United Nations Environment Programme

Distr.
GENERAL

UNEP/GC.14/19
24 February 1987

ORIGINAL: ENGLISH

GOVERNING COUNCIL
Fourteenth session
Item 10 of the provisional agenda

PROGRAMME MATTERS

List of selected environmentally harmful chemicals substances, processes and phenomena of global significance

Report of the Executive Director

Summary

The present report is being submitted in compliance with Governing Council decision 12/11 in which the Executive Director was requested to obtain the comments of Governments, relevant international organizations, industry and non-governmental organizations on the list of environmentally dangerous chemical substances and processes of global significance (UNEP/GC.12/16) and to submit an updated version of the report to the Governing Council at its fourteenth session, taking into considerations the comments and suggestions received.

Following an explanation of the report's objectives and of the approach adopted in its formulation, including the criteria followed for the identification of the environmentally harmful chemical substances, processes and phenomena of global significance, six chemical substances, three processes and one phenomenon of global significance are listed: cadmium; lead; mercury; carbon dioxide; nitrogen oxides and photochemical oxidants; sulphur dioxide and derivatives; production and use of coal and other fossil fuels; injudicious use of pesticides; oil pollution; and eutrophication. A brief description is given of each chemical, process and phenomenon, followed by a summary of their impact on humans and the environment. Finally a set of recommendations is proposed with regard to each.

Na.87-0090 - 8702c

/...

Suggestion action by the Governing Council

The Governing Council may wish to:

1. Note the updated report of the Executive Director;

2. Request the Executive Director to:

(a) Refer the report to Governments, relevant international organizations, industry and non-governmental organizations for further study and action, as appropriate;

(b) Obtain their comments on the report, in particular on the recommendations contained therein;

(c) Submit an updated version of the present report to the Governing Council in 1991, taking into consideration the comments and suggestions received.

/...

INTRODUCTION

1. In its decision 9/6 of 25 May 1981, the Governing Council requested the Executive Director to develop a short list of environmentally dangerous chemical substances harmful at the global level, to which environmental policies should pay special attention. The Governing Council discussed the list (UNEP/GC.10/5/Add.3) at its tenth session in May 1982, and adopted decision 10/15, in which it requested the Executive Director to obtain the comments of Governments, the scientific community and other international organizations on the report. Governments were asked, in preparing comments on the report, to give priority attention to the recommendations on the substances and processes contained in the list. The Executive Director was requested to review the list, on the basis of the comments obtained, and to report on the results to the Governing Council at its twelfth session. Finally, the Council decided that, as from 1984, the list should be reviewed and updated periodically, preferably every three years.

2. An updated version of the report (UNEP/GC.12/16) was prepared during 1983 and submitted to the Governing Council for discussion at its twelth session in 1984. The Council, in decision 12/11, which was similar to that adopted in 1982, requested the Executive Director to obtain the comments of Governments, relevant international organizations, industry and non-governmental organizations, and submit an updated version of the report to the Governing Council at its fourteenth session in 1987.

3. During the second half of 1984, the Executive Director invited Governments, international organizations, industry and non-governmental organizations to study the report, to take action, as appropriate, and to submit comments. During 1985 and 1986 replies were received from 28 Governments, 12 international organizations, and 11 industrial and non-governmental organizations. Among the replies received, 18 expressed general approval without specific comment. Most other responses received involved suggestions for the following: inclusion of additional or more recent data, formulation of new or amended recommendations, additions/deletions to the list for future consideration, or editorial changes and changes in the format of the report.

4. A small expert meeting was held in Geneva from 8 to 12 December 1986 to review all comments received as well as any new scientific evidence that had come to light since the previous version of the list had been prepared. An updated version of the list was then prepared after individual appraisal of all comments, and other material. The meeting recommended a change in the title of the report so as to include the term "harmful environmental phenomenon".

5. No attempt has been made to list in priority order either the selected chemicals, processes or phenomena or the recommendations pertaining to each of them, as it was recognized that priorities differ not only between countries, but also between different areas.

/...

6. All chemical substances, processes and phenomena in the report were also evaluated to see if they should be retained in the updated list. In this connection, the meeting took full account of ongoing or planned international programmes and assessments related to any of them. The meeting expressed its view on potential deletions and changes to be taken into consideration for future versions of the list. It also submitted a subsidiary list of substances, processes and phenomena, suggested by both respondents and members of the expert group for possible future inclusion. A limited number of copies of the report of the expert meeting, in English only, will be available on request to delegations at the Council's fourteenth session.

/...

I. OBJECTIVES

7. The purpose of the study dealt with in this report is to stimulate awareness among Governments and the public about the hazardous effects of environmental chemicals on man and the environment, so that necessary measures may be adopted to prevent serious impacts.

8. At its ninth session, in its decision 9/6, the Governing Council recognized that the preparation of a list of environmentally dangerous chemical substances harmful at the global level, to which special attention should be paid in environmental policies would contribute to the promotion of public awareness of their possible environmental hazards.

9. Lists of priority chemical/pollutants have been prepared by many national authorities and international organizations. Such lists help Governments and international bodies to focus on major problems and ensure that invariably limited resources are allocated where needed.

10. Chemicals that are widely distributed in the environment in significant quantities by human activities represent potential threats to ecosystems as well as to human health. The choice of chemicals listed in this report reflects the need to protect ecosystems and populations of non-human organisms per se as well as human health.

11. Certain chemicals are not listed although they are the subject of substantial concern and merit careful consideration. They are either presently not considered to be of global concern, or they have been excluded because they are already specifically being dealt with by UNEP and/or other international organizations.

12. The list should not be regarded as exhaustive or final, but rather as another step in identifying global environmental and human health priorities. It is intended for both international and national organizations.

II. APPROACHES

A. Definitions

13. The UNEP Governing Council, by decision 9/6, limited the list of priority chemicals to substances harmful at the global level. Chemicals of global significance have been defined in the context of this report as those which occur widely in the environment in significant quantities as a result of their transport through air, water and food chains, or because they are present in commodities traded internationally on a large scale. Chemicals of global environmental significance also include those that have regional or local significance but that are of such frequent occurrence as to cause common concern in a large number of countries.

14. Harmful chemicals can be defined as those that enter the environment, as the product or the by-product of human activities, that appear to pose, directly or indirectly a real threat to man and the environment, and that, at least now, can only be eliminated from the environment with difficulty.

/...

15. A harmful process is one that involves manufacture, transportation, use, or disposal, and which releases significant amounts of one or more harmful chemicals into the environment in the above sense.

16. A harmful phenomenon is an environmental event of importance related to adverse effects due to chemical pollution such as eutrophication.

B. Criteria

17. In this report a two-part approach is used to identify chemicals which are dangerous in a global sense. There are criteria that must be satisfied if a chemical is to be regarded as having global significance and other criteria that determine the threat to man and the environment. Information on the distribution and behaviour and harmful effects of chemicals needs to be evaluated in accordance with the following criteria:

1. Production, distribution and release;
2. Secondary substances;
3. Persistence and transformation;
4. Bioaccumulation and biomagnification;
5. Exposed populations;
6. Toxicity and exposure level;
7. Effects on the physical and chemical environment.

18. It is necessary to identify chemicals which exist in the environment in large quantities, which persist and are widely disseminated, and the behaviour of which may place certain populations at risk. Each of the criteria is examined in turn below in greater detail.

1. Production, distribution and release

19. Potential global significance is determined by applying the following considerations:

(a) The quantity of chemical industrially produced, including its relative importance when compared to natural sources;

(b) The geographical spread of production centres;

(c) The fraction of the chemical ultimately lost to the environment;

(d) The geographical distribution and type of pollutant sources;

(e) The dispersion and distribution of the chemical in the environment;

(f) The likelihood of future increase.

/...

2. Secondary substances

20. In many or most cases chemicals are not pure compounds, but mixtures. Impurities may be present which, although at low levels, are so toxic as to be in fact more significant than the primary compound. Chemical products as released may consist of complicated mixtures, the toxicity of each component being poorly understood. Additives, for example as carriers, emulsifiers, and dispersants, may also be present and can significantly alter (or change the selectivity of) the effective toxicity of the primary compound.

3. Persistence and transformation

21. The widespread release of a persistent chemical into the environment can result in global dispersion if the chemical is mobile in the environment, and hence a large number of organisms, ecosystems, and human populations may be exposed. In many cases, injury to organisms can take place in areas remote from the point of release. Persistence increases the possibility of this happening; furthermore, persistence means that corrective measures require a larger time to take effect. The persistence of a chemical in tropical ecosystems may differ from that in temperate ecosystems. Transformation products of chemicals must also be considered, as they may be more persistent or toxic than the original chemical.

4. Bioaccumulation and biomagnification

22. Organisms can take up substances from both their food and biotic environment (bioaccumulation). Some chemicals increase in concentration along some food chains (biomagnification). These processes can lead to toxic concentrations within the organisms, which may then adversely affect whole populations. Biomagnification is especially important at higher trophic levels; for example, chlorinated hydrocarbon insecticides have had a great impact on populations of birds of prey. Human diets can be so diverse in content and geographic origin that it may be difficult to control man's exposure to chemicals from food.

5. Exposed populations

23. If a chemical is globally dispersed, then the possibility of exposing any population (human or non-human) will also be global. However, global distribution tends not to be uniform, and due consideration should therefore be given to populations which are possibly at risk. In this context it is also important to recognize that background levels vary from place to place, and that a slight increase in exposure of any already exposed population may be particularly significant.

6. Toxicity and exposure level

24. Being toxic does not automatically imply that a chemical will produce adverse health or environmental effects when released into the environment. Toxicity refers to the potential of a chemical to cause harm in organisms. In reality, however, we are concerned with the extent to which toxic effects

/...

actually occur. So, in principle, the danger of a chemical can only be assessed properly if two types of information are available: data on environmental occurrence and distribution from which the degree and time-course of exposure of man and other organisms can be estimated; and data on the chemical's toxicity to a variety of organisms.

25. The measure of a pollutant's environmental effect is the degree to which populations of individual species are affected. Only for cultivated and domesticated species are we concerned with effects on individual organisms. However, special attention should be paid to endangered species. Natural events cause many populations to vary greatly in size from time to time, changes due to pollutants are superimposed on these natural changes, and can therefore be difficult to detect.

7. Effects on the physical and chemical environment

26. Global processes or phenomena involving chemicals may not exert direct toxic effects on man or other species, but may, instead, affect some abiotic parameter of the environment such as temperature, rainfall or nutrient availability.

C. Follow-up activities

27. The selection of environmentally harmful chemical substances, processes and phenomena of global significance should be reflected in activities at the national and international levels. At the international level it is to be expected that substances, processes and phenomena selected in this list will be incorporated in the framework of Earthwatch. The list reflects priorities for instituting or continuing activities in monitoring, in particular biological monitoring, and research under the Global Environmental Monitoring System (GEMS). It also points to areas where a continuous process of assesment, where not yet in existence, should be instituted in order to secure timely warning.

28. The result of such an assessment may call for activities aimed at improving chemical management and educating users and producers of the selected substances. Where appropriate, such activities should be internationally co-ordinated with the active participation of the relevant international agencies and organizations.

III. EXECUTIVE SUMMARIES WITH RECOMMENDATIONS

A. Cadmium

1. Background

29. Cadmium is a toxic trace metal whose environmental release from human activities is a feature of the twentieth century. Commercial production of cadmium only began this century and over half of all the cadmium ever produced has been refined in the last two decades. Currently, world-wide production of cadmium totals about 18,000 tons per year. The major cadmium-containing products tend to be disposed of rather than recycled after end-use, resulting in the environmental release of substantial quantities of the metal. Significant emissions of cadmium also arise from inadvertent sources. An

/...

insight into the impact of human activities on the global cadmium cycle may be gained when it is noted that atmospheric cadmium emissions from man-made sources of the order of 7,000 tons per year exceed those of natural origin by about an order of magnitude. Sewage sludge and phosphate fertilizers can contain appreciable cadmium concentrations and are responsible for significant inputs of the metal to agricultural land, where the metal may be retained for many years. Atmospheric deposition may present a significant localized source of contamination. Soil acidification can result in increased mobilization of cadmium.

2. Human and environmental impact

30. Dietary intake is the predominant source of cadmium exposure in the general population, but tobacco can be a more important source in smokers. Plant-based food-stuffs, particularly cereal products, usually make the largest contribution to dietary intake. Thus, the transfer of cadmium from soil to crop plants is the critical exposure pathway for the general population. Average dietary intake values reported from most countries are usually below the provisional tolerable intake value proposed by FAO/WHO. However, one study estimated that about 15 per cent of the adolescent male population in the United States of America exceeds this value. The proportion of dietary cadmium which is absorbed averages about 5 per cent, but a marked individual variation in uptake exists with some subjects absorbing much more of the metal than others. In addition, iron deficiency increases the absorption efficiency of cadmium.

31. Several distinct groups are at risk from excessive dietary cadmium exposure, either because their food is contaminated or because of unusual dietary habits. These include individuals who eat large quantities of shellfish or kidneys and those regularly consuming food plants from contaminated soils. Smokers may also be considered at risk because of the high uptake from tobacco smoke.

32. Different exposure regimes and variability in absorption efficiency in the general population result in a range of overall daily retention values of about 1-9 µg. The amount of cadmium needed to be retained daily to cause impaired kidney function after 50 years is about 10-15 µg, indicating that a proportion of the general population is already approaching this critical value.

33. Absorbed cadmium is stored mainly in the liver and kidney where it accumulates with age, reflecting the long residence time of the metal in humans. The first signs of kidney damage are those of impaired function. The cadmium concentration needed to cause this effect in middle-aged males is higher than the average values reported from different countries. Nevertheless, it is more meaningful to focus upon individuals at the upper end of the distribution. In these groups there is only a small margin of safety for some countries while in other there appears to be none at all.

34. In addition to renal effects, larger cadmium body burdens have been associated with effects on bone-structure. In one area in Japan, a syndrome termed itai-itai disease has been identified, mainly in elderly females with poor nutritional status. Symptoms in this particular group included renal dysfunction and osteomalacia. Elderly females from a city in Belgium have

/...

been found to have larger cadmium burdens and a higher prevalence of signs of renal dysfunction compared with an age-matched control population. It was suggested that cadmium aggravates the age-related decline in renal function at moderate exposure levels and that the critical level of renal cadmium in elderly females appears to be lower than in middle-aged males.

35. Cadmium and certain cadmium compounds have been shown to be carcinogenic in experimental animal studies. In 1982, the International Agency for Research on Cancer concluded that there was limited evidence for cadmium being a human carcinogen. However, further studies have since been published, and a re-evaluation is to be undertaken in 1987.

36. Elevated cadmium burdens in biota are generally restricted to those organisms living close to sources of the metal. Several plant species have evolved cadmium tolerance in such areas. There is also evidence that elevated cadmium fall-out close to smelters has led to reduced rates of leaf litter decomposition, which may have long-term effects on nutrient cycling. Kidney damage observed in certain seabirds has been linked to the very high cadmium concentrations found in these species. This accumulation is considered to be a natural phenomenon.

37. There is evidence that the marked increase in the environmental dissipation of cadmium in this century has been accompanied by an increase of exposure levels to the metal, as present kidney cadmium concentrations are much higher than historical specimens from the turn of the century. A forecast of future trends of dietary cadmium intake predicts a further rise in exposure as a result of increases in crop cadmium levels.

3. Recommendations

38. (a) More information including monitoring is needed on the relative significance of cadmium inputs from phosphate fertilizers, sewage sludge, waste disposal, and atmospheric deposition to the levels of cadmium in crop plants, together with the implications for future dietary intake. This will allow the implementation of efficient control strategies to minimize the accumulation of cadmium in soils and increased dietary intake.

(b) Further research is required into the factors influencing the uptake of cadmium from the diet (both food and water). The proportion of the general population with elevated cadmium exposure and at risk from developing renal dysfunction needs to be estimated more accurately. This may be achieved by initiating a biological monitoring programme.

(c) Further health-related studies of elderly females from cadmium-polluted areas are needed, in order to take into account the age-related increase in sensitivity to cadmium in the elderly.

(d) Cadmium should only be used in industry where a suitable alternative is not available. Emissions from industrial sources should be controlled so as to comply with WHO air quality guidelines.

/...

B. Lead

1. Background

39. Lead is a natural constituent of the environment but its distribution has been overshadowed by the man-made dissemination of the metal. The major uses of lead are in the manufacture of batteries, pigments, cables and the fuel additive, tetra-alkyl lead.

40. World-wide atmospheric lead emissions from human activities have been estimated to total 450,000 tons per year compared with just 25,000 tons per year from natural sources. Inorganic lead, produced from combustion of alkyl lead in automobiles, accounts for over half of the man-made emissions. However, in countries where unleaded petrol is being introduced, emissions from this source are rapidly declining. Other major sources include the smelting and refining of the metal itself and certain other metal ores, coal combustion and refuse incineration, as well as the production of lead-based products.

2. Human and environmental impact

41. Although alkyl lead compounds exhibit a greater degree of toxicity *per se*, inorganic lead has a greater environmental health impact.

42. Humans are exposed to lead via food, air and water; in children, dust, paint and soils may also be important. Uncertainty still exists regarding the relative contribution of different sources to total exposure. About 90 per cent of airborne lead is derived from the exhaust gases of motor vehicles. Consequently, air lead concentrations are elevated in urban areas and long-term mean values often reach 1 µg per cubic metre, compared with less than 0.2 µg per cubic metre in rural areas. In some countries a decrease in the use of lead in petrol has been linked to a reduction in urban air lead values.

43. Elevated soil and plant lead concentrations are found close to roads and industrial sources, such as smelters. Airborne lead deposited on soils is retained for many years. In urban areas, household and street dusts commonly contain lead levels of 1 mg per gram, derived from vehicle emissions, eroded paint, industrial sources or soil. The concentrations of lead in drinking water are generally below 10 µg per litre, but the use of lead piping in soft water areas can cause marked contamination, and concentrations can exceed 1 mg per litre in some instances.

44. Estimates of daily dietary lead intakes from different countries range from less than 100 µg to more than 400 µg. A provisional tolerable weekly intake for adults equivalent to about 400 µg a day has been proposed by FAO/WHO, but this value should be lower for children. Canned foods can make a significant contribution to dietary intake, as a result of the use of lead solder in can manufacture. Improperly glazed ceramics and certain other consumer products may contribute to the total lead intake to a varying degree. Plant-based foods are the major source of dietary lead but the relative contribution from soil uptake and atmospheric deposition to plant

lead burdens is unclear. In adults, lead intake from water is about 10 µg a day, but exposure increases in soft water areas with lead plumbing, and bottle-fed infants can ingest large amounts of lead from this source. Lead intake from the ingestion of dust is considered to be an important source of exposure in certain infants. The uptake of lead from the gut is about 10 per cent in adults; in children the situation is less certain, but figures up to 50 per cent have been recorded. Uptake of lead from lungs is about 50 per cent in adults. Respiratory uptake was reported to account for about 30 per cent of total uptake in adults from some urban populations, but is the main source of lead in occupational exposure.

45. Lead taken into the body enters the blood from where it is redistributed to soft tissues and the skeleton. Skeletal tissue is the long-term storage site for lead and contains most of the body burden of the metal. Lead in blood (Pb-B) is biologically active and is used not only as an indicator of recent exposure but also to evaluate the likelihood of health effects. Values of Pb-B in the general population show considerable variability and average values in a recent survey of nine countries ranged from 6 to 22 µg per decilitre. Adults and children from inner city areas have higher values of Pb-B than outer city dwellers. Occupationally exposed workers have elevated values of Pb-B; levels of 40-60 µg per decilitre are only representative of situations where exposure is relatively well controlled.

46. The following manifestations of clinical lead poisoning occur in adults occupationally exposed to high levels of lead: abdominal colic, anaemia, renal damage, neuropathy and, rarely, encephalopathy. Recent studies in males indicate a causal relationship between lead exposure and increased blood pressure, although a threshold Pb-B level for this effect was not evident. Some effects in individuals may be found at Pb-B levels below 60 ug per decilitre. The toxic effects of lead on the human foetus have prompted restrictions in employment of females of child-bearing age in lead-using industries. According to the International Agency for Research on Cancer the evidence for carcinogenicity of lead and lead compounds to humans is presently inadequate.

47. Lead causes a variety of biological effects, of which the disturbance of the haem synthesis pathway is best characterized. The inhibition of the enzyme catalysing the formation of haem is considered to be the first sign of physiological impairment due to lead. The haem synthesis pathway is affected at levels of lead exposure commonly encountered in urban children.

48. Children are the population most at risk from the toxic effects of lead because of their higher intake and uptake per unit weight as well as the greater sensitivity of the developing nervous system. Acute lead poisoning in children is relatively uncommon and is generally caused by ingestion of lead-rich paint. Severe symptoms arising from such episodes include irreversible damage to the central and peripheral nervous system. Of greater potential impact is the occurrence of subtle neurobehavioural effects of lead in urban-dwelling children from the general population. Recent surveys from

several countries have reported an association between estimates of lead burden and measurements of performance and intelligence. Difficulties exist in interpreting these findings and the threshold for these effects is ill-defined. Nevertheless, there is a growing consensus that these imply a causal relationship.

49. Large numbers of aquatic birds are poisoned through the ingestion of spent lead gun shot and discarded fishing weights and an estimated two million ducks die every year from the former source in North America.

3. Recommendations

50. (a) Alkyl lead fuel additives should be phased out as soon as possible, and the use of fuel with a reduced lead content should only be viewed as a temporary stage in the ban. The health and environmental impact of alternative additives should be carefully evaluated prior to introduction.

(b) In areas with lead piping and where the water readily dissolves lead, steps should be taken to reduce the lead level in drinking water as far as possible (by replacing lead pipes and lead solder used in plumbing) or to at least below the WHO recommended limits.

(c) Public attention should be drawn to the potential dangers to children of leaded household paintwork and certain consumer products, (such as toys). Action should be taken to abolish the use of leaded paints for these purposes. There should be continued vigilance on the use of lead in other consumer products.

(d) Wherever possible the use of lead solder for cans containing food and drink products should be abolished and replaced by welded side-seams or appropriate alternatives.

(e) Research should continue into the neurobehavioural effects of lead in children, the threshold for certain adverse effects of occupational exposure and the relative contribution from different sources of exposure in the general population.

(f) Properly designed epidemiological studies incorporating biological monitoring of Pb-B levels should be carried out globally to elucidate the lowest levels causing effects.

(g) Alternatives to lead shot and fishing weights are required to prevent the deaths of large numbers of wildfowl.

C. Mercury

1. Background

51. Mercury is a natural trace component of the environment occurring in both inorganic and organic forms. Mercury is released from soil in significant amounts by natural degassing processes. Various estimates exist on the atmospheric release of mercury with annual natural fluxes ranging from 18,500 to 27,000 tons and 5,000 to 10,000 tons from human activities. The major

/...

man-made sources include the mining and smelting of mercury and other ores, fossil fuel combustion, the chloralkali processes and refuse incineration. Uncertainty still surrounds the precise quantities emitted from these sources and the influence of human activities on the natural mercury cycle. Commercial mercury deposits are highly localized and only ten countries account for over 90 per cent of world mercury production. Production peaked at over 10,000 tons in 1971 but has since fallen; in 1981, world production totalled 7,000 tons. The major uses of mercury are in the chloralkali process and in the manufacture of electrical components. Other applications include laboratory equipment, paints, pigments, agrochemicals and catalysts. The metal is still used in the acetaldehyde and vinyl chloride industries in some countries. The use of organomercurials in the pulp and paper industry is no longer legal in many countries.

2. Human and environmental impact

52. Environmental mercury levels are generally low but discharges from chloralkali works and pulp mills have produced elevated concentrations in water and Sediments. Sediments are an important receptor for aquatic discharges of inorganic mercury where concentrations are generally between 1,000 and 10,000 times those of the surrounding water. Mercury levels in marine and freshwater sediments are generally less than 1 µg per gram, but much higher values may occur near point sources. Sediments are also the site for transformation of the inorganic mercury to methylated forms. This process is of crucial importance because methylation increases the metal's potential for toxicity and uptake through the aquatic food chain. The significance of this process was first revealed in the 1960s when high concentrations of methyl mercury were found in fish from waters receiving only inorganic mercury.

53. Virtually all the mercury in fish muscle tissue is in the form of methyl mercury and consumption of fish is by far the most important source of human exposure. Average weekly intakes of total mercury range from 35 to 360 µg in different countries. The provisional tolerable weekly intake proposed by FAO/WHO is 300 µg of total mercury of which no more than 200 µg should be methyly mercury. Elevated intakes have been reported in fishing communities from coastal and inland areas in several parts of the world, particularly in localities contaminated with industrial discharges. Elevated methyl mercury intakes are also found in groups with a high intake of tuna and other species of fish which accumulate mercury from natural sources. Background mercury levels in most edible freshwater fish range from 0.05 to 0.2 µg per gram although in contaminated areas levels may reach 5 µg per gram or more. Most marine fish also have concentrations below 0.3 µg per gram except for the larger predatory species (e.g. tuna) where mercury levels around 1 µg per gram are typical.

54. Dietary methyl mercury is efficiently absorbed and is rapidly distributed to all body tissues, including the brain and the foetus. Methyl mercury is also present in maternal milk, indicating that exposure to the foetus and newborn may be of special concern. Methyl mercury intoxication is characterized by effects on the central nervous system, particularly those areas associated with sensory and co-ordination functions. The foetal nervous system is more sensitive than that of the adult; pregnant women may also be

/...

more sensitive than other adults. Estimated thresholds in adults for initial effects are 200-500 µg per millilitre for blood, 50-125 µg per gram -1 for hair, and 1,500-3,500 µg for weekly intake. However, thresholds may be lower in populations with long-term exposure and in pregnant women and considerably lower in the foetus.

55. Several epidemics of organic mercury intoxication have arisen from different types of exposure. The first type, characterized by Minamata disease, took place in Japan and resulted from the long-term consumption of highly contaminated fish. In this case the industrial discharges included both inorganic and methyl mercury. Populations with high intakes of fish from other parts of the world have also been examined but evidence of methyl mercury intoxication is equivocal. The other type of exposure is characterized by the Iraqi outbreak in 1971 and 1972, where victims consumed bread made from grain dressed with alkyl mercury fungicides. Previous outbreaks of this kind occurred in Iraq, Pakistan, Guatemala and Ghana.

56. Fish-eating birds and mammals can accumulate elevated mercury concentrations, particularly in polluted localities. Mercury may have caused mortality and hatching failure in several bird populations and contributed to adverse effects on reproduction in sea mammals. The use of alkyl mercury seed dressings in the 1950s and 1960s led to the deaths and population decline of seed-eating birds and their avian predators. The subsequent banning of these chemicals resulted in a rapid decline in the mercury burdens of susceptible species.

57. Three different factors may interact to cause increased mercury exposure in fishing communities at some time in the future. The first is related to methyl mercury's propensity to accumulate in fish; increased reliance on fish in the future may cause excessive intakes in such populations. Secondly, coal combustion, one of the major sources of mercury arising from human activity, is increasing and is likely to increase further as an energy source in the near future. This, together with increased waste incineration, will lead to larger mercury emissions to air and, conceivably, cause an increase in fish mercury levels. Thirdly, recent increases in the mercury content of fish from Swedish lakes has been linked to an increased mobility of mercury, caused by the acidification of these waters. When taken together, these points suggest that populations consuming large quantities of fish may be exposed to excessive levels of mercury in the future.

3. Recommendations

58. (a) Human populations with elevated mercury intakes should be regularly monitored to provide an early warning of potential problems. Special attention should be paid to changes in the mercury content of fish from acidic waters and to an increased reliance on fish as the staple source of protein.

(b) The use of mercury in chloralkali plants, in the pulp and paper industries and in the acetaldehyde and vinyl chloride producing industries, should be phased out wherever feasible. In the mean time, mercury containing wastes should be considered hazardous and disposed of accordingly. More information should be obtained on the world-wide use and discharge of mercury from industrial sources.

/...

(c) More information is required on the global mercury cycle, on the impact of increased surface-water acidification on this cycle, and on changes in future human exposure.

(d) Recent evidence seems to indicate extreme fetal sensitivity towards mercury exposure. Possible verification of these preliminary results should be pursued with a high priority.

D. Carbon dioxide

1. Background

59. Carbon dioxide (CO_2) is a natural trace constituent of the earth's atmosphere. The present mean concentration of CO_2 is around 340 parts per million (ppm) by volume. CO_2 has a critical role in the global heat balance in that it is essentially transparent to the incoming solar radiation but absorbs the infra-red radiation emitted by the earth. This radiation trap causes a warming of the lower atmosphere which is known as the "greenhouse effect". Agents such as methane, nitrous oxide, ozone and chlorofluorohydrocarbons and other substances exhibiting similar "warming" properties may also contribute significantly to this phenomenon.

60. The global nature of the CO_2 problem results largely from the combustion of fossil fuels (oil, coal and natural gas) whose consumption has been increasing steadily since the beginning of the last century. The corresponding release of CO_2 has resulted in a significant build-up in the atmosphere, from an estimated concentration of less than 300 ppm in the middle of the nineteenth century to the present day value. Reduced energy demand since the mid-1970s has caused a slight reduction in the annual increase in fossil fuel use and consequent CO_2 emissions, whereas other gases, mentioned above, are continuing to increase in the atmosphere.

2. Global impact

61. Several uncertainties surround the CO_2 issue and these place constraints on the assessment of the global impact. There are also deficiencies in our knowledge of the natural carbon cycle and its reaction to perturbation by human activities. For example, only about half of the CO_2 discharged from fossil fuels over the last two decades can be found in the atmosphere. It is commonly suggested that the oceans act as the main sink for this "missing" fossil fuel CO_2 although it is uncertain whether net transfer to the oceans can account for all the deficit. There is also uncertainty over the magnitude of CO_2 release arising from man's wide-scale and increasing forest clearance activities, with estimates ranging from insignificant to an amount comparable with fossil fuel CO_2. Most projections indicate that, in the long term, fossil fuel emissions will be an order of magnitude larger than biospheric emissions. If the latter is true, the fraction of man-made CO_2 which remains airborne is lower than present estimates indicate, suggesting that CO_2 increases will occur more slowly than currently predicted.

62. Uncertainties also surround the earth's future demand for fossil fuels and consequent CO_2 release. Some recent predictions estimate that atmospheric CO_2 concentrations may pass 600 ppm in the third quarter of the next century; this value represents a doubling of the pre-industrial

concentration. With a continuing increase of other above-mentioned gases, the warming effect linked with the doubling of CO_2 may occur as early as 2030. It has also been forecast that the greatest increase in CO_2 release from fossil fuels will be in the developing countries.

63. It is generally accepted that future increases in the atmospheric CO_2 level will cause a rise in the average global temperature. However, there is still debate over the magnitude of this warming. Calculations with three-dimensional, time-dependent models of the global atmospheric circulation indicate that a doubling of the CO_2 level will cause an average global warming of $1.5^\circ - 4.5^\circ C$ with the greatest increases predicted for the higher latitudes of the northern hemisphere.

64. These increases in temperature may lead to effects such as altered precipitation and evaporation régimes, which could affect agriculture and the distribution of food resources. Effects on the oceans may also be significant, as changes in wind circulation would affect ocean currents, causing the relocation of nutrient-rich areas leading to the redistribution of marine organisms and the consequent melting may cause a rise in the sea level in the order of one metre. One recent study considers a global rise of between 144 cm and 217 cm likely to occur by the year 2100.

65. Currently there is no evidence that there has been a CO_2-induced increase in the global temperature. The detection of such an effect is made difficult by the inherent variability in climate. In addition, predictions of the time when a global warming will be detectable are highly dependent on the assumed rate of heat exchange between different parts of the oceans.

66. Several approaches to control the CO_2 problem have been proposed. The "technical fixes" which involve the collection and disposal of CO_2 are not considered to be practical or economical. Alternative energy systems which do not emit CO_2 might be developed to reduce the reliance on fossil fuels, although such actions are currently considered to be of limited effectiveness and prohibitively expensive. Energy conservation is considered to be an important means of reducing CO_2 emissions from fossil fuels.

3. Recommendations

67. (a) Because replacement of fossil fuels by alternative energy sources is probably still not feasible economically and politically, priority should be given to work geared to the development of long-term energy options not based on combustion of fossil fuels. Energy conservation measures should also be encouraged on an international scale.

(b) The size of reservoirs and fluxes in the biogeochemical cycle of carbon should be determined with greater accuracy.

(c) The modelling of CO_2-induced climate changes should be further refined to reflect, for example, interactions of the ocean-atmosphere interface in order to establish more accurately the size and extend of predicted effects. Regional climatic modelling should be enhanced, particularly by nations heavily dependent on agriculture.

/...

(d) Research and development should give priority to better predictions of future fossil fuel use and corresponding CO_2 release to the atmosphere. More information should be made available to decision makers and the general public.

(e) Future measures taken to reduce/prevent the "greenhouse effect" must take into account, not only the reduction of CO_2 emissions, but also the control of other greenhouse gases. International co-operation should be encouraged.

E. Nitrogen oxides and photochemical oxidants

1. Background

68. The oxides of nitrogen, NO and NO_2, generally referred to as NO_x, present in the atmosphere arise from both natural and man-made sources; current estimated annual emissions total 150 million tons of nitrogen dioxide. Natural production is derived mainly from bacterial action in soil and from forest fires. Man-made emissions arise from the high temperature combustion of fossil fuels which produces about 50 million tons of NO per year localized in centres of population in the northern hemisphere. NO is emitted in about equal proportions by two major source types: stationary sources such as fossil fuel power plants, and mobile sources such as motor vehicles and aircraft. Mobile sources account for much of the direct exposure of the population to NO_x because most stationary sources discharge through tall stacks. NO undergoes various reactions in the atmosphere in the presence of ultraviolet radiation and volatile organic compounds to form NO_2, nitric and nitro-arenes. Additionally, NO_x is the principal precursor of "photochemical smog". Under certain weather conditions, NO and other pollutants, termed photochemical oxidants. These include NO_2, ozone and peroxyacetylnitrate (PAN) which, together with several organic compounds, constitute photochemical smog. It should be stressed that ozone levels may be elevated over widespread areas even in rural locations partly as a result of long-range transport from polluted areas.

2. Human and environmental impact

69. Photochemical oxidants vary in their toxicity, with ozone being about 5 to 10 times more toxic to humans than NO_2, the NO_x component of human health concern. The health hazard from photochemical smog is greatest in urban locations, where NO_x concentrations can be 10-100 times higher than in rural areas. The trend of increasing concentrations of NO_x and photochemical oxidants especially ozone in urban areas should be viewed with concern.

70. The rapid increase in the volume of traffic in cities of developing countries has already caused problems with photochemical smog; these problems are likely to increase as vehicle numbers rise. Indeed, monitoring activities indicate that emissions and ambient levels of NO_x are increasing in urban areas throughout the world. There is evidence of increased respiratory disease and decreased lung function in some urban populations as a consequence of exposure to NO_x and other photochemical oxidants. However, the situation is complicated by the presence of other air pollutants, including sulphur

/...

dioxide (SO_2), and this presents problems when attempting to determine the precise cause of these effects. Asthmatics and bronchitics may be especially susceptible to NO_x and photochemical oxidants. Tobacco smokers will be exposed to elevated levels of NO_x. In addition, indoor exposure to NO_x is of special concern, as unvented gas cooking appliances can produce markedly elevated levels of NO_2. Indeed, indoor levels commonly exceed the WHO proposed limit for short-term exposure to NO_2. Such exposures in children may cause an increased incidence of respiratory disease and impaired pulmonary function.

71. Direct toxic effects of NO_x on plants are unlikely, even in urban areas. But it can interact in a synergistic manner with relatively low levels of SO_2, and ozone to cause extensive damage. Ozone itself is an important phytotoxic agent being toxic to vegetation at the levels prevailing in many parts of the world. Of particular importance is the wide-scale reduction in crop yields caused by ozone. In addition, urgent attention is now being paid to the possible role of ozone in forest decline. At present, however, it is not possible to say whether ozone is the main agent responsible or just a contributing factor in the damage of trees already stressed by disease and wheather.

72. The contribution of NO_x to acid deposition is variable but can account for one third to one half of the total acidity. The nitric acid aerosol formed may have a fertilizing effect in soils, at least in the short term, but may also have a direct toxic effect on vegetation. In addition, the rapid release of nitric acid during snowmelt can cause a surge of acidity toxic to fish and their eggs. The observed nitrogen saturation of certain soils indicates that irrespective of an increase in NO_x emissions, nitric acid will assume an increasingly important role in the acidification of fresh water systems and forest decline.

3. Recommendations

73. (a) Effective emission regulations for NO_x, including development and implementation of modified combustion techniques, should be encouraged.

(b) More experimental and epidemiological data are needed on both the health effects and threshold level of NO_x, its products and the photochemical oxidants, particularly ozone and peroxyacylnitrates. Particular attention should be paid to the extent and significance of indoor exposure to NO_x.

(c) More study is required into the precise role of NO_x and hydrocarbons in the production of ozone, to allow for optimum control strategies for both NO_x and ozone.

(d) The phytotoxicity of NO_x alone and in combination with SO_2 and ozone requires further investigation, especially with respect to the role of ozone in forest decline.

/...

F. Sulphur dioxide and derivatives

1. Background

74. Numerous natural sources of sulphur exist and on a global scale account for about half the estimated total emissions of SO_2 (150-200 million tons a year of sulphur). However, man-made emissions of SO_2 exceed natural sources by about 30 per cent in the northern hemisphere where over 90 per cent of total anthropogenic emissions arise. In addition, man-made sources show a marked regional concentration in the populated and industrialized areas of North America, Europe and Japan. In contrast, natural emissions are widely distributed over the globe and have low discharge rates. Fossil fuel combustion is responsible for about 80 per cent of all man-made SO_2 emissions, with metal smelting and refining being a significant source at the local level. SO_2 emissions have decreased in many developed countries over the last decade, as a result of economic recession, shifts in the pattern of energy consumption, and increased controls to limit emissions. However, an overall increase in regional and global SO_2 emissions has been predicted, as a consequence of increased coal consumption, increased industrialization in developing countries and a deterioration of fuel quality. The east Asia is now close behind Europe and North America with respect to SO_2 emissions. Other sources of SO_2, such as biomass burning in tropical countries will also contribute to regional and global SO_2 burdens.

75. Man-made SO_2 discharges are widely distributed, not only because of the multitude of individual sources but because a significant part of such emissions is made via tall stacks which, though reducing SO_2 levels close to source, enable emissions to travel greater distances from original sources and thus cross national boundaries. In response to this, the 1979 Convention on Long-range Transboundary Air Pollution, came into force in March 1983. Under the Convention certain parties (21 out of 34 as at July 1985) have undertaken to develop policies and strategies for reducing SO_2 emissions by at least 30 per cent between 1980 and 1993. The Convention also emphasizes the importance of the co-operative programme for the monitoring and evaluation of the long-range transmission of air pollutants in Europe (EMEP). This is the first example of international co-operation regarding this problem.

2. Human and environmental impact

76. SO_2 and NO_x (see section on nitrogen oxides and photochemical oxidants) emissions arising from man's activities readily undergo atmospheric oxidation and hydrolysis to form acidifying substances, mainly sulphuric and nitric acids. Photochemical oxidants including ozone are thought to play a role in these reactions. The various components of this complex mixture of chemical species either alone or in combination have been linked with a variety of health and environmental effects. During certain episodes of urban pollution elevated levels of SO_2 in conjunction with respirable particulates have been shown to be associated with deleterious effects on lung function.

77. Deposition of SO_2 and NO_x and their transformation products has increased over the last two decades in a number of regions especially in Europe. Some deposition (mainly wet) may occur hundreds and even thousands of kilometres from the source of emission. Adverse environmental and ecological effects have been linked with increased deposition of SO_2 and acidifying

/...

derivatives. Acid deposition is associated with acidification of both soil and surface water via a complex of inter-related ion-transfer processes. A marked decline in the diversity and density of aquatic plants and animals has been linked to acidification of lakes. Indeed a decline in fisheries or loss of fish species has been reported for many lakes and streams in Scandinavia and North America. Increases in acidity per se are toxic to fish, although acid-mediated changes in water quality, in particular the mobilization of aluminium, are considered to play a more important role in declining fish populations. Concentrations of mercury in fish appear to increase in acidified lakes. The acidification of ground waters has led to elevated levels of aluminium and heavy metals in drinking-well waters and may also cause the dissolution of metals from piping systems. Naturally high soil acidity in many tropical regions has created considerable concern that even moderate increases in the input of sulphur compounds might have severe effects.

78. Ambient sulphur dioxide can cause direct damage to vegetation in the vicinity of an emission source. Forest damage found in eastern Europe has been linked to this process. The direct effects of SO_2 include damage to leaves and, in the long run, stunted growth and reduced productivity. Such effects are of economic importance in agricultural and forestry areas.

79. Of much greater significance are the extensive forest diebacks in Europe and North America, phenomena considered by some workers to be caused in part by acid precipitation with circumstantial evidence strongly indicating involvement of ozone, perhaps in combination with other stresses. Mosses and lichens are sensitive to SO_2 and many species are absent from urban and industrial locations. It is becoming clear that SO_2 can predispose plants to injury by other environmental stresses, such as effects caused by certain pathogenic diseases and adverse climatic conditions. This may play a vital role in forest decline. The natural decay of certain man-made materials is accelerated by the deposition (mainly dry) of SO_2. Many buildings and monuments, including India's Taj Mahal and the Parthenon in Greece, have been affected by atmospheric pollutants.

3. Recommendations

80. (a) Increased monitoring of transboundary air pollution should be undertaken and encouraged particularly in areas where it does not exist, and greater emphasis should be given to understanding its impact.

(b) Control strategies which would minimize acid precipitation should be introduced especially by major SO_2-emitting countries. These strategies should be co-ordinated internationally.

(c) Effective control strategies for reducing SO_2 emissions should be implemented by the use of low sulphur fuels, the desulphurization of fuels, the modification of combustion, and the removal of SO_2 from flue gases. Furthermore, energy conservation measures together with combined heat and power systems should be introduced.

(d) The lack of relevant data presently precludes recommendations for air quality guideline values for acid aerosols. Research into the health effects of such aerosols should therefore be encouraged.

/...

(e) Land-use planning and control should be used by national authorities to minimize the impact of air pollution.

G. Production and use of coal and other fossil fuels

1. Background

81. Coal, oil and natural gas provide the vast majority of the world's energy needs for electricity generation, heating and transportation. Coal is also used for coke production. Enormous quantities of fossil fuels are consumed to meet this demand, resulting in a significant impact at the global level. Nevertheless fossil fuel combustion only represents one component of the complete fuel cycle, and account must also be taken of the impacts from extraction, processing, transportation and storage. It is predicted that coal will assume an increasingly important role in the future world energy scene. In addition the conversion of coal to liquid and gaseous products is expected to become feasible in the future in many countries.

2. Human and environmental impact

82. Fossil fuel extraction results in many deaths and injuries and, in the case of coal, a high incidence of pneumoconiosis and other respiratory diseases. Such practices can also cause extensive land disturbance, and this impact has led to the development of techniques which enable the successful reclamation of a variety of damaged habitats in temperate areas. There is, however, much less expertise available on the reclamation of such sites in other parts of the world. An increase in the acidity of waters which flow through mines can result in a problem of acidic drainage.

83. Accidents to workers and the general population are associated with all forms of fossil fuel transportation. Environmental impacts arise during the loading, transportation and unloading of fuels. Large quantities of water are often used to enhance the extraction of oil, and precautions must be taken to prevent the contamination of watercourses with the oily wastes produced. Oil refineries have safety problems arising from the risk of fire and explosion and also emit a range of airborne pollutants similar to those released from oil combustion.

84. Fossil fuel combustion, however efficient, produces several important airborne pollutants including carbon dioxide, sulphur dioxide, nitrogen oxides, particulates, trace elements and organic compounds. The solid wastes and heat produced from fossil fuel combustion also pose environmental problems. The impact of CO_2, NO_x, SO_2 and mercury are considered in separate sections but it is relevant to note that the production of pollutants per unit of energy is greatest for coal, followed by oil and lastly natural gas. The predicted increase in coal consumption is therefore likely to increase emissions of SO_2, NO_x, CO_2, particulates, and possibly organics. It should be noted however that the release of pollutants varies with the type of coal and combustion conditions.

85. Many potentially toxic trace elements are present in coal and oil at relatively low concentrations, but significant mobilization on a global basis can still take place because of the large quantities of these fuels consumed.

/...

For example, arsenic emissions from coal combustion are comparable to the total emissions from all natural sources, while oil combustion is the single largest source of nickel from human sources and accounts for over half the total man-made emissions.

86. The large quantities of solid wastes arising from coal combustion pose considerable disposal problems. Fly ash is used for commercial purposes but stockpiles are increasing all the time. Disposal is carried out either in ash ponds or in landfills. Elevated levels of certain trace elements can be found in ash ponds, their effluent waters and plants and animals inhabiting such sites. Several cases of large-scale fish mortality and reproductive failure have been linked to selenium discharges from ash ponds.

87. Coal consumption represents a major emission source of polycyclic aromatic hydrocarbons (PAHs) a large group of compounds, some of which are carcinogens. These compounds are mainly emitted from the incomplete combustion of coal, particularly cooking and domestic burning; power generation is a relatively minor source. In some countries, improvements in the design of residential heating systems and industrial facilities has led to a reduction in PAH emissions. There is still a lack of information on the amounts of individual PAHs emitted from the different coal use sectors and this constrains any assessment of the carcinogenic risk to humans.

88. Domestic coal burning is the major energy source for heating and cooking in certain developing countries, and this gives rise to elevated levels of SO_2, particulates and other pollutants (including PAHs) in ambient air of urban conglomerates, particularly in the wintertime. Additionally in such situations the indoor levels of these pollutants can be raised as a result of inadequate ventilation. A parallel problem has become apparent in developed countries where efficient thermal insulation of modern housing causes an accumulation of indoor combustion products, particularly nitrogen dioxide and carbon monoxide.

89. Recommendations pertaining to mercury, carbon dioxide, nitrogen oxides and sulphur dioxide are listed in the relevant sections above.

3. Recommendations

90. (a) Further research is required on the potential environmental and health impacts of increased coal utilization. Better assessments of trace element mobilization by fossil fuel consumption are required, with attention paid to the significance of atmospheric emissions and leaching from ash disposal sites. The extent of PAH and arsenic emissions from coal consumption and the carcinogenic risk posed by these pollutants to the general population both require evaluation.

(b) Further development and more widespread application of particulate emission control devices, as well as other methods of reducing emissions together with monitoring procedures should be encouraged; these should include the control of domestic smoke pollution problems.

(c) With the anticipated increase in the use of coal and fossil fuels, it is essential to develop appropriate techniques for the reclamation and revegetation of coal-mining areas.

/...

H. Injudicious use of pesticides

1. Background

91. The control of crop pests and disease vectors has relied increasingly on the use of pesticides, including insecticides, herbicides, fungicides, rodenticides, nematicides. Insecticides have saved millions of people and livestock from vector-borne diseases, which include malaria, yellow fever and river blindness, and are still widely used for public health purposes. In crop protection, pesticides still remain important tools in the first line of defence in pest control. It has been reported that losses in crop production due to pests and diseases are between 40 and 75 per cent, and that increases in productivity of several hundred per cent may occur following pesticide use. Quantitative data on global pesticide usage is extremely difficult to obtain, largely due to the reluctance of manufacturers to release information and, in developing countries, due to inadequate import records and lack of government control over distribution and application. In 1980, a total of 49,610 tons of pesticides were used by 103 developing countries in national disease vector-control programmes alone with a predicted rise to approximately 66,000 tons in 1984. It has also been estimated that such programmes account for only 10 per cent of current pesticide use, the remainder being used mainly in crop protection and weed control.

92. Besides the benefits, unwanted or adverse effects on man and other organisms have occurred in many countries, mainly as a result of the injudicious use of pesticides.

2. Human and environmental impact

93. Each year thousands of people handling pesticides, are seriously poisoned, often fatally. In addition, there is practically a continous stream of reports and publications referring to undesirable side-effects in many species of animals and plants. There are limited data concerning the outcome of effects at the population level, but severe consequences have already been perceived, particularly in certain species of fish and birds.

94. Adverse effects have also arisen in crustaceans, soil micro-organisms and non-target insects including beneficial species such as pollinators, predators and parasites of both target and non-target organisms. Other effects include the loss of certain plant species, pest resistance, and pest resurgence. The rising incidence of resistance to many insecticides is reducing the choice of effective compounds for vector-control and the situation is steadily worsening. The growth in incidence of fungicide resistance by plant pathogens is also an increasing problem in crop production.

95. When considering both the human and environmental impact of pesticides, it is important to point out that in general a low proportion of the applied pesticide actually reaches the target organisms, and, hence, most of the pesticide ends up in other parts of the environment, possibly affecting non-target species in agro-ecosystems and other ecosystems. In addition, pesticides used to protect harvested crops may result in an increased exposure to humans via their diet.

96. Although there has been a gradual phasing out of the more environmentally persistant organochlorine insecticides, particularly in developed countries, these have been replaced mainly by organophosphorous and carbamate insecticides which are more toxic to mammals and consequently present a greater hazard to human health.

97. Current pest management practice generally pays insufficient attention to the wide variability in the structure and function of ecosystems in different parts of the world which may result from differences in species, climate, geochemistry and physiography. Consequently, pesticide applications considered to be safe in certain areas are not necessarily compatible with other ecosystems. Undesirable side-effects can often be avoided if the local ecosystem conditions are sufficiently taken into account when deciding the most adequate control technology.

98. Several international organizations and bodies have focused on the problems of the safe use of pesticides, and the International Code of Conduct on the Distribution and Use of Pesticides has been developed under the auspices of FAO. Increasing attention is being focused on the further development of integrated pest management techniques which seek an approach to pest control based on the integration of all control methods, including biological control such as the introduction of naturally occurring predators and parasites of the pests and crop rotation measures.

99. It should be stressed that there are no completely safe pesticides but that implementation of integrated pest management techniques and adherence to existing guidelines and codes of conduct would reduce to a minimum the risks of pesticide handling and application. However, such an ideal situation does not yet exist in many regions of the world mainly because insufficient attention is paid to potential human exposure and local environmental conditions.

100. Examples of deficiencies in the use of pesticides include the following:

(a) Measures aimed at the protection of the health of people in the use of pesticides (retailers, formulators, spraymen, etc.) are frequently inadequate;

(b) Certain highly toxic pesticides are used under climatic conditions where adequate personal protection is extremely difficult to achieve;

(c) Measures aimed at the protection of the general public against pesticide hazards are inadequate in many countries, which has often resulted in serious accidents, such as the misuse of pesticide-treated grain for consumption and indiscriminate domestic use;

(d) Insufficient attention is paid to possible damage to non-target animals and plants (including natural enemies of pests) mainly due to inadequate efforts to optimize the selectivity of the control measures applied;

(e) Insufficient consideration is usually made to the formulations and methods of application, both of which affect the proportion of active ingredients which reach the target species and affect the resultant toxicity to both target and non-target organisms;

/...

(f) Insufficient attention is paid to the possibilities of secondary effects on soil, surface and ground waters arising from both the use of pesticides and inappropriate disposal of pesticide waste, time-expired stock and empty containers;

(g) Methods to reduce the likelihood of resistance developing in pest organisms are not applied consistently.

101. Other deficiencies include:

(a) Lack of basic knowledge of the biology and ecology of pests and disease vectors;

(b) Inadequate training and extension facilities;

(c) Insufficient dissemination of adequate information on the properties of pesticides (e.g. improper labelling);

(d) Insufficient technical means, suboptimal legislative and regulatory provisions (both at the national and international levels);

(e) Insufficient recognition of the geographical variability of ecological conditions, which lead to marked differences in the vulnerability of ecosystems to pesticides.

3. Recommendations

102. (a) On a world-wide scale much more attention should be paid to the implementation of sound pest management practices such as those considered under integrated pest management (IPM).

(b) National systems and laws for safe use of pesticides should be developed and implemented. The International Code of Conduct on Distribution and Use of Pesticides, which has been developed under the auspices of FAO, and other international guideline documents should be used as examples for this purpose.

(c) Surveillance systems for pesticide residues in food, animal feed, and wildlife, and other appropriate biological monitoring strategies should be implemented to serve as early warning systems for Governments.

(d) The marked variation in the susceptibility of the world's ecosystems to pesticides necessitates a full appraisal of the local ecosystem conditions prior to the use of chemical control methods. International organizations should be prepared to assist Governments to make such appraisals.

(e) Adequate information should be broadcasted on the occupational, public health and environmental implications of pesticide use.

I. Oil pollution

1. Background

103. World oil production has increased dramatically over the last 100 years and currently exceeds 3 billion tons. In 1981 it was estimated that about 3.5 million tons of oil are released into the marine environment each year. These releases are divided about equally between land-based and sea-based sources. The largest land-based inputs come from municipal and industrial wastes, which account for about 25 per cent of total marine inputs. Inputs from refineries account for less than 3 per cent of the total. Sea-based inputs are linked mostly to marine transport discharges (about 40 per cent total marine input), almost half of which are from oil tanker operations with the remainder distributed almost equally between tanker accidents and bilge/fuel discharges from general shipping. Other main sources are marine seepage (10 per cent) and atmospheric deposition (10 per cent). Off-shore production may be a more important source than hitherto appreciated because of the considerable discharge of oil-based drilling muds during routine operation, and on a global scale it may account for an input similar to operational discharges from tankers.

104. Oil pollution of terrestrial and freshwater habitats may also occur. Major sources include urban run-off, industrial effluents, natural seepage, atmospheric deposition, transportation-related losses and oil spills. In addition, oil may also be added to land as a deliberate policy of waste disposal.

105. A global analysis of marine oil pollution has been carried out by the Integrated Global Ocean Station Systems Pilot Project on Marine Pollution (Petroleum) Monitoring. Visible slicks were most frequently reported along the major tanker routes between the Middle East to Europe and Japan and in regions to the north and east of South America. The most polluted waters were encountered in the Mediterranean Sea and the Indian Ocean (particularly along the western coastline of India).

106. Despite increases in oil production and transportation by sea during the last decade downward trends in oil pollution are apparent. This decrease has been related to technological improvements and introduction of legislation at national and international levels. The 1973 International Convention for the Prevention of Pollution from Ships only entered into force in 1983 and should lead to a significant reduction in marine oil pollution resulting from routine operations. The 1982 United Nations Convention on the Law of the Sea is also expected to have a similar impact.

2. Environmental impact

107. The environmental impact of an oil spill is influenced by the quantity and composition of oil discharged, the prevailing environmental conditions and the geographical location of the spill. Little is known about the impact of oil pollution in aquatic and terrestrial environments. Oil spills from oil exploration or production may present a serious environmental impact in some regions. Spills in lakes which have limited throughflow are likely to present

/...

problems in terms of persistence and slow recovery rates. Terrestrial oil spills may penetrate the water table, with the risk of polluting drinking water sources. Soil properties and microbial populations are affected by oil contamination. In tundra regions soil disturbance, especially of the permafrost area, is likely to cause rapid erosion.

108. In the marine environment, contamination becomes most noticeable when an oil slick reaches the coastline. Indeed, the oiling of beaches, if persistent, may have adverse effects on tourism. Sheltered coastlines, such as marshes, estuaries and bays are the most sensitive to contamination because oil can be retained for many years at such locations. In contrast, exposed rocky coastlines are generally subjected to heavy wave action, resulting in high dispersion rates of the oil. IUCN has produced environmental classifications of the vulnerability of shorelines to oil-spill damage and priorities for protection and restoration. In Arctic regions low volatilization, solubility and microbial biodegradation due to cold temperatures and entrainment in ice increase the persistence of oil spills.

109. Damage to organisms in both marine and freshwater environments can occur from toxic effects, smothering and tainting. Tainting, although not usually associated with adverse effects, may lead to commercial loss of seafood (i.e. molluscs and seaweed). Toxic effects and smothering may be lethal or sub-lethal. In areas affected by or immediately adjacent to oil slicks, local populations of invertebrates, birds and mammals may be greatly reduced and badly oiled vegetation may die. The penetration of oil into sediments can have a major impact on bottom-living organisms and recovery may take several years. In the marine environment effects are particularly severe in shallow waters and at the air-sea interface. At particular risk are fish nursery areas, shellfish beds and breeding or feeding populations of seabirds. Such effects may be detectable for many years in badly affected areas, even after pollution has receded. The effects of oil on seabirds have always been a matter of great public concern. Even small spills can result in heavy mortality, while cold weather conditions appear to increase sensitivity to oil stress. Recent assessments have, however, failed to determine whether such incidents have had any effect on sea-bird species at the population level.

110. Sub-lethal effects of oil pollution have been reported in many organisms but are difficult to evaluate in terms of population changes or ecological alterations due to seasonal and natural background variations. Particularly vulnerable habitats are polar regions, salt-marshes, mangrove forests and coral reefs. The impacts of oil contamination on salt-marshes and mangrove forests are of particular concern because these systems can retain oil in their sediments for many years. Mangroves are particularly sensitive to oil spills as the smothering of the root structures responsible for respiration can lead to rapid death or long-term retardation of growth.

111. It should be noted that discharges of oily wastes from land-based sources to both freshwater and marine environments may contain highly toxic contaminants, such as PCBs, PCTs and dioxins. Such contaminants, if present, in significant quantities, may present an additional environmental impact to that of oil *per se*.

/...

112. The problem of oil pollution can never be fully eradicated, simply because most spills are caused by human error. Response plans and clean-up capacity are therefore essential in order to minimize the environmental impact. A variety of remedial or containment measures have been developed which are dependent on the properties of the oil and local environmental conditions. Some of the more widely used measures (e.g. chemical treatment) may present additional environmental problems. Chemical dispersants can be used in certain circumstances to break up oil slicks. Dispersants should, however, only be used after consideration of the benefits and disadvantages involved as oil/dispersant emulsions have, in certain cases, resulted in a greater environmental impact than oil alone. Enhanced biodegradation techniques using fertilizer additions, recommended in certain cases of terrestrial oil pollution, should be approached carefully. In very sensitive areas, remedial measures are often futile and oil pollution prevention is the only viable means of control.

113. Monitoring systems are continually being developed to provide "early warning" of oil pollution. Oil concentrations in sediments and selected organisms have been monitored together with ecosystem effects. Considerable research is also being carried out in "fingerprinting" oil spills (i.e. identifying sources), oil pollution detection, and, in particular, remote-sensing of sea-surface oil.

3. Recommendations

114. (a) The International Convention for the Prevention of Pollution from Ships and other protocols and regulations that cover various aspects of oil pollution from routine transportation, should be strictly enforced in order to reduce further marine oil discharges.

(b) Countries without contingency plans for oil spills should be encouraged to develop carefully prepared plans of response. Consideration should be given to the likely impact on shorelines and to the identification of other areas to be protected and their order of priority. This could be done in conjunction with the relevant international organizations and associations of oil companies.

(c) Governments are urged to introduce controls which will provide adequate protection of particularly vulnerable ecosystems from the harmful effects of oil pollution.

(d) Further research effort should be invested in development of remote-sensing techniques for detection and monitoring of oil pollution.

(e) An important gap in knowledge that deserves attention is the biological effects in offshore exploration fields where oil-based drilling muds have been used extensively, as preliminary evidence suggests that substantial quantities of oil can reach the sea-bed from this source. Governments are urged to regulate the use of oil-based drilling muds placing particular emphasis on requirements for mud recovery and cuttings cleaning systems and mandatory use of low toxicity oils.

(f) An assessment of the impact (freshwater or marine) of oily wastes (from industrial and municipal sources) contaminated with highly toxic substances should be encouraged.

J. Eutrophication

1. Background

115. Eutrophication is the biological consequence of increased concentrations of inorganic plant nutrients and can occur in both terrestrial and aquatic ecosystems. Terrestrial eutrophication results from the application of fertilizers and is characterized by a reduction in species diversity.

116. Of greater significance is the phenomenon of aquatic eutrophication which results from the discharge of nutrients into water bodies. Lakes and reservoirs are primarily affected, although rivers, estuaries and coastal waters can also become eutrophic. Generally, phosphorus is associated with freshwater eutrophication, but nitrogen may be responsible in marine waters.

117. Eutrophication may be a natural phenomenon in lakes, but during the last decennia the process has been accelerated by man's direct input of nutrients in densely populated areas of the world. These activities also result in the input and transport of increased amounts of nutrients, phosphates and ammonia in many rivers. The biological impact of these inputs may be difficult to detect because the high flow rates, turbidity and turbulence of rivers can mask the phenomenon. Nevertheless, several cases of grossly eutrophic rivers have been reported.

118. The transport of nutrients via rivers can also lead to undesirable effects in coastal waters and sea shelf areas under particular meteorological conditions. For example, marked effects have been noted in parts of the Baltic Sea and the Adriatic Sea.

119. The major sources of nitrate inputs to water bodies are fertilizers; other sources include animal manure and sewage effluents. It is now recognized that atmospheric fall-out of nitrogen compounds can be important in coastal seas. The principal sources of phosphates are the excreta and detergents in sewage effluents as well as wastes from intensive livestock rearing. In those developing countries where there is no sewage collection or treatment, the use of detergents may result in the direct input of phosphate into water bodies. Fertilizers are usually a less significant source of phosphates because these are leached less readily from soil than nitrates. The relative importance of these different sources is dependent on local conditions.

2. Environmental impact

120. One of the first effects of freshwater eutrophication is an increase in plant growth and this arises in both phytoplankton and macrophytes. Phytoplankton biomass may increase to such an extent that the water becomes depleted in oxygen as a result of the breakdown processes after the organisms' death. Partial depletion of oxygen may even arise in the bottom layers of deep lakes. Increased phytoplankton biomass will also decrease light

/...

penetration and increase turbidity and in some cases this may lead to the destruction of rooted vegetation. One noticeable effect is the periodic occurrence of algal blooms and the accumulation of algae on the surface of water bodies. These unsightly blooms consist mainly of blue-green algae, and can affect water supply, both by blocking filters and by tainting. Further, the poisonous excretion products of some algal species will have an adverse effect on the quality of drinking water and can be lethal to fish. Herbicides are sometimes applied to control excessive plant growth in eutrophic waters; such actions can, however, cause undesirable side-effects. Freshwater eutrophication can also exert effects on fish populations and, in some instances, this may result in an increase in the overall fish biomass, but this occurs in an unpredictable manner. Furthermore, loss of sensitive species such as trout can affect the harmonic balance of the community.

121. Depleted oxygen in bottom waters is also associated with marine eutrophication and this may have adverse effects on the eggs of commercial fish species. Marine eutrophication has also been linked with the episodic blooms of toxic algae which may pose a human hazard when consumed by edible shellfish.

122. It is often impractical to prevent eutrophication in lakes and reservoirs but it may be possible to reduce the extent of this phenomenon. However, no changes may be acceptable in those water bodies of environmental importance. On the other hand, certain changes may be acceptable for water bodies used solely for navigation or agricultural purposes. The criteria for such decisions will vary between countries and even between lakes in the same country. Decisions of this nature may be aided by a model devised by an OECD study which can be used to predict the probability of a water body becoming eutrophic. A recent update of this model has been successfully applied to lakes in mediterranean and tropical regions and also to estuaries.

123. Important methods of reducing eutrophication outside the water body include tertiary treatment of sewage and rational management of agricultural sources including prudent use of fertilizers, containment, and judicial application of animal manure to soils. Liquid manure should not be discharged to surface waters. Further, costs of tertiary treatment can be reduced by using phosphate-free detergents. The precise measures required will depend largely on local conditions. In urban areas, appropriate sewage treatment has to be given priority, while in rural areas measures to correct agricultural practices will have to be taken. Other more direct methods to reduce eutrophication include the physical removal of plankton, plants or fish, or the addition of herbicides. Remedial action should only be taken after determining both the precise importance of point and diffuse sources of nutrients, and the cost effectiveness of possible control measures.

124. It should be borne in mind that much of the phosphate entering lakes normally accumulates in the sediments. This represents an important and long-term source of phosphate which may reduce the effectiveness of future control measures. Inactivation and removal of sediments may need to be considered in such situations.

3. Recommendations

125. (a) Water authorities should make clear and definite decisions on the degree of eutrophication which is acceptable for different types of water bodies.

(b) Adequate surveys aided by appropriate models, such as that of OECD, are needed in order to identify water bodies liable to rapid eutrophication, to assess the present state of flora and fauna and to identify all nutrient sources as a basis for selecting control measures.

(c) A range of site specific measures needs to be used to prevent and/or reduce eutrophication. These include construction of tertiary sewage treatment plants, use of phosphate-free detergents, improved management practices in agriculture to reduce loss of fertilizers, and the control of discharges resulting from animal husbandry. In some cases inputs from other diffuse sources should also be taken into account.

(d) There is an urgent need for international co-ordination in assessing the occurrence and extent of the phenomenon at the global level.
