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GEMS: Global Environment Monitoring System

THE QUALITY OF THE ENVIRONMENT: A HEALTH-BASED GLOBAL ASSESSMENT

Report of a Meeting of UNEP/WHO Government-designated Experts
Geneva, 12-16 September 1988

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REPORT OF A MEETING OF UNEP/WHO GOVERNMENT-DESIGNATED EXPERTS ON HEALTH RELATED ENVIRONMENTAL MONITORING
Geneva, 12-16 September 1988

CONTENTS

I. INTRODUCTION

1. Health-related environmental monitoring is one of the four major components of the Global Environment Monitoring System (GEMS), the others being climate, natural resources and oceans. The health-related environmental monitoring programme, started in the mid-1970s, includes the global assessment of urban air quality, freshwater quality and food contamination. Within the framework of this programme, the Executive Director of the United Nations Environment Programme (UNEP) and the Director-General of the World Health Organization (WHO) convened a meeting of Government-designated Experts in Geneva, from 12-16 September 1988, to review and comment upon draft global assessments of environmental quality in relation to human health.

2. The meeting was opened by Mr G. Ozolins, Manager, Prevention of Environmental Pollution of WHO and Dr M. D. Gwynne, Director, GEMS Programme Activity Centre of UNEP on behalf of the Executive Heads of their respective Organizations. They reviewed the development and current status of the health-related component of GEMS and highlighted its relationship with activities, both within their own and other organizations. The Experts were asked to consider two broad objectives:

(i) to undertake a review and assessment of the levels, trends and environmental and health impacts of urban air pollution, freshwater pollution and food contamination at a global and regional level; and

(ii) to advise the Secretariats of UNEP and WHO on the best way future global assessments of environmental health issues should be undertaken.

3. In the light of these objectives, Dr. Gwynne and Mr. Ozolins urged the participants to consider questions such as the following:

- what is the current global situation and trends with respect to fresh water quality, urban air quality and contaminants in food?
- what conclusions can be drawn regarding health risks posed by air and water pollution and by contaminants in food?
- what changes should be made to the data bases on environmental contamination, or to the gathering and presentation of such data to improve future assessments of environmental quality, trends and health risks?
- can the task be made more effective by limiting the number of variables investigated and increasing global coverage?
- how can the findings be brought more effectively to the attention of the world community?
- what mechanisms are available and could be utilized to involve a larger number of countries in global assessments?.

4. This was the third meeting of Government-designated Experts on Health-related Environmental Monitoring. The first and second meetings had been held in 1977 and 1982 respectively; the task on those occasions was to review and recommend how the programme on health-related monitoring should be further developed and improved. The establishment of pilot studies on biological monitoring, exposure to air pollutants, and integrated human

exposure assessment resulted from these deliberations. The present meeting was convened with the expressed purpose of evaluating and drawing conclusions on the environmental quality and health risks based on the data which had been assembled since the beginning of the GEMS programme. It was noted that these assessments also drew upon data gathered from other sources.

5. Dr. Ahmed Amin El-Gamal, Adviser, Egyptian Environment Agency, was elected Chairman of the Meeting, following nomination by Mr. J. Winter, USA, and seconding by Mr. El Hindi, Sudan. Dr V.C. Armstrong, Head, Criteria Section, Environmental Health Directorate, Canada agreed to serve as the Rapporteur. Twelve countries and the World Meteorological Organization were represented at the Meeting. Moreover, written comments on the draft documents were received from the Federal Republic of Germany, which was unable to be represented. The Secretariat was comprised of staff members from WHO, UNEP and the Food and Agriculture Organization of the United Nations (FAO). The list of participants is attached as Annex I and the Agenda as Annex II.

II. REVIEW OF GLOBAL ASSESSMENTS

6. The Meeting was provided with three comprehensive background documents prepared by the Secretariat, with the assistance of the Monitoring and Assessment Research Centre (MARC), other consultants and advisers. These documents contained detailed information on sources, levels and trends of selected pollutants in urban air, fresh water and food. They also provided assessments of the severity of pollution problems and, to the extent possible, the potential health risks involved.

7. The report entitled "Assessment of Urban Air Quality Worldwide" presented data from the GEMS/AIR project on sulphur dioxide and suspended particulate matter. Data for nitrogen dioxide, carbon monoxide and lead were also included but these were obtained from national reports, scientific publications and through use of a questionnaire. For each pollutant, data were presented on emission strengths and urban concentrations in cities world-wide. Ambient concentrations were compared with WHO guidelines in order to estimate populations living in areas where guidelines were exceeded. Finally, case studies were used to highlight the relation between emissions, ambient concentrations and control strategies.

8. A wide range of pollutants and water characteristics, were reviewed in the report entitled "Global Freshwater Quality Assessment Report", including pathogens, organic matter, nutrients, heavy metals and organic micropollutants. Effects of municipal and industrial wastewaters and the use of fertilizers and pesticides in agriculture were examined. Data were included from the GEMS/WATER project and from national reports and other scientific publications. Trends in the type and degree of water pollution, regionally and globally, were identified on the basis of historic patterns of environmental deterioration.

9. The third document "Chemical Contaminants in Food - Global Situation and Trends" drew both on data compiled under the GEMS/FOOD project and national reports and other scientific publications. It reviewed contaminant concentrations in food and dietary intakes of polychlorinated biphenyls (PCBs), lead, cadmium, mercury, aflatoxins and several organochlorine and organophosphorus pesticides.

10. At the beginning of the Meeting, the Expert Group heard presentations on these reports from WHO members of the Secretariat. Supplementary information was provided by the consultants and advisers who had collaborated in the preparation of the reports. Also, a brief description was made of the activities of FAO in connexion with food contamination monitoring. Preliminary discussions resulted in the identification of a number of issues which the Meeting would need to address. These included the suitability and

representativeness of the data for global assessment, the need to broaden the database both with respect to parameters studied and geographical areas monitored, the importance of quality assurance and differences in the scope and emphasis of the three reports.

11. Three ad-hoc Working Groups were formed to consider these and other issues, to examine carefully the draft assessments and conclusions reached in each of the reports and to recommend ways in which future assessments might be improved. These sub-groups were chaired by Dr. G. de Cean (Food), Mr J. Winter (Water) and Dr V.C. Armstrong (Air).

12. The Government-designated Expert Group examined the three assessments referred to in paragraphs 7 to 9 of this report, introduced certain modifications where they were deemed appropriate and gave their formal approval on the contents and conclusions of the assessments as modified. The comments of the Government-designated experts pertaining to the three assessment reports are described in the following paragraphs. The revised summary chapters are included as annexes III to V.

A. Urban air quality

13. The Meeting endorsed the general content of the report; it was emphasized, however, that the conclusions were based on data gathered up to and including 1984. It was noted that the assessment report carefully delineates limitations of the assessment, such as monitoring coverage, site representativeness and data quality.

14. In discussing the urban air quality assessment report, the Meeting considered and dealt with a number of different issues as follows:

(a) Emphasize the significance of indoor air pollution - this matter is already discussed in some detail in Section 2 and also quite extensively in Appendix 1 of the urban air quality assessment report. However, in Section 8, p.76, paragraph 1, the text was changed to make it clearer that indoor air pollution may be a problem in both developing and industrialized countries.

(b) Broaden the scope of the document to include emerging issues including stratospheric ozone, acid rain, global climate changes, and the greenhouse effect - the Meeting was of the opinion that these are major issues of global importance but that they fall outside the scope of the urban air pollution assessment objectives. This is already discussed accordingly in Section 2 of the assessment report.

(c) Inadequate geographical coverage, especially in developing countries - it was recognized that this was a considerable limitation of the Programme which needed to be emphasized by inserting an additional sentence on this issue in the last paragraph of Section 8.1 of Annex III.

(d) What are the health consequences of high pollution days and what implication might this have for future health assessments? - the assessment should stress that in a number of cities the frequency of days when concentrations are above the WHO guidelines is high. The text was expanded with a new paragraph within Section 8.1, and an additional sentence in Section 8.2 referring to the need for information on possible health consequences and providing suggestions on how this may be accomplished.

(e) Implications of increased diesel usage throughout the world - the significance of this emission source, which is increasing in many cities, was recognized and an additional comment was made in Section 8.4 of Annex III.

(f) The impact of monitoring site placements on representativeness of the data - this issue was considered to require further emphasis and a statement describing the importance of periodic verification of site representativeness was added to Section 8.3.2 in Annex III. A further recommendation was made underlining the importance of this factor in localising future monitoring sites.

(g) The need for including other pollutants within the GEMS/AIR monitoring project - a recommendation was made to include additional pollutants in the project.

B. Freshwater quality

15. The Meeting endorsed the global freshwater quality assessment report, but decided that some modifications and minor additions were necessary in its concluding chapter. It was considered important to strengthen the emphasis in the text on the effects that hazardous waste disposal can have on groundwaters and to comment on the issue of climatic changes on future water quality. In order to incorporate these and other comments in the concluding chapter, the section dealing with future water pollution issues was reorganized and expanded particularly with respect to those issues which are expected to emerge as globally significant in the future. The Meeting appreciated that the global assessment presented to it was a summary of a more comprehensive and substantial review of global freshwater quality and expressed an interest in seeing the full report generally available as a published reference book.

16. The data base established under the present GEMS/WATER project, and water monitoring and research in general, were considered insufficient for the purpose of water quality assessments on a global scale. Related inadequacies are addressed in Section 5.4 and will provide the basis for improving the GEMS/WATER project. The Meeting discussed possible modifications which could be made, but concluded that any major changes should be considered by a separate review.

17. It was noted that some important objectives of the project had been successfully achieved, such as helping developing countries to establish water quality monitoring facilities. Problems have occurred, however, in the regular transfer of monitoring data to the global database. Also, for many stations and variables there was insufficient coverage to allow globally representative assessments or to identify trends. It was therefore proposed that an alternative to the current network could consist of a few selected trend stations which monitor all variables on a long-term basis. In addition, for the developed countries, more use could be made of the information contained in their evaluation and reporting of water quality already undertaken on a regular basis nationally. Developed countries could help developing countries to establish and operate monitoring stations.

18. The difficulties in collecting and combining data from a large network were highlighted particularly with respect to integrating data for assessment. Clarity was requested as to how GEMS/WATER stations were selected, particularly the number of stations per country, and whether stations in the network were unique to GEMS/WATER. Attention was also drawn to the fact that the network is very incomplete, especially for certain areas of the world. Many of these areas are important as they are rapidly developing and may have increasing water quality problems.

19. Concern was expressed about the quality of some GEMS/WATER data generated on heavy metals and organic micropollutants. Greater attention needs to be given to quality control with respect to analytical methods and data collection and validation. It was also felt by several delegates that the number of indicators measured could probably be reduced. Given the complexity of chemical methods for water analysis, it was also suggested that more use be made in the GEMS/WATER project of bioassay and biomonitoring techniques, particularly for micropollutants. Nevertheless, if biomonitoring is used, chemical analysis of water would still be necessary as a back-up. Sediment samples have proved to be useful for integrated measurements in other surveillance programmes. The Group endorsed the view that sediment cores provide an important record of historic trends in water pollution and enable the effects of control measures or management practices to be demonstrated.

20. The question of the number of variables is to some extent unresolvable. If the assessment of the severity and trends in the contamination of water bodies is to remain an objective of the GEMS/WATER project then the true number of variables that might have to be measured would be as high as 150. It was noted that the procedures for selection of monitoring stations, appropriate methodology and quality control are given in the GEMS/WATER Operational Guide. For most participating countries the GEMS/WATER stations are those already included in national water monitoring programmes.

21. Concern was expressed for the lack of feedback of programme information and evaluated data to participating countries. The current GEMS/WATER data reporting procedures should be changed to allow more frequent and up-to-date publications of data summaries. In addition it was noted that there has been no recent programme evaluation for the whole GEMS/WATER project and that such evaluations should be produced periodically.

22. Regarding pesticides in water, the Meeting noted that the WHO guideline values for drinking-water quality were actually based upon a very small percentage of the acceptable daily intake of pesticide residues in food. Consequently, some of the resulting concentration limits are very low and might pose difficulties for laboratories not adequately equipped for such sophisticated analyses. Ambient concentrations of pesticides are, however, not only of interest for domestic water supplies but of equal and sometimes even much higher importance to freshwater fish and other aquatic biota. A global assessment of water quality has, therefore, to take all environmental aspects into account when evaluating the seriousness of water pollution by pesticides.

23. The close link between water resources, water quantity (as in river flow) and water quality was discussed and the question was raised whether this relationship had been sufficiently taken into account in the assessment as it could affect the interpretation of the data. This aspect was not extensively covered in the report.

C. Food contamination

24. The statement in part 10, Annex V, that the available information on food contamination on a global or even regional basis is largely insufficient to allow a comprehensive and definitive evaluation of its severity or trends was endorsed by the participants. While accepting that this problem was unlikely to be overcome in view of national differences in food contamination surveillance programmes, the Meeting agreed that all possible actions to attain continuity and uniformity of reporting and improving the accuracy and validity of data should be undertaken.

25. Members generally agreed with the assessment and the conclusions reached in the report. The Meeting reviewed in detail Section 10 of the food contamination report and made minor changes.

26. While the food contamination assessment report does not identify any specific or major hazard, the intakes by particular population groups at times exceed health guidelines for lead, cadmium, aflatoxins, PCBs and organochlorine pesticides. Food contamination has the potential to cause major and widespread health hazards. Continuing surveillance of food for contaminants and their reporting internationally was considered essential.

27. A paper on analytical quality assurance and related matters prepared by FAO was circulated to the Meeting's participants. The paper highlighted the risk of continuing the collection of data through GEMS/FOOD which were in some cases of questionable validity. Such information could lead to incorrect conclusions being reached regarding trends in food contamination and development of inappropriate control measures. The reduction of funds for the GEMS/FOOD and confidentiality requirements of the AQA have limited the ability of the GEMS/FOOD to identify those areas requiring strengthening within participating institutions or to help in remedial actions. While there was no question of public identification of individual laboratories, those in need of assistance should be identified on a confidential basis to the Agencies involved to allow appropriate follow-up actions and the optimal interpretation and assessment of data. The FAO paper also presented some proposals for future actions, including the preparation of an analytical quality assurance manual, the organization of regional and subregional workshops in AQA principles and procedures, the implementation of training exercises based on the common problems noted during the 1985-87 AQA studies performed by GEMS/Food, and the provision of assistance in assessing local AQA needs. Some of the proposals were incorporated in a recommendation by the Meeting.

III. RECOMMENDATIONS

28. After reviewing the individual assessment reports, the Meeting discussed various possibilities for improving the scope and geographical coverage of the Programme, including future assessments. It made several general recommendations in this respect as well as more specific proposals for each of the three projects.

General

29. The findings of the three GEMS health-related monitoring assessments, as approved by the Government-designated Experts, are of sufficient environmental and health significance to warrant the timely attention of governments at the highest level. The assessments should, consequently, be brought to the attention of the respective governing bodies of WHO, UNEP and other international agencies involved for consideration by the Member States on the need to improve future assessments by expanding geographical coverage, particularly for developing countries; by improving quality assurance procedures to increase the reliability of data, and by identifying those pollutants/factors which are of highest relevance for health and the environment. This can best be done by urging Member States and the relevant international organizations to cooperate more fully in the GEMS programme.

30. The Government-designated Expert Group recognized that the recommendations made for improving future assessments and the three health-related monitoring networks require more financial support than is currently available. The Meeting therefore called upon governments to considerably increase support to these important activities. The Organizations involved should also make efforts to secure extra budgetary funds for the implementation of the health-related environmental monitoring programme.

31. Whenever an assessment is made of total human exposure to environmental contaminants, information on contaminant levels in water as consumed should be taken into consideration.

32. Where necessary in the evaluation of the effects on human health, particular attention should be given to monitoring of pollutants and contaminants in human tissue and fluids in order to obtain a better assessment of total human exposure. It was noted that some such activities are already under way within the WHO/UNEP "Human Exposure Assessment Location" or HEALs project.

33. The Government Experts underlined the need to put greater emphasis, at country level and internationally, on the integration of environmental monitoring data with other relevant information to facilitate the process of decision-making for sustainable development.

Urban air quality

34. There is concern that pollutants other than those currently included in GEMS/AIR can have adverse effects on human health. Based on the information presented in the assessment of urban air quality, it is recommended that available data on nitrogen dioxide, carbon monoxide and lead continue to be included in future assessments. Ozone should also be included, given its toxicity and reports of increasing levels in urban areas. It is further recommended that, to the extent possible, these data be gathered as a component of the GEMS/AIR project. Any additional information should be compiled from the scientific literature and national reports to provide as complete a data base as possible.

35. Given the highly variable nature of suspended particulate matter, it is recommended that efforts be made by participants of the GEMS/AIR project to obtain information on the inhalable portion (PM-10) and the chemical composition of suspended particulate matter. Attention also needs to be paid to determining the contribution that natural sources make to the urban concentrations of suspended particulate matter. This is particularly true in areas where wind-blown dust is prevalent.

36. GEMS/AIR data on sulfur dioxide and suspended particulate matter and other information available for carbon monoxide, nitrogen dioxide and lead suggest that emissions of these pollutants are increasing in developing countries. However, in many such countries data are sparse or not yet available, and verification of such trends is required. It is therefore recommended that, to the extent possible GEMS/AIR should actively encourage participation of additional countries.

37. It is recommended that further work be undertaken to assess the potential health impact on populations residing in cities where the estimated number of high pollution days exceeds the WHO guidelines. This may be accomplished in conjunction with the GEMS/HEAL project by choosing new HEAL sites in urban areas identified with frequent high pollution exposure days.

38. The data gathered from fixed monitoring sites are not always directly applicable for conducting human exposure assessments. For example, concentrations of traffic-related air pollutants decrease rapidly with increasing distance from the roadway, both horizontally and vertically. It is therefore recommended that the siting of monitoring stations be carefully considered when the data are to be used to assess human exposure.

C. Freshwater quality

39. The Meeting considered that the current GEMS/WATER project needs review with respect to overall geographic coverage, measurements of toxic metals and organics, and usefulness of project data for global assessments of water quality and trend analyses. A thorough review of the GEMS/WATER project should thus be undertaken with respect to:

- the objectives of the ongoing project and its relationship to other environmental monitoring programmes;

- the achievements of the project to date;

- the future direction of the project, taking into account the recommendations contained in the following paragraphs.

40. The views concerning improvements in water quality monitoring expressed in Section 5.4 of Annex IV should be adopted for the improvement of the whole GEMS/WATER project.

41. A greater effort should be made to control data quality (accuracy and validity) during all stages of data generation and reporting, data summary production and evaluation.

42. In view of the currently inadequate exchange of GEMS/WATER information a means of improving communication and data exchange between participating countries and administrating agencies and organizations should be explored at all levels. It is also suggested that the preparation of periodic regional data evaluation be encouraged in addition to both the improvements in and more rapid publication of global data summary reports.

43. More training activities are needed at the local, regional and international level to improve monitoring capabilities in participating countries.

44. WHO should investigate the use of third party funds for the support of GEMS/WATER project activities, perhaps in the form of bilateral agreements between developed and developing countries.

45. The possibility of co-operation with the newly established International Lake Environment Committee (ILEC) and their lake management programme should be investigated in order to avoid potential overlap.

46. As the quality of estuarine waters is not adequately addressed on the global scale at the present time, this problem should be considered by the concerned international organizations and their programmes.

47. In future an attempt should be made to integrate GEMS/WATER data with available hydrometric information at the national level or through international hydrological programmes.

48. New coliphage test procedures should be considered by the GEMS/WATER project as a practical, inexpensive method for monitoring faecal pollution.

Food contamination

49. Members expressed their support for a GEMS/FOOD project but saw the need for modification of its operation in relation to:

- Data collection - the number of countries participating should be expanded

- Data coverage - the number of contaminants reported and the quantity and uniformity of data made available should be optimised

- Data presentation - 90th percentile levels and dietary intakes should be reported wherever possible

- Data validity - analytical quality assurance should be strengthened as it has been shown that some laboratories have problems, and that in some cases the quality of data is not improving over time.

50. High priority should be given to:

- Implementation by the Secretariat of those recommendations which are within its province

- Convening of the Technical Advisory Committee to consider those recommendations which are of a highly scientific nature or those which require selection of priorities by member governments.

51. The issues raised in Section 9 of the food contamination assessment report concerning the prevention and control of chemical contaminants in food were commended to member governments for their consideration. Implementation of the measures described therein would materially assist governments in minimizing food contamination.

52. In order to improve the reliability of the food monitoring data, the GEMS/FOOD project should - as a priority - expand its current Analytical Quality Assurance (AQA) studies and strengthen its AQA by holding workshops, and providing assistance to selected laboratories. The AQA manual under preparation by FAO should be distributed to GEMS/FOOD project participants. Concern was expressed that the confidentiality provisions applied to the AQA studies had, in some cases, prevented the optimal provision of training and assistance to laboratories which had difficulties in accurately measuring low levels of some contaminants. While there was no question of public identification of individual laboratories, those in need of assistance should be identified on a confidential basis to the Organizations involved to allow appropriate follow-up action and the optimal interpretation and assessment of data.

53. In order to expand the scope of the data obtained on levels of contaminants in food and dietary intake, the GEMS/FOOD project should make greater use of the available data from Codex Contact Points and from national and international reports, including those dealing with import and export of food.

54. It was noted that the geographical coverage of data submitted to the GEMS/FOOD project was far from complete. It was thus recommended that additional countries should be encouraged to join the GEMS/FOOD project, and to submit data on contaminant levels in individual foods as well as in the diet.

55. The GEMS/FOOD project should urge its participating laboratories to include drinking water in their dietary intake studies.

56. Participating countries should ensure that the 90th percentiles are reported to permit a more accurate assessment of health risks. Member States should give due consideration to the 90th percentiles when assessing the safety of their food supply.

57. The Meeting recognized that several of the organophosphorus pesticides, and some of the organochlorine pesticides, are little used in some countries which submit data on these contaminants to GEMS/FOOD. The low residue levels thus reported may therefore merely reflect the lack of use of these pesticides. Other pesticides which are widely used are not at present included in the project. More attention should be paid to collecting pesticide data relevant to different countries and regions. Information on use patterns would be useful in the selection of pesticides to be reported.

58. A very large number of different foods are surveyed and these vary widely between countries and within countries from year to year. One of the aims of GEMS/FOOD is to identify trends in residue levels over time. Since this depends on the same food being monitored in successive years, the preparation of a "core" list of staple foods should be considered. Information on the relative dietary importance of different foods in the different countries would be essential.

59. Participating countries in GEMS/FOOD should be urged to specify the geographical origin of samples whenever possible so that population exposures to contaminants can be more readily estimated.

60. In relation to contamination of foods with PCBs, the Codex Committee on Pesticide Residues has recommended that data be collected on specific congeners rather than total PCBs. Reservations were expressed regarding the usefulness of this approach, both in terms of the high cost of such analyses on many samples, and because of the lack of data on the health significance of exposure to individual congeners. The Secretariat should nevertheless seek advice regarding the health significance of PCB congeners.

ANNEX I

Meeting of UNEP/WHO Government Experts on
Health-related Environmental Monitoring

Geneva, 12-16 September 1988

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* In addition, the following countries were invited to participate but could not attend: Federal Republic of Germany, Guatemala, Morocco, Saudi Arabia, Tanzania, USSR.

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Meeting of UNEP/WHO Government
Experts on Health-related
Environmental Monitoring

Geneva, 12-16 September 1988

ANNEX II

AGENDA

1. Opening of the Meeting
2. Election of Chairman and Rapporteur
3. Adoption of the agenda
4. Assessment of global levels and trends of urban air quality/pollution
5. Assessment of global levels and trends of water pollution
6. Assessment of global levels and trends of food contamination
7. Recommendations of the expert group
8. Approval of the report of the meeting
9. Closure of the meeting

ANNEX III

SUMMARY ASSESSMENT - URBAN AIR QUALITY

8.1 Emissions and ambient air pollution levels in cities

In this report, air pollution emissions have been compiled for a number of countries for each of the five pollutants concerned: SO_2, Suspended Particulate Matter (SPM), NO_x, CO and Pb. These emissions estimates are nationwide and cover the period 1973 to 1984. Information on various control strategies employed in the different countries was gathered to permit an in-depth explanation of trends in emissions and ambient levels. The ambient air pollution levels reported relate just to cities and were calculated from data in the GEMS/Air data bank for SO_2 and Suspended Particulate Matter and from various reports and the open literature for NO_2, CO and Pb. Because of the availability of whole data sets for SO_2 and Suspended Particulate Matter, more detailed analyses of ambient conditions could be made for these two pollutants than for the others.

Based on the information base described above the following conclusions were reached:

- In the industrialized western countries various control strategies are showing their effect and trends in emissions of SO_2, Suspended Particulate Matter and Lead are generally downward since the mid-seventies.

- For CO and NO_x control strategies are less generally applied. For CO, emissions are decreasing in some countries while they are increasing in others. Based on a sample of industrialized countries NO_2 emissions have slightly increased (about 8%) over the past five years. It should be noted that these pollutants are closely associated with automobile traffic and that the number of vehicles is still increasing almost everywhere.

- The data base for pollution emissions in the developing countries is very incomplete. However, in many of these countries there are indications that emissions for all five pollutants studied are increasing. Further efforts should be made to clarify the trend.

- Taking into consideration total (man-made) global emission estimates for the different pollutants and similar estimates for industrialized countries the latter account for well over half of all emissions. This leaves proportionately less for the developing world.

- Ambient air pollution levels in urban areas are generally a reflection of emissions and the effort that is made to control such emissions. For SO_2 and Suspended Particulate Matter ambient concentrations are declining in the industrialized western countries. Also, lead levels in ambient air are decreasing. For NO_2, ambient levels in cities are generally constant or slightly increasing, except in North America where they are declining. For CO, ambient levels are variable, declining where controls are being applied.

- There are a substantial number of cities where the number of "high pollution days" exceeds the WHO guideline of a maximum of seven days per year. These cities occur both in industrialized and developing countries for SO_2, but mostly in developing countries for Suspended Particulate Matter.

The picture that emerges is that for SO_2, Suspended Particulate Matter and Lead the situation is improving in many industrialized countries as a result of various control and prevention strategies that are being applied. The data show that depending on the combination of control strategies the impact on ambient levels can be quite significant. Although, as the next section will show, ambient levels of SO_2 and Suspended Particle Matter in urban areas still give rise for concern in many urban areas, strategies to reduce SO_2 (as well as NO_2) pollution now tend to concentrate on control of acid deposition to limit ecological damage.

With regard to automobile related pollutants (NO_2 and CO) control efforts are much less generally applied. Reasons for this are that many sources (every car) need to be controlled which increases the complexity and cost of the effort involved. Both NO_2 and CO are potent toxic substances that can affect human health at relatively low concentrations and continued vigilance is required.

The image that can be formed about the situation in developing countries again demands continued attention. The data and information available are scanty but nevertheless indicate deteriorating conditions. Increased efforts to evaluate the problem in more detail by improved monitoring coverage, especially in Africa, Europe and South America, and to develop adequate protection measures for the populations affected are urgently required.

8.2 Health implications

The air quality guidelines, as recommended by the WHO, indicate the level and exposure time at which no adverse effects are expected and below which there is no hazard expected to the health of the population. However, guidelines are only given for single pollutants: exposure to pollutant mixtures may lead to adverse effects at levels below the recommended guidelines for individual pollutants.

Comparisons of ambient levels in each of the urban areas with WHO guidelines have been made for the five pollutants. In the case of SO_2 and Suspended Particulate Matter, as monitored by the GEMS/Air, extrapolations to the global urban population have been possible. It is estimated that out of an urban population of 1.8 billion, nearly 1.2 billion or two-thirds reside in areas with annual average SO_2 levels within or above the WHO guideline range. In the case of Suspended Particulate Matter, the situation is slightly worse, with 1.4 billion of the 1.8 billion urban population living in cities having air quality considered to be marginal or unacceptable. Many cities in the GEMS network frequently experience short-term high levels of SO_2 and SPM. Twenty per cent of the reporting GEMS cities have, on average, more than 30 days per year on which SO_2 levels exceed 150 ug/m^3. The health impact of these high pollution days cannot, at the present time, be accurately evaluated. These cities are distributed throughout both developed and developing nations. In nearly 40% of cities, populations are exposed to levels of suspended particulate matter in excess of the short-term guidelines for more than 30 days a year. Such cities are predominantly in the developing countries. Many of the cities with high particulate levels are in areas where natural wind-blown dusts make a significant contribution to the urban aerosol.

Based on the data available, estimates of the proportion of cities with exceedances of WHO guidelines, both in the short-term and long-term are calculated for NO_2, CO and Pb and given in Table 8.1. Because of the smaller sample sizes for these pollutants, no extrapolations leading to estimates of total urban populations exposed should be made.

Table 8.1 Percentages (rounded to nearest 5%) of cities reporting site-year averages in excess of guideline values. (Figures in brackets are numbers of cities for which data were available)

Cities exceeding:	SO_2(a)	SPM(b)	Smoke(b)	NO_2(c)	CO(d)	Pb(e)
Long-term guidelines	30(54)	60(41)	30(16)	0(42)	-	20(23)
Short-term guidelines	45(54)	(55(41)	45(16)	30(28)	55(15)	-

Sources of data

(a) Table 3.1, based on annual averages and 98 percentiles exceeding guideline range.

(b) Table 4.1, based on annual averages and 98 percentiles exceeding guideline range.

(c) Section 5.5, based on annual averages (against US standard) and either the 1-hour or 24-hour guideline.

(d) Section 6.5, based on 8-hour guidelines.

(e) Section 7.5, based on annual averages above guideline range.

In the case of NO_2 there is no WHO guideline and the US standard was used. On average none of 40 cities exceeds the US air quality standard of 100 ug/m^3 (annual mean). However, in 10% of the cities, annual mean levels of NO_2 approached that value at least once during the period 1980-1984. Approximately 30% of the cities exceed the WHO short-term guidelines, and it may be inferred that in these cities the urban population may be at increased risk of adverse effects from short-term exposures to NO_2.

Exceedances of the short-term guideline for CO appear relatively common in the reporting cities. Exposures to levels of CO which may pose a risk to health are more likely in locations with high traffic densities during commuting hours.

With regard to Pb levels, in 30% of cities annual guidelines are never exceeded, another 30% of cities are, on average, within or above the guideline range while the remainder occasionally exceeds. Locations where Pb guidelines are exceeded can be in cities of both developed and developing nations. Some biological monitoring studies have indicated that reduction of the lead content of petrol has led to concomitant decreases in the blood-lead levels of the general population.

8.3 Information gaps and need for further work

Air pollution in urban areas arises from a number of sources which will vary from location to location. The actual concentration of air pollutants depends not only on the quantities that are emitted but also on the ability of the atmosphere to either absorb or disperse these emissions. In an assessment of urban air pollution worldwide, it is important to recognize that the accuracy of the assessment relies heavily on the accuracy and completeness of the emission data, the coverage, representativeness and quality of the monitoring data, and finally the extent to which exposure to the population can be inferred from the monitoring data. Each of these three areas will be discussed in some detail below relative to the present assessment.

8.3.1 Emissions

Ideally emission inventories or global assessments should include city-wide emission inventories summarized by source category (e.g. transportation) collected over the same periods for which there are monitoring data. In this report, however, the emission data were limited to nationwide estimates mostly from developed countries. From this information it was possible to obtain a very general picture of the countrywide emission situation: however, these patterns do not always parallel the monitored air pollution patterns. There are many reasons for these disparities, such as local source control and meteorological and topographical features of the specific urban location. Nevertheless, the extent to which there is general agreement between the concentration patterns and emission inventories is a strong indication that results of country-wide control efforts are reflected in the air people breathe in the local urban areas used in this report.

8.3.2 Monitoring

The combined effects of source configurations and of meteorological and topographical features are unique to each and every area. As a result, the monitoring network design is very important - it must have sites properly located to give adequate coverage so as to capture the varying levels of air pollution across the city and to be representative of the surrounding areas. Appropriate quality asurance measures applied to the collection and analysis of the data are also required. This includes periodic visits to the site to determine that the immediate surroundings have not changed and that there are no new emission sources which could influence the representativeness of the site. The monitoring data used in this report fall into two different categories, of known and relatively unknown quality.

Known quality: For the suspended particulate matter and SO_2 data, the GEMS air network provides the following four standard features: monitoring system design, training, methods comparisons and data validation. In monitoring system design, guideline documents have been prepared which discuss the acceptable monitoring methods and suitable siting requirements. Sites in each city are chosen by the local staff, generally to represent in an acknowledged way residential, commercial and industrial areas of the city. Samplers are usually placed 3-15 metres above ground level in an area not greatly influenced by nearby sources. Training is provided when needed, especially in the operation and maintenance of the equipment.

The quality of the resulting data is a primary concern. Because data validation is primarily the responsibility of the reporting country, the GEMS data management system assists in this process by comparing the actual reported data against specified criteria to judge results of the reported

returns. These acceptance procedures can identify various types of anomalies in the data so as to check for possible errors and to seek subsequent verification by the country.

Data summaries and statistical analyses are performed on the validated data provided data completeness requirements are met. Such a provision ensures that the seasonal cycles are adequately represented before a yearly summary is constructed. This procedure permits a more accurate and meaningful assessment of the air pollution results: it may not guarantee a perfect outcome but will reduce some of the uncertainity.

Unknown quality: The NO_2, Pb and CO data have been provided directly by individual countries or have been taken from published reports. The characteristics of these data include uncertainities as to the monitoring procedures, the siting requirements, representativeness of the site location and data and quality assurance practices. In addition, the very limited data available from which to judge world-wide levels makes inferences dependant upon qualitative knowledge of similar conditions elsewhere where data may not be available. A future assessment would be strengthened with the inclusion of data from Eastern Europe, Africa and a better mixture of urban locations from developing and developed countries.

8.3.3 Exposure

The variable nature of air pollution implies that actual exposure of an individual as he or she goes through his or her daily activities will be a summation of exposures experienced in successive "zones" with differing air pollution levels. Different life-styles and associated living conditions in different parts of the world will also contribute to widely varying human exposure to air pollution.

Exposure assessment is in fact the weakest link in the chain when considering the possible risks to health resulting from air pollutants. It may be reasonable to use ambient air monitoring data as an indicator of the exposure of population groups within a country or region experiencing a fairly uniform lifestyle, but the relationships between such data and actual exposures are likely to vary greatly among individuals and between population groups in different regions. One of the most important factors is the time spent indoors, which may be as much as 90% in developed countries in temperate zones, and the contrasts in air pollution inside and out. Thus the data in Appendix I indicate that certain risks may be enhanced indoors, as in the case of suspended particulate matter from cooking activities inside homes in many countries, or in respect of NO_2 from the use of unflued gas appliances.

Ambient concentrations are related to actual emission levels and reflect the results of nationwide control. The validity of using monitoring data as a surrogate for actual exposure can be checked in the one example available, for lead, where it can be seen that patterns in blood levels reflected a change with countrywide control and levels dropped below the WHO guideline of 20 ug/dl, consistent with recorded ambient levels. Biological monitoring is also possible for CO, but in general, assessment of individual exposures to each of the pollutants considered here requires the use of personal samplers. Pilot studies of that type would help to establish relationships between exposure and ambient results for use in future assessment reports. The WHO/HEALs programme will be of assistance in this effort.

8.4 Issues requiring further attention

Although great progress has been made by many countries in reducing air pollution problems, the situation worldwide is still of great concern. It is certainly true that many developed countries in recent years have been able to make significant reductions in emissions of SO_2 and particulates. This has been achieved in some cases through controls on large numbers of small sources, such as domestic coal fires, and in others by reducing emissions from large single sources such as power stations. Examination of emission inventories and ambient air levels of the different pollutants as described in this report can, coupled with a knowledge of local practices, point the way forward to the type of action required to improve air quality.

The information presented in the section on nitrogen oxides indicates that only very few countries have introduced measures which have been sufficiently strict to reduce the overall emissions of NO_x, and in most countries, there is little indication of any significant improvement in urban levels of this pollutant. Other countries show increasing emissions of NO_x. Indeed, it is considered that NO_x will become an increasingly important air pollution issue in both the developing and developed world. In rapidly industrializing countries, large increases in traffic density will lead to increases in NO_2 levels in city areas. The rapid population growth and influxes to urban aras which characterize these countries will lead to larger numbers of people exposed to NO_2 levels approaching or exceeding guideline values. In developed countries, the controls planned for vehicle emissions may well be offset by the increasing numbers of motor vehicles. Although not addressed in this report directly, increasing attention is being paid to the role of NO_x along with SO_x emissions in the issue of acid deposition.

The issue of NO_x is also of concern for another reason; namely because of its role in the formation of photochemical oxidants, the most familiar being ozone. Although not discussed in detail in this report, there are worrying indications that levels of ozone are increasing in many European and North American cities. This pollutant is of particular concern because commonly recorded levels cause damage to crops and pose a health threat to city population at large: because of the nature of the photochemical processes, resulting oxidants are not confined to the immediate areas of emission of the precursor pollutants (NO_x and hydrocarbons).

Motor vehicle emissions of carbon monoxide and lead are also major issues of concern in developing countries. Careful urban planning is needed, both in order to minimize the buildup of these pollutants and to locate housing away from areas of high traffic density. However, the question of controlling these emissions in the ways being done in Europe and North America poses problems of cost in many developing countries. Another major issue in need of urgent attention is the question of particulate emissions from diesel powered vehicles. This source can make an important contribution to the urban suspended particulate matter burden. Furthermore, diesel vehicle densities are increasing in cities worldwide, but very few countries currently apply controls of any kind to this source.

Suspended particulate matter has been shown to be present at unacceptably high levels in many cities around the world. This class of pollutant is actually a highly complex and variable mixture of different sized particles with many chemical components from different sources. There is an urgent need to characterize both the inhalable portion and chemical composition of urban particulate loadings in different parts of the world. The high levels of organics, particularly PAHs, present on suspended particulate matter is of continuing concern because of the carcinogenicity of many of these compounds.

Problems of indoor pollution are discussed further in Appendix I, but it is appropriate to note here that the right perspective needs to be maintained in each situation in order to achieve the greatest benefits to health. Thus, in countries where it is seen that there are problems of indoor pollution that far outweigh the current ones outdoors, attention might need to be directed to them first.

Where large gaps in the data base for both emissions and ambient concentrations have been identified in this report, notably in respect of developing countries, it may be possible to fill some of them in relatively simple ways. The information gathered to date has already indicated links, albeit somewhat incomplete, between types of source, emissions, inventories, control measures (or the lack of them) and ambient concentrations. The starting point in areas where little information is as yet available need not be an extension of the monitoring network: the above features can be examined in sequence, looking first and foremost at the types of source, which will then indicate whether there could be problems in relation to human health, leading on to decisions about making emission inventories or considering control measures. Some pilot measurements of relevant pollutants could be helpful at that stage, but there may not be an immediate need to implement a monitoring programme.

Finally, the information in the present report should not be seen in isolation, but should be viewed as an integral part of the GEMS programme. Thus human intakes of some pollutants, such as lead, are influenced by ingestion as well as inhalation, and sources such as food and drink must be taken into account in assessing total uptake and in interpreting the impact of control measures on environmental concentrations and ultimate effects. Similarly, health is not the only outcome to consider for a wide range of pollutants. Increasingly, it is being recognized that damage to vegetation or other (indirect) effects such as acidification of lakes and rivers, to the detriment of fish stocks, can occur through the release of acid gases into the atmosphere. Resolution of these problems may create more stringent requirements for control than those based on health.

Annex IV
Summary Assessment - Freshwater Quality

5 Conclusions

In the course of human history, the extent of water pollution has moved from local problems to regional, continental and now global problems. A general increase in the severity and range of pollution problems has occurred since the Roman period (Figure 25) where severe pollution cases occurred locally in mining areas due to heavy metals or in major cities due to contamination of water with pathogens. At the beginning of the industrial revolution in Europe, regional problems of domestic wastes pollution began to occur, while at the turn of this century the problems had already reached a continental scale in Europe and a regional one in the U.S.A. By the 1960s, the first evidence of global contamination of waters was found in Antarctic ice cores due to long-range atmospheric transport. This means that there are no longer pristine water bodies anywhere, even in remote areas. When a given pollution problem reaches the continental scale, even if some continents are not yet contaminated (as is the case with regard to South America and non-atmospheric pollutants), the global budget of pollutants carried to the oceans begins to be affected. This is already the case for some salts (Na^+, Cl^-, SO_4^{2-}) and for nutrients (N and P) (Meybeck 1979, 1982). If no drastic action is taken at a global level, through national and international enforcement of environmental laws, the worst situation suggested in Figure 25 might well be observed.

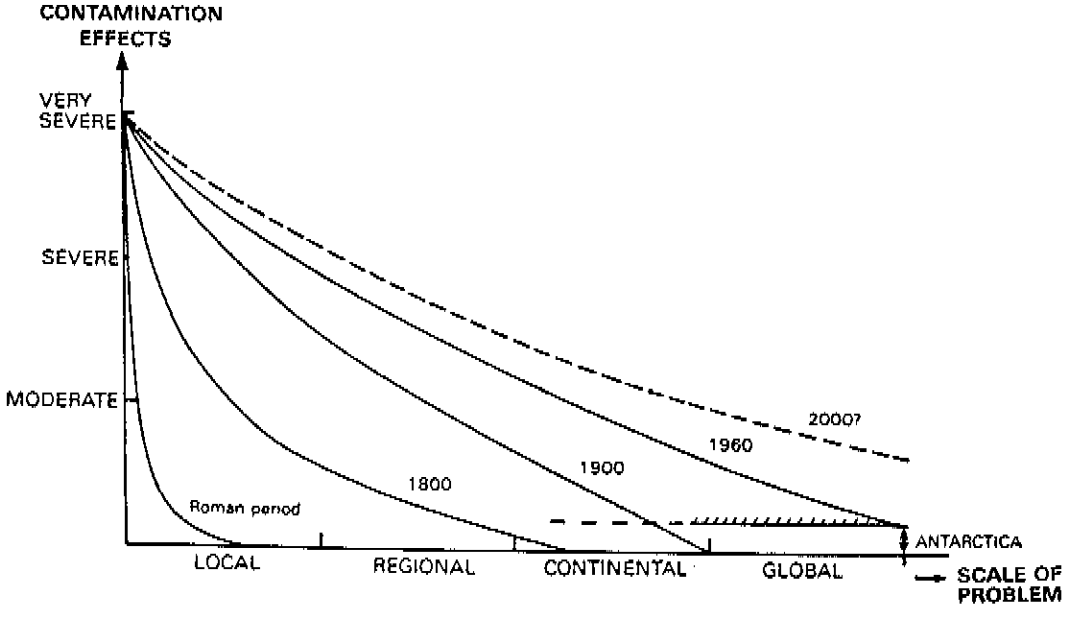

Figure 25 Evolution of water pollution problems

Accidental pollution of water should be considered separately. When it occurs it can cause severe effects on water bodies at various scales. Although this report does not consider radioactive contamination, the recent Chernobyl accident unfortunately illustrated the concept of global pollution. Due to atmospheric transport, the fallout of radionuclides has been recorded in both hemispheres and the maximum fallout has already caused many casualties at the accident site and will probably induce others in the Chernobyl vicinity. In Western Europe radioactivity in vegetables and milk exceeded the permissible guidelines for a short period. Accidents concerning the previously considered pollutants can cause severe local pollution, particularly in ground waters which may remain polluted for a long period. Human casualties linked to such accidents

through water intake are probably few (see Figure 26). Major industrial fires caused the pollution by pyrocatechine of the Rhone river in June 1985 downstream of Peage de Roussillon (60 tonnes of fish were killed and the river water downstream was unfit for drinking in 69 villages for at least 2 days) and the Rhine river pollution in November 1986 by miscellaneous products (the Sandoz accident) which also resulted in similar problems on a greater scale (Com. Int. du Rhin 1988). More recently, spillage from an oil tanker caused major pollution in the Ohio river in January 1988 which also resulted in the closure of water intakes for drinking purposes in some places. A major nuclear accident on a large river, although unlikely, would probably cause a complete and direct deterioration of downstream waters to the sea and indirect contamination (through the atmosphere) at a regional scale which would last much longer than any other type of accident, due to persistent sediment and groundwater contamination.

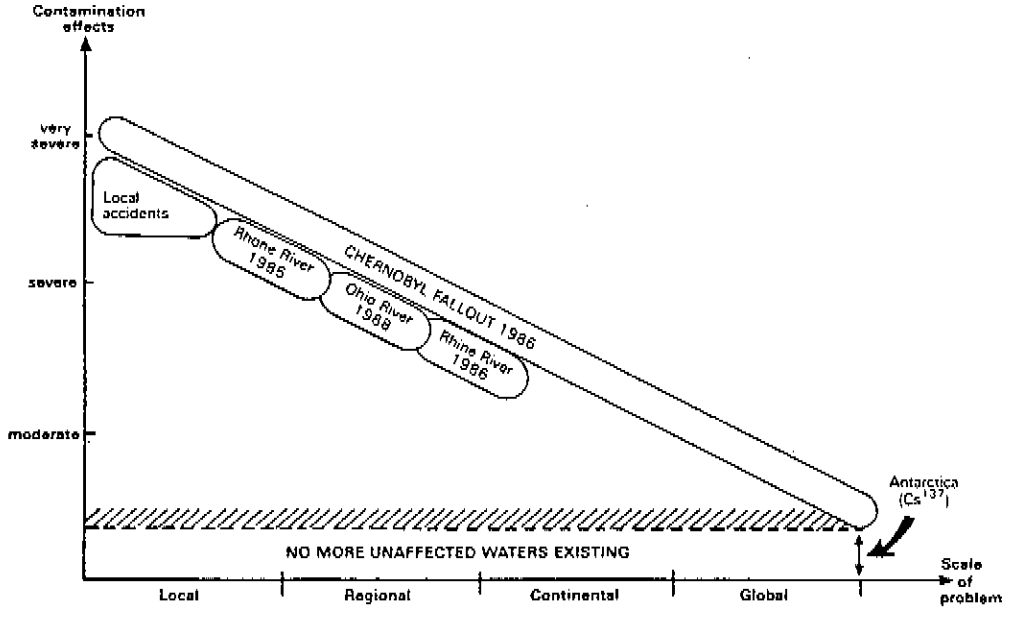

Figure 26 Occurrence and importance of accidental water pollution

5.1 Global Trends in Water Pollution

Today's most important problem areas are summarized below in order to highlight trends in water pollution and the need to measure and control their impact on the environment and on human health. The present global pollution assessment report has revealed, among other findings, that the concern over pollution issues varies not only geographically and thematically, but also with the socio-economic situation of a country or region.

For the purpose of generalizing pollution trends, countries may be categorized into one group of highly industrialized countries, another of moderate-to-rapidly industrializing countries, and a third group of countries at a low level of industrial activity with a predominantly traditional agricultural structure (WHO 1985). In countries with a low level of development, including the least-developed countries, point-source pollution is only a marginal problem mainly due to the lack of sewerage networks in the cities. Although water pollution within city areas may be severe, water resources in general do not suffer greatly from pollution. This, however, is not the case in areas where mineral resources are exploited on a large scale. Mining waste deposits and acid mine drainage often have far-reaching pollution impacts on surface and groundwater resources, due to the large scale of the operations.

Examples of the severity of organic pollution in relation to the spatial scale of contamination of world waters with respect to pathogens, oxygen balance, nutrients and eutrophication and nitrates are given in Figure 27. Very severe pathogen pollution causing infant deaths occurs in many developing countries, particularly when water availability is low. Many streams and rivers in central and tropical South America, the Indian Sub-continent and South East Asia illustrate the maximum evolution of organic contamination for a given basin size, as indicated by faecal coliforms, BOD or O_2 and nutrient levels. Although very poorly documented so far, African rivers are likely to present the same situation. The river Ganges in some stretches is probably the most polluted river of its size due to the high population density along its banks and in the catchment; a major action plan is now under way to reduce this pollution. In contrast, the Mississippi river shows evidence of only limited contamination which is contained by the waste treatment plant that was built 20-30 years ago.

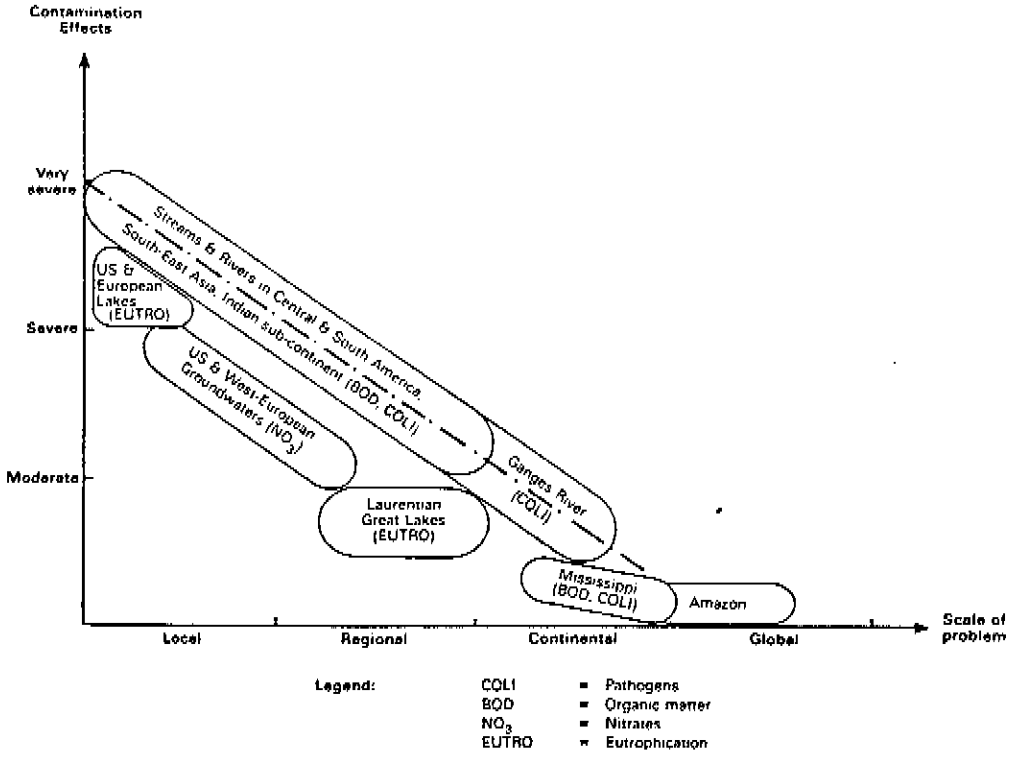

Figure 27 Occurrence and importance of organic water pollution

Eutrophication, which is often directly connected to organic waste, started about 30 years ago and has already badly affected many small lakes in Europe, U.S.A. and, more recently, in Asia. In Europe the problem is also affecting small and medium-sized reservoirs built in agricultural regions where nutrient sources are multiple and sometimes diffuse. In developing countries such as China, 25 per cent of major Chinese lakes are already eutrophic or hypereutrophic (Hou Ranjie and Zhu Xuan 1987). Increased nitrate levels in ground waters is currently a severe problem in many western European countries as well as in the U.S.A. In many places, the WHO guideline value for drinking water quality has already been exceeded. There are also groundwater

problems in arid and semi-arid areas with nitrate concentrations, and where no alternative water sources are available.

Salinization resulting from evaporation has always been associated with irrigation, but has now reached a regional to continental scale in ground waters in Sahelian Africa and in the arid belt from the Middle East to India. In many coastal aquifers where salt intrusion has been enhanced by overpumping, the water has become unfit for any use. In continental rivers the presence of salts is mainly due to mining (mine tailings wastes) and has already resulted in severe contamination in many places such as in the Alsace Rhine aquifer, the Weser and the Rhine rivers. In Alsace, Cl^- has exceeded WHO guidelines, whilst in the Rhine the water salinity causes major damage to the vegetable and flower crops of the Netherlands. Evidence of slight to marked salt increases in waters can now been found in many populated and developed regions, although levels are usually 10 to 50 times less than any guideline (e.g., Lake Geneva and Laurentian Great Lakes, Figure 28). Deforestation can be considered to have affected surface waters on a larger scale than salinization. However, the resultant increase in levels of suspended matter is sometimes counter-balanced by river damming which retains most of the particulate matter. Dams can also decrease water quality by causing salinization, retaining nutrients that were previously needed for irrigation and encouraging water-related diseases.

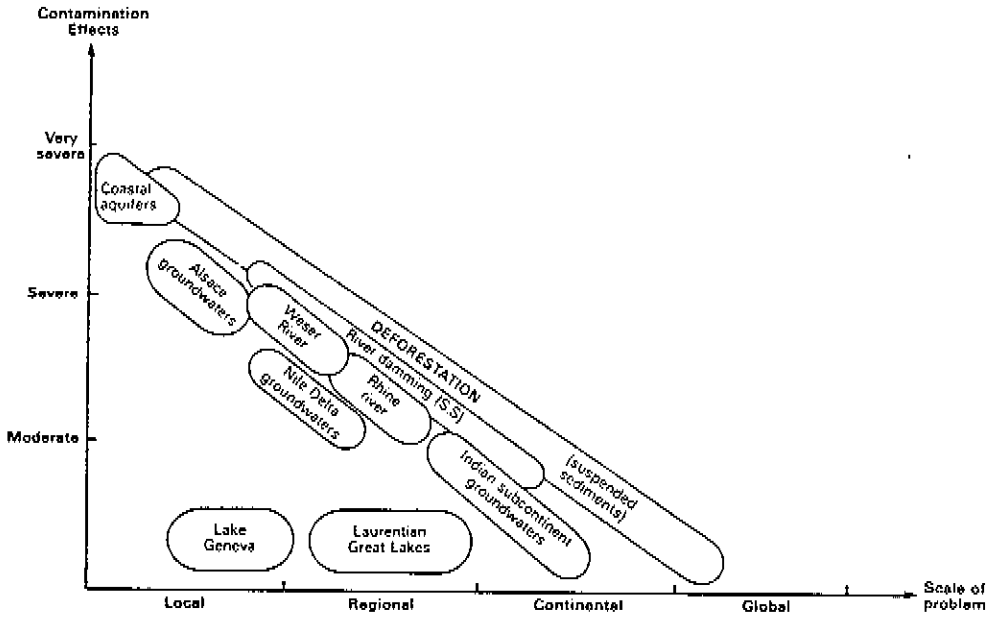

Figure 28 Occurrence and importance of salinization and of sediment loads

Metal contamination of water resources probably started with major Roman mining operations and evidence of such pollution can be found in some Welsh lake sediments and also in Lago di Monterosi near Rome (Hutchinson 1970). Examples of the worst deterioration in water quality can be found from local to regional scales (Figure 29). Pollution of the Jinzu river by cadmium caused the well known "Itai-Itai" disease. The Elbe river is still severely contaminated with cadmium and mercury, and the latter has polluted some Canadian lakes downstream from chloralkali plants. The Sudbury smelter in Canada has long been considered one of the largest single-point sources of metal pollution which has contaminated, through atmospheric transport, extensive

areas of the Ontario and Quebec provinces. At the global scale, lead levels have increased in Greenland and even in Antarctic ice cores. Scandinavian and North American rivers and lakes are now affected by acid deposition which results in marked increases in dissolved aluminium. This problem is not yet recorded in developing countries, but could emerge as a result of increased fossil fuel burning for power production.

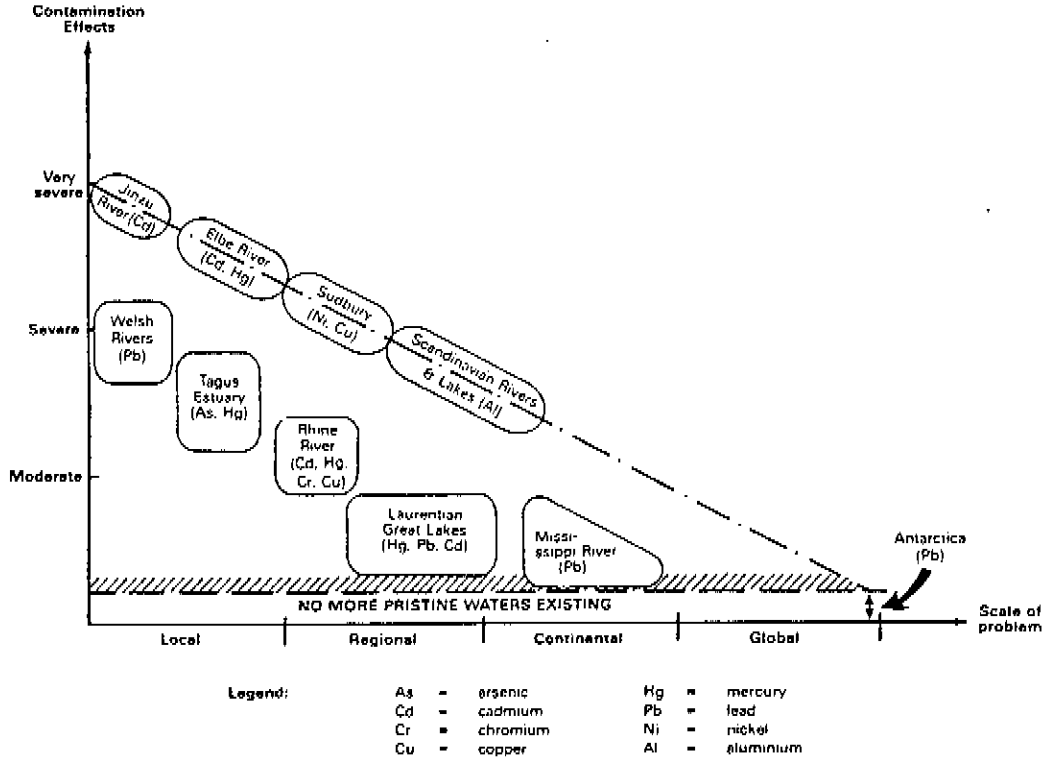

Figure 29 Occurrence and importance of heavy metal water pollution

Contamination by synthetic organic micropollutants is a more recent phenomenon, although in some places of major concern. It is difficult to assess water quality on a global scale for this category of contaminants, due to the lack of appropriate surveys. Even in developed countries, such as in Europe and North America, state surveys are still insufficient to draw general conclusions. The number of critical substances is rapidly increasing as new substances replace older ones. Therefore, a major uncertainty exists in Figure 30 relating to the maximum extent of contamination on a continental scale. Other scales are much better documented - local incidents in rivers and ground waters (such as Zurich, Long Island N.Y. and many others) are known to have caused very severe pollution, although the related casualties have not been reported. On investigation many rivers are found to be contaminated, such as the Jamuna river near Delhi (DDT) and the Seine and Rhine rivers (PCBs, chlorinated solvents, chlorophenols, volatile aromatic compounds). Pesticides are also likely to be found in many South-East Asian and African rivers. Trace contamination of large water bodies is now reported, such as in Lake Superior, and is

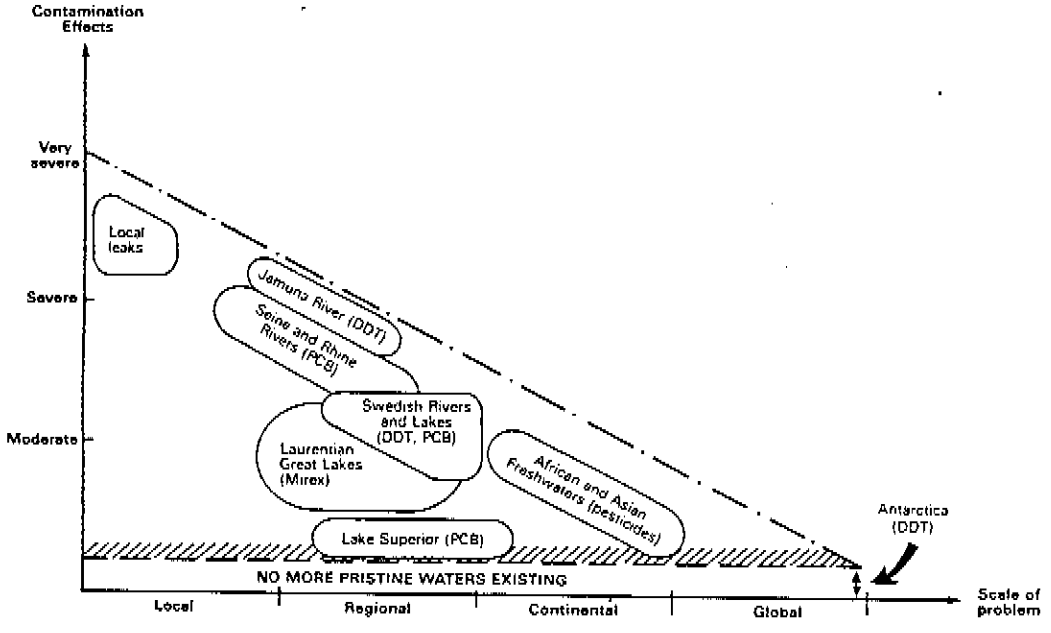

Figure 30 Occurrence and importance of organic micropollutant water pollution

generally attributed to atmospheric transport of pollutants. Improvements in water quality with respect to organic micropollutants is evident in many places at various scales, for example, Lake Geneva (DDT decrease), the Laurentian Great Lakes (Mirex insecticide), and Swedish waters and their aquatic wildlife (DDT, PCB).

5.2 Control Measures

Today advanced countries (mainly those in Europe) have experienced severe pollution and have undertaken a series of control measures designed to mitigate and curb water pollution. These measures include sewage disposal regulations, construction of city sewerage schemes, wastewater treatment installations, industrial effluent treatment and recycling, substitution of harmful or deleterious consumer products (non-biodegradable detergents, phosphates, alkyl lead) and banning of hazardous pesticides (DDT) and industrial chemicals (PCBs). Decreases in Pb in sediments in the Gulf of Mexico indicate decreases in Pb levels in the Mississippi watershed due to reductions in Pb emissions from automobiles.

The need for the control of transboundary emissions of SO_2 and NO_x is now recognized by the majority of industrialized nations. Acid deposition not only causes adverse impacts on freshwater quality but is also implicated in forest damage and deterioration of building materials. Reductions in SO_2 emissions have already been achieved in some of the industrialized countries and these are expected to continue in the future. However, emissions of NO_x have not generally declined and international agreements for their reduction are not as far advanced as those for SO_2. It may therefore be expected that nitrogen compounds will play a greater role in water acidification in the future. Greater emphasis on the contribution of NH_4^+ deposition is also likely, especially in regions where emissions of NH_3 from agricultural sources are significant.

Major water pollution threats exist today in industrializing countries with rapidly growing popu-

lations such as Brazil, China, India, Indonesia, Mexico and Nigeria, where pollution sources and demands upon water resources are expanding. Only 10 out of the 60 countries in this category have established effective laws, regulations, and enforcement infrastructures to cope with new and growing pollution problems (Helmer 1987). The appearance of traditional and modern types of water pollution, which occurred over 100 years or more in Europe, occur within one generation in developing countries, as shown in Figure 31. Achieving control over pollution issues in these countries has, therefore, become a question of ecologically and economically sustainable development. In these developing countries urban air pollution has already had obvious impacts in several large urban agglomerations, whereas the deterioration of the surrounding surface and groundwater quality is less visible, partly due to inadequate surveillance programmes. However, the consequences are no less costly to remedy.

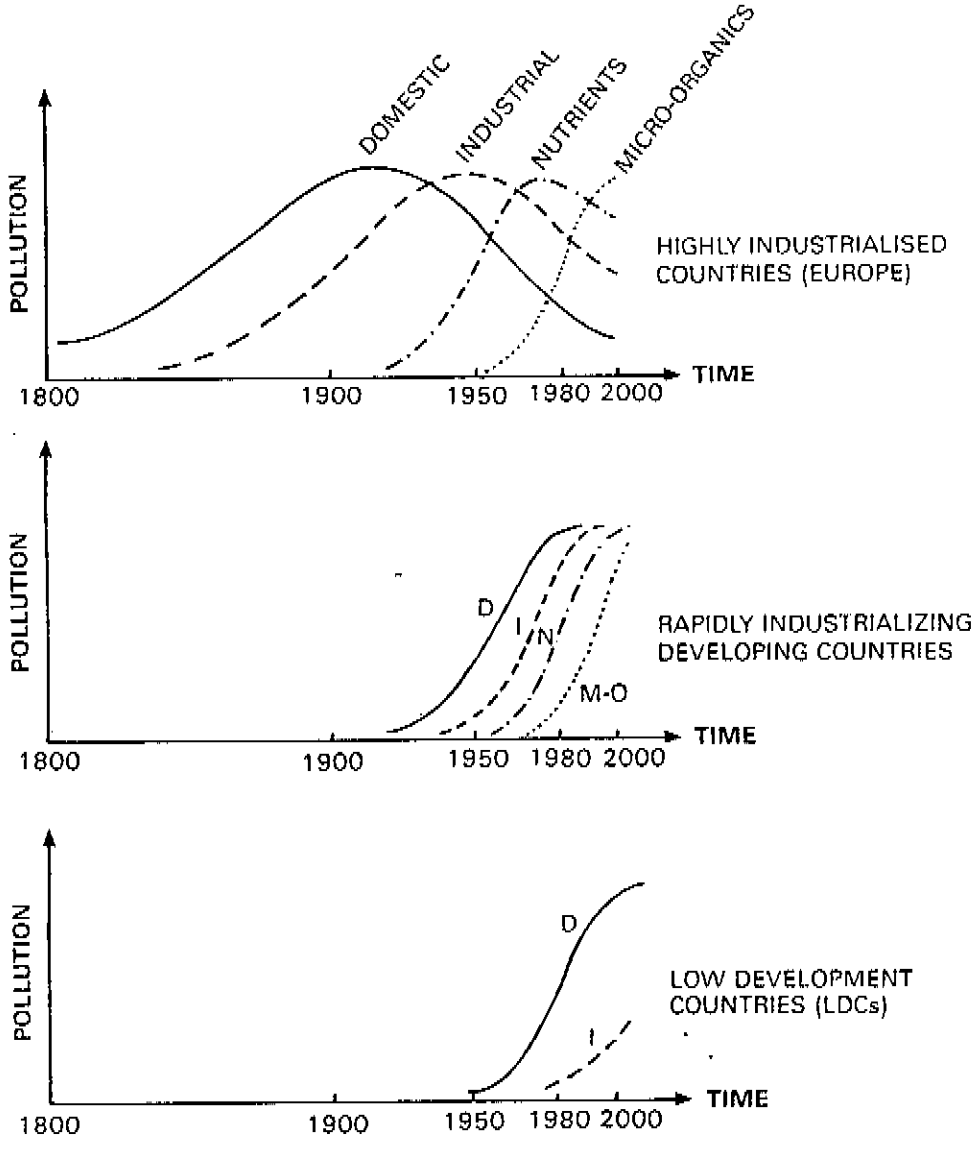

Figure 31 Evolution of water polution problems in countries according to development pace and status

Collection and treatment of wastewaters and control of effluents are not alone sufficient to combat water pollution. The time period between the introduction of a new chemical substance and its environmental levels being brought under control has always been rather long. For example, the complete cycle between the invention of a new product such as DDT and its environmental control was up to 30 years. The simultaneous appearance of different pollutants (heavy metals, organic micropollutants, etc.) requires the initiation of much faster responses by the relevant environmental protection authorities. Furthermore, innovative control mechanisms need to be imposed or made economically attractive. Major reductions in water demands and effluent discharges have been achieved in this way in many industrial and manufacturing sectors. Re-use of water and rational water quality management, together with a policy for the safe use of chemicals, are indispensable for the maintenance of water quality at the levels necessary for the water users.

In principle, measures are available to combat salinity and waterlogging. For example, the use of micro-irrigation techniques can greatly reduce infiltration and therefore avoid the problem of rising water levels. Their effectiveness as a preventive measure against waterlogging is evident from the countries where they have been extensively adopted, such as Israel. Where problems of waterlogging and salinity are already present, more efficient irrigation by itself is not adequate as a remedial measure. Instead, leaching out of salts by excess irrigation combined with effective and rapid downward drainage are required. In the case of soda salinization, chemical treatment of the soil may also be necessary. Examples of very effective control of waterlogging and salinity are hard to find. Prevention of water quality deterioration from irrigation requires the whole combination of measures, otherwise the salinity problem is merely pushed further along the hydrological cycle. Combating soil salinity by leaching from excess irrigation, for example, transfers the salt to the underlying ground water. Implementing extensive drainage measures may successfully prevent waterlogging and salinity, but the saline drainage water requires disposal and can cause water quality problems when returned to rivers. Truly comprehensive and effective drainage measures may therefore only be possible where highly saline effluent can be released into the sea.

Only radical changes in agricultural practices could reverse the overall trend in nitrate pollution; these would involve significant losses in productivity and the recovery would be over a long term (Foster et al. 1985). Current proposals for groundwater protection policies under consideration envisage the changing of agricultural practices in areas defined by groundwater recharge to public supply sources. Many of the management approaches available in Europe and North America are, however, not applicable in the institutional and financial framework of the developing countries. Appreciation of the potential impact of intensive agriculture on shallow ground water in tropical areas is relatively recent, but problems are likely to become increasingly acute, more widespread and difficult to control.

5.3 Emerging Global Water Pollution Issues

These issues already exist to a small degree in some countries but will become significant on a global scale in the future.

5.3.1 Accidental Pollution

Major industrial accidents resulting in the large-scale contamination of vital water resources will probably occur with increasing frequency. The large number of manufacturing, production and storage facilities along river banks in many countries leads to a high probability of accidental spillage. In view of the socio-economic constraints under which most companies operate in the developing countries, there is little realistic hope that effective safeguards against such accidents will be introduced in the near future. Consequently, the possibility of major accidents must be

taken into account by the responsible water quality management authorities and procedures for rapid action established. These could include administrative safety regulations at a national and international level (e.g., through inter-state river agencies or any other appropriate agencies), monitoring and contingency plans and the creation of emergency clean-up and pollution containment services.

With respect to the consequences of accidental spillage into water resources, rivers generally recover more easily than static waters due to the flushing effect of the river flow. Although a pollutant wave could destroy all higher forms of aquatic life in a section of the river, restoration is usually achieved quite rapidly. In the case of contaminants infiltrating accidentally into aquifers, the consequences are less visible, but may be more severe and longer-lasting. Residence times of ground water are much longer and the exchange processes with water-bearing geological strata are slower. These phenomena together require a period of years to recover. Special studies are, therefore, recommended to develop technological methods for accelerated groundwater clean-up and for the rapid containment of pollutants in case of an accidental spill.

As a long-term strategy, water authorities must exert pressure for the establishment of environmentally oriented practices for industrial plant safety and for accident prevention. The occurrence of major accidents in all countries is likely to increase. Although industrial accidents are often the only obvious sign of pollution inputs, they are generally more severe in their immediate consequences and may serve as the life-threatening disaster which triggers enough public awareness over environmental issues to make more profound and lasting pollution control measures possible.

5.3.2 Land disposal and mine tailings

The disposal of mine tailings and industrial and municipal waste substances in landfills without adequate environmental safeguards has developed into a hazardous source of pollution. These landfills generally date back to a time when no regulations existed in either the industrialized or the developing countries. Such sources of pollution will become more and more significant as traditional point sources of pollution come under control. At present the annual quantities of heavy metals disposed to land as a result of production and consumption (Nriagu and Pacine, 1988) are equivalent to, or up to, eight times greater than the total river fluxes to the oceans.

5.3.3 International transport of wastes

The transfer of solid and liquid wastes, particularly from industrialized to developing countries, may lead to severe and unpredictable water pollution problems in the future. This practice is considered unacceptable and efforts to discourage it will be required.

5.3.4 Water disinfection by-products

Drinking-water chlorination has been enormously successful for disinfection and should be continued. Nevertheless, a threat of contamination from the formation of halogenated organics and other toxic compounds has been recognized in recent years. The potential carcinogenicity of compounds such as trihalomethanes formed during the chlorination of surface waters containing organic substances (e.g., humic and fulvic acids) has raised concerns. Assessments of health risks from such compounds relative to the recognized benefits from chlorination should be undertaken.

5.3.5 Deterioration of biogeochemical cycles and water quality

The magnitude of anthropogenic activities influencing the environment has increased dramatically during the last few decades and has affected terrestrial ecosystems, the freshwater and marine environment and the atmosphere. Large-scale mining and fossil fuel burning have started to interfere measurably with natural hydrogeochemical cycles resulting in a new generation of

environmental deterioration and pollution problems. The scale of socio-economic activities — including urbanization, industrial operations and agricultural production — has reached a level where it interferes not only with natural processes within the same watershed, but has an impact on water resources and their quality elsewhere. As a result, a very complex picture of interrelationships between socio-economic factors and natural hydrological and ecological conditions emerges. Some of the issues emerging as the most relevant ones for global water quality are the following:

- Pollution from fossil fuel burning, industrial production, mining and smelting, and agricultural practices has contaminated the atmosphere on a global scale. This has led in turn to significant acidification of lakes and increasing contamination of surface waters (even in remote areas) with toxic chemicals. Such atmospheric pollution is also predicted to cause future climate warming.
- The rapid increases in water use, particularly the ground water withdrawals observed in semi-arid and coastal zones, will lead to widespread salinization and other water quality problems in future years.
- Large-scale deforestation in river basins, such as the Amazon, results in erosion of irreplaceable top soil and substantive nutrient losses.
- The shift of pollution problems one or more steps down the hydrogeological cycle, rather than solving them at the point of occurrence, has emerged as a major wide-scale issue. Examples include the Alsacian potassium mining wastes which when dissolved and discharged into the Rhine River rendered it unfit for use in greenhouse market-gardening in the Netherlands, the downstream export of salts from irrigation farming in Arizona to Mexico and the eutrophication of lakes and marine coastal waters from increased river nutrient loads.
- Damming of major rivers, such as the Nile, has led to decreased sediment transport and increased nutrient retention so that sediments and nutrients are lost to downstream irrigation areas and estuarine fisheries.
- The widespread destruction of wetlands eliminates a natural filter and biodegradation mechanism for many common pollutants.

5.4 Improvement of Water Quality Assessment

Data collection and evaluation for this assessment was hampered by a lack of data for certain geographic regions and variables. For example, the geographic coverage of the GEMS/WATER network is largely determined by the co-operation afforded the project by the countries and their participating institutions. Information from most Eastern European countries has not been made available. African water resources are very rarely monitored for their quality, and water quality surveillance programmes are only operational in some countries in Latin America and South-East Asia.

No routine monitoring data on organic micropollutants exist for most of the world's freshwater bodies or ground waters. Many aquifers are monitored locally but little integrated information on groundwater quality exists on a regional scale.

There are many difficulties involved in the sampling, preparation, analysis and interpretation of heavy metals and persistent organic micropollutants in the water phase. Suspended particulate matter and sediments should thus be used for reconnaissance surveys and routine monitoring of

these pollutants. Most metals and many of the organics are attached to particulate matter, for which they tend to show a much greater affinity than to the liquid phase. Aquatic biota can also be monitored, since some organisms tend to concentrate and also integrate a number of organic and inorganic contaminants. Aquatic bryophytes (mosses) and mussels have already been used for this purpose in some countries.

Another new direction in the monitoring of aquatic toxicity is the use of laboratory and/or *in-situ* bioassays. These are relatively simple and inexpensive and have the potential to provide an integrated measure of the combined or synergistic effects of micro-organics, metals and other unidentified contaminants.

In most developing countries neither the necessary laboratory instrumentation nor the highly specialized personnel are available to monitor micropollutants accurately. However, simple integrative measurements of categories of pollutants, such as specific conductivity for ions or dissolved oxygen and oxygen demand for organic pollution, can be carried out. Total chlorinated hydrocarbons, for example, could serve as a general indicator of water pollution until such time when detailed analyses become possible.

Many of the heavy metal and trace organic data from past years are unreliable due to sample contamination. Water containers, pumps and filtration units which do not release any of the substances which are to be measured must be used. Utmost care in sampling is required, particularly for ground waters where dissolved pollutants are present at low concentrations.

The reliability of the analysis of water is another important step in the global assessment of water quality. For many variables the intercomparability of analytical methods is not always possible and the essential analytical quality control is not always performed.

Trace metals are at present inadequately researched with regard to their fate and behaviour in the aquatic environment. More insight is required regarding their behaviour under different environmental conditions (pH, redox potential, salinity, uptake and metabolism in biota), especially for the more unstable forms (organic metal compounds, dissolved metals). This knowledge is an indispensable prerequisite for building realistic models of their pathways and behaviour.

Much research is under way on the identification and quantification of various organic micropollutants. More studies are needed, however, on the absorption and degradation of pesticides, industrial solvents and PCBs, particularly once they are leached into the unsaturated and saturated zones of ground water. Field and laboratory research is needed to verify the factors determining the attenuation of these pollutants and their microbial degradation for each type of aquifer.

Better understanding of the basic biogeochemical processes and interactions between particulate and dissolved forms of pollutants, biota and sediment is required to assess the fate and pathways of pollutants in the aquatic environment. Models need to be developed for this purpose and reliable data generated to verify their validity and practical relevance. Although adequate models for biodegradable organic matter and oxygen balance in rivers exist, there have been only a few models generated to describe the fate of metals and organic micropollutants. Ground water models which describe the transfer of miscible and immiscible pollutants into the microporous matrix of aquifers are also lacking.

ANNEX V

SUMMARY ASSESSMENT - FOOD CONTAMINATION

The available information on food contamination on a global or even regional basis is largely insufficient to allow a comprehensive and definitive evaluation of its severity or trends. This is particularly true for the developing countries for which data on food contamination are very sparse at best. The task of trying to make comparisons among countries or in observing trends is compounded by the vast differences which exist among countries in the foods which are monitored, by the analytical methods which are used and by the lack of continuity in the data sets which are made available, as well as by lack of assurance of quality of data obtained from some laboratories. These limitations should be kept in mind when interpreting the results of the current assessment.

The information which has been collected by GEMS/Food over 14 years, together with the results obtained by individual researchers, does provide some insights into what is the general situation regarding contaminants in food. On the basis of the available information, summarized in this report, it can be said that:

(i) particularly in the industrialized countries, the current median/mean levels of contaminants in individual foods and in total diet are generally well within established health criteria, guidelines or standards;

(ii) there are, however, some exceptions where the current median/mean levels are close to or can even exceed such criteria or guidelines. These include, in quite a few countries, the levels of organochlorine pesticides and PCBs in human milk, of mercury and PCBs in fish, of lead in canned foods and of aflatoxins in nuts and cereals. It should be noted that exposure of infants to organochlorine compounds in human milk is limited to a short period in a lifetime and therefore may not be a significant health hazard. Furthermore, the alternatives for feeding the infants may subject them to even greater health risks.

(iii) while data relating to the developing countries are much less complete, there are indications that the median/mean levels - particularly organochlorine pesticides and aflatoxins - can in many places be quite high and in excess of health guidelines;

(iv) in the industrialized countries, the trend in contaminant levels in food, while mixed, is generally downward, as the use of the persistent pesticides and other toxic chemicals is curtailed or banned altogether; and

(v) there are situations, as reported by specific investigations, where, in both the developed and developing countries, considerable contamination of food occurs; while the general population may not be at risk, specific population groups may be unduly exposed.

The major findings about the status of food contamination by the individual substances is highlighted in the following paragraphs.

In general PCB contents of foods are low, although extremely high concentrations have been found in isolated cases. The highest concentrations are typically found in fish from inland waters, estuaries and enclosed seas. Where fish constitutes a major item in the diet, the total dietary intake of PCBs is substantially higher than for populations elsewhere. The average intakes of PCBs reported are, however, low when compared with the available health guideline and, moreover, the general trend is downward for both dietary intakes and levels in fish. An exception may be human milk, where the measured levels are often in excess of the established maximum limits for dairy milk. The data from the present report are based on results on total PCBs received from individual countries without further specification as to individual congeners. In some countries PCB analysis is actually performed by determining individual congeners. This makes a comparison with data concerning total PCBs difficult.

The monitoring of lead in food is more widespread and much more data are available for lead than for most other contaminants. In general, the dietary intake of lead by adults, infants and children is within established health guidelines, with the intakes by infants and children at times approaching or exceeding the standards. Exposures above acceptable levels have been shown to occur in heavily industrialized areas, in areas of high traffic density, and especially in areas with high lead concentrations in tap water. As regards individual raw foods, the highest concentrations of lead are generally found in shellfish, fish and animal kidney and liver. Canned foods may also contain elevated concentrations of lead. The available data show that the use of cans with lead-soldered side seams adds substantial amounts of lead to the food.

Notable decreases in the dietary intake of lead have now been evident for several years, particularly in the developed countries, as the governments have taken measures to reduce the environmental emissions of lead and to change to non-lead-soldered cans.

The situation for cadmium is different from that with lead. The dietary intake levels are much closer to the established standards and guidelines. In general, the average cadmium levels in the diet are within the acceptable range. However, in one fourth of the reporting countries, exposure of particular groups may exceed tolerable intake levels. Particular groups identified were infants exposed to high cadmium in water, consumers of large amounts of kidney and mussels or some people living in industrialized areas.

Shellfish and animal kidney are the foods most likely to contain high levels of cadmium. While relatively low levels of cadmium are found in staple items such as cereals or potatoes, the fact that they are consumed in large quantities means that they make an important contribution to the overall cadmium intake.

From the limited data which are available, it appears that over the last five or six years the levels of cadmium in the diet are, in general, relatively stationary with no clear upward or downward trend.

The main problem of mercury in foodstuffs is the high concentrations found in fish at some locations, e.g. in the Mediterranean, especially near mining sites, and in fresh water lakes in Scandinavian countries. The large carnivorous fish species such as shark and swordfish may contain mercury levels that exceed national regulatory limits. Foods other than fish seldom contain elevated levels of mercury. For this reason, total intake of mercury is generally dependent on the amount of fish consumed and the concentration of mercury in fish.

Dietary intake of mercury is usually well below toxicologically acceptable intake levels. However, where populations consume above average quantities of fish, as might occur in fishing communities, or where industrial discharges have resulted in the contamination of fish, such intakes exceed toxicologically acceptable levels. This is of particular concern since pregnant women and nursing mothers are at greater risk to adverse effects from mercury.

Aflatoxin contamination is of particular concern in many developing countries where the climate is conducive to growth of mycotoxin-producing moulds, and where resources are limited for preventing and controlling aflatoxins in the food supply. Levels of aflatoxins in food commodities indicate that many countries are taking effective steps to limit the formation of these substances in food and animal feed. However, there are instances where high levels occur, especially in maize, groundnuts and pulses.

The highest concentrations of organochlorine pesticides (aldrin and dieldrin, DDT, HCH, heptachlor, lindane, endrin, endosulfan and HCB) usually occur in fat-containing foods, especially milk and milk products. Of particular concern is the pesticide content of human milk, which is monitored quite extensively in several countries. Aside from aldrin and dieldrin and DDT in human milk, the contents of the other organochlorine pesticides in milk, including human milk, are with some exceptions well within established guidelines.

In the information reported to GEMS/Food the total dietary intake of these pesticides is also very low when compared to the established ADIs. As regards aldrin plus dieldrin in human milk, the situation is different. The information reported shows that in the ten reporting countries the estimated intakes exceed the ADI.

With the exception of HCB, where the main current source is considered to be industrial emissions, there has been a downward trend in the concentration of organochlorine pesticides in food. It must be remembered, however, that the available data are largely from countries that have taken steps to curtail or ban altogether the use of these pesticides. This may not be the case in other countries; for example, studies conducted in India and Egypt show high levels of DDT and total HCH in dairy products as well as in staple grains and vegetables.

Contrasting with the organochlorine compounds, organophosphorus pesticides are not stable in the environment and are metabolized extensively by animals. Thus, residues usually occur in raw crops but not in food of animal origin. Organophosphorus pesticides are seldom detected in foods. However, sporadic instances of higher levels in cereal products, fruit and vegetables indicate that contamination of crops can occur under certain conditions of use.

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