past 47 years this life style has completely changed. Thailand, like many countries, has been rushing to upgrade the standard of living by investing capital in research and development. The competition has been speeding up to full momentum as new technologies have been invented. But it seems that "the more we gain the more we loose" and the word "POLLUTION" can now be written in the dictionary in capital letters.

CONTRADICTION OF BEING A NIC

In Thailand, as in many countries, the population boom is the first obstacle to be encountered. Industrial growth is mostly concentrated around big cities, like Bangkok, and the consequence is the migration of people from different parts of the country in search of better jobs and with the dream of a bright future. Some are successful and some meet failure. Whichever the case, residential problems have arisen and sky scrapers as well as slums are booming in parallel with each other. Transportation growth has resulted in vehicles producing uncontrolled poisonous exhaust gases. The Chao Phya River has become the sink for industrial and public wastes, including insecticides from the paddy fields and orchards. "The Office of the National Environment Board - ONEB" was established in 1975 in an attempt to solve pollution problems. The toughest problem it has to face is the indiscipline of the public. At present, the total population of Thailand is 56 million, of which 6 million dwell in Bangkok. The ONEB has tried its best to restore the green areas of the nation, but so far it has not achieved great success. The forest is being destroyed continuously despite the strong measures that have been imposed (Table 1). In 1992 the National Assembly amended the environmental protection law and this will be enforced soon.

THE PROBLEMS OF GREATER BANGKOK

We can consider these problems under three major subheadings:

1. Land
2. Water
3. Air

1. **Land:** Bangkok is located in the most perfect strategic geographic location for both cultivation and transportation. The long history and life style of the Thai people has depended on agriculture and Bangkok was named "The Venice of the East". Now the canals are converted to roads for transportation.

The first motor cycle was brought to Thailand in 1904 and the asphalt road in 1916. In those days, the green land remained intact. Forty years later, the economic status has changed and the land owners, mostly farmers, have become poorer. This has provided golden opportunities for the business sector to purchase the lower priced land and build high price apartments, supermarkets or skyscrapers. The green areas, which once used to be the lungs of the public, have perished.

2. **Water:** The Chao Phya River plays various important roles for Bangkok's dwellers - for cultivation, transportation, metropolitan waterworks, etc. As the population on both banks has increased, so the Chao Phya River has had to bear a heavy burden from the wastes of factories, the public, paddy fields, orchards, etc. Metropolitan Bangkok has tried its best to stop pollution, and has been successful to some extent.

3. **Air:** Since the green areas are diminishing, this means a reduction in clean fresh air. Transportation in Bangkok, mostly motor cars, motor cycles and public buses, is powered by either diesel or gasoline engines. Due to the dense population, traffic congestion is common during rush hours. Carbon dioxide, carbon monoxide and noise emitted by these vehicles increase the pollution and worsen the situation.

Table 1: *A comparison of changes in forest area (Km²) in different regions of Thailand between 1976 and 1989*

Region	Total area[1]	National forest reserve[2]	Forest area [and, in brackets the % of total area represented] 1976[3]	1978[4]	1982[5]	1985[6]	1988[7]	1989[8]
North	169,644.288	114,209	102,327 [60.32]	94,937 [55.96]	87,756 [51.73]	84,126 [49.59]	80,402 [47.39]	80,222 [47.29]
East	36,502.500	14,475	12,631 [34 60]	11,037 [30.24]	8,000 [21.92]	7,990 [21.89]	7,834 [21.46]	7,786 [21.33]
North east	168,854.333	55,089	41,494 [24 57]	31,221 [18.49]	25,886 [15.33]	25,580 [15.15]	23,693 [14.03]	23,586 [13.97]
Central	67,398 703	20,448	21,826 [32 38]	20,426 [30.31]	18,516 [27.47]	17,685 [26.24]	17,244 [25.59]	17,223 [25.55]
South	70,715.187	28,172	20,139 [28.48]	17,603 [24.89]	16,442 [23 25]	15,485 [21.90]	14,630 [20.69]	14,600 [20.65]
Total	513,115.011	232,393	198,417 [38.67]	175,224 [34.15]	156,600 [30.52]	150,866 [29.40]	143,803 [28.03]	143,417 [27.95]

Data from: (1) Ordnance Survey maps; (2) Maps published in the Government Gazette; (3) and (4) Landsat - 2; (5) Landsat -3 and 4, (6) and (7) Landsat - 4 and 5, and (8) Landsat - TM. Courtesy of the Remote Sensing Sub-Division, Forestry Management Division, Royal Forest Department, Thailand.

CONCLUSIONS

In order to restore as far as possible the natural environment or at least minimize the damage done, various suggestions can be made as follows:

1. The authorities concerned have to perform their duties efficiently.
2. The law should be enforced with stronger measures.
3. There should be more publicity in all media.
4. There should be a pollution monitoring center to warn the public concerning environmental hazards.
5. Since it is a global problem, every country should join hands in the fight against pollution and the industrialised countries must be a spearhead for these activities.

THE "POLLUTER PAYS PRINCIPLE": THE DISTRIBUTION OF ECONOMIC IMPACTS

KA Rahim
Faculty of Economics and Management, Universiti Pertanian Malaysia

INTRODUCTION

Vigorous environmental control is generally presumed to be 'bad' for an economy in the international arena, in that it is disadvantageous for the competitive position of domestic producers who have to compete with goods in export markets and with imports for the home market. As pollution control pushes up domestic prices relative to foreign prices, so the argument goes, the volume of exports is bound to drop while the volume of imports is bound to rise, and this will adversely influence the nation's balance of trade and balance of payments. This is fine in theory, and permits the formulation of some reasonably coherent cause and effect relationships that can serve as the basis for prediction. But it is not necessarily the way the world works, and the techniques which nations use to implement environmental policy are of central importance in gauging its international economic consequences.

Effluent charges are only one of the instruments available for pollution control, and together with enforcement of standards are categorised under the 'polluter pays principle' (PPP), which has been accepted by member countries of the Organisation for Economic Cooperation and Development (O.E.C.D.) as the most appropriate implementation framework. The document formalising acceptance of the PPP in the O.E.C.D. states quite explicitly:

> This principle means that the polluter should bear the expenses of carrying out ... measures decided by public authorities to ensure that the environment is in an acceptable state. In other words, the cost of these measures should be reflected in the cost of goods and services which cause pollution in production and/or consumption. Such measures should not be accompanied by subsidies that would create significant distortions in international trade and investment.

A number of issues dealing with equity and cost allocation, however, suggests that the PPP will not be observed if competing national priorities such as income redistribution and regional development are to be met as well. Under the PPP, the cost of internalising environmental externalities is at least partly passed forward to consumers of final products, in proportion to their direct and indirect expenditures on those products. The ability to pass forward environmental-control costs depends largely on the relevant price elasticities of demand and supply.

The equity dimension of the PPP becomes even more complex when suppliers of productive factors are considered. The burden of pollution controls may not only be passed forward onto the consumers, it can also be shifted backwards onto the various factors of production in the form of reduced earnings. Despite their potential significance, these backward incidences have received little attention in the literature.

METHODOLOGY

In an open, trade-dependent economy, changes in the export demand for products are linked to corresponding changes in the demand for the factors of production and intermediate inputs. Until recently, trade and resource theories have not been integrated and there are few, if any, attempts to develop empirically useful integrated models. With growing international trade, the need to study the effects of a domestic policy in an open economy has taken on new urgency. This is one of few efforts to quantify the effects of environmental regulation in an open economy. The theoretical and empirical models highlight the analytical treatment of both multiple product production processes and a multiple sector industry, with regulations imposed on an intermediate sector. The methodology employs dual models to derive demand and supply functions and uses theoretically consistent functional forms for estimation.

THE CASE OF MALAYSIAN PALM OIL

Malaysia is one of the few trade-dependent industrializing nations to move decisively against pollution in a key export industry. The economic consequences are instructive for other industrializing nations which have been more reluctant, fearing serious economic losses.

In the Malaysian palm oil industry, a clearly defined marketing channel exists: the production of fresh fruit bunches (FFB) - crude palm oil (CPO) - refined palm oil (RPO) to the export of RPO. Such a channel is called a vertical market structure. Thus, an environmental policy in the CPO sector can affect RPO and FFB sectors substantially. An export duty on RPO would clearly affect the domestic CPO prices and hence profits of the refiners. Similarly, an agricultural policy encouraging the increase in the planting of oil palms would increase the supply of fruits affecting the prices of FFB, CPO and RPO in different directions. In such cases, a policy change involved in one market can obviously transmit important economic consequences to others. This research demonstrates the use of such a vertically related market model for a more integrated analysis of the production structure than has been possible by traditional piece-meal approaches.

The model consists of equations describing the output supply and resource demand functions and each contains more than one endogenous variable in each sector. In the presence of this simultaneity, three-stage least squares (3SLS) are used that are consistent, asymptotically normally distributed, and asymptotically efficient in the complete system.

RESULTS AND DISCUSSION

The RPO sector: The quantity of RPO supplied depends positively on the price of RPO. However, more significant are the past quantity of production, past RPO price and current CPO price. Other input prices, such as the wage rate and the price of capital, are not significant in influencing the supply of RPO. The RPO supply elasticity derived from this estimate is a low 0.844 at the means of current price and quantity (Table 1).

Table 1: *Price elasticity estimates, 1982-1986 (calculated from parameter estimates using mean annual values of price and quantity for the year)*

	Year					
	1982	1983	1984	1985	1986	Mean
RPO Supply	0 881	0 801	1 317	0.998	0 401	0 844
CPO Demand	-0.458	-0 640	-0 742	-0.494	-0.252	-0 502
CPO Supply	0 037	0.052	0 061	0.040	0 021	0.041
FFB Demand	-0.070	-0 107	-0 117	-0.078	-0.037	-0 079

Since CPO is an input in the production of RPO, the quantity of CPO demanded depends on the relative prices of CPO and RPO as well as the relative prices of other inputs. The estimated coefficient on the relative prices of RPO and CPO implies that an increase of M$1 increases the quantity of CPO demanded by 2,714 tonnes. Conversely, an increase in CPO prices reduces the relative RPO/CPO prices leading to a decrease in CPO demand. Based on the reported estimates and samples, the price elasticity of demand for CPO is a low -0.502.

The CPO sector: The quantity of CPO supplied and the production of palm oil mill effluents (POME) as a joint output are significantly affected by past quantity supplied, the capital service price and Biochemical Oxygen Demand (BOD) standards. Wage rates and the current CPO price are not significant in influencing the supply of CPO. However, assuming that the CPO price coefficient is plausible, a M$1 increase in the price of CPO increases the quantity of CPO and palm kernels supplied by only 21 tonnes *ceteris paribus*. An increase of M$1 in the capital service price decreases the quantity of CPO supplied by 570 tonnes. POME is highly correlated with CPO output. Our estimates imply that a tonne of CPO is accompanied by 2.4 tonnes of POME. Increases in BOD limitations increase the cost of CPO production and would decrease the quantity of CPO supplied *ceteris paribus* by 28 tonnes per unit reduction in BOD. This translates into an increase of M$56 per tonne of CPO demanded by the RPO sector.

The quantity of FFB demanded depends significantly on the current FFP price and the quantity of CPO produced. An increase of M$1 in FFB price *ceteris paribus* decreases the quantity of FFB demanded by 735 tonnes using our estimates. This relationship, showing a downward sloping demand, is expected. At the mean quantities and prices values, the price elasticity of demand for FFB is -0.079, which is inelastic. An increase of 1,000 tonnes of CPO produced increases the demand for FFB by 4,064 tonnes. Thus, a reduction of 28 tonnes of CPO per unit reduction in BOD level results in a reduction of 114 tonnes of FFB demanded at each price level. This is translated into a reduction in price of $83.79 per tonne FFB if the supply of FFB does not respond to its demand.

The FFB sector: The price of FFB follows closely the price of CPO. However, FFB price may not necessarily increase when CPO production costs rise due to environmental control. Increasing stringency of CPO pollution control *ceteris paribus* increases the costs of production, increases the CPO price, and decreases the quantity of CPO supplied at equilibrium. Thus, associated with the leftward shift in the supply function for CPO due to pollution control is a leftward shift in the demand for FFB.

Economic losses: Environmental regulations imposed on CPO producers cost FFB producers more in lost economic surpluses than any other sector. The values of production for the three sectors are presented in Table 2. The incremental losses were 9.11% to 29.30% of the respective values of FFB production. Of the total monthly losses by the industry 72.23% was borne by the FFB producers in 1982, 64.54% in 1983 and 66.05% in 1986 (Table 3).

Table 2: *Average monthly values of production (M$'000)*

Year	RPO	CPO	FFB	Total
1982	259,162	224,850	208,365	692,377
1983	295,324	229,744	222,450	747,518
1986	288,686	198,506	164,588	651,780

Table 3: *Economic effects of reducing a unit of BOD*

Year	BOD standards[2] (mg L⁻¹)	Producer welfare effects by sector[1] RPO	CPO	FFB	Total
1982	250	-86.805 (0 033%) [8 37%]	-7 087 (0 003%) [0 79%]	-244.166 (0 117%) [29 30%]	-338.058 (0.049%) [12.21%]
1983	150	-74 197 (0.025%) [2.51%]	-38.047 (0.017%) [1 66%]	-203 510 (0.09%) [9 15%]	-315.754 (0.042%) [4.22%]
1986	50	-109 816 (0 038%) [1.90%]	-44 301 (0 022%) [1.12%]	-299.902 (0.182%) [9.11%]	-454 019 (0.070%) [3 48%]
Cumulative effect of changes from pre-1982 to post- 1986[3]		-18,230 4 (0 011%) [4 7%]	-3,163 1 (0 003%) [1.2%]	-115,945 7 (0.098%) [44.0%]	-137,339.2 (0 037%) [14 8%]

1. Main values are M$'000 per month per unit reduction in BOD from the previous standard Values in ( ) are percentages of total values of production for one unit BOD reduction Values in [ ] are percentages of total values of production for units of BOD reduction as required under the regulation.
2. The baseline for 1982 and the cumulative change is the previous standard of 500 mg/L⁻¹. The 1982 standard is the baseline for the change in 1983, etc
3. Change evaluated at sample mean prices and output quantities.

The incremental losses in CPO producers' surplus due to regulation are small relative to the values of production: only 0.79% of the total monthly value of CPO production in 1982, 1.66% in 1983 and 1.12% in 1986. CPO producers bore only 2.1% of the total loss for the industry in 1982, 12.5% in 1983 and 9.76% in 1986. The losses in RPO producers' surplus represent about 8.37%, 2.51% and 1.90% of the monthly average gross revenue of RPO production in 1982, 1983 and 1986 respectively. RPO producers bore 25.68% of the total monthly losses of the industry in 1982, 23.50% in 1983 and 24.19% in 1986.

CONCLUSION

The demand for the essential factors of production in the Malaysian palm oil industry are highly inelastic with respect to price. Thus, exogenous shocks imposed (such as an environmental policy in the CPO sector as demonstrated in this study) increase the cost of CPO production and, through the shifting of the CPO supply, higher CPO price is borne by the refiners and lower FFB price is paid to the smallholders. Other policies such as increasing FFB production through expansion of oil palm acreages tend to depress FFB price by a larger percentage. This can have a negative impact on the welfare of FFB suppliers, especially the plantation owners. Thus, any policy change along the vertically related marketing channel affects the smallholders. Knowledge of the demand for smallholders' output is important for any policy if it is to increase the welfare of the agricultural population.