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United Nations Industrial Development Organization

Training Course
Ecologically Sustainable Industrial Development

Learning Unit 2

The Need for Ecologically Sustainable Industrial Development

Includes:

Glossary of Environmental Terms

Further information may be obtained from:
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Contents

Additional Course Material

Video: *Our Common Future*, a film by the Centre for Our Common Future

Introduction

Learning Unit 2 is designed to acquaint you with environmental problems that have led to a worldwide call for ecologically sustainable industrial development (ESID). It also contains a glossary of environmental terms that may be useful to you throughout the course.

Objectives

The specific learning objectives of this unit are as follows:

- To relate trends in economic development since 1970 to the most important industry-related environmental issues.
- To describe the main environmental problems that result from industrial development.
- To begin to use the language of environmental management.

Key Learning Points

1 Past development trends have resulted in very limited well-being for developing countries. In 1992, 80 per cent of the world population received only about 20 per cent of the world's income and produced only a small share of industrial output.

2 Industrial activity is a major contributor to environmental deterioration.

3 It currently seems inevitable that both global population numbers and per capita income will increase. The challenge we face is to reconcile the demands of population growth, the desire for continued industrial development and the need to preserve our environment.

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4 We must find new approaches to industrial development, both in developed and developing countries, that will allow us to preserve the ability of our environment to sustain us. In short, we must achieve ecologically sustainable industrial development.

5 The only way to do this is to reduce the "pollution intensity" of industrial activities.

Suggested Study Procedure

1 Look at the test at the beginning of the *Review*. Think about the questions raised and what you need to learn from this Learning Unit.

2 Work through the *Study Materials*, including the *Reading Excerpts* and the video.

3 Prepare answers to the questions posed for the *Case Studies*. If possible, work with a small group to discuss the questions raised. Compare your answers with those suggested.

4 Complete the exercises in the *Review*.

Study Materials

This Learning Unit is designed to help you become familiar with worldwide environmental problems that have prompted the call for ecologically sustainable industrial development. Learning Unit 2 contains information on economic and environmental trends, water pollution, atmospheric pollution, toxic chemicals and hazardous wastes, acidification and global climate change.

Economic Trends

Since 1970, overall world industrial output (manufacturing value added, or MVA) grew at about 3.6 per cent annually, compared with a population increase of about 1.8 per cent.

Compare the average annual growth rates, 1970-1990, in developed and developing countries:

Region	MVA	Population
Developed countries	3.1%	0.7%
East Asia South-East Asia	9.1%	2.1%
Latin America	1.0%	2.1%
Africa	2.1%	3.0%

The growth in industrial output of developing countries failed to meet expectations. Overall, their share of global industrial output, in current prices, increased from only 9.3 per cent to 13.8 per cent between 1970 and 1990, mainly in the years 1970-1980.

This small share of global industrial output was achieved by only a few developing countries. Thus, 60 per cent of the growth was achieved by 12 of the 118 countries and 80 per cent by 18 of them.

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Environmental Trends

While there are natural emissions of most major pollutants, industrialization is still a major threat to the biosphere.

Emissions of carbon dioxide (CO_2) from fuel burning are a primary contributor to the greenhouse effect.

Emissions of chlorofluorocarbons (CFCs) from refrigerators and air-conditioners, solvents and plastic foam blowing are major causes of the "ozone hole", leading to ultraviolet radiation, skin cancers, loss of immunity, crop/fishery yield reduction, smog etc.

Emissions of sulphur dioxide (SO_2) and nitrogen oxides (NO_x) create acidity in the natural environment (freshwater lakes, rivers, forests and soils) and the deterioration of metal and building structures etc.

Emissions of toxic chemical substances, heavy metals (lead, cadmium, mercury and arsenic) and aromatic polychlorinated compounds (PCBs, pentachlorophenol, dioxin) threaten aquatic ecosystems and soils in whole regions and seas.

Industry is a major contributor to these environmental concerns with its manufacturing, mining, utilities and construction activities. The table on the next page summarizes the environmental effects of some of the major industrial polluters.

For a long time such energy- and pollution-intensive industries were confined mainly to developed countries, but they are now growing twice as fast in developing countries.

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Table 1. Environmental Effects of Selected Industrial Sectors

Industrial sector	Raw material use	Air	Water resources: Quantity	Water resources: Quality	Solid wastes and soil	Risk of accidents	Other (noise, workers' health and safety, consumer products)
Textiles	Wool, synthetic fibres, chemicals for treating	Particulates, odours, SO^2, HC	Process water	BOD, suspended solids, salts, sulphates, toxic metals	Sludges from effluent treatment		Noise from machines, inhalations of dust
Leather	Hides, chemicals for treating and tanning		Process water	BOD, suspended solids, sulphates, chromium	Chromium sludges		
Iron and steel	Iron ore, limestone, recycled scrap	Major polluter: SO^2, particulates, NO_x, HC, CO, hydrogen sulphide, lead, and mists	Process water	BOD, suspended solids, oil, metals, acids, phenol, sulphides, sulphates, ammonia, cyanides, effluents from wet-gas scrubbers	Slag, wastes from finishing operations, sludges from effluent treatment	Risk of explosions and fires	Accidents, exposure to toxic substances and dust, noise
Petrochemical refineries	Inorganic chemicals	Major polluter: SO^2, HC, NOx, CO, particulates, odours	Cooling water	BOD, COD, oil, phenols, chromium, effluent from gas scrubbers	Sludges from effluent treatment, spent catalysts, tars	Risk of explosions and fires	Risk of accidents, noise, visual impact
Chemicals	Inorganic and organic chemicals	Major polluter: organic chemicals (benzene, toluene), odours, CFCs		Organic chemicals, heavy metals, suspended solids, COD, cyanide	Major polluter: sludges from air and water pollution treatment, chemical process wastes	Risk of explosions, fires and spills	Exposure to toxic substances, potentially hazardous products
Non-ferrous metals (e.g. aluminium)	Bauxite	Major local polluter: fluoride, CO, SO^2, particulates		Gas scrubber effluents containing fluorine, solids and hydrocarbons	Sludges from effluent treatment, spent coatings from electrolysis cells (containing carbons and fluorine)		
Micro-electronics	Chemicals (e.g. solvents, acids)	Toxic gases		Contamination of soils and groundwater by toxic chemicals (e.g. chlorinated solvents), accidental spillage of toxic material			Risk of exposure to toxic substances
Biotechnology				Used for effluent treatment	Used for clean-up of contaminated land		Fears of hazards from the release of micro-organisms into the environment

Source: *The State of the Environment* (OECD, 1991).

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The Challenge: To Develop Industry While Protecting the Environment

The challenge is to reconcile the demands of population growth, the desire for continued industrial development and the need to protect our environment.

Trends	1900-1990 (actual)	1990-2040 (projected)
Population	4x	2x
Economic activity	20x	3.5x
Fossil fuel use	30x	3x
Industrial production	50x	3x

Past development trends have resulted in very limited well-being for developing countries. In 1992, 80 per cent of the world population received only about 20 per cent of the world income and produced only a small share of industrial output.

In 1990, WHO admitted that the goal of health for all by the year 2000 could not be achieved under the existing world conditions of poverty and inequality. Will UNIDO find in the year 2000 that environmental protection cannot be achieved under such conditions?

New approaches to industrial development must be found, both in developed and developing countries, that will allow us to preserve the ability of our environment to sustain us. In short, we must achieve ecologically sustainable industrial development.

Next Steps

1 Look at the questions below.

2 Read the excerpt from "The road to ecologically sustainable industrial development", included at the end of this Learning Unit.

3 Test your comprehension of the information by answering the questions below. Compare your answers with those suggested.

Questions

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1 What is industry's share of fossil fuel combustion? Is this share increasing or declining?

2 The anthropogenic emissions of which heavy metal dramatically exceed its emissions from natural sources?

3 What are the "smokestack" industries? During 1970-1988, how did the growth of smokestack industries in developing countries compare with their growth in developed countries?

4 Is industry the sector that uses the most water?

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5 **What is the difference between ambient standards and total loading standards?**

6 **In 1985, what were the industrialized countries' share of emissions of CO_2, CFCs and SO_2?**

Answers

1. About 35 per cent. Worldwide, industry's share is declining, but in many developing countries it is increasing.

2. ; and

3. Smokestack industries are the most energy-, material- and pollution-intensive industries. They include iron and steel, non-ferrous metals, non-metallic minerals, pulp and paper and chemicals. In 1970-1988, the smokestack industries grew faster in developing countries than in developed countries; in 1980-1985, they grew twice as fast.

4. No, in most countries, agriculture is the biggest water user, but industry pollutes the water more.

5. Ambient standards were formulated to protect local environments. They focus on ambient concentrations of single pollutants. Total loading standards focus on the cumulative stock of pollutants in the environment.

6. CO_2—50%; CFCs—70%; SO_2—40%

Next Steps

1 Look over the questions below so that you have some idea of what you will want to learn from the video.

2 Watch the video *Our Common Future*.

3 Test your comprehension of the video by answering the questions below. Compare your answers with those suggested.

Questions

1 What are some of the unintended environmental consequences of development?

2 How did the World Commission on Environment and Development (WCED) define sustainable development?

3 What did WCED call for? Do you think this is a controversial statement?

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4 **Is protection of the environment incompatible with economic growth?**

5 **Does WCED believe that the world has the potential to achieve sustainable development?**

Answers

1. Global warming, ozone depletion, acid rain and deforestation.

2. Sustainable development was defined as meeting the needs of the present without compromising our ability to meet those of the future.

3. WCED called for a new era of economic growth that is more equitable and more responsive to environmental limits. This conclusion is controversial because many say that "zero" growth and large-scale financial transfers are the only actions that are compatible with environmental limitations. WCED, however, argues that growing populations and poor populations require goods and services to meet their essential needs and that only economic growth can meet those needs.

4. No, protection of the environment is a sound economic investment needed to help living standards rise. Long-term economic growth is not possible if it destroys the natural resource base on which it is based.

5. Yes, WCED believes it technically possible to use less energy and resources to produce more goods and to grow enough food without destroying the natural resource base.

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Next Steps

The following sections are designed to acquaint you with the major environmental problems associated with industrial development. Read each section carefully and answer the questions that follow. Compare your answers with those provided.

Water Pollution

Selected and adapted, with permission, from *Saving Our Planet: Challenges and Hopes* (UNEP, 1992), pp. 25-40.

Marine Pollution

The two pathways by which most potential pollutants reach the oceans are the atmosphere and rivers. The atmospheric pathway accounts for more than 90 per cent of the lead, cadmium, copper, iron, zinc, arsenic, nickel, PCBs, DDT and hexachlorofluorohexane found in the open oceans water. River inputs are generally more important than those from the atmosphere in coastal zones, although in certain areas and for some substances (e.g. lead and hexachlorofluorohexane in the North Sea and nitrogen in the Mediterranean) atmospheric inputs are similar or even dominant.

Aside from physical degradation of the coastal and near-shore zones, pollution is the main problem affecting these zones. Most of the liquid wastes and a growing fraction of the solid wastes from man's activities on land are introduced into the oceans through the land/sea interface. Coastal areas receive direct discharges from rivers, surface run-off and drainage from the hinterland, domestic and industrial effluents through outfalls, and various contaminants from ships.

Most types of wastes, once introduced into the sea, cannot be removed. Their fate is determined by their chemical composition and by the physical transport processes (e.g. mixing, sea currents) of the recipient waters. The distance they can reach depends on these processes and on the rate of their decomposition, with the non-degradable wastes having the ability to travel for long distances.

Some wastes are easily decomposed into harmless substances, although their end-products, if excessively concentrated, may seriously disturb the ecosystem (e.g. eutrophication, which is due to an excess of nutrients). Other wastes, such as metals and persistent organic compounds, cannot be degraded; they usually remain adsorbed on bottom sediments near the sources of discharges.

Some marine organisms have a remarkable ability to accumulate such substances from sea water, even when the substances are present in extremely low concentrations. Others can convert some substances into more toxic ones; for example, the well-known conversion of inorganic mercury into methylmercury, which caused the outbreak of disease at Minamata in Japan in the 1950s and 1960s.

The principal problem for human health on a worldwide scale is the existence of pathogenic organisms discharged with domestic sewage into coastal waters. Bathing in sea water that receives such sewage and the consumption of contaminated fish and shellfish cause a variety of infections.

Epidemiological studies have provided unequivocal evidence that swimmers in sewage-polluted sea water have an above-normal incidence of gastric disorders. Studies have also indicated an increased incidence of non-gastric disorders, such as ear, respiratory and skin infections. The consumption of contaminated seafood is firmly linked with serious illness, including viral hepatitis and cholera.

Many compounds discharged into the sea tend to accumulate in various organisms. Halogenated hydrocarbons accumulate in fatty tissues, and the amount accumulated may increase through the food chain, so that high concentrations are found in the bodies of the top predators among birds, fish and mammals. Where the contamination has built up over decades, such as in enclosed bodies of water like the Baltic and the Wadden Sea, the reproductive capacity of marine mammals and birds has been affected.

Polychlorinated biphenyls (PCBs) accumulated in seafood can reach unacceptable levels. Tributyltin affects a wide range of invertebrates, and its use in marine paints was recently restricted in France, the United Kingdom of Great Britain and Northern Ireland, and several states in the United States of America.

Freshwater Pollution

Assuring an adequate supply is not the only water problem facing many countries: they also need to worry about water quality. Concerns about water quality have been growing since the 1960s. At first, attention centred on surface-water pollution from point sources (industrial plants and cities). More recently, however, groundwater pollution and non-point sources (agricultural lands, forests, roads etc.) have been found to be at least as serious problems.

The basic type of pollution is that caused by the discharge of untreated or inadequately treated waste water into rivers, lakes and reservoirs. With the growth of industry, industrial waste waters discharged into water bodies have created new pollution problems. One important water quality problem is the increasing eutrophication of rivers and lakes, caused mainly by the run-off of fertilizers from agricultural lands. The acidification of lakes by acidic deposition is common in some European countries and in North America. Wastes can also be carried to lakes and streams along indirect pathways, for example, when water leaches through contaminated soils and transports the contaminants to a lake or river.

Dumps of toxic chemical waste on land have become a serious source of groundwater and surface-water pollution. In areas of intensive animal farming or where large amounts of nitrate fertilizers are used, nitrates in groundwater often reach concentrations that exceed guidelines established by the World Health Organization (WHO). The problem has become a cause for concern in some European countries and in the United States and is growing in magnitude in some developing countries.

About 10 per cent of all the rivers monitored in the water project of the Global Environment Monitoring System (GEMS) may be described as polluted (they have a biochemical oxygen demand (BOD) of more than 6.5 mg/l). The two most important nutrients, nitrogen and phos- phorus, are well above natural levels in the monitored waters. The median nitrate level in unpolluted rivers is 100µg/l. The European rivers monitored by GEMS show a median value of 4,500µg/l. In contrast, rivers monitored by the GEMS project outside Europe show a much lower median value,

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250μg/l. The median phosphate level in rivers monitored in the project is 2.5 times the average for unpolluted rivers (10μg/l). Since 1970, regulatory measures have led to a marked decrease of lead in most rivers of countries that are members of the Organization for Economic Cooperation and Development (OECD). Trends for other metals and toxic substances are less encouraging, despite efforts to reduce discharges. Such substances are often persistent, accumulate into bottom sediments and can be released over long periods of time once initially deposited. Levels of organochlorine pesticides recorded in some rivers in developing countries (e.g. Colombia, Malaysia and the United Republic of Tanzania) are higher than those recorded in European rivers.

The quality of fresh water depends not only on the quality of waste entering the water but also on the decontamination measures that have been put into effect. Although organic waste is biodegradable, it nonetheless presents a significant problem, especially in developing countries. Human excreta contain pathogenic micro-organisms, which are water-borne agents of cholera, typhoid fever and dysentery. Contaminated water has caused the outbreak of epidemics of these diseases in several developing countries.

Industrial waste may include heavy metals and many other toxic and persistent chemicals not readily degraded under natural conditions or removed in conventional sewage-treatment plants. Unless these wastes are adequately treated at the source or prevented from being discharged into watercourses, the freshwater quality can be seriously impaired. The high content of nutrients in rivers and lakes has led to eutrophication. Apart from ecological and aesthetic damage, eutrophication brings increasing difficulties and costs for water treatment plants that have to produce safe, palatable drinking water. The acidification of freshwater lakes has affected aquatic life to various degrees.

In most developing countries, the pollution of rivers by municipal and industrial wastes is on the increase and decontamination efforts are often neglected. In these countries, industrialization has had a higher priority than the reduction of pollution. As a consequence, in some regions (East Asia, for example) the degradation of water resources is now considered the gravest environmental problem. In many of these countries, aquatic life has been affected. The deterioration of water quality is a growing threat to aquaculture, which provides a sizeable amount of fish for the population.

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Questions

1 **Name two land-based toxic pollutants that affect coastal areas.**

2 **Why do small quantities of metals and persistent organic compounds cause a problem in aquatic environments?**

3 **Describe two types of contamination of fresh water that can be partially attributed to industrial activities.**

Answers

1. Cadmium and arsenic.

2. Some marine organisms accumulate these substances and some convert them into more toxic ones.

3. Contamination by heavy metals and acidification.

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Atmospheric Pollution

Selected and adapted, with permission, from *Saving Our Planet: Challenges and Hopes* (UNEP, 1992), pp. 1-8.

Air pollution is defined for the purposes of this document as the presence in the outdoor or indoor atmosphere of one or more gaseous or particulate contaminants in quantities, characteristics or durations such as to be injurious to human, plant or animal life or to property or to unreasonably interfere with the comfortable enjoyment of life and property.

The combustion of fossil fuels results in the exothermic oxidation of carbon, hydrogen, sulphur and nitrogen. If complete combustion is achieved, CO_2, water vapour, SO_2, NO_x and volatile and non-volatile trace metals such as arsenic, cadmium, lead and mercury are the principal pollutants emitted. In practice, complete combustion does not occur and additional particulate and gaseous pollutants are produced. These include carbon monoxide and organic and elemental carbon particulates; polycyclic aromatic hydrocarbons may also be evolved, either absorbed on to particulate matter or as a gas. Further emissions may be produced by fuel additives such as tetraethyllead, tetramethyllead and various hydrocarbons.

Generally, pollutant emissions are determined by the method of combustion and the type of fuel used. Coal is the most polluting fuel per unit energy produced, based on current combustion technology. It provides 20-25 per cent of the total energy consumed in most regions. In China, however, 80 per cent of all primary energy is derived from coal, representing 22.6 per cent of the world's coal consumption. This presents unique pollution problems associated with SO_2 and particulate matter. Similar pollution problems were common in industrialized countries until the 1950s and 1960s, when clean air legislation was introduced. It is predicted that coal will once again play an increasingly important role in energy production. World trade in coal has increased by 40 per cent since 1980.

Atmospheric pollution is a major problem facing all the countries of the world. Various chemicals are emitted into the air from both natural and man-made sources. Emissions from natural sources include those from living and non-living sources (e.g. plants, radiological decomposition, forest fires, volcanic eruptions and emissions from soil and water). These emissions lead to a natural background concentration that varies according to the local source of emission and prevailing weather conditions. People have caused air pollution since they learned how to use fire, but man-made air pollution (anthropogenic air pollution) has increased rapidly since industrialization began.

Research over the past two decades has revealed that, in addition to the previously known common air pollutants (SO_x, NO_x, particulate matter, hydrocarbons and carbon monoxide), many volatile organic compounds and trace metals are emitted into the atmosphere by human activities. Although our knowledge of the nature, quantity, physico-chemical behaviour and effects of air pollutants has greatly increased in recent years, more needs to be learned about the fate and transformation of different pollutants and about their combined (synergistic) effects on human health and the environment.

Data from the Global Environmental Monitoring System (GEMS) air project from 1980 to 1984 indicate that of 54 major cities, 27 have acceptable levels of SO2 in the air, among them Auckland, Bucharest, Bangkok, Toronto and Munich, with SO2 concentrations below 40mg/m3 (WHO established a range of 40-60mg/m3 as a guideline for exposure to avoid increased risk of respiratory diseases). Eleven cities, among them New York, Hong Kong and London, have marginal air quality, with SO2 concentrations between 40 and 60mg/m3. The remaining 16 cities, including Rio de Janeiro, Paris and Madrid, have unacceptable air quality, with SO2 concentrations exceeding 60mg/m3.

Data for 41 cities indicate that 8, including Frankfurt, Copenhagen and Tokyo, have acceptable air quality with respect to suspended particulate matter (SPM), with concentrations below 60mg/m3 (the WHO range is 60-90mg/m3). Ten cities, including Toronto, Houston and Sydney, have borderline concentrations of suspended particulate matter, between 60 and 90mg/m3, and 23 cities, including Rio de Janeiro, Bangkok and Tehran, have SPM concentrations exceeding 90mg/m3. The extraordinary levels in some cities in developing countries can be partially explained by natural dust; other culprits include the black, particulate-laden smoke spewed out by vehicles fuelled on low quality diesel without even rudimentary pollution control. The GEMS assessment concluded that nearly 900 million people living in

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urban areas around the world are exposed to unhealthy levels of SO_2 and more than 1 billion people are exposed to excessive levels of particulates.

Air pollution affects human health, vegetation and various materials in the following ways:

- The notorious sulphurous smog that occurred in London in 1952 and 1962 and in New York in 1953, 1963 and 1966 clearly demonstrated the link between excessive air pollution and mortality and morbidity. Such acute air pollution episodes occur from time to time in some urban areas. In January 1985, an air pollution episode occurred throughout western Europe. Near Amsterdam, the 24-hour average concentrations of suspended particulate matter and SO_x were both in the range 200-250$\mu g/m^3$, much higher than the WHO guideline values. During the episode, several people were affected; pulmonary functions in children were 3-5 per cent lower than normal. This dysfunction persisted for about 16 days after the episode. Athens is known for frequent acute air pollution episodes. Even in the absence of such episodes, long-term exposure to air pollution can affect several susceptible groups (the elderly, children and those with respiratory and heart conditions).

- Air pollution can cause substantial damage to many materials. The most striking examples of such damage are illustrated by the effects of air pollutants (especially SO_x) on historical buildings and monuments. The Acropolis, the Coliseum and theTaj Mahal withstood the influence of the atmosphere for hundreds or even thousands of years without any great damage, yet in the past few decades their surfaces have suffered great damage because of increased air pollution.

- Indoor air pollution has a number of effects. The sick building syndrome can cause a substantial amount of disease and absenteeism from work or school. Recently, attention has focused on the possible health hazards of radon emissions in houses.

- Emissions from the burning of biomass fuels, especially in rural areas of developing countries, are a major source of indoor air pollution. The most important identified

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adverse effects are chronic obstructive pulmonary disease and naso-pharyngeal cancer.

Questions

1 List three common air pollutants along with their chemical names or their acronyms.

2 What is the primary source of common air pollutants?

3 Name two air pollutants of special concern in cities.

4 Describe the health effects that result from burning biomass.

Answers

1. Carbon monoxide (CO), sulphur dioxide (SO_2), nitrogen oxides (NO_x).

2. Combustion of fossil fuels.

3. SO_2 and suspended particulate matter.

4. The most important effects are chronic obstructive pulmonary disease and naso-pharyngeal cancer.

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Toxic Chemicals and Hazardous Wastes

Selected and adapted, with permission, from *Saving Our Planet: Challenges and Hopes* (UNEP, 1992), pp.75-83.

Worldwide, about 10 million chemical compounds have been synthesized in laboratories since the beginning of the present century. Approximately 1 per cent of these—100,000 organic and inorganic chemicals—are produced commercially (the *European Inventory of Existing Commercial Chemical Substances* lists 110,000 chemicals). Between 1,000 and 2,000 new chemicals appear each year. Some of these chemicals, including pesticides and fertilizers, are used directly, but most of them are "basic" or "intermediate" chemicals used for the manufacture of millions of end-products for human use. There is virtually no sector of human activity that does not make use of chemical products, many of which have indeed benefitted man and his environment.

In recent years, however, there has been growing concern worldwide about the harmful effects of chemicals on human health and the environment. The deleterious effects of pesticides, vinyl chloride and polychlorinated biphenyls (PCBs) have been well documented since the 1960s. Over the past two decades many other substances have captured public attention, e.g. dioxin, methyl isocyanate, lead, mercury, other heavy metals and chlorofluorocarbons.

All chemicals are toxic to some degree. The health risk from a chemical is primarily a function of toxicity and exposure. Only a few parts per billion of a potentially toxic compound like dioxin may be sufficient to cause a health hazard following brief exposure. In contrast, only high doses of other compounds like iron oxide or magnesium carbonate pose problems after extended exposure. An important development in the past two decades has been the shift from a focus on just the acute health effects of chemicals to a focus on their chronic effects as well. These chronic effects, which include birth defects, genetic and neurological disorders and cancer, are of particular concern to the public, and this makes regulatory decisions both more visible and more difficult.

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Toxic chemicals are released into the environment directly as a result of human application (e.g. the use of pesticides, fertilizers and various solvents) and indirectly by waste streams from various human activities, such as mining, industrial processes, incineration and fuel combustion. The chemicals may be released in solid, liquid or gaseous form and the release may be to air, water or soil. The distribution and fate of chemicals in the environment is a highly complex process, governed by the physico-chemical properties of the chemicals and of the environment itself. Many chemicals do not remain confined to the vicinity of their sources of release and are transported locally, regionally or globally to cause widespread contamination of the environment. The use of pesticides in California, for example, led to fog contamination there; 16 pesticides and their alteration products have recently been found in fog far from the place where the pesticides were used. PCBs have been transported by the atmosphere from the places of their release in industrial countries to as far as the Arctic. Mainly because they eat contaminated fish and aquatic mammals, inhabitants of the Arctic are experiencing near-toxic levels of PCB exposure.

Other examples of such toxic substances that are distributed to distant places include DDT, mercury, lead, other metals and hexachlorocyclohexane. General concern about growing global chemical pollution is reflected in concern about the effects of chlorofluorocarbons and other chemicals on the ozone layer and of greenhouse gases on climate.

Wastes are substances or objects that are disposed of, intended to be disposed of, or required, by law, to be disposed of. Certain wastes produced by human activities are described as hazardous. Although the term has a different connotation in different countries. wastes containing metallic compounds. halogenated organic solvents, organohalogen compounds, acids, asbestos, organophosphorus compounds, organic cyanides. phenols or others are considered hazardous.

Most hazardous wastes are produced by industry, but it is now recognized that there are hundreds of thousands of small-quantity generators of hazardous wastes, each generating up to 1,000 kg of waste per month. These include households, medical facilities (their wastes are referred to as biomedical wastes), garages and auto-repair workshops, petrol stations and small-scale industries and businesses. In the United States, 115,000 such small-scale hazardous waste generators are now being regulated under the Resource Conservation and Recovery Act and the Hazardous and Solid Waste Amendment.

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It has been estimated that, worldwide, about 338 million tonnes of hazardous wastes are produced annually, of which 275 million tonnes, or 81 per cent, are produced in the United States alone. For comparison, hazardous waste generation in Singapore amounts to 28,000 tonnes per year, in Malaysia, 417,000 tonnes per year and in Thailand, 22,000 tonnes per year. It should be noted that these figures represent conservative estimates since many countries have no records of the amounts of wastes generated. This is particularly true for small-scale waste generators. The variable composition of the wastes adds to the problem (constituents that are considered hazardous in some countries may not be considered so in others). In general, most hazardous wastes are chemicals. In the European countries that are members of OECD, the main hazardous wastes are solvents, waste paint, heavy metals, acids and oily wastes.

The traditional low-cost methods of hazardous waste disposal are landfill, storage in surface impoundments and deep-well injection. Thousands of landfill sites and surface impoundments used for dumping hazardous wastes have been found to be entirely unsatisfactory. Corrosive acids, persistent organics and toxic metals have accumulated in these sites for decades. For example, the largest site identified in the United States is the Clark Fork Mining Complex in western Montana, where wastes from copper and silver mining and smelting activities have accumulated for 125 years. It is considered the largest hazardous waste dump in the world. At the time such sites were established, little thought was given to their environ- mental impacts. When leaks occurred, threatening public health and contaminating groundwater and soil, policy makers took remedial actions in response to growing public concern and pressure.

By 1990, the United States Environment Protection Agency (USEPA) had identified 32,000 sites in its inventory of potential hazardous sites; about 1,200 of these need immediate remedial action. In Europe, some 4,000 unsatisfactory sites have been identified in the Netherlands, 3,200 sites in Denmark and 50,000 sites in western Germany. Although some industrialized countries have initiated steps to clean up the problem sites, the cost of remedial action has been found to be very high. Estimates indicate that about US$ 30 billion are needed for remedial operations in the former Federal Republic of Germany, US$ 6 billion in the Netherlands and US$ 100 billion in the United States.

Other unsatisfactory dumping of hazardous wastes has exposed people directly to hazardous chemicals. Perhaps the most notorious incident of all was the outbreak of disease in the town of Minamata on Kyushu Island, Japan, in the 1950s and 1960s. Discharges from a chemical factory into the sea led to the contamination of fish by mercury. When the local people ate fish, thousands of them suffered neurological disorders. As a result of this and a similar incident at Niigata on the east coast of Honshu, about 400 people died. Although the dumping of waste at sea is controlled under international and regional conventions, several countries are still using this route for the disposal of hazardous wastes. Between 10 and 15 per cent of hazardous wastes produced in Europe are dumped at sea.

Questions

1 List two heavy metals of environmental concern.

2 Give three examples for the direct release of chemicals and three for their indirect release.

3 List some health effects associated with exposure to toxic chemicals.

Answers:

1 Lead, mercury.

2 Direct release: use of pesticides, fertilizers, solvents. Indirect release: mining, incineration, fuel combustion.

3 Cancer, birth defects, genetic and neurological disorders

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Acidification

Selected and adapted, with permission, from *Chemical Pollution: A Global Overview*, a joint publication of IRPTC and the Monitoring and Assessment Research Centre of GEMS, 1992, pp. 35-47.

Acidification, in an environment context, can be considered as a change towards more acidic conditions in one or more compartments of the biosphere or a reflection of the processes that bring this change about. This definition recognizes that, initially, acid deposition may be absorbed, even in sensitive areas, by the natural buffering capacity of the environment and that the onset of acid conditions in an environment may occur long after an increase in acid deposition.

The predominant anthropogenic source of acid-forming gases, primarily sulphur dioxide and nitrogen oxides, fossil fuel combustion; additional sources include metal ore smelting, sulphuric acid manufacture and other industrial processes. Other sources of acid-forming gases that may assume greater significance in less industrialized regions include the burning of biomass for fuel, deforestation and grassland management. The treatment, decomposition and incineration of human excreta and other wastes can release significant quantities of NO_x into the atmosphere or directly into watercourses. Similarly, the application of nitrogen fertilizers may affect soil pH levels.

A 1986 survey of the pH of precipitation over western Europe showed that typical Atlantic background values of pH, above 5.0, drop to less than 4.4 over Scandinavia. Similarly, a 1985 survey of North American precipitation showed pH values above 5.0 in the west of the continent, dropping to less than 4.2 in the northeast. Other regions of known high levels of acid deposition include the Czech Republic, Germany, Hungary and Slovakia, where the pH of the rainfall is typically 3.9-4.5. Evidence is also now available from south-western China (pH<3.5) and from tropical areas such as south-eastern Brazil (pH<4.0) and Venezuela (pH<4.0) that acid rain is occurring in developing countries. It appears that if the average pH of a station is below 5.0 the possibility of anthropogenic sources of acid

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deposition should be suspected; below an average pH of 4.5, the possibility becomes a probability.

The gradual onset of anthropogenic acidification and the concurrence with the growth of air pollution generally, as well as the episodic occurrence of natural climatic events, often makes it difficult to ascribe observed effects to acidification alone. Nevertheless, there is at least circumstantial evidence that acid deposition is implicated in the following effects:

- Acid deposition is suspected as one of the causal factors in the reported decline of European and North American forests. In the 1980s, a striking increase in foliar damage to plants, particularly the forest trees in Europe, was reported. European forest damage surveys provide strong circumstantial evidence for pollution-related foliar damage. It has been suggested that the level of damage observed in coniferous forest trees can be correlated with air pollution loading.

- Most countries in Europe have lakes and rivers that are susceptible to further acidification. There are also many river and lakes systems in Africa, Asia and South America with low pH and buffering capacity, which makes them potentially susceptible to acid rain. It is important to realize that fish may die not as a result of average conditions in streams but during short-lived acid flushes brought on by heavy rains after a dry spell or by the melting of snow, when water of high acidity melts first and causes very low pH levels in melt-water run-off.

- The impact of acidification on human health is both direct and indirect. Direct effects have been reported when acid sulphate aerosols come into contact with sensitive mucus membrane surfaces of the respiratory tract and lungs. For example, the bronchial clearance function has been shown to decline in adolescent asthmatics. In tests on animals, high long-term exposure leads to changes in surface cells and a narrowing of the airways.

- All materials suffer degradation from natural weathering processes, but air pollution has accelerated degradation rates since the mid-nineteenth century. Acidic deposition causes corrosion and tarnishing of metals; erosion and soiling of surface stone, brick and concrete; and erosion, discolouration and peeling of paint. Limestone and

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marble, which were commonly used in historic buildings and monuments, are also highly susceptible to damage by gaseous SO_x. Irreversible damage has also been caused to stained glass windows in historic churches. In the past remedial measures sometimes compounded the damaging effects. For example, corrosion of the iron rods used to strengthen limestone blocks has produced severe cracking of monumental structures.

Questions

1 What is the major cause of acid deposition?

2 What are the four main adverse effects of acid deposition?

Answers

1. Fossil fuel combustion

2. Decline in the forests, acidification of inland waters, direct and indirect impacts on human health and corrosion of metals and erosion of stone and paint.

Global Climate Change

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Selected and adapted, with permission, from *Saving Our Planet: Challenges and Hopes* (UNEP, 1992), pp. 25-40.

An important descriptor of climate is temperature. Sunlight heats up the sea and land. The warmed surface of the earth then radiates heat back towards space. On its way out, some of this heat (infrared radiation) is absorbed by trace gases in the atmosphere, notably CO_2 and water vapour, and thereby keeps the earth's temperature suitable for life. Without this natural greenhouse effect of CO_2 and water vapour, the temperature at the earth's surface would be some 33°C cooler than it is today, i.e. below the freezing point. The natural concentration of CO_2 in the atmosphere is controlled by the interactions of the atmosphere, the oceans and the biosphere in what is known as the geochemical carbon cycle. Human activities can disturb this cycle by injecting carbon dioxide into the atmosphere. This leads to a net increase in carbon dioxide concentration in the atmosphere, which enhances the natural greenhouse effect.

It had been thought that CO_2 was the only greenhouse gas. However, research over the last two decades has identified other gases such as nitrous oxide, methane, chlorofluorocarbons and tropospheric ozone as potential greenhouse gases.

The atmospheric CO_2 concentration is now 353 parts per million by volume (ppmv), 25 per cent greater than the pre-industrial (1750-1800) value of about 280 ppmv, and it is currently rising at about 0.5 per cent per year owing to anthropogenic emissions. The latter are estimated to amount to about 5,700 million tonnes of carbon per year due to fossil fuel burning, plus 600-2,500 million tonnes of carbon per year due to deforestation. Between 40 and 60 per cent of the CO_2 emitted into the atmosphere remains there, at least for the short term; the rest is taken up by natural sinks, particularly the oceans but also forests. Future atmospheric CO_2 concentrations depend on the amounts of CO_2 released from fossil fuel burning, which will be determined by the amount and type of energy sources to be used; the CO_2 released from biotic sources, which is determined by the rate of future deforestation and changes of other vegetative cover; and the uptake of CO_2 by various natural sinks. The Intergovernmental Panel on Climate

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Change (IPCC) has estimated that if anthropogenic emissions of CO_2 could be kept at present-day rates, atmospheric CO_2 would increase to 460-560 ppmv by the year 2100 because of the long residence time of CO_2 in the atmosphere and the long lead-time for its removal by natural sinks.

Over the past 100 years, the atmospheric CO_2 concentration increased by about 25 per cent. A range of model calculations suggests that the corresponding equilibrium temperature rise should be 0.5°-1.0°C. If this is corrected for the effects of the thermal inertia of the oceans, which slows down climate change for a period of 10-20 years, the changing composition of the atmosphere should have produced a warming of 0.35°-0.7°C superimposed on the natural fluctuations of the atmosphere.

Detailed analysis of temperature records of the past 100 years indicates that the global mean temperature has risen by 0.3°-0.6°C. Much of the warming since 1900 has been concentrated in two periods, the first between about 1910 and 1940 and the other since 1975; the five warmest years on record were all in the 1980s. The size of the warming over the last century is broadly consistent with the predictions of climate models, but is also of the same mag- nitude as natural climate variability.

The main impacts of climate change are as follows:

- Sufficient evidence is now available to indicate that changes in climate would have an important effect on agriculture and livestock. Negative impacts could be felt at the regional level as a result of changes in weather (e.g. more frequent and more severe storms) and the arrival of pests associated with climate change, necessitating innovations in technology and agricultural management practices. There may be a severe decline in production in some regions (e.g. Brazil, the Sahel region of Africa, South-East Asia, the Asian region of the former Soviet Union and China), but there may be an increase in other regions because of a prolonged growing season.

- Natural terrestrial ecosystems could face significant consequences as a result of climate changes. Their evolution would lag behind these climate shifts: they might survive in their location but flora and fauna could find themselves, in effect, in a different climatic regime. These regimes may be more or less hospitable and could increase the productivity of some species and decrease that of others.

- Relatively small changes in climate can cause large water resource problems in many areas, especially in semi-arid regions and in those humid areas where demand or pollution has led to water scarcity.

- Global warming will accelerate the rise in sea level, modify ocean circulation and change marine ecosystems, with considerable socio-economic consequences. The IPCC predicted that under the business-as-usual scenario, an average rise in the global mean sea level of about 6 cm per decade could occur over the next century. The predicted rate would mean a 20 cm rise in global mean sea level by 2030 and 65 cm by the end of the century.

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Questions

1 Name five greenhouse gases.

2 Which of these causes the most harm?

3 Name two natural carbon sinks.

Answers

1. CO_2, nitrous oxide, methane, CFCs and tropospheric ozone.

2. CO_2

3. The ocean and the forests.

Ozone Depletion

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Selected and adapted, with permission, from *Saving Our Planet: Challenges and Hopes* (UNEP, 1992). pp. 25-40.

In contrast to the harmful ozone formed as a photochemical oxidant at ground level (tropospheric ozone), ozone in the stratosphere, between 25 and 40 km above the earth's surface, is the natural filter that absorbs and blocks the sun's short-wavelength ultraviolet (UV-B) radiation, which is harmful to life.

Ozone exists in equilibrium in the stratosphere, balanced between formation from molecular oxygen and destruction by ultraviolet radiation. The presence of reactive chemicals in the stratosphere, such as the oxides of hydrogen, nitrogen and chlorine, can accelerate the process of ozone destruction and therefore upset the natural balance. leading to a net reduction of the amount of ozone. These chemicals can participate in many ozone-destroying reactions before they are removed from the stratosphere.

In 1974, it was found that man-made CFCs. although inert in the lower atmosphere, can survive for many years and migrate into the stratosphere. There, they are destroyed by ultraviolet radiation, releasing atomic chlorine. which attacks the stratospheric ozone layer. This leads to another reaction that regenerates atomic chlorine. which in turn destroys more stratospheric ozone. This chain reaction can cause the destruction of as many as 100.000 molecules of ozone per single atom of chlorine.

CFCs are used as propellants and solvents in aerosol sprays; fluids in refrigeration and air-conditioning equipment; foam-blowing agents in plastic foam production; and solvents, mainly in the electronics industry. Studies in the 1980s showed that emissions of bromine can also lead to a significant reduction in stratospheric ozone. Bromofluorocarbons (halons 1211 and 1301) are widely used to extinguish fires. and ethylene dibromide and methyl bromide are used as fumigants.

The concentration of chlorine in the stratosphere is set mainly by anthropogenic sources of CFCs. carbon tetrachloride

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and methylchloroform. Methyl chloride is the only natural organochlorine compound found in the atmosphere. The concentration of chlorine in the atmosphere due to methyl chloride has remained unchanged since perhaps 1900. The major additions of chlorine to the atmosphere have occurred mainly since 1970 and have been attributed to anthropogenic sources. At present the total chlorine in the atmosphere due to organochlorine compounds is approaching 4.0 parts per billion by volume (ppbv), a 2.6-fold increase in only 20 years.

UV-B radiation is known to have a multitude of effects on humans, animals, plants and materials:

- Exposure to increased UV-B radiation can suppress the body's immune system, which might lead to an increase in the occurrence or severity of infectious diseases such as herpes, leishmaniasis and malaria and a possible decrease in the effectiveness of vaccination programmes. En- hanced levels of UV-B radiation can lead to increased damage to the eyes, especially cataracts, and to an increase in the incidence of non-melanoma skin cancer.

- Plants vary in their sensitivity to UV-B radiation. Some crop species, such as peanut and wheat, are fairly resistant, while others, such as lettuce, tomato, soybean and cotton, are sensitive. UV-B radiation alters the reproductive capacity of some plants and also the quality of harvestable products, seriously affecting food production in areas that already suffer acute shortages.

- Increased UV-B radiation has negative effects on aquatic organisms, especially small ones such as phytoplankton, zooplankton, larval crabs and shrimp, and juvenile fish. Because many of these small organisms are at the base of the marine food web, increased UV-B exposure may have a negative effect on the productivity of fisheries.

Questions

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1 **What are the two kinds of ozone? What is the difference between them?**

2 **How do CFCs affect the ozone layer?**

3 **Name six uses of ozone-depleting substances.**

4 **Name four adverse health and environmental risks resulting from increased UV-B radiation.**

Answers

1. Tropospheric ozone exists at the ground level and is harmful. Stratospheric ozone exists between 25 and 40 km above the earth's surface and serves as a filter against ultraviolet radiation.

2. They are destroyed by ultraviolet radiation and the resulting elements destroy the stratospheric ozone (chemical chain reaction).

3. Aerosol sprays, solvents, foam production, fire extinguishers, refrigerator fluids and fumigants.

4. Negative effects on the human immune system, on maritime organisms and on some plants, and increased risk of skin cancer.

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Next Steps

A glossary of environmental terms is provided at the end of this Learning Unit. Read through the definitions in the glossary and then answer the questions below.

Exercise

Locate the technical term for each of the following in the glossary:

1 The level of atmospheric pollutants prescribed by regulations that may not be exceeded during a specified time in a defined area.

2 The amount of oxygen consumed in the biological processes that break down organic matter in water.

3 Treating pollutants at the end of a process, by filters, catalysts or scrubbers, instead of preventing their occurrence.

4 The slow aging process in which a lake, estuary or bay becomes a bog or marsh and eventually disappears.

5 A site used to dispose of solid wastes without environmental controls.

6 Minimizing the generation of waste by recovering usable products that might otherwise become waste.

7 A pollutant remaining in the environment after a natural or technological process has taken place.

8 An air pollution control device that uses a spray of water or reactant or a dry process to trap pollutants in emissions.

9 Market mechanism for controlling pollution; it entails issuing permits to pollute up to fixed limits and grants the right to sell unused portions of these permits.

Answers

1. Air quality standard
2. Biochemical oxygen demand
3. End-of-pipe treatment
4. Eutrophication
5. Dump
6. Recycling
7. Residual
8. Scrubber
9. Tradeable permits.

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Additional Suggested Reading

This concludes the study section of Learning Unit 2. For additional information on global environmental problems, you may refer to the following sources.

UNEP, *The World Environment 1972-1992: Two Decades of Challenge*, M.K. Tolba and others, eds. (London, Chapman and Hall, 1992).

UNIDO, *Industry and Development: Global Report 1990/91* (UNIDO publication, Sales No. E.90.III.E.12), chap. III.

WCED, *Sustainable Development—A Guide to Our Common Future: The Report of the World Commission on Environment and Development* (Geneva, The Centre for Our Common Future, 1990).

World Resources Institute, *World Resources 1992-93: A Guide to the Global Environment* (New York, Oxford University Press, 1992).

Case Studies

Next Steps

1 Study the case below, adapted from UNIDO, *Industry and Development: Global Report* 1990/91 (UNIDO publication, Sales No. E.90.III.E.12), pp.132-133, and answer the questions that follow, if possible working in a small group.

2 Compare your answers with those suggested.

Case Study 1: Metal Contaminants in Poland

Industrial pollution problems encountered in the region around Katowice, Poland, situated 250 km south of Warsaw, adjacent to the Czech Republic, may typify the severity of environmental damage caused by industrial pollution in other highly industrialized regions of eastern Europe. Most of the so-called dirty-process plants in Poland are concentrated in the Katowice region. The bulk of these plants use out-of-date technologies.

This region accounts for nearly all the zinc and lead minerals mined and processed in Poland, 98 per cent of the hard coal produced, 52 per cent of the steel and 31 per cent of the coke manufactured, and 32 per cent of the coal-fired electric power generated. All these activities occur in an area that covers 2.1 per cent of Poland. As a result, more than 20 out of 54 pollutants listed by the Council of Ministers of Poland exceeded national standards in the Katowice region; worse yet, many of these pollutants have annual average

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concentrations that exceed the national standards by 500-2,000 per cent.

Air and water pollutants in the Katowice region contain a large variety of hazardous substances, including carcinogenic compounds, hydrogen cyanide, phenol and heavy metals. The Institute of Environmental Protection at Katowice recently measured the exposure of the local population (10 per cent of the Polish population live in that region) to two toxic metals, lead and cadmium, by the consumption of vegetables grown in the metal-contaminated soils of the region.

Lead is known to be harmful to the circulatory system and to cause neurological disorders. The main sources of lead emission is non-ferrous metallurgical plants, mainly zinc and lead smelters in this region. Other sources, such as iron and steel plants (mainly open-hearth furnaces) and automobiles, are also important. Cadmium is known to damage the lungs, blood, liver and kidneys. The main sources of cadmium emission are zinc smelting plants (cadmium is a trace element in zinc ores). Not surprisingly, the highest concentrations of cadmium are found around such plants in the Katowice region.

To estimate the average weekly per capita intake of lead and cadmium through vegetable consumption by the local population, a study was conducted covering 431 vegetable plots in the Katowice region, on the basis of a random sample of the most commonly consumed vegetables from each plot, that is, carrots, parsley, celery, red beets and potatoes. From each selected plot, 30-50 sample vegetables were picked, washed as normally done in households, dried, ground and mineralized, and then the metal content for each vegetable was measured.

The sample results show that vegetable leaves are, not surprisingly, more readily exposed to metal contamination than roots. Thus, the highest concentrations were found in celery leaves and parsley leaves, followed by celery roots, carrot roots, red-beet roots, parsley roots and potatoes. The study group also estimated the average weekly per capita consumption of selected vegetables from a sample survey of 205 households in the Katowice region to arrive at the weekly intake of lead and cadmium through vegetable consumption. The estimates of weekly vegetable consumption and weekly metal intake are given below. Particularly notable is a very high per capita consumption of potatoes, around 2 kg per week.

Metal Consumption from Selected Vegetables in the Katowice Region

District	Metal	Weekly metal intake (mg)
Katowice	Lead	2.80
	Cadmium	0.71
Chorzow	Lead	3.30
	Cadmium	0.81
Zabkowice	Lead	3.50
	Cadmium	0.99

Source: R. Kucharski and E. Marchwinska, "Exposure of edible and pasture plants and consumers in the Katowice District", Institute of Environmental Protection (Katowice, 1990).

Given the maximum concentration limits, recommended by the Food and Agriculture Organization of the United Nations (FAO) and WHO, of 3 mg per week for lead and 0.4-0.5 mg for cadmium, the estimated lead intakes of the local population all exceeded the desired limits except in the Katowice region. Cadmium intakes are almost twice the maximum limits for all districts. These estimates of metal intake are based on the measurement of metal concentrations in a small number of selected vegetables grown in the region and exclude the local consumption of many other vegetables and fruits that may be exposed to metal contamination, as well as intakes from other sources such as inhalation of air-borne pollutants and consumption of contaminated livestock products. They are, therefore, likely to be considerable underestimates.

These results are much more shocking than comparable results obtained from west European countries. Investigations carried out in Austria, Belgium, Denmark, France and the Federal Republic of Germany in 1979-1982 showed that the weekly per capita consumption of vegetables, fruits and corn products resulted in an intake of between 0.5 and 1.5 mg of lead and between 0.11 and 0.34 mg of cadmium. The intakes of lead and cadmium in the Katowice region are several times higher than comparable figures in west European countries.

The study showed that the thorough washing of vegetables in tap water reduced their lead content by over 20 per cent but had little effect on their cadmium content. Peeling root vegetables also removed some of the metals: 20 per cent of the lead and 20-30

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per cent of the cadmium. Over 90 per cent of lead and cadmium was removed from potatoes and deposited in the waste when potatoes were subjected to alcoholic fermentation. These contaminated wastes are, however, often fed to livestock as a fodder in the Katowice region.

Given the relatively large quantities of potatoes consumed in Poland as a staple food (the per capita weekly consumption ranges between 2 and 5 kg, nearly twice the consumption in other countries), scientists at the Institute of Environmental Protection at Katowice investigated lead and cadmium concentration in raw potato samples from 13 regions in Poland. Four of these regions, including the Katowice region, are highly industrialized and the remaining nine are less so. As expected, all the districts in the Katowice region as well as the region as a whole showed much higher concentrations of lead and cadmium than other regions. In fact, most of the districts in the Katowice region greatly exceeded the maximum tolerance limits set by the Gov- ernment of Poland for lead and cadmium concentrations in potatoes, 0.4 and 0.6 mg/kg of potatoes, respectively. By contrast, lead and cadmium concentrations in raw potatoes in other regions of Poland appear to be less serious, with a few exceptions.

Questions

1 What activities are most likely to be responsible for the high emissions of lead in the Katowice region? For cadmium?

2 Are the estimates of lead and cadmium consumption produced by this survey likely to be close to the actual levels of lead and cadmium consumed? Why or why not?

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3 Do you think that the people of Poland can reduce their consumption of lead and cadmium significantly if they wash their vegetables? Why or why not? Can you suggest any other things that the people might do to reduce lead and cadmium content of their vegetables?

Answers

1 The main sources of lead emissions are non-ferrous metallurgical plants, mainly zinc and lead smelters in the region. Other sources such as iron and steel plants (mainly open-hearth furnaces) and automobiles are also important. The main source of cadmium emissions are zinc smelting plants, as cadmium is a trace element in zinc ores. Not surprisingly, the highest concentrations of cadmium are found around zinc-processing plants in the Katowice region.

2 These estimates of metal intake are based on the measurement of metal concentrations in a small number of selected vegetables grown in the region and exclude local consumption of many other vegetables and fruits that may be exposed to metal contamination as well as intakes from other sources such as inhalation of air-borne pollutants and consumption of contaminated livestock products. They are, therefore, likely to be considerably underestimated.

3 The study showed that the thorough washing of vegetables in tap water reduced their lead content by only 20 per cent and had little effect on their cadmium content. Peeling root vegetables also removed some of the metals: 20 per cent of the lead and 20-30 per cent of the cadmium. Over 90 per cent of the lead and cadmium was removed from potatoes and deposited in the waste when potatoes were subjected to alcoholic fermentation. These contaminated wastes were, however, often fed to livestock as a fodder in the Katowice region.

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Case Study 2: Industrial Pollution in Pakistan

Next Steps

1 Read the excerpt from *The Pakistan National Conservation Strategy*, included in this Learning Unit.

2 Prepare a table like that outlined on the opposite page summarizing the principal industries that contribute to pollution in Pakistan and the environmental problems they create. If it is possible to get the relevant information (from, for example, a national report to UNCED), prepare a table for your own country. Obviously, no single correct answer can be provided for this assignment.

Industrial Pollution Problems in Pakistan

Media	Polluting industries	Major pollutants	Environmental problems
Water			
Air			
Land			

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Review

Test

The following test will help you review the material presented in Learning Unit 2.

1 The developing countries' share of industrial output in 1990 was approximately

a. 10 per cent
b. 15 per cent
c. 20 per cent
d. 25 per cent

2 The region with the highest growth rate in industrial output in 1970-1990 was

a. Developed countries
b. East Asia South-East Asia
c. Latin America
d. Africa

3 The region with the lowest growth rate in industrial output in 1970-1990 was

a. Developed countries
b. East Asia South-East Asia
c. Latin America
d. Africa

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4 In developing countries, the main cause(s) of pollution is (are) usually

a. Old heavy industry
b. Population, poverty and agriculture
c. Women
d. Business

5 Industry uses approximately

a. One fifth of the world's energy
b. One quarter of the world's energy
c. One third of the world's energy
d. One half of the world's energy

6 Emissions of CO_2 from fossil fuel burning are a major cause of

a. Greenhouse effect
b. Aquatic system damage
c. Ozone depletion
d. All of the above

7 Emissions of CFCs come from

a. Refrigerators
b. Solvents
c. Foams
d. All of the above

8 Increases in UV-B radiation, as a result of the destruction of the ozone layer, contribute to all of the following effects except

a. Suppression of the body's immune system
b. Alteration of the reproductive capacity of plants
c. Non-melanoma skin cancer
d. Leukemia

9 Acid rain results primarily from emissions of

a. Sulfur dioxide
b. Nitrogen oxides
c. Hydrocarbons
d. Particulate matter

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10 Which of the following is not a toxic heavy metal?

a. Mercury
b. Lead
c. Cadmium
d. Dioxin

11 The most polluting fuel per unit energy is

a. Oil
b. Coal
c. Nuclear
d. Natural gas

12 The official name of the report prepared by WCED is

a. Brundtland Report
b. *Saving Our Planet*
c. *Our Common Future*
d. *Sustainable Development*

13 The WCED called for

a. Zero economic growth
b. Economic growth that is equitable and compatible with the environment
c. Large-scale financial transfers to developing countries
d. Preservation of the world's resources

14 Which percentage (approximately) of world income did 80 percent of the world population receive in 1992?

a. 30
b. 20
c. 40
d. 50

15 The challenge for industry is how to reconcile environment with projected

a. Growth of population and gross national product (GNP) per capita
b. Growth of technology
c. Pollution
d. Growth of industrial output

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Answers

1-5 bbcbc

6-10 addad

11-15 bcbbd

Some Ideas to Think About

The following are some additional questions about the environment. Take some time to think about them. If possible, work in a small group and try to achieve a consensus.

1 Which pollution do you find most disturbing? Why?

2 If the earth's axis were to tip by just two degrees, would it make any difference to the environment and the world of business?

3 Is zero pollution possible in old or new industries?

4 Should a developing country have lower environmental standards than developed countries?

5 Which is more fragile, the environment or mankind?

Glossary of Environmental Terms

Acid deposition. A complex chemical and atmospheric phenomenon that occurs when emissions of sulfur and nitrogen compounds and other substances are transformed by chemical processes in the atmosphere, often far from the original sources, and then deposited on earth in either a wet or dry form. The wet forms, popularly called acid rain, can fall as rain, snow or fog. The dry forms are acidic gases or particulates.

Acid rain. See Acid deposition.

Air quality standards. The level of pollutants prescribed by regulations that may not be exceeded during a specified time in a defined area.

APELL. Awareness and Preparedness for Emergencies at a Local Level, UNEP training courses offerred by the Industry and Environment Programme Activity Centre of UNEP.

Assimilation. The ability of a body of water to purify itself of pollutants.

Basel Convention. The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1989) aims to control the transboundary movement and disposal of hazardous wastes.

BATNEEC. Best available techniques not entailing excessive cost.

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Baghouse filter. Large fabric bag, usually made of glass fibers, used to eliminate intermediate and large (greater than 20 microns in diameter) particles. This device operates in a way similar to the bag of an electric vacuum cleaner, passing the air and smaller particular matter while entrapping the larger particulates.

Biochemical oxygen demand (BOD). A measure of the amount of oxygen consumed in the biological processes that break down organic matter in water. The greater the BOD, the greater the pollution.

Biodegradable. The ability to break down or decompose rapidly under natural conditions and processes.

Biological magnification. Refers to the process whereby certain substances such as pesticides or heavy metals move up the food chain, work their way into a river or lake and are eaten by aquatic organisms such as fish, which in turn are eaten by large birds, animals or humans. The substances become concentrated in tissues or internal organs as they move up the chain.

Biological oxidation. The way bacteria and micro-organisms feed on and decompose complex organic materials. Used in self-purification of water bodies and in activated sludge waste-water treatment.

Biological treatment. A treatment technology that uses bacteria to consume waste. This treatment breaks down organic materials.

Biosphere. The portion of the earth that supports life, including the surface waters and the air. Similar to ecosphere.

Biotechnology. Techniques that use living organisms or parts of organisms to produce a variety of products, from medicines to industrial enzymes, to improve plants or animals or to develop micro-organisms for specific uses such as removing toxics from bodies of water or killing pests.

Brunddland Report. Popular name for report produced in 1987 by the World Commission on Environment and Development. This United Nations-sponsored body produced a global agenda for change and specified how sustainable development could be achieved. The commission was chaired by Gro Harlem Brundtland, the then—and subsequently re-elected—Prime Minister of Norway. LU2

Cadmium. Toxic heavy metal used mainly for metal plating and as a plastic pigment. Significant by-product in zinc smelting and concern in phosphate manufacture.

Carbon cycle. The circulation of carbon in the biosphere. Carbon is an essential part — a building block — of the molecules that make up all living cells. In the atmosphere it circulates as carbon dioxide, which is released by respiration, combustion and decay and fixed in complex carbon compounds during photosynthesis in plants and certain micro-organisms.

Carbon dioxide (CO_2). A colorless, odorless, non-poisonous gas that results from respiration, combustion and decay and is normally a part of the ambient air.

Carbon sink. See Sink.

Carcinogen. Any substance that can cause or contribute to the onset of cancer.

Catalytic converter. An air pollution abatement device that removes pollutants from motor vehicle exhaust, either by oxidizing them into carbon dioxide and water or reducing them to nitrogen and oxygen.

Chemical oxygen demand (COD). A measure of oxygen required to oxidize all compounds in water, both organic and inorganic.

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Chlorofluorocarbons (CFCs). A family of inert, nontoxic and easily liquefied chemicals used in refrigeration, air conditioning, packaging and insulation or as solvents and aerosol propellants. Because CFCs are not destroyed in the lower atmosphere they drift into the upper atmosphere, where their chlorine components destroy ozone.

Cleaner Production. A concept of industrial production that minimizes all environmental impacts through careful management of resource use, of product design and use, systematic waste avoidance and management of residuals, safe working practices and industrial safety. Sometimes called pollution prevention or waste minimization.

Clean technologies. Production processes or equipment with a low rate of waste production. Treatment or recycling plants are not classed as clean technologies.

Cradle-to-grave. Term used to imply the whole life cycle of a product, from raw material to final disposal.

DDT. The first chlorinated hydrocarbon insecticide (chemical name: dichlorodiphenyltrichloroethane). It has a half-life of 15 years and can collect in fatty tissues of certain animals. USEPA banned registration and interstate sale of DDT for virtually all but emergency uses in the United States in 1972 because of its persistence in the environment and accumulation in the food chain.

Dilution ratio. The relationship between the volume of water in a stream and the volume of incoming water. If affects the ability of the stream to assimilate waste.

Dioxin. Any of a family of compounds known chemically as dibenzo-*p*-dioxins. They are of concern because of their potential toxicity and contamination in commercial products. Tests on laboratory animals indicate that dioxins are among the more toxic man-made chemicals known.

Disposal. Final placement or destruction of toxic, radioactive or other wastes; surplus or banned pesticides or other chemicals; polluted soils; and drums containing hazardous materials from removal actions or accidental releases. Disposal may be accomplished through use of approved secure landfills, surface impoundments, land farming, deep well injection, ocean dumping or incineration.

Dissolved oxygen (DO). The oxygen freely available in water. Dissolved oxygen is vital to fish and other aquatic life and for the prevention of odors. Traditionally, its level has been accepted as the single most important indicator of a water body's ability to support desirable aquatic life. Secondary and advanced waste treatment are generally designed to protect DO in waste-receiving waters.

Dump. A site used to dispose of solid wastes without environmental controls.

Eco-capacity. Refers, on the one hand, to the capacity of an ecosystem to be resilient, that is, to maintain its patterns of behaviour in the face of disturbance and, on the other hand, to its capacity to remain stable, that is, to maintain its equilibrium in response to normal fluctuations in the environment.

Eco-efficiency. Maximization of industrial output from a given level of resource input, thus ensuring waste minimization and appropriate use of human, renewable and non-renewable resources.

Ecology. The relationship of living things to one another and their environment, or the study of such relationships.

Ecologically sustainable industrial development (ESID). Patterns of industrialization that enhance the contribution of industry to economic and social benefits for present and future generations without impairing basic ecological processes.

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Ecosystem. The interacting system of a biological community and its non-living environmental surroundings.

EEIS. Energy and Environment Information System.

End-of-pipe treatment (abatement). Treating pollutants at the end of a process (by, for example, filters, catalysts and scrubbers) instead of preventing their occurrence.

Environment. The sum of all external conditions including physical and social factors, affecting the life, development and survival of an organism.

Environmental compliance audit. Systematic review and testing by professional environmental auditors of the management, production, marketing, product development and organizational systems of an enterprise to determine and assess compliance with environmental regulations.

Environmental impact assessment. An analysis to determine whether an action would significantly affect the environment.

Equity. 1. The opportunity for all countries to share the wealth of industrial development at present, i.e. intra-generational equity. 2. Equal opportunity for present and future generations to share such wealth, i.e intergenerational equity.

Eutrophication. The slow aging process in which a lake, estuary or bay becomes a bog or marsh and eventually disappears. During the later stages of eutrophication the water body is choked by overabundant plant life as the amounts of nutritive compounds such as nitrogen and phosphorus increase. Human activities can accelerate the process.

Externality. The cost or benefits to parties other than the supplier and the purchaser of an economic transaction.

FAO. Food and Agriculture Organization of the United Nations.

GDP. Gross domestic product. The total market value of all the goods and services produced within a nation (excluding income from abroad) during a specified period.

GEMS. Global Environment Monitoring System, managed by UNEP. Makes comprehensive assessments of major environmental issues and thus provides the scientific data needed for the rational management of natural resources and the environment; provides early warning of environmental changes by analyzing monitoring data.

Global warming. The consequences of the greenhouse effect, caused by rising concentrations of greenhouse gases. The suspicion is that global warming will disrupt weather and climate patterns. It could lead to drought in some areas and flooding in others. One of the most serious environmental problems facing the world.

GNP. Gross national product. The total market value of all the goods and services produced by a nation (including income from abroad) during a specified period.

Good housekeeping. Efficient management of the property and equipment of an institution or organization. In the context of Cleaner Production, it often refers to the procedures applied in the operation of a production process.

Greenhouse effect. The warming of the earth's atmosphere, caused by a build-up of carbon dioxide or other trace gases. It is believed by many scientists that this build-up allows light from the sun's ray to heat the earth but prevents a counterbalancing loss of heat.

Greenhouse gases. The gases, such as carbon dioxide, water vapor, methane, nitrous oxides and CFCs, that trap the sun's heat in the lower atmosphere and prevent it from escaping into space.

Major source of increased concentration in the atmosphere is the combustion of fossil fuels. See **Greenhouse effect**.

Groundwater. The supply of fresh water found beneath the earth's surface (usually in aquifers) that is often used for supplying wells and springs. Because groundwater is an important source of drinking water, there is growing concern about areas where agricultural or industrial pollutants or substances from leaking underground storage tanks are contaminating groundwater.

Halons. Bromine-containing compounds with long atmospheric lifetimes whose breakdown in the stratosphere can cause depletion of ozone. Halons are used in fire-fighting.

Hazardous waste. By-products of society that can pose a substantial hazard to human health or the environment when improperly managed. Characterized by at least one of the following: ignitability, corrosivity, reactivity or toxicity.

Heavy metals. Metallic elements with high atomic weights, e.g. mercury, chromium, cadmium, arsenic and lead. They can damage living things at low concentrations and tend to accumulate in the food chain.

Hydrocarbon (HC). Chemical compounds consisting entirely of carbon and hydrogen.

ICC. International Chamber of Commerce.

ICPIC. International Cleaner Production Information Clearinghouse.

IDA. Industrial Development Abstracts database of INTIB.

IE/PAC. Industry and Environment Programme Activity Centre of UNEP, in Paris; formerly called the Industry and Environment Office.

ILO. International Labour Organisation of the United Nations.

Incineration. 1. Burning of solid, liquid or gaseous materials. 2. A treatment technology involving destruction of waste by controlled burning at high temperature, e.g. burning sludge to remove the water and reduce the remaining residues to a safe, non-burnable ash that can be disposed of safely on land, in some waters or in underground locations.

INEM. International Environmental Management Association. Coordinates and supports national associations of environmentalist business management associations or business enterprises. Described in the European Community publication *Business and Environment*.

INTIB. Industrial and Technological Information Bank of UNIDO.

IPCC. Intergovernmental Panel on Climate Change.

IRPTC. International Register of Potentially Toxic Chemicals, at Geneva. A cooperative activity of UNEP WHO ILO. Maintains a global system for assessing environmental effects of chemicals. Topics include identification of knowledge gaps; chemical hazards; evaluation and control of chemicals in the environment; numerical data: production, use and characteristics of chemicals; laws and regulations affecting man, living species and natural resources.

Landfills. 1. Sanitary landfills are land disposal sites for non-hazardous solid wastes, where the waste is spread in layers, compacted to the smallest practical volume and cover material applied at the end of each operating day. 2. Secure chemical landfills are disposal sites for hazardous waste. They are selected

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and designed to minimize the chance of hazardous substances being released into the environment.

Leachate. A liquid produced when water collects contaminants as it trickles through wastes, agricultural pesticides or fertilizers. Leaching may occur in farming areas, feedlots or landfills and may result in hazardous substances entering surface water, groundwater or soil.

Media. Specific environments—air, water, soil—that are the subject of regulatory concern and activities.

Mercury. A heavy metal that can accumulate in the environment and is highly toxic if breathed or swallowed. See **Heavy metals.**

Minimization. Actions to avoid, reduce or in other ways diminish the hazards of wastes at their source. Recycling is, strictly speaking, not a minimization technique but is often included in such programmes for practical reasons.

Minamata. A fishing village in Japan. In the 1950s and 1960s the people who lived there were poisoned by mercury pumped into the bay by a local company. The mercury was absorbed by fish later eaten by the people. The mercury caused nervous disorder in adults and cerebral palsy in children.

Montreal Protocol. The Montreal Protocol on Substances that Deplete the Ozone Layer, adopted 16 September 1987, sets limits for the production and consumption of damaging CFCs and halons.

MVA. Manufacturing value added.

NGO. Non-governmental organization. Examples are Greenpeace, International Chamber of Commerce, International Environmental Management Association and many others.

NIMBY. Acronym for "not in my back yard." Political jargon to describe a situation in which the electorate might agree to, say, industrial dumping or incineration, as long as it does not take place near their homes.

Nitrate. A compound containing nitrogen that can exist in the atmosphere or as a dissolved gas in water and that can have harmful effects on humans and animals. Nitrates in water can cause severe illness in infants and cows.

Non-point source. Pollution sources that are diffuse and do not have a single point of origin or are not introduced into a receiving stream from a specific outlet. The pollutants are generally carried off the land by storm-water run-off. The commonly used categories for non-point sources are agriculture, forestry, urban areas, mining, construction, dams and channels, land disposal and salt-water intrusion.

NO_x. Chemical formula that stands for all the oxides of nitrogen, mainly NO_2, but also N_2O, NO, N_2O_3, N_2O_4 and NO_3, which is unstable.

Nutrient. Any substance assimilated by living things that promotes growth. The term is generally applied to nitrogen and phosphorus in waste water but is also applied to other essential and trace elements.

OECD. Organization for Economic Cooperation and Development. Twenty-four countries, all market economies, are members: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States. It collects and analyzes information, including data on environmental degradation and spending on environmental protection.

Off-site facility. A hazardous waste treatment, storage or disposal area that is located away from the generating site.

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Ozone (O_3). Found in two layers of the atmosphere, the stratosphere and the troposphere. In the stratosphere (the atmospheric layer beginning 7-10 miles above the earth's surface), ozone is a form of oxygen found naturally which provides a protective layer, shielding the earth from ultraviolet radiation's harmful health effects on humans and the environment. In the troposphere (the layer extending up 7-10 miles above the earth's surface), ozone is a chemical oxidant and a major component of photochemical smog. Ozone can seriously affect the human respiratory system and is one of the most prevalent and widespread pollutants. Ozone in the troposphere is produced through complex chemical reactions between nitrogen oxides, which are among the primary pollutants emitted by combustion sources, hydrocarbons, which are released into the atmosphere by the combustion, handling and processing of petroleum products, and sunlight.

Ozone depletion. Destruction of the stratospheric ozone layer, which shields the earth from ultraviolet radiation harmful to life. This destruction of ozone is caused by certain chlorine- and/or bromine-containing compounds (chlorofluorocarbons or halons), which break down when they reach the stratosphere and catalyse the destruction of ozone molecules.

PCBs. A group of toxic, persistent chemicals (chemical name: polychlorinated biphenyls) used in transformers and capacitators for insulating purposes and in gas pipeline systems as a lubricant.

Phenols. Organic compounds that are by-products of petroleum refining, tanning and the manufacture of textiles, dyes and resins. Low concentrations cause taste and odour problems in water; higher concentrations can kill aquatic life and humans.

Phosphates. Certain chemical compounds containing phosphorus.

Phosphorus. An essential chemical food element that can contribute to the eutrophication of lakes and other water bodies. Increased phosphorus levels result from discharge of phosphorus-containing materials into surface waters.

Photochemical smog. Air pollutant formed by the action of sunlight on oxides of nitrogen and hydrocarbons.

Pollutant. Generally, any substance introduced into the environment that has the potential to adversely affect the water, soil or air. See **Residual**.

Pollution. Generally, the presence of matter or energy whose nature, location or quantity produces undesired environmental effects.

PVC. A tough, environmentally indestructible plastic (chemical name: polyvinyl chloride) that releases hydrochloric acid when burned.

Recycling. The process of minimizing the generation of waste by recovering usable products that might otherwise become waste. Examples are the recycling of aluminium cans, waste paper and bottles.

REED. Referral Database on Energy and Environment.

Residual. A pollutant remaining in the environment after a natural or technological process has taken place, e.g. the sludge remaining after initial waste-water treatment or particulates remaining in air after the air passes through a scrubbing or other pollutant removal process.

Risk assessment. The qualitative and quantitative evaluation performed in an effort to define the risk posed to human health and/or the environment by the presence or potential presence and/or use of specific pollutants.

Scrubber. An air pollution control device that uses a spray of water or reactant or a dry process to trap pollutants in emissions.

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Sink. In air pollution, the receiving area for material removed from the atmosphere, e.g. by virtue of photosynthesis plants are sinks for carbon dioxide.

Solvents. Liquids that dissolve other substances. Chemical solvents are used widely in industry. They are used by pharmaceutical makers to extract active substances; by electronics manufacturers to wash circuit boards; by paint-makers to aid drying. Most solvents can cause air and water pollution and can be a health hazard.

Sulphur dioxide (SO_2). A colourless, irritating pungent gas formed when sulphur burns in air, one of the main air pollutants that contribute to acid rain and smog. Comes from the combustion of the sulphur present in most fossil fuels.

Superfund. Levy on industry to pay for cleaning up the most contaminated industrial dumps and sites in the United States.

Suspended Particulate Matter (SPM). Fine liquid or solid particles such as dust, smoke, mist, fumes or smog, found in air or emissions.

Sustainable development. Development that meets present needs without compromising the ability of future generations to meet their own needs. Necessarily based on limited data due to our current inability to forecast accurately 50-100 years ahead.

Synergistic. Interaction between two or more forces such that their combined effect is greater than the sum of their individual effects.

Tradeable permits. Market mechanism for controlling pollution; it entails issuing permits to pollute up to fixed limits and grants the right to sell unused portions of the permits.

UNCED. United Nations Conference on Environment and Development; it took place at Rio de Janeiro in June 1992 and was convened by the General Assembly in its resolution 44/228.

UNDP. United Nations Development Programme.

UNEP. United Nations Environment Programme.

USEPA. United States Environmental Protection Agency. Established in 1970 by Presidential Executive Order, it brought together the parts of various government agencies involved with the control of pollution.

UV-B. Short wavelength ultraviolet radiation.

Valdez Principles. Ten standards of corporate responsibility, formulated by the Social Investment Forum in United States after the *Exxon Valdez* accident. Encourages sustainable development and good environmental practice by companies.

Waste. Unwanted materials left over from a manufacturing process and refuse from places of human or animal habitation.

Waste reduction audit. Highly cost-effective technique that follows material inputs into the production process and accounts for them quantitatively, in any form (solid, liquid, gaseous), to identify losses (wastes), which can then be reduced by changes in input materials, process technology, product design and recycling.

Waste minimization. The reduction of waste by changing materials, processes or on-site disposal arrangements in a way that is profitable for the enterprise and the environment. Also called waste reduction.

Water quality standards. Ambient standards for water bodies. The standards address the use of the water body and set water quality criteria that must be met to protect the designated use or uses.

WCED. World Commission on Environment and Development.

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WHO. World Health Organization.

WICE. World Industry Council for the Environment, a division of the International Chamber of Commerce that raises environmental awareness on the part of industry in developing and developed countries.

WICEM II. Second World Industry Conference on Environmental Management, organized by the International Chamber of Commerce in 1991.

Reading Excerpts

The Road to Ecologically Sustainable Industrial Development

Excerpted from UNIDO, *Proceedings of the Conference on Ecologically Sustainable Industrial Development*, Copenhagen, Denmark, 14-18 October 1991 (PI/112), Working paper No. 1, chaps. I and IV.

Chapter I: Past Trends in Industrial Growth and Pollution

For the world as a whole, industrial output (taken as manufacturing value added) grew at an annual rate of 3.6 per cent during the last 20 years (see table 1), while population grew at 1.8 per cent. The manufacturing value added (MVA) of developed market economies grew at an annual rate of 3.1 per cent, while their population grew at 0.7 per cent. In the third world, noteworthy gains occurred in some regions, particularly East Asia and South-East Asia, which experienced annual growth of 9.1 per cent in industrial output compared with annual growth of 2.1 per cent in population.[1]

This growth in the industrial output of developing countries did not meet expectations, particularly in the 1980s. Overall, the share of these countries in global industrial output, in current prices, increased only modestly, from 9.3 per cent to 13.8 per cent from 1970 to 1980 (figure 1). Moreover, 10 countries accounted for over 60 per cent of the total MVA of all 116 developing countries, and 18 countries for nearly 80 per cent.

[1] UNIDO, *Handbook of Industrial Statistics 1988*, (UNIDO publication, Sales No. E/F.88.III.E.5)

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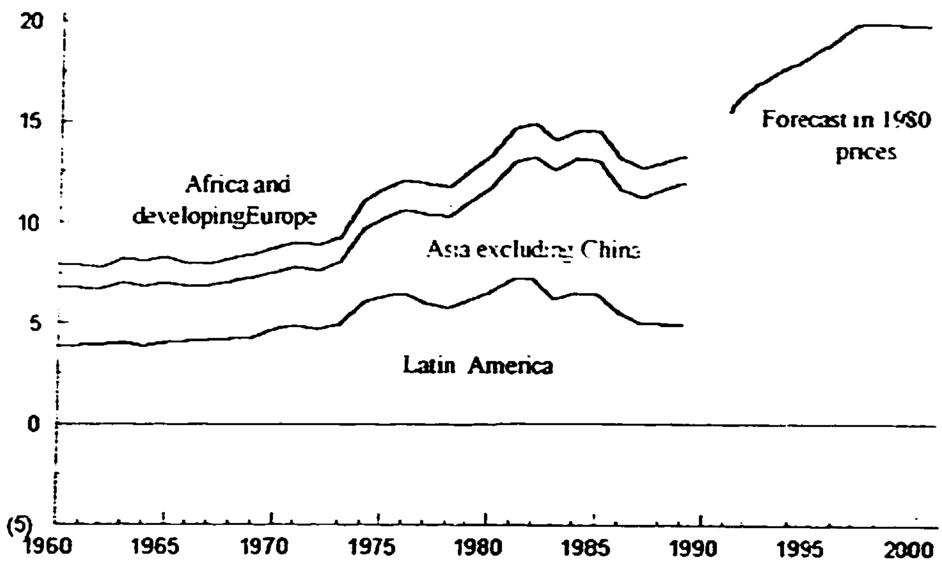
Figure 1. Share of Developing Countries in World (excluding China) Manufacturing Production*



Current prices (1960-1989) and constant 1980 prices (1980-1992) (including forecasts to 2000)

*The Lima Declaration and Plan of Action on Industrial Development and Co-operation, adopted by the Second General Conference of UNIDO, held at Lima from 12-26 March 1975, called for their share to be increased to the maximum possible extent and as far as possible to at least 25 per cent of total world industrial production by the year 2000

Events over the past 20 years are disturbing also in respect of environmental deterioration for all countries. Most startling are the threats to the biosphere, to which industrialization contributes a significant share.

One such threat is the concentration in the atmosphere of carbon dioxide (CO_2), a primary contributor to the greenhouse effect, which has increased by [illegible] per cent over the last 20 years (Figure 2).* As a result of increasing emissions of CO_2 and other greenhouse gases, the average global temperature will probably increase from 15.2° C in the [illegible] to between 16.7 and 19.7° C by 2030.* Approximately two thirds of the CO_2 released into the atmosphere can be attributed to human activities, particularly fossil fuel combustion, and about one third of fossil fuel combustion is either directly or indirectly connected to industrial activity.

* Other anthropogenic greenhouse gases are nitrous oxide from the chemical industry and [illegible] synthetic nitrogenous fertilizers, methane from rice cultivation, grazing animals, natural gas [illegible] leaks and coal mining, and synthetic chlorofluorocarbons (CFCs).

* Global Education Associates, "The global environment", *Breakthrough*, vol. 10, No. [illegible] (1989), p. [illegible]

Table 1. Population, GDP, MVA and Their Growth Rates, 1970 to 2010
(Millions of persons and millions of 1980 US dollars)

Region*	1970			Growth rate 1970-1980			1980		
	Pop.	GDP	MVA	Pop.	GDP	MVA	Pop.	GDP	MVA
World	3 698	7 836	1 881	1.9	3.8	4.1	4 450	11 405	2 844
Developed									
DME	706	5 677	1 413	0.8	3.1	3.2	762	7 764	1 953
CPE Eastern Europe and USSR	331	651	255	0.9	5.1	6.6	361	1 080	494
Other developed	38	191	38	2.0	3.0	3.0	46	257	51
Developing									
North Africa	83	73	7	2.6	6.6	6.2	108	140	12
Tropical Africa	257	95	8	2.9	3.0	3.7	345	128	12
Latin America	285	418	96	2.4	5.8	6.1	362	747	177
Western Asia	99	237	17	3.0	5.8	7.0	133	424	35
Indian subcontinent	753	168	22	2.3	3.2	4.4	943	232	35
East and South-East Asia	262	150	25	2.3	7.7	10.9	329	325	75
CPE Asia	884	176		1.8	5.6		1 062	307	
Developing	2 623	1 317	176	2.2	5.6	6.8	3 282	2 304	345
Developed	1 075	6 520	1 706	0.8	3.3	3.8	1 169	9 101	2 499

* DME denotes developed market economies and CPE denotes centrally planned economies.

Region*	1980			Growth rate 1980-1990			1990		
	Pop.	GDP	MVA	Pop.	GDP	MVA	Pop.	GDP	MVA
World	4 450	11 405	2 844	1.7	2.9	3.2	5 289	15 178	3 921
Developed									
DME	762	7 764	1 953	0.6	2.7	3.1	805	10 174	2 669
CPE Eastern Europe and USSR	361	1 080	494	0.7	2.4	3.1	388	1 378	675
Other developed	46	257	51	1.9	2.6	1.4	56	332	59
Developing									
North Africa	108	140	12	2.8	2.6	5.3	142	182	21
Tropical Africa	345	128	12	3.0	1.6	2.1	467	150	14
Latin America	362	747	177	2.1	1.3	1.0	448	852	195
Western Asia	133	424	35	3.3	-0.1	5.3	186	421	60
Indian subcontinent	943	232	35	2.2	5.3	7.2	1 179	394	71
East and South-East Asia	329	325	75	1.9	6.0	7.4	400	593	157
CPE Asia	1 062	307		1.4	8.2		1 220	701	
Developing	3 282	2 304	345	2.1	3.6	4.1	4 040	3 293	518
Developed	1 169	9 101	2 499	0.7	2.7	3.1	1 249	11 885	3 402

* DME denotes developed market economies and CPE denotes centrally planned economies.

Region*	1990 Pop.	1990 GDP	1990 MVA	Growth rate 1990-2000 Pop.	Growth rate 1990-2000 GDP	Growth rate 1990-2000 MVA	2000 Pop.	2000 GDP	2000 MVA
World	5 289	15 178	3 921	1.7	3.4	3.5	6 260	21 387	5 563
Developed									
DME	805	10 174	2 669	0.4	3.0	3.4	838	13 734	3 749
CPE Eastern Europe and USSR	388	1 378	675	0.7	3.5	1.5	416	1 956	784
Other developed	56	332	59	1.6	3.2	4.7	65	457	95
Developing									
North Africa	142	182	21	2.3	3.5	5.6	180	258	36
Tropical Africa	467	150	14	3.3	4.0	5.5	647	223	25
Latin America	448	852	195	1.9	4.2	5.6	542	1 296	341
Western Asia	186	421	60	3.2	4.0	6.0	254	628	109
Indian subcontinent	1 179	394	71	2.0	5.0	6.1	1 439	650	132
East and South East Asia	399	593	157	2.0	5.5	6.2	487	1 029	292
CPE Asia	1 220	701		1.3	5.0		1 392	1 155	
Developing	4 040	3 293	518	2.0	4.6	5.9	4 941	5 240	935
Developed	1 249	11 885	3 402	0.6	3.1	3.1	1 319	16 147	4 628

* DME denotes developed market economies and CPE denotes centrally planned economies.

Region*	2000			Growth rate 2000-2010			2010		
	Pop.	GDP	MVA	Pop.	GDP	MVA	Pop.	GDP	MVA
World	6 260	21 387	5 563	1.5	3.5	3.6	7 238	30 236	7 934
Developed									
DME	838	13 734	3 749	0.3	2.8	3.1	863	18 172	5 112
CPE Eastern Europe and USSR	416	1 956	784	0.5	4.0	2.0	438	2 918	957
Other developed	65	457	95	1.4	3.1	4.5	75	623	149
Developing									
North Africa	180	258	36	2.0	4.6	6.1	219	409	67
Tropical Africa	647	223	25	2.7	5.0	6.8	847	368	49
Latin America	542	1 296	341	1.5	5.0	6.0	630	2 137	622
Western Asia	254	628	109	2.8	4.5	7.3	336	985	225
Indian subcontinent	1 439	650	132	1.8	5.0	6.1	1 723	1 072	212
East and South-East Asia	487	1 029	292	1.8	4.7	5.6	583	1 646	511
CPE Asia	1 392	1 155		0.9	5.0	6.1	1 523	1 905	
Developing	4 941	5 240	935	1.7	4.9	3.0	5 862	8 523	1 716
Developed	1 319	16 147	4 628	0.4	3.0		1 376	21 713	6 218

* DME denotes developed market economies and CPE denotes centrally planned economies

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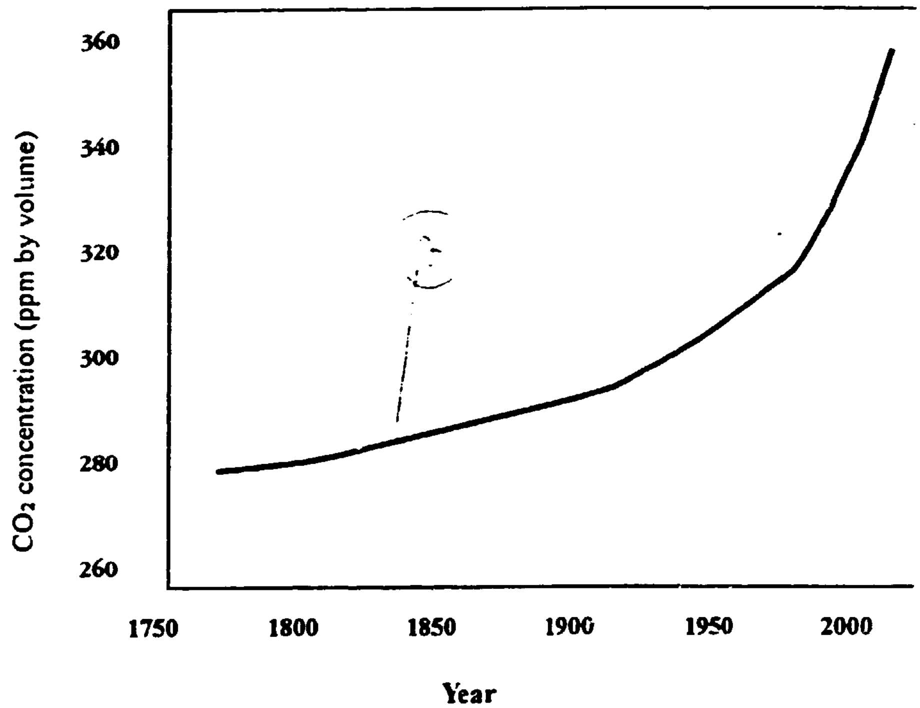
Figure 2. Global CO_2 Concentrations



Source: Heaton, G., R. Repetto, and R. Sobin, eds., *Transforming Technology: An Agenda for Environmentally Sustainable Growth in the 21st Century* (World Resources Institute, April 1991).

A second area of concern is the concentration in the atmosphere of chlorofluorcarbons (CFCs), which have increased dramatically (figure 3). CFCs are used in refrigerators and air-conditioners, in the blowing of plastic foam and as a solvent. They are the main cause of the "ozone hole", the name given to the decline in stratospheric ozone, which protects the surface of the earth from damaging ultraviolet radiation. Increased ultraviolet radiation promotes skin cancers and cataracts and depresses human immune systems; it also reduces crop yields, depletes marine fisheries, accelerates the deterioration of materials and increases smog. The higher concentration of CFCs also contributes to global warming.

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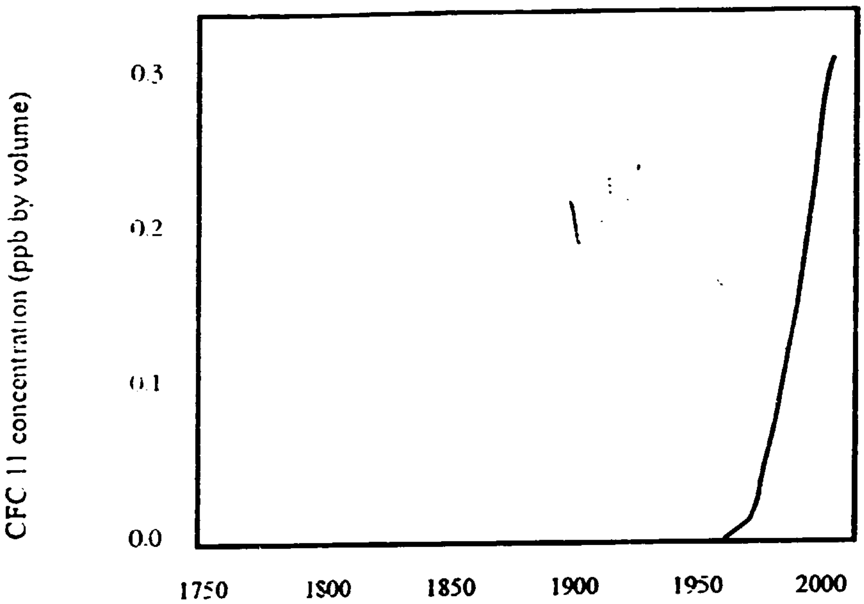
Figure 3. Concentration of Trichlorofluoromethane (CFC 11)



Source: Intergovernmental Panel on Climate Change. *Climate Change: The IPCC Scientific Assessment* (World Meteorological Organization and United Nations Environment Programme, 1990)

A third area of concern is the increasing emissions of sulphur dioxide (SO_2) and nitrogen oxides (NO_x), which increased by [illegible] per cent and [illegible] per cent, respectively, from 1960 to 1980 (figure 4). These pollutants are the main reasons for the growing acidity of the natural environment, especially freshwater lakes, rivers, forests and soils, and they contribute to the deterioration of the man-made environment, especially stone buildings and metallic infrastructure. These pollutants are produced mainly by the combustion of fossil fuels, primarily from power plants. It should be noted that the effects of acidification may have been masked until comparatively recently by the buffering effects of alkaline fly ash. However, the increasing use of smoke control technology, especially electrostatic precipitators, may tend to accelerate the acid build up by decreasing the buffering effect.

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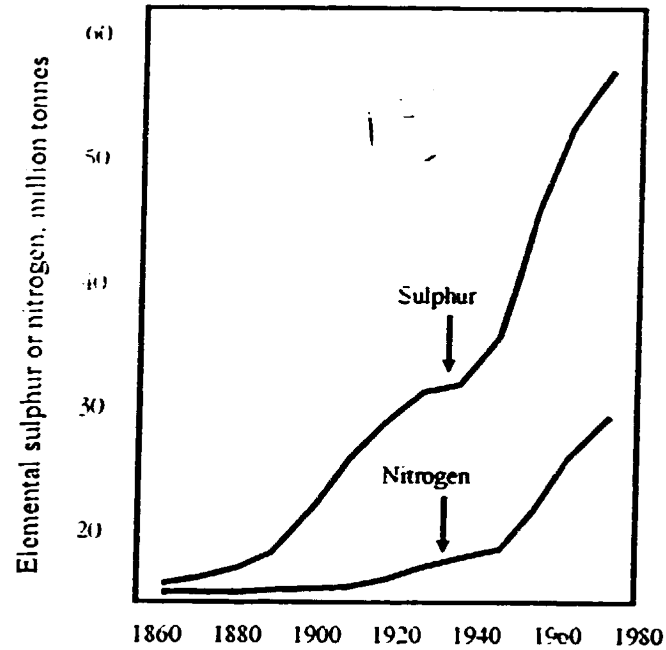
Figure 4. Global Emissions of Nitrogen and Sulphur Oxides from Fossil Fuel Consumption



Source: J. Dignon and S. Hameed, "Global emissions of nitrogen and sulfur oxides from 1860 to 1980", *Journal of the Air Pollution Control Association*, vol. 39, no. 2 (1989), p. 183

A fourth area of concern is wastes, primarily toxic chemicals and heavy metals, which are dispersed locally and build up in soils or sediments. The most polluted areas are probably United States and European river basins, such as those of the Thames, the Rhine-Schelde, the Elbe, the Danube, the Vistula, the Po, the Hudson-Raritan, the Delaware, the Ohio and the lower Mississippi, which became industrialized in the last 100-150 years. There are no global data on such accumulations. There are, however, global estimates of annual atmospheric emissions of heavy metals (table 2). Anthropogenic emissions of lead, cadmium, vanadium, and zinc exceed emissions from natural sources by factors of 28, 6, and 3, respectively. Industrial contributions of arsenic, copper, mercury, nickel and antimony are as much as twice those from natural sources. In addition, atmospheric fallout, domestic and industrial wastewater discharges and urban runoff have caused significant inputs of trace metals into aquatic ecosystems and soils, threatening the biosphere as a whole, including regional seas and the oceans.

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Industry is a major contributor to these environmental concerns.[4] It includes activities such as manufacturing, mining, utilities and construction. Of these sectors, manufacturing alone accounts for, on average, one third of total final energy consumption. More specifically, five manufacturing subsectors are known to be the most energy- and materials-intensive as well as the most pollution-intensive activities: iron and steel; nonferrous metals; nonmetallic minerals; chemicals; and pulp and paper.[5]

For a long time, industry in developed countries has been the major contributor to these problems of the biosphere, but the situation is changing with the rapid industrialization of developing countries. Whereas the developed countries have to some degree delinked energy and industrial output, developing countries have done just the reverse. In fact, the delinking phenomenon is partly due to structural shifts, namely the gradual relocation of resource-based (and energy-intensive) industries, such as steel, aluminium and petrochemicals, from the industrialized countries to the developing countries. Industrial final energy consumption in developed countries declined at an annual rate of 0.65 per cent in 1973-1985 and 1.93 per cent in 1980-1985, while industrial output increased at an annual rate of 1.50 per cent in 1973-1980 and 3.24 per cent in 1980-1985. In sharp contrast, industrial energy consumption in the developing countries as a whole, excluding China, grew at an annual rate of 6.32 per cent in 1973-1980 and 4.83 per cent in 1980-1985, while industrial output grew by 3.82 per cent and 0.03 per cent in the same periods. Similarly, four out of the five materials, energy and pollution-intensive manufacturing sectors listed above grew faster in developing countries than in developed countries during 1970-1988 and grew twice as fast in developing countries as in developed countries during 1980-1985.[6]

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[4] For the purpose of collecting data, industry is defined to include all operations falling into categories 2, 3 and 4 of the International Standard Industrial Classification (ISIC). Thus it includes mining, petroleum and gas extraction, electricity, waterworks and related activities. However, manufacturing (ISIC 3) is the largest and most important industrial sector, and it is in this sector that the work of UNIDO concentrates. It is also to this sector that the term "industry" mainly refers in all Working Papers.

[5] UNIDO, *Industry and Development: Global Report 1990/1991* (United Nations publication, Sales No. E.90.III.E.12).

[6] UNIDO, *Industry and Development: Global Report 1988/89* (United Nations publication, Sales No. E.89.III.E.5), p. 106.

Table 2. Worldwide Atmospheric Emissions of Trace Metals
(Thousand tonnes per year)

Element	Energy production	Smelting, refining and mining	Manufacturing processes	Commercial uses, waste incineration and transportation	Total anthropogenic contributions	Total contributions by natural activities
Antimony	1.3	1.5		0.7	3.5	2.6
Arsenic	2.2	12.4	2.0	2.3	19.0	12.0
Cadmium	0.8	5.4	0.6	0.8	7.6	1.4
Chromium	12.7		17.0	0.8	31.0	43.0
Copper	8.0	23.6	2.0	1.6	35.0	28.0
Lead	12.7	49.1	15.7	254.9	332.0	12.0
Manganese	12.1	3.2	14.7	8.3	38.0	317.0
Mercury	2.3	0.1		1.2	3.6	2.5
Nickel	42.0	4.8	4.5	0.4	52.0	3.0
Selenium	3.9	2.3		0.1	6.3	29.0
Thallium	1.1		4.0		5.1	5.1
Tin	3.3	1.1		0.8	5.1	10.0
Vanadium	84.0	0.1	0.733.4	1.2	86.0	28.0
Zinc	16.8	72.5	33.4	9.2	132.0	45.0

Source: Nriagu, J.O., "Global metal pollution: poisoning the biosphere?", Environment, Vol. 32, No. 7 (1990), pp. 7-32

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Chapter IV: Progress Towards Ecologically Sustainable Industrial Development

The question that now arises is, How well is industry doing in achieving ESID? It is a difficult question to answer because there is a lack of industry-specific data, but a reasonable assessment can be made using existing data and approximate measures.

UNIDO suggests two ways to measure progress towards protecting the biosphere. One is compliance with ambient environmental standards. The other is compliance with total loading standards.

Ambient Standards

Industry is only one of many contributors to the degradation of the environment. Agriculture, mining, energy, transport, services and households also contribute in varying degrees. Not enough data are available at the global level to assess the relative contribution of these various sources to ambient environmental deterioration. There is information, however, on the relative contribution of pollutant loadings into the environment.

Environmental deterioration associated with industrial development occurs at both the input and the output sides of production activities. Industrial production requires the input of a wide variety of natural resources, such as water, energy, minerals, forest products and other raw materials whose rapid depletion may cause environmental damage and ecological disruption. On the output side, the manufacturing process generates myriad wastes, including hazardous wastes, toxic chemicals and thermal wastes, that pollute the soil, the air and surface water and groundwater. On the output side, too, many manufactured end-products, such as pesticides, detergents, paints, plastics and combustion engines, add to the pollution.

In *Industry and Development: Global Report 1990/91*, UNIDO assessed the global degradation of the environment from both the input and output sides of production activities.[7] On the input side, it looked at the consumption of water, energy and mineral resources.

- **Water** Industry uses much less water than agriculture, but it pollutes the water more. Although more than 80 per cent of the water used for cooling and cleaning is returned, the returned water is often contaminated by industrial effluents and thermal pollution.

[7] UNIDO, *Industry and Development: Global Report 1990/91* (United Nations publication, Sales No. E.90.III.E.12).

- **Energy** In the countries of the Organization for Economic Co-operation and Development (OECD), industry used more energy than any other sector in 1970-1987. Its share ranged from 40 per cent in 1970 to 33 per cent in 1987. The industrial share of energy consumption in developing countries varied from country to country, ranging from 63 per cent in China to 20 per cent in West Africa;

- **Mineral resources** There seems to be no cause for concern about the exhaustion of mineral resources within the foreseeable future, although political disruptions can always lead to temporary shortages. More important in connection with mineral resources are the environmental problems posed by their production and industrial use.

On the output side, the *Global Report* analysed air pollution, water pollution, solid wastes, hazardous wastes and toxic chemicals:

- **Air pollution** The manufacturing sector is not the sector that generates most air pollutants. Each major air pollutant has a different major source: electricity generation accounts for the bulk of anthropogenic emissions of SO_2; transport activities, for NO_x and CO; and motor vehicles, for hydrocarbons and lead. Industry, however, is a major source of particulate emissions in many countries;

- **Water pollution** Industry is responsible for a fairly large share of waste-water discharges containing traditional pollutants. Estimation of the share is complicated by the fact that in many countries industry discharges its waste into municipal waste-water systems. Fragmentary data indicate that the share of industry in total waste-water discharges is roughly 20 per cent;

- **Solid wastes** An inter-country comparison of solid waste generation is difficult owing to the different definitions for categories of wastes. A few country estimates are as follows: industry's share of solid waste generation accounts for 17 per cent of the total in the United States, 9 per cent in France and 60 per cent in Japan;

- **Hazardous wastes** National data on hazardous wastes are scarce and incomplete. Even when available, they are not comparable because of the widely varying definitions and classification schemes for hazardous wastes adopted by different countries. Bearing these limitations in mind, the fragmentary data show that, with some minor exceptions, the largest portion of hazardous wastes is generated by industrial production. For instance, in the United States over 85 per cent of the hazardous waste is accounted for by the manufacturing sector; in Thailand, this share is over 95 per cent.

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- **Toxic chemicals**. It is difficult to estimate the quantity of toxic chemical wastes produced in different countries each year, partly because the term "toxic" is defined differently in different countries. Some recent data from the United States seem, however, to permit the identification and quantification of the types and sources of toxic chemical wastes. The chemical industry accounted for 54 per cent of the total releases, followed by the paper products and primary metals subsectors.

In summary, while the available data allow a reasonable assessment for industrialized countries, the relative contribution of industry to overall environmental degradation in developing countries is little known. For OECD countries, the industrial sector in 1987 accounted for 15 per cent of the total water use, 25 per cent of NOx, 35 per cent of final energy use, over 40 per cent of SO_2 emissions, 50 per cent of greenhouse gas emissions, 60 per cent of the water pollution (biochemical oxygen demand), 75 per cent of non-hazardous inert waste and 90 per cent of toxic substances discharge to water. For developing countries, as well as the countries of Eastern Europe, the data on the relative contribution of industry to environmental deterioration are very fragmentary, as can be seen in a recent report from the Economic and Social Commission for Asia and the Pacific (ESCAP).[8] There is obviously significant variation, given the different levels of industrialization, between developed and developing countries as well as among developing countries. For example, industry's share of total final energy use, which use constitutes a major threat to the biosphere, was 34 per cent in Africa, 40 per cent in Latin America and around 55 per cent in Eastern Europe.[9]

Total Loadings

Meeting current ambient standards is insufficient to prevent global and regional environmental problems. These ambient standards were formulated to protect local populations and natural resources, and they focus on concentrations, or flows, of pollutants. Total loading standards for some pollutants reflect the fact that the cumulative stocks of these pollutants in the environment, as well as the flows into it, are significant and must be reduced. Except in the case of CFCs, the extent to which they must be reduced is an open question.

Global emissions of CO_2 from energy use, expressed on a total carbon basis, increased from 4.0 billion tonnes in 1970 to approximately 5.2 billion tonnes in 1985 (table 3). They are projected to reach 10.2 billion tonnes

[8] Economic and Social Commission for Asia and the Pacific, *State of the Environment in Asia and the Pacific 1990* (ST/ESCAP/915).

[9] UNIDO, *Industry and Development: Global Report 1989/90* (United Nations publication, Sales No. E.89.II.B.5).

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(the mid-point estimate) in the year 2025.[10] Industry's share of these emissions is estimated to have been 2.9 billion tonnes in 1985, assuming that industry uses slightly more than one third of the world's energy. In 1985, the industrialized countries emitted about 50 per cent of this total, the former Union of Soviet Socialist Republics (USSR) and the countries of Eastern Europe about 25 per cent and the developing countries about 25 per cent. In 2025, the distribution is projected to be 35 per cent, 25 per cent and 40 per cent owing to more rapid industrialization in developing countries and the positive linkage between energy consumption and industrial output. Currently, developing countries are experiencing the most rapid increase in CO_2 with average annual growth of 3.7 per cent compared to 1.2 per cent and 2.6 per cent for OECD countries and the USSR and Eastern European, respectively.

Global emissions of CFCs increased from 0.8 billion tonnes in 1970 to 1.5 billion tonnes in 1985 and are estimated to increase to 3.9 billion tonnes by 2025 (table 3). In 1985, the industrialized countries emitted about 70 per cent of the world's total, the former USSR and the countries of Eastern European about 15 per cent and developing countries (including China) about 15 per cent. In 2025, the industrialized countries are projected to emit about 40 per cent of the world's total, the former USSR and countries of Eastern Europe about 15 per cent and developing countries about 45 per cent.

Global emissions of SO_2 increased from 63 million tonnes in 1970 to 80.5 million tonnes in 1985 and are projected to increase to 235 million tonnes by 2020 (table 4). These emissions are primarily (85 per cent) attributable to fossil fuel combustion (coal and oil) and secondarily to petroleum refining, the smelting of sulphur-containing ores (copper, lead and zinc) and sulfuric acid production. Assuming that industry uses one third of the world's energy, it was either directly or indirectly (by purchases of electricity) responsible in 1985 for 30 million tonnes of SO_2 emitted into the atmosphere. In 1985, industrialized countries emitted about 40 per cent of the total emissions, the former USSR and countries of Eastern Europe for slightly more than [illegible] per cent. In 2020 the industrialized countries are projected to emit about 15 per cent of the world's total, the republics of the former Soviet Union and the countries of Eastern Europe about 15 per cent and developing countries about 70 per cent. Most of the increase in emissions by 2020 will be attributable to the increased use of coal in China.

Data on the accumulation of trace metals in soils and sediments over the past decades are limited, especially in developing countries.[11] In the past developed countries were the main culprits in the discharge of trace

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10 Schwengels, Paul and Barry Solomon, "Energy technologies for reducing greenhouse gas emissions in developing countries and Eastern Europe", Environmentally Sound Technology Assessment (ESTA) (New York, Centre for Science and Technology for Development, United Nations, 1991

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metals, but the trend is reversing: "... the combination of natural resource endowments, the constraints imposed by population growth and economic development, and the lack of government regulations can only lead to an increase in the rates of toxic metal discharge in developing countries".[12]

Three activities are usually of greatest concern: the mining, smelting and refining of metals; the burning of fossil fuels for energy production; and the manufacturing processes, especially the production of metallic commercial products. A brief look at table 2 confirms that these activities are the main contributors of trace metals into the atmosphere. Manufacturing processes alone, ignoring energy use, are significant contributors of chromium, manganese, nickel, thallium and zinc.

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[11] The annual production of metals, both from virgin ores and from secondary sources, is known with reasonable accuracy. The annual consumption of non ferrous metals has been roughly constant or even declining in the United States for the last 20 years. The fraction obtained each year from secondary sources has also remained roughly constant except in the case of lead, where the fraction derived from secondary sources has risen sharply owing to the ban on lead in gasoline. What these data mean is that between half and seven eights of the annual consumption of each of the heavy non ferrous metals becomes dispersed and dissipated beyond economic recoverability. The situation in developing countries may be slightly better owing to greater incentives to conserve, but the range of uses is much the same and for most dissipative uses, from paint to pesticides, recovery is simply not feasible.

[12] Nriagu, J.O., "Global metal pollution: poisoning the biosphere" *Environment*, vol. 32, no. 7 (199[illegible] pp. 7-32.

Table 3. Emissions of CO_2 and CFCs in 1985 and 2020

Category	Country or region	CO_2				CFCs			
		1985		2020		1985		2025	
		10^6 tonnes/yr as C	%	10^6 tonnes/yr as C	%	10^6 kg/yr	%	10^6 kg/yr	%
Industrialized countries	United States	1 398	50	1 699-2 110	35	441	70	548	40
	OECD Europe/Canada	795		1 096-1 397		417		765	
	OECD Pacific	302		411-603		199		306	
Centrally planned economies	Eastern Europe/USSR	1 398	25	1 754-2 822	25	232	15	567	15
Developing countries	Centrally planned Asia	521	25	1 014-2 000	40	29	15	212	45
	Middle East	110		493-712		13		90	
	Africa	192		192-795		65		458	
	Latin America	192		438-904		46		291	
	South-East Asia	302		493-1 370		88		618	
Total		5 210	100	7 590-12 713	100	1 530	100	3 855	100

Sources. *United Nations Environment Programme, Environmental Data Report, second ed., 1989/90, prepared by GEMS Monitoring and Assessment Research Centre (Oxford, Blackwell, 1989). U.S./Japan Expert Group (1990); Task A Report (1990).*

Table 4. Emissions of SO_2 in 1970, 1985 and 2020

Region	1970		1985		2020	
	Emissions (million tonnes/yr)	Share of world total (%)	Emissions (million tonnes/yr)	Share of world total (%)	Emissions (million tonnes/yr)	Share of world total (%)
Industrialized countries	23.0	37	31.0	40	35.0	15
Centrally planned economies	26.0	41	26.0	30	36.0	15
Developing countries	14.0	22	23.5	30	164.0	70
Total	63.0	100	80.5	100	235.0	100

Sources: Galloway, J.N., "Atmospheric acidification: projection for the future", Ambio, vol. 18, No. 3 (1989), pp. 161-166, Global Environment Monitoring System (GEMS), UNEP, Environmental Data Report, second ed., 1989/90 (Oxford, Blackwell, 1989).

The Pakistan National Conservation Strategy

Excerpted, with permission, from *The Pakistan National Conservation Strategy* (Karachi, World Conservation Union, 1992), chap. 3.4. (Submitted as the national report to UNCED by the Government of Pakistan.)

Pollution

Most people think of environmental conservation in terms of the prevention of pollution—the control of discharges of unwanted, sometimes toxic wastes to the water, the air, or the land. This is only partially correct and reflects an urban bias; yet the importance of controlling pollution cannot be denied and is growing more urgent by the year.

Water Pollution

Water pollution has three main sources: bacterial and organic liquids and solids from urban and rural domestic sewage; toxic metals, organics, acids, and other less-toxic but still polluting substances from industrial discharges; and chemical pollution in the form of pesticide and fertilizer run-off from agricultural lands.

All three can contaminate both surface and groundwater supplies of water and render them unfit for other uses such as fisheries and recreation, or expensive to treat for industrial and municipal water supply uses. The costs of treatment places a heavy burden on municipal authorities and industries that must rely on polluted sources.

Domestic and Human Waste-Water Discharges

Solid and liquid excreta generated in human settlements along with kitchen and wash waste water are the major sources of water pollution in Pakistan and the cause of widespread water-borne diseases. The seriousness of the situation is clear from a World Health Organization study: diseases of a gastro-intestinal nature account for 25-30% of the cases seen at public hospitals and dispensaries in Pakistan. Approximately 60% of infant deaths are due to infectious and parasitic diseases, most of them water-borne. Losses to the national economy, not to mention the human suffering, caused by water-borne diseases are high. A study in India found that 73 million work-days a year were lost through such disease. The cost in terms of medical treatment and lost production was reported to be on the order of US$ 600 million per year.

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As indicated, the source of most water-borne diseases is human excrement. Pakistan generates 34,370 wet tonnes of excreta per day, 12.5 million tonnes per year. Karachi alone discharges approximately 300 million gallons per day of sewage; Lahore, approximately 240 million gallons. The organic load discharged, measured in terms of biological oxygen demand, for all of Pakistan is 2,265 tonnes per day.

The breakdown by source is 26,370 tonnes excreta from rural areas a day and 8,000 tonnes from urban areas. An estimated 21,096 tonnes from the rural areas (80%) is deposited in fields. An estimated 4,160 tonnes of the urban excreta (52%) is disposed of into sewers, with the remainder being deposited on the roadside, into waterways, or incorporated in solid waste.

Major cities dispose of their largely untreated sewage into irrigation systems, where the waste water is reused, and into streams and rivers, without any consideration for the rivers' assimilative capacity. Consequently, not only does serious bacterial contamination result, threatening human health, but the organic load of the sewage seriously depletes the dissolved oxygen content of the receiving waters, causing unaesthetic conditions and making them unfit for fish. It has been reported that pollution of the River Ravi—into which Lahore discharges its untreated waste water—has meant 5,000 fewer tonnes of fish production per year.

Industrial Waste-Water Discharges

The major industries creating environmental hazards are the manufacture of chemicals (including pesticides), textiles, pharmaceuticals, cement, electrical and electronic equipment, glass and ceramics, and pulp and paper board; leather tanning; food processing; and petroleum refining. Pollutants associated with various industrial subsectors are shown in table 1.

No systematic or complete survey has been done of the sources, volumes, and characteristics of industrial pollution in Pakistan, although partial surveys, investigations of particular sources, and observations have shown the seriousness of industrial pollution in a number of locations. A preliminary study of hazardous chemical industries conducted in 1985 for the Environment and Urban Affairs Division surveyed 100 plants scattered throughout the country. Only three, two of which were branches of multi-national companies, treated their wastes to commonly accepted standards. The remainder did nothing except dispose of their wastes in the most convenient way.

For all practical purposes, industries do not control their waste-water effluents through process controls, waste recycling, or end-of-pipe treatment. In Kala Shah Kaku industrial area near Lahore, for example, the various chemical industries, tanneries, textile plants, steel re-rolling mills, and other operations discharge effluents containing hydrochloric acid and high levels of organic matter directly into streams and canals. Biological oxygen demand levels of 193 to 833 milligrams per litre and mercury levels of 5.6 milligrams per litre have been measured. (The proposed interim relaxed Government standards for these are 200 and 0.1, respectively.) These discharges have rendered the nullah (drainage course) water unfit for irrigation use and livestock consumption, and have caused an annual reduction in the fish catch of 400 tonnes, valued at Rs. 10 million.

In the vicinity of Karachi, industrial pollution discharges combined with mangrove destruction and overfishing have resulted in a sharp decrease in shrimp production, which translates into lower foreign exchange earnings. Toxic substances occurring in effluents from sample industries in Karachi are shown in table 2.

Two large industrial zones in Sindh Province—SITE (Sindh Industrial Trading Estate) and LITE (Landhi Industrial Trading Estate)—discharge large quantities of organic matter, heavy metals, oils and greases, and other materials into local rivers. In Korangi in Karachi, where LITE is located, 35 tonnes of suspended solids, 376 tonnes of dissolved solids, 2 tonnes of ammonia, and 1.4 tonnes of arsenic oxide, among other chemicals, are discharged into the city's already polluted harbour each day.

Leather tanning operations near Peshawar are polluting the Kabul River, threatening its use for domestic and irrigation purposes as well as its freshwater fishery. Over 235 industries in Faisalabad discharge high levels of solids, heavy metals, aromatic dyes, inorganic salts, and organic materials directly into the municipal sewers without any pretreatment, polluting nearby agricultural land

Another area for concern is the contamination of shallow ground water in urban areas near industrial plants as industrial wastes are discharged directly into or onto the ground. Groundwater pollution is often permanent, in that hundreds or even thousands of years may be necessary for pollutants such as toxic metals from tanneries to be flushed out of a contaminated aquifer. Surface waters, on the other hand, can be rehabilitated if pollutant loadings are reduced or eliminated.

Agricultural Run-off

The use of fertilizers has grown 7.1% annually during the Sixth Five-Year Plan. Annual expenditure on pesticides currently amounts to Rs. 3.2 billion nationally. In 1986, 1.1 million tonnes of nitrogen and 93,000 tonnes of phosphate fertilizer were produced locally, and another 700,000 tonnes of fertilizer were imported. Pesticide imports have similarly grown rapidly, increasing from 7,083 tonnes in 1980/81 to 20,617 tonnes in 1986/87—a growth rate of 190% over the six-year period.

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Table 1. Selected Pollutants Associated with Industry

Industrial Subsector	Potential Pollutants*
Chemicals	Sulphuric and nitric acids, ammonia fluorocarbons
Pesticides	Organohalogens, organophosphates other toxic organics, arsenic
Textiles	Hydrochloric, sulphuric acids. high BOD (organic content). dye, various organic chemicals and detergents
Pharmaceuticals	Ammonia, acids, zinc
Leather tanning	Heavy metals (chromium, cadmium. etc.), various organic chemicals, acids, high BOD
Food processing	Ammonia, sulphur dioxide
Cement	Alkalines, limestone dust
Electrical/electronics	Fluorocarbons, heavy metals (including cadmium, nickel, selenium)
Glass/ceramics	Arsenic, fluorine
Petroleum refining	Phenols, sulphides, oily residues. ammonia
Pulp and paperboard	Mercaptans (organic sulphides) high BOD and organic solids. mercury

* Quantities and characteristics dependent on type of manufacturing process and whether waste treatment exists.

Source: Derived from Ahmed. Dr. Junaid, *NCS Sector Paper on Industries*.

Indiscriminate use of agricultural chemicals, mainly fertilizers and various pesticides including insecticides, fungicides, and herbicides, is contributing to chemical pollution of the environment. Agricultural run-off from fields where these have been used incorrectly or inappropriately can raise the levels of these substances in waterways.

The effects include excess nutrient loadings from fertilizer run-off and subsequent uncontrolled algal growth in waterways, and pesticide contamination of waters, resulting in fish kills. Dead fish, apparently due to pesticides, have been reported on the banks of the Kabul River in certain seasons. Pesticides are of particular concern because of their bioaccumulation in fish and animal tissue and in the soil, and because of their persistence in the environment.

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Other risks include contamination of shallow wells used for drinking-water supplies for villages and cities, and pesticide residues on cereal and vegetable crops where care has not been taken in their application. Such residues may be harmful to humans. At least one case of poisoning resulting in a number of deaths, involving the pesticide endrin in foodstuffs, has been reported in Pakistan.

Increasing use of nitrogen fertilizers may also lead to excess nitrate levels in groundwater wells. High nitrate levels in drinking water are converted to more toxic nitrites in the stomach of adults and infants, and are known to cause blood disorders in infants. No studies to date have assessed groundwater contamination in Pakistan from pesticide or fertilizer use in agriculture.

Air Pollution

The classic source of air pollution is the factory smoke stack. Such stationary, point-source emissions are highly visible and represent a significant threat to those living nearby. By volume, however, they represent less of a threat to the overall health of Pakistanis than do the multiple mobile sources of the automobile and other vehicles. Nevertheless, the combined emissions of air pollutants from industry, power generation, transportation, domestic activities (particularly energy use), agriculture, and commercial institutions are growing rapidly. (See table 4).

Table 2 Toxic Substance Concentrations in Effluents of Sample Industries, Karachi

Type of Industry	Copper	Cadmium	Zinc (mg/litre)	Nickel	Lead
Suggested standard*	1.00	0.10	5.00	1.00	0.50
Food processing	0.43	0.03	0.24	0.27	0.23
Oil mill	0.03	0.03	2.19	0.65	0.48
Beverage	0.09	0.04	2.06	0.41	0.04
Textile	0.02	0.05	5.30	0.51	—
Tannery	0.30	0.15	7.00	1.14	1.80
Chemical-alkali	0.14	0.03	0.22	1.18	0.66
Paint manufacture	0.07	0.94	0.48	0.20	3.88
Shipyard	0.28	0.10	1342.50	0.74	11.75
Cement	0.33	0.33	2.66	1.00	0.79

*Based on EEC report to EUAD

Source: *NCS Agriculture Sector Paper* by Dr. G.R. Sandhu.

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Industry and power generation are becoming major sources of carbon dioxide and sulphur dioxide emissions. The rapid increase in thermal power generating capacity currently under way will result in substantial increase in emissions of these two gases and of nitrogen oxide from the burning of oil and coal in new generating stations. Pakistan's low thermal-value, high-sulphur coal reserves will cause a rapid increase in these emissions as they come into production to feed the thermal generating stations.

Similarly, use of natural gas, coal, and oil as fuels by industry is expected to cause a substantial increase in air pollution. The expected effects of these emissions, unless they are controlled at the source, include deterioration of soil quality in the vicinity of factories, potential damage to crops (particularly from sulphur dioxide and nitrogen oxides), and possibly human health effects. Many studies in a number of countries have quantitatively linked air pollution with respiratory disease, including lung cancer.

Vehicle Emissions and Urban Air Pollution

As table 3 indicates, the truly dangerous pollutants to human health—those that can cause bronchial irritation, hasten asthma attacks, and irritate the eyes—arise primarily from non-stationary sources in urban areas. Motor vehicle emissions in Lahore account for approximately 90% of the total annual emissions of hydrocarbons, aldehydes, and carbon monoxide, and for smaller but still the largest proportion of the emissions of sulphur dioxide and nitrogen oxides.

Table 3 Annual Emissions of Air Pollutants Lahore, 1985

Source	Particulates		SO_2		CO		Hydrocarbons		NO_2		Aldehydes	
	tonnes	%	tonnes	%	tonnes	%	tonnes	%	tonnes	%	tonnes	%
Motor vehicles	2,014	26	1,377	49	123,054	96	29,536	91	14,565	73	209	89
Railway	171	2	756	27	657	—	447	1	1,878	9	26	11
Natural gas	54	1	5	—	193	—	51	—	1,553	8	—	—
Wood, coal, solid waste	1,119	14	302	11	4,622	4	1,569	5	3,424	9	—	—
Industrial unit	4,406	57	358	13	285	—	1,010	3	162	1	—	—
Total emissions	7,764		2,798		128,811		32,613		21,582		235	

Source: Tariq, Dr. Nawaz and Waris Ali, *NCS Sector Paper on Municipal Discharges.*

Table 4 Estimated Air Pollutants from Various Economic Sectors
(thousand tonnes)

Sector	1977/78			1987/88			1997/98		
	CO_2	SO_2	NO_x	CO_2	SO_2	NO_x	CO_2	SO_2	NO_x
Industry	12.308	19	n/a	26.680	423	n/a	53.429	982	n/a
Transport	7.068	52	n/a	10.254	57	n/a	18.987	105	n/a
Power	3,640	4	3	21.216	95	n/a	53.962	996	76
Domestic	16,601	5	n/a	24.054	16	n/a	3.998	40	n/a
Agriculture	845	5	n/a	4,490	28	n/a	6.368	40	n/a
Commercial	1,726	11	n/a	2,587	13	n/a	4.261	25	n/a

(n.a=not applicable)
Source: *NCS Sector Paper on Energy.*

Metropolitan reliance on buses and light commercial vehicles also has various air pollution consequences. Old vehicles stay on the roads because of the absence of emission regulations, lack of enforcement of motor vehicle fitness regulations, and the owners' lack of capital to purchase replacements. Thus the average Pakistani vehicle emits 20 times as much hydrocarbons, 25 times as much carbon monoxide, and 3.6 times as much nitrous oxides in grams per kilometre as the average vehicle in the United States. As such, air pollution along busy roads and narrow streets of the main cities is an order of magnitude greater than would be predicted from the number of vehicles on the road.

The pollutants recorded are the standard emissions monitored throughout the world. Sulphur dioxide, a precursor of acid rain, is an irritant to the eyes, nose, and throat as well as to the lungs. It is also phytotoxic, damaging plants. Aldehydes are particularly noteworthy for their obnoxious smell.

Carbon monoxide is considered to be the most toxic common urban air pollutant, since it reduces the oxygen carrying capacity of the blood. Carbon monoxide levels in the range of 8-30 parts per million (ppm) and 6-40 ppm have been recorded for Lahore and Karachi respectively.

Exposure for an eight-hour period at these levels is known to cause temporary impairment of nervous system functions, including eyesight sharpness.

Hydrocarbons are an important source of particulate air pollution in Pakistan's major cities. These substances are the precursors of photo-

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chemical smog, in conditions where exposure to sunlight changes the material into an eye and lung irritant. Smog is also known to inhibit plant growth.

Nitrogen dioxide is the component of the family of nitrogen oxides that has the potential for the greatest adverse effects on human health and hence is the chemical form of nitrogen oxides usually measured. In laboratory tests, nitrogen oxide levels of 100 ppm cause illness if breathed for a short time. Levels of 700 ppm are fatal if breathed for 30 minutes. The standard recommended by the World Bank for nitrogen dioxide is 0.05 ppm

The most dangerous of vehicle-related emission, lead, does not appear in table 3 because urban lead emission levels have been measured only sporadically in Pakistan. In Karachi, ambient lead levels have been measured at between 0.024 and 0.13 micrograms per cubic metre. Estimated lead released from emissions to the air in Pakistan is 520 tonnes.

Lead is added to gasoline to increase the octane rating and to reduce engine knock. When lead is ingested by young and growing children, it is deposited in the brain and has been shown to cause a reduction in intelligence quotient. Lead from auto emissions is a particular hazard for inner-city residents living, working, or playing along heavily travelled urban roads. It is for this reason that all industrial nations have moved towards lead-free gasolines. In Britain, a reduction in the lead content of gasoline from 0.06% to 0.015% led to a halving of blood lead levels among affected groups.

Uncontrolled open burning of garbage is another source of urban air pollution. Such burning, which typically takes place at relatively low temperatures, has been found in the West to be a major source of dioxins, an extremely toxic product. Open dumping and treatment by weathering will eventually produce a harmless product, but before that happens the dump will be a malodorous home for rats and flies, and, via leachates, another source of groundwater contamination.

Industrial Emissions

Little information exists on the nature of industrial air emissions in Pakistan; neither comprehensive nor spot surveys have been reported. But observations in the vicinity of a number of industrial zones have shown the effects of these pollutants. In Kala Shah Kaku industrial area, gaseous emissions are believed to be responsible for adverse effects on downwind crops. The Punjab Environmental Protection Agency has recently begun preliminary air pollution surveys with the assistance of the Institute for Public Health Engineering and Research at the University of Engineering and Technology (Lahore) and the Pakistan Council for Scientific and Industrial Research.

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Air pollution is primarily an urban problem, where the density of industry and vehicles is sufficient to overcome the ability of the air to disperse the pollutants or dilute them quickly enough. In rural areas, air quality is not normally a problem except in the vicinity of particularly obnoxious and large discharges of pollutants.

For example, most cement plants in Pakistan have not installed equipment to control dust emissions, and pose a nuisance and a potential health hazard for surrounding residents. Large fuel-burning sources, such as thermal generating stations and industries that burn coal for steam boilers, could create localized problems from deposition of particular ash matter and sulphur compounds, especially if the coal used has a high sulphur content, as does much of Pakistan's indigenous coal supplies. Peri-urban brick-making kilns are currently the largest user of coal and emit quantities of ash and sulphur. But their effects are usually localized, due to the relatively small amount of emissions they generate.

Land Pollution

Pakistan generates 47,920 tonnes of solid waste per day—19,190 tonnes from urban areas and 28,730 tonnes from rural areas. This amounts to 17.5 million tonnes per year. In cities such as Lahore and Karachi, waste disposal typically accounts for 20-25% of municipal expenditures. Even so, only about 55% of these two urban areas, typically the wealthier sections, benefit from municipal collections. The composition of the waste includes a compostable content of 73% for Lahore (56% for Karachi) and a paper content of 5-6%.

Solid domestic waste is typically dumped onto low-lying land in Pakistan, and not even with the benefit of modern sanitary landfill methods. The result is unsightly and unsanitary conditions at and around dump sites, the use of land that could be turned to more productive purposes, and the loss of potentially valuable recyclable materials. The very elements that cause the problem, the organic matter content, give it a potential value as compost if it is encapsulated in soil and the organic matter is reduced to an enriched sterile fertilizer. Recycling the organic content of solid wastes has begun with a 500 tonne/day composting plant operating in Karachi. Others are planned for Lahore, Islamabad, and other cities. Sanitary landfills are also under consideration for Lahore and Islamabad.

Of considerable concern is the likelihood that quantities of toxic industrial wastes have been dumped in municipal disposal areas or are being dumped directly onto lands adjacent to factories with no record of their location, quantity, or toxic composition. The experience in many countries has shown that such 'toxic real estate' has grave social and economic implications for the future: serious health problems among local residents, large liabilities for cleanup incurred by the industries, lowered

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property values, and considerable public expense for identification and rehabilitation of contaminated sites.

Coastal Pollution

Pakistan has two ports (Karachi and Port Qasim) and four fish harbours either operational or under construction (Karachi, Pasni, Gwadar, and Korangi). Karachi port and harbour are the most used areas, and it is here that the greatest pollution is seen, both from vessels (illegally pumping out bilges and refuse), and from the port's oil terminal. An estimated 90,000 tonnes per year of oily discharges are pumped out within port limits. No oily ship waste reception or treatment facility exists within the port. Dredging operations, necessary to keep the approach channels open, also have a major impact.

The shipping lanes in the Arabian Sea are some of the busiest in the world, and it is fortunate that Pakistan has not experienced a spill greater than that of the 'Akbar', an oil barge that sank and discharged 700 tonnes of crude in 1984. Pakistan has no capacity to cope with an oil spill, minor or major, or with any other kind of shipping accident with environmental consequences.

Recently, another potential hazard has also come to light: the possibility of toxic waste dumping either at sea or, through the subterfuge of wrongly labelled containers on ships, on land. The port authorities are untrained and ill-equipped to recognize and deal with such cases.

About 45% of Pakistan's industry (by value added) is located in Karachi. All its effluents plus the domestic sewage from a city of more than 8 million people and all agricultural run-off from the hinterland and in the Indus River find their way, untreated, into the sea. No comprehensive, systematic assessment of industrial or domestic/municipal pollution in the coastal zone of Pakistan has been done. Some studies indicate that eutrophication caused by pollution from sewage (or other organic biodegradables such as fish processing wastes), though increasing overall biomass in the form of algal blooms, has reduced economically important marine fauna. Water-borne disease vectors and the interaction of sewage with other materials also have serious implications for human health, particularly for villages on the coast.

The three main coastal industries with the largest volumes of effluents are the steel mill, power plants, and refineries. But the many smaller industrial units have more significant polluting effects on the marine environment.

Surveys of industrial pollution, by virtue of being localized and based on a limited number of water and sediment samples, cannot represent accurately the degree or extent of water pollution or the problem of materials leaching into soil and groundwater resources. The synergistic and cumulative effects of interactions among different inorganic chemical compounds and between these compounds and organic matter remain to be investigated. For example, the effluent from the Karachi Shipyard is recorded as having a pH level of 4 with 110 milligrams per litre of zinc in suspension. The synergistic effects of this level of zinc in acid effluents is likely to be far more dangerous to the coastal environment than is recognized in current reports. The continuing piecemeal study of pollutants and lack of consideration of interactions among different ones represents a major weakness in current assessments.

Other negative impacts on the coast include that of thermal pollution, increased turbidity and siltation due to dredging, oil spills, tarballs, plastics, and toxic effluents, including heavy metals. Field studies of heavy metal concentrations in coastal sediments and fish indicate levels typical of coastal waters off an industrial city. However, certain 'hot spots' of chromium and mercury indicate that caution is now required in effluent disposal. Baseline surveys have yet to be undertaken to assess natural radioactivity levels along the coast, so as to assess the impact of the KANUPP nuclear power plant.

If present trends continue, with no checks being instituted, it is expected that the present zone of oxygen-deficient bottom conditions in Karachi harbour will extend to cover most of that area and its backwaters, except the channels where tidal flushing is effective in dispersing pollution loads. These conditions will slowly spread into the creeks, with serious consequences to marine bottom-dwelling species and benthic fauna. The resulting deterioration in water quality will adversely affect pelagic flora and fauna, the extent of eutrophication will increase, and phytoplankton blooms and red tides will become regular features. The bioaccumulation of toxic substances in marine fauna will increase and heavy metal pollution will spread seawards, eventually approaching toxicity levels within commercially important fish stock, with potentially disastrous implications to the fishing economy.

@MAJOR HEADING = United Nations Industrial Development Organization
@TOP = Training Course
@TOP = Ecologically Sustainable Industrial Development
@CHAPTER TITLE = Learning Unit 2
@CHAPTER # = The Need for Ecologically Sustainable Industrial Development<P19BI>

@SMTITLE = Includes:<P18>
@SMTITLE = Glossary of Environmental Terms

@SOURCE = <P12>Further information may be obtained from:<P255>
@SOURCE = <P12>Environment Coordination Unit, UNIDO<P255>
@SOURCE = <P12>Telephone: (Austria) 43-1-21131-0 / Fax: 43-1-230-74-49<P255>

@CHAPTER TITLE = Contents

@PAGE BREAK =
@CHAPTER # = Introduction
@FIRSTPAR = <%-2>L<%1>earning Unit 2 is designed to acquaint you with environmental problems that have led to a worldwide call for ecologically sustainable industrial development (ESID). It also contains a glossary of environmental terms that may be useful to you throughout the course.<%0>
@MAJOR HEADING = Objectives
The specific learning objectives of this unit are as follows:
@BULLET = To relate trends in economic development since 1970 to the most important industry-related environmental issues.
@BULLET = To describe the main environmental problems that result from industrial development.
@BULLET = <%-2>To begin to use the language of environmental management.<%0>
@MAJOR HEADING = Key Learning Points
@QUESTIONS = 1 Past development trends have resulted in very limited well- being for developing countries. In 1992, 80 per cent of the world population received only about 20 per cent of the world's income and produced only a small share of industrial output.
@QUESTIONS = 2 <%2>Industrial activity is a major contributor to environmental<%0> deterioration.

@QUESTIONS = 3 It currently seems inevitable that both global population numbers and per capita income will increase. The challenge we face is to reconcile the demands of population growth, the desire for continued industrial development and the need to preserve our environment.

@QUESTIONS = 4 We must find new approaches to industrial development, both in developed and developing countries, that will allow us to preserve the ability of our environment to sustain us. In short, <%2>we must achieve ecologically sustainable industrial de-<%0> velopment.

@QUESTIONS = 5 The only way to do this is to reduce the "pollution intensity" of industrial activities.

@PAGE BREAK =

@CHAPTER # = Study Materials

@FIRSTPAR = This Learning Unit is designed to help you become familiar with worldwide environmental problems that have prompted <%2>the call for ecologically sustainable industrial development.<%0> Learning Unit 2 contains information on economic and environ-<%2>mental trends, water pollution, atmospheric pollution, toxic<%0> chemicals and hazardous wastes, acidification and global climate change.

@MAJOR HEADING = Economic Trends

@FIRSTPAR = Since 1970, overall world industrial output (manufacturing value added, or MVA) grew at about 3.6 per cent annually, compared with a population increase of about 1.8 per cent.

Compare the average annual growth rates, 1970-1990, in developed and developing countries:

@BODNOIND =

@BODNOIND = <T><T>Region<T> MVA Population

@BODNOIND =

@BODNOIND = <T><T>Developed countries<T>3.1% <T>0.7%

@BODNOIND = <T><T>East Asia/South-East Asia<T>9.1% <T>2.1%

@BODNOIND = <T><T>Latin America<T><T>1.0% <T>2.1%

@BODNOIND = <T><T>Africa<T><T>2.1% <T>3.0%

<%2>The growth in industrial output of developing countries failed to meet expectations. Overall, their share of global industrial output, in current prices, increased from only 9.3 per cent to 13.8 per cent between 1970 and 1990, mainly in the years 1970-1980.<%0>

<%2>This small share of global industrial output was achieved by only a few developing countries. Thus, 60 per cent of the growth was achieved by 12 of the 118 countries and 80 per cent by 18 of them.<%0>

@PAGE BREAK =

@MAJOR HEADING = Environmental Trends

@FIRSTPAR = While there are natural emissions of most major pollutants, industrialization is still a major threat to the biosphere.

Emissions of carbon dioxide (CO_2) from fuel burning are a primary contributor to the greenhouse effect.

<%-2>Emissions of chlorofluorocarbons (CFCs) from refrigerators and air-conditioners, solvents and plastic foam blowing are major causes of the "ozone hole", leading to ultraviolet radiation, skin cancers, loss of immunity, crop fishery yield reduction, smog etc.<%0>

Emissions of sulphur dioxide (SO_2) and nitrogen oxides (NO_x) create acidity in the natural environment (freshwater lakes, <%2>rivers, forests and soils) and the deterioration of metal and<%0> building structures etc.

Emissions of toxic chemical substances, heavy metals (lead, cadmium, mercury and arsenic) and aromatic polychlorinated compounds (PCBs, pentachlorophenol, dioxin) threaten aquatic ecosystems and soils in whole regions and seas.

Industry is a major contributor to these environmental con- cerns with its manufacturing, mining, utilities and construction activities. The table on the next page summarizes the environ- mental effects of some of the major industrial polluters.

For a long time such energy- and pollution-intensive in- dustries were confined mainly to developed countries, but they are now growing twice as fast in developing countries.

@PAGE BREAK =

@MAJOR HEADING = The Challenge: To Develop Industry While<R>Protecting the Environment

@FIRSTPAR = The challenge is to reconcile the demands of population growth, the desire for continued industrial development and the need to protect our environment.

@SPACE =

@BODNOIND = <T><T>Trends <T> 1900-1990 1990-2040

@BODNOIND = <T><T><T><T>(actual) (projected)

@BODNOIND = <T><T>Population<T> <T> 4x<T> 2x

@BODNOIND = <T><T>Economic activity<T> 20x<T> 3.5x

@BODNOIND = <T><T>Fossil fuel use<T> <T> 30x<T> 3x

@BODNOIND = <T><T>Industrial production <T> 50x<T> 3x

Past development trends have resulted in very limited well-being for developing countries. In 1992, 80 per cent of the world population received only about 20 per cent of the world income and produced only a small share of industrial output.

In 1990, WHO admitted that the goal of health for all by the year 2000 could not be achieved under the existing world conditions of poverty and inequality. Will UNIDO find in the year 2000 that environmental protection cannot be achieved under such conditions?

New approaches to industrial development must be found, both in developed and developing countries, that will allow us to preserve the ability of our environment to sustain us. In short, we must achieve ecologically sustainable industrial development.

@MAJOR HEADING = Questions

@QUESTIONS = 1 What is industry's share of fossil fuel combustion? Is this share increasing or declining?

@QUESTIONS = 2 The anthropogenic emissions of which heavy metal dramati- cally exceed its emissions from natural sources?

@QUESTIONS = 3 What are the "smokestack" industries? During 1970-1988, how did the growth of smokestack industries in developing countries compare with their growth in developed countries?

@QUESTIONS = 4 Is industry the sector that uses the most water?

@PAGE BREAK =
@QUESTIONS = 5 <%-2>What is the difference between ambient standards and total<%0> load- ing standards?

@QUESTIONS = 6 In 1985, what were the industrialized countries' share of emis- sions of CO_2, CFCs and SO_2?

@PAGE BREAK =

@MAJOR HEADING = Questions
@QUESTIONS = 1 What are some of the unintended environmental consequences of development?
@QUESTIONS =
@QUESTIONS =
@QUESTIONS =
@QUESTIONS = 2 How did the World Commission on Environment and Develop-<%2> ment (WCED) define sustainable development?
@QUESTIONS =
@QUESTIONS =
@QUESTIONS =
@QUESTIONS = 3 What did WCED call for? Do you think this is a controversial statement?
@QUESTIONS =
@QUESTIONS =
@PAGE BREAK =
@QUESTIONS = 4 Is protection of the environment incompatible with economic growth?
@QUESTIONS =
@QUESTIONS =
@QUESTIONS =
@QUESTIONS =
@QUESTIONS =
@QUESTIONS = 5 Does WCED believe that the world has the potential to achieve sustainable development?
@QUESTIONS =
@QUESTIONS =
@QUESTIONS =
@QUESTIONS =
@PAGE BREAK =
@MAJOR HEADING = Understanding Environmental Problems
@MINOR HEADING = Global Climate Change
@FIRSTPAR = The natural concentration of CO_2 in the atmosphere is controlled by the interactions between the atmosphere, the oceans and the biosphere in what is known as the geochemical carbon cycle. Human activities can disturb this cycle by injecting additional CO_2 into the atmosphere, thereby aggravating the natural greenhouse effect. Over the past 100

years, the global mean temperature has risen by 0.3° to 0.6°C. A doubling of atmospheric concentrations of CO_2 is expected to increase the global mean temperature in the range of 1.5° to 4.5°C.

It has been thought that CO_2 was the only greenhouse gas. However, research over the last two decades has found that other gases such as nitrous oxide, methane, chlorofluorocarbons (CFCs) and tropospheric ozone may also be greenhouse gases.

@MINOR HEADING = Ozone Depletion

In contrast to the harmful ozone formed as a photochemical oxidant at ground level (tropospheric ozone), ozone in the stratosphere, between 25 and 40 km above the earth's surface, is a natural filter that absorbs and blocks the sun's short-wave-length ultraviolet (UV-B) radiation, which is harmful to life.

CFCs are used as propellants and solvents in aerosol sprays; as fluids in refrigeration and air-conditioning equipment; as foam-blowing agents in plastic foam production; and as solvents, mainly in the electronics industry. Studies in the 1980s showed that emissions of bromine can also lead to a significant reduction in stratospheric ozone. Bromofluorocarbons are widely used to extinguish fires, and ethylene dibromide and methyl bromide are used as fumigants.

@MINOR HEADING = Acidification

<%2>Acidification refers to the gradual increase in acidic conditions in soils, forests and lakes. Such an increase occurs in urban environments as well where it contributes to the deterioration of metals and stone. Acid deposition may be absorbed, even in sensitive areas, by the natural buffering capacity of the environment. However, the onset of acid conditions in an environment may occur long after an increase in acid deposition.<%0>

The main anthropogenic source of acid-forming gases, primarily SO_2 and NO_x, is the burning of fossil fuels. Additional sources include metal ore smelting, sulphuric acid manufacture and other industrial processes.

@MINOR HEADING = Toxic Chemicals and Hazardous Wastes

All chemicals are toxic to some degree. The health risks from a chemical depend mainly on its toxicity and on the exposure. Only a few parts per billion of a highly toxic compound like dioxin may constitute a threat to health after only brief exposure. In contrast, only high doses of compounds like iron oxide or magnesium carbonate pose problems after extended exposure. An important development has been the shift from a focus on just the acute effects of chemicals to a focus on their chronic effects as well. These chronic effects include birth defects, genetic and neurological disorders and cancer.

Although the term "hazardous" has different connotations among countries, it is widely applied to wastes containing metallic compounds, halogenated organic solvents, organohalogen compounds, acids, asbestos, organophosphorus compounds, organic cyanides and phenols. Most hazardous wastes are produced by industry, but it is now recognized that there are hundreds of thousands of facilities that generate hazardous wastes. These include households, medical facilities, garages and auto-repair workshops, petrol stations and small-scale industries and businesses.

@PAGE BREAK =

@MINOR HEADING = Atmospheric Pollution

Air pollution refers to gaseous or particulate contaminants in quantities, characteristics or durations that are injurious to human, plant or animal life or to property. The combustion of fossil fuels, both for power generation and transportation, is the major source of atmospheric pollution.

The previously known common air <%2>pollutants<%0> <%2>are SO<MV%4<2<D>, <%2>NO<MV<x<D>,<%0> suspended particulate matter (SPM), hydrocarbons (HC), carbon

monoxide (CO) and lead (Pb). More recently, research has demonstrated the adverse effects of volatile organic compounds and trace metals. Both particulate matter and lead are serious threats to human health in the rapidly urbanizing areas in developing countries.
@MINOR HEADING = Water Pollution
Some water pollutants, such as organic wastes from agro-industries and human settlements, are easily decomposed into substances that are normally harmless. However, at high concentrations, they may seriously disturb the ecosystem. Other pollutants, such as metals and persistent organic compounds, cannot be degraded; they usually remain adsorbed on bottom sediments near the source of discharge. Some organisms have a remarkable ability to accumulate such pollutants, even when they are present in extremely low concentrations.
Both the atmosphere and rivers contribute to marine pollution. The atmospheric pathway accounts for more than 90 per cent of the lead, cadmium, copper, iron, zinc, arsenic nickel, PCBs, DDT and hexachlorofluorohexane found in the waters of the open ocean. The chief contaminant of fresh waters is untreated or inadequately treated waste water from cities and industrial plants. Contaminants from agricultural lands, forests and roads can be significant in rural areas.
@PAGE BREAK =

@MAJOR HEADING = Questions
@QUESTIONS = 1 Name five greenhouse gases.

@QUESTIONS = 2 Which of these causes the most harm?

@QUESTIONS = 3 Name two natural carbon sinks.

@QUESTIONS = 4 What are the two kinds of ozone? What is the difference between them?
@PAGE BREAK =
@QUESTIONS = 5 How do CFCs affect the ozone layer?

@QUESTIONS = 6 Name six uses of ozone-depleting substances.

@QUESTIONS = 7 Name four adverse health and environmental risks resulting from increased UV-B radiation.

@QUESTIONS = 8 What is the major cause of acid deposition?

@QUESTIONS = 9 What are the four main adverse effects of acid deposition?

@QUESNONUM = <P16BJ243>10<P255DJ0> List two heavy metals of environmental concern.

@QUESNONUM = <P16BJ243>11<P255DJ0> Give three examples for the direct release of chemicals and three for their indirect release.

@PAGE BREAK =
@QUESNONUM = <P16BJ243>12<P255DJ0> <%2>List some health effects associated <%4>with exposur<%6>e t<%4>o toxi<%2>c<R>chemicals.<%0>

@QUESNONUM = <P16BJ243>13<P255DJ0> List <%2>three common air pollutants along with <%4>thei<%2>r chemica<%0>l<R>names or their acronyms.

@QUESNONUM = <P16BJ243>14<P255DJ0> What is the primary source of common air pollutants?

@QUESNONUM = <P16BJ243>15<P255DJ0> Name two air pollutants of special concern in cities.

@QUESNONUM = <P16BJ243>16<P255DJ0> Describe the health effects that result from burning biomass.

@QUESNONUM = <P16BJ243>17<P255DJ0> Name two land-based toxic pollutants that affect coastal areas.

@PAGE BREAK =
@QUESNONUM = <P16BJ243>18<P255DJ0> Why do small quantities of metals and persistent organic com- pounds cause a problem in aquatic environments?

@QUESNONUM = <P16BJ243>19<P255DJ0> Describe two types of contamination of fresh water that can be partially attributed to industrial activities.

@PAGE BREAK =

@MAJOR HEADING = Exercise

@BODY4 = L<%-2>ocate the technical term for each of the following in the <MI>Glossary<D>:<%0>

@QUESTIONS = 1 The level of atmospheric pollutants prescribed by regulations that may not be exceeded during a specified time in a defined area.

@QUESTIONS = 2 The amount of oxygen consumed in the biological processes that break down organic matter in water.

@QUESTIONS = 3 Treating pollutants at the end of a process, by filters, catalysts or scrubbers, instead of preventing their occurrence.

@QUESTIONS = 4 The slow aging process in which a lake, estuary or bay becomes a bog or marsh and eventually disappears.

@QUESTIONS = 5 A site used to dispose of solid wastes without environmental controls.

@QUESTIONS = 6 Minimizing the generation of waste by recovering usable pro- ducts that might otherwise become waste.

@QUESTIONS = 7 A pollutant remaining in the environment after a natural or technological process has taken place.

@QUESTIONS = 8 An air pollution control device that uses a spray of water or reactant or a dry process to trap pollutants in emissions.

@QUESTIONS = 9 Market mechanism for controlling pollution; it entails issuing permits to pollute up to fixed limits and grants the right to sell unused portions of these permits.

@PAGE BREAK =

@MAJOR HEADING = Additional Suggested Reading

@BIBLIOGRAPHY2 = UNEP. *The World Environment 1972-1992: Two Decades of Challenge*, M.K. Tolba and others. eds. (London, Chapman and Hall, 1992).

@BIBLIOGRAPHY2 = UNIDO. *Industry and Development: Global Report 1990/91* (UNIDO publication, Sales No. E.90.III.E.12), chap. III.

@BIBLIOGRAPHY2 = WCED. *Sustainable Development – A Guide to Our Common Future: The Report of the World Commission on Environment and Development* (Geneva. The Centre for Our Common Future. 1990).
@BIBLIOGRAPHY2 = World Resources Institute. *World Resources 1992-93: A Guide to the Global Environment* (New York. Oxford University Press. 1992).
@PAGE BREAK =
@CHAPTER = = Case Studies
@MAJOR HEADING = Case Study 1: Metal Contaminants in Poland
@FIRSTPAR = Industrial pollution problems encountered in the region around Katowice, Poland. situated 250 km south of Warsaw, adjacent to the Czech Republic. may typify the severity of environmental damage caused by industrial pollution in other highly industrialized regions of eastern Europe. Most of the so-called dirty- process plants in Poland are concentrated in the Katowice region. The bulk of these plants use out-of-date technologies.

<%2>This region accounts for nearly all the zinc and lead minerals mined and processed in Poland. 98 per cent of the hard coal produced, 52 per cent of the steel and 31 per cent of the coke manufactured. and 32 per cent of the coal-fired electric power generated. All these activities occur in an area that covers 2.1 per cent of Poland. As a result. more than 20 out of 54 pollutants listed by the Council of Ministers of Poland exceeded national standards in the Katowice region: worse yet. many of these pollutants have annual average <%0>concentrations that exceed the national standards by 500-2.000 per cent.
Air and water pollutants in the Katowice region contain a<%2> <%0>large variety of hazardous substances. including carcinogenic compounds. hydrogen cyanide, phenol and heavy metals. The Institute of Environmental Protection at Katowice recently measured the exposure of the local population (10 per cent of the Polish population live in that region) to two toxic metals. lead and cadmium. by the consumption of vegetables grown in the metal-contaminated soils of the region.
Lead is known to be harmful to the circulatory system and to cause neurological disorders. The main sources of lead emis- sion <%-2>is non-ferr<%0>ous metallurgical plants. mainly zinc and lead<%2> smelters in this region. Other sources, such as iron and steel plants (mainly open-hearth furnaces) and automobiles. are also important. Cadmium is known to damage the lungs, blood, liver and kidneys. The main sources of cadmium emission are zinc<%4> <%2>smelting plants (cadmium is a trace element in zinc ores). Not surprisingly. the highest concentrations of cadmium are found around such plants in the Katowice region.<%0>
To estimate the average weekly per capita intake of lead and cadmium through vegetable consumption by the local population, <%2>a study was conducted covering 431 vegetable plots in the<%0> Katowice region. on the basis of a random sample of the most commonly consumed vegetables from each plot. that is, carrots, parsley, celery, red beets and potatoes. From each selected plot, 30-50 sample vegetables were picked. washed as normally done in households. dried, ground and mineralized. and then the metal content for each vegetable was measured.
<%2>The sample results show that vegetable leaves are. not<%0> surprisingly. more readily exposed to metal contamination than roots. Thus, the highest concentrations were found in celery leaves and parsley leaves. followed by celery roots. carrot roots. red-beet roots. parsley roots and potatoes. The study group also estimated the average weekly per capita consumption of selected <%2>vegetables from a sample survey of 205 households in the Katowice region to arrive at the weekly intake of lead and cadmium through vegetable consumption. The estimates of<%0> weekly vegetable consumption and weekly metal intake

are given below. Particularly notable is a very high per capita consumption of potatoes, around 2 kg per week.

Given the maximum concentration limits, recommended by the Food and Agriculture Organization of the United Nations (FAO) and WHO, of 3 mg per week for lead and 0.4-0.5 mg for cadmium, the estimated lead intakes of the local population all exceeded the desired limits except in the Katowice region. Cad- mium intakes <%2>are almost twice the maximum limits for all districts. These estimates of metal intake are based on the measurement of metal concentrations in a small number of se<%0>lected vegetables grown in the region and exclude the local consumption of many other vegetables and fruits that may be exposed to metal contamination, as well as intakes from other sources such as inhalation of air-borne pollutants and consump- tion of contaminated livestock products. They are, therefore, likely to be considerable underestimates.

These results are much more shocking than comparable results obtained from west European countries. Investigations carried out in Austria, Belgium, Denmark, France and the Federal Republic of Germany in 1979-1982 showed that the weekly per capita consumption of vegetables, fruits and corn products re- sulted in an intake of between 0.5 and 1.5 mg of lead and between 0.11 and 0.34 mg of cadmium. The intakes of lead and cadmium in the Katowice region are several times higher than comparable figures in west European countries.

The study showed that the thorough washing of vegetables in tap water reduced their lead content by over 20 per cent but had little effect on their cadmium content. Peeling root vegetables also removed some of the metals: 20 per cent of the lead and 20-30 per cent of the cadmium. Over 90 per cent of lead and cadmium was removed from potatoes and deposited in the waste when potatoes were subjected to alcoholic fermentation. These con- taminated wastes are, however, often fed to livestock as a fodder in the Katowice region.

Given the relatively large quantities of potatoes consumed in Poland as a staple food (the per capita weekly consumption ranges between 2 and 5 kg, nearly twice the consumption in other countries), scientists at the Institute of Environmental Protection at Katowice investigated lead and cadmium concentration in raw potato samples from 13 regions in Poland. Four of these regions, including the Katowice region, are highly industrialized and the remaining nine are less so. As expected, all the districts in the Katowice region as well as the region as a whole showed much higher concentrations of lead and cadmium than other regions. In fact, most of the districts in the Katowice region greatly exceeded the maximum tolerance limits set by the Government of Poland for lead and cadmium concentrations in potatoes, 0.4 and 0.6 mg/kg of potatoes, respectively. By contrast, lead and cadmium concentrations in raw potatoes in other regions of Poland appear to be less serious, with a few exceptions.

@MAJOR HEADING = Questions

@QUESTIONS = 1 What activities are most likely to be responsible for the high emissions of lead in the Katowice region? For cadmium?

@QUESTIONS = 2 Are the estimates of lead and cadmium consumption produced by this survey likely to be close to the actual levels of lead and cadmium consumed? Why or why not?

@PAGE BREAK =

@QUESTIONS = 3 Do you think that the people of Poland can reduce their con- sumption

of lead and cadmium significantly if they wash their <%2>vegetables? Why or why not? Can you suggest any other<%0> things that the people might do to reduce lead and cadmium content of their vegetables?
@PAGE BREAK =
@MAJOR HEADING = Case Study 2: Industrial Pollution in Pakistan
@PAGE BREAK =
@TITLECTR = Industrial Pollution Problems in Pakistan

@Z_TBL_BEG = COLUMNS(4), DIMENSION(IN), HGUTTER(.0555), VGUTTER(.0555), BOX(Z_DOUBLE), HGRID(Z_SINGLE), VGRID(Z_SINGLE), KEEP(OFF), RULE(Quesnoind,R0C0..R1C4)
@Z_TBL_BODY = TABLE1, TABLE1, TABLE1, TABLE1
Media<$!B01>, Polluting industries<$!B01>, Major pollutants<$!B01>, Environmental problems<$!B01>
@Z_TBL_BODY = TABLE4, TABLE4, TABLE4, TABLE4
Water<$!B01>, , ,
Air<$!B01>, , ,
Land<$!B01>, , ,
@Z_TBL_END =
@PAGE BREAK =
@CHAPTER # = Review
@MAJOR HEADING = Test

@TEST? = 1 The developing countries' share of industrial output in 1990 was approximately
@TEST2 = a. 10 per cent
@TEST2 = b. 15 per cent
@TEST2 = c. 20 per cent
@TEST2 = d. 25 per cent
@TEST? = 2 The region with the highest growth rate in industrial output in 1970-1990 was
@TEST2 = a. Developed countries
@TEST2 = b. East Asia/South-East Asia
@TEST2 = c. Latin America
@TEST2 = d. Africa
@TEST? = 3 The region with the lowest growth rate in industrial output in 1970-1990 was
@TEST2 = a. Developed countries
@TEST2 = b. East Asia/South-East Asia
@TEST2 = c. Latin America
@TEST2 = d. Africa
@QUESTIONS2 =
@TEST? = 4 In developing countries, the main cause(s) of pollution is (are) usually
@TEST2 = a. Old heavy industry
@TEST2 = b. Population, poverty and agriculture
@TEST2 = c. Women
@TEST2 = d. Business
@TEST? = 5 Industry uses approximately
@TEST2 = a. One fifth of the world's energy
@TEST2 = b. One quarter of the world's energy
@TEST2 = c. One third of the world's energy

@TEST2 = d. One half of the world's energy
@TEST? = 6 <%-2>Emissions of CO<MV>2<D> from fossil fuel burning are a major cause of <%0>
@TEST2 = a. Greenhouse effect
@TEST2 = b. Aquatic system damage
@TEST2 = c. Ozone depletion
@TEST2 = d. All of the above
@TEST? = 7 Emissions of CFCs come from
@TEST2 = a. Refrigerators
@TEST2 = b. Solvents
@TEST2 = c. Foams
@TEST2 = d. All of the above
@TEST? = 8 Increases in UV-B radiation, as a result of the destruction of the ozone layer, contribute to all of the following effects except
@TEST2 = a. Suppression of the body's immune system
@TEST2 = b. Alteration of the reproductive capacity of plants
@TEST2 = c. Non-melanoma skin cancer
@TEST2 = d. Leukemia
@TEST? = 9 Acid rain results primarily from emissions of
@TEST2 = a. Sulfur dioxide
@TEST2 = b. Nitrogen oxides
@TEST2 = c. Hydrocarbons
@TEST2 = d. Particulate matter
@PAGE BREAK =
@TEST? = <P15BJ243>10<P255DJ0> Which of the following is not a toxic heavy metal?
@TEST2 = a. Mercury
@TEST2 = b. Lead
@TEST2 = c. Cadmium
@TEST2 = d. Dioxin
@TEST? = <P15BJ243>11<P255DJ0> The most polluting fuel per unit energy is <P15B>
@TEST2 = a. Oil
@TEST2 = b. Coal
@TEST2 = c. Nuclear
@TEST2 = d. Natural gas
@TEST? = <P15BJ243>12<P255DJ0> The official name of the report prepared by WCED is
@TEST2 = a. Brundtland Report
@TEST2 = b. Saving Our Planet
@TEST2 = c. *Our Common Future*
@TEST2 = d. *Sustainable Development*
@TEST? = <P15BJ243>13<P255DJ0> The WCED called for
@TEST2 = a. Zero economic growth
@TEST2 = b. Economic growth that is equitable and compatible with<R> the environment
@TEST2 = c. Large-scale financial transfers to developing countries
@TEST2 = d. Preservation of the world's resources
@TEST? = <P15BJ243>14<P255DJ0> Which percentage (approximately) of world income did 80<R> percent of the world population receive in 1992?
@TEST2 = a. 30

@TEST2 = b. 20
@TEST2 = c. 40
@TEST2 = d. 50
@TEST2 = <P15BJ243>15<P255DJ0> The<%2> challenge for industry is how to reconcile e<%0>nvironment<R> with projected
@TEST2 = a. Growth of population and gross national product (GNP)<R> per capita
@TEST2 = b. Growth of technology
@TEST2 = c. Pollution
@TEST2 = d. Growth of industrial output
@MINOR HEADING =
@MAJOR HEADING = Some Ideas to Think About
@QUESTIONS =
@QUESTIONS = 1 Which pollution do you find most disturbing? Why?

@QUESTIONS = 2 If the earth's axis were to tip by just two degrees, would it make any difference to the environment and the world of business?

@QUESTIONS = 3 Is zero pollution possible in old or new industries?

@QUESTIONS = 4 Should a developing country have lower environmental stand- ards than developed countries?

@QUESTIONS = 5 Which is more fragile, the environment or mankind?
@CHAPTER # = Glossary of Environmental Terms
@GLOSSARY = **Acid deposition.** A complex chemical and atmospheric phenomenon that occurs when emissions of sulfur and nitrogen compounds and other substances are transformed by chemical processes in the atmosphere, often far from the original sources, and then deposited on earth in either a wet or dry form. The wet forms, popularly called acid rain, can fall as rain, snow or fog. The dry forms are acidic gases or particulates.

@GLOSSARY = **Acid rain.** See **Acid deposition**

@GLOSSARY = **Air quality standards.** The level of pollutants prescribed by regulations that may not be exceeded during a specified time in a defined area.

@GLOSSARY = **APELL.** Awareness and Preparedness for Emergencies at a Local Level, UNEP training courses offerred by the Industry and Environment Programme Activity Centre of UNEP.

@GLOSSARY = **Assimilation.** The ability of a body of water to purify itself of pollutants.

@GLOSSARY = **Basel Convention.** The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1989) aims to control the transboundary movement and disposal of hazardous wastes.

@GLOSSARY = **BATNEEC** <%2> Best available techniques not entailing excessive cost.<%0>
@PAGE BREAK =
@GLOSSARY = **Baghouse filter.** Large fabric bag, usually made of glass fibers, used to eliminate intermediate and large (greater than 20 microns in diameter) particles. This device operates in a way similar to the bag of an electric vacuum cleaner, passing the air and smaller particular matter while entrapping the larger particulates.

@GLOSSARY = **Biochemical oxygen demand (BOD).** A measure of the amount of oxygen consumed in the biological processes that break down organic matter in water. The greater the BOD, the greater the pollution.

@GLOSSARY = **Biodegradable.** The ability to break down or decompose rapidly under natural conditions and processes.

@GLOSSARY = **Biological magnification.** Refers to the process whereby certain substances such as pesticides or heavy metals move up the food chain, work their way into a river or lake and are eaten by aquatic organisms such as fish, which in turn are eaten by large birds, animals or humans. The substances become concentrated in tissues or internal organs as they move up the chain.

@GLOSSARY = **Biological oxidation.** The way bacteria and micro-organisms feed on and decompose complex organic materials. Used in self-purification of water bodies and in activated sludge waste-water treatment.

@GLOSSARY = Biological treatment A treatment technology that uses bacteria to consume waste. This treatment breaks down organic materials.

@GLOSSARY = **Biosphere.** The portion of the earth that supports life, including the surface waters and the air. Similar to ecosphere.

@GLOSSARY = **Biotechnology.** Techniques that use living organisms or parts of organisms to produce a variety of products, from medicines to industrial enzymes, to improve plants or animals or to develop micro-organisms for specific uses such as removing toxics from bodies of water or killing pests.

@GLOSSARY = **Brundtland Report.** Popular name for report produced in 1987 by the World Commission on Environment and Development. This United Nations-sponsored body produced a global agenda for change and specified how sustainable development could be achieved. The commission was chaired by Gro Harlem Brundtland, the then—and subsequently re-elected—Prime Minister of Norway.

@GLOSSARY = **Cadmium** Toxic heavy metal used mainly for metal plating and as a plastic pigment. Significant by-product in zinc smelting and concern in phosphate manufacture.

@GLOSSARY = **Carbon cycle.** <%2>The circulation of carbon in the biosphere.<%0> Carbon is an essential part — a building block — of the molecules that make up all living cells. In the atmosphere it circulates as carbon dioxide, which is released by respiration, combustion and decay and fixed in complex carbon compounds during photosynthesis in plants and certain micro-organisms.

@GLOSSARY = **Carbon dioxide (CO_2).** A colorless, odorless, non-poisonous gas that results from respiration, combustion and decay and is normally a part of the ambient air.

@GLOSSARY = **Carbon sink.** See **Sink**

@GLOSSARY = **Carcinogen.** Any substance that can cause or contribute to the onset of cancer.

@GLOSSARY = **Catalytic converter.** An air pollution abatement device that removes pollutants from motor vehicle exhaust, either by oxidizing them into carbon dioxide and water or reducing them to nitrogen and oxygen.

@GLOSSARY = **Chemical oxygen demand (COD).** A measure of oxygen required to oxidize all compounds in water, both organic and inorganic.

@GLOSSARY = **Chlorofluorocarbons (CFCs).** A family of inert, nontoxic and easil<%2>y liquefied chemicals used in refrigeration, air conditioning, packaging and insulation or as solvents and aerosol propellants. Because CFCs are not destroyed in the<%4> lo<%2>wer at- mosphere they drift into the upper atmosphere, where their chlorine components destroy ozone.<%0>

@GLOSSARY = **Cleaner Production** A concept of industrial production that minimizes all environmental impacts through careful management of resource use, of product design and use. systematic waste avoidance and management of residuals, safe working practices and industrial safety. Sometimes called pollution prevention or waste minimization.

@GLOSSARY = **Clean technologies.** Production processes or equipment with a low rate of waste production. Treatment or recycling plants are not classed as clean technologies.

@GLOSSARY = **Cradle-to-grave** Term used to imply the whole life cycle of a product, from raw material to final disposal.

@GLOSSARY = **DDT.** The first chlorinated hydrocarbon insecticide (chemical name: dichlorodiphenyltrichloroethane). It has a half-life of 15 years and can collect in fatty tissues of certain animals. USEPA banned registration and interstate sale of DDT for virtually all but emergency uses in the United States in 1972 because of its persistence in the environment and accumulation in the food chain.

@GLOSSARY = **Dilution ratio.** The relationship between the volume of water in a stream and the volume of incoming water. If affects the ability of the stream to assimilate waste.

@GLOSSARY = **Dioxin.** Any of a family of compounds known chemically as dibenzo-*p*-dioxins. They are of concern because of their potential toxicity and contamination in commercial products. Tests on laboratory animals indicate that dioxins are among the more toxic man-made chemicals known.

@GLOSSARY = **Disposal.** Final placement or destruction of toxic, radioactive or other wastes; surplus or banned pesticides or other chemicals; polluted soils; and drums containing hazardous materials from removal actions or accidental releases. Disposal may be accomplished through use of approved secure landfills, surface impoundments, land farming, deep well injection, ocean dumping or incineration.

@GLOSSARY = **Dissolved oxygen (DO).** The oxygen freely available in water. Dissolved oxygen is vital to fish and other aquatic life and for the prevention of odors. Traditionally, its level has been accepted as the single most important indicator of a water body's ability to support desirable aquatic life. Secondary and advanced waste treatment are generally designed to protect DO in waste-receiving waters.

@GLOSSARY = **Dump.** A site used to dispose of solid wastes without environmental controls.

@GLOSSARY = **Eco-capacity.** Refers, on the one hand, to the capacity of an ecosystem to be resilient, that is, to maintain its patterns of behaviour in the face of disturbance and, on the other hand, to its capacity to remain stable, that is, to maintain its equilibrium in response to normal fluctuations in the environment.

@GLOSSARY = **Eco-efficiency.** Maximization of industrial output from a given level of resource input, thus ensuring waste minimization and appropriate use of human, renewable and non-renewable resources.

@GLOSSARY = **Ecology.** The relationship of living things to one another and their environment, or the study of such relationships.

@GLOSSARY = <B%-2>Ecologically sustainable industrial development <%0>(ESID). Patterns of industrialization that enhance the contribution of industry to economic and social benefits for present and future generations without impairing basic ecological processes.

@GLOSSARY = **Ecosystem.** The interacting system of a biological community and its non-living environmental surroundings.

@GLOSSARY = **EEIS.** Energy and Environment Information System.

@GLOSSARY = **End-of-pipe treatment (abatement).** Treating pollutants at the end of a process (by, for example, filters, catalysts and scrubbers) instead of preventing their occurrence.

@GLOSSARY = **Environment.** The sum of all external conditions including physical and social factors, affecting the life, development and survival of an organism.

@GLOSSARY = **Environmental compliance audit.** Systematic review and testing by professional environmental auditors of the management, production, marketing, product development and organizational systems of an enterprise to determine and assess compliance with environmental regulations.

@GLOSSARY = **Environmental impact assessment.** <%2>An analysis to determine whether an action would significantly affect the environment.<%0>

@GLOSSARY = **Equity**. 1. The opportunity for all countries to share the wealth of industrial development at present. i.e. intra-generational equity 2. Equal opportunity for present and future generations to share such wealth, i.e intergenerational equity.

@GLOSSARY = **Eutrophication** <%-2> The slow aging process in which a lake, estuary or bay becomes a bog or marsh and eventually disappears. During the later stages of eutrophication<%0> the water body is choked by overabundant plant life as the amounts of nutritive compounds such as nitrogen and phosphorus increase. Human activities can accelerate the process.

@GLOSSARY = **Externality**. The cost or benefits to parties other than the supplier and the purchaser of an economic transaction.

@GLOSSARY = **FAO**. Food and Agriculture Organization of the United Nations.

@GLOSSARY = **GDP**. Gross domestic product. The total market value of all the goods and services produced within a nation (excluding income from abroad) during a specified period.

@GLOSSARY = **GEMS**. Global Environment Monitoring System, managed by UNEP. Makes comprehensive assessments of major environmental issues and thus provides the scientific data needed for the rational management of natural resources and the environment; provides early warning of environmental changes by analyzing monitoring data.

@GLOSSARY = Global warming. The consequences of the greenhouse effect, caused by rising concentrations of greenhouse gases. The suspicion is that global warming will disrupt weather and climate patterns. It could lead to drought in some areas and flooding in others. One of the most serious environmental problems facing the world.

@GLOSSARY = **GNP**. Gross national product. The total market value of all the goods and services produced by a nation (including income from abroad) during a specified period.

@GLOSSARY = **Good housekeeping.** Efficient management of the property and equipment of an institution or organization. In the context of Cleaner Production, it often refers to the procedures applied in the operation of a production process.

@GLOSSARY = **Greenhouse effect**. The warming of the earth's atmosphere, caused by a build-up of carbon dioxide or other trace gases. It is believed by many scientists that this build-up allows light from the sun's ray to heat the earth but prevents a counterbalancing loss of heat.

@GLOSSARY = **Greenhouse gases.** The gases, such as carbon dioxide, water vapor, methane, nitrous oxides and CFCs, that trap the sun's heat in the lower atmosphere and prevent it from escaping into space. Major source of increased concentration in the atmosphere is the combustion of fossil fuels. See **Greenhouse effect**

@GLOSSARY = **Groundwater.** The supply of fresh water found beneath the ea<%2>rth's surface (usually in aquifers) that is often used for supplying wells and springs. Because groundwater is an important source of drinking water, there is growing concern about areas where agricultural or industrial pollutants or substances from leaking u<%0>nderground storage tanks are contaminating groundwater.

@GLOSSARY = **Halons.** Bromine-containing compounds with long atmospheric lifetimes whose breakdown in the stratosphere can cause depletion of ozone. Halons are used in fire-fighting.

@GLOSSARY = **Hazardous waste.** By-products of society that can pose a substantial hazard to human health or the environment when improperly managed. Characterized by at least one of the following: ignitability, corrosivity, reactivity or toxicity.

@GLOSSARY = **Heavy metals.** Metallic elements with high atomic weights, e.g. mercury, chromium, cadmium, arsenic and lead. They can damage living things at low concentrations and tend to accumulate in the food chain.

@GLOSSARY = **Hydrocarbon (HC).** Chemical compounds consisting entirely of carbon and hydrogen.

@GLOSSARY = **ICC.** International Chamber of Commerce.

@GLOSSARY = **ICPIC.** International Cleaner Production Information Clearinghouse.

@GLOSSARY = **IDA.** Industrial Development Abstracts database of INTIB.

@GLOSSARY = IE/PAC. Industry and Environment Programme Activity Centre of UNEP, in Paris: formerly called the Industry and Environment Office.

@GLOSSARY = **ILO.** International Labour Organisation of the United Nations.

@GLOSSARY = **Incineration.** <%-2>1. Burning of solid, liquid or gaseous materials. 2. A treatment technology involving destruction of waste by control<%0>led burning at high temperature, e.g. burning sludge to remove the water and reduce the remaining residues to a safe, non-burnable ash that can be disposed of safely on land, in some waters or in underground locations.

@GLOSSARY = **INEM.** International Environmental Management Association. Coordinates and supports national associations of environmentalist business management associations or business enterprises. Described in the European Community publication *Business and Environment.*

@GLOSSARY = <B%2>INTIB<D>. Industrial and Technological Information Bank of<%0> UNIDO.

@GLOSSARY = **IPCC.** Intergovernmental Panel on Climate Change.

@GLOSSARY = **IRPTC.** International Register of Potentially Toxic Chemicals, at Geneva. A cooperative activity of UNEP/WHO/ILO. Maintains a global system for assessing environmental effects of chemicals. Topics include identification of knowledge gaps; chemical hazards; evaluation and control of chemicals in the environment; numerical data; production, use and characteristics of chemicals; laws and regulations affecting man, living species and natural resources.

@GLOSSARY = **Landfills.** 1. Sanitary landfills are land disposal sites for non-hazardous solid wastes, where the waste is spread in layers, compacted to the smallest practical volume and cover material applied at the end of each operating day. 2. Secure chemical landfills are disposal sites for hazardous waste. They are selected and designed to minimize the chance of hazardous substances being released into the environment.

@GLOSSARY = **Leachate.** A liquid produced when water collects contaminants as it trickles through wastes, agricultural pesticides or fertilizers. Leaching may occur in farming areas, feedlots or landfills and may result in hazardous substances entering surface water, groundwater or soil.

@GLOSSARY = **Media.** Specific environments—air, water, soil—that are the subject of regulatory concern and activities.

@GLOSSARY = **Mercury.** A heavy metal that can accumulate in the environment and is highly toxic if breathed or swallowed. See **Heavy metals**.

@GLOSSARY = **Minimization.** Actions to avoid, reduce or in other ways diminish the hazards of wastes at their source. Recycling is, strictly speaking, not a minimization technique but is often included in such programmes for practical reasons.

@GLOSSARY = **Minamata.** A fishing village in Japan. In the 1950s and 1960s the people who lived there were poisoned by mercury pumped into the bay by a local company. The mercury was absorbed by fish later eaten by the people. The mercury caused nervous disorder in adults and cerebral palsy in children.

@GLOSSARY = **Montreal Protocol.** The Montreal Protocol on Substances that Deplete th<°a2>e Ozone Layer, adopted 16 September 1987, sets limits for the production and consumption of damaging CFCs and halons.<%0>

@GLOSSARY = **MVA.** Manufacturing value added.

@GLOSSARY = **NGO.** Non-governmental organization. Examples are Greenpeace, International Chamber of Commerce, International Environmental Management Association and many others.

@GLOSSARY = **NIMBY.** Acronym for "not in my back yard." Political jargon to describe a situation in which the electorate might agree to, say, industrial dumping or incineration, as long as it does not take place near their homes.

@GLOSSARY = **Nitrate.** A compound containing nitrogen that can exist in the atmosphere or as a dissolved gas in water and that can have harmful effects on humans and animals. Nitrates in water can cause severe illness in infants and cows.

@GLOSSARY = **Non-point source.** Pollution sources that are diffuse and do not have a single point of origin or are not introduced into a receiving stream from a specific outlet. The pollutants are generally carried off the land by storm-water run-off. The commonly used categories for non-point sources are agriculture, forestry, urban areas, mining, construction, dams and channels, land disposal and salt-water intrusion.

@GLOSSARY = **NO_x**. Chemical formula that stands for all the oxides of nitrogen, mainly NO_2, but also N_2O, NO, N_2O_3, N_2O_4 and NO_3, which is unstable.

@GLOSSARY = **Nutrient.** Any substance assimilated by living things that promotes growth. The term is generally applied to nitrogen and phosphorus in waste water but is also applied to other essential and trace elements.

@GLOSSARY = **OECD.** Organization for Economic Cooperation and Development. Twenty-four countries, all market economies, are members: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States. It collects and analyzes information, including data on environmental degradation and spending on environmental protection.

@GLOSSARY = **Off-site facility.** A hazardous waste treatment, storage or disposal area that is located away from the generating site.

@GLOSSARY = <B%-2>Ozone (O<B\>3<B>).<D> Found in two layers of the atmosphere, the stratosphere and the troposphere. In the stratosphere (the atmospheric layer beginning 7-10 miles above the earth's surface), ozone is a form of oxygen found naturally which provides a protective layer, shielding the earth from ultraviolet radiation's harmful health effects on humans and the environment. In the troposphere (the layer extending up 7-10 miles above the earth's surface), ozone is a chemical ox<%0>idant and a major component of photochemical smog. Ozone can seriously affect the human respiratory system and is one of the most prevalent and widespread pollutants. Ozone in the troposphere is <%2>produced through complex chemical reactions between nitrogen oxides, which are among the primary pollutants emitted by combustion sources, hydrocarbons, which are released into the atmosphere by the combustion, handling and processing of petroleum products, and sunlight.<%0>

@GLOSSARY = Ozone depletion. Destruction of the stratospheric ozone layer, which shields the earth from ultraviolet radiation harmful to life. This destruction of ozone is caused by certain chlorine- and/or bromine-containing compounds (chlorofluorocarbons or halons), which break down when they reach the stratosphere and catalyse the destruction of ozone molecules.

@GLOSSARY = **PCBs.** A group of toxic, persistent chemicals (chemical name: polychlorinated biphenyls) used in transformers and capacitators for insulating purposes and in gas pipeline systems as a lubricant.

@GLOSSARY = Phenols. Organic compounds that are by-products of petroleum refining, tanning and the manufacture of textiles, dyes and resins. Low concentrations cause taste and odour problems in water; higher concentrations can kill aquatic life and humans.

@GLOSSARY = <B%-2>Phosphates.<D> Certain chemical compounds containing phosphorus.<%0>

@GLOSSARY = **Phosphorus.** An essential chemical food element that can contribute to the eutrophication of lakes and other water bodies. Increased phosphorus levels result from discharge of phosphorus-containing materials into surface waters.

@GLOSSARY = **Photochemical smog.** Air pollutant formed by the action of sunlight on oxides of nitrogen and hydrocarbons.

@GLOSSARY = **Pollutant.** Generally, any substance introduced into the environment that has the potential to adversely affect the water, soil or air. See **Residual.**

@GLOSSARY = **Pollution.** Generally, the presence of matter or energy whose nature, location or quantity produces undesired environmental effects.

@GLOSSARY = **PVC.** A tough, environmentally indestructible plastic (chemical name: polyvinyl chloride) that releases hydrochloric acid when burned.

@GLOSSARY = Recycling. The process of minimizing the generation of waste <%2>by recovering usable products that might otherwise become<%0> waste. Examples are the recycling of aluminium cans, waste paper and bottles.

@GLOSSARY = **REED.** Referral Database on Energy and Environment.

@GLOSSARY = <B%2>Residual.<D> A pollutant remaining in the environment after a<%0> natural or technological process has taken place, e.g. the sludge remaining after initial waste-water treatment or particulates remaining in air after the air passes through a scrubbing or other pollutant removal process.

@GLOSSARY = **Risk assessment.** The qualitative and quantitative evaluation performed in an effort to define the risk posed to human health and/or the environment by the presence or potential presence and/or use of specific pollutants.

@GLOSSARY = **Scrubber.** An air pollution control device that uses a spray of water or reactant or a dry process to trap pollutants in emissions.

@GLOSSARY = **Sink.** In air pollution, the receiving area for material removed from the atmosphere, e.g. by virtue of photosynthesis plants are sinks for carbon dioxide.

@GLOSSARY = **Solvents.** Liquids that dissolve other substances. Chemical sol<%-2>vents are used widely in industry. They are used by pharmaceutical makers to extract active substances; by electronics manufacturers to wash circuit <%1>boards; by paint-makers to aid drying. Most solvents can cause air and water pollution and<%-2> can be a health hazard.<%0>
<B%2>
@GLOSSARY = **Sulphur dioxide (SO<BV%2>2<B>). <D> A colourless, irritating pungent gas<%0> formed when sulphur burns in air, one of the main air pollutants that contribute to acid rain and smog. Comes from the combustion of the sulphur present in most fossil fuels.**

@GLOSSARY = Superfund. Levy on industry to pay for cleaning up the most contaminated industrial dumps and sites in the United States.

@GLOSSARY = **Suspended Particulate Matter (SPM).** Fine liquid or solid particles such as dust, smoke, mist, fumes or smog, found in air or emissions.

@GLOSSARY = <B%2>Sustainable development. <D> Development that meets present<%0> needs without compromising the ability of future generations to meet their own needs. Necessarily based on limited data due to our current inability to forecast accurately 50-100 years ahead.

@GLOSSARY = **Synergistic.** Interaction between two or more forces such that their combined effect is greater than the sum of their individual effects.

@GLOSSARY = **Tradeable permits.** Market mechanism for controlling pollution; it entails issuing permits to pollute up to fixed limits and grants the right to sell unused portions of the permits.

@GLOSSARY = **UNCED.** United Nations Conference on Environment and Development; it took place at Rio de Janeiro in June 1992 and was convened by the General Assembly in its resolution 44/228.
@GLOSSARY = **UNDP.** United Nations Development Programme.

@GLOSSARY = **UNEP.** United Nations Environment Programme.

@GLOSSARY = **USEPA.** United States Environmental Protection Agency. Established in 1970 by Presidential Executive Order, it brought together the parts of various government agencies involved with the control of pollution.

@GLOSSARY = **UV-B.** Short wavelength ultraviolet radiation.

@GLOSSARY = **Valdez Principles.** Ten standards of corporate responsibility, formulated by the Social Investment Forum in United States after the *Exxon Valdez* accident. Encourages sustainable development and good environmental practice by companies.

@GLOSSARY = <B%2>Waste. <D> Unwanted materials left over from a manufacturing<%0> process and refuse from places of human or animal habitation.

@GLOSSARY = Waste reduction audit. Highly cost-effective technique that follows material inputs into the production process and accounts for them quantitatively, in any form (solid, liquid, gaseous), to identify losses (wastes), which can then be reduced by changes in input materials, process technology, product design and recycling.

@GLOSSARY = **Waste minimization.** The reduction of waste by changing materials, processes or on-site disposal arrangements in a way that is profitable for the enterprise and the environment. Also called waste reduction.

@GLOSSARY = <B%4>Water quality standards<D> Ambient standards for water <%2>bod<%0>ies. The standards address the use of the water body and<%2> set water quality criteria that must be met to protect the designated use or uses.<%0>

@GLOSSARY = **WCED.** World Commission on Environment and Development.

@GLOSSARY =
@GLOSSARY = **WHO.** World Health Organization.

@GLOSSARY = **WICE.** World Industry Council for the Environment, a division of the International Chamber of Commerce that raises environmental awareness on the part of industry in developing and developed countries.

@GLOSSARY = **WICEM II.** Second World Industry Conference on Environmental Management, organized by the International Chamber of Commerce in 1991.

@CHAPTER # = Reading Excerpts
@CHAPTER TITLE = The Road to Ecologically Sustainable Industrial Development
@MAJOR HEADING = Chapter I: Past Trends in Industrial<R>Growth and Pollution
@FIRSTPAR = For the world as a whole, industrial output (taken as manufacturing value added) grew at an annual rate of 3.6 per cent during the last 20 years (see table 1), while population grew at 1.8 per cent. The manufacturing value added (MVA) of developed market economies grew at an annual rate of 3.1 per cent, while their population grew at 0.7 per cent. In the third world, noteworthy gains occurred in some regions, particularly East Asia and South-East Asia, which experienced annual growth of 9.1 per cent in industrial output compared with annual growth of 2.1 per cent in population.
This growth in the industrial output of developing countries did not meet expectations, particularly in the 1980s. Overall, the share of these countries in global industrial output, in current prices, increased only modestly, from 9.3 per cent to 13.8 per cent from 1970 to 1980 (figure 1). Moreover, 10 countries accounted for over 60 per cent of the total MVA of all 116 developing countries, and 18 countries for nearly 80 per cent.
Events over the past 20 years are disturbing also in respect of environmental deterioration for all countries. Most startling are the threats to the biosphere, to which industrialization contributes a significant share.
One such threat is the concentration in the atmosphere of carbon dioxide (CO_2), a primary contributor to the greenhouse effect, which has increased by 10 per cent over the last 20 years (Figure 2).[2] As a result of increasing emissions of CO_2 and other greenhouse gases, the average global temperature will probably increase from 15.2 C in the 1980s to between 16.7 and 19.7 C by 2030.[3] Approximately two thirds of the CO_2 released into the atmosphere can be attributed to human activities, particularly fossil fuel combustion; and about one third of fossil fuel combustion is either directly or indirectly connected to industrial activity.
<%2>A second area of concern is the concentration in the atmosphere of chlorofluorcarbons (CFCs), which have increased dramatically (figure 3). CFCs are used in refrigerators and air-conditioners, in the blowing of plastic foam and as a solvent. They are the main cause of the "ozone hole", the name given to the decline in stratospheric ozone, which protects the surface of the earth from damaging ultraviolet radiation. Increased ultraviolet radiation promotes skin cancers and cataracts and depresses human immune systems; it also reduces crop yields, depletes marine fisheries, accelerates the deterioration of materials and increases smog. The higher concentration of CFCs also contributes to global warming.<%0>
@PAGE BREAK =
A third area of concern is the increasing emissions of sulphur dioxide (SO_2) and nitrogen oxides (NO_x), which increased by 40 per cent and 100 per cent, respectively, from 1960 to 1980 (figure 4). These pollutants are the main reasons for the growing acidity of the natural environment, especially freshwater lakes, rivers, forests and soils, and they contribute to the deterioration of the man-made environment, especially stone buildings and metallic infrastructure. These pollutants are produced mainly by the combustion of fossil fuels, primarily from power plants. It should be noted that the effects of acidification may have been masked until comparatively recently by the buffering effects of alkaline fly ash. However, the increasing use of smoke-control technology, especially electrostatic precipitators, may tend to accelerate the acid build-up by decreasing the buffering effect.
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<%2>A fourth area of concern is wastes, primarily toxic chemicals and heavy metals, which are dispersed locally and build up in soils or sediments. The most polluted areas are probably United States and Europea°a4 n river basins, such as those of the Thames, the

Rhine-<°o2>Schelde, the Elbe, the Danube, the Vistula, the Po, the Hudson-Rari<°o4>tan, the Delaware, the Ohio and the lower Mississippi, which became industrialized in the last 100-150 years. There are no global data on such accumulations. There are, however, global estimates of annual atmospheric emissions of heavy metals (table 2). Anthropogenic emissions of lead, cadmium, vanadium, and zinc exceed emissions from natural sources by factors of 28, 6, and 3, respectively. Industrial contributions of arsenic, copper, mercury, nickel and antimony are as much as twice those from natural sources. In addition, atmospheric fallout, domestic and industrial wastew<%2>ater discharges and urban runoff have caused significant inputs of trace metals into aquatic ecosystems and soils, threatening the biosphere as a whole, including regional seas and the oceans.<%0>

Industry is a major contributor to these environmental concerns.[4] It includes activities such as manufacturing, mining, utilities and construction. Of these sectors, manufacturing alone accounts for, on average, one third of total final energy consumption. More specifically, five manufacturing subsectors are known to be the most energy- and materials-intensive as well as the most pollution-intensive activities: iron and steel; nonferrous metals; nonmetallic minerals; chemicals; and pulp and paper.[5]

For a long time, industry in developed countries has been the major contributor to these problems of the biosphere, but the situation is <%2>changing with<%4> the rapid industrialization of developing countries.<%2> Whereas the developed countries have to some degree delinked energy and industrial output, developing countries have done just the reverse. In fact, the delinking phenomenon is partly due to structural shifts, namely the gradual relocation of resource-based (and energy-intensive) industries, such as steel, aluminium and petrochemicals, from the industrialized countries to the developing countries. Industrial final energy consumption in developed countries declined at an annual rate of 0.65 per cent in 1973-1985 and 1.93 per cent in 1980-1985, while industrial output increased at an annual rate of 1.50 per cent in 1973-1980 and 3.24 per cent in 1980-1985. In sharp contrast, in<%0>dustrial energy consumption in the devel<°o2>oping countries as a whole, excluding China, grew at an annual rate of 6.32 per cent in 1973-1980 and 4.83 per cent in 1980-1983, while industrial output grew by 3.82 per cent and 0.03 per cent in the same periods. Similarly, four out of the five materials, energy and pollution-intensive manufacturing sectors listed above grew faster in developing countries than in developed countries during 1970-1988 and grew twice as fast in developing coun<%0>tries as in developed countries during 1980-1985.[6]

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@MAJOR HEADING = Chapter IV: Progress Towards Ecologically<R>Sustainable Industrial Development

@FIRSTPAR = The question that now arises is, How well is industry doing in achieving ESID? It is a difficult question to answer because there is a lack of industry-specific data, but a reasonable assessment can be made using existing data and approximate measures.

UNIDO suggests two ways to measure progress towards protecting the biosphere. One is compliance with ambient environmental standards, the other is compliance with total loading standards.

@MINOR HEADING = Ambient Standards

Industry is only one of many contributors to the degradation of the environment. Agriculture, mining, energy, transport, services and households also contribute in varying degrees. Not enough data are available at the global level to assess the relative contribution of these various sources to ambient environmental deterioration. There is information, however, on the relative contribution of pollutant loadings into the environment.

Environmental deterioration associated with industrial development occurs at both the input and the output sides of production activities. Industrial production requires the input of a wide variety of natural resources, such as water, energy, minerals, forest products and other raw materials whose rapid depletion may cause environmental damage and ecological disruption. On the output side, the manufacturing process generates myriad wastes, including hazardous wastes, toxic chemicals and thermal wastes, that pollute the soil, the air and surface water and groundwater. On the output side, too, many manufactured end-products, such as pesticides, detergents, paints, plastics and combustion engines, add to the pollution.

In *Industry and Development: Global Report 1990/91* UNIDO assessed the global degradation of the environment from both the input and output sides of production activities.7 On the input side, it looked at the consumption of water, energy and mineral resources:

@BULLET = **Water**. Industry uses much less water than agriculture, but it pollutes the water more. Although more than 80 per cent of the water used for cooling and cleaning is returned, the returned water is often contaminated by industrial effluents and thermal pollution;

@BULLET = **Energy**. In the countries of the Organization for Economic Co- operation and Development (OECD), industry used more energy than any other sector in 1970-1987. Its share ranged from 40 per cent in 1970 to 33 per cent in 1987. The industrial share of energy consumption in developing countries varied from country to country, ranging from 63 per cent in China to 20 per cent in West Africa;

@BULLET = **Mineral resources**. T<%2>here seems to be no cause for concern about the exhaustion of mineral resources within the fore- seeable future, although political disruptions can always lead to temporary shortages. More important in connection with mineral resources are the environmental problems posed by their production and industrial use.<%0>

<%2>On the output side, the <MI°ó0>Global Report<%2> <D>analysed air pollution, water pollution, solid wastes, hazardous wastes and toxic chemicals:<%0>

@BULLET = **Air pollution**. The manufacturing sector is not the sector that generates most air pollutants. Each major air pollut<%-2>ant has a different major source: electricity generation accounts for the bulk of anthropogenic emissions of SO<MV>2<D>, transport activities, for NO<MV>x<D> and CO; and motor vehicles, for hydrocarbons and lead. Industry, however, is a major source of particulate emissions in many countries;<%0>

@BULLET = **Water pollution**. Industry is responsible for a fairly large share of waste-water discharges containing traditional pollutants. Esti- mation of the share is complicated by the fact that in many countries industry discharges its waste into municipal waste-water systems. Fragmentary data indicate that the share of industry in total waste-water discharges is roughly 20 per cent;

@BULLET = **Solid wastes**. An inter-country comparison of solid waste gen- eration is difficult owing to the different definitions for categories of wastes. A few country estimates are as follows: industry's share of solid waste generation accounts for 17 per cent of the total in the United States, 9 per cent in France and 60 per cent in Japan;

@BULLET = **Hazardous wastes**. National data on hazardous wastes are scarce and incomplete. Even when available, they are not comparable because of the widely varying definitions and classification schemes for hazardous wastes adopted by different countries. Bearing these limitations in mind, the fragmentary data show that, with some minor exceptions, the largest portion of hazardous wastes is generated by industrial production. For instance, in the United States over 85 per cent of the hazardous waste is accounted for by the manufacturing sector; in Thailand, this share is over 95 per cent;

@BULLET = **Toxic chemicals**. It is difficult to estimate the quantity of toxic chemical wastes produced in different countries each year, partly because the term "toxic" is defined differently in different countries. Some recent data from the United States seem, however, to permit the identification and quantification of the types and sources of toxic chemical wastes. The chemical industrv accounted for 54 per cent of the total releases, followed by the paper products and primary metals subsectors.

<%2>In summary, while the available data allow a reasonable assessment for industrial<%0>ized countries, the relative contribution of industry to overall environmental degradation in developing countries is little known. For OECD countries, the industrial sector in 1987 accounted for 15 per cent of the total water use, 25 per cent of NOx, 35 per cent of final energy use, over 40 per cent of SO_2 emissions, 50 per cent of greenhouse gas emissions, 60 per cent of the water pollution (biochemical oxygen demand), 75 per cent of non-hazardous inert waste and 90 per cent of toxic substances discharge to water. For developing countries, as well as the countries of Eastern Europe, the data on the relative contribution of industry to environmental deterioration are very fragmentary, as can be s<%2>een in a recent report from the Economic and Soci<%4>al Commission for Asia and the Pacific (ESCAP).<M^>8<D> There is obviously significant variation, given the different levels of industrialization between developed and developing countries as well as<%2> among developing coun- tries. For example, industry's share of total final energy use, which use constitutes a major th<%0>reat to the biosphere, was 34 per cent in Africa, 40 per cent in Latin America and around 55 per cent in Eastern Europ<%2>e.<M^>9<D%0>

@MINOR HEADING = Total Loadings

Meeting current ambient standards is insufficient to prevent global and regional environmental problems. These ambient standards were formulated to protect local populations and natural resources, and they focus on concentrations, or flows, of pollutants. Total loading standards for some pollutants reflect the fact that the cumulative stocks of these pollutants in the environment, as well as the flows into it, are significant and must be reduced. Except in the case of CFCs, the extent to which they must be reduced is an open question.

Global emissions of CO_2 from energy use, expressed on a total carbon basis, increased from 4.0 billion tonnes in 1970 to approximately 5.2 billion tonnes in 1985 (table 3). They are projected to reach 10.2 billion tonnes (the mid-point estimate) in the year 2025[10] Industry's share of these emissions is estimated to have been 2.0 billion tonnes in 1985, assuming that industry <%2>uses slightly more than one third of the world's energy. In 1985, the industrialized countries emitted about 50 per cent of this total, the former Union of Soviet Socialist Republics (USSR) and the countries of Eastern Europe about 25 per cent and the <%0>developing countries about 25 per cent. In 2025, the distribution is projected to be 35 per cent, 25 per cent and 40 per cent owing to more rapid industrialization in developing countries and the positive linkage between energy consumption and industrial output. Currently, developing countries are experiencing the most rapid increase in CO_2 with average annual growth of 3.7 per cent compared to 1.2 per cent and 2.6 per cent for OECD countries and the USSR and Eastern European, respectively.

<%2>Global emissions of CFCs increased from 0.8 billion tonnes in 1970 to 1.5 billion tonnes in 1985 and are estimated to increase to 3.9 billion tonnes by 2025 (table 3). In 1985, the industrialized countries emitted about 70 per cent of the world's total, the former USSR and the countries of Eastern European about 15 per cent and developing countries (including China) about 15 per cent. In 2025, the industrialized countries are projected to emit about 40 per cent of the world's total, the former USSR and countries of Eastern Europe about 15 per cent and developing countries about 45 per cent.<%0>

Global emissions of SO_2 increased from 63 million tonnes in 1970 to 80.5 million tonnes in 1985 and are projected to increase to 235 million tonnes by 2020 (table 4). These emissions are primarily (85 per cent) attributable to fossil fuel combustion (coal and oil) and secondarily to petroleum refining, the smelting of sulphur-containing ores (copper, lead and zinc) and sulfuric acid production. Assuming that industry uses one third of the world's energy, it was either directly or indirectly (by purchases of electricity) responsible in 1985 for 30 million tonnes of SO_2 emitted into the atmosphere. In 1985, industrialized countries emitted about 40 per cent of the total emissions, the former USSR and countries of Eastern Europe for slightly more than 30 per cent. In 2020, the industrialized countries are projected to emit about 15 per cent of the world's total, the republics of the former Soviet Union and the countries of Eastern Europe about 15 per cent and developing countries about 70 per cent. Most of the increase in emissions by 2020 will be attributable to the increased use of coal in China.

Data on the accumulation of trace metals in soils and sediments over the past decades are limited, especially in developing countries.[11] In the past developed countries were the main culprits in the discharge of trace metals, but the trend is reversing: "... the combination of natural resource endowments, the constraints imposed by population growth and economic development, and the lack of government regulations can only lead to an increase in the rates of toxic metal discharge in developing countries".[12]

Three activities are usually of greatest concern: the mining, smelting and refining of metals; the burning of fossil fuels for energy production; and the manufacturing processes, especially the production of metallic commercial products. A brief look at table 2 confirms that these activities are the main contributors of trace metals into the atmosphere. Manufacturing processes alone, ignoring energy use, are significant contributors of chromium, manganese, nickel, thallium and zinc.

@CHAPTER TITLE = Understanding Environmental Problems
@MAJOR HEADING = Global Climate Change
@FIRSTPAR = An important descriptor of climate is temperature. Sunlight heats up the sea and land. The warmed surface of the earth then radiates heat back towards space. On its way out, some of this heat (infrared radiation) is absorbed by <°o2>trace gases in the atmosphere, notably CO<MV>2<D> and water vapour, and thereby keeps the earth's temperature suitable for life. Without this natural greenhouse effect of CO<MV>2<D> and water vapour, the temperature at the earth's surface would be some 33<M'>o<D>C cooler than it is today, i.e. below the freezing point. The natural concentration of CO<MV>2<D> in the atmosphere is controlled by the interactions of the at- mosphere, the oceans and the biosphere in what is known as the geochemical carbon cycle. Human activities can disturb this cycle by injecting carbon dioxide into the atmosphere. This leads to a net increase in carbon dioxide concentration in the atmosphere, which enhances the natural greenhouse effect.<°o0>
It had been thought that CO_2 was the only greenhouse gas. However, research over the last two decades has identified other gases such as nitrous oxide, methane, chlorofluorocarbons and tropospheric ozone as potential greenhouse gases.
<°o1>The atmospheric CO<MV>2<D> concentration is now 353 parts per<°o-2> million by volume (ppmv), 25 per cent greater than the pre-industrial (1750-1800) value of about 280 ppmv, and it is currently<%0> rising at about 0.5 per cent per year owing to anthropogenic emissions. The latter are estimated to amount to about 5,700 million tonnes of carbon per year due to fossil fuel burning, plus 600-2,500 million tonnes of carbon per year due to deforestation. Between 40 and 60 per cent of the CO_2 emitted into the atmosphere remains there, at least for the short term; the rest is taken up by natural sinks, particularly the oceans but also forests. Future atmospheric CO_2 concentrations depend on the amounts of CO_2 released from fossil fuel burning, which will be determined by the amount and type of energy sources to be used; the CO_2 released from biotic sources, which is determined by the rate of future deforestation and changes of other vegetative cover; and the uptake of CO_2 by various natural sinks. The Intergovernmental Panel on Climate Change (IPCC) has estimated that if anthropogenic emissions of CO_2 could be kept at present-day rates, atmospheric CO_2 would increase to 460-560 ppmv by the year 2100 because of the long residence time of CO_2 in the atmosphere and the long lead-time for its removal by natural sinks.
Over the past 100 years, the atmospheric CO_2 concentration increased by about 25 per cent. A range of model calculations suggests that the corresponding equilibrium temperature rise should be 0.5°-1.0°C. If this is corrected for the effects of the thermal inertia of the oceans, which slows down climate change for a period of 10-20 years, the changing composition of the atmosphere should have produced a warming of 0.35-0.7°C superimposed on the natural fluctuations of the atmosphere.
Detailed analysis of temperature records of the past 100 years indicates that the global mean temperature has risen by 0.3°-0.6°C. Much of the warming since 1900 has been concentrated in two periods, the first between about 1910 and 1940 and the other since 1975; the five warmest years on record were all in the 1980s. The size of the warming over the last century is broadly consistent with the predictions of climate models, but is also of the same magnitude as natural climate variability.
The main impacts of climate change are as follows:
@BULLET = <%2>Sufficient evidence is now available to indicate tha<%0>t changes in climate would have an important effect on agriculture and livestock. Negative impacts could be felt at the regional level as a result of changes in weather (e.g. more frequent and more severe storms) and the arrival of pests associated with climate change necessitating innovations in technology and agricultural management practices. There may be a severe

decline in production in some regions (e.g. Brazil, the Sahel region of Africa, South-East Asia, the Asian region of the former Soviet Union and China), but there may be an increase in other regions because of a prolonged growing season.
@BULLET = N<%2>atural terrestrial ecosystems could face significant conse- quences as a result of climate changes. Their evolution would lag ehind these climate shifts: they might survive in their location but flora and fauna could <%4>find themselves, in effect, in a different climatic<%2> regime. These regimes may be more or less h<%0>ospitable and could increase the productivity of some species and decrease that of others.
@BULLET = Relatively small changes in climate can cause large water resource problems in many areas, especially in semi-arid regions and in those humid areas where demand or pollution has led to water scarcity.
@BULLET = Global warming will accelerate the rise in sea level, modify ocean circulation and change marine ecosystems, <%2>with considerable socio-economic consequences. The<%0> IPCC predicted that under the business-as-usual scenario, an average rise in the global mean sea level of about 6 cm per decade could occur over the next century. The predicted rate would mean a 20 cm rise in global mean sea level by 2030 and 65 cm by the end of the century.
@MAJOR HEADING = Ozone Depletion
@FIRSTPAR = In contrast to the harmful ozone formed as a photochemical oxidant at ground level (tropospheric ozone), ozone in the stratosphere, between 25 and 40 km above the earth's surface, is <%-2>the natural filter that absorbs and blocks the sun's<%0> short-wavelength ultraviolet (UV-B) radiation, which is harmful to life.
Ozone exists in equilibrium in the stratosphere, balanced between formation from molecular oxygen and destruction by ultraviolet radiation. The presence of reactive chemicals in the <%2>stratosphere, such as the oxides of hydrogen, nitrogen and<%0> chlorine, can accelerate the process of ozone destruction and therefore upset the natural balance, leading to a net reduction of the amount of ozone. These chemicals can participate in many ozone-destroying reactions before they are removed from the stratosphere.
In 1974, it was found that man-made CFCs, although inert in the lower atmosphere, can survive for many years and migrate into <%2>the stratosphere. There, they are destroyed by ultraviolet radiation, releasing atomic chlorine, which attacks the stratospheric ozone layer. This leads to another reaction that <%0>regenerates atomic chlorine, which in turn destroys more stratospheric ozone. This chain reaction can cause the destruction of as many as 100,000 molecules of ozone per single atom of chlorine.
CFCs are used as propellants and solvents in aerosol sprays; fluids in refrigeration and air-conditioning equipment; foam-blowing agents in plastic foam production; and solvents, mainly in the electronics industry. Studies in the 1980s showed that emissions of bromine can also lead to a significant reduction in <%-2>stratospheric ozone. Bromofluorocarbons (halons 1211 and 1301) ar<%0>e widely used to extinguish fires, and ethylene dibromide and methyl bromide are used as fumigants.
The concentration of chlorine in the stratosphere is set mainly by anthropogenic sources of CFCs, carbon<%2> tetrachloride and<%0> methylchloroform. Methy<%-2>l chloride is the only natural organo<%0>-chlorine compound found i<%-2>n the atmo<%0>sphere. The concentration of chlorine in the atmosphere due to methyl chloride has remained unchanged since perhaps 1900. The major additions of chlorine to the atmosphere have occurred mainly since 1970 and have been attributed to anthropogenic sources. At present the total chlorine in the atmosphere due to organochlorine compounds is approaching 4.0 parts per billion by volume (ppbv), a 2.6-fold increase in only 20 years.
UV-B radiation is known to have a multitude of effects on humans, animals, plants and

materials:
@BULLET = Exposure to increased UV-B radiation can suppress the body's immune system, which might lead to an increase in the occurrence or severity of infectious diseases such as herpes, leishmaniasis and malaria and a possible decrease in the effectiveness of vaccination programmes. Enhanced levels of UV-B radiation can lead to increased damage to the eyes, especially cataracts, and to an increase in the incidence of non-melanoma skin cancer.
@BULLET = Plants vary in their sensitivity to UV-B radiation. Some crop species, such as peanut and wheat, are fairly resistant, while others, such as lettuce, tomato, soybean and cotton, <%-3>are sensitive. UV-B radiation alters the reproductive<%0> capacity of some plants and also the quality of harvestable products, seriously affecting food production in areas that already suffer acute shortages.
@BULLET = Increased UV-B radiation has negative effects on aquatic organisms, especially small ones such as phytoplankton, zoo- plankton, larval crabs and shrimp, and juvenile fish. Because many of these small organisms are at the base of the marine food web, increased UV-B exposure may have a negative effect on the productivity of fisheries.
@MAJOR HEADING = Acidification
@FIRSTPAR = Acidification, in an environment context, can be considered as a change towards more acidic conditions in one or more compartments of the biosphere or a reflection of the processes that bring this change about. This definition recognizes that, initially, acid deposition may be absorbed, even in sensitive areas, by the natural buffering capacity of the environment and that the onset of acid conditions in an environment may occur long after an increase in acid deposition.
The predominant anthropogenic source of acid-forming gases, primarily sulphur dioxide and nitrogen oxides, is fossil fuel combustion; additional sources include metal ore smelting, sulphuric acid manufacture and other industrial processes. Other sources of acid-forming gases that may assume greater significance in less industrialized regions include the burning of biomass for fuel, deforestation and grassland management. The treatment, decomposition and incineration of human excreta and other wastes can release significant quantities of NQ into the atmosphere or directly into watercourses. Similarly, the application of nitrogen fertilizers may affect soil pH levels.
A 1986 survey of the pH of precipitation over western Europe showed that typical Atlantic background values of pH, above 5.0, drop to less than 4.4 over Scandinavia. Similarly, a 1985 survey of North American precipitation showed pH values above 5.0 in the west of the continent, dropping to less than 4.2 in the northeast. Other regions of known high levels of acid deposition include the Czech Republic, Germany, Hungary and Slovakia, where the pH of the rainfall is typically 3.9-4.5. Evi<%2>dence is also <%4>now available from south-western China<%2> (pH<<3.5) and from tropical areas such as south-eastern Brazil (pH<<4.0) an<%0>d Venezuela (pH<<4.0) that acid rain is occurring in developing countries. It appears that if the average pH of a station is below 5.0 the possibility of anthropogenic sources of acid deposition should be suspected; below an average pH of 4.5, the possibility becomes a probability.
The gradual onset of anthropogenic acidification and the concurrence with the growth of air pollution generally, as well as the episodic occurrence of natural climatic events, often makes it difficult to ascribe observed effects to acidification alone. Nevertheless, there is at least circumstantial evidence that acid deposition is implicated in the following effects:
@BULLET = Acid deposition is suspected as one of the causal factors in the reported decline of European and North American forests. In the 1980s, a striking increase in foliar damage to plants, particularly the forest trees in Europe, was reported. European forest damage surveys provide strong circumstantial evidence for pollution- related foliar damage. It has

been suggested that the level of damage observed in coniferous forest trees can be correlated with air pollution loading.

@BULLET = Most countries in Europe have lakes and rivers that are susceptible to further acidification. There are also many river and lakes systems in Africa, Asia and South America with low pH and buffering capacity, which makes them potentially susceptible to acid rain. It is important to realize that fish may die not as a result of average condi<%2>tions in streams but during short-lived acid flushes<%0> brought on by heavy rains after a dry spell or by the melting of snow, when water of high acidity melts first and causes very low pH levels in melt-water run-off.

@BULLET = The impact of acidification on human health is both direct and indirect. Direct effects have been reported when acid sulphate aerosols come into contact with sensitive mucus membrane surfaces of the respiratory tract and lungs. For example, the bronchial clearance function has been shown to decline in adolescent asthmatics. In tests on animals, high long-term exposure leads to changes in surface cells and a narrowing of the airways.

@BULLET = All materials suffer degradation from natural weathering processes, but air pollution has accelerated degradation rates since the mid-nineteenth century. Acidic deposition causes corrosion and tarnishing of metals; erosion and soiling of surface stone, brick and concrete; and erosion, <%2>discolouration and peeling of paint. Limestone and<%0> marble, which were commonly used in historic buildings and monuments, are also highly susceptible to damage by gaseous SQ. Irreversible damage has also been caused to stained glass windows in historic churches. In the past remedial measures sometimes compounded the damaging effects. For example, corrosion of the iron rods used to strengthen limestone blocks has produced severe cracking of monumental structures.

@MAJOR HEADING = Toxic Chemicals and Hazardous Wastes

@FIRSTPAR = <%-2>Worldwide, about 10 million chemical compounds have been synthesized in laboratories since the beginning of the present century. Approximately 1 per cent of these—100,000 organic and inorganic chemicals—are produced commercially (the <MI>European Inventory of Existing Commercial Chemical Substances<D> lists 110,000 chemicals). Between 1,000 and 2,000 new chemicals appear each year. Some of these chemicals, including pesticides and fertilizers, are used directly, but most of them are "basic" or "intermediate" chemicals used for the manufacture of millions of end-products for human use. There is virtually no sector of human activity that does not make use of chemical products, many of which have indeed benefitted man and his environment.<%0>

<%-2>In recent years, however, there has been growing concern worldwide about the harmful effects of chemicals on human health and the environment. The deleterious effects of pesticides, vinyl chloride and polychlorinated biphenyls (PCBs) have been well documented since the 1960s. Over the past two decades many other substances have captured public attention, e.g. dioxin, methyl iso<%1>cyanate, lead, mercury, other heavy metals and chlor-ofluorocarbons.<%0>

<%-2>All chemicals are toxic to some degree. The health risk from a chemical is primarily a function of toxicity and exposure. Only a few parts per billion of a potentially toxic compound like dioxin may be sufficient to cause a health hazard following brief exposure. In contrast, only high doses of other compounds like iron oxide or magnesium carbonate pose problems after extended exposure. An important development in the past two decades has been the shift from a focus on just the acute health effects of chemicals to a focus on their chronic effects as well. These chronic effects, which include birth defects, genetic and neurological disorders and cancer, are of particular concern to the public, and this makes regulatory decisions both more visible and more difficult.<%0>

<%-2>Toxic chemicals are released into the environment directly as a result of human

application (e.g. the use of pesticides, fertilizers and various solvents) and indirectly by waste streams from various human activities, such as mining, industrial processes, incineration and fuel combustion. The chemicals may be released in solid, liquid or<%0> gaseous form and the release may be to air, water or soil. The distribution and fate of chemicals in the environment is a highly complex process, <%-2>governed by the physico-chemical properties of the chemicals and of the environment itself. Many chemicals do not remain confined to the vicinity of their sources of release and are transported locally, regionally or globally to cause widespread con- tamination of the environment. The use of pesticides in California, for example, led to fog contamination there: 16 pesticides and their alteration products have recently been found in fog far from the place where the pesticides were used. PCBs have been transported by the atmosphere from the places of their release in industrial countries to as far as the Arctic. Mainly because they eat contaminated fish and aquatic mammals, inhabitants of the Arctic are experiencing near-toxic levels of PCB exposure. <%0>

<%-2>Other examples of such toxic substances that are distributed to distant places include DDT, mercury, lead, other metals and hexachlorocyclohexane. General concern about growing global chemical <%1>pollution is reflected in concern about the effects of chlorofluorocarbons and other chemicals on the ozone layer and of<%-2> greenhouse gases on climate.<%0>

<%-2>Wastes are substances or objects that are disposed of, intended to be disposed of, or required, by law, to be disposed of. Certain wastes produced by human activities are described as hazardous. Although the term has a different connotation in different countries, <%1>wastes containing metallic compounds, halogenated organic solvents, organohalogen compounds, acids, asbestos, organophosphorus compounds, organic cyanides, phenols or ethers as constituents are considered hazardous. <%0>

Most hazardous wastes are produced by industry, but it is now recognized that there are hundreds of thousands of small-quantity generators of hazardous wastes, each generating up to 1,000 kg of waste per month. These include households, medical facilities (their wastes are referred to as biomedical wastes), <%2>garages and auto-repair workshops, petrol stations and small-scale industries and businesses. In the United States,<%0> 115,000 such small-scale hazardous waste generators are now being regulated under the Resource Conservation and Recovery Act and the Hazardous and Solid Waste Amendment.

<%-2>It has been estimated that, worldwide, about 338 million tonnes of hazardous wastes are produced annually, of which 275 million<%0> tonnes, or 81 per cent, are produced in the United States alone. For comparison, hazardous waste generation in Singapore amounts to 28,000 tonnes per year, in Malaysia, 417,000 tonnes per year and in Thailand, 22,000 tonnes per year. It should be noted that these figures represent <%-2>conservative estimates since many countries have no records of the amounts of wastes generated. This is particularly true for small-scale waste generators. The variable composition of the wastes adds to the problem (constituents that are considered hazardous in some countries may not be considered so in others). In general, most hazardous wastes are chemicals. In the European countries that are members of OECD, the main hazardous wastes are solvents, waste paint, heavy metals, acids and oily wastes.<%0>

<%-2>The traditional low-cost methods of hazardous waste disposal are landfill, storage in surface impoundments and deep-well injection. Thousands of landfill sites and surface impoundments used for dumping hazardous wastes have been found to be entirely unsatisfactory. Corrosive acids, persistent organics and toxic metals have accumulated in these sites for decades. For example, the largest site identified <%-3>in the United States is the Clark Fork Mining Complex in western Montana, where wastes from copper and silver mining and smelting activities have accumulated for 125 years. It is considered the largest

hazardous waste dump in the world. At the time such sites were established, little thought was given to their environmental impacts. When leaks occurred, threatening public health and contaminating ground-water and soil, policy makers took remedial action<%-2>s in response to growing public concern and pressure.<%0>
<%-2>By 1990, the United States Environment Protection Agency (USEPA) had identified 32,000 sites in its inventory of potential hazardous sites; about 1,200 of these need immediate remedial <%1>action. In Europe, some 4,000 unsatisfactory sites have been<%-2> identified in the Netherlands, 3,200 sites in Denmark and 50,000 sites in western Germany. Although some industrialized countries have initiated steps to clean up the problem sites, the cost of remedial action has been found to be very high. Estimates indicate that about US$ 30 billion are needed for remedial operations in the former Federal Republic of Germany, US$ 6 billion in the Netherlands and US$ 100 billion in the United States.<%0>
<%-2>Other unsatisfactory dumping of hazardous wastes has exposed people directly to hazardous chemicals. Perhaps the most notorious incident of all was the outbreak of disease in the town of Minamata on Kyushu Island, Japan, in the 1950s and 1960s. Discharges from a chemical factory into the sea led to the contamination of fish by mercury. When the local people ate fish, thousands of them suffered<%0> neurological disorders. As a result of this and a similar incident <%2>at Niigata on the east coast of Honshu, about 400 people died. Although the dumping of waste at sea is controlled under international and regional conventions, several countries are still using this route for the disposal of hazardous wastes. Between 10 and 15 per <%0>cent of hazardous wastes pro- duced in Europe are dumped at sea.
@MAJOR HEADING = Atmospheric Pollution
@FIRSTPAR = Ai<%2>r pollution is defined for the purposes of this document as the presence in the outdoor or indoor atmosphere of one or more gaseous or particulate contaminants in quantities, characteristics or durations such as to be injurious to human, plant or animal life or to property or to unreasonably interfere with the comfortable enjoyment of life and property.<%0>
The combustion of fossil fuels results in the exothermic oxidation of carbon, hydrogen, sulphur and nitrogen. If complete <%2>combustion is achieved, CO<MV>2<D>, water vapour, SO<MV>2<D>, NO<MV>x<D> and <%0> volatile and non-volatile trace metals such as arsenic, cadmium, lead and mercury are the principal <%2>pollutants emitted. In practice, complete combustion does not occur and additional particulate and gaseous pollutants are produced. These include carbon monoxide and organic and elemental carbon particulates; polycyclic aromatic hydrocarbons may also be evolved, either absorbed on to particulate matter or as a gas. Further emissions may be produced by fuel additives such as tetraethyllead, tetramethyllead and various hydrocarbons.<%0>
Generally, pollutant emissions are determined by the method of combustion and the type of fuel used. Coal is the most polluting fuel per unit energy produced, based on current combustion technology. It provides 20-25 per cent of the total energy consumed in most regions. In China, however, <%2>80 per cent of all primary energy is derived from coal, representing 22.6 per cent of the world's coal consumption. This presents unique pollution problems associated with SO<MV>2<D> and particulate matter. Similar pollution problems were common in industrialized countries until the 1950s and 1960s, when clean air legislation was introduced. It is predicted that coal will once again play an increasingly important role in energy production. World trade in coal has increased by 40 per cent since 1980.<%0>
Atmospheric pollution is a major problem facing all the countries of the world. Various chemicals are emitted into the air from both natural and man-made sources. Emissions from natural sources include those from living and non-living sources (e.g. plants, radiological

decomposition, forest fires, volcanic eruptions and emissions from soil and water). These emissions lead to a natural background concentration that varies according to the local source of emission and prevailing weather conditions. People have caused air pollution since they learned how to use fire, but man-made air pollution (anthropogenic air pollution) has increased rapidly since industrialization began.

Research over the past two decades has revealed that, in addition to the previously known common air pollutants (SO_2, NO_x, particulate matter, hydrocarbons and carbon monoxide), many volatile organic compounds and trace metals are emitted into the atmosphere by human activities. Although our knowledge of the nature, quantity, physico-chemical behaviour and effects of air pollutants has greatly increased in recent years, more needs to be learned about the fate and transformation of different <%2>pollutants and about their combined (synergistic) effects on<%0> human health and the environment.

Data from the Global Environmental Monitoring System (GEMS) air project from 1980 to 1984 indicate that of 54 major cities, 27 have acceptable levels of SO_2 in the air, among them Auckland, Bucharest, Bangkok, Toronto and Munich, with SO_2 concentrations below 40mg/m3 (WHO established a range of 40-60mg/m3 as a guideline for exposure to avoid increased risk of respiratory diseases). Eleven cities, among them New York, Hong Kong and London, have marginal air quality, with SO_2 concentrations between 40 and 60mg/m3. The remaining 16 cities, including Rio de Janeiro, Paris and Madrid, have unacceptable air quality, with SO_2 concentrations exceeding 60mg/m3.

Data for 41 cities indicate that 8, including Frankfurt, Copenhagen and Tokyo, have acceptable air quality with respect to suspended particulate matter (SPM), with concentrations below 60mg/m3 (the WHO range is 60-90mg/m3). Ten cities, including Toronto, Houston and Sydney, have borderline concentrations of suspended particulate matter, between 60 and 90mg/m3, and 23 cities, including Rio de Janeiro, Bangkok and Tehran, have SPM concentrations exceeding 90mg/m3. The extraordinary levels in some cities in developing countries can be partially explained by natural dust; other culprits include the black particulate-laden smoke spewed out by vehicles fuelled on low quality diesel without even rudimentary pollution control. The GEMS assessment concluded that nearly 900 million<%2> people living in urban areas around the world are exposed to u<%0>nhealthy levels of SO_2 and more than 1 billion people are exposed to excessive levels of particulates.

Air pollution affects human health, vegetation and various materials in the following ways:

@BULLET = The notorious sulphurous smog that occurred in London in 1952 and 1962 and in New York in 1953, 1963 and 1966 clearly demonstrated the link between excessive air pollution and mortality and morbidity. Such acute air pollution episodes occur from time to time in some urban areas. In January 1985, an air pollution episode occurred throughout western Europe. Near Amsterdam, the 24- <%2>hour average concentrations of suspended particulate<%0> matter and SO_2 were both in the range 200-250<F128W1>m<F255D>g m3, much higher than the WHO guideline values. During the episode, several people were affected; pulmonary functions in ch<%-2>ildren were 3-5 per cent lower than normal. This dysfunction persisted for about 16 days after the episode. Athens is known for frequent acute air pollution episodes. Even in the absence of such episodes, long-term exposure to <%1>air pollution can affect several susceptible groups (the elderly, children and those with respiratory and heart<%-2> conditions).<%0>

@BULLET = <%2>Air pollution can cause substantial damage to many<%0> materials. The most striking examples of such damage are illustrated by the effects of air pollutants (especially SO_x) on historical buildings and monuments. The Acropolis, the Coliseum and the Taj Mahal withstood the influence of the atmosphere for hundreds or even thousands of years without any great damage, yet in the past few decades their surfaces have suffered great damage because of increased air pollution.

@BULLET = Indoor air pollution has a number of effects. The sick building syndrome can cause a substantial amount of disease and absenteeism from work or school. Recently, attention has focused on the possible health hazards of radon emissions in houses.

@BULLET = Emissions from the burning of biomass fuels, especially in rural areas of developing countries, are a major source of indoor air pollution. The most important identified adverse effects are chronic obstructive pulmonary disease and naso-pharyngeal cancer.

@MAJOR HEADING = Water Pollution

@MINOR HEADING = Marine Pollution

@FIRSTPAR = The two pathways by which most potential pollutants reach the oceans are the atmosphere and rivers. The atmospheric pathway accounts for more than 90 per cent of the lead, cadmium, copper, iron, zinc, arsenic, nickel, PCBs, DDT and hexachlorofluorohexane found in the open oceans water. River inputs are generally more important than those from the atmosphere in coastal zones, although in certain areas and for some substances <%2>(e.g. lead and hexachlorofluorohexane in the North Sea and<%0> nitrogen in the Mediterranean) atmospheric inputs are similar or even dominant.

Aside from physical degradation of the coastal and near- shore zones, pollution is the main problem affecting these zones. Most of the liqu<%2>id wastes and a growing fraction of the solid wastes from man's activities on land are introduced into the oceans through the land sea interface. Coastal areas receive direct discharges from rivers, surface run-off and drainage from the hinterland, domestic and industrial effluents through outfalls, and various contaminants from ships.<%0>

Most types of wastes, once introduced into the sea, cannot be removed. Their fate is determined by their chemical composition and by the physical transport processes (e.g. mixing, sea currents) of the recipient waters. The distance they can reach depends on these processes and on the rate of their decomposition, with the non-degradable wastes having the ability to travel for long distances.

<%2>Some wastes are easily decomposed into harmless substances, although their end-products, if excessively concentrated, may seriously disturb the ecosystem (e.g. eutrophication, which is due to an excess of nutrients). Other wastes, such as metals and persistent organic compounds, cannot be degraded; they usually remain adsorbed on bottom sediments near the sources of<%0> discharges.

Some marine organisms have a remarkable ability to accumulate such substances from sea water, even when the substances are present in extremely low concentrations. Others can convert some substances into more toxic ones: for example, the well-known conversion of inorganic mercury into methylmercury, which caused the outbreak of disease at Minamata in Japan in the 1950s and 1960s.

The principal problem for human health on a worldwide scale is the existence of pathogenic organisms discharged with domestic sewage into coastal waters. Bathing in sea water that receives <%2>such sewage and the consumption of contaminated fish and<%0> shellfish cause a variety of infections.

<%2>Epidemiological studies have provided unequivocal<%0> evidence that <%2>swimmers in sewage-polluted sea water have an above-normal incidence of gastric disorders. Studies have also indicated an increased incidence of non-gastric disorders, such as ear, respiratory and skin infec<%0>tions. The consumption of <%2>contaminated seafood is firmly linked with serious illness,<%0> including viral hepatitis and cholera.

Many compounds discharged into the sea tend to accumulate in various organisms. Halogenated hydrocarbons accumulate in fatty tissues, and the amount accumulated may increase through the food chain, so that high concentrations are found in the bodies of the top predators among birds, fish and mammals. Where the contamination has built up over decades, such as in enclosed <%2>bodies of water like the Baltic and the Wadden Sea, the<%0> reproductive capacity of marine mammals and birds has been affected.

Polychlorinated biphenyls (PCBs) accumulated in seafood can reach unacceptable levels. Tributyltin affects a wide range <%2>of invertebrates, and its use in marine paints was recently<%0> restricted in France, the United Kingdom of Great Britain and Northern Ireland, and several states in the United States of America.

@MINOR HEADING = Freshwater Pollution

Assuring an adequate supply is not the only water problem facing many countries: they also need to worry about water quality. Concerns about water quality have been growing since the 1960s. At first, attention centred on surface-water pollution from point sources (industrial plants and cities). More recently, however, groundwater pollution and non-point sources (agricultural lands, forests, roads etc.) have been found to be at least as serious problems.

The basic type of pollution is that caused by the discharge of untreated or inadequately treated waste water into rivers, lakes and reservoirs. With the growth of industry, industrial waste waters discharged into water bodies have created new pollution problems. One important water quality problem is the increasing eutrop<%2>hication of rivers and lakes, caused mainly by the run-off of fertilizers from agricultural lands. The <%0>acidification of lakes by acidic deposition is common in some European countries and in North America. Wastes can also be carried to lakes and streams along indirect pathways, for example, when water leaches through contaminated soils and transports the contaminants to a lake or river.

Dumps of toxic chemical waste on land have become a serious source of groundwater and surface-water pollution. In areas of intensive animal farming or where large amounts of nitrate fertilizers are used, nitrates in groundwater often reach concentrations that exceed guidelines established by the World Health Organization (WHO). The problem has become a cause for concern in some European countries and in the United States and is growing in magnitude in some developing countries.

About 10 per cent of all the rivers monitored in the water project of the Global Environment Monitoring System (GEMS) may be described as polluted (they have a biochemical oxygen demand (BOD) of more than 6.5 mg/l). The two most important nutrients, nitrogen and phosphorus, are well above natural levels in the monitored waters. The median nitrate level in unpolluted rivers is 100<F128W1>m<F255D>g/l. The European rivers monitored by GEMS show a median value of 4,500<F128W1>m<F255D>g/l. In contrast, rivers monitored by the GEMS project outside Europe show a much lower median value, 250<F128W1>m<F255D>g/l. The median phosphate level in rivers monitored in the project is 2.5<F128W1> <F255D>times the average for unpolluted rivers (10<F128W1>m<F255D>g/l). <%2>Since 1970, regulatory measures have led to a marked decrease of lead in most rivers of countries that are members of the<%0> <%2>Organization for Economic Cooperation and Development<%0> (OECD). Trends for other metals and toxic substances are less encouraging, despite efforts to reduce discharges. Such sub- stances are often persistent, accumulate into bottom sediments and can be released over long periods of time once initially deposited. Levels of organochlorine pesticides recorded in some rivers in developing countries (e.g. Colombia, Malaysia and the United Republic of Tanzania) are higher than those recorded in European rivers.

The quality of fresh water depends not only on the quality of waste entering the water but also on the decontamination measures that have been put into effect. Although organic waste is biodegradable, it nonetheless presents a significant problem, especially in developing countries. Human excreta contain path<%2>ogenic micro-organisms, which are water-borne agents of<%0> cholera, typhoid fever and dysentery. Contaminated water has caused the outbreak of epidemics of these diseases in several developing countries.

Industrial waste may include heavy metals and many other toxic and persistent chemicals not readily degraded under natural conditions or removed in conventional sewage-treatment plants. <%2>Unless these wastes are adequately treated at the source or<%0> prevented from being discharged into watercourses, the fresh- water quality can be seriously impaired. The high content of nutrients in rivers and lakes has led to eutrophication. Apart from ecological and aesthetic damage, eutrophication brings increasing difficulties and costs for water treatment plants that have to produce safe, palatable drinking water. The acidification of freshwater lakes has affected aquatic life to various degrees.

In most developing countries, the pollution of rivers by municipal and industrial wastes is on the increase and decontamination efforts are often neglected. In these countries, industrialization has had a higher priority than the reduction of pollution. As a consequence, in some regions (East Asia, for example) the degradation of water resources is now considered the gravest environmental problem. In many of these countries, aquatic life has been affected. The deterioration of water quality is a growing threat to aquaculture, which provides a sizeable amount of fish for the population.

@CHAPTER TITLE = The Pakistan National Conservation Strategy
@MAJOR HEADING = Pollution
@FIRSTPAR = Most people think of environmental conservation in terms of the prevention of pollution—the control of discharges of unwanted, sometimes toxic wastes to the water, the air, or the land. This is only partially correct and reflects an urban bias; yet the importance of con- trolling pollution cannot be denied and is growing more urgent by the year.
@MINOR HEADING = Water Pollution
Water pollution has three main sources: bacterial and organic liquids and so<%2>lids from urban and rural domestic sewage; toxic metals, organics, acids, and other less-toxic but still polluting substances from industrial discharges; and chemical pollution in the form of pesticide and fertilizer run-off from agricultural lands.<%0>
<%2>All three can contaminate both surface and groundwater supplies of water and render them unfit for other uses such as fisheries and recreation, or expensive to treat for industrial and municipal water supply uses. The costs of treatment places a heavy burden on municipal authorities and industries that must rely on polluted sources.<%0>
@DECKHEAD = <%2>Domestic and Human Waste-Water Discharges<%0>
<%2>Solid and liquid excreta generated in human settlements along with kitchen and wash waste water are the major sources of water pollution in Pakistan and the cause of widespread water-borne diseases. The seriousness of the situation is clear from a World Health Organization study: diseases of a gastro-intestinal nature account for 25-30% of the cases seen at public hospitals and dispensaries in Pakistan. Approximately 60% of infant deaths are due to infectious and parasitic diseases, most of them water-borne. Losses to the national economy, <%0>not to mention the human suffering, caused by water-borne diseases are high. A study in India found that 73 million work-days a year were lost through such disease. The cost in terms of medical treatment and<%2> <%0>lost production was reported to be on the order of US$ 600 million per year.
As indicated, the source of most water-borne diseases is human excrement. Pakistan generates 34,370 wet tonnes of excreta per day, 12.5 million tonnes per year. Karachi alone discharges approximately 300 million gallons per day of sewage; Lahore, approximately 240 million gallons. The organic load discharged, measured in terms of biological oxygen demand, for all of Pakistan is 2,265 tonnes per day.
The breakdown by source is 26,370 tonnes excreta from rural areas a day and 8,000 tonnes from urban areas. An estimated 21,096 tonnes from the rural areas (80%) is deposited in fields. An estimated 4,160 tonnes of the urban <%2>excreta (52%) is disposed of into sewers, with the remainder being deposited on the roadside, into waterways, or incorporated in solid waste.<%0>
<%2>Major cities dispose of their largely untreated sewage into irrigatio<%4>n systems, where the waste water is reused, and into streams and rivers, without any consideration for the rivers' assimilative capacity. Consequently, not only does serious bacterial contamination result, threatening human health, but the organic load of the sewage seriously depletes the dissolved oxygen content of the receiving waters, causing unaesthetic conditions and making them unfit for fish. It has been reported that pollution<%2> of the River Ravi—into which Lahore discharges its untreated waste water—has meant 5,000 fewer tonnes of fish production per year.<%0>
@DECKHEAD = <%2>Industrial Waste-Water Discharges<%0>
<%4>The major industries creating environmental hazards are the manufacture of chemicals (including pesticides), textiles, pharma- ceuticals, cement, electrical and electronic equipment, glass and ceramics, and pulp and paper board; leather tanning; food pro- cessing; and petroleum refining. Pollutants associated with various industrial subsectors are shown in table

1.<%0>

<%2>No systematic or complete survey has been done of the sources, volumes, and characteristics of industrial pollution in Pakistan, although partial surveys, investigations of particular sources, and observations have shown the seriousness of industrial pollution in a number of locations. A preliminary study of hazardous chemical industries con- ducted in 1985 for the Environment and Urban Affairs Division surveyed 100 plants scattered throughout the country. Only three, two of which were branches of multi-national companies, tr<%1>eat<%2>ed t<%1>heir wastes to co<%2>mmonly ac<%1>cepted s<%2>tand<%1>ards. The remainder did <%2>nothing except dispose of their wastes in the most convenient way.<%0>

<%2>For all practical purposes, industries do not control their waste-water effluents through process controls, waste recycling, or end- of-pipe treatment. In Kala Shah Kaku industrial area near Lahore, for example, the various chem<%1>ical industries, tanneries, textile plants, <%0>steel re-rolling mills, and other operations discharge effluents containing<%2> hydrochloric acid and high levels of organic matter directly into streams and canals. Biological oxygen demand levels of 193 to 833 milligrams per litre and mercury levels of 5.6 milligrams per litre have been measured. (The proposed interim rela<%0>xed Government standards for these are 200 and 0.1, respectively.) These discharges have rendered the nullah (drainage course) water <%2>unfit for irrigation use and livestock con- sumption, and have caused an annual reduction in the fish catch of 400 tonnes, valued at Rs. 10 million.<%0>

In the vicinity of Karachi, industrial pollution discharges combined with mangrove destruction and overfishing have resulted in a sharp decrease in shrimp production, which translates into lower foreign ex- change earnings. Toxic substances occurring in effluents from sample industries in Karachi are shown in table 2.

Two large industrial zones in Sindh Province—SITE (Sindh Industrial Trading Estate) and LITE (Landhi Industrial Trading Estate)—discharge large quantities of organic matter, heavy metals, oils and greases, and other materials into local rivers. In Korangi in Karachi, where LITE is located, 35 tonnes of suspended solids, 376 tonnes of dissolved solids, 2 tonnes of ammonia, and 1.4 tonnes of arsenic oxide, among other chemicals, are discharged into the city's already polluted harbour each day.

Leather tanning operations near Peshawar are polluting the Kabul River, threatening its use for domestic and irrigation purposes as well as its freshwater fishery. Over 235 industries in Faisalabad discharge high levels of solids, heavy metals, aromatic dyes, inorganic salts, and organic materials directly into the municipal sewers without any pretreatment, polluting nearby agricultural land.

Another area for concern is the contamination of shallow ground water in urban areas near industrial plants as industrial wastes are discharged directly into or onto the ground. Groundwater pollution is often permanent, in that hundreds or even thousands of years may be necessary for pollutants such as toxic metals from tanneries to be flushed out of a contaminated aquifer. Surface waters, on the other hand, can be re- habilitated if pollutant loadings are reduced or eliminated.

@DECKHEAD = <%2>Agricultural Run-off<%0>

The use of fertilizers has grown 7.1% annually during the Sixth <%2>Five-Year Plan. Annual expenditure on pesticides currently amounts to Rs.<%0> 3.2 billion nationally. In 1986, 1.1 million tonnes of nitrogen and 93,000 tonnes of phosphate fertilizer were produced locally, and another 700,000 tonnes of fertilizer were imported. Pesticide imports have similarly grown rapidly, increasing from 7,083 tonnes in 1980/81 to 20,647 tonnes in 1986/87—a growth rate of 190% over the six-year period.

Indiscriminate use of agricultural chemicals, mainly fertilizers and various pesticides including insecticides, fungicides, and herbicides, is contributing to chemical pollution of the environment. Agricultural run-off from fields where these have been used incorrectly or inappropriately can raise the levels of these substances in waterways.

The effects include excess nutrient loadings from fertilizer run-off and s<%2>ubsequent uncontrolled algal growth in waterways, and pesticide contamination of waters, resulting in fish kills. Dead fish, apparently due to pesticides, have been reported on the banks of the Kabul River in certain seasons. Pesticides are of particular concern because of their bioaccumulation in fish and animal tissue and in the soil, and because of their persistence in the environment.<%0>

<%2>Other risks include contamination of <%0>shallow wells used for drinking-water supplies for villages and cities, and pesticide residues on cereal and vegetable crops where care has not been taken in their application. Such residues may be harmful to humans. At least one case of poisoning resulting in a number of deaths, involving the pesticide endrin in foodstuffs, has been reported in Pakistan.

Increasing use of nitrogen fertilizers may also lead to excess nitrate levels in groundwater wells. High nitrate levels in drinking water are converted to more toxic nitrites in the stomach of adults and infants, and are known to cause blood disorders in infants. No studies to date have assessed groundwater contamination in Pakistan from pesticide or fertilizer use in agriculture.

@DECKHEAD = Air Pollution

<%2>The classic source of air pollution is the factory smoke stack. Such stationary, point-source emissions are highly visible and represent a significant threat to those living nearby. By volume, however, they represent less of a threat to the overall health of Pakistanis than do the multiple mobile sources of the automobile and other vehicles. Never-the<%4>less, the combined emissions of air pollutants from industry, power<%2> generation, transportation, domestic activities (particularly energy use), agriculture, and commercial institutions are growing rapidly. (See table 4).<%0>

Industry and power generation are becoming major sources of carbon dioxide and sulphur dioxide emissions. The rapid increase in thermal power generating capacity currently under way will result in<%2> substantial increase in emissions of these two gases and of nitrogen oxide from the burning of oil and coal in new generating stations. Pakistan's low thermal-value, high-sulphur coal reserves will cause a<%4> rapid increase in these emissions<%2> as they come into production to feed the thermal generating stat<%0>ions. Similarly, use of natural gas, coal, and oil as fuels by industry is expected to c<%2>ause a substantial increase in air pollution. The expected effects of these emissions, unless they are controlled at the source, include deterioration of soil quality in the vicinity of factories, potential damage to crops (particularly from sulphur dioxide and nitrogen oxides), and possibly human health effects. Many studies in a number of countries have quantitatively linked air pollution with respiratory disease, including lung cancer.<%0>

@DECKHEAD = <%2>Vehicle Emissions and Urban Air Pollution<%0>

<%2>As table 3 indicates, the truly dangerous pollutants to human health—those that can cause bronchial irritation, hasten asthma attacks, and irritate the eyes—arise primarily from non-stationary sources in urban areas. Motor vehicle emissions in Lahore account for approximately 90% of the total annual emissions of hydrocarbons, aldehydes, and carbon monoxide, and for smaller but still the largest proportion of the emissions of sulphur dioxide and<%0> nitrogen oxides.

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Metropolitan reliance on buses and light commercial vehicles also has various air pollution consequences. Old vehicles stay on the roads because of the absence of emission regulations, lack of enforcement of motor vehicle fitness regulations, and the owners' lack of capital to purchase replacements. Thus the average Pakistani vehicle emits 20 times as much hydrocarbons, 25 times as much carbon monoxide, and 3.6 times as much nitrous oxides in grams per kilometre as the average vehicle in the United States. As such, air pollution along busy roads and narrow streets of the main cities is an order of magnitude greater than would be predicted from the number of vehicles on the road.

<%2>The pollutants recorded are the standard emissions monitored thr<%0>oughout the world. Sulphur dioxide, a precursor of acid rain, is an irritant to the eyes, nose, and throat as well as to the lungs. It is also phytotoxic, damaging plants. Aldehydes are particularly noteworthy for their obnoxious smell.

Carbon monoxide is considered to be the most toxic common urban air pollutant, since it reduces the oxygen carrying capacity of the blood. Carbon monoxide levels in the range of 8-30 parts per million (ppm) and 6-40 ppm have been recorded for Lahore and Karachi respectively.

Exposure for an eight-hour period at these levels is known to cause temporary impairment of nervous system functions, including eyesight sharpness.

Hydrocarbons are an important source of particulate air pollution in Pakistan's major cities. These substances are the precursors of<%2> photo<%0>chemical smog, in conditions where exposure to sunlight changes the material into an eye and lung irritant. Smog is also known to inhibit plant growth.

Nitrogen dioxide is the component of the family of nitrogen oxides that has the potential for the greatest adverse effects on human health and hence is the chemical form of nitrogen oxides usually measured. In laboratory tests, nitrogen oxide levels of 100 ppm cause illness if breathed for a short time. Levels of 700 ppm are fatal if breathed for 30 minutes. The standard recommended by the World Bank for nitrogen dioxide is 0.05 ppm.

<%2>The most dangerous of vehicle-related emission, lead, does not appear in table 3 because urban lead emission levels have been measured only sporadically in Pakistan. In Karachi, ambient lead levels have been measured at between 0.024 and 0.13 micrograms per cubic metre. Estimated lead released from emissions to the air in Pakistan is 520 tonnes.<%0>

<%2>Lead is added to gasoline to increase the octane rating and to reduce engine knock. When lead is ingested by young and growing children, it is deposited in the brain and has been shown to cause a reduction in intelligence quotient. Lead from auto emissions is a particular hazard for inner-city residents living, working, or playing along heavily travelled urban roads. It is for this reason that all industrial nations have moved towards lead-free gasolines. In Britain, a reduction in the lead content of gasoline from 0.06% to 0.015% led to a halving of blood lead levels among affected groups.<%0>

Uncontrolled open burning of garbage is another source of urban air pollution. Such burning, which typically takes place at relatively low temperatures, has been found in the West to be a major source of dioxins, an extremely toxic product. Open dumping and treatment by weathering will eventually produce a harmless product, but before that happens the dump will be a malodorous home for rats and flies, and, via leachates, another source of groundwater contamination.

@DECKHEAD = <%2>Industrial Emissions<%0>

Little information exists on the nature of industrial air emissions in<%2> Pak<%0>istan; neither comprehensive nor spot surveys have been reported. But observations in the vicinity of a number of industrial zones have shown the effects of these pollutants. In Kala Shah Kaku industrial area, gaseous emissions are believed to be responsible for adverse effects on downwind crops. The Punjab Environmental Protection Agency has recently begun preliminary air pollution surveys with the assistance of the Institute for Public Health Engineering and Research at the University of Engineering and Technology (Lahore) and the Pakistan Council for Scientific and Industrial Research.

Air pollution is primarily an urban problem, where the density of industry and vehicles is sufficient to overcome the ability of the air to disperse the pollutants or dilute them quickly enough. In rural areas, air quality is not normally a problem except in the vicinity of particularly obnoxious and large discharges of pollutants.

For example, most cement plants in Pakistan have not installed equipment to control dust emissions, and pose a nuisance and a potential health hazard for surrounding residents. Large fuel-burning sources, such as thermal generating stations and industries that burn coal for steam boilers, could create localized problems from deposition of particular ash matter and sulphur compounds, especially if the coal used has a high sulphur content, as does much of Pakistan's indigenous coal supplies. Peri-urban brick-making kilns are currently the largest user of coal and emit quantities of ash and sulphur. But their effects are usually localized, due to the relatively small amount of emissions they generate.

@MINOR HEADING = <%2>Land Pollution<%0>

Pakistan generates 47,920 tonnes of solid waste per day—19,190 tonnes from urban areas and 28,730 tonnes from rural areas. This amounts to 17.5 million tonnes per year. In cities such as Lahore and Karachi, waste disposal typically accounts for 20-25% of municipal expenditures. Even so, only about 55% of these two urban areas, typically the wealthier sections, benefit from municipal collections. The composition of the waste includes a compostable content of 73% for Lahore (56% for Karachi) and a p<%2>aper content of 5-6%<%0>

<%2>Solid domestic waste is typically dumped onto low-lying land in Pakistan, and not even with the benefit of modern sanitary landfill methods. The result is unsightly and unsanitary conditions at and around dump sites, the use of land that could be turned to more productive purposes, and the loss of potentially valuable recyclable materials. The very elements that cause the problem, the organic matter content, give it a potential value as compost if it is encapsulated in soil and the organic matter is reduced to an enriched sterile fertilizer. Recycling the organic content of solid wastes has begun with a 500 tonne/day composting plant operating in Karachi. Others are planned for Lahore, Islamabad, and other cities. Sanitary landfills are also under consideration for Lahore and Islamabad.<%0>

Of considerable concern is the likelihood that quantities of toxic industrial wastes have been dumped in municipal disposal areas or are being dumped directly onto lands adjacent to factories with no record of their location, quantity, or toxic composition. The experience in many countries has shown that such 'toxic real estate' has grave social and economic implications for the future: serious health problems among local residents, large liabilities for cleanup incurred by the industries, lowered<%2> <%0>property values, and considerable public expense for identification and rehabilitation of contaminated sites.

@MINOR HEADING = <%2>Coastal Pollution<%0>

Pakistan has two ports (Karachi and Port Qasim) and four fish harbours either operational or under construction (Karachi, Pasni, Gwadar, and Korangi). Karachi port and harbour are the most used areas, and it is here that the greatest pollution is seen, both from vessels (illegally pumping out bilges and refuse), and from the port's oil terminal. An estimated 90,000 tonnes per year of oily discharges are pumped out within port limits. No oily ship waste reception or treatment facility exists within the port. Dredging operations, necessary to keep the approach channels open, also have a major impact.

The shipping lanes in the Arabian Sea are some of the busiest in the world, and it is fortunate that Pakistan has not experienced a spill greater than that of the 'F14W1> '<F255D>Akbar', an oil barge that sank and discharged 700 tonnes of crude in 1984. Pakistan has no capacity to cope with an oil spill, minor or major, or with any other kind of shipping accident with environmental consequences.

Recently, another potential hazard has also come to light: the possibility of toxic waste dumping either at sea or, through the subterfuge of wrongly labelled containers on ships, on land. The port authorities are untrained and ill-equipped to recognize and deal with such cases.

About 45% of Pakistan's industry (by value added) is located in Karachi. All its effluents plus the domestic sewage from a city of more than 8 million people and all agricultural run-off from the hinterland and in the Indus River find their way, untreated, into the sea. No comprehensive, systematic assessment of industrial or domestic municipal pollution in the coastal zone of Pakistan has been done. Some studies indicate that eutrophication caused by pollution from sewage (or other organic biodegradables such as fish processing wastes), though increasing overall biomass in the form of algal blooms, has reduced economically important marine fauna. Water-borne disease vectors and the interaction of sewage with other materials also have serious implications<%2> for human health, pa<%0>rticularly for villages on the coast.

The three main coastal industries with the largest volumes of effluents are the steel mill, power plants, and refineries. But the many smaller industrial units have more significant polluting effects on the marine environment.

Surveys of industrial pollution, by virtue of being localized and based on a limited number of water and sediment samples, cannot represent accurately the degree or extent of water pollution or the problem of materials leaching into soil and groundwater resources. The<%2> synergistic <%0>and cumulative effects of interactions among different inorganic chemical compounds and between these compounds and organic matter remain to be investigated. For example, the effluent from the Karachi Shipyard is recorded as having a pH level of 4 with 110 milligrams per litre of zinc in suspension. The synergistic effects of this level of zinc in acid effluents is likely to be far more dangerous to the coastal environment than is recognized in current reports. The continuing piecemeal study of pollutants and lack of consideration of interactions among different ones represents a major weakness in current assessments.

Other negative impacts on the coast include that of thermal pollution, increased turbidity and siltation due to dredging, oil spills, tarballs, plastics, and toxic effluents, including heavy metals. Field studies of heavy metal concentrations in coastal sediments and fish indicate levels typical of coastal waters off an industrial city. However, certain <F14W1>'<F255D>hot spots' of chromium and mercury indicate that caution is now required in effluent disposal. Baseline surveys have yet to be undertaken to assess natural radioactivity levels along the coast, so as to assess the impact of the KANUPP nuclear power plant.

If present trends continue, with no checks being instituted, it is expected that the present zone of oxygen-deficient bottom conditions in Karachi harbour will extend to cover most of that area and its backwaters, except the channels where tidal flushing is effective in dispersing pollution loads. These conditions will slowly spread into the creeks, with serious consequences to marine bottom-dwelling species and benthic fauna. The resulting deterioration in water quality will adversely affect pelagic flora and fauna, the extent of eutrophication will increase, and phytoplankton blooms and red tides will become regular features. The bioaccumulation of toxic substances in marine fauna will increase and heavy metal pollution will spread seawards, eventually approaching toxicity levels within commercially important fish stock, with potentially disastrous implications to the fishing economy.