1.11 Priorities for Environmental Chemistry in the Asia-Pacific Region

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The large population centres of the Asia-Pacific region now heavily impinge on the region's environment. This impact by Man is immense and, coupled with the limited availability of resources, requires that priorities be set in order to apply adequate controls to manage and preserve such resources. However, such control requires an understanding of pollution processes in the environment before their control can be made adequately. Environmental chemistry plays a key role in the understanding of the pathways and fates of chemicals in the environment (1).

In order to set the kind of priorities described, an initiative led by the Commonwealth Science Council was developed through a process of peer review of proposals from various countries to identify where regional research effort was really needed as distinct from issues of prime interest to the global environment where significant effort may already be applied - eg. global warming and sea-level rise induced by an increase in atmospheric carbon dioxide concentration. Seven components were identified and form Project CREN (Chemical Research and Environmental Needs) (2). These are:

1. Atmospheric acidification.

2. Environmental (chemical) impact of fertiliser use.

3. Gaseous emissions from agricultural sources.

4. Pesticide residues.

5. Chemical transport processes and sediments in rivers.

6. Air Pollution modelling

7. Environmental analytical techniques.

Each component covers a problem area of regional significance. A parallel example of environmental chemistry concerning the complete control of uranium mining at a tropical location in a World Heritage National Park in the Northern Territory, Australia, shows how to pursue development and yet protect the natural environment. Environmental chemistry is seen to play an important role in achieving sustainable development.

Atmospheric Acidification

This component considers the composition and acidity of rainwater in the region taking into account the impact of sulphur, nitrogen and organic acids and their inventories.

The phenomenon of acid rain is now well described in the Northern Hemisphere. Recent observations have shown that large variations in the acidity of rainwater from region to region exist in the tropics. Over continental Australia, rainwater with pH in the range of 8.6 - 4.8 has been observed. Over India, the pH values are most often above 6.9 and similar high values are found at some stations in China. The acidity in tropical rainwater can be partially or completely neutralised by ammonia and alkaline soil dusts entrained in rain. Calcareous material, probably from central Asian deserts, appear to play a major role in determining the pH of rainwater over the Asian continent. Large scale perterbations of the S and N cycles have resulted in significant changes in the Northern Hemisphere. It is therefore of great interest to examine air pollution in industrialised regions and acidification in the tropics.

This project seeks to cooperate with other agencies (3) in producing and circulating reliable deposition data.

Another interesting possibility is the application of the Malaysian Watch Acid Rain Project in other countries. Secondary schools throughout Malaysia collected rainwater during the inter-monsoon period and measured pH using indicator strips. The data was analysed and a contour map of the country compiled (4).

Environmental Impact of Fertilizers

This component considers the effect of fertiliser and fertiliser factory wastes on water quality and utilization of urea factory ammoniated waste water for agricultural use. The project will focus on Bangladesh initiality, being typical of a country requiring urea fertilizer production to assist with an enormous food production requirement.

Bangladesh has five large urea plants in operation with more being planned,. Urea manufacture is based on the reaction of natural gas, air and steam. The process releases pollutants including ammonia. A seminar on the protection of the environment of fertilizer industries and a workshop on environmental chemistry priorities in Bangladesh (5) identified the areas of importance in fertilizer impact. In view of the fact that Bangladesh is covered by a vast surface water area almost throughout the year, water pollution is the most acute problem.

Gaseous Emissions from Agricultural Sources

This component considers trace gas emissions from agricultural wastes and will investigate methane, nitrous oxide and other trace atmospheric gaseous emissions, including those from animal husbandry. Global warming from the increase in greenhouse gases has become a major scientific and political issue during the past decade (6). Methane, nitric oxide and CFCs, although individually less abundant than carbon dioxide, together produce a comparable greenhouse effect.

The major sources of methane include rice paddy fields, enteric fermentation, biomass burning, land fills, coal mining, natural gas flaring, automobiles, swamps, oceans, etc. Of these the increase in emissions from paddy fields and ruminants are closely linked with increasing food production needed to meet growing populations. Research is needed to assess methane emission from cattle (including buffalo and camel) and estimates are scanty on methane from tropical forests and estuaries (mangroves). Less information is available for nitrous oxide than for methane.

Pesticide Residues

This component seeks to identify problem areas with residues in food, soil and water. Though less developed than others in Project CREN it is none the less important. At a meeting held in New Delhi in January 1991, the pesticide programme was discussed and considered to comprise the following:

(i) selection of pesticides of most significance;

(ii) identification of resource people from different countries with a view to preparing a toxicological atlas (ie. one exists for India) giving details of production, amounts of pesticides used and levels in water and foods;

(iii) study of bacteria which degrade organo-chlorine pesticides;

(iv) identifying training centres;

(v) development of appropriate pesticides.

The handling and fate of pesticides has been discussed by McEwan (7). Chemicals may be applied directly to animals to control external parasites or they may be incorporated in feeds or remain in feeds from a use during growth or storage. Plants may be treated at any stage of growth or for storage or transport. Soils may be treated pre-planting and during plant growth for weed or pest control. Formulations and modes of application vary widely. The organo-chlorine pesticides are still the most important pesticide residues in the environment and in animals. DDT remains in use in India for the control of malaria. Due to a wide range of factors it is not possible to be precise about half-lives of pesticides.

Chemical Transport Processes and Sediments

This component deals with the role of sedimentation in the pollution of rivers and oceans in the region by metals, hydrocarbons and pesticides. The parts of the region considered are both from largely populated areas and pristine coastal upstreams and coral reefs of the Indian and Pacific Oceans. Papua New Guinea (PNG) will be a prime site for study.

Water is a major carrier of particulates which can be transported from a disposal site usually in insoluble form but for certain species in dissolved states (8). It is therefore important to understand the phenomena responsible for retarding chemical fluxes and those which are, in contrast, capable of increasing species mobility in order to select disposal sites giving minimum pollution dispersion from the point source.

In spite of their different origin, mine tailings and dredged materials present strong similarities in behaviour and environmental impact (8). At the Ok Tedi gold and copper mine in the western province of PNG, discharge of chemically treated tailings is permitted provided an acceptable level of suspended sediment in the Fly River is not exceeded.

At the Bouganville copper mine on Bouganville Island, PNG, 600 million tonnes of tailings overburden and natural catchment erosion have entered the river system since the commencement of mining. The system operates in a high rainfall, high seismicity and mountainous zone and to date 40% of the material disposed into the river system has deposited on land. Treatment of the waste dump leachate system appears to have little effect on copper chemistry if the tailings are not adequately stabilised.

Organic matter, together with iron and manganese oxides, coat the suspended sediment of rivers and change the nature of the sediment (8). The organic coating is chemically bonded to the clay and silt and can sorb organic solutes.

In natural systems the log partition coefficient of organic solutes for soil, and the log aqueous solubility give linear isotherms of neutral organic compounds (eg. chlorined hydrocarbons) over a wide range of concentrations relative to solute solubility (9). Partition coefficients of organic substances on soil vary from 20 to 200,000 with the largest coefficients being for the least soluble compounds, such as PCBs and DDT. A relatively water soluble compound, 1,2-dichloroethane, has a small distribution coefficient of 19 but an insoluble compound such as DDT (solubility 0.004 μm/litre) has a large coefficient of 220,000 (9). The sorption of organic solutes from water is related to the aqueous solubility of the solute with the least soluble organic compounds most highly sorbed onto soil sediment. These factors are the prime controllers of transport of organic substances to be considered.

Air Pollution Modelling

This component considers the application of air pollution modelling as a predictive aid, the availability of practical (usable) models, suitable for local conditions and incorporating radiation and photochemical processes. Urban air pollution is comprised of a highly complex mixture of gaseous and particulate components.

There is a range of urban pollution models currently is use (10). In all instances, the models usually do not accurately predict the time of occurrence and location of the maximum pollution episodes. If the requirements of time and space pairing of predictions and observations is relaxed, then the models usually can predict the worst case pollution levels to within a factor of two, the best that can be expected from any model, given the inherent uncertainty in air pollutions measurements. However, many models require detailed data sets which are not always available and severe local problems such as sea breeze effects and complex terrain complicate model performance and increase these problems.

Environmental Analytical Techniques

This component seeks to evaluate specific analytical methods and sampling techniques in use and to produce a Directory of Methods. It is planned to initiate inter-comparisons of laboratories. Attention will be given to improving specific analytical techniques and identifying methods not involving the use of hazardous chemicals. Field methods, with attention being given to simplicity, will be reviewed. There is scope for interaction with the IUPAC Programme 'Chemistry and the Environment' (11).

A specific example of the improvement and development of an analytical technique for the purpose of application to a regional environmental problem is a procedure to measure faecal sterols such as coprostanol (5β(H)-cholestan-3β-ol (12,13). The measurement of this and other sterols may be used to trace the pathway of human sewage in river water, seawater and marine foods. Coprostanol is unaffected by various treatments such as chlorination or aeration of overlaying water or even irradiation and is therefore indicative of the transfer of human sewage throughout most of the food chain.

The Northern Territory - An Example of Control in Development to Preserve Nature

Uranium mining has been undertaken in a national park in the Alligator Rivers Region of the Northern Territory of Australia. The origins of a very rigorous regulatory regime in the Alligator Rivers Region began with the Ranger Uranium Environmental Inquiry (Fox, 14). The Northern Territory is partly located in the tropics and can be considered as a model of a small tropical country with a stable political regime.

Controlled development based on regular review is seen to provide an efficient means of safeguarding the environment from developments such as mining. After ten years operation the environmental impact has been minimal.

Comparison with Global Problems

A comparison can be made between the project components selected above and the general recommendations for the UN Conference on Environment and Development (UNCED) to be held in Brazil in June 1992. The general recommendations of UNCED are as follows:

Protection of the atmosphere (including global climate changes), ozone layer depletion, atmospheric transboundary transfer of pollutants;

Protection of terrestrial and oceanic resources;

Protection of biological diversity;

Conservation of drinking water resources;

Environmental safety of biotechnological production and applications;

Ecotoxicologically acceptable re-use of waste;

Safe treatment and discharge of toxic chemicals; and

Assessment of health risk of environmental pollution and changes for human health.

It is seen that these recommendations are more general than those on the regional scale considered in this paper.

Conclusions

A means of setting priorities for environmental chemistry has been developed and described. Through Project CREN, the application of environmental chemistry is seen to provide a means of dealing with specific pollution problems facing the Asia-Pacific region. With the limited resources and facilities available, the role of co-ordination is seen to be of prime importance to make effective use of the limited resources, provide training to give skills to control pollution adequately and provide a forum for the development of inter-country co-operation within the region. Controlled development through use of adequate authorizations is seen to provide an efficient means of ensuring that no detriment to the environment occurs from development such as mining.

The Northern Territory provides the example as a model of a small country in the tropics for such environmental controls. The model of Project CREN presented should be applicable to other regions such as in Africa and the Caribbean/South America.

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