8. Rivers, Lakes, Ground Water, Snow and Ice

8.1. INTRODUCTION

Man deliberately uses rivers for waste disposal, disturbing the biota and creating downstream pollution problems. Sometimes chemical substances, such as fertilizers and pesticides, inadvertently find their way into rivers by run-off, erosion and leaching, or into ground-water by percolation.

Not all river pollution is man-made, of course. Berner (1971), for example, has estimated that about 28% of the world river sulphur resulted from human activities, the remainder coming from sedimentary rock weathering, volcanic emanations and hot springs, and sulfur carried inland from the oceans and subsequently falling in rain. Rock weathering is of course accelerated by human activities such as highway construction, which may release significant amounts of trace substances (including heavy metals) into the environment.

Many watersheds are shared by several countries. In addition, the continental water systems ultimately drain into the oceans. The problem of river pollution is therefore of both international and global significance..

One of the particularly difficult problems associated with obtaining a mass budget of river pollution (or of transfer rates into lakes and oceans) concerns sedimentation. There is often no clear demarcation between the river and the river floor. Furthermore, because pollution often enters the human food chain through minute biological organisms living in this "grey zone", the need to study sediments and their transports cannot be too strongly emphasized. Of importance is the fact that the smallest particles absorb relatively the most pollution and are transported the farthest, other things (currents, etc.) being equal. Mention should be made here of the UNESCO-IHD program on river sediments. During the first phase of the project, a survey of existing data was carried out by UNESCO with the cooperation of IAHS. Data on total erosion in 100 major rivers of more than 20 countries are now available for the computation of the gross sediment transport to the oceans. On the other hand, data on the annual specific erosion and annual turbidity collected from more than 100 rivers give an idea of the importance of erosion in the different climatic and ecological zones of the globe. Both these surveys are being updated.

One of the difficulties encountered in the execution of this program has been the lack of standard methods for measuring sediment transport.

To overcome this, the UNESCO Secretariat, in co-operation with IAHS, is preparing guidance material on modern methods of measuring sediment transport, including radiosotope techniques, with the co-operation of other international organizations. The execution of this project is being co-ordinated by the IAHS through its Commission on Erosion and Sedimentation.

Turning next to lakes, their physical and biochemical characteristics are rather different from those of the sea. Even in very large lakes, there are trapped fauna, slow hydrologic turnovers, seiches, etc. The design of a monitoring network for one of the Great Lakes is therefore likely to be quite different from that in the North Sea, for example.

Ground-water, which is estimated to contain more than 95% of the world's fresh water, is an important long-term sink for pollution. Paradoxically, the scientific community has given little attention to the problem of preserving the quality of this natural resource, which does enjoy a measure of short-term protection from environmental degradation. However, gradual contamination by petroleum hydrocarbons is in fact an almost irreversible process. Of equal or in some cases greater significance is the depletion of ground-waters by man in many parts of the world. This in turn may cause local harmful secondary effects through land subsidence and (along sea-coasts) salt water intrusions. Although recognizing the importance of monitoring both the quality and quantity of ground-water, the sampling problems are very considerable, due in part to the natural and man-induced variabilities occurring even within small areas.

Finally, the snow and ice surfaces of the globe must also be included in discussion concerning GEMS. In the first place, indications of past trends (sometimes over centuries) in pollution concentrations can be obtained from chemical analyses of snow and ice cores. Secondly, the secular trends in world snow and ice distributions are important in the context of climatic change. (See Recommendation 4). Here the important contribution of the International Commission of Snow and Ice of IAHS should be mentioned.

8.2. MONITORING PROGRAMS

UNESCO-WMO have a very extensive IHD network of stations in rivers, lakes* and watersheds. Extensive documentation is available, e.g., UNESCO (1969), and technical manuals have been written. Because the main emphasis within the IHD program has been on water quantity rather than on water quality, however, the station locations may not be entirely suitable for GEMS. Nevertheless, river flow rates are certainly required to interpret pollution transfer rates. In addition, the detailed physical picture that has been obtained of a number of small watersheds is a prerequisite for the design of pollution monitoring networks.

In the context of GEMS, the following classification of rivers, lakes and ground-water is proposed:

a) *remote areas*—hydrological basins where there are no upstream man-made emissions of pollutants arising from agricultural, industrial or urban activities;

*The IHD lakes are at least 100 km² in area or 10 km³ in volume.

b) *intermediate areas*—hydrological basins where there are no upstream emissions from industrial or urban sources, although there may be agricultural fertilizers and insecticides entering the water system through runoff.

c) *impact areas*—hydrological basins into which industrial and/or urban wastes are being released.

Using this terminology, the following recommendations are made.

Recommendation 24: It is recommended that the appropriate Specialized Agencies develop, and seek intergovernmental agreement on, a minimum river and lake water-quality monitoring program at remote and intermediate stations (but not at impact locations) using, for example, pH, BOD, dissolved oxygen, chlorophyll *a*, phosphorus, nitrogen and coliform bacteria as indicators, sampling at least once a month in intermediate areas, and once a season in remote areas. As soon as methodologies and site criteria have been incorporated into technical manuals, the program may contribute data to GEMS Phase I.

Recommendation 25: It is recommended that the appropriate Specialized Agencies examine the IHD river and lake networks in the light of requirements for inland water quality monitoring and that Member States be encouraged to offer to host pilot studies. In this connection, the possibility should be examined of designating 5 to 10 small lakes at isolated locations (in the arctic, for example) as remote monitoring areas. Finally it is recommended that in 1976, a proposal for expanded pilot and/or operational programs for monitoring inland water quality be prepared.

Recommendation 26: It is recommended that an expert committee be appointed to assess the present state of the world's major aquifers and to make recommendations on the feasibility of world-wide monitoring of ground-water, both for quantity and quality.

Recommendation 27: It is recommended that SCOPE be encouraged to propose long-term research programs for monitoring methodologies for inland water quality and for related biological indicators and accumulators.

Recommendation 28: Noting that a number of national and international river authorities are engaged in research and modelling of the chemical and biological qualities of water in impact areas, it is recommended that they be invited to submit program outlines through the appropriate Specialized Agencies to UNEP, for consideration as GEMS pilot projects. For the developing countries, financial support from UNEP might be required.

8.3. COMPLEMENTARY MONITORING ACTIVITIES

As already indicated, the IHD water quantity network, and the associated research investigations of IHD basins, will provide essential information in the design and implementation of the inland water quality component of GEMS.