THE STATE OF THE ENVIRONMENT:

SELECTED TOPICS – 1977

UNITED NATIONS
ENVIRONMENT PROGRAMME

Contents

The text of this publication was presented to Governments at the fifth session of the Governing Council of the United Nations Environment Programme held in Nairobi in May 1977 and is published for the United Nations by:

PERGAMON PRESS

Oxford • New York • Toronto • Sydney
Paris • Frankfurt

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Foreword

This is the first of the annual state of the environment reports which, instead of covering a broad range of environmental issues, focuses on a limited number of environmental problems of international importance – in this instance, the ozone layer, environmental cancers, land loss and soil degradation, and firewood. The Executive Director of the United Nations Environment Programme intends to prepare a report of this kind each year, with an analytical and comprehensive report every five years.

The present report is based upon the viewpoints expressed in discussions with various members of the scientific communities on the above selected environmental problems. It was presented to Governments at the fifth session of the Governing Council of the United Nations Environment Programme, held in Nairobi in May 1977, 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 Governing Council decided at its fourth session that in future the annual state of the environment report should be selective in its treatment and that an analytical, comprehensive report on developments regarding each of these issues should be prepared every fifth year.* While the annual state of the environment report has in previous years (1974, 1975 and 1976) covered a broad spectrum of environmental issues, the report this year focuses instead on four specific subjects: the ozone layer, environmental carcinogens, soil loss and firewood. Out of hundreds of potential topics, why have these few been selected?

2. Man does not deliberately damage his own environment, any more than a rational person would purposely destroy his own house. But when man takes action to satisfy his needs – when he grows food, rears cattle, builds roads, establishes industries – his activities often involve side-effects which are environmentally harmful. Sometimes these environmental side-effects may make it difficult or even impossible for man to sustain his original activities.

3. Essentially, environmental management is a twofold operation. First, man must seek to identify where environmental degradation and resource depletion are making it difficult to meet the basic human needs of food, shelter, health, clothing, education and work. Second, he must work towards the modification of human activities so as to eliminate any undesirable side-effects and satisfy these basic needs on a sustainable basis.

4. The confrontation between the rising aspirations of a growing world population and the physical and ecological constraints of the biosphere has brought mankind face to face with the *outer limits* of what the planet can sustainably provide. The imperative need to satisfy basic human needs reflects *inner limits* which are no less inflexible. Rising aspirations, outer and inner limits are the main components of the environmental issues, of which the international community, national Governments and the world population at large have become increasingly aware since the United Nations Conference on the Human Environment in Stockholm in June 1972.

5. The tenth anniversary of Stockholm, 1982, will be for the United Nations Environment Programme a year of audit. UNEP will publish a major study analysing the changes that have taken place in the human environment over the decade, and evaluate the first ten years in which mankind has consciously and co-operatively attempted the rational management of a small planet. A similar exercise will be repeated every five years, forming a set of quinquennial state of the environment reports which will complement and consolidate the series of essays on single topics contained in this and subsequent annual state of the environment reports.

6. In response to decisions of the General Assembly* and of the Governing Council,† the subjects chosen for treatment in the annual reports will generally attempt to satisfy the following criteria, which are listed in order of priority:

First, the topics should be of *international importance,* either because they have global or regional significance, or because, while primarily national, they represent problems which are widely shared;

Second, the topics should be *emerging,* in that they have been attracting great public or governmental attention, or because new scientific knowledge or hypotheses have recently been developed, or because there has been (or may soon be) a change in the situation;

Third, the topics should be *urgent,* in that the consequences of the problem could be serious or occur in the near future;

Fourth, the topics should be ones which have received *insufficient attention* from Governments and the United Nations system;

Fifth, the topics will often represent problems which

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* Governing Council decision 47 (IV), Section 1, para. 10.

* Resolution 2997 (XXVII) of 15 December 1972 called on UNEP "to 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".

† Governing Council decision 20 (III) of 2 May 1975 considered that the report "seeks to identify emerging problems requiring the attention of Governments". The suggestion of the Executive Director for a "brief factual annual report highlighting only those issues of international significance which have emerged or changed significantly in the previous year" was endorsed at the Governing Council's fourth session (document A/31/25, para. 41).

UNEP has itself contributed towards resolving, or on which it intends to work.

7. The present report is the first annual state of the environment report prepared in line with Governing Council decision 47 (IV). The first topic presented in it deals with the *ozone layer,* which lies in the high stratosphere 10–50 km above the surface of the earth and forms a vital protective barrier against harmful ultraviolet radiation from the sun. Certain human activities (such as supersonic air transport, use of some aerosol propellants, production and use of nitrogenous fertilizers and atmospheric nuclear explosions) which are designed to meet perceived human needs (such as rapid travel, household insecticide spraying, agriculture and defence) may adversely affect this ozone layer, and could therefore inhibit the satisfaction of other human requirements (such as the health of man, of his livestock and crops, or of the seas and oceans).

8. A likely effect of damage to the ozone layer would be an increase in skin cancer in man. This is only one of many forms of cancer, a disease which in many developed countries is today responsible for 17.2 per cent of all deaths [1]. Well over half of all cancers are now thought to be of environmental origin, initiated by chemical compounds released by modern technologies or lifestyles. The second topic, *environmental cancers,* is therefore another example of the satisfaction of one perceived need at the expense of degrading the environment and damaging human health. This is only one example of a large class of environmental diseases.

9. The third topic of this year's report, *land loss and soil degradation,* deals with an even more fundamental threat to human well-being: damage to the agricultural base of food production. Present agricultural practices (such as the cultivation of steep slopes, slash-and-burn and deforestation) may damage the soil cover irreparably, and activities designed to meet other human needs (such as the construction of housing, roads and airports) may remove valuable land from agricultural production.

10. The fourth topic, *firewood,* illustrates how the extensive and indiscriminate use of trees for firewood is resulting in a rapid and alarming depletion of a key renewable ulting in a rapid and alarming depletion of a key renewable resource, as well as bringing in its train erosion and soil damage.

11. These four essays do not pretend to be exhaustive. They are, rather, designed to illustrate that as always in environmental management, certain critical choices must be made: among various needs, among various ways of meeting them, among specific practices, and among the unlooked-for effects which may result from them.

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1. *Sixth Annual Report of the Council of Environmental Quality,* Washington, DC: United States Government Printing Office (December 1975).

II. Chemicals and environment: possible biological effects of ozone reduction in the atmosphere

12. Ozone – a form of oxygen – is of vital importance to man, although it makes up less than one millionth part of the earth's atmosphere. The largest concentrations of ozone occur in the stratosphere, the region of the atmosphere in the altitude range from about 10–50 km at high latitudes and 18–50 km at low latitudes. The dominant energy source for the stratosphere is the absorption of ultraviolet radiation by ozone, and it is this absorption process which explains the average temperature rise from about 50°C below zero to 3°C below zero between the lower boundary (tropopause) and the upper boundary of the stratosphere (stratopause). An increase of temperature with altitude (a so-called temperature inversion) reduces the vertical mixing of air in the atmosphere considerably [1]. This is the main reason why injected materials can remain a long time in the stratosphere.

13. Even at its highest concentration, around 30 km high [2], ozone is present at not more than one part per hundred thousand. Nevertheless, this small amount of ozone is of crucial importance for life on earth, since it protects organisms at ground level from the harmful ultraviolet component in sunlight. (It should be noted that ozone is also produced in photochemical smog [3] at a relatively low level (around 1 km) in the troposphere. Added to the small concentrations of ozone which diffuse down from the ozone layer, smog-produced ozone can adversely affect human health and plant growth. This is a separate, but related, environmental problem).

14. Without sunlight, life on earth would not exist. Yet too much sunlight can be injurious to living organisms. The spectrum of solar radiation is divided into three different parts: *visible light* (from 380 to 770 nm in wavelength: a nanometre (nm) is one billionth of a metre), longer wavelengths are known as the infrared and shorter wavelengths as the ultraviolet (UV). In the UV part of the spectrum there is not much total energy, but the individual photons are much more energetic than those at longer wavelengths.

15. Ecologically, the most important part of the UV spectrum is the UV-B region [4], from 280 to 320 nm, which causes sunburn in man, and has other marked biological effects. The stratospheric ozone layer to a great extent protects life on earth from the damaging effects of UV-B; indeed, without this protective shield, the present forms of terrestrial life could not have developed. The ozone filters out UV radiation, beginning at 320 nm, becoming increasingly effective at shorter wavelengths, and completely preventing radiation below about 290 nm from reaching the ground [5]. Other mechanisms besides that of the ozone layer are involved in absorbing UV radiation in the stratosphere, which complicates analysis of the precise amount of harmful UV-B to reach ground level. The net result of these factors, however, is that, averaged over the year, more than 70% of the total UV-B to reach the planetary surface falls on the equatorial regions between latitudes 30°N and 30°S [6].

16. Under natural conditions the main ozone-destroying catalysts are found in the atmospheric hydrogen system (hydroxyl radical – OH) and in the atmospheric nitrogen system (nitric oxide – NO). The effect of these naturally occurring catalysts on the ozone layer is to maintain the stratospheric ozone budget at its current relatively steady global level. However, in spite of the natural protection against pollution which the troposphere and the tropopause

afford it, there are a number of human activities which affect the ozone balance by adding substantial amounts of ozone-destroying catalysts to the stratosphere.

17. First, there is the production of compounds, such as the chlorofluoromethanes used as aerosol propellants and refrigerants, and a number of other synthetic chemicals such as carbon tetrachloride and methyl chloroform. These substances are chemically inert in the lower atmosphere, but in the stratosphere they are converted by UV radiation to form the ozone-destroying catalyst, free chlorine. These chemicals are already thought to have reduced the ozone layer by 1%, and if releases continue at 1973 rates, they could cause as much as a 3% reduction in ozone by the year 2000, and up to a 10% reduction by 2050. Significant damage to the ozone layer would be expected to continue for 50–200 years after man stops the release of these synthetic compounds [7].

18. Second, there is the production of ozone-destroying catalysts within the stratosphere when aircraft, civil and military, flying above the tropopause release nitrogen oxides in their exhaust gases. In 1970–1971 it was thought possible that several hundred civil supersonic transport aircraft would eventually fly in the stratosphere, and that these would be sufficient to reduce the average global ozone cover by 10% or more. The effective abandonment of civil supersonic projects has removed this immediate threat; there is little information on the frequency of stratospheric flights by military aircraft. The use of chlorine-containing gases in the planned United States space shuttle may also lead to a small (0.1%) decrease in ozone [8]. A recent report by WMO [9], prepared in collaboration with UNEP and ICSU, concluded that "currently planned supersonic transport aircraft due to their lower flight altitudes of 17 km and their limited number (30–50 projected) are not predicted to have an effect that would be significant or that could be distinguished from natural variations" but that "a large fleet of supersonic aircraft flying at greater altitudes is predicted to have a noticeable effect on the ozone layer".

19. Third, there are the risks related to nuclear explosions in the atmosphere. Such action would result in "punching a hole" in the tropopause, propelling nitrogen oxides (NO and NO_2) and ozone-attacking chlorine into the stratosphere. One of the environmental consequences of a global nuclear war has been predicted to be a reduction of the ozone layer by 20–70% for 5–10 years [10].

20. Fourth, there is the possible production of nitrogen oxides due to the production and use of nitrogen fertilizers on a sustained and intensive scale for raising agricultural production. To raise yields, nitrate fertilizer is often added to the soil, or leguminous and other plants are grown which "fix" nitrogen from the atmosphere. Eventually, soil nitrate is converted back to nitrogen or nitrous oxide(N_2O) by the bacteria in soils and water. Some projections suggest that the nitrous oxide produced as a result of agriculture could at least double within the next 50 years. If an appreciable fraction of this entered the stratosphere, the ozone layer could eventually be depleted by as much as 15% [11]. However, there are many uncertainties: other calculations lead to lower estimates [1]. Also the burning of fuels (oil, gas, coal, wood and dung) adds substantial amounts of nitrogen compounds to the atmosphere. These enter into the nitrogen cycle and parts will eventually reach the stratosphere as N_2O and cause ozone destruction. It is therefore important to monitor the concentrations of atmospheric N_2O and to learn more about its production and destruction mechanisms.

21. The weight of scientific evidence at present suggests that large-scale civil or military flying in the stratosphere, increased use of inorganic nitrogenous fertilizers and the continued release of chlorofluoromethanes into the lower atmosphere may perturb stratospheric ozone levels sufficiently to require world-wide controls, and that a global nuclear war could in this respect alone have disastrous consequences. Moreover, it should be realized that none of these effects should be judged separately from the others, as the damage done to the ozone layer by each of the various mechanisms is probably additive. Until 1970, the study of ozone and atmospheric chemistry was a severely neglected field of science, and integrated, interdisciplinary research is urgently needed. With this in view, UNEP together with the Government of United States of America, convened a special conference on ozone in Washington in March 1977.

22. If the ozone layer were to be permanently weakened in one of the above ways, and an increase of UV radiation did reach the earth's surface, the most serious long-term consequence might be undesirable global perturbations in the earth's climate. However, this report is primarily concerned with the effects on living organisms.

23. UV-B can kill micro-organisms outright, and in plants and animals it can destroy individual cells. The molecular structures of proteins and nucleic acids, which are the building blocks of plant and animal tissue and together make up the greater part of its dry weight, are damaged by UV radiation so that they can no longer properly perform their biological functions. Proteins are most sensitive to UV radiation at 280 nm, and nucleic acids at 260 nm, but in each case radiation around these peak wavelengths produces similar, though lesser, damage [12]. It will be recalled that at present the ozone layer completely prevents UV less than 290 nm in wavelength from reaching the ground, so that the continued functioning of this stratospheric protection is clearly vital to all life on earth.

24. Over a long period of time, organisms have evolved mechanisms to withstand the amounts of UV reaching the surface of the planet under normal conditions – that is, under the protection of the ozone layer. They use four principal means: protective covering and pigmentation, which screens out the UV radiation; behavioural adaptation to avoid the sunlight; photoreactivation or photo-protective mechanisms; and dark repair mechanisms. In these ways, nature may have adjusted to a fairly high degree of short-term variability in UV exposure (there are 10–20% fluctuations in ground-level UV from one year to another), but any significant and sustained increase of UV could be expected to disturb the existing balance of life [4].

25. When plants are subjected to increased UV-B radiation in the laboratory, some crop species such as peanut, wheat, milo, and fescue prove fairly resistant, while others such as lettuce, pea, tomato, cotton, and radish are sensitive. In general, seedlings are much more sensitive than vegetative structures like leaves [13]. Where the amount of UV-B radiation is increased to simulate the effects of a 35–50% ozone reduction in the stratosphere, minor changes in leaf anatomy, disruption of photosynthesis, and decreases in

growth rates are observed in about half of the wild and crop species studied. The long-term biological implications, especially genetic changes, may be far-reaching [14].

26. Preliminary investigations with phytoplankton, the microscopic floating plants which are the basis of the food chain in marine ecosystems, show that UV-B radiation reduces photosynthesis. Experiments off the coast of Africa suggest that under increased UV-B radiation photosynthesis of plankton may be inhibited by as much as 60%. UV radiation can penetrate through water. For example 75% of the UV radiation at 318.5 nm was transmitted to a depth of 1m in natural waters off the coast of Corsica, and 43% at 321 nm off the coast of Brittany. Additional studies are required to determine the exact magnitude of UV effects on marine ecosystems [15].

27. Increased levels of solar UV-B radiation may also modify freshwater ecosystems by destroying micro-organisms, thus reducing the efficiency of natural water purification. The impact of this modification on man depends on the body of water under study, and the quality of water considered tolerable for human consumption [16].

28. The effects of increased UV-B on animals other than man have received little attention, as it has generally been assumed that the radiation is absorbed by hair, feathers, scales, shells, and normal skin pigments. Presumably these factors will continue to provide some degree of protection, but some animals may already be at their UV-B tolerance limit, and further increases may produce harmful effects in animals that at present show no damage [17]. Unlike humans, most animals will not expose themselves to full sunlight unless they have a way of preventing excessive amounts of light from reaching sensitive tissues. Most marine species hide during the day, in crevices in rocks, burrows, or in deep water, coming out by night to browse on seaweed. Most terrestrial wild animals are nocturnal in habit, or keep in the shade of a forest during the day [18].

29. In man, solar UV-B can cause sunburn, ageing and weathering of the skin and various forms of skin cancer. The skin's peak sensitivity for tanning and sunburn occurs around the wavelength of 297 nm. The wavelength most responsible for suntan, however, when the sun is at an elevation of 60°, is 307.5 nm. This peak effectiveness would be shifted downward in wavelength by about 5 nm – much nearer the wavelength to which man is most sensitive – and the total impact more than doubled if the amount of ozone in the stratosphere were to be reduced by one half. For smaller changes, the likelihood of sunburn in man increases by about 2% for each 1% decrease in stratospheric ozone [19].

30. UV-B is also known to damage DNA – the genetic material of cells – and thus cause mutations. It is a reasonable hypothesis that skin cancer also involves the absorption of UV radiation by DNA; essentially the same radiation spectrum responsible for sunburn is responsible for skin cancer as well. Fatal forms of skin cancer are not confined to those areas of the body that are habitually exposed to direct sunlight. Skin cancer is more common in outdoor workers, and it is less common for heavily pigmented than for light skinned populations. The incidence of skin cancer among white-skinned Caucasians, particularly of the malignant melanoma (a dark-coloured molo-like growth), rises with decreasing latitude and exposure to sun. In Queensland, Australia (10–30°S), the incidence of melanoma is three times and in Texas, United States (30°N) twice that of Central Europe (50°N) [20], and in southern Norway (58°N) there are almost three times more melanomas than in northern Norway (70°N). Exposure to the sun, of course, is a question not only of latitude but also of climate, habit and clothing. Over a 20-year period (1955–1974), the incidence of malignant melanoma in Norway has more than tripled for both sexes. Estimated outdoor exposure is far higher in melanoma patients, compared to a control group without skin cancer in New York [21].

31. Nuclear weapons, aerosol sprays, supersonic transport, enhancement of food production to feed the people of the world are all examples of technological advances, but they would not normally be considered in the same context. It now appears, however, that they do have something else in common: they are all potential sources of catalytic agents that penetrate the earth's stratosphere and decompose the ozone that shields living things from the worst of the sun's UV radiation. The full extent of the environmental hazard associated with this phenomenon is still uncertain, despite several years of investigation. But it is increasingly clear that a wide range of human activities have the capability of disrupting the delicate photochemical balance on which the earth's ozone buffer, and perhaps life itself, depends.

32. Pending the outcome of the Washington Conference, it would be premature to recommend specific regulations to abate the threat to the ozone layer: the complexities of atmospheric physics and chemistry together with the intertwined interactions between air, water, soil, plants, animals and man make it exceedingly difficult today to express in quantitative terms the consequences of the human activities discussed above. But such uncertainties call for immediate interdisciplinary research in this important area of atmospheric–biospheric science.

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III. Environmental disease: cancer

33. The relationship between cancer and the environment has been known since 1775, when Pott observed a correlation between scrotal skin cancer and heavy exposure to soot among chimney sweepers [1]. Since then, many environmental pollutants have been shown to produce cancer in various parts of the body: aromatic amines cause bladder cancer, "blue" asbestos (crocidolite) causes mesothelioma of the lining of the lung and abdomen; uranium causes cancer of the lung. In recent years, a growing body of evidence from all over the world indicates that cancer, after heart disease the leading killer in industrialized societies, is overwhelmingly due to environmental factors. In 1958, it was suggested that 70–80% of cancers were directly or indirectly related to the environment. Although the concept was challenged at the time, it is generally agreed today that 60–90% of all cancer is in one way or another related to environmental factors, although it is clear that other factors are also involved.

34. All cancers are characterized by the unrestrained growth of cells. Cells naturally grow and multiply, but in a healthy body this growth is controlled by a complex series of mechanisms. Cancers occur when the control breaks down. In connective tissues (such as bone, cartilage, tendon, muscle) cancers are called sarcomas; in epithelial tissues (such as skin, bladder, lung, breast) they are called carcinomas; and in cells of the blood system they are named leukaemias. In most cases of cancer, unrestrained growth leads to the formation of tumours which spread into and often kill normal tissue. When not attended to, such a tumour (which is known as malignant) ordinarily leads to death, but there can be a long delay between its onset and the appearance of obvious symptoms.

35. Although cancer is widespread throughout the animal and plant kingdoms, it is best known and most important in human beings. The mortality due to cancer differs greatly in different places. In countries located in the tropical belt where communicable diseases are still rampant, the percentage of deaths due to cancer is much lower than in industrialized countries with temperate climates, where life expectancies extend to approximately 70 years. For example, in 1972 only 3.5% of all deaths in the Philippines were due to cancer, while in Canada in the same year the figure was 20% [2]. For specific forms of cancer, the international variation is even more striking. Thus (for people of the same age-groups) cancer of the liver is almost a hundred times more frequent in Bulawayo, Rhodesia, than in Bombay, India, while citizens of Bombay have 50 times more mouth and pharynx cancers than people in rural Norway. Ibadan, Nigeria, has 12 times less stomach cancers than Miyagi, Japan and over 40 times less cancer of the rectum than Saskatchewan, Canada [3].

36. Cancer can be caused by a wide variety of factors, often acting in combination with one another, over periods of many years. It appears that certain cancers, for example Burkitt's lymphoma, nasopharyngeal carcinoma and perhaps cancer of the uterine cervix, are associated with herpesvirus infection. Other forms of cancer are casued by hereditary factors – for example, the rare tumour of the eye in children, retinoblastoma. But the overwhelming number of causative factors which have been isolated are in one way or another environmental: they relate to the air people breathe or the water they drink, to the environment in which they work or live, to their personal diet or way of life, to habits like smoking tobacco or drinking alcohol. In industrialized societies such environmental agents have been proved to be responsible for 30–40% of human cancers, and much research into the causes of cancer is now based on the hypothesis that all cancers are environmetally caused until the contrary is proved [4, 5].

37. The significance of environmental factors in carcinogenesis has been defined mainly through epidemiological studies, i.e. studies of the origin, nature, pathology and prevention of diseases temporarily prevalent in a community or throughout a large area. A large number of environmental carcinogens have thus been recognized, as shown in Table 1 [6]. The epidemiological approach has been very useful, too, in assessing the effects of a combination of environmental stimuli, e.g. cigarette smoking and living in areas polluted by industrial fumes.

38. Our most comprehensive understanding of environmental cancer is for the relationship between cigarette smoking and lung cancer. From our study of occupational exposure, we have learned a great deal about the nature of chemical carcinogenesis. This is partly because carcinogens are likely to be at their highest concentrations in factories, but has more to do with the existence of records of employment which have sometimes survived the long latent period – up to 40 years or more in some cases – between exposure to the carcinogen and appearance of the cancer. The causation of many occupational cancers is now known: lung cancer among asbestos insulation workers, respiratory cancer in workers exposed to arsenic in smelters and vineyards, liver cancer among workers with vinyl chloride,

Table 1. Summary of high-risk groups indicating nature of exposure, potential risk, and organs involved (shortened after [6])

Chemical	Exposure patterns*	Relative risk	Site of neoplasm
Aflatoxin	General population (high in Africa): 0.12–0.35 μg/kg in food + 0.05–0.17 μg/l. in beer in Kenya	Low	Liver
Arsenic	Ind. – Vineyards, miners, copper smelters (8047) Med. – Fowlers solution Env. – Water (total number of persons exposed unknown)	High	Respiratory tract
Asbestos	Ind. – Miners, insulation and brake-lining workers (total number of persons exposed unknown)	Very high	Lung and Pleura
Auramine	Ind. – Exposure during manufacture (total number of workers exposed unknown)	High	Bladder
Benzene	Ind. – Shoemaking, solvents (total number of workers exposed unknown, but in the thousands)	Moderate	Leukaemia
Diethylstilbestrol (DES)	Med. – in one study 49 of 66 cases developing vaginal cancers had been exposed to DES in utero	Unknown	Vagina
Hematite	Ind. – Mining of hematite, underground workers (more than 5000 studied)	2–10 times increase in miners compared with non-miners or surface workers	Lung
2-Naphthylamine	Ind. – Manufacture and use as antioxidant in rubber (total number of exposed workers unknown)	Very high	Bladder
Nickel	Ind. – Refining, mainly in workers exposed prior to 1925	5–10 100–900 times expected figures	Lung Nasal cavity
Soot and tars	Ind. – Mainly to tars (thousands of workers exposed)	High	Skin (scrotum)
Vinylchloride	Ind. – Cleaning of polymerization reactors (exposures of 500–2000 ppm; 13 cases; > 20 000 workers exposed)	Very high	Liver (blood vessels)

* Ind. = occupational; Env. = environmental; Med. = drug.

leukaemia among shoemakers and other exposed to benzene solvents, nasal cancer among nickel workers are only some of the examples [7].

39. The boundary between strict occupational exposure to carcinogens, and a more general contamination of the environment outside, is a narrow one. A rare form of cancer of the lining of the lungs or the abdomen, mesothelioma [8, 9], is now known to occur mainly among people who had worked with "blue" asbestos (crocidolite) up to 40 years previously. But some cases are known among the families of asbestos workers, who presumably brought the toxic dust home on their clothes, while other cases again occur with people who once lived a kilometre or two away from a "blue" asbestos works but never worked there.

40. No food additives are known to be related directly or indirectly to carcinogenic effects, but, in canned meats, nitrates may be reduced to nitrites and then react with amino groups to form N-nitroso compounds, which are among the most potent animal carcinogens known. Millions of people in Africa and elsewhere are exposed to aflatoxins, caused by fungal contamination of stored food, which can cause liver cancer. In general, cancers of the digestive system – mouth, gullet, stomach, rectum, etc. – seem to be related less to specific food additives than to general diet. Certainly, in the United States the incidence of stomach cancer varies mainly by ethnic groups, and is presumably related to their different eating habits.

41. Some drugs normally used under medical supervision are now known to cause cancer. A drug formerly given to pregnant women to prevent abortion, diethylstilbestrol is associated with vaginal cancer in their young daughters by transplacental carcinogenesis, for example, and the drug chlornaphthazine given to treat leukaemia appears to cause bladder cancer [6, 10]. Medical X-rays, like radiation from nuclear power plants, can significantly increase the incidence of cancer, though their effects can be minimized by proper management of the radiation. And, as was discussed in the previous chapter, the UV radiation from the sun causes skin cancer.

42. Heavy tobacco-smoking causes lung cancer, and excessive alcohol-drinking causes oesophageal and liver cancer. It is now well established that (for United States males) a person who smokes 10–19 cigarettes per day is more than eight times more likely to die of lung cancer, and someone who smokes over 40 cigarettes per day is nearly 20 times more likely to die of cancer than is a non-smoker [11].

43. With smoking, the risk solely affects the individual concerned, and it may be argued that since he alone chooses to smoke we are not dealing with a strictly environmental cancer. But, as in the case of occupation-related carcinogens, the distinction is a fine one. Research has already demonstrated that non-smoking children in families which include a heavy smoker are substantially more likely to contract coughs, colds and other respiratory infections than children in non-smoking families. It is possible in practice, by applying modern statistical epidemiological techniques, to distinguish between the effects of cigarette smoking and other carcinogens in polluted air.

44. At a high dose level, a carcinogen may be enough to cause cancer by itself. But after a lower dose, which by itself would not lead to cancer, other carcinogens and other non-carcinogenic factors may act during the latent period to potentiate the initial exposure. An experimental animal treated with a low dose of carcinogenic polycyclic aromatic hydrocarbon has a greater chance of developing a liver tumour if the liver is at the same time subjected to a mild injury. These hydrocarbons are, incidentally, found in charcoal-grilled steaks. Uranium miners and coke-oven operators, who have a greater chance of dying from lung cancer than the bulk of the population, substantially increase their risk if they are cigarette smokers as well.

45. In the last quarter of a century, there has been an expotential increase in the numbers and quantities of organic chemicals manufactured and used in industrialized countries. Some half million chemicals are currently in use, and another 10 000 or so new ones are produced each year in quantities of over 500 kg; a large proportion of these eventually enters the human environment. Very many are undoubtedly carcinogenic, but the cancers they produce may take years to manifest themselves in man, and it may be far longer before a causal relationship can be established between carcinogen and cancer. This makes it essential for such chemicals to undergo careful laboratory screening for carcinogenesis before they are widely used and distributed.

46. Once released to the environment, a cancer-producing chemical becomes part of a total carcinogenic milieu, acting together with many other carcinogens, potentiators and other factors to build up the rapidly growing spectrum of cancer which now affects developed countries. As the less developed countries become industrialized and the life expectancy of their citizens increases through control of infectious and parasitic diseases, the problem of cancer control is bound to become more and more significant on a global level.

47. An entirely carcinogenic-free environment would be an impossibility, if only because there is no practical way of screening all human beings from solar ultraviolet and background ionizing radiations, but there is an urgent need to recognize the carcinogenic (and other) hazards of environmental contaminants and weigh them critically against the benefits they confer. Since the direct and indirect costs of cancer in the United States alone are estimated at $15 000 million annually [12], there are clear economic, as well as other incentives to effect a drastic reduction in environmental carcinogens.

48. The activities of the World Health Organization (WHO) and the International Labour Organization (ILO) in respect to occupational cancer are of course central in this field. Moreover, the roles of the International Agency for Research on Cancer (IARC) in preparing a register of carcinogenic chemicals (data on about 300 compounds have already been assessed and published) and of the International Register of Potentially Toxic Chemicals (IRPTC), established by UNEP with WHO, are clearly important. Since environmental contaminants do not recognize political boundaries, further international, regional and national action is necessary to monitor the occurrence of carcinogenic agents in the environment and undertake epidemiological studies of their effects on exposed groups.

49. Action to combat the growing scourge of environmental cancer must be taken at every level: in the hospital and clinic, in the workplace by public health authorities, on the local, national, regional and international scale. Nevertheless, government-sponsored campaigns against cigarette smoking and excessive alcohol consumption, the control of chemical pollution by strict industrial and environmental

regulations, and other community action can never be entirely successful. To prevent many cancers, some degree of personal involvement is not only possible but essential. The evidence suggests that in the developed world a man who lives outside urban areas, does not smoke, eats and drinks with moderation, and reduces his exposure to sunlight may reduce his risk of cancer by at least 30–40%; the figure for women is somewhat less [4, 13]. The development of such a disciplined personal cancer plan is the individual's responsibility. The younger the age at which such disciplines are practised the more they have to offer. So what a man does not do for himself, because of age or lack of will power, he could at least ensure that his children have the opportunity to do.

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IV. Decreasing agricultural base of food production: land and soil loss

50. Man depends for his food on the productivity of terrestrial and aquatic ecosystems, which he exploits through farming, ranching and fisheries. The productivity of agroecosystems – farmland – overwhelmingly depends on the capacity of the soil to respond to management. Soil provides a medium for a wide variety of biological and biogeochemical processes, and its reactions are basic to the functioning of the agroecosystem, since it provides plants with the essential requirements for growth. The formation and development of soil was a process spread over millenia. Its destruction or degradation, under excessive human pressure or misguided human activity, can occur over a few decades or even years, and is often irreversible.

51. In recent decades, man's management of agroecosystems has been steadily intensified, through irrigation and drainage, heavy inputs of energy and chemicals, and improved crop varieties increasingly grown as monocultures. Although bringing some general recent growth in agricultural production, this has made agroecosystems more and more artificial and often unstable, with the growing risk of such sudden failures as major pest outbreaks. Various forms of agricultural rotation – grass to crop to fallow, for instance – have become less and less used to remedy the "soil fatigue" which uninterrupted growth of one crop often brings. The organic humus content of the soil has declined as a result. For example, some soils in the United Kingdom of Great Britain and Northern Ireland are now suffering from dangerously low levels of organic matter, and cannot be expected to sustain present farming systems [1]. At the same time, urbanization and the explosive growth of populations have led to the development of two distinct types of human settlement, urban and rural, with the rural settlements providing the food for the industrialized urban settlements. The closed cycle of the traditional agroecosystem has become open-ended. The near-natural recycling of materials that characterizes subsistence farming has been broken; nutrients and organic materials drain away into the urban sewerages and are no longer returned to farm soil, which instead receives a heavy input of industrial chemicals.

52. Throughout human history, there have been two aspects to agricultural development: the extension of farming to virgin soil, and the intensification of agriculture on land which is already farmed. On the one hand, low-productive land, such as deserts, solonchak, swamps and fenlands, has frequently become highly productive through heavy and costly ameliorations. A further major expansion of food-producing land is the object of large-scale programmes all over the world: the present 1500 million ha of crop-producing land represent about one half of the 3200 million ha of land considered to be potentially suitable for agriculture [2], although the virgin soil left for potential expansion of agriculture is more difficult and much more costly to reclaim and to make productive, as the best soil has been already utilized throughout the world. On the other hand, the productivity per unit area has been increased through more intensive management.

53. Pressure to expand the area under farming has resulted in more and more utilization of marginal land. Often, the appropriate technology for farming this land on a sustained basis does not exist; where such technology is available, it has frequently been disregarded for social or economic reasons or reasons of political expediency. Overgrazing and overcultivation on steep hillsides everywhere has led to serious erosion; increasing pressure of slash-and-burn agriculture and forest industry is destroying tropical forests in South-East Asia, Central Africa and Latin America, leading to serious soil erosion; deforestation in the Himalayas is contributing to the increase in frequency and severity of

flooding in India, Pakistan and Bangladesh; and overgrazing and deforestation is contributing to the southward march of the Sahara in the Sudano–Sahelian zone of Africa.

54. Unfortunately, at the same time as these trends are becoming apparent, the food-producing system is steadily losing vast areas of productive land. It has been estimated that, against the 1500 million ha of land currently used for crop production, nearly 2000 million ha of land have been lost in historical times. If present trends continue, it seems that all the programmes for adding more land to the food-producing system may not compensate for the areas lost as a result of soil degradation, and through competing land uses. Indeed, as Table 2 shows, some calculations suggest that the final quarter of this century will see a net loss of cultivable land. If this proves to be the case, it is clear, when allowance is made for projected population growth, that this process will halve the area of farmland per person, which cannot be compensated by the growth of productivity per unit area through more intensive management during the same period.

Table 2. Projection for the period 1975–2000 regarding soil loss and reclamation

1975	Population	4000 million [5]
	Cultivated land	1240 million ha [6]
	Cultivated land per person	0.31 ha
1975–2000	Loss to urbanization	300 million ha
	Loss to soil degradation (mostly erosion)	300 million ha
	Potential land added to arable base	300 million ha
2000	Population (Medium variant)	6253 million*
	Cultivated land	940 million ha
	Cultivated land per person	0.15 ha

* ECOSOC E/CN.9/324 (1977).

55. The present rates of soil loss through erosion may be as high as 2500 million metric tons per year – over half a ton of soil for every man, woman and child on the planet. Mankind simply cannot afford such a loss of the very basis of agriculture.

56. Soil erosion is one of the most pressing and difficult problems facing the world community, yet its characteristics have been known for centuries. North Africa, for example, which was once the fertile granary of the Roman Empire, is currently a desert or semi-desert which has to import much of its food. In the great plains of the United States at least 6 million acres (2.5 million ha) unsuitable for cultivation with the then available technology were ploughed between 1880 and 1920; in 1933 and 1934, following a severe drought, vast dust storms blew away from 5 to 30 cm of topsoil in what became known as the dust bowl [3]. Techniques such as terracing, contour ploughing, strip cropping and shelter belts, clean fallowing and several other anti-erosion systems have largely prevented a recurrence of such sudden disastrous losses of soil, but less dramatic soil erosion occurs today on every continent. In El Salvador, 77% of the land area is suffering from accelerated erosion, and the silt load of the Citarum river in Java, whose basin is badly eroding through excessive cultivation, has increased sevenfold in 3 years [4]. In the eastern hills of Nepal, 38% of the land area consists of fields which have had to be abandoned because the topsoil has washed away, while downstream in the plains of the Nepalese Terai, the same topsoil causes the river beds to rise by 15–30 cm a year. A measure of the rapidity of soil erosion is often given by the speed at which new irrigation and power generation reservoirs fill with silt. The Achicaya dam in Colombia lost almost one quarter of its storage capacity through siltation within 21 months of opening in 1955, and was nearly three quarters full of silt within a decade [7]. Pakistan's Tarbela dam, completed in 1975 at a cost of over $1.2 billion, is expected to have a life of no more than 50 years because of silt washed down from the deforested and eroded Himalayas [4].

57. Overgrazing can also create serious problems of soil loss and degradation. For example, in the Sudanese province of Kordofan on the Saharan fringe, the domestic livestock population quadrupled between 1957 and 1966; the numbers have increased further since then [8]. Such over-grazing breaks down the dynamic equilibrium which once existed between livestock and natural rangeland, creating semi-desert vegetation dominated by ephemeral annuals. Eventually, the destruction of plant cover creates patches of bare soil, causing serious wind erosion. Similar problems due to overgrazing have been observed in other parts of Africa, in Latin America, around the Mediterranean basin, in the Indian subcontinent, in Australia and elsewhere. For sustained long-term productivity of grassland and rangeland, the carrying capacity of land must be carefully evaluated and not exceeded. The world plan of action to combat desertification, to be considered at the United Nations Conference on Desertification in August 1977, offers a comprehensive long-term global campaign to conserve the soils of arid lands.

58. A decline in soil fertility or even a total loss of land to agriculture, due to increase in salinity or alkalinity, is a common problem in many parts of the world. Without adequate drainage, excessive or unwise irrigation can lift salts to the soil surface, and even in the absence of subsurface salts, waterlogging may reduce fertility. A study of major modern irrigation schemes in the Punjab shows that seepage from unlined canals has, in the first 10 years of operation, raised the water table 7–9 m above previous levels. In Pakistan in the early 1960s, 22% of all irrigated land was seriously damaged by waterlogging or salinity [7], while in India in 1972 the figure was 15% [4]. Some experts claim that the fertility of between 30 and 80% of the world's irrigated land is currently being affected to a greater or lesser extent by salinization [4]. Among other major areas affected by salinization are the Helmut valley in Afghanistan, the Imperial valley and Colorado basin in the United States, the Mexicali valley in Northern Mexico, and the Euphrates and Tigris basins in Syria and Iraq.

59. On a global scale 200 000–300 000 ha of irrigated land, an area the size of Luxembourg, are being lost by salinization and waterlogging every year. There are other ways, too, in which soil structure, fertility and productivity may be damaged. Over-use of pesticides and inorganic and other fertilizers, for example, can damage the natural microflora and microfauna of the soil. Excessive or inappropriate cultivation can also reduce the soil's agricultural

potential. In the Tunisian Sahel tractor-drawn ploughs and disc harrows are breaking up the surface soil and thereby causing wind erosion far more than did the animal-drawn ploughs they have replaced, while in parts of the United Kingdom drainage and thus crop yields have been reduced by compaction and loss of soil structure caused by the use of heavy machinery in unsuitable weather [1]. Of course, such processes as irrigation, machine cultivation, and the use of synthetic pesticides and fertilizers have played – and will continue to play – a key role in raising agricultural productivity. But in many areas of the globe insufficient care is taken to ensure that a rise in short term productivity is not obtained at the price of temporary or permanent damage to the soil on which all agriculture ultimately depends.

60. Another important problem is the loss of productive agricultural land to competing uses. In the United States, about one million hectares of arable cropland are annually lost to highways, urbanization, and other non-farming uses, although this loss is partially offset by the addition each year (primarily through irrigation and drainage) of half a million hectares of newly developed cropland [9]. World-wide, large cities are growing in area at approximately twice the rate at which they grow in population, and since they nearly all lie on fertile plains, this causes a serious loss of arable land [10].

61. There is a related aspect of this problem: the influence of soil on climate. Soil bacteria play a key role in regulating atmospheric gases, and via them in most biogeochemical cycles, such as nitrogen, carbon or phosphorus. Dust particles of mineral and plant origin, which mainly come from the soil, are the basis of cloud formation and rainfall, and also affect the planetary temperature by influencing the proportion of solar radiation which is reflected back into space. Changes in soil cover may therefore influence planetary climate, just as the climate in its turn may influence the ease with which ecological mismanagement destroys the soil.

62. If adequate food for all of the world's expanding population is to be produced, the present rates of loss or degradation of agricultural land cannot be continued. Overgrazing, excessive cultivation, unwise irrigation, urbanization: solutions to the many and complex problems of soil deterioration and loss, and the permanent damage to the agricultural base of food production which this process entails, will vary from one continent, country, region and locality to another. But while the sustainable management of any agroecosystem must be a matter of sound husbandry based on adequate scientific knowledge related to the particular local environment, a wider global perspective is necessary. UNESCO and FAO are already working towards this end; the United Nations Water Conference (Mar del Plata, Argentina 14–25 March 1977) has drawn attention to the key role of water supply; and the United Nations Conference on Desertification will focus on the various aspects of soil degradation in arid lands.

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V. Use and management of renewable resources: firewood

63. Many developing countries depend upon wood as their major source of fuel. In rural areas of the Third World where wood is readily available, nearly 95% of households use it as a primary source of energy. In 1974, according to statistics supplied by Governments to FAO, over 45% of the total world round timber production was used as firewood or as charcoal [1] (see Table 3). Since the greater part of firewood production and usage takes place outside commercial channels and therefore goes largely unrecorded, as much as substantially over half the world's wood crop could be burned as fuel. In developing regions, the proportion is much higher; according to FAO statistics, 93% of wood cut in Africa south of the Sahara is ued as fuel, and 86% is so used over all the developing world [2].

64. In the world as a whole, wood is considered the fourth most important source of energy, after oil, coal and natural gas. These fossil fuels account for 90% of the world's energy use but in 1971 wood provided only 6% of the estimated total world energy consumption. In developing countries as a whole, wood accounts for 28% of energy use, and in Africa south of the Sahara the figure is 75%. Again, since most wood does not pass through the market system and is therefore not recorded, these figures are certainly underestimates. For the world as a whole 50% of the wood consumed as fuel is used for cooking, and 30% for domestic heating; the remaining 20% is used for other household purposes, for processing agricultural products, and for industry. For the greater part of mankind, wood is the energy source which satisfies the basic needs of cooking and warmth [3].

65. The magnitude of firewood consumption in the world, especially in the developing countries, as well as its significance in the everyday life of well over two billion people, was not realized until recently. The energy crisis which started in 1973, together with the increasing attention now being given to rural economies in general, and rural energy requirements in particular, have attracted new interest to the problems of firewood.

66. Most firewood is for family use. The collection and transport of wood in rural areas is mainly by human and animal labour, so it is normally gathered from areas within walking distance of the consumer, a distance which in hard-pressed firewood areas such as the Indian subcontinent and the Sudano–Sahelian region may be as much as 50 km. Even though firewood for the market moves over considerably greater distances, supply zones tend to be limited. Wood is an inefficient fuel compared with other energy

sources, being relatively heavy compared to its output of heat and while a barrel of oil is worth transporting round the world, a load of firewood rarely travels more than a few hundred kilometres.

67. Firewood, then, comes overwhelmingly from local sources, and this puts growing pressure on the trees, bushes and shrubs near to centres of population long before the demand for fuelwood leads to complete destruction of the tree cover, it can have a markedly degrading environmental effect. Excessive pruning of the branches may reduce a tree's capacity for growth; removal of the more easily-felled younger trees may reduce the regenerative ability of the forest; excessive opening of the canopy through the removal of too many trees can render the forest susceptible to damage from wind and sun; the removal of all residues, even to the point in some areas of sweeping up the leaves, removes the nutrients that should return to the soil to maintain its fertility; removal of rocks, stumps, bushes and shrubs can destroy much of what remains of the soil's protective cover and binding structure. And eventually, the whole forest may be felled and disappear.

68. The uncontrolled and indiscriminate collection of firewood for cooking and heating, therefore, can have the most serious implications. Until the 1940s, forests had completely disappeared from most of China, because the trees had been cut down for fuel; in recent years, though, this trend has been reversed and vast areas have been successfully reafforested. In much of India, though, the forests are still rapidly declining [4]. With the growth of human populations, the forests are being cut down faster than they can grow, partly to make room for new farmlands, and partly for use as fuel. As a consequence, the upland areas – the watersheds for the great rivers which flow through the plains – are subjected to destructive erosion, while the resulting sediments cause rapid filling of reservoirs and destructive floods downstream severely reduce the cover of cultivable soil and the food which can be produced from it.

69. In semi-arid regions the ecological consequences of firewood consumption contribute to the process of desertification. Firewood is a scarce and expensive item throughout sub-Saharan Africa, all the way from Senegal to Ethiopia. A manual labourer in Niamey must now spend nearly one quarter of his income on fuel. But the price is higher than even he realizes. The caravans that bring this precious resource into the towns are contributing to the creation of desert-like conditions in a wide band along the desert's edge. Virtually all the trees within 70 km of Ouagadougou have been consumed as fuel by the city's inhabitants, and the circle of land stripped bare for firewood is continually expanding [5].

70. Another negative environmental impact of the firewood shortage in India and some other countries is the burning of dung for fuel (see Table 4). Not only does this deprive the land of essential nutrients which should be returned to the soil, but it causes severe air pollution which can be grossly harmful to health. The burning of firewood and charcoal adds sizeable amounts of smoke and carbon dioxide to the atmosphere, whose impacts on global climate are not yet fully established.

71. In addition to its ecological consequences, the scarcity of firewood imposes its economic and social burdens most especially upon the poor. The inhabitants of rural villages in the developing world – usually the women – must walk

Table 3. Estimated fuelwood and charcoal consumption, 1971

	Population (millions)	Woodfuel consumption		
		Total million (m^3)	m^3/capita	As a percentage of total roundwood consumption
World	3683	1381	0.37	52
Developed economies*	1125	161	0.14	13
Developing economies	2558	1220	0.48	86
South-East Asia and Oceania	306	278	0.91	88
South Asia	711	267	0.38	95
China and rest of Asia	839	148	0.18	75
Near East, North Africa	194	68	0.35	88
West and Central Africa	119	110	0.92	93
East and South Africa	103	117	1.14	93
Central America and Caribbean	92	33	0.36	75
South America	194	199	1.03	83

*Australia, Canada, Europe, Israel, Japan, South Africa, U.S.A., U.S.S.R.

Sources: IBRD Atlas 1973; FAO Yearbook of forest production 1973; Table 4.

increasing distances to secure domestic fuel. In terms both of labour and money, half the world's population finds the price of firewood too high to pay.

72. Unlike fossil fuels such as coal, oil and natural gas, wood is a renewable resource. The question for most developing country villages is not only how to replace firewood with other renewable sources of energy, but also how to supply firewood in an environmentally sound and sustainable way. There are two approaches which seem most promising at present with respect to firewood: using firewood more efficiently, and the more sustainable production of wood via fuelwood plantations. As burnt at present, firewood is not an efficient fuel. Cooking on an open, slow burning fire requires about five times as much energy as cooking on a kerosene stove [5]. A study in Indonesia found that on the usual type of firewood stove 94% of the heat value of the wood was wasted [6]. Simple improvements to stove design cut this loss by about 20%. Cutting the wood some weeks before use and then drying it in the open air reduced the loss by a further 10%, and a new type of cooking pot, partly sunk into the stove, cut heat loss by an additional 30%. In all, the consumption of firewood for cooking was reduced in these ways by about 70%. Another means of burning firewood more efficiently is to convert it into charcoal, yet less than 5% of all fuelwood is used in this way.

73. Trees, unlike oil, are a renewable resource, provided appropriate management and conservation measures are taken. The logical immediate response to the firewood shortage, one that will have many incidental ecological benefits, is to plant more trees in plantations, farms, along roads, in shelter belts, and on unused land throughout the rural areas of the poor countries. For many regions, fast-growing tree varieties are available that can be culled for firewood within a few years, especially if the trees are coppiced (cut off at ground level and the stumps allowed to sprout new shoots). Some calculations, for example, suggest that if improved efficiency in stoves reduces consumption by 50%, a 10 ha plantation could supply the fuelwood needs of a 1000 family village in rural India [7].

74. To make such land available in heavily-cultivated areas would face considerable political and cultural resistance, and the experience of the tree-planting programmes of many governments in wood-short countries over the past few decades has not always been encouraging. Nevertheless, if the energy needs of developing country villages are to be satisfied without continuing an increased environmental degradation, some way must be found of growing fuelwood on a sustainable basis in addition to the concerted efforts to harness other renewable sources of energy, especially solar, wind and biogas.

Table 4. Energy uses in rural India [4]

Source of energy	Energy used (kcal)					
	Agriculture	Domestic activities	Lighting	Pottery brickmaking metalwork	Transportation and other uses	Total
Human labour	0.59×10^{14}	0.39×10^{14}		0.01×10^{14}	0.09×10^{14}	1.08×10^{14}
Bullock work	1.35×10^{14}				0.26×10^{14}	1.61×10^{14}
Firewood and charcoal						1.60×10^{14}
Cattle dung		6.78×10^{14}		0.75×10^{14}		1.86×10^{14}
Crop residues						1.07×10^{14}
Total from local sources	1.94×10^{14}	7.17×10^{14}		0.76×10^{14}	0.35×10^{14}	10.22×10^{14}
Petroleum and natural gas						
fertilizer	0.35×10^{14}					0.35×10^{14}
fuel	0.08×10^{14}		0.42×10^{14}			0.50×10^{14}
Soft coke		0.14×10^{14}				0.14×10^{14}
Electricity						
Hydro*	0.03×10^{14}		0.01×10^{14}			0.04×10^{14}
Thermal†	0.12×10^{14}		0.05×10^{14}			0.17×10^{14}
Total from commercial sources	0.58×10^{14}	0.14×10^{14}	0.48×10^{14}			1.20×10^{14}
Total, local and commercial	2.52×10^{14}	7.31×10^{14}	0.48×10^{14}	0.76×10^{14}	0.35×10^{14}	11.42×10^{14}
Daily per capita	1.57×10^{3}	4.55×10^{3}	0.30×10^{3}	0.47×10^{3}	0.22×10^{3}	7.11×10^{3}

* Potential energy in water used to generate hydroelectric power.

† Energy in coal used to generate thermoelectric power.

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VI. Protection and improvement of the environment

75. In many fields first-hand experience and sufficient knowledge is now available to effect a worth-while improvement in the quality of environment. Efforts have already been made to eliminate oil pollution of the seas, to clean rivers, to safeguard wildlife and landscape and to prevent the misuse of pesticides. The following paragraphs briefly describe successful efforts to improve the quality of the environment in the areas discussed in this report.

A. Reduction of ozone layer

1. Warning on fluorocarbons

76. The Food and Drug Administration (FDA) of the United States, which has authority over products such as deodorants, perfumes, hair sprays and anti-perspirants, announced in the last week of November 1976 that the following statement should be printed on the label of aerosol spray cans containing fluorocarbon propellants [1]:

Warning: Contains a chlorofluorocarbon that may harm the public health and environment by reducing ozone in the upper atmosphere.

The warning labels will probably be required from early 1977, though no date has yet been set. The products regulated by the FDA account for about 80 per cent of the total release of fluorocarbons into the atmosphere. The Consumer Product Safety Commission of the United States has proposed a separate action to reduce and ultimately eliminate the use of fluorocarbons in aerosol products not regulated by the FDA.

2. Ozone monitoring

77. Based at the Lawrence Livermore Laboratory in the United States, a global ozone monitoring system collecting data from up to four satellites will go into operation early in 1977 [2]. The major objective is to analyse day-to-night variations in ozone levels and to study the impact of natural events such as volcanic eruptions which may inject contaminants in amounts sufficient to alter the chemistry of the ozone cycle. The effect of unusually high radiation levels from solar storms on ozone levels will also be studied. A series of ozone maps will be prepared by relaying 68 000 measurements a day from each satellite to the laboratory via the United States Air Force Global Weather Central in Omaha, Nebraska where data will be checked against readings made by ground stations in Antarctica, Africa, Australia, Europe, Japan, North Amercia and South Amercia.

3. Nitrous oxide monitoring in air

78. In order to build a better living environment, about 300 private groups in Tokyo and its surroundings have established an unofficial system for checking the volume of nitrous oxide in the atmosphere. Not less than 22,000 atmospheric measuring stations have been set up which use litmus paper placed in bottles and collected at the end of 24-h periods to determine the chemical contents of the paper. A comprehensive map of nitrous oxide pollution in the seven regions is being completed and will be publicized [3].

B. Cancer

1. Logical framework of cancer research

79. A team of six scientists at the United States National Cancer Institute and the University of Maryland seems to have made the first step in finding a logical framework for cancer research based on epidemiology. The procarcinogenic polynuclear aromatic hydrocarbons in cigarette smoke are converted into carcinogens by enzymes in the tissues of the lungs. The resultant metabolites can become bound to important cellular molecules, including DNA, though it is not very clear that the binding is directly linked with carcinogenesis [4]; however, a correlation has been found between the two in some work with animals. The ability of the lung cells to break down hydrocarbons is related to the amount of actual carcinogen to which the lung tissue is exposed, while the binding of the breakdown products is a measure of the lung cell activity. Experiments have been made on 37 individuals, including 29 with lung cancer, to find out individual differences in the extent of the binding after exposure to a particular hydrocarbon, benzo-alpha-pyrene, of human lung cells grown in culture. Although many problems are still to be clarified before any definite conclusion about human lung cancer is reached, there seems at least to be a system to work on to find the answers.

2. Substitute for asbestos

80. A substitute for asbestos (which is associated with lung cancer) has been announced [5] by a Danish manufacturer and has been named "Low Temperature Ceramic". It can be shaped, pigmented and used in conjunction with other materials such as steel and wood. The new material has already found markets in Japan and the United States.

3. Effective rapid tests for detecting potential carcinogens

81. The laboratory tests developed in recent years for detecting carcinogenic and mutagenic compounds present in the human environment have recently been evaluated against a group of 120 well known carcinogens. The so called Ames test – based on the identification of mutations in the bacterium *Escherichia coli* – and the "cell transfor-

mation test" – using cells of Syrian hamster kidney fibroblasts, human diploid lung fibroblasts or human liver cells – proved to be the most reliable out of a total of 6 different experimental procedures [6].

4. Monitoring of the marine environment for mutagens

82. To detect chemical compounds capable of inducing genetic mutations and cancer the mussel *Mytilus edulis,* which is widely distributed in the tidal zone and shallow coastal waters of the northern and southern hemispheres, has been used. Tissues of this mollusc were screened for mutagenic action using yeast cultures as well as bacterial tests. Convincing evidence has thus been obtained from a number of maritime environments. The numerous observed correlations between chemicals showing mutagenic and carcinogenic activity suggest that such agents also represent a possible source of chemically induced carcinogenesis [7].

C. Land and soil loss

1. Reforestation to prevent silting

83. The Government of Pakistan planted 22.8 million trees during the 1975 monsoon rainy season (July–August). The major objective is to prevent silting of the country's huge dams, such as the Tarbela, the world's largest earth-filled dam, and extensive network of rivers and canals [8].

2. Prevention of erosion

84. Extensive research has been carried out in the United States to prevent erosion and to preserve eight inches of topsoil for a maximum period. Parallel furrows across the slant of the land keep the fertilizers and rainfall in the sloping and dry earth and help prevent erosion. The life of the topsoil depends on the way it is ploughed and can be preserved for 36 years, 104 years and 2224 years under straight-line ploughing, contouring and terracing, and a new concept of drilling seeds into untilled, mulched and contoured terraces, respectively. According to the scientists, the last method if used by farmers, could safeguard the topsoil for a hundred generations [9].

3. Date plantation to arrest desert encroachment

85. A massive date cultivation programme has been planned to arrest the encroachment of the Rajasthan desert, which is swallowing one per cent of India's 306 million ha of land each year. With the aid of UNDP, the Government intends to plant date palms all along the fringes of the desert on a huge scale. For this purpose about 3500 date suckers will be imported from California. Meanwhile, the Indian Council of Agricultural Research is exploring the latest techniques in date production, processing and packing [10].

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VII. Conclusion

86. There are many success stories to indicate that much can be achieved to improve the quality of the environment in countries with very different political and ideological systems. In order to create better conditions of life for a greater proportion of mankind in an environment which is not being damaged irreparably, international collaboration on a scale no seen so far in the history of mankind is essential. What is needed is planned action towards integrated environmental management, rather than incremental *ad hoc* steps for environmental protection. It is for governments to consider their specific national action for environmental control. No general guidelines or specific prescriptions are possible. The basis of national action is so much rooted in the varied conditions in each country that all than can possibly be done is to draw attention to selected environmental problems of major concern at the regional or global levels. However, a top priority for both developed and developing countries should be to broaden their knowledge through exchange of information and experience in the environmental field.