THE STATE OF THE ENVIRONMENT 1980

UNITED NATIONS
ENVIRONMENT PROGRAMME

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SELECTED TOPICS

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ERRATA

	Change from	To read
Page iii, Contents	IV. Transport and environment	IV. Transport and the environment
Page 4, para. 14 line 4	3,600 x 10^{15}g	36,000 x 10^{15}g
Page 13, para. 43, line 6	0.26 $\mu g/m^3$	0.026 $\mu g/m^3$ (38)
Page 13, para.44, line 10	0.5 – µg/g	0.5 – 1 µg/g
Page 15, para.51, line 9	in Iran	in Iraq
Page 16, para.54, line 8	9 – 3000 µg/g	9 – 300 µg/g
Page 21, para.77, line 10	blochemical	biochemical
Page 24, IV	TRANSPORT AND ENVIRONMENT	TRANSPORT AND THE ENVIRONMENT
Page 31, para.110 (e) line 4	through –	through IMCO,
Page 32, para.110 (g) line 19	ECA	ECWA
Page 38, para.128, line 2	met	meet
Page 42, line 3	C. Concluding	D. Concluding
Page 48, para.160 (e) line 6	(UNFDAC)	United Nations Fund for Drug Abuse Control (UNFDAC)

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FOREWORD

The present annual state of the environment report deals with five topics of international significance selected by the Governing Council of the United Nations Environment Programme at its seventh session: carbon dioxide and climate, heavy metal hazards, transport and the environment, the environmental effects of military activity, and the child and the environment. In order to sharpen the focus of treatment of these problems, the presentation is given under four main subheadings: facts and figures, the problem, major actions taken or planned, and concluding remarks.

The report is based upon the viewpoints expressed in discussions with various members of the scientific communities on the above selected environmental problems. It does not suggest solutions or give recommendations, but is designed to stimulate discussion and public awareness from which solutions may emerge. It was initially presented to Governments at the eighth session of the Governing Council of the United Nations Environment Programme, held in Nairobi in April 1980, and there was general agreement that the report realistically and accurately presented emerging environmental issues on which the international community at large and UNEP in particular should focus their attention.

I. INTRODUCTION

1. The environment — defined as that outer physical and biological system in which man and other organisms live — is a whole, albeit a complicated one with many interacting components. The wise management of that environment depends upon an understanding of those components: of its rocks, minerals, soils and waters, of its lands and their present and potential vegetation, of its animal life and potential for livestock husbandry, and its climate. It demands positive and realistic planning that balances human needs against the potential the environment has for meeting them.

2. By resolution 2997 (XXVII) of 15 December 1972, the General Assembly of the United Nations decided that the Governing Council of the United Nations Environment Programme should "keep under review the world environmental situation in order to ensure that emerging environmental problems of wide international significance receive appropriate and adequate consideration by Governments".

3. To assist the Governing Council in this task, the Executive Director prepares each year a report on the state of the environment. The first reports (1, 2, 3) discussed a broad spectrum of environmental issues, such as climatic change, the condition of the biosphere, the effects of toxic substances, food, energy and raw materials, population growth, stress and social tension and pollution. At its fourth session, the Governing Council decided[1] that the annual state of the environment report should be selective in its treatment and that an analytical, comprehensive state of the environment be prepared every fifth year. Accordingly, subsequent annual state of the environment reports (4, 5, 6) dealt with some selected topics: the ozone layer, environmental cancers, land loss and soil degradation, firewood, chemicals and the environment, malaria, the use of agricultural and agro-industrial residues, energy conservation, schistosomiasis, resistance to pesticides, noise pollution, and tourism and the environment. This year, the state of the environment report deals with five topics selected by the Governing Council at its seventh session.[2] These and other issues dealt with in the annual state of the environment reports will be treated in greater depth in the first comprehensive analysis of the state of the environment to be carried out for the decade after the conduct at Stockholm of the United Nations Conference on the Human Environment, which will be published on the tenth anniversary of the Stockholm Conference in 1982.

1. Governing Council decision 47 (IV), sect. 1, para. 10.
2. Governing Council decision 7/1, sect. IV, para. 1.

4. The first topic is *climatic changes, deforestation, carbon dioxide and the carbon cycle.* Carbon dioxide is unavoidably produced when fuels like coal, oil or wood are burned or when forests are cleared. Its concentration in the atmosphere is rising. It is possible that this could cause changes in climate — most probably a general warming, accompanied by alterations in the distribution of rainfall and possibly a rise in sea level. At the moment there is great scientific uncertainty about the mechanisms that could produce such effects, and the priority is to learn more about them — and also to consider whether, in the event that such changes seem likely, measures could be taken to prevent them or to ease their impact.

5. The second topic — *environmental health: heavy metal hazards* — deals with problems which arise from a wide range of localized activities. Mining, smelting and industrial processes of many kinds have raised the environmental concentrations of many heavy metals in different parts of the world to the point at which they can constitute a hazard to health. In some instances, knowledge of the cause and effect is adequate to have allowed corrective action. In other cases, there is need for better scientific understanding of the forms in which heavy metals enter, migrate in and affect the human environment. The topic thus illustrates what is sometimes called a "universal" pollution problem: a problem that recurs in many places but does not arise from the world-wide spread of a substance to affect people everywhere.

6. *Transport and the environment,* the third topic, illustrates the various ways in which a generally beneficial activity that is central to the development of modern communities can nonetheless have costly and unwelcome side effects. The problem is one of balancing costs and benefits, and ensuring international co-ordination of control, where these are necessary to ensure that one nation's ships, aircraft or vehicles do not cause unacceptable damage to the environment of other States.

7. *The environmental effects of military activity,* the fourth topic, arises not only directly through the devastation of the places involved in armed conflict, but indirectly because the enormous world expenditure on the production, testing and stockpiling of weapons absorbs huge amounts of natural resources, money and skill that could otherwise be applied to beneficial environmental development. In the event of a full-scale nuclear war, man's environment could be so utterly destroyed that no scientist can give an assurance that it could continue to sustain human life. Recovery from the devastation of conventional war is an arduous, costly and time-consuming task. The relics of past wars, including mines at sea as well as abandoned installations and explosives on land, also cause serious environmental problems and take up money and manpower that could be better used (7). The diversion of even a small proportion of the wealth the world community annually devotes to military activity would make a major contribution to satisfying the basic needs of deprived people in the poorer parts of the world and a betterment of the quality of life for all on this earth.

8. Finally, the chapter on *the child and the environment,* topical immediately after the International Year of the Child, looks at the section of the human population which is most vulnerable to pollution, disease, bad water and sanitation, and unhealthy settlements, and which at the same time will have a central role in building the environment of the future. Here the problems are not scientific uncertainty about what to do to make life much better for millions of people, but questions of resources and above all of commitment on the part of Governments and local communities.

9. The five topics dealt with in this report are important contemporary issues, although not the only urgent ones confronting mankind. A global pollution problem that is not yet upon us, and may yet prove to be illusory, a series of pollution problems encountered in many places around the world, and needing solutions that fit many individual substances and situations, a beneficial — indeed essential — activity that can, nonetheless, have damaging side effects, largely preventable by good design and planning, a hazardous activity that threatens immense direct environmental and social damage, and is already damaging because of the resources it draws away from constructive purposes, a vital but vulnerable group of people whose lot could be greatly improved by the application of knowledge that is commonplace: taken together, these five topics illustrate today's human and environmental dilemmas.

10. It is not the intention to give here a detailed description of these issues but to present a balanced brief account highlighting the problems encountered and the attempts to solve them. The report does not pretend to give any final solutions or recommend plans of action. It is rather designed to stimulate discussions from which solutions may emerge. In order to sharpen the focus of treatment of these problems,[3] the presentation is given under four main subheadings: facts and figures, the problem, major actions taken or planned, and concluding remarks.

3. Governing Council decision 7/1, sect. V, para. 5(b).

II. CLIMATIC CHANGES, DEFORESTATION, CARBON DIOXIDE AND THE CARBON CYCLE

11. Throughout the history of the world, climate has had a dominant influence on life. Geological and historical records indicate that climate variations occur naturally, on various time scales. Today, man may also be changing the global climate by altering the amounts of carbon dioxide, ozone and dust in the atmosphere. This chapter summarizes the evidence for the belief that the current increase in carbon dioxide could have a significant effect.

A. Facts and figures

12. It is estimated that before 1850 the concentration of carbon dioxide (CO_2) in the atmosphere was between 265 and 290 parts per million by volume (ppmv) (8). Direct measurements from the last century are uncertain because of possibly unrepresentative sampling sites and of less accurate analytical techniques than are available today. The data indicate, however, that it is more likely that the pre-industrial value was in the upper part of the range indicated. By 1978 the atmospheric CO_2 concentration had risen to 330 ppmv, which is an increase from about 313 ppmv during the last 20 years, for which accurate observations are available (8).

13. It is assumed that this CO_2 comes from the burning of fossil fuels and the oxidation of carbon stored in trees and soil humus and released when forests are cleared. But the process must be considered within the context of the global geochemical cycle of carbon.

14. The major carbon reservoirs are the atmosphere, the oceans (with their inorganic and organic matter), land biota, soils, sediments and fossil fuels. In 1978 the atmosphere contained about 695×10^{15} g carbon (8). The total amount of inorganic carbon in the sea is about $3{,}600 \times 10^{15}$ g, of which most is in the form of bicarbonate ions. There is furthermore about $1{,}000 \times 10^{15}$ g of carbon in the sea in the form of dissolved organic matter (8). In contrast to these figures, there is only about 4×10^{15} g of carbon locked in living organic matter in the oceans, primarily phytoplankton. The exchange of carbon in the form of carbon dioxide between the atmosphere and the sea is quite rapid, but much slower between the surface waters and the deep ocean.

15. Life on land contains about 800×10^{15} g carbon, 90 per cent of it in forests (8). Each year photosynthesis withdraws from the atmosphere some $50\text{-}75 \times 10^{15}$ g more carbon than is returned to the air by respiration. About 20×10^{15} g of this is taken up by forests. The soil probably contains between $1{,}000$ and $3{,}000 \times 10^{15}$ g carbon (8), but the figures are uncertain primarily because of difficulties in estimating how much peat there is in the world.

Carbon deposited in peat returns only slowly to the cycle, but that in other soils remains there for only a few years or decades.

16. Most of the world's carbon is stored in rocks. Carbonate sediments (limestones and chalk) are estimated to contain more than $10{,}000{,}000 \times 10^{15}$ g of carbon (9); recoverable fossil fuels contain more than $5{,}000 \times 10^{15}$ g. Under natural conditions this carbon is returned to the cycle extremely slowly.

17. The global biogeochemical carbon cycle is thus a complex system. How much exists in the main reservoirs, and what the main transfer routes between them are, are known, within broad limits, but there is much less certainty about the rates of transfer and about some of the detailed processes involved. In particular, there are uncertainties about the rates of removal of carbon from the atmosphere by the sea and by land plants.

18. The problem examined in this chapter arises because man has significantly modified the rate of two transfer processes in the cycle: the return of carbon to the atmosphere from fossil fuels and from the forests. The crucial questions concern the scale of this modification, its consequences, and the likely trends in future.

19. Man has been burning fossil fuels at an accelerating rate since the middle of the last century. Altogether about 140×10^{15} g of fossil carbon has been emitted into the atmosphere in this way during the last 125 years (8, 9). The annual input has increased at a rate of about 4 per cent since the 1940s, but has remained almost constant since 1974 at a level of about 4.5×10^{15} g per year. Observations of the CO_2 concentration in the atmosphere show an annual increase during these later years of about 2.2×10^{15} g (i.e. about half of the output due to fossil fuel combustion (8)).

20. The use of fossil fuels is far from uniform over the globe. The United States of America alone produces more than 25 per cent of the total fossil fuel CO_2; North America, Europe (East and West) and the Union of Soviet Socialist Republics account for 75 per cent (10). One analysis suggests that in A.D. 2025, 23×10^{15} g carbon will be released annually as CO_2 (i.e. 4.5 times the present amount), and that the largest rate of growth in CO_2 production will occur in the developing countries, which will produce 33 per cent of fossil fuel CO_2 then, as against 13 per cent in 1974 (10).

21. These figures must not be accepted uncritically, and other studies do not envisage so large an increase in the demand for fossil fuel energy. Conservation and renewable sources of energy are assumed by many to have an increasing role in meeting a part of the growing energy needs (11), reducing thereby the consumption of fossil fuels.

22. Another uncertainty surrounds the fate of CO_2. If only about half the annual production from fossil fuels remains in the atmosphere, the remainder is presumably absorbed by the ocean, land biota or other "sinks".

Oceanographic studies (12, 13) suggest that the seas are capable of absorbing 35-40 per cent of the fossil fuel CO_2, and the budget seems balanced within a few per cent. A significantly higher uptake of CO_2 appears incompatible with established knowledge of carbon chemistry and current understanding of vertical mixing in the sea (14, 15, 16).

23. Recently, these analyses have been questioned by ecologists, who have argued that they fail to take account of the additional inputs of CO_2 to the atmosphere due to the destruction of forests and of soil organic matter, especially in the tropics (17,18). It is certainly true that there have, in recent years, been increasing deforestation, soil deterioration and desertification in the tropics. Estimates suggest a reduction in the area of closed tropical rain forests from $1.5\text{-}1.7 \times 10^9$ hectares in the period before the phase of rapid population growth to about $0.9\text{-}1.1 \times 10^9$ hectares today (19,20,21). The Food and Agriculture Organization (FAO) has recently estimated an average loss of 5 to 6 million hectares a year over the past 25 years, while other estimates range as high as 20 millon hectares annually (22, 23, 24), and if the amount taken for shifting cultivation and later allowed to revert to woodland is included the figures are higher still (25). Nearly all this deforestation is in the humid tropics, and it is chiefly due to the spread of agriculture, although commercial timber cutting and local cutting of wood for fuel are also important.

24. Knowledge of the extent of forests and of the rate of their removal remains incomplete. but is steadily improving, especially because of monitoring from aircraft and satellites. Forest clearance may well continue, since the rapidly increasing world population will probably require the use of all land suitable for agriculture within the next half century. FAO, however, expects the rate of deforestation to slow down in the future (22, 23, 24).

25. One estimate indicates that oxidation of the carbon contained in the "standing crop" of 8 million hectares of forest produces about as much CO_2 as burning about 400 million metric tons (tonnes) of coal. Since the annual world energy consumption at present is equivalent to about 10,000 million tonnes of coal, this implies that fossil fuels are much more important than forest clearance as a source of carbon dioxide (26). However, some studies (8, 27) have shown that the input from forest cutting, forest burning, and other anthropogenic sources of CO_2 is of the same order of magnitude as the input of CO_2 from fossil fuel burning. It has been estimated that the gross transfer to the atmosphere of non-fossil fuel CO_2 amounts to 4.8×10^{15}g carbon per year, about as much as the annual input from fossil fuels in 1976. Assuming that 50 per cent of the CO_2 is recycled to the land biota, the net transfer to the atmosphere would be about 2.5×10^{15}g carbon per year (8).

26. It is clear that there are many uncertainties about the source, likely trends, and processes and rates of removal of atmospheric CO_2. Nevertheless, the use of fossil fuels and the transformation of woodland to herbaceous vegetation seem likely to increase as world population mounts. At

least during the next 20 to 30 years, these processes seem likely to contribute CO_2 to the atmosphere much as they have during recent decades, and for the remainder of this century it is probably safe to assume that the rise in atmosphere CO_2 will be equivalent to about half that released from fossil fuel combustion. If fossil fuel consumption were to increase by 4 per cent per annum this would produce an atmospheric CO_2 concentration of about 380 ppmv by the turn of the century (a 2 per cent per annum rate of increase would produce about 365 ppmv). Many projections suggest a doubling of the pre-industrial concentration of around 290 ppmv within the next hundred years (8, 28, 29, 30, 31).

B. The problem

27. The main reason for concern about the increasing concentration of atmospheric CO_2 is that it may increase the temperature of the lower atmosphere through what is called the "greenhouse effect". This occurs because although CO_2 is relatively transparent to incoming (short-wave) solar radiation it is a good absorber and emitter of the long-wave radiation coming from the earth's surface, and some of this re-emitted radiation is reflected downwards towards the lower atmosphere. But while rising CO_2 concentration may therefore mean rising atmospheric temperatures, it is not obvious what the over-all climatic effects will be. The climate results from many interacting processes, and these can amplify or cancel out disturbances. For example, a warming of the lower atmosphere could lead to increased cloud formation, which would reduce the amount of incoming solar radiation and counteract any warming due to increased CO_2 absorption (28). Human activities may also be raising the amount of fine dust in the atmosphere, reducing incoming radiation, while changes in atmospheric ozone concentration could also affect temperature.

28. It has frequently been pointed out that a warming of the lower atmosphere would have various effects on the different forms of snow and ice cover (ice sheets, sea ice and permanent or seasonal snow cover). There is great uncertainty about the probabilities and likely rate of these changes. In low and middle latitudes warming could decrease the frequency of snowfall and the duration of snow cover on the ground. In high latitudes (where snowfall is limited by the dryness of the air, in turn caused by the low temperatures) a warming could cause more snowfall and only marginally affect the duration of ground cover. There have also been speculations about the possible reduction or disappearance of the floating sea ice of the Arctic Ocean (32), which could be of major significance for climate in middle and lower as well as arctic latitudes. Finally, it is remotely possible that a warming could cause displacement and melting of some grounded polar ice sheets, especially in West Antarctica, causing a world-wide rise in sea level.

29. Since the impact of an increase in CO_2 cannot be established by direct experiment, various indirect approaches must be used. Some information can be obtained from an analysis of past climate, but the most favoured technique is the use of mathematical models of climate. A number of

these have explored the likely consequences of an increase in atmospheric CO_2 from 300 ppmv to 600 ppmv. But this technique has shortcomings. First it is not easy to adapt models of present climate in this way. Among the difficulties are that the models need to consider each season separately (the response in summer is not likely to be the same everywhere as the response in winter); that they should describe the interactions between atmosphere, ocean and ice and better represent the radiation budget and the role of clouds; that changes in temperature gradient higher up in the atmosphere (which influence such features as storm tracks) are not the same as at the earth's surface. Other human effects — for example on dust or ozone — also need to be allowed for. At present there is no agreement on which models best describe these processes.

30. At present the output from these models is provisional and uncertain. Papers, including some presented to the World Climate Conference in 1979 (33), suggest that if CO_2 concentration were doubled there might be an average world-wide temperature increase of 1.5-3°C, but that regional changes would be greater than the global average, some regions experiencing increases and others declines in temperature and rainfall. Polar regions would probably experience greater warming than the equatorial zones, an effect that would lead to changes in the large-scale circulation of the atmosphere and ocean, with concomitant changes in precipitation and temperature patterns over much of the globe. There would be changes in polar snow, ice and sea ice cover. Significant regional changes in rainfall and temperature, with consequent impact on agriculture, are also likely. Some regions would benefit, and others suffer. But reliable prediction of what would happen where, and how agricultural productivity and social institutions would be affected, is not possible. The need for such knowledge, if the world community is to prepare itself to adjust to the impacts — or to devise and implement effective solutions — is evident.

31. If there was an increase in temperature, or consequent effect on climate because of rising CO_2 levels, how soon could it be detected, and how certainly could they be ascribed to the CO_2 increase? Because the climate exhibits natural variation, the change due to CO_2 would have to be larger than this variability if it is to be detected. An effect on snow and ice cover might be noticeable on a time scale of 10 to 100 years. This question of detecting "signal" amidst inevitable "noise" is important because of the risk that CO_2-induced effects on climate would not be detected before irreversible and undesirable climatic changes had begun.

32. Other problems surround the feasibility of corrective action, should the threat to climate from rising CO_2 prove to be real. In addition to measures to control or limit the amount of CO_2 entering the atmosphere by limiting the burning of fossil fuels and deforestation, there have been suggestions of measures that might produce an atmospheric cooling and so cancel out the effect. At present the effects of these hypothetical counteracting measures cannot be predicted, but because the climate system is so complex

and variable it is unlikely that one process could be exactly balanced against another, and climatic anomalies would remain.

C. Major actions taken or planned

33. It is clear from the preceding analysis that the main need at present is for better scientific information and understanding, leading to better models and forecasts and perhaps to "early warning" systems. It is also obvious that the carbon dioxide question cannot be considered in isolation from other natural and man-made causes of atmospheric change. Many of the most significant recent actions have therefore been concerned with improving man's basic knowledge of climate.

34. There have been numerous national reports on different aspects of these problems. At the international level the following main actions have been taken:

a) In 1976 the World Meteorological Organization (WMO) organized a workshop in co-operation with the United Nations Environment Programme (UNEP) to discuss the details of a comprehensive model of the climatic consequences of increased amounts of CO_2 in the atmosphere (34);

b) In 1976 IIASA, in co-operation with UNEP, began to examine the interrelationships between future energy demands and climate;

c) UNEP, WMO and the Scientific Committee on Problems of the Environment (SCOPE) have cosponsored an IIASA Conference on Carbon Dioxide, Climate and Society, which reviewed the ability of available models to predict the regional climatic changes likely to result from a doubling of atmospheric CO_2;

d) SCOPE has carried out a review of what is known about the global carbon cycle (9);

e) A workshop at Aspen, Colorado, has examined how society might respond to probable climate change. It concluded that no matter whether communities decided to try to control the change or to adapt to it, there would be a need to mobilize resources and analyse the balance of gains and losses. Problems would arise because costs and benefits would be unevenly distributed (35);

f) In 1979 WMO, with the support of UNEP, organized a World Climate Conference which reviewed the factors determining climate, the extent to which predictions were possible and the limitations of existing models, and concluded that, of the several forms of potential human impacts on climate already identified, the impacts that may arise specifically from the accumulation of carbon dioxide deserve most urgent attention by the world community of nations (33);

g) The Eighth Congress of WMO agreed to undertake a World Climate Programme (WCP) in association with other international organizations: WMO and the International Council of Scientific Unions (ICSU) are jointly undertaking a World Climate Research Programme (WCRP); UNEP is taking the lead in a Climate Impact Study Programme (CIP), and has examined assessment of such changes within Earthwatch; WMO is leading in a Climate Applications Programme (CAP) and a Climate Data Programme (CDP), as well as providing over-all co-ordination. The problem of CO_2 and its relationship to climate and climatic change is an element in each of the components of the Programme. The monitoring of CO_2 in the atmosphere and ocean is part of CDP, while the potential influence of CO_2 on climatic change is part of WCRP. Among the scientific priorities of WCP is research to resolve major uncertainties about the role of the ocean and land biota in the carbon cycle and the linkages between the carbon cycle and those of other major elements. Improved descriptions of ocean-atmosphere interchange and of the mixing of carbon in the ocean need to be incorporated in models.

35. While it is accepted that economic and population pressures will cause deforestation to continue in many tropical areas, community-based forestry schemes and other projects could help Governments to minimize its harmful impacts (36). In China the land under forest has been increased from 5 per cent in 1949 to 12.7 per cent in 1978. The Republic of Korea has also undertaken major forestry schemes in the past decade, and the process of deforestation has been reversed in Gujarat in India (36). Such actions are a matter for Government, and success clearly depends on attitudes, social organization and land-use practices.

D. Concluding remarks

36. Although there is a growing consensus that increasing atmospheric CO_2 will produce a global warming in the next century, the problem is still fraught with very large scientific uncertainties. Consequently it is right to give first priority to improving, through WCRP, understanding of the carbon cycle and the likely global and regional impacts of an increase in atmospheric CO_2 concentration and its relationship to other changes caused by man. Climate models must be improved. Monitoring of CO_2 levels and fluxes in the atmosphere and ocean (at different depths) and of changes in forest and other vegetation cover on land must proceed in parallel.

37. While this research proceeds and better models are developed, it is a matter of common prudence to give further thought to how the world community could adapt to, or control, changes in climate that might result from rising carbon dioxide levels. Alternative energy strategies (including energy conservation) and ways of avoiding forest and soil destruction need urgent consideration.

III. ENVIRONMENTAL HEALTH: HEAVY METAL HAZARDS

38. Heavy metals are arbitrarily defined as those metals having a density at least five times greater than that of water. Such metals occur naturally in the earth's crust in different concentrations, and in some locations in highly concentrated form, constituting ore deposits. Although metals have many physical properties in common, their chemical reactivity is quite diverse, and their toxic effect on biological systems is even more diverse. Only a few are important environmentally: those most likely to cause concern include copper, cadmium, mercury, tin, lead, vanadium, chromium, molybdenum, manganese, cobalt and nickel. In addition, there are elements including antimony, arsenic and selenium which have some metallic properties (and are sometimes called "metalloids"); these are not considered in this chapter. Uranium, plutonium and other actinides also have metallic properties, and are a cause for concern, but the problems they present are different from those covered here.

39. Many heavy metals are essential to life, even though they occur only in trace amounts in the body tissues. But heavy metals can be toxic. A metal can be regarded as toxic if it injures the growth or metabolism of cells when it is present above a given concentration. Almost all metals are toxic at high concentrations, and some are severe poisons even at very low concentrations. Copper, for example, is a micronutrient, a necessary constituent of all organisms, but if the copper intake is increased above the proper level, it becomes highly toxic. Like copper, each metal has an optimum range of concentration, in excess of which the element is toxic. The toxicity of a metal depends on its route of administration and the chemical compound with which it is bound. The combining of a metal with an organic compound may either increase or decrease its toxic effects on cells. On the other hand, the combination of a metal with sulphur to form a sulphide results in a less toxic compound than the corresponding hydroxide or oxide, because the sulphide is less soluble in body fluids than the oxide. Toxicity generally results (a) when an excessive concentration is presented to an organism over a prolonged period of time, (b) when the metal is presented in an unusual biochemical form or (c) when the metal is presented to an organism by way of an unusual route of intake. Less well understood, but perhaps of equal significance, are the carcinogenic and teratogenic properties of some metals.

40. Man has been exposed more and more widely to metallic contaminants in his environment, resulting from the products of industry. Smelting of ores and refining of metals has been going on for a long time, introducing metals into air and water, but human exposures were usually local; during the past 50 years they have become fairly general. Exposures to lead have occurred in circumscribed areas of the world for 3,000 years or more, and were high among the Roman upper classes; the use of lead pipes in soft water areas has lead to sporadic episodes of lead poisoning in persons drinking these waters, but not until 1924, when alkyl lead was put into

gasoline as an antiknock agent, were whole populations exposed to lead at an annual increasing rate. Cadmium was an industrial curiosity in 1900, but today its use is sharply increasing, with resultant contamination of air, water and food. Mercury has been widely used for amalgamation of gold from crushed ore, but discovery of its catalytic and fungicidal properties has resulted in considerable local contamination from seeds and from the dumping of effluents into stagnant lakes. Nowadays, man is exposed to metals in amounts exceeding those to which his forebears were exposed. The earth is rapidly becoming a place where few human beings can be found who are exposed only to background environmental levels. As a result, the human body burden of many metals has considerably increased over that of primitive man. The question naturally arises: do any of these metals exhibit recondite toxicity, expressed as metabolic breakdown resulting in disease or as slow metabolic deterioration resulting in decreased longevity? Suspicion falls on any metal which accumulates in human tissues with age. Of the trace metals essential to life, health and optimal function, none accumulates under present exposures, except in unusual and individual exposure situations.

41. Metals are among the most important substances in terms of occupational health, and have been studied in that context for a long time. For this reason, a good deal is known about their impact on man. But metals are not necessarily more important contaminants of the general environment than some other substances, even if substantial hazards may arise in certain localities. Because of the initial concentration of research on their role in the working environment, we are still relatively ignorant of their ecological effects on non-human targets.

A. Facts and figures

1. *Cadmium*

42. Cadmium occurs in zinc-lead-copper ores. Zinc ores constitute the main industrial source of cadmium and the metal is fractionated during the smelting or electrolytic processes employed for the refining of zinc. There is, therefore, the possibility of a considerable release of cadmium into the environment during zinc-refining operations and, to a lesser extent, during lead and copper smelting. Man has, therefore, been unwittingly releasing cadmium into the environment from the time he was first able to smelt and refine these metals thousands of years ago. The marked increase in cadmium use during the last three decades has caused a corresponding increase in environmental contamination and in problems caused by exposure at different stages. Cadmium is now used industrially as an antifriction agent, as a rust proofer, in plastics manufacture, in alloys, as an orange colouring agent in enamels and paints, in alkaline storage batteries and for many other purposes.

43. The main pathways of cadmium to man are via inhalation or food intake. Cadmium is released into the air as a result of incineration or disposal of cadmium-containing products (for example, rubber tyres and plastic containers) and as a by-product in the refining of other metals, primarily zinc. Near smelters, atmospheric cadmium concentration can be as high as 0.5

micrograms[4] per cubic metre ($\mu g/m^3$). High concentrations have been also encountered in some working environments, although more typical levels are now around 0.05-0.02 $\mu g/m^3$(37). One study showed that of 58 cities in the United States of America, cadmium was found in the air of 36, in concentrations ranging between 0.002 and 0.370 $\mu g/m^3$(38). Of 29 non-urban areas, 17 showed cadmium levels of 0.004 to 0.26 $\mu g/m^3$ (38). In nearly all cases cadmium was associated with zinc.

44. Cadmium concentrations are also higher in soil and fresh waters around smelters and industries processing materials that contain the metal. The amount of water-borne cadmium is affected by acidity, but concentrations up to 10 $\mu g/l$ are found in some mining areas, while in neutral or alkaline waters suspended particulate matter can contain as much as 700 $\mu g/l$ of cadmium. Concentrations in sediments can exceed 100 $\mu g/g$ (39). Plants vary in their ability to take up cadmium from soil, but some grasses, wheat and lettuce do so fairly readily, and plant/soil ratios for most crops range between 0.5:1 and 2:1 (40). When rice is grown in an environment highly contaminated by cadmium, concentrations can reach 0.5- $\mu g/g$, which is 10 to 15 times higher than in non-contaminated areas. The sensitivity of plants to cadmium also varies, spinach, lettuce and soya bean being affected when levels reach 3 to 4 $\mu g/g$, while other species may tolerate concentrations ten or a hundred times greater. Aquatic organisms vary more widely in their sensitivity.

45. The main impact of prolonged human exposure to cadmium is on the kidney, although obstructive lung disorders can also result from respiratory exposure (41). The effect on the kidney is due to accumulation of cadmium in the renal cortex, leading to tubular protein urea. Cadmium absorbed by the body is only slowly excreted; as a consequence, cadmium toxicity is markedly cumulative (41), so that there is the possibility of chronic cadmium poisoning among industrial workers regularly exposed to this metal or its compounds. An epidemiological survey of workers exposed to cadmium dust found excessive proteinuria due to kidney damage in 68 per cent of a group of male workers with over 20 years of exposure (42). Occupational exposure to cadmium oxide dust has been suggested to increase the risk of prostate cancer in man (43).

46. Probably the most notorious case of cadmium toxicity was the disorder known as Itai-Itai disease which occurred in Japan in the late 1940s. The disease arose from increased uptake of cadmium in locally consumed rice grown in paddy fields irrigated with cadmium-contaminated river water. The disorder involved was essentially an osteomalacia, associated with kidney damage and proteinuria (41), affecting villagers who were dependent on the rice crop as a main source of food. It is now established that Itai-Itai disease is caused by chronic cadmium poisoning, although there are a number of predisposing factors — sex, age, nutrition — which have an effect on susceptibility.

4. A microgram (μg) is one millionth of a gram.

47. Comparable environmental contamination has been reported around a cadmium-emitting plant in Sweden and more recently at Shipham in the United Kingdom, where houses have been built on the waste heaps of an abandoned mine. The main difference between these sites and those in Japan is that the daily diet of the population in these two locations is more varied (44, 45, 46, 47) as compared with the nearly regular daily rice diet at the affected site in Japan.

2. *Mercury*

48. The major source of mercury is the natural degassing of the earth's crust, which releases between 25,000 and 125,000 tonnes per year (48). Several of man's activities (mining and smelting of mercury ores, industrial processes using mercury, e.g. burning of fossil fuels, smelting of sulphide ores, etc.) account for substantial releases of mercury into the environment. It was estimated that the total anthropogenic release of mercury was of the order of 20,000 tonnes per year in 1975 (48). The concentration of mercury in the atmosphere is usually below 0.05 $\mu g/m^3$ and averages approximately 0.02 $\mu g/m^3$. Bodies of fresh water for which there is no independent evidence of contamination contain mercury at less than 0.2 $\mu g/l$. Oceanic mercury is usually less than 0.3 $\mu g/l$ (48). Industrially polluted river waters commonly contain about 5 $\mu g/l$ and the level can reach 50 $\mu g/l$ near points of discharge (49).

49. It seems unlikely that aquatic life will be affected by mercury, even in highly contaminated waters, since algae, shrimps and other crustaceans and fish do not normally show symptoms until concentrations reach 5 $\mu g/l$ or more (although there is some evidence of growth retardation in algae at much lower levels). The normal mercury concentration in the eggs of aquatic birds is as high as 20 $\mu g/g$ (50,51,52) but there is insufficient information about the toxic effects of mercury on non-human targets.

50. In humans, mercury poisoning leading to damage to the central nervous system can occur through inhalation of mercury vapour or through ingestion of organic compounds such as methyl mercury. About 80 per cent of inhaled mercury vapour is retained; after absorption from the lungs, it is transported in the bloodstream and readily reaches the brain. Mercury poisoning through inhalation generally occurs only in industrial situations, but a sustained atmospheric concentration of 0.05 $\mu g/m^3$ would lead to a daily intake of about 1 μg and in "hot spots" near mines, smelting works and refineries daily intakes as high as 30 μg, could occur and need further investigation (48).

51. Food provides the main pathway of mercury to man. It is well known that inorganic mercury can be converted to the more hazardous methyl form by micro-organisms in the environment and taken up by fish. Methyl and ethyl mercury compounds have been the cause of several major epidemics of poisoning in the general population, due either to the consumption of contaminated fish or to eating bread prepared from cereals

treated with alkyl mercury fungicide. The two major epidemics of methyl mercury poisoning in Japan in Minamata Bay and in Niigata were caused by the industrial release of methyl and other mercury compounds into Minamata Bay and the Agano River, followed by accumulation of the mercury by edible fish (48). The epidemics resulting in the largest number of cases of poisoning and of fatalities have been caused by the ingestion of contaminated bread prepared from wheat and other cereals treated with alkyl (methyl or ethyl) mercury fungicides: the largest recorded epidemic, in the winter of 1971-1972 in Iran, resulted in the admission of over 6,000 patients to hospital and over 500 deaths in hospital (48). Previous epidemics have occurred in Pakistan, in Guatemala, and on a limited scale in other countries (48). Methyl mercury from food is practically completely absorbed by the gastro-intestinal tract, is relatively stable in the body, with a biological half-life of more than two months and is highly neuro-toxic. Exposure to organic mercury compounds during pregnancy can also cause pre-natal brain damage.

3. *Lead*

52. Lead occurs naturally in the earth's crust in the concentration of about 13 mg/kg. As with many other metals, there are some areas with much higher concentrations including the lead ore deposits scattered throughout the world. The major sources of anthropogenic lead in the environment that are of significance arise from the industrial and other technological uses of lead. About half of the lead consumed annually is for the manufacture of electric storage batteries, about 12 per cent for alkyl lead fuel additives, 12 per cent for chemical pigments, 10 per cent for alloys and the rest for various other industries. The combustion of alkyl lead additives in motor fuels accounts for the major part of all inorganic lead emissions. The consumption of lead for the manufacture of alkyl leads in 1973 was estimated at 380,000 tonnes, of which over 70 per cent entered the environment immediately after combustion, the rest being trapped in the crank-case oil and the exhaust system of the vehicles (53). Moreover, part of the lead retained in the lubricating oil will enter the environment through different pathways. The degree of pollution from the combustion of alkyl lead differs from country to country, depending on the car density. Because of current legislative actions with respect to the maximum permissible concentration of lead in gasoline, the consumption of lead for the production of alkyl lead additives decreased from 1973 to 1975, and a further decline for the latter half of the 1970s was anticipated as more cars equipped with catalysts that require lead-free gasoline came into use.

53. From a mass balance point of view, the transport and distribution of lead from stationary or mobile sources is mainly via air. Although large amounts are probably also discharged into soil and water, lead tends to localize near the points of such discharge. Lead that is discharged into the air over areas of high traffic density falls out mainly within the immediate metropolitan zone. The fraction that remains airborne (about 20 per cent, based on very limited data) is widely dispersed. Residence time for these small particles is of the order of days and is influenced by rainfall. In spite of wide-

spread dispersion, with consequent dilution, there is evidence of lead accumulation at points extremely remote from human activity, e.g. in glacial strata in Greenland (53).

54. Lead concentrations in the soil are raised by this deposition, especially near to industries using the metal. In turn, concentrations in plants, including vegetables, may be raised (although only a small proportion of the lead in the soil is generally taken up by plant roots). Drinking water generally contains less than 10 μg lead/1, but in some areas where lead water pipes and tanks are used and the water is chemically able to attack them, the concentration may reach 2,000-3,000 μg/l (53). Sea waters in the Mediterranean generally contain up to 7.2 μg/l and sediments 9-3000 μg/g lead, while concentrations in organisms range from 1.5 μg/g in fish to 480 μg/g (dry weight) in mussels. The latter, like other filter-feeding aquatic organisms, accumulate lead and other metals in their tissues (54).

55. There is a good deal of information about the toxicity of lead to non-human target species. Most plants and micro-organisms appear tolerant of quite high concentrations (55). Among aquatic species the most sensitive fish (such as trout) show symptoms if exposed to around 100 μg/l over long periods, although rainbow trout display some effects at concentrations down to 6-16 μg/l and reproduction of the crustacean *Daphnia magna* stops at lead concentrations around 30 μg/l (56). There is least information about effects on birds and mammals, but poisoning of domestic livestock has been reported in areas near lead smelters.

56. The concentration of lead in air varies from 2-4 $\mu g/g^3$ in large cities with dense automobile traffic to less than $0.2 \mu g/m^3$ in most suburban areas and still less in rural areas (38, 53). The presence of lead in the air represents an increasing hazard to the health of urban dwellers. The metal's effects include damage to the liver, kidney, brain and central nervous and reproductive systems. Children are especially susceptible to lead poisoning; effects include mental retardation and other central nervous system damage. Alkyl lead is more toxic than inorganic lead (38, 53). At 20 cubic metres of air inhaled per day, the bodily intake of lead in cities would be 40 to 80 μg per day. About 35 per cent of this inhaled lead is absorbed by the lungs (38, 53).

57. About 90 per cent of the lead swallowed by human adults passes through the gut to the faeces. Once absorbed into the body, lead is distributed to all the tissues. Concentrations in the blood and soft tissues fluctuate rapidly according to uptake and excretion rates, but lead is only slowly exchanged between these tissues and the bones, where the half-life of the metal is 10 years or more. At concentrations in blood only a little above those commonly found in urban populations, biochemical changes can be produced. At higher but still moderate levels of exposure, there may be some signs of impairment to the central nervous system, especially in children, and certain haematological effects. Severe lead poisoning can cause major damage to the brain and is also associated with gastric and kidney disorders. Kidney failure

can occur slowly, appearing long after exposure. Some effects on human reproduction have also been reported (53).

4. *Other metals*

58. *Manganese* is one of the more abundant elements in the earth's crust and in soils, waters and living things. Mining of manganese ores, metallurgical processing and other industrial uses can cause pollution with fumes, dust and aerosols, chiefly of manganese oxides. Some environmental contamination can also come through the use of manganese compounds in making linoleum, matches, fireworks and dry cell batteries, through the use of organo-manganese fuel additives, and from the use of the metal in fertilizers and fungicides (57).

59. Manganese poisoning, especially as a result of high-speed drilling of alloys, which produces large amounts of manganese dioxide dust, is a potential industrial hazard. Over 400 cases of chronic manganese poisoning have been reported (57). Excessive inhalation has caused pneumonia among workers (58), and inhalation and ingestion of heavily contaminated water have also been reported as associated with chronic and irreversible brain disorder resembling Parkinson's disease (59, 60, 61). There is less information about possible hazards to the general population. The daily exposure to airborne manganese of people living outside industrial areas is estimated at 2-10 μg, whereas adults are likely to take in 2,000-8,000 μg/ day from food. However, there are some signs that there might be effects on the respiratory system of people living close to industrial plants emitting manganese (62, 63, 64).

60. *Tin* is another element that might be of concern in certain localities. The smelting process is wasteful because of the structure of the tin ore (cassiterite), and 20-50 per cent of the metal is lost in the processs. Tin is used mainly for tin-plating, food cans and solders, but its organic compounds are catalysts, pesticides and stabilizers in plastics (65).

61. Except near some industrial sites, tin is either undetectable in the air or present at concentrations below 0.01 $\mu g/m^3$. In soil, where detected, concentration ranges from 2 to 200 ppm, the metal being strongly absorbed by humus. It has been found only occasionally in fresh and sea waters (65). It has not been detected in plants, but lichens and mosses may accumulate it.

62. Little is known about the rates at which various forms of tin are absorbed by man. Vomiting, diarrhoea and other acute symptoms have followed consumption of canned food with a high tin content (66) and gastro-intestinal disturbances have been produced in volunteers drinking 5 to 7 ml/kg body weight of fruit juice containing 1,370 ppm of tin (65). Inhalation of tin in industry produces a benign form of pneumoconiosis, while ingestion of organic tin compounds appears to damage the central nervous system (67, 68).

63. *Copper* is essential to all living organism, has a wide range of effects depending on concentration and chemical formulation, and is widely

used by man in the electrical industry in such alloys as brass, in chemical catalysts, and in algicides, wood preservatives and antifouling paints.

64. There are wide variations in the toleration of copper by animals. Trace concentrations one tenth to one twentieth of those accepted in drinking water can kill fish in areas where the water is very soft (low in calcium and magnesium). Exposure to copper may also make fish more prone to die from disease, since it is known to reduce their production of certain antibodies (69). In mammals, ruminants like sheep are poisoned by 20-100 mg/kg body weight copper sulphate (single dose) and cattle by 200-800 mg/kg, whereas swine, rats and certain other non-ruminants will tolerate five times as much (70). Copper poisoning in ruminants can occur through their eating plants contaminated by copper-containing pesticides, or where pastures are contaminated in mining areas. In considering the biological effects of different levels of exposure to copper, particularly in ruminants, the interactions with molybdenum and sulphur are especially important (71).

65. *Molybdenum* occurs naturally in high concentrations in some soils and is a trace element important to plants and animals. It is used by man in steel alloys, steel alloys, catalysts, pigments, glass and as an additive to lubricants. Cattle fed a diet high in molybdenum and low in copper develop anaemia, gastro-intestinal disturbances, bone disorders, retarded growth and reduced reproduction (71). A gout-like disease has been reported in man in an area of Armenia where the soil is high in molybdenum, and this is not surprising since industrial exposure to molybdenum causes biochemical changes which could be expected to lead to increased formation of uric acid — the cause of gout (47, 72).

66. *Chromium* is an important industrial metal. It is mainly used in alloys (64 per cent of consumption), refractory bricks, electroplating, tanning, paint and wood preservatives. Hexavalent chromium has been stated to cause lung cancer after a few years of industrial exposure (73, 74). There is no evidence of hazard from non-occupational exposure.

67. *Nickel* is widely distributed throughout the earth's crust and is a relatively plentiful element. It occurs in marine organisms, is present in the oceans, and is a common constituent of plant and animal tissues. Foods can be contaminated with nickel during handling, processing, and cooking by utensils containing large quantities of nickel. Nickel is also used frequently as a catalyst. Nickel carbonyl, $Ni(CO)_4$, is one of the most toxic nickel compounds and is a major industrial hazard (38). Nickel usually is not readily absorbed from the gastro-intestinal tract except as nickel carbonyl. This compound has caused most of the acute toxicity of nickel. Recently it has been shown that nickel has a carcinogenic property (58, 75) and may be involved in hypersensitivity reactions. Nickel dermatitis is reported with increasing frequency in industrial workers, especially nickel platers. It produces an allergic dermatitis on almost any skin area. Nickel workers have approximately 150 times more cancer of the nasal passages and sinuses than the general population, and approximately five times more lung cancer (38).

68. *Cobalt* exposure in industry has caused a lung disease ("hard metal pneumoconiosis") and skin allergies; as regards the general population, some concern about it has resulted from the allegation of damage to the cardiovascular system in some heavy beer drinkers consuming beer with a high cobalt concentration (76).

69. *Iron* deficiency increases the absorption of certain metals, like cadmium. Consumption of excessive doses of absorbable iron over long periods can cause disturbances of the bloodstream and liver cirrhosis (77, 78). This has happened in southern Africa, where locally brewed beer had a high iron content, and further iron was added to the diet from cooking vessels (79). Accidental ingestion of large amounts of iron has also caused severe poisoning in children. These effects are all much more certain than reports that iron oxide plays some part in the development of lung cancer in occupationally exposed workers (80).

B. The problem

70. The essential problem with heavy metals is that many of them have been used for centuries and are fundamental to major industries, yet they have the potential to damage human health and disturb the balance of environmental systems if they are allowed to reach excessive concentrations in air, water, soil or food.

71. It is clear from the preceding section that the effects of each metal have to be considered specifically, and in relation to the particular circumstances: the sources of the metal, the precise chemical and physical form in which it occurs in the environment and the ways in which it is dispersed, the factors governing the exposure of people and other living things, and the costs and benefits of changes in practice. It is also clear that while much is known about the effects of some metals on man, there are major areas of uncertainty.

72. There are three main kinds of *source* of metals in the environment. The most obvious is the process of extraction and purification: mining, smelting and refining. The second, and less familiar, is the release of metals from fossil fuels such as coal or oil when these are burned. Cadmium, lead, mercury, nickel, vanadium, chromium and copper are all present in these fuels, and considerable amounts enter the air, or are deposited in ash, from them. The third and most diverse source is production and use of industrial products containing metals, which is increasing as new applications are continuously being found. Modern chemical industry, for example, uses many metals or metal compounds as catalysts. Production of many plastics uses metal compounds as stabilizers. Metals are added to lubricants, and so find their way into the environment. The relative role of these various activities as sources (and their significance in relation to the natural background in various areas) needs careful assessment if potential hazards are to be evaluated.

73. Metals follow many *pathways and cycles* in the environment, and some of them undergo transformations in the process — like the conversion of inorganic mercury to the more toxic methyl form, and the subsequent accumulation of the latter by fish. Some plants and invertebrate animals also accumulate metals to potentially toxic levels. The possibility of such accumulation and transformation must be considered when judgements are made about the safety of a particular metal-laden discharge to the environment. This is especially so because once toxic concentrations have been reached, it may take a long time to reduce them to non-toxic levels.

74. Pathways within man and other targets are also crucially important. The rates and mechanisms of absorption and excretion, and the extent to which metals are deposited in such tissues as bone or the kidney cortex and then only slowly removed, need to be known if risks are to be assessed. The biological half-life of methyl mercury in man, for example, is about 70 days, that of cadmium around 20 years, and that of lead only a few weeks in blood and soft tissue, but at least 10 years in bone.

75. The *effects of metals on ecosystems* are very inadequately known (81). Some appear to affect the rate of basic processes; molybdenum deficiency, for example, may inhibit bacteria responsible for the fixation of nitrogen, while small amounts of copper may slow the decomposition of forest litter. Small amounts of copper and zinc are, however, essential nutrients for most organisms. There are also wide variations in the uptake of metals from the soil by different plants. Some plant species tolerate high lead levels and absorb little of the metal, whereas mercury and cadmium in the soil are toxic to most organisms (82). Some crops, including wheat and rice, can, however, take up so much cadmium from the soil that they become hazardous to consumers. Cadmium accumulates in the organs of grazing animals (83) and lead levels in the kidneys and livers of sheep grazing near major roads, and mercury in the feathers of birds in areas where alkyl mercury fungicides were used have likewise been shown to be raised (84, 85). Where metal-rich mine drainage enters fresh waters there are often obvious ecological effects, including a great reduction in the invertebrate fauna and the absence of fish.

76. Attention to the *effects of metals on man* focused first on acute poisoning following industrial exposure or through diet. Many metals have been known for centuries to be toxic. Inhalation of mercury vapour in both the mining and felt hat industries used to cause many cases of damage to the central nervous system. Lead poisoning was for decades a well-known hazard to smelters, and later to those engaged in storage battery production. Inhalation of manganese has been known for many years to cause irreversible damage to the central nervous system. Cadmium, mercury, tin, lead, vanadium, chromium, molybdenum, manganese, cobalt and nickel are all known to pose hazards to those working with them.

77. Since the 1960s, attention has focused especially on lead, cadmium and mercury, because they have also been shown to cause more general environmental hazards, in each case mainly through the ingestion of excessive quantities of the metal. The risk from cadmium appears limited largely to groups of people consuming food produced in areas where the soil or irrigation water is contaminated, although there is concern about rising cadmium levels in the environment. Mercury is a problem where populations eat large amounts of fish taken from contaminated waters. Lead is the most widespread potential hazard, since quite small increases in lead consumption can raise blood lead levels to the point where blochemical changes are detectable. Children (see chapter VI) appear to be more sensitive to exposure to heavy metals than adults, and are consequently the focus of concern.

78. Today, increasing emphasis is being placed on the carcinogenic effects of metals. Chromium, nickel, lead and cadmium are all proven or suspected causes of certain cancers associated with industrial processes. Large doses of cadmium and nickel are teratogenic in animals, but this effect of metals is not well established in man.

79. No pollutant acts on a target in isolation. Other variables—such as the presence of other substances or the age and nutrition or reproductive state of the subject—have a major influence. The availability of metals to plants is affected by acidity, organic content and other features of the soil. Lead absorption and toxicity appear higher in children than in adults. Copper and molybdenum modify one another's effects. Iron deficiency increases the absorption of cadmium. Selenium is believed to be protective against inorganic and methyl mercury compounds. Insufficient emphasis has been placed in many analyses on the need to look at susceptibility to metals in the over-all context of the physiology of the whole target organism, and to search for the environmental and other variables that can accentuate — or reduce — an impact.

C. Major actions taken or planned

80. Many national Governments have a long history of action to protect workers in mining, metal processing and other industries from occupational hazard, and standards in this respect have been steadily increasing, aided by the free interchange of scientific information. Action to limit contamination of the environment around points of discharge, and to control the concentrations of metals in drinking water, food, medicines, paint and other products that can be significant pathways to man, has also been taken by many Governments. Concentrations of alkyl mercury in some areas, for example, have fallen as a result of such action (48).

81. The main role of the international community in this is twofold. First, through collaborative programmes of research and analysis, the collective knowledge of the world scientific community can be harnessed to support Governments in their regulatory tasks. Second, international negotiations can lead to harmonization of standards and regulations, where

these are desirable in order to avoid interference with trade, or so as to maintain a comparable high standard of human safety everywhere.

82. The following major international initiatives have been taken:

a) In 1973, the World Health Organization (WHO), with substantial support from UNEP, launched the UNEP/WHO Environmental Health Criteria Programme. This is producing assessments, termed *Criteria Documents,* of the best available information about the relationship between exposure to specified pollutants and the effects on human health. Where possible these reviews also provide guidelines for the establishment of primary protection standards. UNEP has also supported the FAO/WHO *Codex Alimentarius* work, which aims at establishing tolerance levels of trace metals in food among other contaminants;

b) In 1973 the Organisation for Economic Co-operation and Development (OECD) adopted a recommendation to reduce, man-made emissions of mercury to the environment, and member countries have supplied details of national consumption and emission for 1973-1976; data for 1979 are now being sought. In 1978, the Council of OECD established a Special Programme on the control of chemicals, in which 13 countries and the European Economic Community (EEC) are participating;

c) In 1976 UNEP established the International Register of Potentially Toxic Chemicals (IRPTC). This is a collection of information about the properties of substances judged likely to cause hazards in the environment, for use as a data base by those making national and international decisions;

d) In 1978 the United Nations Economic Commission for Europe (ECE), in collaboration with the United Kingdom Government, organized a research seminar on trace metals: exposure and health effects;

e) A Joint Occupational Health Programme has been maintained by the International Labour Organisation (ILO) and WHO, both of which are concerned to improve the safety of the working environment. ILO has adopted International Convention and Recommendations to reduce occupational risk and has recently launched an International Programme for the Improvement of Working Conditions and Environment (PIACT) to promote or support the actions of member States to combat airborne toxic substances;

f) In 1979, at the request of the World Health Assembly, WHO further developed plans for an International Programme on Chemical Safety, starting in 1980, which will expand and accelerate the evaluation of the effects of chemicals on health, including the development of guidelines for exposure limits. It will also include the development and harmonization of methodology, co-ordinate studies, and promote international co-operation in emergency and for the training of specialists. ILO, FAO, UNEP and WHO have discussed joint sponsorship of the programme, which is to be implemented through a network of national institutions linked to a central unit for planning and co-ordination. Consideration is being given to widening the programme to include the effects of chemicals on non-human targets.

D. Concluding remarks

83. It has been well established that many metals can pose problems in the occupational environment, and there is growing evidence that they can cause problems with respect to the general environment, where they act alongside, or at times in combination with, many other pollutants. Some have been familiar hazards for decades or centuries, and have been controlled progressively by national agencies; others pose problems because of new industrial uses or because unsuspected impacts have only lately come to light.

84. One essential area of international action is scientific. More information about sources, pathways, transformations, protection limits and impacts of metals acting, singly and in combination, on man and other targets is urgently needed. Collaboration in research and in the evaluation of the results should lead to a definition of the relative scale of risk posed by different substances under different conditions, and hence aid Governments in deciding where priorities for action to protect people and environmental systems should lie.

85. International action is also needed to protect areas of shared resources — such as the actions under way in the Mediterranean or other regional seas, or major continental rivers. There is a natural overlap, therefore, between international actions related to metals and actions to safeguard the areas of the environment which they pollute. Finally, because metals are themselves objects of trade and occur in many traded goods, and because people themselves expect food and water of comparable wholesomeness wherever they go, there is room for action to co-ordinate the approaches by different national authorities.

IV. TRANSPORT AND ENVIRONMENT

86. From the earliest times, transport has been a vital influence in the evolution of civilizations. Today, more people travel over greater distances, and more fuels, raw materials and products are transported around the world than ever before. Transport industries make a major contribution to national economies. But like many other activities, transport has some undesirable impacts on the environment. This chapter reviews trends in transport on land, at sea and by air and examines the nature of their impacts, before considering the central question of how to obtain the greatest possible benefit from the world's transport system at the least environmental costs.

A. Facts and figures

87. Most cities were built long before the development of the automobile. Their narrow streets were designed for pedestrian and animal-drawn waggons. Today, they are being overwhelmed by motor cars, lorries and buses, and are finding this increase in motorized traffic increasingly difficult and expensive to accommodate. Congestion, reducing average road speeds to below 15 kilometres per hour, neutralizes the benefits of the motor vehicle and leads to pressure for more urban roads, at monetary costs above $2 million per land-kilometre and further costs due to social upheaval (86).

88. In 1950, 63 per cent of the population in the United States of America and Western Europe lived in towns; today 75 per cent do. In Eastern Europe and the USSR the respective figures are 43 and 55 per cent, and a similar trend is manifest in the south of Europe as well (87). In the United States, car ownership is approaching one for every two people. Between 1960 and 1970, while the population of the OECD countries rose by under 11 per cent, the number of motor vehicles almost doubled. One estimate suggests that the 1972 figure of 200 million will rise to 320 million by 1985 (88). The trend is just as marked in developing countries, where car ownership has been rising at 10 per cent per year, and at more than double that rate in some cities. Annual car imports to Nigeria since 1972, for example, have been rising by between 20 and 40 per cent (89, 90).

89. Road freight has also increased in scale and efficiency. Modern diesel-powered lorries, commonly with trailers, are providing a dramatically increased level of community service, especially over short distances. Containerization has made transfer from one mode of transport to another easier, and further reduced costs. Pipelines are transporting coal, gas, petroleum and other bulk materials over long distances. In 1975 nearly 140,000 km of such pipeline existed or was planned in the world (91).

90. All this means that more land is demanded for transport. In 1974 11.4 million hectares (1.2 per cent of the total land area) of the United States of America was devoted to transport; of this 9.3 million hectares was under

roads, 1.3 million ha used by railways and 0.8 million ha as airports (92). In the cities of the developed countries, roads typically occupy 15-25 per cent of the total urban area (but up to 30 per cent in newer, low-density, North American cities) whereas in the developing world the proportion rarely exceeds 15 per cent, and is often below 10 per cent. Public resistance to the taking of more land for highways is growing and there are mounting demands for control of road traffic and for better use of the railways.

91. There have been equally dramatic changes at sea. In 1954, for example, the world tanker fleet consisted of just under 3,500 totalling 37 million deadweight tons (dwt). By 1977 there were nearly 340 million dwt (93). One feature of this expansion has been the great increase in the size of ships. The largest tanker in service in 1954 was around 30,000 dwt; today there are several ships of more than 500,000 dwt.

92. The rate of growth in air transport has exceeded that of national economies (in terms of GNP), and this trend is expected to continue. Air services have taken over from railways much of the intercity passenger traffic over distances above about 600 km, while international passenger and freight traffic has grown even more rapidly than that within countries. Because aircraft have been getting larger, the number of actual flights has increased more slowly than the volume of passenger and freight traffic, and this trend is also expected to continue. Air freight conveys only a tiny fraction by weight of all goods transported, but carries a significant quantity of manufactured goods and in the United States of America air shipments account for about 20 per cent by value of national trade (94).

93. The environmental impacts of transport arise at many stages, but especially from the provision of "infrastructure" (the construction of airports, roads, railways or pipelines), the manufacture of vehicles, and the operation of vehicles, ships and aircraft. The expansion of rail and marine transport in the past, and more recently of road and air transport, has obviously consumed much land, both for new tracks and highways and around ports and airports. New transport corridors also have a secondary effect on land use, because they attract industrial development. New highways can sever wildlife habitats and stimulate uncontrolled and inappropriate rural development, while new seaports are often placed in coastal areas also valued for wildlife and recreation. Because the density of development is lower in cities built to accommodate road traffic, public services may be more costly to operate there. But there are also problems when poorly designed roads are flooded with vehicles. Drainage systems can be interfered with, and costs of maintenance of both roads and vehicles can become unacceptably high.

94. WHO estimates that a quarter of a million people are killed and several million injured every year in road accidents, a considerable proportion of them being pedestrians (95). The death rate per million vehicle kilometres in many developing countries is about six times that in the United States of America. In older cities like Caracas or Bangkok, with narrow and

congested streets, pressure for road space has meant such encroachment on the pavements that space for pedestrians barely exists and walking and cycling are dangerous and unpleasant. And people are not the only victims. A recent survey in the United States of America indicated that 120,000 deer and 1,200 other large wild animals are killed each year, in addition to many thousand domestic pets, and the cost of damage to vehicles involved in collisions with animals was put at over $30 million annually (96).

95. Transport is a great consumer of energy, accounting in the United States for about 55 per cent of liquid fuels (petroleum products); in Europe, the figure is about 31 per cent (97). In the developing countries, the bulk of liquid fuels is used in the transport sector (e.g. more than 65 per cent in Kenya). The efficiency of energy utilization varies considerably. Railroads and waterways, for example, are more efficient than aircraft or automobiles. The latter are the least efficient, and they account for the bulk of energy consumption in the transport sector. Substantial energy savings can be made in the tranpsort system by improving engineering, by improving load factors on existing modes, by switching increasing volumes of traffic to more efficient modes and, more important, by changing habits of transport (5). The predominant use of light automobiles in some countries and the switch to buses and fixed rail transport systems in intracity travel have led to considerable energy savings. Conservation efforts in the transport sector often bring unexpected secondary benefits. For example, the reduction of highway speed limits in the United States (which was intended to increase fuel efficiency), had the additional benefit of increasing automobile tyre life and, more important, reducing highway accidents and deaths (5).

96. The most familiar environmental impacts of road transport are those from air pollution. Petro-burning vehicles emit carbon monoxide, hydrocarbons and oxides of nitrogen. Diesel engines emit relatively little of these, but produce more particulates and smoke (98). Alkyl lead is still added to vehicle fuel in many countries, and is emitted in the exhaust as very small particles. In confined spaces (like tunnels or very narrow streets) carbon monoxide concentrations can rise to levels hazardous to health, especially to people with heart or lung weakness. Oxides of nitrogen and hydrocarbons, on the other hand, are not directly toxic, but interact in the presence of sunlight to produce an oxidant smog which irritates the eyes and lungs and damages sensitive plants. This kind of smog made Los Angeles notorious before emissions were controlled, and remains a problem in many large cities such as Tokyo (99).

97. Aircraft and railway locomotives together emit a far smaller volume of air pollutants than road vehicles do. However, high-flying aircraft release oxides of nitrogen directly into the lower stratosphere where they may become involved in chemical reactions which could reduce the concentration of ozone, important as a screen against ultra-violet radiation from the sun. Aircraft also contribute carbon monoxide, hydrocarbons, particulates and nitrogen oxides at lower levels, locally, around airports. The best available

evidence suggests, however, that none of these impacts is significant (94).

98. Noise is one of the most widely recognized and resented environmental consequences of the increase in road and air transport. It interferes with work, prevents sleep, has psychological effects and can even damage hearing. The problem is especially serious in the town centres of developing countries, where motorcycles and old cars and lorries crowd the streets and where exhaust silencer systems are among the lowest priorities for maintenance.

99. All these problems of noise and pollution can be solved. Noise can be reduced by setting new roads in cuttings, or screening them with walls. Traffic management systems (including computer controls that relate the timing of traffic lights to the flow of vehicles through an urban road system) help to reduce noise and air pollution caused by unnecessary stopping and starting. When traffic has been excluded from parts of city centres there have been dramatic improvements. In Gothenburg, noise levels have fallen from 74 dBA to 67 dBA in pedestrian streets (the decibel scale is logarithmic, and a decline of 10 units is equivalent to a halving of noise levels), and carbon monoxide concentrations from 65 ppm to 5 ppm. Besancon has reduced carbon monoxide in the town centre by 67 per cent, while all vehicle-produced pollutants have been reduced by 16 per cent in Nagoya (100).

100. However, redistributing traffic simply redistributes pollution, unless it is complemented by direct curbs on emissions like those enacted under United States laws. In the United States, hydrocarbon emission standards have dropped from 3.7 g/km in 1968 model cars to 0.25 g/km in 1980 models. Carbon monoxide emission standards (Federal Emission Standards) were similarly reduced from 32 g/km to 4.4 g/km. These improvements were largely achieved by modifying engine design and controls, and further advances (including reductions in emissions of nitrogen oxides) have been achieved through the use of catalytic converters and more stringent maintenance. A parallel trend is apparent in Europe, where EEC standards for gaseous emissions from petrol-engined vehicles are being widely applied, the lead content of petrol is being reduced and limits are being set on smoke emissions from diesel engines and on vehicle noise. Because lead damages the catalysts used in pollution control equipment, lead-free petrol has to be supplied in countries where these devices are fitted, with further environmental benefits.

101. Annoyance to people living near airports caused by the noise of jet take offs and landings has become a psycho-physiological and economic problem of enormous magnitude and complexity. As a result of the expansion of air traffic, airports tend to occupy large land areas, with multiple runways, and large airspaces for landing and take-off procedures. At the same time, under the pressure of population, communities tend to expand towards airports and thus to enter zones of higher noise. At present, aircraft noise affects people near airports, but an increase in the use of vertical and

short take-off and landing aircraft and of the SST is likely to affect a much wider population. It can be said with assurance that the existing problems with aircraft noise are much less serious now than they would have been, had they not been recognized early, and serious steps taken to reduce their impact (6). Aircraft noise has been curbed in many places by a combination of operational controls and new technology. Many airports have banned night flights. They often require aircraft to reduce their thrust soon after take-off, and climb more slowly, and to approach and leave along corridors that avoid residential areas. At the same time, aircraft engines are becoming much quieter.

102. The increasing industrialization of the world has led to the transport of more and more oil, liquefied gas, petrochemicals, toxic chemicals and radioactive materials. The volumes carried as a single cargo (whether in a ship, rail, car, lorry or pipeline) have also increased. At sea, the result has been several very large oil spills from wrecked vessels. The *Torrey Canyon* released about 80,000 tonnes, the *Metula* 52,000 tonnes and the *Amoco Cadiz* about 220,000 tonnes. Spills like these kill large numbers of sea birds, damage oyster beds and other shellfish and foul shores and salt marshes, causing both ecological change and disaster for tourism. Recovery takes many years, or even decades, and the costs both of the damage and of cleaning up can be very great. The damage caused by the wrecking of the *Amoco Cadiz* is estimated at about $300 million (101). On land, despite the much smaller volumes of cargoes, there have been serious losses of life following accidents to railway cars and road tankers containing propane and other fuels, and several smaller-scale accidents involving toxic chemicals; evacuation of large numbers of people has sometimes been necessary. Accidents can never be completely prevented, but more and more effort is being devoted to improving the design and operation of ships, road tankers and railway cars carrying hazardous materials, and to controlling the routes they follow and ensuring that accurate information about their cargoes is available. The dispersants used to deal with oil pollution at sea are now much less toxic than those sprayed after the wreck of the *Torrey Canyon*.

B. The problem

103. The central problem with transport is how to strike a balance. There is no doubt that modern transport systems provide great benefits to individual people and to communities. The extension of these systems is vital to development, and the sound planning of new ports, airports, roads and railways is of fundamental importance to the growth of the third world. But at the same time, there is no doubt that transport systems consume scarce natural resources of land and energy, kill many people in accidents, and cause severe local pollution of air and water.

104. Transport is a service, and must match the needs of the community. It must be thought of as a component of national, social and industrial life, and the precise pattern of investment in the various modes — air, sea, rail or road — related to national priorities. It must be organized in a flexible way, because national priorities, technical possibilities and costs will

change. But within this overall approach it is often helpful to examine three main requirements for transport planning: putting the right services in the right place (locational control); improving the designated construction of ships, aircraft and land vehicles (design control); and controlling the services so that they match the need (operational control).

105. Locational control is a component of national land-use planning, and must be carried out as part of a strategy for the development of settlements and industries. A new transport corridor will often stimulate development along its length, and have a long-term impact which cannot always be foreseen when it is first built. It is wise, accordingly, not just to construct new routes (or to improve old ones) to meet today's needs, but to evaluate what the future consequences may be, and these consequences will affect not only the urban and industrial environment, or the farming communities whose produce will reach markets more easily. One of the major impacts of modern transport on the environment has come through the growth of tourism, now reaching areas as remote as Antarctica or the islands of the Pacific and Indian oceans. This tourism can bring with it new pressures on wildlife, and place severe stresses on local human communities. The ecological and human consequences are not easy to foresee, and cost-benefit analyses are extremely difficult.

106. The primary aim of those designing new ships, aircraft, rail or road vehicles must be to achieve efficiency in operation. Today, economic use of energy is a vital concern. But it is also essential that such vehicles are as safe as possible — both to those who operate or travel in them and those liable to be hurt if there is an accident. A fourth need is to make them cause as little noise and pollution as possible — both when operated normally and if they are involved in an accident. These features interrelate: a lightweight road vehicle, for example, generally uses less energy than a heavy one, but may be more dangerous to travel in, and may lose its energy economy if extra devices have to be added on to prevent air pollution.

107. Operational controls take many forms. They include the routing of vessels and aircraft so as to minimize the risk of collision and to avoid noise to people on the ground. They include the management of road traffic to avoid the centres of historic towns and so that vehicles flow as smoothly, quietly and efficiently as possible. They should obviously include the effective enforcement of regulations — something that is often done very inadequately at present. They also include difficult issues such as striking the right balance between private and public transport. Generally, public passenger transport systems are more efficient in terms of energy use and have less environmental impact – but as communities become wealthier it is normal for people to want their own cars, and for public transport to become unprofitable. Analysis by OECD (102) has shown how varied this problem is from one country to another, but also that there are ways of encouraging the use of public transport (including educational efforts).

108. Most of the decisions in these three areas rest with national Governments, and different countries, at different stages of development and with different priorities, will choose different solutions. But transport is international, and there is a clear need to ensure that variations in the design of ships, aircraft or land vehicles do not make them unacceptable to some of the countries over, past or through which they may travel. There are thus practical reasons for harmonizing standards for design — and also for ensuring a reasonably uniform qualification for drivers and crews. And, as in other fields, it is valuable to exchange scientific and practical experience between nations so that the world community can make the best use of the total stock of available knowledge.

109. Transport is a highly competitive commercial field. So is the energy supply industry with which it interacts. It would be unrealistic to expect the free interchange of information that could weaken competitive advantage. It is equally unrealistic to expect that Governments will not from time to time adopt measures — and press for international actions — that favour their national transport industries. Conflict between the need to nurture industry and the need to ensure that its products attain a high standard of pollution control, for example, has occurred on several occasions. But the international community can assist Governments in setting realistic standards for the design and operation of transport, without interfering with the commercial operations of industry within those limits.

C. Major actions taken or planned

110. The major actions taken by the international community in the transport field have been in two fields: information exchange and the harmonization of regulations affecting design and operations:

a) *For air transport* the International Civil Aviation Organization (ICAO) carries out a broad range of activities in pursuance of the 1944 Chicago Convention and the decisions of its assembly, council and other bodies. ICAO has developed and distributed guidance on the planning of airports and their surroundings and on airport operations. It has also taken major initiatives on aircraft noise, identified as a major potential problem even before jet aircraft came into commercial service. In September 1968 the sixteenth assembly of ICAO adopted a resolution on this subject and since then international specifications have been issued as noise certification requirements under annex 16 of the Conventions on International Civil Aviation. Following these requirements, present wide-bodied civil jet aircraft are 16 to 20 EPNdb quieter than the first generation of such aircraft. ICAO has also published a circular on the certification procedure for subsonic turbine engines, and plans to issue mandatory requirements for control of smoke, vented fuel and certain gaseous emissions from future subsonic and supersonic turbojet and turbofan engines as an annex to the Convention on International Civil Aviation. Studies of the possible operational control of aircraft engine emissions are also in progress (94);

b) WMO supports ICAO by providing meteorological services, the International Telecommunication Union (ITU) arranges communications services for aircraft, and the World Bank has made loans for development related to air transport totalling $143 million in 1972-1976 (103);

c) *For marine transport,* the Intergovernmental Maritime Consultative Organization (IMCO) is responsible for technical matters relating to international shipping and ports, including marine safety, technology and measures (including assistance) to facilitate travel and transport by sea. In February 1978 IMCO passed regulations requiring new oil tankers to have segregated ballast and systems to minimize pollution during tank cleaning (101, 102). In the same year it adopted more stringent requirements for inspection and certification of tankers and the training of their crews. IMCO continues to seek safer and more accident-proof systems for ship design and for the handling of hazardous cargoes (104). Particular attention is being given to explosives, compressed and liquefied gases, inflammable liquids and solids, oxidizing agents, poisonous materials, corrosives and radioactive substances;

d) In 1978 the Third United Nations Conference on the Law of the Sea, at its seventh session, developed new procedures to prevent, reduce or control pollution from ships, and proposed new authority for States to prosecute ships causing pollution in their economic zones;

e) WMO, ITU and the ILO perform the same supporting functions for transport by sea as they do for air transport. The United Nations Development Programme (UNDP) has relatively few projects in this field, but works through the United Nations Conference on Trade and Development (UNCTAD), ILO, the regional United Nations Economic Commissions and the World Bank (which provided $1 billion in loans for ports, shipping and inland water transport in 1972-1976);

f) *On land* the United Nations Department of International Economic and Social Affairs, UNCTAD, and the five regional Economic Commissions have the over-all co-ordinating functions carried out by ICAO in the air and IMCO/UNCTAD at sea. This fragmentation partly reflects the fact that there is less need for world-wide international co-ordination of land transport. But there are some new kinds of transport activity which are being looked at globally. UNCTAD has an Intergovernmental Preparatory Group on Multimodal Transport, which is preparing a draft Convention, and an *ad hoc* Intergovernmental Group on Container Standards for International Multimodal Transport. Virtually all the organizations and regional Economic Commissions involved with transport have an interest in this work (103);

g) The land transport activities of the regional Economic Commissions vary. ECE is placing special emphasis on road and inland water transport, and has done significant work on road signs and signals, road safety, motor vehicle construction, noise and pollution control standards, and the European highway network. The ECE Secretariat has also assisted the Economic and Social Council's Committee of Experts on the Transport of Dangerous Goods in developing a possible world-wide convention on this subject. The Economic Commission for Asia and the Pacific (ESCAP) has been more concerned with the development of road and rail systems, including the Trans-Asian Railway Project and the Asian Highway. The Economic Commission for Africa (ECA) has also done much to promote development, including the creation of eight trans-African highways, and the Economic Commission for Latin America (ECLA), too, has concentrated on the development of railway and highway infrastructure. But interregional links have also been considered, and plans are being laid for a modern highway system linking the ECE, ECA and ESCAP areas. Railway links have also been discussed. Inevitably, the transport systems in the developing regions will differ from those of the developing world and the results of its meetings and discussions may merit wider dissemination. The Department of International Economic and Social Affairs provides a focal point for information about the new developments in transport technology, economics and management which may help developing countries as well as underpinning technical assistance projects;

h) ILO includes land transport workers in its area of interest, but ITU and WMO are less concerned with land than with air and sea transport. However, projects on land make up most of the transport activities of the World Bank, which in 1972-1976 loaned $2 billion for highway schemes and $1.4 billion for railways. UNDP also contributes to many projects (103);

i) The environmental impacts of *all forms of transport* are the concern of UNEP, which encourages other organizations to give proper attention to them (103). In 1976 UNEP brought together over 200 experts from Governments, motor vehicle manufacturers and relevant international institutions in a seminar on the impact of the motor vehicle industry. UNEP and ECE have collaborated in this field, UNEP being concerned with pollution control, energy and safety, and especially the international harmonization of legislation (taking account of the needs and resources of developing countries). Through the UNEP Regional Seas Programme, studies and legislative actions are supported and encouraged to protect the marine waters and coastal areas from oil pollution. Through efforts of UNEP, the Mediterranean States, for example, agreed on the creation of a Regional Oil Combating Centre in Malta to facilitate co-operation among the Mediterranean States in the event of a massive oil spillage (105).

111. All these activities are complementary to, and support, the very large number of measures taken by individual Governments, some of which are referred to in the preceding section of this chapter. Air pollution control, limits on aircraft and vehicle noise, traffic routing and management (including the establishment of traffic-free zones in town centres), new mass transit systems and measures to divert people from their own vehicles to public transport, measures to improve the handling of dangerous goods and ensure prompt action in emergency, regulations affecting the handling of shipping in ports and inland waterways, and many other national efforts apply the conclusions reached in international discussion, and in turn provide fresh experience to guide new international planning. Many countries also have substantial transport research programmes, and some of these are co-ordinated internationally, for example, through the Roads Programme of OECD. In most countries, too, transport regulations are backed by considerable publicity — persuading people not to drink and drive, to use energy more wisely, to maintain their vehicles better, or to make more effective use of public transport. It is often useful to exchange information about the success of such measures internationally (103).

D. Concluding remarks

112. In contrast to the issues debated in the two earlier chapters of this report, many of the environmental impacts of transport are relatively well understood. While it is necessary to balance efforts to reduce these impacts against parallel efforts to improve efficiency, energy economy and safety, there is little reason to doubt that further advances can be made. The major problems surrounding transport in the future are likely to include achieving a proper balance between different modes, and especially ensuring that people's understandable desire for their own cars does not so undermine public transport systems that the very young, the very old, the poor, and those who for other reasons cannot run their own transport are severely hampered. There will also be continuing concern over the taking of land for highways and airports, the risks from hazardous goods transported in ever-increasing volume, and the intrusion of traffic into town centres and areas celebrated for their history, their natural beauty or their wildlife.

113. Within the next 50 years supplies of oil are likely to diminish, and alternative fuels for transport will have to be found. New kinds of engines and vehicles may well appear. Some people think that hydrogen may become the new aircraft fuel. In towns, there may be an increasing role for electric vehicles — which are quiet, non-polluting, and reasonably efficient for short journeys (especially those involving frequent stops and starts). Synthetic liquid hydrocarbon fuels made from coal provide another alternative. Railways powered by electricity generated from nuclear sources may take over more of the long-haul overland market. These are, to a considerable degree, matters of

speculation. What is clear is that the futures of transport and energy are inseparable, and that the international community will in future, as today, be concerned with the harmonization of standards for design, operation and environmental impact. There is a pressing need to evaluate the future prospect now — before short-term pressures become overwhelming.

114. There remain some major uncertainties which demand research. One is the real impact on humans of noise and of some pollutants emitted by transport. The seriousness of carbon monoxide and lead pollution from petrol-driven cars, for example, is still a matter of dispute. Another is the extent to which the transport technologies of developed countries can be transferred to the developing world. Although there is a great deal of relevant experience, more research is needed to provide good and economical guidelines for transport planning and development guidelines (including environmental impact assessment). It is appreciated that accidents cannot be totally avoided; they will inevitably occur from time to time, especially with the great increase in transport in terms of load or of distances. Greater efforts are therefore needed to reduce the occurrence of such accidents through more stringent transportation rules and procedures at the national, regional and international levels. This applies to transport by land, sea or air of all goods, and in particular of those which are likely to affect the environment when spilled in case of accidents.

V. THE ENVIRONMENTAL EFFECTS OF MILITARY ACTIVITY

115. War is a deeply rooted habit of human societies, but its direct and indirect impact has been greatly amplified by modern technology. Nuclear world war undoubtedly now constitutes the greatest single threat to man and his environment. The total destructive power in the world's arsenals has increased several millionfold in the past 30 years. War not only destroys human life and devastates the scenes of conflict, but wastes social, financial and natural resources. This chapter is primarily concerned with the environmental consequences of warfare and the relics of past wars, but it is necessary to begin with facts and figures that define the scale of the waste and suffering wars and preparations for wars have caused over recent decades.

A. Facts and figures

116. Some 130 civil and regional wars took place between 1945 and 1979, involving some 81 countries, mostly in the third world (106, 107). Apart from great human suffering and an astronomical waste of resources, at least 12 of these caused considerable environmental damage (108, 109).

117. Global military expenditure has increased 30-fold since 1900. It now absorbs well over $400 billion a year — approaching $1 million per minute (106) — and if the current trend continues, could reach $1,000 billion a year in current prices by 2000 (110). Third world military expenditure has, in real terms, quadrupled in the past 20 years (106). The global trade in military equipment is running at about $20 billion a year (106). Major weapons — tanks, aircraft, missiles or ships — were imported by 119 countries in 1978, 90 of them in the third world. Some 70 per cent of the major weapons sold go to the third world, and the traffic in arms accounts for a significant proportion of the total trade of third world countries (106). According to the Stockholm International Peace Research Institute (SIPRI) valuations, the value of major weapons for developing countries rose from $3 billion in 1970 to $14 billion in 1978 (106). Several third world countries are now themselves suppliers of arms (110).

118. Between 1945 and 1978, there were 1165 nuclear explosions, mostly to test weapons; 667 of these were after the 1963 Partial Test Ban Treaty prohibited tests in the atmosphere (106). About 595 devices have been exploded in at least five major deserts, 130 of them above ground. With the increase in the nuclear weapons arsenal, there are growing fears of possible accidents during transport or manoeuvres, or of deliberate sabotage. Fears are also increasing regarding the proliferation of nuclear technology associated with power production and the possibilities of diversion of nuclear material for non-peaceful uses.

119. The oceans and space are becoming increasingly militarized. During 1978, 112 military satellites were launched, about one every three days. This brings the total of military or part-military satellites launched since 1957 to 1,601, or about 75 per cent of all the satellites launched (106). They are used mainly to aid navigation, for target identification and surveillance (the latter useful in the verification of arms control agreements) (111). The number of nuclear-powered submarines has also increased to well over 200 (106).

120. These activities absorb vast human and natural resources. One estimate sets the annual world military consumption of oil at twice that of the whole of Africa (111). About 60 million people, equivalent to the entire labour force in manufacturing industries in Europe outside the USSR, are engaged in military or related occupations (111). Moreover, many of these are highly qualified people: one estimate suggests that military research and development absorbs scientific and technological capabilities 10 times as great as are available to all the developing countries together (111). About 400,000 highly qualified scientists work in military research and development; this is some 40 per cent of world scientists involved in research (112). Two fifths of the world research and development expenditure — \$25 billion — is devoted to military research and development (112).

121. The most obvious and horrifying direct effects of war are on people. But past wars have also had direct and indirect effects through the changes they have brought about in the environment, changing agriculture, shifting the margins of deserts and disturbing the balance of ecosystems.

122. Most wars have devastated farmlands. The Second World War caused a short-term reduction of 38 per cent in the agricultural productivity of 10 nations; recovery progressed at about 8.3 per cent per annum. In most recent wars new types of weapons, including high explosive munitions, chemical agents and incendiaries, have been deployed with still greater environmental effects. In South Vietnam chemical herbicides completely destroyed 1,500 square kilometres of mangrove forest and caused some damage to about 15,000 square kilometres more, and natural recovery is proceeding disturbingly slowly (109, 113). More than 100 kg of dioxin was inadvertently disseminated as an impurity in one of these defoliants, and this substance has since been linked to human birth defects and miscarriages and to liver cancer (111). Millions of people in South-East Asia have been displaced from their settlements and cultivated lands, leading to further environmental deterioration including the development of secondary vegetation and collapse of drainage systems. Recovery from these various impacts is likely to take decades. Agricultural pests and vectors of human disease have been spread as another inadvertent consequence of warfare; during the Second World War Italy suffered from the invasion of a moth *(Hyphantria cunea)* whose larvae defoliate valuable trees (113).

123. Even worse environmental disruption is likely if new weapons now being developed and tested come into widespread use. Nuclear arsenals

are increasing and constitute a major threat to mankind. A full-scale nuclear war would destroy all major cities in the northern hemisphere, and kill the bulk of the urban population in the northern hemisphere by blast and fire and the bulk of the rural population by radiation. It would, in addition, kill many millions in the southern hemisphere by radiation from fallout. The long-term consequences, though unpredictable, could affect the global climate, causing a serious reduction in the ozone layer. In addition, there might well be genetic effects from radiation (106). The testing of nuclear weapons has seriously contaminated the atmosphere with radioactive materials and has damaged significant areas of desert. Detonation of weapons in the 10-kiloton range causes complete or severe destruction of vegetation over 400-1,300 hectares (113). Use of these weapons in a full-scale war would destroy vegetation and lead to soil erosion over large areas, as well as inject huge amounts of radioactive dust into the stratosphere. Ecological recovery in such eroded areas would certainly be extremely slow (114, 115, 116). Nuclear explosions in the stratosphere would, at least temporarily, deplete ozone concentrations and increase the amount of ultra-violet radiation reaching the earth's surface, increasing the incidence of several effects, harmful to man and ecosystems (4). The neutron bomb (a low-yield nuclear weapon designed to kill or incapacitate people in armoured vehicles mainly by ionizing radiation rather than blast or heat) would also do appreciable environmental damage. It is estimated that detonation of a one-kiloton bomb 200 metres above the ground will cause death to a wide range of micro-organisms over an area of 40 hectares, to many insects over 100 hectares, to many amphibians and reptiles over 330 hectares, to many species of higher plants over 350 hectares and to many species of exposed mammals and birds over 490 hectares (117).

124. The use of chemical and biological weapons could also have serious environmental consequence, since they involve, in effect, deliberate pollution by the release of toxic chemicals or harmful micro-organisms. Chemical deforestation in tropical areas with fragile soils, or semi-arid areas already delicately poised on the brink of desert, could create rapid erosion and irreversible desertification. Wide-scale use of incendiary chemicals, such as napalm, could have similar results (114, 118, 119). As experience in recent wars in South-East Asia shows, even in areas that are ecologically robust, damage by fire and chemicals to natural vegetation and to crops grown for food and fibre is often long-lasting. If, despite international agreements, chemical, bacteriological or biological weapons are used, the effects of deliberately disseminating quantities of up to a dozen species of highly virulent pathogenic bacteria are less certain (much would depend on whether they attacked livestock or crop species as well as man, and on how long they sustained themselves in the wild), but it is easy to see ways in which the agriculture and ecological balance could be disturbed for a long time (107, 114, 120, 121).

125. There have been speculations about the possibility of causing economic or other damage to the population of an enemy through environmental modifications (114, 122, 123). Methods of weather

modification are being developed for peaceful purposes, and there is concern not only that those using them could cause accidental damage to neighbouring States, but that such techniques could have hostile applications. For example, cloud and rainfall might be deliberately increased in one area in order to create drought and agricultural damage elsewhere. Such operations could be carried out covertly, and would be very hard to detect or counteract. The mere possibility of such actions could poison international relations because of the difficulty in deciding whether a flood, drought or crop failure was due to natural causes or the actions of an enemy.

126. The hazards of war do not end with the coming of peace. Unexploded mines, bombs and shells can hamper mineral exploitation, make land unsafe to farm, hamper development and endanger people who disturb them. Bomb craters, wrecked vehicles or derelict defences and buildings are a blot on the landscape and reduce its value for recreation. Mines in rivers or at sea can be a serious danger to fishermen, hamper their work, and, if washed ashore, also imperil those living on the coast.

127. A UNEP survey of the environmental effects of the remnants of war attracted a response from 44 Governments (124). The volume of munitions left behind in some of their territories by the Second World War is staggering. One Government reported that it had cleared 14,469,600 land mines, and that clearance was continuing at the rate of 300,000 to 400,000 a year. Many thousands of shells, bombs and other munitions had also had to be dealt with in various countries. The country most seriously affected reported that the remnants of war had killed 3,834 people, most of them children, and injured 8,384 others of whom 6,783 were children. For the past five years 30 to 40 people had been killed each year and 50 to 80 injured. Some 460 disposal personnel had been killed, and 655 injured. Other replies also indicated serious losses of life, and a cost of clearance running at tens or hundreds of thousands of dollars a year. Coastal States reported parallel difficulties with marine mines and with dumped ammunition and wrecked ships (some containing explosives).

128. The safe disposal of these remnants demands skills that many developing countries lack, and imposes costs they cannot easily met (124). Records of where mines were laid may have been lost, or be held by the original belligerents and not be readily available. Even unused weapons can pose disposal problems when they become obsolete. The safe storage and ultimate disposal of chemical or biological weapons pose greater difficulties. High-level radioactive wastes need to be stored in isolation for many centuries, and satisfactory ways of doing this are still being sought.

129. Another important aspect of military activity and post-military activity is human migration. The millions of refugees have not only suffered economical and social losses and disruption, but have also exerted pressures on the ecosystems in the areas to which they migrated. In most cases, the living conditions in the new habitat are intolerable in human terms. Since it lacks adequate infrastructures, disease, malnutrition and social disruption

have become common problems. In spite of the different international efforts to alleviate the problems of refugees, they will continue to increase in magnitude with increases in tension and military activity.

130. Despite all these detrimental effects of military activity, it can be argued that substantial advances in aviation, ground transport, electronics, communication and many other fields have been due to "military" research and development.

B. The problem

131. The growing volume and destructive power of the world's weapon stocks poses an obvious risk to man and to his environment. Even the testing of these weapons can cause serious environmental damage, as can accidents in their handling, transport or storage. The use of weapons against the environment—especially to remove sheltering forests or to destroy the crops on which an enemy depends—brings with it the risk of long-term or even irreversible damage to soil, agriculture, and the ecological balance. If environmental manipulation became an effective agent of war, a further dimension for damage would be added.

132. While these direct impacts on man, his settlements, his food and his habitat have in one form or another been familiar features of wars down the centuries, wars have become increasingly disruptive of the environment, and the power of the world's armed forces to devastate large areas is many times greater now than it has ever been. Moreover, the arms race is also having serious environmental consequences because it is competing for the resources with other forms of development which are essential if the quality of life on earth is to be raised to more acceptable levels.

133. The current increase in military expenditure is taking place at a time when 1,500 million people (nearly 40 per cent of the world's population) have no effective medical services, nearly 570 million people are severely undernourished, about 3,000 million lack access to safe water, and nearly 750,000 die each month from water-borne diseases. About 800 million people are illiterate, and nearly 250 million children under the age of 14 do not attend school (110). Yet it is in the developing countries, where these problems are most acute, that military expenditure, including expenditure on arms imports, is growing most rapidly. These countries are choosing, sometimes for compelling reasons of security, to spend less money than they could on economic development in order to buy weapons. Scarce scientific and technical manpower is being diverted from the development of the social and environmental foundation for prosperity to the development of military power. And world military spending is over 20 times as great as the total official development aid given by developed to developing countries. The

third world spends more than four times as much on military expenditures as it receives in official development aid.

134. The effects of the arms race and military expenditure on trade, aid, technological and scientific co-operation and other kinds of exchange between countries are far-reaching. Political and strategic considerations distort the flow of trade and aid. The only politically realistic way for most rich countries to increase their aid to poor ones is to reduce military spending, since money cannot be taken from other parts of national budgets. In the absence of such action, the diversion of resources away from investment that could increase the wiser use of the environment for production and growth can only contribute to inflation and economic crisis and to a widening of the gap between developed and developing countries. On any logical analysis the world cannot afford the arms race — the developing countries least of all. Yet as long as suspicion and uncertainty remain so prevalent in international affairs, this situation is likely to continue.

C. Major actions taken or planned

135. For obvious reasons, international actions in this field tend to aim not at reducing the environmental impact of military activity, but at seeking to reduce the likelihood of such activity taking place. In addition to reducing the risk of war through strict observance of the United Nations Charter, one main line of approach that offers some hope of curbing threats to the environment from the hostile use of military weapons is the negotiation of international agreements concerning the use of certain weapons. Parallel to this approach is the effort since the Second World War to seek agreements that curb the arms race in one way or another. The two approaches overlap. There are international conventions of both kinds, although they are limited in scope and not all States are yet parties to them (113, 118).

136. "Environmental related" agreements include:

a) The 1977 Convention on the Prohibition of Military or any other Hostile Use of Environmental Modification Techniques (118). The prohibited uses are those having "widespread, long-lasting or severe effects," and are understood to include herbicides whose impacts can be so described;

b) The Antarctic Treaty of 1 December 1959, which prohibits military measures of any nature in Antarctica and reserves the area's use for peaceful purposes only;

c) Protocol 1, Additional to the Geneva Convention of 12 August 1949 and Relating to the Protection of Victims of International Armed Conflicts, opened for signature in 1977. Article 35 prohibits "methods or means of warfare which are intended, or may be expected, to cause widespread, long-term and severe damage to the natural environment by way of reprisals";

d) The protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare signed at Geneva on 17 June 1925. This also places some limitations on chemical weapons;

e) The 1972 Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxic Weapons, and on Their Destruction;

f) Resolution 2603A (XXIV) of the Geneva Assembly, which declares it contrary to the generally recognized rules of international law to use in armed conflict any chemical agents which might be employed because of their direct toxic effects on man, animals and plants;

g) Article 23 (a) of the 1907 Hague Regulations respecting the Laws and Customs of War on Land, which forbids the employment of poison or poisoned weapons and is generally interpreted as forbidding, *inter alia,* the poisoning of wells and water supplies (116);

h) The Treaty Banning Nuclear Weapons Tests in the Atmosphere, in Outer Space and Under Water;

i) The Treaty on Prohibition of the Emplacement of Nuclear Weapons and Other Weapons of Mass Destruction on the Sea-Bed and the Ocean Floor and in the Subsoil Thereof;

j) The Treaty between the United States of America and the USSR on the Limitation of Underground Nuclear Weapon Tests;

k) The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space including the Moon and Other Celestial Bodies.

137. The second group, concerned primarily with limiting weapons, includes:

a) The Treaty on the Non-Proliferation of Nuclear Weapons;

b) The Treaty for the Prohibition of Nuclear Weapons in Latin America;

c) The Soviet—United States Agreements on the Limitation of Strategic Arms;

d) Agreements between the United States of America and the USSR and between France and the USSR on the prevention of nuclear war.

138. These treaties and agreements have contributed towards building better international understanding (110), as did the General Assembly's special session on disarmament in 1978. At present the Committee on Disarmament, in Geneva, is giving priority to two issues — stopping all

nuclear tests and banning all chemical weapons — the realization of which would both bring environmental benefits.

C. Concluding remarks

139. There are some obvious contradictions in the attitude of the world community to the whole question of military activity. On the one hand the numerous conventions, treaties and agreements provide clear evidence of a widespread desire to prevent the more devastating forms of warfare. On the other, the evidence of mounting military expenditure around the world implies a lack of conviction in the practicability of disarmament, or even of holding forces and arsenals at constant size. And there are further contradictions between the demands for agricultural, social and economic development so vital to the future of the world, in particular the developing countries, and the increasing allocation of limited resources for military purposes.

140. It can be stated without hesitation that the questions of disarmament, development and environmental protection are closely linked and represent some of the most important issues before the international community today. Development can hardly proceed at the required pace and a healthy environment cannot be guaranteed amidst a widening and constantly escalating arms race. Moreover development and environmental efforts are threatened by the armaments, especially nuclear weapons already stockpiled, the use of which either by intent or in error or sheer madness would severely jeopardize mankind's very existence.

141. One of the most urgent tasks, therefore, is to arrest the technological spiral at the centre of the international arms race and, through substantial and substantive disarmament measures, to pave the way for major reductions in world military expenditures. A major breakthrough in the disarmament field would release vast financial, technological and human resources for more productive uses in both developing and developed countries in an international political climate of much reduced tension. Even if only 20 per cent, for example, of annual military expenditures were to be diverted, for instance to an international fund for sustainable development projects, the developing countries would thus be enabled to attain their socio-economic objectives more effectively.

142. In the environmental field, the immediate needs are first to develop means of predicting the kinds of stress various weapon systems will place upon different ecosystems, and second to improve methods for the restoration of lands devastated by war. More needs to be known about the ecological disruption that could be caused through the hostile use of all weapons, especially "mass destruction" weapons, including the deliberate dispersion of pathogenic micro-organisms, and special attention must be given to the possible military use of weather modification techniques. In addition, the restoration of farmlands and forests, provisions to secure the removal of hazardous relics of past wars, and international action to ensure the safe disposal of radioactive wastes and obsolete explosives and chemical and biological weapons all merit continuing attention and effective action.

VI. THE CHILD AND THE ENVIRONMENT

143. There are two reasons—apart from the fact that 1979 was the Year of the Child — for devoting a special chapter to children and their environment. First, there is good evidence that children are more vulnerable than adults to pollutants and environmental stresses: standards for environmental quality accordingly need to be set with them very much in mind. Second, today's children will form the communities and shape the environment of the next century. If these analyses of the state of the environment show anything, it is that they will have great problems to face.

A. Facts and figures

144. There were 1,439 million children under 15 in the world in 1975, nearly 1,158 million of them in developing countries, in some of which they made up nearly half the population (125). Between now and the end of the century, the number of children in Africa is expected to increase by 72 per cent (median estimates), in Asia by 48 per cent, in South America by 47 per cent, in the United States of America by 10 per cent and in Europe by only 4 per cent. In the most populous and lowest-income countries the number of children will be almost twice as great as it now is, despite the fact that birth rates are expected to fall considerably, in Africa from 45.6 to 38.6 per thousand, in Asia from 43.4 to 31.4, and in South America from 38.8 to 28.1 per thousand (126, 127).

145. There is no doubt that the environment to which a pregnant woman is exposed has a marked effect on the development of the embryo and the foetus. For example, the greatest teratological hazard (risk of birth defects) is generally accepted as occurring in the embryonic period, when tissue differentiation and organogenesis occur. Such hazard has been attributed to exposure to certain chemicals and/or drugs. Thalidomide, for example, given in early pregnancy caused abnormalities of the foetus. In a study of 46 mothers delivered of deformed babies, it was established with certainty that 41 had taken thalidomide in early pregnancy (128). Furthermore, malnutrition, environmental stress, air pollutants, unhealthy habitat, etc., all have a certain impact on the foetus, and are factors controlling the "degree" of health of the born babies.

146. In 1977 about 125 million children were born. Between 12 and 13 million are estimated to have died before their first birthday from diseases and malnutrition. Most of these early deaths were in developing countries (129). In Africa in 1975 first-year mortality was set at 147 per thousand; in Asia, 105; in Latin America, 85; in Europe, 20; and in North America, 15(125). Another 4 to 5 million of these children born in 1977 will die before they are five. There is a clear relationship between poverty and infant mortality. In industrialized countries there are 15 deaths per 1,000 live births, while in developing

countries the figure ranges from 25 deaths per 1,000 in high-income through 35 in upper-middle-income and 48 in intermediate-middle-income to 129 in low-middle-income countries (126). Mortality is particularly high in Africa and Asia, where poverty is concentrated (127). However, life expectancy at birth is increasing. In 1960 a child in a typical low-income country would have been expected to live only 36 years, but in 1975 its life expectancy was 43 years (127).

147. Like all people, children have basic needs: clean water, enough wholesome food, sufficient clothing and shelter, sanitation, health care, play and education. They are more vulnerable than adults, partly because they more rapidly absorb and are harmed by certain toxic substances, and partly because of their lack of experience, knowledge and strength. They therefore need to be shielded from things in their environment that may harm them, and to be provided with proper nourishment, surroundings and experience so that they develop their full potential of body and mind.

148. In 1975 some 350 million children lacked even the basic necessities of life (130). About 590 million had no access to safe water supplies (125). WHO has estimated (125) that up to 80 per cent of disease cases are traceable to impure water and poor sanitation. Polluted water carries cholera, typhoid and contagious hepatitis, and may contain guinea worms, snails and other animals that cause urinary, rectal and various other infections. Scabies, yaws, leprosy, typhus and trachoma are prevalent where there is a lack of water, inadequate waste disposal and poor personal hygiene. Lack of sanitation is a particular hazard to children in the slums and shanty towns of the developing world. Pools, swamps and damp woodlands near to settlements are a breeding ground for mosquitoes and other insects that carry yellow fever, malaria, sleeping sickness, and other diseases.

149. About 200 million out of 230 million undernourished children live in developing countries (131). Severe vitamin A deficiency leads to over 100,000 children going blind each year (131). Nutritional anaemia afflicts children in most parts of the developing world. Malnutrition in a child's first year retards physical and mental development irreversibly (132, 133, 134, 135). FAO's Fourth World Food Survey in 1977 indicates that world food production is barely keeping pace with population growth (136). The nutritional prospects for those who will be children in the year 2000 look bleak.

150. In developing countries it is the exception rather than the rule for children to have access to a nurse or midwife, and qualified physicians are rarer still. In Asia 70 per cent of babies are born without any trained medical help. In the world as a whole, 10 to 15 per cent of about 125 million births a year are to mothers under 20 years old. Babies born to adolescent girls are much more vulnerable than the children of women in their twenties. The risks are at their greatest in rural areas of developing countries, where less than 15

per cent of people live within walking distance of any kind of health facility. In the developing countries diphtheria, whooping cough, infantile paralysis, measles, tetanus, and tuberculosis together kill about 5 million children every year. In developed countries these are largely prevented by immunization, and most child deaths are due to accidents or birth defects (125)

151. The massive migration of people from rural areas to the cities, and from country to country, inevitably disturbs the stability of children's lives, especially if families are broken up in the process (137). Current estimates suggest that as a result of both birth and migration, the number of poor people clustered in slums and shanty towns is increasing annually by 10 to 15 per cent (125, 130, 131). Conditions in these places are appalling. The overcrowded shelters are commonly tarpaper shacks or huts made of empty tins, discarded gunny bags or muddy straw (138). There is no provision for sanitation, water supply or garbage removal. The inhabitants often live under threat of forced eviction. The result is tension, depression, and violence superimposed on physical hardship and a constant threat of disease. Broken families and neglected, or even battered, children are common.

152. Even in wealthier communities, the special needs of children have sometimes been forgotten amid the proliferation of public health and sanitary codes, building codes, safety regulations and planning laws. High-rise apartment blocks which meet all these rules often still provide a bad environment for the development of children. There is a real need for studies that will ensure that houses in future provide a mini-environment which enhances child development (133). Good urban design is certain to be even more important in future as populations increase, land becomes scarcer and more precious, transport systems expand and industrial development extends. These new settlements must provide areas where children (who spend 80-100 per cent of their time within the immediate community) can find shelter, recreation, education and later work, and have access to a range of opportunities, and this demands careful linkage of such small-scale areas to the rest of the human settlement system (139).

153. Many chemical pollutants can cause a hazard to children, especially in urban and industrial areas. Air pollution by smoke, sulphur oxides, nitrogen oxides, ozone and lead, contamination of air, food and water by metals and toxins (including those formed by the growth of fungus on badly stored food) and the passage of chlorinated hydrocarbons along the food chain have all given rise to concern. Although information about the contamination of human milk is incomplete, mothers exposed to high levels of these pollutants can act as an intermediary for the transfer of traces of the pollutants to their infants. There is also evidence of undesirably high levels of lead in the blood of children in the United States of America: out of 126,347 screened in April-June 1979, 7,449 required treatment to reduce lead burdens (140).

154. A child's capacity to learn develops most rapidly in the early years of life. Educational prospects, especially in developing countries, remain far from bright. In Africa and Asia, educational developments progressed more slowly in the 1970s than in the 1960s. In a typical poor country, only 58 per cent of children go to primary school and only 9 per cent to secondary school. At least 100 million children aged between 7 and 10 in developing countries are not learning to read, write or handle simple numbers (131). In contrast, almost all children in industrialized countries go to primary school and 79 per cent receive secondary education. Poverty in many developing countries forces the parents not to educate their children and to employ them at an early age as an additional source of income to the family. This is particularly true in rural areas, where children are employed in seasonal farming, gathering of crops or other related activities. In urban centres children go around selling goods and handicrafts, or work in small shops and factories. In Africa 27 per thousand of the population start work when young, compared with 14 in Asia, 6 in South America and 1 in Europe and the United States of America. In a typical low-income country in 1975, 32 children per thousand population were members of the labour force (126, 127). The effect can be to stunt development and cause work to be seen as something to be avoided (141).

155. Public awareness about the importance of education is, therefore, an important prerequisite for improving the quality of life of children. Parents, in the first place, should be aware of this. In addition, adequate kindergartens and primary and technical school systems should be developed and strengthened. In developing countries the shortage of teachers is a major problem, although numbers have been rising more rapidly than in the developed world.

156. Play is important in preparing children for adult life. Games mimic situations encountered later in life, and provide a diversity of experiences hard to get in any other way (142). However, while it is generally assumed that a child's development is handicapped if its experience — including that of play — is limited, there have been no surveys that establish just what effect this has on the adult personality. It is, however, generally recognized that provision for safe and varied play must be made when human settlements are designed (143). Streets appeal to children as playgrounds because they are close to home and familiar territory; if traffic makes them unsafe, open spaces at distance may be a less-satisfactory substitute (144).

B. The problem

157. Millions of children live in poor urban areas of developing countries. Children make up half the population of many slums and shanty towns. Slum populations are increasing three or four times faster than those of the more modern parts of cities — often at a rate of 10 or 15 per cent yearly. Over 810 million children are growing up in remote rural areas where infant mortality, malnutrition, disease and illiteracy rates are very high and there are few basic services (125, 130, 131).

158. The need for development spans the whole range from water supplies, sanitation, better food and better basic shelter to improvements in the design of settlements, better health services, control of environmental pollution, disease eradication, education and the prospect of employment. The scale of the problem is daunting.

159. This is not an area in which action is hampered by scientific uncertainty. Effective methods of providing clean water, dealing with human wastes and refuse, designing low-cost housing, inoculating children against disease, and providing basic education are familiar to every Government. The problem is one of resources. International action can help to increase the information available, and through aid, to increase the available resources. But the problems can only be solved by vigorous action at local level, area by area, pressed on by the wholehearted commitment of Governments.

C. Major actions taken or planned

160. It is inevitable that the actions so far taken at the international level have included much exhortation and advice. Fortunately, these have been backed by a good deal of more practical aid. At the international level the main actions have been:

a) In 1959 the General Assembly adopted a Declaration of the Rights of the Child. Recognizing that "mankind owes the child the best it has to give", this Declaration affirmed a list of social and environmental goals which, if achieved, would provide for all children the opportunity for healthy development;

b) General Assembly resolution 31/169 of 21 December 1976 declared 1979 the International Year of the Child (IYC), and urged the world community to reaffirm its concern of the present situation and for the future of its children;

c) The IYC secretariat has visited 65 developing and industrialized countries in order to promote IYC and United Nations Children's Fund (UNICEF) projects. Visits were made by the United Nations special representative for IYC to nearly half of these at the highest Government levels — 166 countries and territories established National Commissions for IYC;

d) At the United Nations Conference on Human Settlements (Habitat), Governments resolved to provide clean water for all the world's people as soon as possible and by 1990 at the latest (145). A Drinking Water Supply and Sanitation Decade has been declared for 1981-1990;

e) Among the United Nations agencies, WHO is taking the lead in matters concerned with health and nutrition and has prepared plans, with the support of UNDP and the World Bank, to achieve the goal of clean water. WHO has achieved a notable success in the eradication of smallpox, which formerly killed large numbers of children and adults. The United Nations Educational Scientific and Cultural Organization (UNESCO) is active in promoting education; FAO, nutrition; ILO, child labour; the World Food Programme (WFP), supplementary feeding; the United Nations Fund for Population Activities (UNFPA), responsible parenthood; the office of the United Nations High Commissioner for Refugees (UNHCR), the needs of refugee children; (UNFDAC), the problems of drug abuse and traffic among the young (146);

f) UNICEF serves as the lead agency in developing a co-ordinated interdisciplinary approach to all questions affecting the welfare of children. In 1975 UNICEF helped 83 countries to improve water and sanitation. It provided advice and material support to developing countries on a wide range of other programmes (147). The UNICEF Executive Board will be examining the priorities for following up IYC in 1980 and 1981, and at the 1980 session will especially examine how to improve the exchange of technical information and cater for the needs of the most disadvantaged groups of children (146).

g) Outside the United Nations system, the Organization of African Unity has prepared a report on the situation of the child in Africa. The Organization of American States passed a resolution supporting IYC in 1977. The Council of Europe, EEC, and OECD have made special studies of such matters as the plight of children of migrant workers, pre-school education, the abused child, day care, legislation for children, economics in relation to children, and the child and the family. An intergovernmental forum on the rights of the child has been held in Budapest. The Intergovernmental Committee for European Migration has held a seminar on the problems of adoption of migrant and refugee children. The Inter-Parliamentary Union has adopted a resolution urging that the impetus of IYC be sustained. A Non-Governmental Organization Committee on IYC has co-ordinated the participation in the Year of some 230 non-governmental organizations, at international, regional, national and local levels (146).

161. These international activities have been backed by many national demonstrations of how to help local communities to improve their own food, water, sanitation, housing, health care and education (146, 147). For example, in the Philippines and Indonesia pilot projects for slum improvement are going on in the city of Manila and in selected shanty towns of Bandung and Surabaya. Other projects are under way in India, the Caribbean and South America.

D. Concluding remarks

162. Given wholehearted national endeavours and international co-operation over the next 20 years, it should be possible by the year 2000 to:

a) Halve infant mortality;

b) Raise life expectancy in the developing countries from 56 to at least 65;

c) Ensure that all children are immunized against the common childhood diseases;

d) Ensure that all children have access to a safe and convenient water supply and adequate sanitation;

e) Ensure that all children have an opportunity for education and increased chances of employment;

f) Ensure that fertility is regulated at a reasonable level.

163. The International Year of the Child, building on the continuing effects of UNICEF, WHO, UNDP and the World Bank, has set in motion plans and programmes which, if they are made to succeed, will remedy the worst of the situations in which children now find themselves. The knowledge to achieve these goals is available, provided that it is matched by the will.

164. As the more immediate problems are solved longer-term objectives must include general improvements in the planning of settlements and the management of the environment. Children themselves should be educated to think about their environment and to seek to safeguard it through such things as good farming practice, responsible disposal of wastes, energy conservation, and a care for natural beauty and wildlife.

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