

# Environment and Natural Resources

Ecological and Economic Perspectives



*Editor*

O.P. Singh

# ENVIRONMENT AND NATURAL RESOURCES

Ecological and  
Economic Perspectives

*Editor*

*Dr. O.P. Singh*

Centre for Environmental Studies  
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## PREFACE

The rapid pace of population growth and economic development in last century has resulted into large scale natural resource depletion and environmental degradation. As a result, mankind is confronted with various kinds of environmental problems including the air, water and land pollution, water scarcity, deforestation, loss of biodiversity, desertification, flash flood, soil erosion, silting and so on. Simultaneously, large scale and rampant exploitation of the Earth's resources for economic development has now started giving a negative feedback to the same very economic growth.

The terms ozone depletion, green house effect, global warming, climate change, etc. are no longer confined to the glossary of scientific community. Rather, these are commonly discussed issues in the society. Wide spread environmental degradation due to deforestation and pollution coupled with demographic explosion, rapid urbanization and industrialization is affecting not only our present generation but also bound to impact the future generations. The environmental degradation has been perceived as a potential threat to economic growth and well being of the people. Frequent disasters such as flood, draught, landslide, severe cyclonic storms and pollution related health problems affecting our quality of life, cultural assets and economic development. Sustainable supply of food, fiber, fuel and other commodities to expanding world population, and maintaining biodiversity

and clean water and air on earth are some of the big challenges the present society is facing today.

To address these problems and move down the path of sustainable development, a broad-based program of environmental policies and regulations is needed. Such program requires an integrated approach by all concerned stakeholders, so that an amicable solution of the problem can be found out.

The protection and regeneration of the environment is vital for sustainable human development and require understanding of the environment and its various facets that support life. In an attempt to enhance our understanding of the problem and finding solution contemporary topics have been discussed in this book.

The discussed topic shall encourage integration of ecological and economic facets of environment and natural resources and thereby develop a deeper understanding of complex environmental problems needed to solve the problem and move on the path of sustainable development.

The book comprises of five Sections on contemporary topics related to environment and natural resources. The Section One includes 6 introductory Chapters on various aspects of Environment, Natural Resources and Environmental Economics. Three Chapters on air, water and soil pollution and their abatement are included under Section Two on Environmental Degradation and Abatement. The Section Three on Development and Environmental Problems comprises of 3 Chapters and deals with case studies on specific issues. Environmental data collection, analysis and management have become important in view of increasing environmental problems the man facing today. Hence, Section Four is devoted to Environmental Data Collection, Analysis and Management and includes 4 Chapters on Remote Sensing and Geographic Information System, ENVIS and Statistical methods. Section Five is fully devoted to Environmental Impact Assessment and deals with identification and evaluation of potential environmental impacts of anthropogenic and developmental activities.

Important documents such as Rio declaration, List of Indicators of Sustainable Development and a Glossary are included as Appendices.

The chapters, contributed by researchers well recognized in their area of study shall help in improving understanding of environment and natural resources in ecological and economic perspectives. I am confident that this book will be useful for students, researchers, officials and general readers interested in improving environmental quality and moving towards sustainable development.

**O.P. Singh**

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## ABBREVIATIONS

A&C	Abatement and Control
BTU	British Thermal Unit
CFC	Chlorofluorocarbon
CFM	Community Forest Management
CO <sub>2</sub>	Carbon dioxide
dB	Decibel
DO	Dissolved oxygen
DNA	Deoxyribonucleic acid
EC50	Effective concentration 50
ED50	Effective dose 50
EIA	Environmental Impact Assessment.
EMP	Environmental Management Plan
ESP	Electrostatic precipitator
FAO	Food and Agriculture Organization
FISD	Framework of Indicators of Sustainable Development
GIS	Geographic Information Systems
GNI	Gross National Income
GDP	Gross Domestic Product
GNP	Gross National Product
GSI	Geological Survey of India
HC	Hydrocarbons
LD50	Lethal dose 50
LPG	Liquefied Petroleum Gas

MAB	Man and Biosphere Program
MAP	Medicinal and Aromatic Plants
MIC	Methyl Isocyanate
NAAQMS	National Ambient Air Quality Monitoring Standards
NDP	Net Domestic Product
NNI	Net National Income
NO	Nitric oxide
NO <sub>2</sub>	Nitrogen dioxide
NO <sub>x</sub>	Oxides of nitrogen or Nitrogen oxide
OPEC	Organization of Petroleum Exporting Countries
O <sub>3</sub>	Ozone
PAHs	Polyaromatic hydrocarbons
PAN	Peroxyacetyl nitrate
PCB	Polychlorinated biphenyl
PM	Particulate matter
RS	Remote Sensing
SAM	Social Accounting Matrices
SD	Sustainable Development
SNA	System of National Accounts
SEA	Socio-Economic Accounts
SEEA	System of Integrated Economic & Environmental Accounts
SPM	Suspended Particulate Matter
SSDA	System of Socio-Demographic Accounts
TEV	Total Economic Value
TDS	Total Dissolved Solids
TSP	Total Suspended Particulate
TSS	Total suspended solids
UNFAO	United Nations Food and Agriculture Organization
UV	Ultraviolet
VOC	Volatile organic compound
WTA	Willingness to Accept
WTP	Willingness to Pay

Chapter 1

INTRODUCTION  
ENVIRONMENT  
AND NATURAL RESOURCES

## SECTION ONE

# Environment, Natural Resources and Environmental Economics

H.N. Pany

Environment is the  
total of all existing  
living organisms  
entire hydrosphere  
evidence of evolution  
together constitute  
Biosphere which  
related to its  
because natural  
technological world  
ecosystem.

DIMENSIONS

The environment  
surrounding all  
space and other  
the environment  
population and

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## Chapter 8

# WATER POLLUTION: TYPES, SOURCES AND ABATEMENT

*S.S. Chaturvedi*

### INTRODUCTION

Comprising over 70% of Earth's surface, water is undoubtedly the most precious natural resource that exists on our planet. Without the seemingly invaluable compound comprised of hydrogen and oxygen, life on earth would be non-existent. It is essential for everything on our planet to grow and prosper. Although we as human recognize this fact, we disregard it by polluting our rivers, lakes, and oceans and subsequently, we are slowly but surely harming our planet. In order to combat water pollution, we must understand the problems and become part of the solution.

Water is a unique liquid having very high capacity to absorb and store heat and is a good liquid solvent. Thus, it can get contaminated easily. Any physical, chemical and biological change in water quality that adversely affects living organisms or make water unsuitable for desired uses can be considered as **water pollution**. The environmental protection agencies had set thresholds or limits of water pollution levels for some, but not all, pollutants. If the pollutant is in a concentration

greater than an established threshold, the water is unsatisfactory for a particular use.

### SURFACE WATER POLLUTION

Pollution of surface water occurs when too much of harmful substances flow into a water body exceeding its natural ability to convert it to a harmless form. It can be categorized as point and non point sources of surface water pollution.

### GROUND WATER POLLUTION

Ninety-five percent of all fresh water on earth is ground water. Ground water is the prime source of water used for the purpose of drinking, industrial and agricultural utilization. The water quality requirement varies with respect to the specific uses, and each use has its own specified quality. The most serious ground water pollution problem is associated with urbanization, industrialization and dumping of solid wastes. Ground water contamination with metals like arsenic and fluoride has posed serious health hazards to various communities in many parts of the world. A typical analysis of well water collected from city of Jorhat adjacent to Civil Hospital is given to show the pollution level in the ground water source (Table 1).

### POINT AND NONPOINT SOURCES OF POLLUTION

Pollution of water occurs when too much of harmful substances flows into a water body, exceeding the natural ability of the water body to remove the undesirable material, dilute it to a harmless concentration, or convert it to a harmless form. Water pollutants can be categorized as point and nonpoint sources. Point sources are those pollution sources, which are discrete and identifiable so they are relatively easy to monitor and regulate. Factories, power plants, sewage treatment plants, underground coalmines, and oil wells are few examples of point sources. These sources can be controlled

**Table 1: Analysis of well water sample from Jorhat, Assam**

Parameter	Sample A (surface)	Sample B (bottom of well)	Standard WHO	Remarks
pH	6.5	7.0	7.8-8.5	Slightly acidic
Hardness	105	110	100	Slightly high
Aluminium (mg/L)	0.3	0.2	1.0	Tolerable
Chromium	0	0.1	0.05	High
Iron	2.5	2.0	0.1	Very high
Manganese	0.5	0	0.05	Very high
Chloride	80	85	200	Tolerable
Fluoride	1.5	2.0	0.7	High
Nitrate	25	20	22.6	Slightly high
DO	0	0	1.5	Too low

through on site treatment or disposal. Nonpoint sources of water pollution are scattered having no specific location and are difficult to monitor and control. Non point sources include run off from farm fields, streets, construction sites, and logging areas and such run off contains all sorts of pollutants from heavy metals to chemicals and sediments.

**Table 2: Nature of waste from material industries**

S. No.	Industrial Source	Kind of Pollutant
1.	Leather industry	Alkaline pH, Sulfides, Metals, Lime and Chromates and Color, High BOD/COD, Dissolved Solids
2.	Textile and apparel	Alkaline pH, Sodium, Organic Matter, Dissolved and Suspended Solids and Coloring Dyes
3.	Food processing	High BOD, Colloidal Solids, Dissolved and Suspended Solids
4.	Slaughter houses	Very high BOD, Phosphates
5.	Durgs and pharmaceuticals	High or low pH, Total Solids, Toxic Organics Compounds and Metals,
6.	Electroplating	Low pH and Toxic Metals, Cyanides
7.	Paper pulp	Strong Colors, Sulfides of Sodium, Alkaline Earth, Sulfonates

**CATEGORIES OF WATER POLLUTION****Toxic inorganic materials**

Toxic inorganic chemicals are released from rocks by weathering and are carried by run off into the lakes or rivers or percolate onto ground water aquifers, but sometimes the transport rates get accelerated thousands times above natural levels through mineral mining processes. Phosphorus and nitrate released by human activity leads to water pollution. Their amount in urban streams is generally high because of the introduction of fertilizers, detergents, and discharge from sewage treatment plants. However, the highest concentrations of phosphorus and nitrogen are found in agricultural areas, where the sources are fertilized farm fields. Nitrate content in domestic supply water ranges from less than 1 mg/l to around 50 mg/l. Its higher concentration in drinking water may lead to the conversion of haemoglobin into methanoglobin and may also reduce body assimilation of iodine causing goiter.

Surface water in some districts of West Bengal, Assam, Andhra Pradesh and other parts of India is found contaminated with Fluoride. Communities exposed to fluoride contamination suffer very much in both short and long term basis. There were reports of bone deformity and associated problems of locomotor organs. The children are more susceptible than the adults.

**Heavy metals**

Among the major heavy elements that pose hazards is mercury, lead, cadmium, nickel, arsenic, selenium, chromium and thallium. These metals are highly persistent and accumulate in food chains, and have a cumulative effect in humans. These elements have uses in industrial units and in the manufacturing process, and are also released as by products of mining and refinery industries. Industries like paint, dyes, chemicals, metal plating discharge their effluents containing these metals into the ground with out any treatment. This probably contributed

**Table 3: Symptoms of some heavy metal toxicity**

<i>Metal</i>	<i>Source</i>	<i>Symptoms</i>
Mercury (organic and inorganic)	Industrial discharge	Central and peripheral nervous systems disorders, renal failure, blurred vision, numbness of limbs, lips muscles etc.
Lead	Industrial waste, dust, polluted food, paint	Nervous disorders, renal failure, blood poisoning and anemia, encephalopathy
Cadmium	Industrial discharge, dust, fumes, polluted water	Renal, pulmonary and skeletal diseases, proteinuria, glucosuria
Arsenic	Industrial, medicinal and agricultural wastes	Respiratory and skin cancer, nervous disorders
Nickel	Aerosols, industrial dust	Pulmonary disorders, dermatitis etc.
Chromium	Industrial waste, fumes	Respiratory disorders including cancer
Tin (organic and inorganic)	Industrial dust, medicinal wastes	Central nervous system disorder, vision disorder and pneumoconiosis

to the increase in the concentration of these heavy metals in the ground water.

**Zinc**

The main source of zinc is galvanization and alloy industry. At lower concentrations it is a necessary element for human and animals, while at higher concentration it causes chill, nausea, vomiting and metal fume fever. Its adverse effects are temporary and patient may recover in 48 hours of exposure.

**Cadmium**

Presence of cadmium in high proportion may be fatal for human health as it interferes with certain enzymes and cause hypertension, liver cancer, lymph, gastro intestinal disorders and heart disease. It may enter the environment via ash from burning of coal in a power plant. Inhalation of 1 mg/m<sup>3</sup> of cadmium over 8 hr may increase salivation, nausea, vomiting, headache, shock, chest pain, bronchial pneumonia, and kidney necrosis in human. Retention of about 4 mg of Cd in the lungs is fatal.

**Lead**

The most important source of lead is auto-exhaust emission as  $(C_2H_4)_4Pb$ . Other sources are glass industry, paint industry, low fusible alloy like solder, accumulator and storage batteries, printing industry (type metal) and water pipes. The presence of lead in higher concentration would replace calcium present in the bone marrow. It also affects the formation of haemoglobin, alteration in structure and function of mitochondrial membrane, impairment of enzyme activities and brain cells damages in human.

**Selenium**

Selenium is necessary trace nutrient for humans and animals. Its deficiency may prove to be a problem, particularly for livestock. It may be toxic in higher concentrations. Selenium rich agricultural wastewater seeps from irrigated lands and is concentrated by evaporation in ponds of the refuge. Selenium oxide causes bronchitis, dyspnea, sleeplessness, nervous and cardiac disorders, loss of appetite and damage to liver and spleen. Other harmful forms of selenium are  $SeOCl_2$  and  $SeO_2H_2$ .

**Arsenic**

Ground water arsenic contamination is known over the years in various part of India. However, the major incidences are noted from West Bengal and Bangladesh where a vast tract is under the arsenic calamity. Several thousands people are suffering from chronic arsenicosis through drinking of contaminated ground water. Sources of arsenic in wastewater are pharmaceutical, paper pulp and glass industry. Arsenic trioxide is used in agriculture, and a considerable amount of it mixes with water. Organic (methyl and dimethyl) arsenic is also found in water because of oxidation, reduction, methylation and demethylation cycles operating in the

environment. Ingestion of arsenic compounds is responsible for arsenic poisoning in animals and man. Acute toxicity causes liver and kidney damage, muscular atrophy, gastrointestinal damage and nervous disorders.

**Mercury**

Organic forms of mercury are more poisonous than its inorganic forms. When effluent from plastic industry, containing mercury, is released into water body, the inorganic mercury gets converted into methyl mercury by the microbial action. This methyl mercury is much more toxic and readily passes through cell membrane and transported by the red blood cells throughout the body. It enters and damages brain cells. The lethal dose for mercury is about 0.5 to 1.0 g for an adult.

**Chromium**

This is one the most toxic heavy metals present in the industrial effluents. The main source of this element is paint, alloy (stainless steel) and glass industry and electroplating and tanneries effluents where  $K_2Cr_2O_7$  is used for hide cleaning and leather treatment. The hexavalent chromium (Cr VI) is more toxic than its trivalent form (Cr III). It causes dermatitis, ulceration and perforation of nasal septum, Cr (VI) compounds cause lung cancer to workers working in paint, pigment and tannery industry.

**Manganese**

The main source of manganese is milling factory, alloy industry, mines and mineral depots, smelting operations, dry cell battery factories and glass industry. It affects the central nervous system, causes gait and speech disturbance tremors, mask like face, uncontrollable laughter, lung troubles. Its symptoms are visible after 2-3 months of exposure.

### Cobalt and Nickel

The main source of cobalt is magnet-making concerns, while Nickel comes from hydrogenation of oil industry and paint industries.  $\text{Co}(\text{CO})_8$  is most toxic and causes lung problem. It causes pulmonary edema, while nickel causes dermatitis, pneumonia, lung and nose cancer, giddiness, headache, nausea and vomiting.

### Acids and bases

Acids and bases are released as byproducts of industrial processes such as leather tanning, metal smelting and plating, petroleum distillation and organic chemical synthesis. Coal mining is an especially important source of acid water pollution. Low pH and toxic materials (like aluminium) brought into solution at lower pH are directly injurious to many fresh water animals and have diverse biological effects. Coal and oil combustion also leads to formation of atmospheric sulfuric and nitric acids, which are disseminated, via precipitation (acid rain, snow, fog or dry deposition) in surface water. Increased acidity may result in leaching of toxic metals from soil and rocks making water unfit for drinking or irrigation as well.

### Organic compounds

Thousands of different natural and synthetic organic chemicals are used in the chemical industries to make pesticides, plastics, pharmaceuticals, pigments and other related products that we use in every day life. Exposure to very low concentrations can cause birth defects, genetic disorders and cancer. Some can persist in the environment because they are resistant to degradation and toxic to organisms that ingest them. Contamination of surface water and ground water by these organic pollutants is a serious threat to the human health.

The two important sources of toxic organic chemicals in water are improper disposal of industrial and household wastes, and run off of pesticides from farm field and other places where they are used in large quantities. Much of this material washes into the nearest waterway where it passes through ecosystem and may accumulate in higher level in certain non-target organisms. The bioaccumulation of DDT and dioxins and other chlorinated hydrocarbons have been shown to accumulate to dangerous level to cause health problems (Table 4).

Table 4: LD50 dose and threshold limiting values (TLV) of some pesticides

Pesticide	LD50 (mg/kg)	TLV (mg/m <sup>3</sup> )
<b>Insecticides</b>		
Aldrin	54-56	0.25
DDT	420-800	1.0
Heptachlor	90	0.5
Lindane	125-200	0.5
Malathion	480-1500	10
Parathion	4-30	0.1
<b>Herbicides</b>		
2,4 D	666	10
2,4,5 T	0.03	-
Dioxane	0.03	-
<b>Fungicides</b>		
CuSO <sub>4</sub>	Very high	-
Pharsenol	825	-

### Oil and grease

Oil discharged into surface water (usually the ocean) has caused major pollution problem. Several large oil spills from under ground oil drilling operation have occurred in recent years sometimes due to accident like collision or rupture of tankers, or military action, huge amount of oil float on the sea surface. Oils and grease deoxygenate water. Oils form blanket over the water surface and inhibits oxygen diffusion, and

may directly coat plants and animals causing injury and death. Oils contain many carcinogens such as polycyclic aromatics and phenols, which mix with water and poison aquatic life.

## ADDITIONAL FORM OF WATER POLLUTANTS

### Oxygen demanding pollutants

The amount of oxygen dissolved in water is a good indicator of water quality. Water with oxygen content above 6 ppm will support desirable forms of aquatic life. Water with less than 2ppm oxygen will support mainly worms, bacteria, fungi and other microorganisms.

The addition of domestic sewage, paper pulp or food processing waste to water stimulates oxygen consumption by micro organisms present in the water body. The impact of these materials on water quality is expressed in terms of **Biochemical Oxygen Demand (BOD)**. BOD values are useful in process design and load calculation as well as the measurement of treatment plant efficiency and operation. An alternative method, called the **Chemical Oxygen Demand (COD)**, is used to monitor the organic material present the water. This method is much faster than BOD test, but normally gives much higher results because it oxidizes compounds not normally metabolizes by bacteria. Another method assessing pollution level is to measure **Dissolved Oxygen (DO)** content.

### Infectious agents

The most serious water pollutants in terms of human health worldwide are pathogenic organisms. Among the most important water born diseases are typhoid, cholera, bacterial and amoebic dysentery, polio, infectious hepatitis and schistosmiasis. The main source of these pathogens is from untreated or improperly treated human wastes. Food processing factories with inadequate waste treatment facilities also are sources of disease causing organisms. The World Health Organization estimates that 80% of all sickness and disease in less developed countries can be attributed to water

borne infectious agents. Because it is often difficult to monitor the disease carrying organisms directly, count of fecal coliform bacteria is used as a standard measure of microbial population and an indicator of disease potential for the water source.

### Thermal pollution

Raising or lowering of water temperature from normal levels can adversely affect water quality and aquatic life. Lowering the temperature of tropical oceans by one degree can be lethal to some corals and other reef species. Oxygen solubility decreases in water as temperature increases, so species requiring high oxygen level are adversely affected by warm water. High temperature of water above the normal range can exacerbate the effects of organic matter pollution by increasing decay rates and hence deoxygenation. It can also cause stress to cold-blooded animals by causing above normal rates of respiration and favour an abnormal biota (for the area), which may include exotic and sometime nuisance species and allow these to become acclimatized to the region. Discharging heated water directly into river and lakes can cause thermal pollution. Electric power plants, metal smelters, petroleum refineries, paper mills, food processing factories and chemical manufacturing plants all use and release large amount of cooling water which causes thermal pollution to the receiving water body.

### Radioactive pollution

Radioactive substances are produced in the from of waste from nuclear power plants, and from the industrial, medical, and scientific use of radioactive materials. Radioactive wastes are also produced during mining and refining of uranium and thorium.

## WATER QUALITY MONITORING

There are three basic kinds of water quality monitoring — physical analysis, chemical analysis and biological assessment.

Normally, surface water quality is monitored by all the three methods but the ground water quality is monitored principally by physical and chemical ways with few bacteriological tests.

In India, river water quality is monitored regularly by joint efforts of Central Water Commission, State and Central Pollution Control Board. In contrary ground water quality is monitored by Central Ground Water Board and also by State Water Investigation Departments. The primary objective of these monitoring are to assess chemical and biological contaminations harmful for mankind. The Central Pollution Control Board has sole responsibility of framing standards for drinking water and effluents discharged from industries and their implementation throughout country. Some core water quality monitoring parameters and water quality criteria for various uses are given.

Data pertaining to water pollution can be collected for the Central Pollution Control Board, respective State Pollution

**Table 5: Core water quality monitoring parameters (as per CPCB)**

S. No. Parameter	Requirement for Waters of Class		
	A-Excellent	B-Desirable	C-Acceptable
1. pH	7.0 to 8.5	6.5 to 9.0	6.5 to 9.0
2. DO (% saturation)	90-110	80-120	60-140
3. BOD (mg/l)	Below 2	Below 3	Below 6
4. EC (umhos/cm)	<1000	<2250	<4000
5. (NO <sub>2</sub> + NO <sub>3</sub> )-Nitrogen (mg/l)	<5	<10	<15
6. Suspended Solid (mg/l)	<25	<50	<100
7. Fecal Coliform (MPN/100 ml)	<20 per 100 ml	<200 per 100 ml	<2000 per 100 ml
8. Bio-assay (Zebra Fish)	No death in 5 days	No death in 3 days	No death in 2 days

**Note:**

1. Dissolved oxygen (DO) not applicable for ground waters.
2. Dissolved oxygen in eutrophicated waters should include measurement for diurnal variation.
3. Suspended solid limit is applicable only during non-monsoon period.
4. Fecal coliform values should meet for 90% times.
5. Static bioassay method may be adopted.

Control Board, Academic Institutions, Research and Development Organizations engaged in pollution researches and NGO's working in the area of water pollution monitoring and management.

**Table 6: Water quality criteria (as per CPCB)**

Designated Best Use	Class of water	Criteria			
		MNP/100	pH	DO (mg/l)	BOD/ (mg/l)
Drinking waste source without conventional treatment but after disinfection	A	50 or below	6.5-8.5	6 or more	2 or less
Outdoor bathing (organized)	B	500 or less	6.5-8.5	5 or more	3 or less
Drinking water source after conventional treatment and disinfection	C	5000 or less	6-9	4 or more	3 or less
Propagation of wild life and fisheries	D	-	6.5-8.5	4 or more	Free ammonia 1.2 mg/l or less
Irrigation, industrial cooling, controlled waste disposal	E	-	6-8.5	EC not more than 2250	SAR not more than 26 & Boron 2 mg/l
	Below E	Not meeting A, B, C, D & E criteria			

## WASTE-WATER TREATMENT

The waste-water from the city or industry must be treated and made harmless before being discharged in to a water body. The treatment of waste-water is carried out in three stages: Primary, secondary and tertiary treatment.

In primary treatment, sieves separate the solid objects. Then the liquid material of the effluent is passed into a series of settling tank where suspended solid organic materials get settle down in the tanks and form sludge.

The organic matter and other impurities after the primary treatment remain in the solution and cannot readily be filtered. The effluent from the primary treatment is passed into the

secondary treatment called activated sludge or aerobic treatment. Here the effluent is aerated for several hours to enhance the bacterial decomposition of organic matter and oxidative sedimentation of suspended and dissolved materials. This process removes about 90% of the biodegradable materials present in the wastewater.

Tertiary treatment is applied to remove detergents, metal ions, nitrates and pesticides, as these are not removed in the earlier treatments. In this process the effluent from the secondary treatment is passed through activated charcoal to absorb the pollutants.

## CONCLUSION

World wide, the most serious water pollutants, in terms of human health, are pathogenic organisms from human and animal wastes. In developed and developing nations, toxic chemical wastes have become an increasing problem. Agricultural and industrial chemicals have been released or spilled into surface waters and are seeping into ground water supplies. The extent of this problem is probably not yet fully appreciated.

Ultimately, all water ends in the ocean. Major causes of ocean pollution are oil spills from tankers bilge, pumping, or accidental and oil well blowouts. Surface run off and sewage outfalls discharge fertilizers, pesticides, organic nutrients and toxic chemicals that have a variety of deleterious effects on marine ecosystem.

The major water pollutants in term of quality are silt and sediments. Farm run off and industrial activities also damage water quality. Drainage from mines and various industries deliver toxic materials to the river. Water pollution is a major source of human health problems. As much as 80 percent of all diseases and some 25 million deaths each year may be attributable to water contamination. Appropriate land use practices and careful disposal of industrial, domestic and agricultural waste are essential for control of water pollution.

Natural processes and living organisms have a high capacity to remove or destroy water pollutants, but these systems become overloaded and ineffective when pollution levels are too high. Municipal sewage treatment is effective in removing organic material from the wastewater, but the sewage sludge is often contaminated with metals and other toxic industrial materials. Reducing the sources of these materials is often the best solution to water pollution problems.

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## Appendix I

# RIO DECLARATION ON ENVIRONMENT AND DEVELOPMENT

(Excerpts of report of the United Nations Conference on the Human Environment, Stockholm, 5–16 June 1972)

The United Nations Conference on Environment and Development, having met at Rio de Janeiro from 3 to 14 June 1992, reaffirming the declaration of the United Nations Conference on the Human Environment, adopted at Stockholm on 16 June 1972, and seeking to build upon it, with the goal of establishing a new and equitable global partnership through the creation of new levels of cooperation among States, key sectors of societies and people, working towards international agreements which respect the interests of all and protect the integrity of the global environmental and developmental system, recognizing the integral and interdependent nature of the Earth, our home, proclaims that:

### PRINCIPLE 1

Human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature.

**PRINCIPLE 2**

States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental and developmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.

**PRINCIPLE 3**

The right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations.

**PRINCIPLE 4**

In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it.

**PRINCIPLE 5**

All States and all people shall cooperate in the essential task of eradicating poverty as an indispensable requirement for sustainable development, in order to decrease the disparities in standards of living and better meet the needs of the majority of the people of the world.

**PRINCIPLE 6**

The special situation and needs of developing countries, particularly the least developed and those most environmentally vulnerable, shall be given special priority. International actions in the field of environment and development should also address the interests and needs of all countries.

**PRINCIPLE 7**

States shall cooperate in a spirit of global partnership to conserve, protect and restore the health and integrity of the Earth's ecosystem. In view of the different contributions to global environmental degradation, States have common but differentiated responsibilities. The developed countries acknowledge the responsibility that they bear in the international pursuit to sustainable development in view of the pressures their societies place on the global environment and of the technologies and financial resources they command.

**PRINCIPLE 8**

To achieve sustainable development and a higher quality of life for all people, States should reduce and eliminate unsustainable patterns of production and consumption and promote appropriate demographic policies.

**PRINCIPLE 9**

States should cooperate to strengthen endogenous capacity-building for sustainable development by improving scientific understanding through exchanges of scientific and technological knowledge, and by enhancing the development, adaptation, diffusion and transfer of technologies, including new and innovative technologies.

**PRINCIPLE 10**

Environmental issues are best handled with participation of all concerned citizens, at the relevant level. At the national level, each individual shall have appropriate access to information concerning the environment that is held by public authorities, including information on hazardous materials and activities in their communities, and the opportunity to participate in decision-making processes. States shall facilitate and encourage public awareness and participation by making

information widely available. Effective access to judicial and administrative proceedings, including redress and remedy, shall be provided.

#### **PRINCIPLE 11**

States shall enact effective environmental legislation. Environmental standards, management objectives and priorities should reflect the environmental and development context to which they apply. Standards applied by some countries may be inappropriate and of unwarranted economic and social cost to other countries, in particular developing countries.

#### **PRINCIPLE 12**

States should cooperate to promote a supportive and open international economic system that would lead to economic growth and sustainable development in all countries, to better address the problems of environmental degradation. Trade policy measures for environmental purposes should not constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction on international trade. Unilateral actions to deal with environmental challenges outside the jurisdiction of the importing country should be avoided. Environmental measures addressing transboundary or global environmental problems should, as far as possible, be based on an international consensus.

#### **PRINCIPLE 13**

States shall develop national law regarding liability and compensation for the victims of pollution and other environmental damage. States shall also cooperate in an expeditious and more determined manner to develop further international law regarding liability and compensation for adverse effects of environmental damage caused by activities within their jurisdiction or control to areas beyond their jurisdiction.

#### **PRINCIPLE 14**

States should effectively cooperate to discourage or prevent the relocation and transfer to other States of any activities and substances that cause severe environmental degradation or are found to be harmful to human health.

#### **PRINCIPLE 15**

In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

#### **PRINCIPLE 16**

National authorities should endeavour to promote the internalization of environmental costs and the use of economic instruments, taking into account the approach that the polluter should, in principle, bear the cost of pollution, with due regard to the public interest and without distorting international trade and investment.

#### **PRINCIPLE 17**

Environmental impact assessment, as a national instrument, shall be undertaken for proposed activities that are likely to have a significant adverse impact on the environment and are subject to a decision of a competent national authority.

#### **PRINCIPLE 18**

States shall immediately notify other States of any natural disasters or other emergencies that are likely to produce sudden harmful effects on the environment of those States. Every effort shall be made by the international community to help States so afflicted.

**PRINCIPLE 19**

States shall provide prior and timely notification and relevant information to potentially affected States on activities that may have a significant adverse transboundary environmental effect and shall consult with those States at an early stage and in good faith.

**PRINCIPLE 20**

Women have a vital role in environmental management and development. Their full participation is therefore essential to achieve sustainable development.

**PRINCIPLE 21**

The creativity, ideals and courage of the youth of the world should be mobilized to forge a global partnership in order to achieve sustainable development and ensure a better future for all.

**PRINCIPLE 22**

Indigenous people and their communities and other local communities have a vital role in environmental management and development because of their knowledge and traditional practices. States should recognize and duly support their identity, culture and interests and enable their effective participation in the achievement of sustainable development.

**PRINCIPLE 23**

The environment and natural resources of people under oppression, domination and occupation shall be protected.

**PRINCIPLE 24**

Warfare is inherently destructive of sustainable development. States shall therefore respect international law providing

protection for the environment in times of armed conflict and cooperate in its further development, as necessary.

**Principle 25**

Peace, development and environmental protection are interdependent and indivisible.

**PRINCIPLE 26**

States shall resolve all their environmental disputes peacefully and by appropriate means in accordance with the Charter of the United Nations.

**PRINCIPLE 27**

States and people shall cooperate in good faith and in a spirit of partnership in the fulfilment of the principles embodied in this Declaration and in the further development of international law in the field of sustainable development.

*Source: UNEP website 2003.*



Chapter of Agenda 21	Driving Force indicators	State indicators	Response indicators
Chapter 33: Financial resources and mechanisms	<ul style="list-style-type: none"> <li>• Net resources transfer/GNP</li> <li>• Total ODA given or received as a percentage of GNP</li> </ul>	<ul style="list-style-type: none"> <li>• Debt/GNP</li> <li>• Debt service/export</li> </ul>	<ul style="list-style-type: none"> <li>• Environmental protection expenditures as a percent of GDP</li> <li>• Amount of new or additional funding for sustainable development</li> <li>• Technical cooperation grants</li> </ul>
Chapter 34: Transfer of environmentally sound technology, cooperation and capacity-building	<ul style="list-style-type: none"> <li>• Capital goods imports</li> <li>• Foreign direct investments</li> </ul>	<ul style="list-style-type: none"> <li>• Share of environmentally sound capital goods imports</li> </ul>	<ul style="list-style-type: none"> <li>• Waste-water treatment coverage</li> <li>• Density of hydrological networks</li> </ul>
<b>Environmental category</b>			
Chapter 18: Protection of the quality and supply of freshwater resources	<ul style="list-style-type: none"> <li>• Annual withdrawals of ground and surface water</li> <li>• Domestic consumption of water per capita</li> </ul>	<ul style="list-style-type: none"> <li>• Groundwater reserves</li> <li>• Concentration of faecal coliform in freshwater</li> <li>• Biochemical oxygen demand in water bodies</li> </ul>	
Chapter 17: Protection of the oceans, all kinds of seas and coastal areas	<ul style="list-style-type: none"> <li>• Population growth in coastal areas</li> <li>• Discharges of oil into coastal waters</li> <li>• Releases of nitrogen and phosphorus into coastal waters</li> </ul>	<ul style="list-style-type: none"> <li>• Maximum sustained yield for fisheries</li> <li>• Algae index</li> </ul>	
Chapter 10: Integrated approach to the planning and management of land resources	<ul style="list-style-type: none"> <li>• Land use change</li> </ul>	<ul style="list-style-type: none"> <li>• Changes in land condition</li> </ul>	<ul style="list-style-type: none"> <li>• Decentralized local-level natural resource management</li> </ul>
Chapter 12: Managing fragile ecosystems: combating desertification and drought	<ul style="list-style-type: none"> <li>• Population living below poverty line in dryland areas</li> </ul>	<ul style="list-style-type: none"> <li>• National monthly rainfall index</li> <li>• Satellite derived vegetation index</li> <li>• Land affected by desertification</li> </ul>	
Chapter 13: Managing fragile ecosystems: sustainable mountain development	<ul style="list-style-type: none"> <li>• Population change in mountain areas</li> </ul>	<ul style="list-style-type: none"> <li>• Sustainable use of natural resources in mountain areas</li> <li>• Welfare of mountain populations</li> </ul>	<ul style="list-style-type: none"> <li>• Agricultural education</li> </ul>
Chapter 14: Promoting sustainable agriculture and rural development	<ul style="list-style-type: none"> <li>• Use of agricultural pesticides</li> <li>• Use of fertilizers</li> <li>• Irrigation % of arable land</li> <li>• Energy use in agriculture</li> </ul>	<ul style="list-style-type: none"> <li>• Arable land per capita</li> <li>• Area affected by salinization and waterlogging</li> </ul>	
Chapter 11: Combating deforestation	<ul style="list-style-type: none"> <li>• Wood harvesting intensity</li> </ul>	<ul style="list-style-type: none"> <li>• Forest area change</li> </ul>	<ul style="list-style-type: none"> <li>• Managed forest area ratio</li> <li>• Protected forest area as a percent of total forest area</li> </ul>
Chapter 15: Conservation of biological diversity		<ul style="list-style-type: none"> <li>• Threatened species as a percent of total native species</li> </ul>	<ul style="list-style-type: none"> <li>• Protected area as a percent of total area</li> <li>• R&amp;D expenditure for biotechnology</li> <li>• Existence of national biosafety regulations or guidelines</li> <li>• Expenditure on air pollution abatement</li> </ul>
Chapter 16: Environmentally sound management of biotechnology			
Chapter 9: Protection of the atmosphere	<ul style="list-style-type: none"> <li>• Emissions of greenhouse gases</li> <li>• Emissions of sulphur oxides</li> <li>• Emissions on nitrogen oxides</li> <li>• Consumption of ozone depleting substances</li> </ul>	<ul style="list-style-type: none"> <li>• Ambient concentrations of pollutants in urban areas</li> </ul>	
Chapter 21: Environmentally sound management of solid wastes and sewage-related issues	<ul style="list-style-type: none"> <li>• Generation of industrial and municipal solid waste</li> <li>• Household waste disposed per capita</li> </ul>		<ul style="list-style-type: none"> <li>• Expenditure on waste management</li> <li>• Waste recycling and reuse</li> <li>• Municipal waste disposal</li> </ul>

Chapter of Agenda 21	Driving Force indicators	State indicators	Response indicators
Chapter 19: Environmentally sound management of toxic chemicals		<ul style="list-style-type: none"> <li>Chemically induced acute poisonings</li> </ul>	<ul style="list-style-type: none"> <li>Number of chemicals banned or severely restricted</li> </ul>
Chapter 20: Environmentally sound management of hazardous wastes	<ul style="list-style-type: none"> <li>Generation of hazardous wastes</li> <li>Imports and exports of hazardous wastes</li> </ul>	<ul style="list-style-type: none"> <li>Area of land contaminated by hazardous wastes</li> </ul>	<ul style="list-style-type: none"> <li>Expenditure on hazardous waste treatment</li> </ul>
Chapter 22: Safe and environmentally sound management of radioactive wastes	<ul style="list-style-type: none"> <li>Generation of radio active wastes</li> </ul>		
<b>Institutional category</b>			
Chapter 8: Integrating environment and development in decision-making			<ul style="list-style-type: none"> <li>Sustainable development strategies</li> <li>Programme of integrated environmental and economic accounting</li> <li>Mandated Environmental Impact Assessment</li> <li>National councils for sustainable development</li> <li>Scientists and engineers engaged in R&amp;D per million population</li> <li>Expenditure on R&amp;D as a percent of GDP</li> </ul>
Chapter 35: Science for sustainable development		<ul style="list-style-type: none"> <li>Potential scientists and engineers per million population</li> </ul>	

Chapter 37: National mechanisms and international cooperation for capacity-building in developing countries			<ul style="list-style-type: none"> <li>Ratification of global agreements</li> <li>Implementation of ratified global agreements</li> </ul>
Chapter 38: International institutional arrangements			
Chapter 39: International legal instruments and mechanisms			
Chapter 40: Information for decision-making		<ul style="list-style-type: none"> <li>Main telephone lines per 100 inhabitants</li> <li>Access to information.</li> </ul>	<ul style="list-style-type: none"> <li>Programmes for national environmental statistics</li> </ul>
Chapter 23-32: Strengthening the role of major groups			<ul style="list-style-type: none"> <li>Representation of major groups in national councils for sustainable development</li> <li>Representatives of ethnic minorities and indigenous people in national councils for sustainable development</li> <li>Contribution of NGOs to sustainable development</li> </ul>

## Appendix III

## LIST OF ENVIRONMENTAL LEGISLATIONS

(Issued in accordance with the Constitution of India to 'protect and improve the environment and to safeguard the forests and wildlife of the country')

### GENERAL ENVIRONMENTAL LEGISLATIONS

1986

**The Environment (Protection) Act** authorizes the central government to protect and improve environmental quality, control and reduce pollution from all sources, and prohibit or restrict the setting and/or operation of any industrial facility on environmental grounds.

1986

**The Environment (Protection) Rules** lays down procedures for setting standards of emission or discharge of environmental pollutants.

1989

**Hazardous waste (Management and Handling) Rules** objective is to control generation, collection, treatment, import, storage and handling of hazardous waste.

1989

**The Manufacture, Storage and Import of Hazardous Chemical Rules** defines the terms used in this context, and sets up an Authority to inspect, once a year, the industrial activity connected with hazardous chemicals and isolated storage facilities.

1989

**The Manufacture, Use, Import,, Export and Storage of hazardous Micro-organisms/Genetically Engineered Organisms or Cells Rules** were introduced with a view to protect the environment, nature and health, in connection with the application of gene technology and micro organisms.

1991

**The Public Liability Insurance Act and Rules and Amendment, 1992** was drawn up to provide for public liability insurance for the purpose of providing immediate relief to the persons affected by accident while handling any hazardous substance.

1995

**National environmental Tribunal Act** has been created to award compensation for damages to persons, property and the environment arising from any activity involving hazardous substances.

1997

**The National Environment Appellate Authority Act** has been created to hear appeals with respect to restrictions of areas in which classes of industries etc are carried out or prescribed subject to certain safeguards under the EPA (Environment Protection Act).

1998

**Biomedical waste (Management and Handling) Rules** is a legal binding on the health care institutions to streamline the process of proper handling of hospital waste such as segregation, disposal, collection and treatment.

#### LEGISLATIONS FOR PROTECTION OF FOREST AND WILDLIFE

1927

**Indian Forest Act and Amendment 1984** is one of the many surviving colonial statutes. It was enacted to 'consolidate the law related to forest, the transit of forest produce and the duty leviable on timber and other forest produce.

1972

**Wildlife Protection Act, Rules 1973 and Amendment 1991** provides for the protection of birds and animals and for all matters that are connected to it whether it be their habitat or the waterhole or the forest that sustain them.

1980

**The Forest (Conservation) Act and Rules 1981** provides for the protection of and the conservation of the forests.

#### LEGISLATIONS FOR PROTECTION OF WATER RESOURCES AND QUALITY

1882

**The Easement Act** allows private rights to use a resource i.e. groundwater, by viewing it as an attachment to the land. It also states that all surface water belongs to the state and is a state property.

1897

**Indian Fisheries Act** establishes two sets of penal offences whereby the government can sue any person who uses dynamite or other explosive substance in any way (whether coastal or inland) with intent to catch or destroy any fish or poisons fish in order to kill.

1956

**The River Boards Act** enables the states to enroll the Central Government in setting up an Advisory River Board to resolve issues in inter state cooperation.

1970

**Merchant Shipping Act** aims to deal with waste arising from ships along the coastal areas within a specified radius.

1974

**The Water (Prevention and Control of Pollution) Act** establishes an institutional structure for preventing and abating water pollution. It establishes standards for water quality and effluent. Polluting industries must seek permission to discharge waste into effluent bodies. The Pollution Control Board (CPCB) was constituted under this act.

1977

**The Water (Prevention and Control of Pollution) Cess Act** provides for the levy and collection of cess or a fees on water consuming industries and local authorities.

1978

**The Water (Prevention and Control of Pollution) Cess Rules** contains the standard definitions and indicate the kind of and location of meters that every consumer of water is required to affix.

1991

**Coastal Regulation Zone Notification** puts regulations on various activities, including construction, are regulated. It gives some protection to the backwaters and estuaries.

#### LEGISLATIONS FOR CONTROL OF AIR POLLUTION

1948

**Factories Act and Amendment in 1987** was the first to express concern for the working environment of the workers. The amendment of 1987 has sharpened its environmental focus and expanded its application to hazardous processes.

1981

**Air (Prevention and Control of Pollution) Act** provides for the control and abatement of air pollution. It entrusts the power of enforcing this act to the Central Pollution Control Board.

1982

**Air (Prevention and Control of Pollution) Rules** defines the procedures of the meetings of the Boards and the powers entrusted on them.

1982

**Atomic Energy Act** deals with the radioactive waste.

1987

**Air (Prevention and Control of Pollution) Amendment Act** empowers the central and state pollution boards to meet with grave emergencies of air pollution.

1988

**Motor Vehicles Act** states that all hazardous waste is to be properly packaged, labeled and transported.

## GLOSSARY

**Abiotic:** Nonliving

**Abatement:** Reduction (Reduction of pollution/emissions)

**Ablation:** Wastage and loss of ice and snow from the surface of an ice-sheet or glacier that is generated by melting and evaporation. It also refers to removal of rock debris by wind action.

**Absolute:** A chemical substance relatively free of impurities.

**Acclimatization:** The adaptation over time of a species to a marked change in the environment.

**Acetone (CH<sub>3</sub>.CO.CH<sub>3</sub>):** Dimethyl ketone, used as a solvent for fats, oils, waxes, resins, rubber, plastics, lacquers, varnishes, rubber cements and in manufacturing plastics, chloroform and many other chemicals.

**Acid rain:** The precipitation of dilute solutions of strong mineral acids, formed in the atmosphere by the reaction of various industrial pollutants (such as sulfur dioxide and nitrogen oxides) with naturally occurring oxygen and water vapor.

**Acid:** An inorganic or organic compound that dissociates in water to yield hydrogen or hydronium ions, it has a pH of less than 7.0, neutralizes bases or alkaline media; and turns litmus paper red.

**Activated carbon:** A highly adsorbent form of carbon used to remove odors and toxic substances from gaseous and aqueous emissions.

**Activated sludge:** An aerobic biological process for conversion of soluble organic matter to solid biomass, removable by gravity or filtration.

**Acute health effect:** Health effects that usually occur rapidly as a result of short-term exposures, and are of short duration. Some examples are irritation, corrosivity (tissue destruction), narcosis, and death.

**Acute lethality:** The death of animals immediately or within 14 days after a single dose of or exposure to a toxic substance.

**Acute toxicity:** Any poisonous effect produced by a single short-term exposure, that results in severe biological harm or death.

**Adaptation:** A change in structure, physiology or habit of an organism that produces better adjustment to its surroundings.

**Adsorbent:** A material, usually solid, capable of holding gases, liquids and/or suspended matter at its surface in exposed pores. Activated carbon is a common adsorbent used in water.

**Adsorption:** Adhesion of an extremely thin layer of molecules (as of gas, solids or liquids) to the surface of solid or liquids with which they are in contact.

**Advanced waste water treatment:** Any treatment of sewage that goes beyond the secondary or biological water treatment stage and includes the removal of nutrients such as phosphorus and nitrogen and a high percentage of suspended solids.

**Aeration tank:** A chamber used to inject air or oxygen into water.

**Aerobic digestion (sludge processing):** Biochemical decomposition of organic matter by organisms living or active only in the presence of oxygen, which results in the formation of mineral and simpler organic compounds.

**Aerobic organism:** An organism that thrive well in presence of oxygen.

**Aerobic treatment:** Process by which microbes decompose complex organic compounds in the presence of oxygen and use the liberated energy for reproduction and growth.

**Aerosol:** A suspension of liquid or solid particles in a gas, the particles often being in the colloidal size range. Fog and

smoke are common examples of natural aerosols; fine sprays (perfumes, insecticides, inhalants, antiperspirants, paints, etc.) are man-made aerosols.

**Agricultural pollution:** The liquid and solid wastes from farming, including, runoff from pesticides, fertilizers, and feed-lots, erosion and dust from plowing, animal manure and carcasses, crop residues, and debris.

**Air pollutant:** Any substance in air which could, if in high enough concentration, harm man, other animals, vegetation, or material. Some of the major air pollutants are SO<sub>2</sub>, NO<sub>x</sub>, CO, HCs, and SPM.

**Air pollution episode:** A period of abnormally high concentration of air pollutants, often due to low winds and temperature inversion that can cause illness and death.

**Air quality standards:** The level of pollutants prescribed by law that cannot be exceeded during a specified time in a defined area.

**Airborne particulates:** Total suspended particulate matter found in the atmosphere as solid particles or liquid droplets. Airborne particulates include windblown dust, particles carbon, lead, mercury.

**Algal blooms:** Sudden spurts of algal growth, which can affect water quality adversely and indicate potentially hazardous changes in local water chemistry.

**Alkali:** Broadly, any compound having highly basic properties; i.e. one that readily ionizes in aqueous solution to yield OH anions, with a pH above 7, and turns litmus paper blue. Alkalies are oxides and hydroxides of certain metals and belong to group IA of the periodic table (Li, Na, K, Rb, Cs, Fr).

**Alkalinity:** Capacity of water to neutralize acids, a property imparted by the water's content of carbonates, bicarbonates, hydroxides, and, occasionally, borates, silicates and phosphates.

**Alpha particle:** A positively charged particle composed of 2 neutrons and 2 protons released by some atoms undergoing radioactive decay. The particle is identical to the nucleus of a helium atom.

- Ambient:** Surrounding conditions.
- Anadromous:** Fish that spend their adult life in the sea but swim upriver to fresh water spawning grounds to reproduce.
- Anaerobic:** Life or process that occurs in absence of oxygen, or not destroyed by, the absence of oxygen.
- Anoxia:** Lack of oxygen from inspired air (literally, "without oxygen").
- Antarctic "ozone hole":** Refers to the seasonal depletion of ozone in a large area over Antarctica
- Antidote:** A remedy to relieve, prevent, or counteract the effects of a poison. Eliminating the poison, neutralizing it, or absorbing it.
- Aquifer:** A porous, subsurface geological structure carrying or holding water; underground source of water.
- Asbestos:** A mineral fiber that can pollute air or water and cause cancer or asbestosis when inhaled.
- Asbestosis:** A disease associated with chronic exposure to and inhalation of asbestos fibers. The disease makes breathing progressively more difficult and can lead to death.
- Asphyxia:** Lack of oxygen and interference with the oxygenation of the blood. Can lead to unconsciousness.
- Asphyxiation:** A condition that causes asphyxia or suffocation. Asphyxiation is one of the principal potential hazardous of working in confined spaces.
- Asthma:** A disease characterized by recurrent attacks of dyspnea, wheezing, and perhaps coughing caused by spasmodic contraction of the main airways in the lungs.
- Atmosphere:** The whole mass of air surrounding the earth, composed largely of oxygen and nitrogen.
- Baghouse:** An air pollution abatement device used to trap particulates by filtering gas streams through large fabric bags usually made of glass fibers.
- Benthic region:** The bottom layer of a water body.
- Benthos:** The plants and animals that inhabit the bottom of a water body.
- Bequest values:** Willingness to pay to preserve the environment for the benefit of our children and grand children.

- Beryllium:** A metal that can be hazardous to human health when inhaled. It is discharged by machine shops, ceramic and propellant plants, and foundries.
- Beta particle:** An elementary particle emitted by radioactive decay that may cause skin burns. It is halted by a thin sheet of metal.
- Bioassay:** Using living organisms to measure the effect of a substance, factor, or condition.
- Biochemical oxygen demand (BOD):** Amount of oxygen in milligrams per liter used by microorganisms to consume biodegradable organics in wastewater under aerobic conditions. BOD(5) refers to the quantity of oxygen used by bacteria in consuming organic matter in a sample of wastewater over a five-day period.
- Bioconcentration:** The build-up of a chemical in plants and animals to levels above what is found in the surroundings.
- Biodegradable:** Any substance that decomposes quickly through the action of microorganisms.
- Biological control:** Using means other than chemicals to control pests, such as predatory organisms, sterilization, or inhibiting hormones.
- Biological magnification:** The concentration of certain substances up a food chain. A very important mechanism in concentrating pesticides and heavy metals in organisms such as fish.
- Biomass:** The amount of living matter in a given unit of the environment.
- Biomonitoring:** The use of living organisms to test water quality at a discharge site or downstream.
- Bioremediation:** Process using enzymatic actions of microbes or organisms to degrade and remove contaminants.
- Biosphere:** The portion of Earth and its atmosphere that supports life.
- Biota:** All living organisms of a region or system.
- Bog:** Wet, spongy land usually poorly drained, highly acid and rich in plant residue; characterizes eutrophication of water body.

- British thermal unit (BTU):** The quantity of heat required to raise the temperature of 1 lb of H<sub>2</sub>O from 63 degrees F to 64 degrees F.
- Buffer zone:** Refers to an area adjacent to a restricted zone, to which personnel may enter, but for which protective measures are recommended to minimize exposure to hazardous materials.
- Bulk density:** The measured density/volume ratio for a solid including or not corrected for the voids contained in the bulk of material, in kg/cubic meter.
- Cancer (carcinoma):** A malignant tumor or cancer; a new growth made up of cells that tend to grow rapidly, infiltrate other cells, and give rise to metastasis (spreading).
- Capital:** The existing stock of productive resources, such as machines and buildings, that have been produced.
- Capitalist economies:** Economies which use market-determined prices to guide peoples choices about the production and distribution of goods; these economies generally have productive resource which are privately owned.
- Carbon tax:** A charge on fossil fuels (coal, oil, natural gas) based on their carbon content. When burned, the carbon in these fuels becomes carbon dioxide in the atmosphere, the chief greenhouse gas.
- Carcinogen:** Agent that either causes cancer in humans, or, animals.
- Catalytic converter:** An air pollution abatement device that removes organic contaminants by oxidizing them into carbon dioxide and water.
- Chlorofluorocarbons (CFCs):** Stable, artificially-created chemical compounds containing carbon, chlorine, fluorine and sometimes hydrogen. Chlorofluorocarbons, used primarily to facilitate cooling in refrigerators and air conditioners, have been found to damage the stratospheric ozone layer which protects the earth and its inhabitants from excessive ultraviolet radiation.
- Chlorosis:** Discoloration of normally green plant parts that can be caused by disease, lack of nutrients, or various air pollutants.

- Chronic health effect:** An adverse effect on a human or animal body with symptoms that develop slowly over a long period of time or that recur frequently.
- Chronic toxicity:** The capacity of a substance to cause long-term poisonous human health effects.
- Clean fuel:** Fuels which have lower emissions than conventional petroleum products Refers to alternative fuels as well as to reformulated petrol and diesel.
- Climate change:** A regional change in temperature and weather patterns. Research indicates a discernible link between climate change and various anthropogenic activities, specifically the burning of fossil fuels.
- Closed economy:** An economy that neither exports nor imports.
- Coliform bacteria:** Bacteria found in the intestinal tract of warm-blooded animals and used as indicators of pollution if found in water. Coliform index- a rating of the purity of water based on a count of fecal bacteria.
- Common property resources:** Resources for which there are no clearly defined property rights; property owned in common by a society.
- Compact fluorescent:** Fluorescent light bulbs small enough to fit into standard light sockets, which are much more energy-efficient than standard incandescent bulbs.
- Compost:** A mixture of naturally decomposed organic wastes, including food wastes, paper, and yard wastes. It is rich in minerals and ideal for gardening and farming as a soil conditioners, mulch, resurfacing material, or landfill cover.
- Conservation:** The protection, improvement, and use of natural resources according to principles that will assure their highest economic or social benefits.
- Consumer surplus:** The difference between what a person would be willing to pay and what he actually has to pay to buy a certain amount of a good.
- Contamination:** Intrusion of undesirable elements. The addition of foreign matter to a substance which reduces the value of the substance, or interferes with its intended use.

- Contingent valuation method:** A valuation method based on directly asking people what they are willing to pay for a benefit and/or willing to receive in compensation for tolerating a cost through a survey or questionnaire. It is subject to a number of biases that make it imprecise. The most serious of these is hypothetical bias.
- Cost-Benefit analysis:** A tally/comparison of expenditures and advantages in monetary terms resulting from various actions.
- Cost-Effectiveness analysis:** Least expensive way of achieving a given environmental quality target, or the way of achieving the greatest improvement in some environmental target for a given expenditure of resources.
- Damage function:** Relationship that shows how pollution damage varies with the level of pollution emitted, and what the monetary value of that damage is.
- Decibel (dB):** A unit for measurement of sound intensity. In general, a sound doubles in loudness for every increase of ten decibels.
- Defoliant:** A herbicide that removes leaves from trees and growing plants.
- Demand curve:** A graphic representation of the relationship between prices and the corresponding quantities demanded per time period. the relationship between quantity demanded of a good and the price, whether for an individual or for the market (all individuals) as a whole.
- Demographic effects:** Effects that arise from changes in characteristics of the population such as age, birthrates, and location.
- Deregulation:** The lifting of government regulations to allow the market to function more freely.
- Desulfurization:** Removal of sulfur from fossil fuels to cut pollution.
- Dioxin:** A man-made chemical by-product formed during the manufacturing of other chemicals and during incineration. Dioxin is one of the most potent animal carcinogen, as well as the cause of severe weight loss, liver problems, kidney problems, birth defects, and death.

- Dissolved oxygen (DO):** The oxygen freely available in water. The level of DO is considered an important indicator of quality of a water body.
- Dissolved solids:** The total of disintegrated organic and inorganic material contained in water. Excesses can make water unfit to drink or use in industrial processes.
- DNA:** Deoxyribonucleic acid, the molecule in which the genetic information for most living cells is encoded.
- E. coli:** *Escherichia coli*, one of the members of the coliform group of bacteria indicating fecal contamination.
- EC50:** Effective concentration 50. The concentration of a material in water, a single dose of which is expected to cause a biological effect on 50% of a group of test animals.
- ED50:** Effective dose 50. The calculated dose, derived experimentally, which would produce a specified effect in 50 percent of the test population.
- Effluent fee:** A fixed tax rate per unit (litre or kilogram) of emissions. It is also referred to as emission charge or emission tax.
- Environmental impact assessment:** An analysis, required legally to be carried out to assess the possible environmental impacts of a development project.
- Electrical conductivity:** Property which allows an electric current to flow when a potential difference is applied. It is the reciprocal of the resistance in ohms measured between opposite faces of a centimeter cube of an aqueous solution at a specified temperature. It is expressed as microohms per centimeter at temperature degrees Celsius.
- Electrostatic precipitator (ESP):** An air pollution control device that removes particles from a gas stream (smoke) after combustion occurs. The ESP imparts an electrical charge to the particles, causing them to adhere to metal plates inside the precipitator. Rapping on the plates causes the particles to fall into a hopper for disposal.
- Emission:** Pollution discharged into the atmosphere from smoke-stacks, other vents, and surface areas of commercial or industrial facilities; from residential chimneys; and from motor vehicle, locomotive, or aircraft exhausts.

- Endangered species:** Animal and plant species, or other living organisms threatened with extinction by man-made or natural changes in their environment.
- Eutrophication:** The slow aging process of a lake due to enrichment of nutrients either naturally or as a result of anthropogenic activities (organic pollution). During eutrophication the lake is choked by abundant plants which after death and decay lead to deficiency of dissolved oxygen. As a result all other aquatic life disappears.
- Existence value:** Value assigned to environmental goods for sheer existence, but not in utilitarian sense. For example, the sheer presence of the Royal Bengal Tiger has a non-use value for the humanity as a whole, as for many other endangered species, animals, birds, plants and so on.
- Fecal coliform bacteria:** A group of organisms found in the intestinal tracts of people and animals. Their presence in water indicates pollution and possible dangerous bacterial contamination.
- Fen:** A type of wetland that accumulates peat deposits. Fens are less acidic than bogs, deriving most of their water from groundwater rich in calcium and magnesium.
- Fluorosis:** An abnormal condition caused by excessive intake of fluorine, characterized chiefly by mottling of the teeth.
- Gamma ray:** The most penetrating waves of radiant nuclear energy. They can be stopped by dense materials like lead.
- Greenhouse effect:** The warming of our atmosphere caused by buildup of carbon dioxide, methane etc. which allows light from the Sun's rays to heat the Earth but prevents loss of the heat.
- Gross National Product (GNP):** The total market value, in terms of money, of all final goods and services produced in a country in one year.
- Groundwater:** The supply of fresh water found beneath the Earth's surface, usually in aquifers, which is often used for supplying wells and springs.
- Habitat:** An identifiable region in which a particular kind of organism lives; The sum of environmental conditions in a

- specific place that is occupied by an organism, population or community.
- Half-Life:** The time taken by certain materials to lose half their amount or strength. For example, the half life of DDT is 15 years and of radium 1,580 years; The time required for half of the atoms of a radioactive element to undergo decay.
- Hardness:** A characteristic of water, imparted by salts of calcium, magnesium and iron, such as bicarbonates, carbonates, sulfates, chlorides and nitrates, that cause curdling of soap, deposition of scale, damage in some industrial processes and sometimes objectionable taste.
- Hazardous waste:** Any solid, liquid or combination of solid or liquid wastes, which, because of its physical, chemical or infectious characteristics, may pose a hazard when improperly managed; Substances that could endanger life if released into the environment.
- Heavy metals:** Metals which can be precipitated by hydrogen sulfide in acid solution, e.g., lead, silver, gold, mercury, bismuth, copper, nickel, iron, chromium, zinc, cadmium and tin.
- Hedonic pricing approach:** Derives values by decomposing market prices into components encompassing environmental and other characteristics through studying property values, wages and other phenomena. The premise of the approach is that the value of an asset depend on the stream of benefits derived, including environmental amenities.
- Herbivores:** Primary consumers; animals that eat plants.
- Heterotrophic organism:** Consumers such as humans and animals, and decomposers chiefly bacteria and fungi — that are dependent on organic matter for food.
- Horizon:** A horizontal layer in the soil. The top layer (A horizon) has organic matter. The lower layer (B horizon) receives nutrients by leaching. The C horizon is partially weathered parent material.
- Humus:** Decomposed organic material in soil.
- Hydrocarbons (HC):** Group of organic compounds consisting of carbon and hydrogen atoms that are evaporated from

- fuel supplies or are remnants of the fuel that did not burn completely, and that act as a primary air pollutant.
- Hydrogeology:** The geology of ground water, with particular emphasis on the chemistry and movement of water.
- Hydrologic cycle:** The water cycle, including precipitation of water from the atmosphere as rain or snow, flow of water over or through the earth and evaporation or transpiration to water vapor in the atmosphere.
- Hydrology:** The science dealing with the properties, distribution, and circulation of water.
- Hydroxyl ion (OH<sup>-</sup>):** A negatively charged particle consisting of a hydrogen and an oxygen atom, commonly released from materials that are alkaline in nature.
- Hypothetical bias:** Difference in actual willingness to pay and willingness to pay revealed in a survey arising from the fact that in actual markets purchasers suffer real costs, while in surveys they do not.
- In situ:** In the original situation.
- Incinerator:** A controlled chamber where waste substances are burnt.
- Indicator:** An organism, species, or community that shows the presence of certain environmental conditions.
- Indoor air pollution:** Chemical, physical, or biological contaminants in indoor air (the breathing air inside a habitable structure or conveyance).
- Industrial wastes:** Liquid or solid wastes generated through industrial processes. It is distinct from domestic or sanitary wastes in terms of its composition.
- Infiltration:** The penetration of water through the ground surface into sub-surface soil or the penetration of water from the soil into sewer or other pipes through defective joints, connections, or manhole walls.
- Insecticide:** A pesticide specifically designed to kill or control insects.
- Integrated pest management:** Combining the best of all useful techniques — biological, chemical, cultural, physical, and mechanical — into a custom-made pest control system.

- Intrinsic Values:** Value that resides 'in' something and that is unrelated to human beings altogether.
- Iron bacteria:** Microscopic organisms which are capable of using ferrous iron, either from the water or from steel pipe, in their metabolism and precipitating ferric hydroxide in their sheaths and gelatinous deposits. *Thiobacillus ferrooxidans* is generally regarded as the principal iron-oxidizing bacterium.
- Isotope:** Atoms of the same element that have different numbers of neutrons.
- Landfills:** Landfills are land disposal sites for non-hazardous solid wastes at which the waste is spread in layers, compacted to the smallest practical volume, and cover material applied at the end of each operating day.
- Law of demand:** People purchase more of any particular good or service as its relative price falls; they purchase less as its relative price rises.
- Law of supply:** At higher relative prices, the quantity supplied of a good will increase; at lower relative prices, smaller quantities will be supplied.
- LD 50/lethal dose:** The dose of a toxicant that kills 50 percent of the test organisms within a designated period of time. The lower the LD 50, the more toxic the compound.
- Leachate:** Materials that pollute water as it seeps through solid waste.
- Leaching:** The downward movement of minerals from the A horizon to the B horizon by the downward movement of soil water.
- Lead:** A heavy metal that is hazardous to health if breathed or swallowed.
- Lime:** A common water treatment chemical. Limestone, CaCO<sub>3</sub>, is burned to produce quicklime, CaO, which is mixed with water to produce slaked, or hydrated, lime.
- Limestone scrubbing:** Process in which sulfur gases moving towards a smokestack are passed through a limestone and water solution to remove sulfur before it reaches the atmosphere.

- Limiting factor:** A condition, whose absence, or excessive concentration, is incompatible with the needs or tolerance of a species or population and which may have a negative influence on their ability to grow or even survive; The one primary condition of the environment that determines the success of an organism.
- Limnology:** The study of the physical, chemical, meteorological, and biological aspects of fresh water.
- Littoral zone:** Region with rooted vegetation in a freshwater ecosystem.
- Macroeconomics:** The study of the sum total of economic activity, dealing with the issues of growth, inflation and unemployment and with national economic policies relating to these issues.
- Macronutrient:** A nutrient, such as nitrogen, phosphorus, and potassium, that is required by plants in relatively large amounts.
- Malthusian trap:** The minimum subsistence level to which humans descend as a result of geometric population growth and arithmetic resource growth.
- Market economy:** A decentralized system where many buyers and sellers interact.
- Market:** A network in which buyers and sellers interact to exchange goods and services for money.
- Mercury:** A heavy metal, highly toxic if breathed or swallowed.
- Microeconomics:** The study of the individual parts of the economy, the household and the firm, how prices are determined and how prices determine the production, distribution and use of goods and services.
- Micronutrient:** A nutrient needed in extremely small amounts for proper plant growth; examples are boron, zinc, and magnesium.
- Mobile source:** A moving producer of air pollution, mainly forms of transportation — cars, motorcycles, planes.
- Monitoring:** Periodic or continuous sampling to determine the level of pollution or radioactivity.
- Monitoring wells:** Wells drilled at a hazardous waste management facility to collect ground-water samples for

- the purpose of physical, chemical, or biological analysis to determine the amounts, types, and distribution of contaminants in the ground water beneath the site.
- Natural resources:** Structures and processes that can be used by humans for their own purposes, but cannot be created by them. They include land, fish, wildlife, biota, air, water, ground water, drinking water supplies, and other such resources.
- Nausea:** A tendency to vomit; a feeling of sickness in the stomach.
- Niche:** The total role an organism plays in a habitat.
- Nitrate:** A compound containing nitrogen which can exist in the atmosphere or as a dissolved gas in water and which can have harmful effects on humans and animals. Nitrates in water can cause severe illness in infants.
- Nitric oxide (NO):** A gas formed by combustion under high temperature and high pressure in an internal combustion engine. It changes into nitrogen dioxide in the ambient air and contributes to photochemical smog.
- Nitrogen dioxide (NO<sub>2</sub>):** Nitric oxide combining with oxygen in the atmosphere forms nitrogen dioxide which is a major component of photochemical smog.
- Nitrogen oxide (NOx):** Refers to various oxides of nitrogen, e.g., NO, NO<sub>2</sub>.
- Nitrogenous wastes:** Animal or plant residues that contain large amounts of nitrogen.
- Noise:** Any undesired sound.
- Nonpersistent pollutants:** Those pollutants that do not remain in the environment for long periods and are biodegradable.
- Nonpoint source:** Pollution sources which are diffuse and do not have a single point of origin or are not introduced into a receiving stream from a specific outlet. Common non-point sources are: agriculture, forestry, urban, mining, construction, dams and channels, land disposal, and saltwater intrusion.
- Nonrenewable energy sources:** Those energy sources that are not replaced by natural processes, or those whose rate of replacement is so slow as to be noneffective.

- Nontarget organism:** An organism whose elimination is not the purpose of pesticide application.
- Nuclear winter:** Prediction by some scientists that smoke and debris rising from massive fires resulting from a nuclear war could enter the atmosphere and block out sunlight for weeks or months. The scientists making this prediction project a cooling of the earth's surface, and changes in climate which could, for example, negatively effect world agricultural and weather patterns.
- Nutrients:** Elements or compounds essential to growth and development of living things; carbon, oxygen, nitrogen, potassium and phosphorus.
- Oligotrophic lakes:** Deep, cold, nutrient-poor lakes that are low in productivity.
- Open dump:** Specifically, any facility or site where solid waste is disposed of in open.
- Opportunity cost:** The highest-valued sacrifice needed to get a good or service.
- Option value:** Potential benefits of the environment not derived from actual use. This expresses the preference or willingness to pay for the preservation of an environment against some probability that the individual will make use of it at some later date.
- Organophosphates:** Pesticides that contain phosphorus, used to control insects. They are short-lived and work by interfering with normal nerve impulses of the organism.
- Overburden:** The layer of soil and rock that covers deposits of desirable minerals. It is cleared away before mining.
- Oxides of nitrogen (NO and NO<sub>2</sub>):** Primary air pollutants consisting of a variety of different compounds containing nitrogen and oxygen.
- Ozone (O<sub>3</sub>):** 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. Found in two layers of the atmosphere, the stratosphere and the troposphere.
- Ozone depletion:** Destruction of the stratospheric ozone layer which shields the earth from ultraviolet radiation harmful to biological life.

- Particulates:** Small pieces of solid materials, such as smoke particles from fires, bits of asbestos from brake linings and insulation, dust particles, or ash from industrial plants, that are dispersed into the atmosphere.
- Peat:** The first stage in the conversion of organic material into coal.
- Pelagic:** Those organisms that swim in open water.
- Periphyton:** Attached organisms in freshwater streams and rivers, including algae, animals, and fungi.
- Permafrost:** Permanently frozen ground.
- Peroxyacetyl nitrate (PAN):** A secondary pollutant created by the action of sunlight on hydrocarbons and nitrogen oxides in the air.
- Persistent pesticide:** A pesticide that remains unchanged for a long period of time as it does not break down chemically in the environment after a growing season.
- Persistent pollutant:** A pollutant that remains in the environment for many years in an unchanged condition.
- pH:** The negative logarithm of the hydrogen ion concentration. A unit for measuring hydrogen ion concentrations. A pH of 7 indicates a "neutral" water or solution. At pH lower than 7, a solution is acidic. At pH higher than 7, a solution is alkaline.
- Photochemical oxidants:** Air pollutants formed by the action of sunlight on oxides of nitrogen and hydrocarbons.
- Photochemical smog:** A yellowish-brown haze that is the result of the interaction of hydrocarbons, oxides of nitrogen, and sunlight.
- Phytoplankton:** Free-floating, microscopic, chlorophyll-containing organisms.
- Point source:** Any discernible, confined, and discrete conveyance from which pollutants are or may be discharged.
- Pollutant:** A contaminant at a concentration high enough to endanger the environment and life therein.
- Pollution costs:** The private or public expenditures undertaken to avoid pollution damage once pollution has occurred and the increased health costs and loss of the use of public resources because of pollution.

**Pollution fee or tax:** Charge for the amount of waste or pollution. Several European nations have air and water pollution charges; Unit pricing for trash pickup, charging by the amount of trash collected (or the size of the container). The charge makes it worthwhile for a producer to cut back, right up to the point where it begins to cost more to reduce pollution than to pay the tax.

**Pollution:** Any undesirable change in physical, chemical and biological characteristics of Environment or its component that may adversely affect the life and property.

**Polychlorinated biphenyl (PCB):** A pathogenic and teratogenic industrial compound used as a heat-transfer agent.

**Population:** A group of interbreeding organisms of the same kind occupying a particular space. The number of humans or other living creatures in a designated area.

**Potable water:** Water that is safe for drinking and used for cooking.

**Present value:** Value today of a sum to be paid or collected in the future to buy a good or service.

**Price:** The amount of money, or other goods, that you have to give up to buy a good or service.

**Primary consumer:** An organism that eats plants (producers) directly.

**Primary pollutants:** Chemicals released directly into the environment in a harmful form. Sulfur dioxide, oxides of nitrogen, carbon monoxide etc. are some of the primary air pollutants.

**Primary sewage treatment:** The first stage of waste water treatment; which removes larger particles by filtering raw sewage through large screens.

**Primary succession:** Succession that begins with bare mineral surfaces or water.

**Producer:** An organism that can manufacture food from inorganic compounds and light energy.

**Property rights:** The conditions of ownership of an asset, the rights to own, use and sell. The right to use or consume something, or trade the right away in return for something else.

**Public goods:** Goods that cannot be withheld from people even if they don't pay for them. A good which, if made available to one person, automatically becomes available to all others in the same amount.

**Radioactive half-life:** The time it takes for half of the radioactive material to spontaneously decompose.

**Radioactive:** Unstable nuclei that release particles and energy as they disintegrate.

**Receiving waters:** Any water body where untreated wastes are dumped.

**Recycling:** The process of reclaiming a resource and reusing it for another or the same structure or purpose.

**Reforestation:** The process of replanting areas after the original trees were removed.

**Regulation:** The legal mechanism that spells out how a statute's broad policy directives are to be carried out.

**Rem:** A measure of the biological damage to tissue caused by certain amounts of radiation.

**Renewable energy sources:** Those energy sources that can be regenerated by natural processes. Sun, wind, water, biomass are some of the renewable energy sources.

**Reserves:** The known deposits from which materials can be extracted profitably with existing technology under present economic conditions.

**Resource exploitation:** The use of natural resources by society.

**Riparian habitat:** Areas adjacent to rivers and streams that have a high density, diversity, and productivity of plant and animal species relative to nearby uplands.

**Run-off:** Water from rain, snow melt, or irrigation that flows over the ground surface and returns to streams. It can collect pollutants from air or land and carry them to the receiving waters.

**Scrubber:** An air pollution control device that uses a spray of water to trap pollutants and cool emissions.

**Secondary sewage treatment:** Biochemical treatment of waste-water after the primary stage, using bacteria to consume the organic wastes. Use of the activated sludge

process removes floating and settleable oxygen demanding substances.

**Sedimentation tanks:** Holding areas for waste water where floating wastes are skimmed off and settled solids are pumped out for disposal.

**Seepage:** Water that flows through the soil and rocks.

**Silicosis:** A condition of massive fibrosis of the lungs causing shortness of breath because of prolonged inhalation of silica dust.

**Silt:** Fine particles of soil or rock that can be picked up by air or water and deposited as sediment.

**Sludge:** Any solid, semi-solid, or liquid waste generated from a municipal, commercial, or industrial wastewater treatment plant, water supply treatment plant, or air pollution control facility exclusive of the treated effluent from a wastewater treatment plant.

**Soft water:** Any water that is not "hard", i.e., does not contain a significant amount of dissolved minerals such as salts containing calcium or magnesium.

**Soot:** Fine particles, usually black, formed by combustion (complete or incomplete) and consisting chiefly of carbon. Soot gives smoke its color.

**Species:** A reproductively isolated aggregate of interbreeding populations of organisms.

**Surface water:** The water naturally open to the atmosphere (rivers, lakes, reservoirs, streams, impoundments, seas, estuaries, etc.).

**Sustainable development:** A principle which states that a development plan must not compromise the welfare of future generations for the benefit of present generations.

**Tailings:** Residue of raw materials or waste separated out during the processing of mineral ores.

**Teratogen:** Substance that causes malformation or serious deviation from normal development of embryos and fetuses.

**Tertiary sewage treatment:** Advanced cleaning of waste water that goes beyond the secondary or biological stage. It

removes nutrients such as phosphorus and nitrogen and most suspended solids.

**Thermal pollution:** Discharge of heated water from industrial processes that can affect the life processes of aquatic plants and animals.

**Tolerance:** The ability of an organism to cope with changes in its environment. Also the safe level of any chemical applied to crops that will be used as food or feed.

**Topography:** The physical features of a surface area including relative elevations and the position of natural and manmade features.

**Total dissolved solids (TDS):** Total amount of dissolved solid materials present in an aqueous solution.

**Total suspended solids (TSS):** Solids found suspended in wastewater or in the stream, which in most cases can be removed by filtration.

**Toxic substances:** Any chemical or material that has evidence of an acute or chronic health hazard.

**Toxicology:** The study of the nature, effects, and detection of poisons in living organisms. Also, substances that are otherwise harmless but prove toxic under particular conditions.

**Travel cost method:** Derives values by evaluating expenditures of recreators. Travel costs are used as a proxy for price in deriving demand curves for the recreation site.

**Turbidity:** A condition in water or wastewater caused by the presence of suspended matter resulting in the scattering and adsorption of light rays.

**Uranium:** A radioactive heavy metal element used in nuclear reactors and the production of nuclear weapons. U 238 and U 235 are naturally occurring isotopes of uranium.

**User benefits/User values:** Benefits or value derived from the actual use of the environment. Anglers, hunters, boaters, nature walkers, bird watchers, etc. use the environment and derive benefits.

**Volatile organic compound (VOC):** Volatile organic compound; family of highly evaporative organic materials

used in a variety of industrial applications, such as paints and solvents; VOC emissions are a component in the formation of ground-level ozone (smog).

**Waste-water:** Any water that has been released from the purpose for which it was intended to be used.

**Water table:** The level of ground water.

**Watershed:** The land area that drains into a stream.

**Wetlands:** An area that is regularly saturated by surface or ground water and subsequently is characterized by a prevalence of vegetation that is adapted for life in saturated soil conditions. Examples include: swamps, bogs, fens, marshes, and estuaries.

**Xenobiotic:** Term for non-naturally occurring man-made substances found in the environment (i.e., synthetic solvents, plastics).

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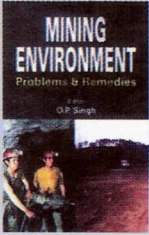
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