

**ENVIRONMENTAL AWARENESS  
AND  
WILDLIFE CONSERVATION**

**ZOOLOGICAL SURVEY OF INDIA  
CALCUTTA  
1989**

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AND  
WILDLIFE CONSERVATION**

*Compiled by*  
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## **FOREWORD**

Environment is the concern of everyone of us. Man's interference with Nature has led to the degradation of the environment which, in turn, is a threat to the existence of wildlife and life-support systems on this planet. Every year, the Environment Day and the Wildlife Week are celebrated throughout the world to create public awareness about the environment and compassion for wildlife.

The Zoological Survey of India, an important institution under the Department of Environment of the Government of India, plays a unique role in the understanding of the faunal elements, their environment, and also their relationship with man.

The Training and Extension Division of the Zoological Survey of India annually undertakes short-term courses to impart training to representatives from Government and non-Government organizations about Environmental Awareness and Wildlife Conservation. The present publication is the outcome of various lectures delivered in these courses, for which the participants have shown keen interest.

I am sure this publication will prove its utility.

Zoological Survey of India  
Calcutta

**Prof. M.S. Jairajpuri**  
**Director**

## **PREFACE**

The Training and Extension Division of the Zoological Survey of India under Ministry of Environment and Forests, Government of India, have made efforts to identify the areas of need for training, both in-service in the Survey and for outside participants. It was felt that one area, which deserves top priority is the subject of "Environmental Awareness and Conservation of Wildlife" Since this is a newly emerging area, lack of trained personnel could be felt specially at a time when eco-development camps, nature camps and other related activities are pursued with the support of the Government for promoting public awareness.

This Leadership Course as such, emerged out of such needs and thoughts and the present publication is aimed at providing the basic understanding to the enormity of the subject area. It embodies the course contents on Environmental Conservation, Population explosion, Land and Soil, Forest and Vegetation, Freshwater Pollution and Wetlands, Conservation of Wildlife and Habitats, Air Pollution and, Noise Pollution. Finally, the Strategies for Conservation indicate the avenues for sustainable development without endangering environment and living resources.

It is expected that this publication will be of use to non-Governmental and Governmental organizations for undertaking eco-development and extension work on environment, ecology and wildlife.

**Acknowledgements** : We are indebted to the Director, Zoological Survey of India, for his keen interest, constant encouragement and facilities for bringing out this hand book. We are grateful to our colleagues who have contributed the articles. Thanks are also due to Shri G. Shivagurunathan, Publication Production Officer for constant supervision during the printing of this hand book and to Shri S.Z. Siddiqui and Shri I.J. Gupta for helping us in various ways. The exacting task of typing on the electronic typewriter by Shri B.B. Giri and some illustrations by Shri S.K. Chanda are gratefully acknowledged.

Zoological Survey of India  
Calcutta.

**A.K. Ghosh**  
**J.K. Jonathan**  
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# **ENVIRONMENTAL CONSERVATION**

**A.K. GHOSH**

“Environment” encompasses both living and non-living natural resources which are deemed vital for survival of man and living world. The components include land, water, air, vegetation, fauna and a series of directly or indirectly inter-related factors and expressed through the effect of living natural resources.

## ***LAND RESOURCES***

The total land area of India is 329 million hectares (Table-1). It is estimated that out of 329 M ha., about 175 M ha. are degraded and are now called wasteland. The wastelands may result from over-grazing, shifting cultivation, mining, water erosion, wind erosion, salinity, alkalinity, etc. The satellite pictures have revealed an alarming loss of good forest and good agricultural land in India, currently at a rate of 1.5 M ha. to 2.5 M ha. annually and loss of forest cover alone is estimated at 1.5 M ha. On the other hand, while, Indian population increased from 238 M. in 1901 to 361 M. 1951 (52% in 50 years), it showed a quantum leap of 90% in next 30 years, reaching 685 M. in 1981. The pressure of population invariably indicates the terms of future demand for development and employment generation on one hand and production of foodgrains and livestock on the other. Both the activities directly affect land resources and forest.

It is reported that with just a fortieth of world's land, India supports over half of its buffaloes, and over a seventh of its cattle and goats. As fodder becomes scarce, people and their animals turn to forest, along with demand of yet another scarce commodity, the fuel-wood. The relationship of land and forests is one of the most intimate one and as pressure on forests increases, top-soil gets lost, siltation results in riverbed and generation of hydel power becomes affected.

Table 1

LAND AREA OF INDIA — (IN MILLION HECTARES)		
1.	Net sown area	143
2.	Area under forest	67
3.	Area under non-agriculture	18
4.	Pastures and Grass Land	16
5.	Cultivable Waste	17
6.	Fallow Land	22
7.	Barren and Uncultivable	22
8.	Area for which no return exists	24
	<b>Total</b>	<b>329</b>

Table 2

ESTIMATED FUELWOOD REQUIREMENTS IN 2004/05 TO BE MET THROUGH PLANTATIONS		
<i>State</i>		<i>Quantity (Mt)</i>
<b><i>Northern Region</i></b>		
1.	U.P.	66.5
2.	Rajasthan	22.5
3.	Punjab	7.0
4.	Haryana	6.0
5.	Himachal Pradesh	2.5
6.	J & K	2.0
<b><i>Eastern &amp; NE Region</i></b>		
7.	West Bengal	13.5
8.	Bihar	20.0
9.	Orissa	19.0
10.	Assam	11.0
<b><i>Southern Region</i></b>		
11.	Andhra Pradesh	35.0
12.	Karnataka	27.0
13.	Tamil Nadu	32.0
14.	Kerala	15.5
<b><i>Western Region</i></b>		
15.	M.P.	28.0
16.	Maharashtra	30.5
17.	Gujarat	14.5
<i>Source : ABE, 1985</i>		

It has become amply clear that degradation of land resources increases poverty and impoverishes quality of life just as poverty increases deforestation and degradation of land resources.

To counteract the process of increasing wasteland a massive wasteland-development programme through greening operation has been initiated by the Government of India. The estimated fuelwood consumption and requirements are given in Tables 2 and 3.

The programme includes planting right type of tree species in right climatic conditions, creation of decentralized nurseries, grant of tree pattas, formation of tree growers co-operatives and grant to voluntary agencies. The target has been set at 1.5 M ha. of wasteland reclamation at the initial year, raising it to 5 M ha. per year in the future, specially for fuel wood and fodder.

### **WATER**

It is interesting to note that India gets an average rainfall of 1170 mm. The total available water for use in India is estimated at 1900 million cubic meters per year of which 86% is in the form of surface run off i.e. in the rivers, streams and wasteland.

The rivers from Himalaya including Ganga and its major tributaries like, Yamuna, Ghagra, Gandak, Gomati, Kosi, Sone and Brahmaputra contribute towards a net work of perennial rivers and rivers like Godavari, Krishna, Cauvery, Narmada, Tapi, Tapti are most rainfed.

The other source of water (other than surface water) is groundwater, whose resource is estimated at 10 times the annual rainfall.

This vast water resource has also been facing several impacts of development. The construction of major irrigation canals and multi-purpose river valley projects (for irrigation, drinking water, hydel-power) on one hand and massive discharge of untreated sewage and industrial effluents on the other, changed the vital character of many a major river in India, the most prominent being the river Ganga. Tables 4, 5 and 6 indicate wastewater treatment facility, Industrial water pollution and recommended limits.

Table 3

ESTIMATED FUELWOOD CONSUMPTION IN 2004/05 IN MT			
Region/State/UT	Fuelwood Consumption		
	Rural	Urban	Total
<b>Northern Region</b>			
1. U.P.	37	10	47
2. Rajasthan	17	4	21
3. Punjab	3.5	0.5	4
4. Haryana	2.0	0.5	2.5
5. Himachal Pradesh	3.0	0.5	3.5
6. J & K	2.5	0.5	3.0
<b>Eastern &amp; NE Region</b>			
7. West Bengal	9.5	0.5	10
8. Bihar	19.5	1.5	21.0
9. Orissa	13.0	3.5	16.5
10. Assam	11.5	1.0	12.5
<b>Southern Region</b>			
11. Andhra Pradesh	26.5	8.5	35.0
12. Karnataka	17.5	7.5	25.0
13. Tamil Nadu	20.0	10.5	30.5
14. Kerala	11.5	4.5	16.0
<b>Western Region</b>			
15. Madhya Pradesh	20.5	6.5	27.0
16. Maharashtra	22.5	5.5	28.0
17. Gujarat	10.0	3.0	13.0
<b>Total</b>	<b>247</b>	<b>69</b>	<b>316</b>

Source: ABE, 1985

Table 4

WASTE-WATER COLLECTION AND TREATMENT SITUATION IN CLASS I CITIES : NON-BASIN AND NON-COASTAL								
State	Class I cities  (No.)	Population	Water supplied Million litres per day (MLD)	Vol. of waste-water			Approx quantity of pollutants discharged/day	
				Gener- ated	Col- lected	Treated	B.O.D.	Suspended Solids
				(MLD)	(MLD)	(MLD)	(Tons)	(Tons)
Andhra Pradesh	2	3,97,014	27.24	21.8	3.40	5.7		
Gujarat	1	3,00,619	25.42	20.3	Nil	Nil		
Karnataka	1	16,53,779	290.56	232.4	290.56	286.02		
Manipur	1	1,00,366	12.30	9.8	Nil	Nil		
Rajasthan	3	7,90,797	88.53	70.8	14.40	Nil		
Tamil Nadu	5	14,17,724	69.41	55.5	22.70	Nil		
<b>Total</b>	<b>13</b>	<b>46,60,299</b>	<b>513.46</b>	<b>410.6</b>	<b>331.06</b>	<b>291.72</b>	<b>66</b>	<b>75</b>
<b>Grand Total</b>	<b>142</b>	<b>6,01,94,627</b>	<b>9,175</b>	<b>6,781</b>	<b>4,596</b>	<b>3,198</b>	<b>1,294</b>	<b>1,723</b>

Source: CPCB, GOI

The impact of growing population, demand for more land for industry-, agriculture, human habitation and communication could be seen from the account of vanishing wetlands. Since, before recorded history, man has settled at water edges to fish in wetland water or farm the rich wetland soil, but ideas have fast changed and for gaining immediate profit, long-term effect of draining of wetlands is hardly conceived.

The vast 6000 k.m. of coastline along with right to explore 200 nautical miles deep inside the ocean puts India in one of the most advantageous positions for a maritime nation. The marine ecosystem however has also been facing environmental degradation due to discharge of silt and pollutants by surface water system, spillage of oil from tanker and off-shore drilling rigs, erosion of coastal line and several other factors. At the same time, never before has this system contributed so much to country's economy through supply of protein food, marine fauna and flora of medical value, polymetallic nodules, oil, natural gas etc.

Development process must be continued but proper steps are to be taken to stop unplanned tapping of surface water, tree-felling in catchment areas, filling-up of wetlands, erosion of coastal line and above all pollution of surface water.

The Ganga Action Plan for a clean Ganga is a beginning in this direction aimed at salvaging Ganga from the highest level of pollution. The Wetland survey and Act to conserve wetlands are other preparatory steps. Setting up of Minimum Indian National Standard (MINAS) for discharge of Municipal sewage and industrial effluent (industry wise) by Central Pollution Control Board is another noteworthy feature. The impact assessment study for multipurpose river valley project (along with other major types of developmental projects) is aimed at ensuring incorporation of correct steps before the actual implementation.

The other aspect of water-resource is related to public health and hygiene. The supply of safe drinking water remains far from being satisfactory both in terms of quality and quantity. More than 1000 townships in India still lack drinking water supply system. Most of the big cities are prone to chronic shortage of supply syndrome. The vast rural area remains a ever-deprived component of nation, so far as

Table 5

WATER POLLUTANTS FROM SOME OF THE MAJOR INDUSTRIES IN INDIA							
Industry	Anticipated annual production (1980-81)	Approx. vol of waste-water generated (Million M <sup>3</sup> /yr)	Pollutants				Others
			C.O.D. (mg/litre)	B.O.D. (mg/litre)	Suspended solids (mg/litre)		
Paper	1.5x10 <sup>6</sup> tons	450	725	160	410		
Cotton	5,100x10 <sup>6</sup> metres of cloth (1974-75)	1,530	400 to 800	200 to 300	350 to 550	Chloride	500 to 1,400 mg/l
Refinery	8.5x10 <sup>6</sup> tons (1974-75)	15	320	160	350	Phenol	20 mg/l
						Sulphides	9 mg/l
						Chromium	0.5 mg/l
						Phosphate	49 mg/l
Nitrogenous fertilizers	6.4x10 <sup>6</sup> tons	52	—	—	—	Total Nitrogen	1,250 mg/l
						Phosphate	70 mg/l
						Arsenic	1.6 mg/l
						Fluoride	15 mg/l
Steel Mills	15x10 <sup>5</sup> tons					Phenol	100 to 1,000 mg/l
						Cyanide	10 to 60 mg/l
Coke oven		9	1,000 to 3,000	200 to 1,100	50 to 500		
Combined		40	200 to 2,000	75 to 150	—	Phenol	20 to 60 mg/l
						Cyanide	1 to 4 mg/l
Sugar	7.5x10 <sup>6</sup> tons	225	600 to 4,000	300 to 2,000	220 to 800	Total Nitrogen	10 to 40 mg/l
Power & Alcohol	60x10 <sup>6</sup> million gallons (1966)	22	3,000 to 75,000	15,000 to 40,000	4,500 to 12,000	pH	4.5 to 5
						Potash	300 to 7,000 mg/l
						Nitrogen	1,000 to 15,000 mg/l
Pesticides	6.5x10 <sup>6</sup> tons	—	3,000 to 10,000	0 to 700	—	Org. Nit	0 to 500 mg/l
						Sulphates	3,000 to 20,000 mg/l
						pH	2 to 10

Source : N.S. Doodhar and K.J. Nath (1981)

Table 6

<b>IS TOLERANCE LIMITS FOR THE SEWAGE (I) AND INDUSTRIAL EFFLUENTS (II) AND THAT OF INLAND SURFACE WATER (III)</b>				
<i>Characteristics</i>	<i>(II)</i>			<i>IS : 2296-1974 (III)</i>
	<i>IS : 4764-1973 (I)</i>	<i>Inland surface water IS : 2490-1974</i>	<i>Public sewers IS : 3306-1974</i>	
BOD (5 day 20°C), mg/l	20	30	500	3
COD, mg/l	—	250	—	—
pH	—	5.5 -9.0	5.5 -9.0	6.0-9.0
Total suspended solids, mg/l	30	100	600	—
Temperature, °C	—	40	45	—
Oil and Grease, mg/l	—	10	100	0.1
Phenolic compounds, mg/l	—	1.0	5	0.005
Cyanides (as CN), mg/l	—	0.2	2.0	0.01
Sulphides (as S), mg/l	—	2.0	—	—
Fluorides (as F), mg/l	—	2.0	—	1.5
Total residual chlorine, mg/l	—	1.0	—	—
Insecticides, mg/l	—	zero	—	zero
Arsenic (as As), mg/l	—	0.2	—	0.2
Cadmium (as Cd), mg/l	—	2.0	—	—
Chromium, hexavalent (as Cr), mg/l	—	0.1	2.0	0.05 (Total chromium)
Copper, mg/l	—	3.0	3.0	—
Lead, mg/l	—	0.1	1.0	0.1
Mercury, mg/l	—	0.01	—	—
Nickel, mg/l	—	3.0	2	—
Selenium, mg/l	—	0.05	—	0.05
Zinc, mg/l	—	5.0	15.0	—
Chloride (as Cl), mg/l	—	—	600	600
Sulphates, mg/l	—	—	—	1,000
% Sodium	—	—	60	—
Ammoniacal Nitrogen, mg/l	—	50	50	—
Nitrates (as NO <sub>3</sub> ), mg/l	—	—	—	50
Radioactive materials:				
α-emitters, μc/ml	—	10 <sup>-7</sup>	—	10 <sup>-9</sup>
β-emitters, μc/ml	—	10 <sup>-6</sup>	—	10 <sup>-8</sup>
Dissolved Oxygen, mg/l	—	—	—	40% of saturation value, or 3 mg/l, whichever is higher.
Coliform organism (monthly average) —MPN per 100 ml	—	—	—	Should not exceed 5,000. (should not exceed 20,000 with less than 5% samples, and 5,000 with less than 20% samples)

Source: NS Deodhar and KJ Nath (1981)

drinking water is concerned. The work for decade of water-supply and sanitation, survey and proper use of ground water, increasing social-service agencies' role for determination of safe drinking water, work during eco-development camps for creating awareness for cleaning up of ponds and small water bodies are all aimed to provide better drinking water.

### *AIR*

The air resources have often been misunderstood or taken for granted. Clean air does not remain clean for long; 'The earth's atmosphere is finite and its capacity to cleanse itself seems to be limited' The continued burning of fuels, industrial emissions, auto-exhausts, all lead to pollution (Table 7). Locally it creates noxious fumes and odour, decreases visibility, causes injury to human health by way of respiratory and other even fatal diseases. Levels of Sulphur dioxide and other particulate matter (which are all pollutants) already exceeded permissible limits in many Indian cities. The Carbon dioxide in air has been increasing alarmingly due to increased use of fossil fuel; of the 48 thermal power stations officially surveyed in 1984, 31 had taken no pollution control measures till 1987. Added to this, enormous amount of coal is used for domestic cooking. The smoke from fuel-wood is now identified as the world's worst air pollution problem for rural women.

All the traditional sources of energy appear to lead to increased air pollution. While Central Pollution Control Board continues to set up standards for emission from specific industries, and technologies are imported to control emission, search for alternative and non-polluting sources of energy received a major thrust in recent years.

The solar energy, wind energy, bio-gas energy are all being investigated for a better use in rural and urban environment. The awareness for better ventilation during monsoon (while using fuelwood to avoid excessive inhalation), energy efficient chullahs and smokeless chullahs are but other attempts to save Indian women from a dangerous health hazard. However, the thrust on additional power generation through burning coal continues to get prominence in national plan, as out of 1,38,000 MW of power generation projected for 2001, 84,000 MW have been shown under thermal power.

Table 7

**MAJOR AIR POLLUTANTS*****THE PRINCIPAL CHARACTERISTICS, SOURCES, AND HEALTH EFFECTS OF PARTICULATE MATTER, SULFUR DIOXIDE, HYDROCARBONS, NITROGEN OXIDES, CARBON MONOXIDE, PHOTOCHEMICAL SMOG, SULFATES, AND LEAD*****1) *Particulate Matter***

- a. *Main Characteristics:* Any solid or liquid particles dispersed in atmosphere, such as dust, pollen, ash, soot, metals, and various chemicals; particles often classified according to size, as settleable particles (larger than 50 microns), aerosols (smaller than 50 microns), and fine particulates (smaller than 3 microns).
- b. *Principal Sources:* Natural events such as forest fires, wind erosion, volcanic eruptions; stationary combustion, especially of solid fuels (e.g., power plants that burn coal), construction activities, industrial processes, atmospheric chemical reactions.
- c. *Principal Health Effects:* Directly toxic effects or aggravation of the effects of gaseous pollutants; aggravation of asthma or other respiratory or cardiorespiratory symptoms; increased cough and chest discomfort; increased mortality.

**2. *Sulfur Dioxide (SO<sub>2</sub>)***

- a. *Main Characteristics:* Colorless gas with pungent odor; oxidizes to form sulfur trioxide (SO<sub>3</sub>) which forms sulfuric acid with water.
- b. *Principal Sources:* Combustion of sulfur-containing fossil fuels, smelting of sulfur-bearing metal ores, industrial processes, natural events such as volcanic eruptions.
- c. *Principal Health Effects:* Classed as mild respiratory irritant; most SO<sub>2</sub> inhaled is absorbed in upper respiratory tract and never reaches lungs; penetrates when clings to particulate matter; aggravates respiratory diseases including asthma, chronic, bronchitis, emphysema; can result in reduced lung function, irritation of eyes, possible increased mortality.

**3. *Hydrocarbons (HCl)***

- a. *Main Characteristics:* Organic compounds in gaseous or particulate form, e.g., methane, ethylene, acetylene; component in formation of photo-chemical smog.
- b. *Principal Sources:* Incomplete combustion of fuels and other carbon-containing substances, such as in motor vehicle exhausts; pro-

Table 7 (contd.)

cessing and distribution and use of petroleum compounds such as gasoline and organic solvents, natural events such as forest fires and plant metabolism; atmospheric reactions.

- c. *Principal Health Effects:* Acute exposure causes eye, nose, and throat irritation; chronic exposure suspected of causing cancer; some groups of combustion hydrocarbons especially implicated in induction of cancer in laboratory animals.

4. *Nitrogen Oxides (NO<sub>x</sub>)*

- a. *Main Characteristics:* Brownish-red gas with pungent odor.
- b. *Principal Sources:* Primarily from internal combustion engine; also high temperature stationary combustion (power plants) and atmospheric reactions; may occur around explosives plants.
- c. *Principal Health Effects:* Major role as component in creation of photo-chemical smog; also has distinct effects apart from those associated with smog; has been shown to be toxic to experimental animals; some studies indicate NO<sub>2</sub> produces disease in animals that have human counterparts (emphysema, other lung disease); in study of school children in high NO<sub>2</sub> area (near TNT plant) found that children contracted significantly more respiratory disease than children in control area; has been shown to aggravate respiratory and cardiovascular illnesses and chronic nephritis.

5. *Carbon Monoxide (CO)*

- a. *Main Characteristics:* Colorless, odorless gas with strong affinity for hemoglobin in blood; usually aware of presence of CO only after early poisoning symptoms appear (such as nausea, headache, dizziness, difficulty in breathing).
- b. *Principal Sources:* Incomplete combustion of fuels and other carbonaceous materials, industrial processes, cigarette smoking, forest fires, decomposition of organic matter; natural processes produce ten times as much CO as automobile and industrial processes combined, but problem is high concentrations in urban environments.
- c. *Principal Health Effects:* Absorbed by lungs; reduces oxygen-carrying capacity of blood; creates reduced tolerance for exercise, impairment of mental function, effects fetal development, aggravates cardiovascular disease; several studies show at prolonged low-level exposure results in diminution of visual perception, manual dexterity, ability to learn and perform intellectual tasks; other studies have produced no such adverse effects at low levels of exposure.

Table 7 (contd.)

**6. Photochemical Oxidants (Smog)**

- a. **Main Characteristics:** Oxidizing type of pollutant found in many urban areas; results from chemical combination of reactive hydrocarbon vapors with nitrogen oxides in presence of sunlight; the resulting production of photo chemical oxidants consists of a number of toxic compounds: ozone, peroxyacetyl nitrates (PAN), aldehydes, other chemical compounds.
- b. **Principal Sources:** Hydrocarbons mostly from motor vehicle exhausts and nitrogen oxides from motor vehicle exhausts and stationary combustion sources; photochemical smog a problem not only in southern California (notorious for smog levels) but also in desert cities of southwest and eastern cities which now may be receiving more sunlight because of reduction in smoke layer. Meteorological conditions necessary for formation of oxidants: stationary high accompanied by adequate sunshine with low early morning wind speeds.
- c. **Principal Health Effects:** Aggravation of respiratory and cardiovascular diseases, irritation to eyes, respiratory tract, impairment of cardiopulmonary function; some concern about possible mutagenic effects of ozone; in Los Angeles one study showed no association between "alert days" when oxidant levels were high and mortality increase; poorer athletic performance has been related to high oxidant levels; possibility of developing tolerance to oxidant pollution such as has been shown for experimental animals may account for the relatively few changes associated with chronic exposure.

**7. Sulfates**

- a. **Main Characteristics:** Aerosol formed by sulfur oxides; in moist environment appears as sulfuric acid ( $\text{H}_2\text{SO}_4$ ) mist or rain.
- b. **Principal Sources:** Atmospheric reactions of  $\text{SO}_2$ ; secondary chemical reactions in atmosphere from other sulfur compounds, Recent indications that automobiles with catalytic converters (designed to decrease hydrocarbon and carbon monoxide emissions) may emit more sulfates than autos without converters.
- c. **Principal Health Effects:** Aggravation of respiratory diseases, including asthma, chronic bronchitis; reduced lung function; irritation of eyes and respiratory tract; increased mortality.

**8. Lead (Pb)**

- a. **Main Characteristics:** Heavy, soft, malleable gray metallic chemical

Table 7 (contd.)

element; often occurs (as environmental contaminant) as lead oxide aerosol or dust.

- b. **Principal Sources:** Leading sources of human exposure: ingestion by young children with pica (abnormal craving for nonfoods) who eat leaded paint and dirt occupational exposure in industries such as melting and battery-making, airborne lead from nonferrous metal smelters, auto exhausts along highways; agricultural use of leaded arsenates; lead salts in some pottery glazes released when in contact with slightly acidic liquid, or heated; in "moonshine" whiskey because often made in apparatus with lead-welded copper tubing or in old automobile radiators.
- c. **Principal Health Effects:** Enters primarily through respiratory tract and wall of digestive system; more than 40 percent of lead inhaled is absorbed into bloodstream; accumulates in body organs; symptoms of lead poisoning not very specific; early signs are impairment of mental function, behaviour problems, and anemia; higher levels cause vomiting, cramps serious impairment of kidneys, nervous system, possible brain damage; study on rats and mice fed lead for life in concentrations comparable to levels in U.S. tissues showed early mortality, shortened life-span, increased susceptibility to infection, visible aging and loss of weight, hardening of the arteries and heart attacks (see Schroeder); another study concluded: "Studies on the fetal mouse show that lead levels at about the currently accepted safe blood levels cause developmental deficiencies in certain individuals...Extrapolation of these effects in the mouse to lower doses and other populations suggests that individuals are being destructively altered at currently acceptable environmental-lead-induced body lead burdens. It seems clear that this destructive process could be halted by the immediate elimination of lead from gasoline and continued public health measures to identify and remove lead-containing materials from the environment..."(see Berry, Osgood, and St. John, P. 529).

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### ***LIVING RESOURCES : FLORA AND FAUNA***

India is considered to be in a unique geographical location with representative of all major ecosystems within its territorial limit. Each of these ecosystems viz. the high mountains, tropical forest, freshwater, desert, estuarine, marine, island etc., provide characteristic climate and habitat condition for development of faunal and floral resources. It is said that India has given many valuable plant and animal genes to the world. It is specially known for rich genetic resources of bamboo, mango, bananas, citrus, melons, mung beans, cowpeas, rice, pepper, cardamom, ginger, turmeric, buffalo, goat, silkworm, to mention few from a long list. India has about 15,000 species of vascular plants, 1700 species of fishes, 195 species of Amphibia, 415 species of reptiles, 1200 species of birds and a very rich mammal fauna. Of the flowering plants, at least 2000 species now suffer from one or other kind of stress, the actual estimate of fish species which have become endangered due to changes in riverine system and pollution-load is yet to be estimated, a number of amphibians, reptiles, birds and mammals have already found their place in the schedules of Indian Wildlife (protection) Act., either for indiscriminate killing of adults or breeding population or for alarming loss of habitat. The role of fauna and flora in the food chain and energy cycle are now well known. The vast unexplored potentiality of an array of wild genetic resources in Himalaya, Western Ghats, Eastern Ghats and Andaman & Nicobar Islands are now accepted by global scientific community. But the developmental processes and inroads into the wilderness have already done irreparable damages to these ecosystems. The environmental impact analysis to determine possible effects of developmental projects on ecology and wildlife and fisheries has now become mandatory. A chain of conservation areas in the form of National Parks (66), Sanctuaries (382), Tiger Reserves (15) and proposed Biosphere Reserves covering an area of 1,32,000 sq. km., representing 15% of total forest area, is aimed at providing shelter to at least some of the endangered flora and fauna. Likewise, the Marine National Park at Gulf of Mannar has been created to protect habitat of some of the marine wildlife. But for a vast area of the country, the demands of development projects (like Silent Valley Project in Kerala, Neora Valley Project in W.B. Missile testing sites at Balasore in Orissa, Dolomite mining at Buxa in W.B., Narmada Valley Project covering parts of Madhya Pradesh, Maharashtra; Telugu Ganga project covering Andhra Pradesh, Karnataka, Tamil

Nadu, etc.) continue i.e. Environment and Development, so as to ensure a process of sustainable development.

### ***OTHER FACTORS***

The questions of occupational health hazard, habitat and environment, pesticides and environment, etc., have not been discussed in the foregoing account. These are all equally vital for an awareness programme. The work environment in industry besides being hazardous in many sectors, often threatens the audibility through the effect of noise and loss of hearing. That noise pollution should be taken up as a serious subject of study is yet to be fully appreciated in India. The effect of noise in factory operations, automobile horns in the public transport and irrational use of microphones, at a particular level (measured in terms of decibels) and period of duration could lead to different degree of deafness, tension, neurosis and other health hazards. Legal measures and simple precautions can however help to control the same (but hardly being followed). The environmental factors are related very closely with human habitats. The land use plans in most cases appear to violate or lack any norms for open space and greenery leading to further health hazards (along with incompetence to supply wholesome water, assure proper drainage and disposal of garbage etc.). But again, the concepts of habitat planning are available and environmental safeguards can only be ensured, if Indian planners and administrators adopt and implement the same without any compromise. The success of green revolution, it is now well known, depended on better varieties of crops, use of fertilizers and pesticides. Unfortunately, India remains one of the major third world countries who has to admit continuous use of toxic, non-biodegradable pesticides. These chemicals, while killing pests, manage to survive as residues in environment and find shelter in soil, water, raw vegetables, fruits, milk, fish and ultimately in the organs of human body. In the process, what was the trace element in the lower forms, gets magnified as it passes through a biological chain. Many of the diseases, both known and unknown, are now being attributed solely or partly to the pesticides in our environment. Laws have been formulated to test the products before they are being marketed and still much of the bulk import and indigenous product continue to be known toxic-pesticides,, (The case of Bhopal still remains fresh). The selection of pesticides and their proper use form a part of the awareness programme, as also channeling a

healthy public opinion to the industry for the safer pesticides. 'Environmental Awareness' as such needs a holistic approach to understand the natural environment, the man-made changes and their effect and finally to ensure development without endangering environment. While the governmental authorities are to bear the major responsibility for the last item, people at large can contribute to their own area by keeping vigil, educating others and forming public opinion in favour of environmental conservation.

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# ENVIRONMENTAL DEGRADATION OWING TO POPULATION EXPLOSION

J.K. JONATHAN

## *INTRODUCTION*

Environment is a condition in which an organism lives. The organism depends upon its environment for its sustenance while the environment provides the organisms with substratum or medium for their various life activities. Environment may be further subdivided into **physical** (or abiotic), and **biotic factors**. The abiotic factors such as temperature, water, light, humidity, wind and air-currents, pH, mineral salts and trace elements, water currents, salinity, wave action, topography etc., required in a certain measure for the growth of population are known as **limiting factors**.

An organism's biotic environment is made up of all the other organisms with which it comes into regular contact. These biotic factors such as **producers, consumers and decomposers** are interconnected. The energy transfer from the producers (mainly plants) through a series of organisms (herbivores-carnivores-decomposers) with repeated eating and being eaten is known to form a **food chain**. From this brief analysis of the environment it can be seen that organisms do not exist in isolation but are continually influencing each other in the form of a unit. This natural unit, composed of living and nonliving components, whose interactions result in a stable, self-perpetuating system, is called **ecosystem**.

## *GROWTH OF POPULATION*

A population is a group of organisms of the same species occupying a particular space. Each species of a population is independent

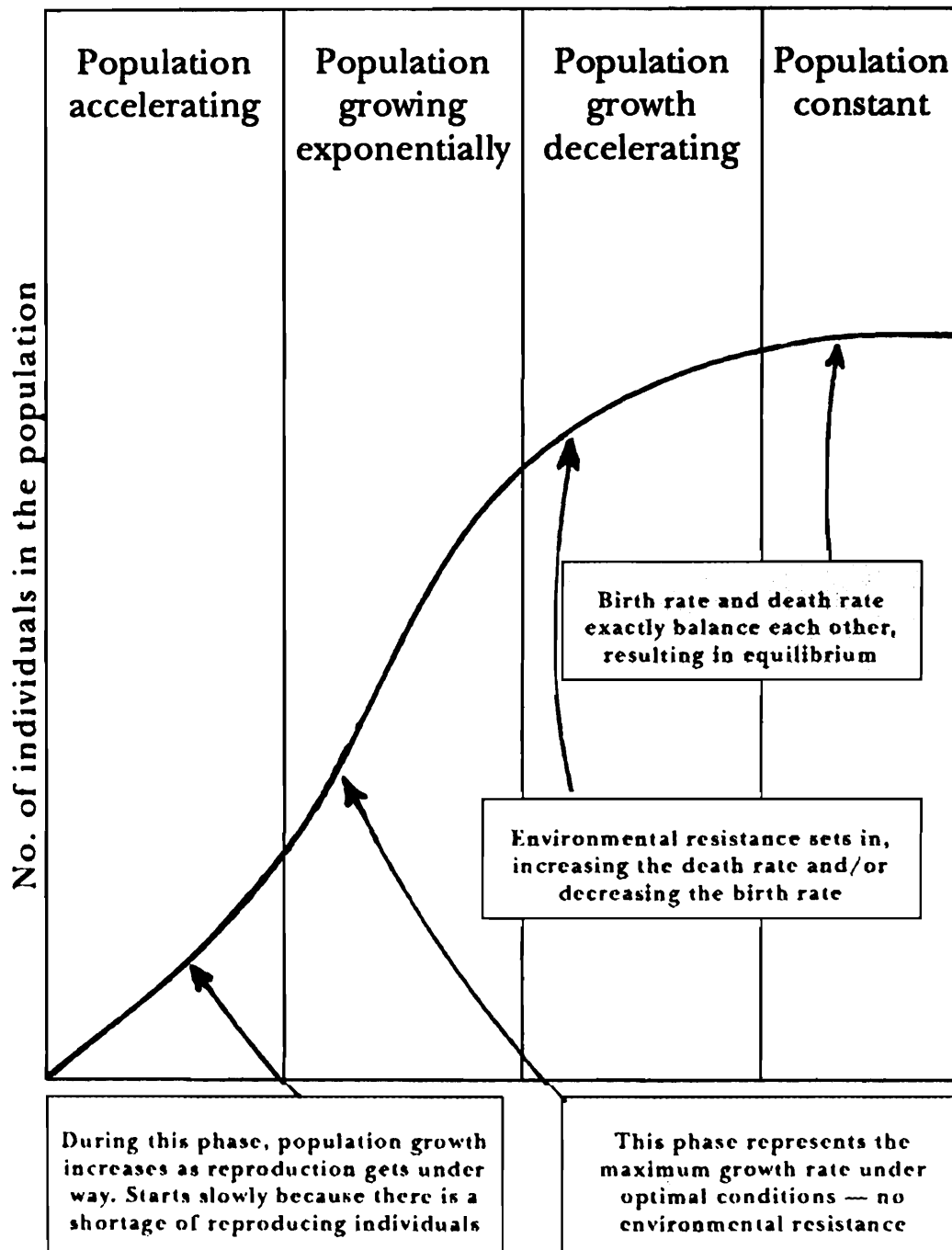


Figure 1. Generalized Graph of Population Growth (after M.B.V. Roberts, 1975)

**in its occurrence and can form a part of any community depending on its interactions with population of other species. Consider what happens if a few individuals enter an unoccupied area where there is no shortage of food, no predators, reproduction will occur and the number of individuals will increase as shown in Figure 1. In the absence of any resistance, the species will attain its full reproductive potential. But ultimately the environment will become saturated and cause growth curve to flatten due to environmental resistance. At this full carrying capacity, it can support no more. This pattern of population growth is the same to all the species groups from bacteria to mammals. The environmental resistance is owing to the following factors, which check indefinite growth of a population:**

1. Shortage of food, water or oxygen.
2. Light (for plants).
3. Predators.
4. Lack of shelter.
5. Disease.
6. Accumulation of toxic waste, etc.

In normal conditions of a ecosystem or environment, a population when reaches equilibrium does not remain absolutely constant but fluctuate because of variations in environmental resistance. An increase or decrease in population sets into motion processes which keep the population on an even keel — the **negative feedback** as shown in Figure 2.

Such an equilibrium can be suddenly changed owing to sudden change in environment, for example, sudden removal of predators, the population of other species would no longer be held in check and would rise exponentially as it did originally. This may be described as **positive feedback**. After removal of the predator (may be by man only) the new set point is maintained and competition for food sets in.

The shifting of set point can also be seen in the growth of human population. In the course of human history there have been three major population explosions, each corresponding to a major change

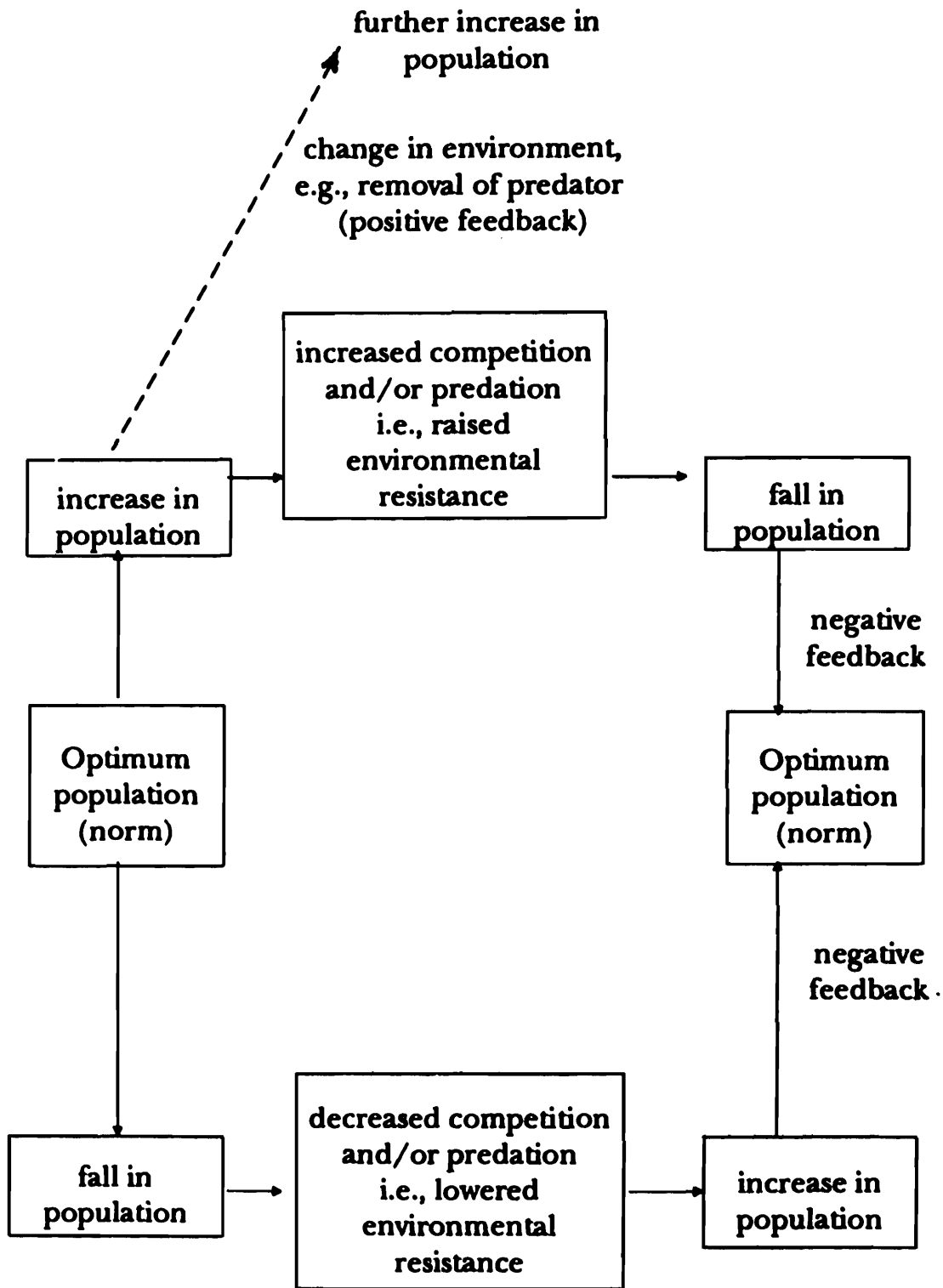


Figure 2. Scheme summarizing the homeostatic control of population (after M.B.V. Roberts, 1976)

in the environment leading to large number of individuals to survive. These are :

1. 20,000 years ago, invention of tools brought revolutionary changes in the methods of hunting and food gathering techniques.
2. Similarly 6000 years ago, a revolution in agriculture led to an improvement in farming techniques.
3. Around 300 years ago the progress in Science and Technology brought radical changes in the spheres of food production, industry, medicine, etc., which are responsible for the population explosion.

Each of these three population explosions, is associated with the substantial shift in the population set point: rise in the birth rate, the decline in the death rate, resulting the population to surge up exponentially to a new level.

Presently, we are in the midst of the third great population explosion. We have reached a stage where the biosphere which humanity has inherited and the technosphere which humanity has created are not only out of balance but dangerously in conflict with each other. The question is how long will the human population continue to rise exponentially, and when will a new equilibrium imposed either by Man or by Nature, be achieved?

The World population is growing at a rate of 150 a minute, 2,20,000 a day and 80 million a year. The world crossed the four billion mark only 14 years ago (1974). The chances are that we will be six billion by the turn of the century. The world population was three billion in 1964. So it is clear that we are now on the "double march" The United Nations Fund for Population Activities designated July 11 as the "Day of Five Billion".<sup>1</sup> For the demographers, the landmark event is a grim reminder of the persisting population pressures that threatened life supporting system in various parts of the world. It is hard to tell whether we should be glad or alarmed over the occasion (Figure 3).

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1 *In Zagreb Yugoslavia was born the world's five billionth child on July 11, 1987. The infant was named Matej Gasper. The world was represented by the United Nations Secretary-General, Mr Perez de Cuellar, who was around for the event.*

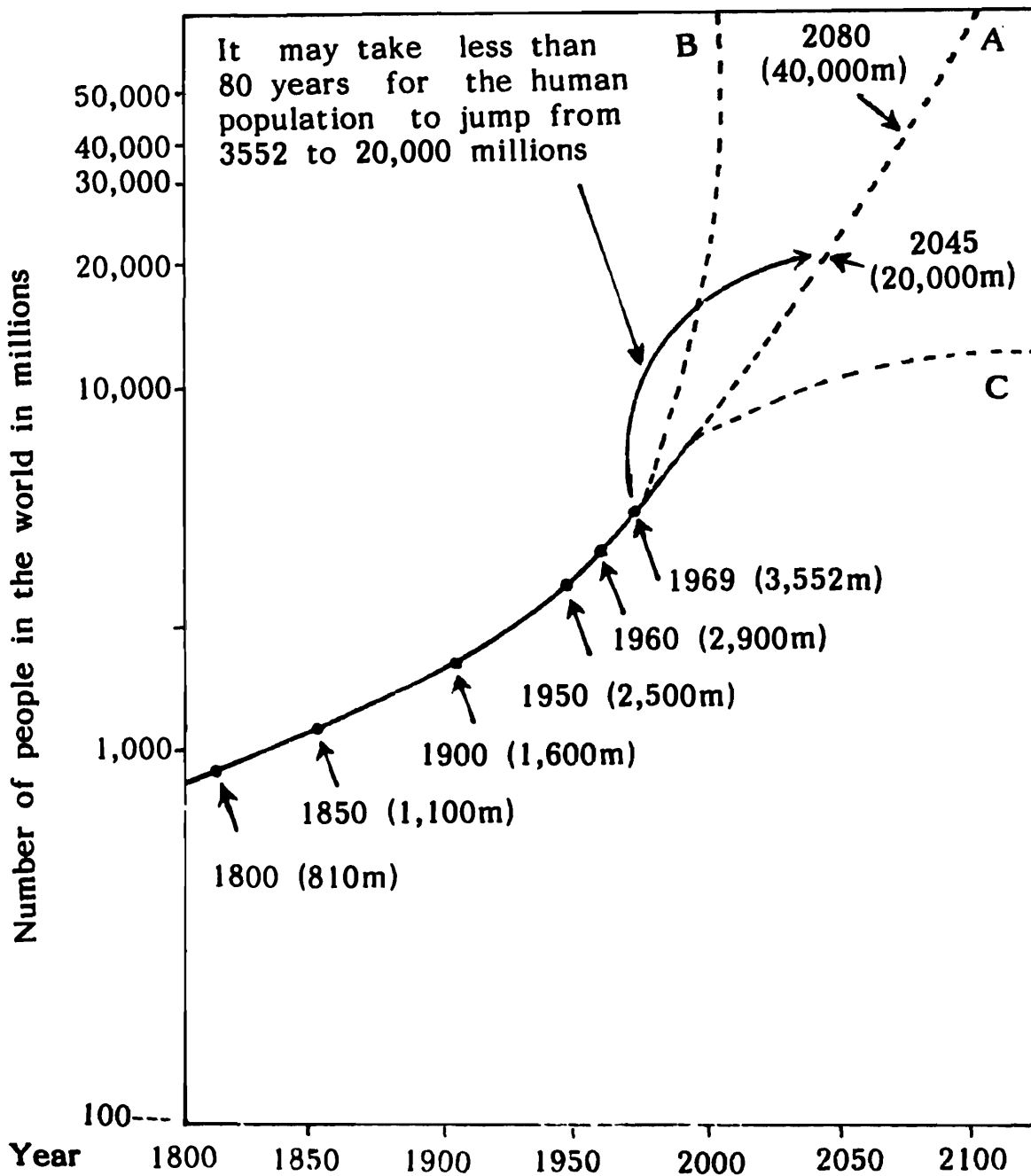


Figure 3. Graph shows how the world population has risen since 1800. The dotted line A represents the projected population growth over the next 120 years assuming that the 1960-69 growth rate is maintained or life continues to increase giving a Curve B, or if checked by men or nature to level off as curve C. (after M.B.V. Roberts 1976, based on United Nations data).

## ***IMPACT OF HUMAN POPULATION***

With the development of agriculture (green revolution), better facilities for health and shelter have given rise to far reaching disturbances in the ecosystem. The impact of human population on environment is measured in terms of following factors:

1. Its density and rate of growth,
2. The rate at which they consume the finite resource (food, etc.),
3. The rate at which they pollute air, water, soil, etc.,
4. The extent of ecological upsetting that they cause (deforestation and increasing Carbon-dioxide level),
5. The extent to which they increase the threat of nuclear holocaust.

As explained earlier that energy in the form of food is obtained from the producers (generally plants), producers are being eaten by herbivores (primary consumers) which are then eaten by carnivores (secondary consumers). As an omnivore, man consumes both plants and animals (both herbivores and carnivores), hence he is a primary, secondary and tertiary consumer. Thus man is the final link in various food chains.

When energy flows through a food chain, only a small portion of the energy taken up by each link is transferred to the next step. At each step most of the energy is lost as heat. Therefore, the size of any human population is limited by the length of such chains. The longer the chain, lesser the energy can be derived from it, and the smaller will be the resulting population. On the other hand, the shorter the chain, more the energy can be derived from it and larger will be the population. For the minimum loss of transformed energy, man should feed on the first link in the chain. In this way a given area of land can support a greater number of people than would be the case if the population were fed on grazing animals.

## ***EFFECT OF MAN ON THE ENVIRONMENT***

The ecosystem is essentially cyclical, balanced and self perpetuat-

ing. If a particular commodity is removed faster than it is replaced, then the ecosystem is in jeopardy. Any amount of over exploitation, more than the carrying capacity of a ecosystem can be equally serious. Since the dawn of civilization man has been changing the ecosystem at his will.

The more complex the ecosystem, the more stable it is. If a link is removed from a food chain the results are likely to be disastrous. For example, the removal of consumer 1 in the food chain will lead to the fatal extinction of consumers 2 and 3. In a complex food web, the removal of one of the organisms may not have such disruptive consequences, because the consumers which feed on this particular organism will have alternative source of food.

One of the main ways in which man affects ecosystem is in his use of pesticides for higher production of food grains, vegetables etc. to feed more individuals. The use of pesticides can upset ecosystem in two ways. Firstly they kill their natural enemies or at least decrease their efficiency as agents of control. Secondly, if the pest starts flourishing again, its natural enemies are no longer there to keep it down.

For example, in 1880 citrus plantation in California was attacked by tiny scale insect, the cottony cushion scale. This was controlled by vedalia beetle, which feeds on it. In the 1940, in hope of still further increasing the yield of fruit, DDT was sprayed, with the result the vedalia beetles were destroyed and the scale insect became a pest again. With the banning of DDT in 1960 the vedalia beetle was reintroduced and the scale kept under control once more. It is clear that to a considerable extent chemical and biological control are in conflict. It is unlikely that chemical pesticides will ever be the final answer to pest control, because, apart from their effects on the ecosystem, resistant strains are constantly evolving. The only answer is to put more emphasis on **biological control**.

The pesticides have more serious effect on the cycling of material than on food chain, e.g. Nitrogen cycle. In the soil there are bacteria that convert ammonia into nitrite and nitrates. If these bacteria are killed by the pesticides, there would be a reduction in the amount of nitrates available to plants and an accumulation of ammonia in the environment. However, even a useful material, if allowed to accumulate, can upset the ecosystem.

The pesticides, when sprayed on plants and crops to kill the pest and to obtain high yield, are consumed by animals, either killing them outright or affecting their reproductive success. The amount of organic Chlorine residues were found more in predatory birds. This suggests that the pesticides get incorporated into food chains and accumulate in the tissues in more concentrated form. The organic Chlorine at a level above 30-40 parts per million is known to be lethal to certain birds. Sublethal doses at levels as low as 1.0 part per million can reduce the fertility and viability of chicks. And as such, the use of pesticides is a danger to wildlife, and a potential hazard to man himself. The DDT has now been banned in U.S.A., U.K. and other developed countries, but still used in developing countries.

### **POLLUTION**

It is difficult to find any where in the world, a news paper or magazine, which during the past few years had not published material on the severe damage which man inflicts on his environment. This undesirable change in the physical, chemical and biological characteristics due to pollution of our air, land and water that may or will harmfully affect human life.

**Air pollution :** The state of the air on our planet, including the fate of Oxygen in the atmosphere, is beginning to evoke anxiety. Every ton of coal burnt, and a motor vehicle per 1000 km consume an equal amount of Oxygen required by one person in one year.

Thermal power plants emit into the atmosphere several million tons of ash and Sulphur-dioxide. A mixture of smoke and fog add to atmospheric pollution—**Smog**. This atmospheric pollution causes intense eye irritation, headache and respiratory problems.

There are two views on the net result of atmospheric pollution. One view is, that if every day about 6000 million tons of Carbon-dioxide is released into the atmosphere due to increased human consumption of more green food, chemicals, insecticides, oil etc., its toxic contents in air will be doubled within 150 years, with the result, the temperature of the Earth surface will rise, consequently Arctic and Antarctic ice will melt and the level of sea will rise by more than 60 metres. The low lands of Western and Central Europe, coastal China and India will be submerged. There will be disappearance of

mighty Antarctica, change in inclination of Earth's axis and rotation, increase in mountain building processes connected with earthquakes and volcanic eruptions. The other view is that if the atmosphere is polluted with the several million tons of ash, Sulphur-dioxide etc., it will result in the loss of transparency of air and transmit less solar rays. The Earth will ultimately become cooler, which may result in a new Ice Age. Thus on one hand we have the spectre of cold dusty Mars and on the other hand that of burning hot and life less Venus.

**Water pollution :** Things stand no better with our fresh water resources. The situation with water would have been more or less satisfactory if the industry, population of towns on taking pure water from rivers, lakes, reservoirs and under ground wells would return it as pure they have received.

The surface, ground and soil water is mainly polluted by the following : (1) *Sewage* : It consists of excreta of human and animals, which is rich in organic matters and nitrogen compounds. In moderate concentration, it can enrich the soil, but if allowed to accumulate in lakes and rivers, it can have serious effect on the ecosystem.

The decomposing bacteria proliferate and consume all the Oxygen and increase the concentration of toxic nitrogen compounds, such as ammonia. This leads to the killing of all the fish and other animal life and rendering water unfit for human consumption. (2) The problem of *thermal pollution*, which is due to the discharge of heat into rivers and estuaries from power plants rises the temperature of water thereby increasing the metabolic rate and high Oxygen consumption of the micro-organisms, and reducing rate of growth of other animals, such as fish. (3) *Oil and its products* which are thrown off into the sea amount to about 5 million tons. This amount is sufficient enough to cover the entire world ocean with a oil film in 7 years time. This will lower the photosynthesis activity of sea microflora which contributes about 70% of the total Oxygen produced by the green plants. It will lead to death of about quarter billion of sea birds and sea fauna.

**Land pollution :** Land is mainly polluted by the disposal of solid waste and chemicals. The disposal of solid waste material including farm and animal manure, crop residue garbage, industrial waste,

**dead animals etc.** add to direct pollution of land. In this age of industrialization large industries emitting chemicals into the air in the form of radio active minerals, Sulphur, Lead and dust. These toxic substances eventually settle on the earth to pollute the soil. Several pesticides and herbicides such as DDT, DDE, DDD and dichlorophenoxy acetic acid which are sprayed in heavy doses find their way into the soil. Several liquid by-products from these industries flow into our river system and finally goes in to the soil. These chemicals are non-degradable pollutants and the food chain.

**Noise pollution :** It has certain ecological, biological and pathological effects on human beings. Any sound which is undesired by the recipient is noise. The noise pollution is mainly caused by the use of heavy machinery in industrial areas; unbearable sound produced by continuous blowing of horns, loudspeakers, small machines, fast running trains, aeroplanes and market places. A sudden or continuous exposure to high level of noise not only causes a permanent loss of hearing, but also increases blood pressure, increased heart rate, contraction of muscles, insomnia, headache, fatigue etc.

**Radioactive pollution :** The most modern on the list of pollutants is radioactive waste. Radioactive isotopes are produced to help human life, but the genetic damage caused by radioactive fallout is the topic of the day: It has been estimated that the radiation derived from peaceful uses (not to talk about nuclear war-wares) such as X-ray diagnosis, radiotherapy, nuclear reactors and even luminous watches amount to a general increase of at least 25% over that which existed previously and yet no measure are taken to stop these things. There is a need for more awareness of the problem and avoidance of indiscriminate use of scientific discoveries.

### ***POPULATION GROWTH IN INDIA***

The total population of India (Table 1) increased from 424,836,000 in 1961 to more than one and half times i.e. 658,141,000 in 1981 but the total geographical area has shrunk from 3,182,900 sq. km. in 1961 to 2,988,200 sq. km. in 1961 and 2,986,400 sq. km. in 1981. Consequently, one sq. km. of area occupied by 138 persons in 1961, was inhabited by 220 persons in 1981. Among Union Territories most thickly populated are Delhi and Chandigarh with 4178 and 3948 persons per sq. km., i.e. about 20 times more than the aver-

TABLE - 1. INDIA : GEOGRAPHICAL AREA, TOTAL POPULATION AND POPULATION DENSITY

India / State / Union Territories	Total Geographical Area (In '000 Sq. Km.)			Total Population (In '000)			Population Density (Persons per Sq. Km.)		
	1961	1971	1981	1961	1971	1981	1961	1971	1981
<b>INDIA</b>	<b>3182.90</b>	<b>2988.20</b>	<b>2986.40</b>	<b>424836</b>	<b>528918</b>	<b>658141</b>	<b>138</b>	<b>177</b>	<b>220</b>
<b>States</b>									
Andhra Pradesh	274.70	277.10	275.10	35983	43503	53593	31	157	195
Assam	114.50	99.70	—	11103	14957	19897	97	150	—
Bihar	173.30	173.90	173.90	46447	56353	69823	268	324	402
Gujarat	184.20	196.30	196.00	20633	26697	33961	112	136	173
Haryana	—	44.20	44.20	—	10037	12851	—	227	291
Himachal Pradesh	—	55.80	55.50	2812	3460	4238	—	62	76
Jammu & Kashmir	136.90	—	—	3560	4616	5987	26	—	—
Kerala	38.90	38.90	39.90	16904	21347	25403	435	549	654
Madhya Pradesh	437.50	443.10	443.10	32372	41654	52138	74	94	118
Maharashtra	360.60	307.40	307.70	39553	50412	62715	129	164	204
Manipur	—	22.40	22.30	*	1073	1411	—	48	63
Meghalaya	—	22.50	22.40	—	1012	1328	—	45	59
Mysore (Karnataka)	191.80	191.50	191.80	23586	29299	37043	123	153	193
Nagaland	—	16.60	16.60	*	516	773	22	31	47
Orissa	155.30	155.60	155.70	17549	21945	26272	113	141	169
Punjab	113.50	50.40	50.40	18845	13551	16670	166	269	331
Rajasthan	341.60	343.50	342.20	20156	25766	34108	59	75	100
Sikkim	—	7.20	7.10	—	210	315	22	29	44
Tamil Nadu	130.10	130.10	130.10	33687	41199	48297	259	371	317
Tripura	—	10.40	10.50	*	1556	2047	107	149	195
Uttar Pradesh	295.00	294.50	294.40	73754	88341	110886	250	300	377
West Bengal	88.60	87.90	88.70	34926	44312	54486	394	504	614
<b>Union Territories</b>									
Andaman & Nicobar Island	N.A.	N.A.	8.20		115	188	N.A.	N.A.	23
Arunachal Pradesh (Now a State)	N.A.	N.A.	0.10		468	628	N.A.	N.A.	7
Chandigarh	N.A.	N.A.	83.70		257	450	N.A.	N.A.	3948
Dadra & Nagar Haveli	N.A.	N.A.	0.50		74	104	N.A.	N.A.	211
Delhi	N.A.	N.A.	1.50		4066	6196	N.A.	N.A.	4178
Goa, Daman & Diu	N.A.	N.A.	3.80		858	1082	N.A.	N.A.	284
Lakshadweep	N.A.	N.A.	0.10		32	40	N.A.	N.A.	1257
Pondicherry	N.A.	N.A.	0.50		472	604	N.A.	N.A.	1228
Mizoram (Now a State)	N.A.	N.A.	21.10		332	488	N.A.	N.A.	23

Note : N.A. stands for not available.

1961 Population of Manipur, Nagaland, Tripura & Arunachal Pradesh together was 3,055 thousands

1961 Population of Union Territories excluding Arunachal Pradesh was 4,137 thousand.

(Source : Urban West Bengal, 1988. Institute of Local Government and Urban Studies, Calcutta).

age of 220 persons occupying 1 sq. km. of area and followed by Lakshadweep and Pondicherry with 1257 and 1228 persons sharing 1 sq. km. The densely populated states are Kerala (654), West Bengal (614), followed by Bihar (402), U.P. (377), Tamil Nadu (371), Punjab (331) and Haryana (291) inhabiting 1 sq. km. area. All the aforesaid environmental hazards are more predominant in densely populated areas and less so in areas with population on an average.

### ***POPULATION STRATEGY : STABILIZATION TIME TABLE***

There is a definite need to stabilize the world population. As already noted that world population will reach 10 billion by the end of the 21st century. This continuously rising population will put more pressure on the earth's resources and ecosystem. Therefore, it is necessary to explore the possibilities for a different demographic future which will ensure population growth to a sustainable level. It is obvious that any further growth in world population can not improve the quality of human existence, or in other words any further rise in population will diminish our well-being. To achieve this, there must be a time bound programme to stabilize the population at or below the optimum level. There is a sharp contrast in current fertility level between the developed and developing countries. Three European countries-West Germany, East Germany and Luxembourg have achieved population stability (Table 2) and birth and death rates are essentially in balance (Figures 4 & 5). The other group of more developed countries such as Austria, Belgium, United Kingdom, Sweden, Finland, Hungary and the United States have low and declining birth rates. On the other hand, at least ten succeeded in reducing their birth rates by well over one birth per thousand per year or it has been much closer to two (Table 3). If the less developed countries make appropriate efforts to reduce birth rate, at least 25 per thousand, much smaller age group would enter the prime reproductive ages between 2005 AD and 2015 AD, and at this stage it would be possible to bring the birth rate into balance with death rate.

As shown in Table 4, there is a substantial decline in birth rates between 1975 and 1985 in both the developed and less developed countries. To have a steadily declining fertility throughout the world, demographers have viewed replacement level fertility. To achieve that extraordinary level, global efforts are needed to change atti-

Table 2

<b>COUNTRIES ACHIEVING OR APPROACHING POPULATION STABILITY, 1973</b>				
	<i>Population (million)</i>	<i>Crude Birth Rate</i>	<i>Crude Death Rate</i>	<i>Annual Rate of Natural Increase (percent)</i>
East Germany	17	11.7	13.9	-0.22
West Germany	62	10.6	11.9	-0.13
Luxembourg	3	11.4	12.4	-0.10
Austria	7	13.4	12.6	+0.08
Belgium	10	13.6	12.5	+0.11
United Kingdom	56	14.7	11.9	+0.28
Finland	5	12.4	9.6	+0.28
Sweden	8	13.4	10.3	+0.31
Hungary	10	14.7	11.5	+0.32
United States	208	15.0	9.4	+0.56
Switzerland	6	14.8	9.4	+0.54

*Source : Preliminary estimates based on United Nations data.*

Table 3

<b>CRUDE BIRTH RATE DECLINE IN SELECTED DEVELOPING COUNTRIES</b>			
<i>Country</i>	<i>Time Span</i>	<i>Average Annual Decline Birth Rate</i>	<i>Crude birth Rate 1972</i>
		<i>(births per thousand per year)</i>	
Barbados	1960-69	1.5	22
Taiwan	1955-71	1.2	24
Tunisia	1966-71	1.8	35
Mauritius	1961-71	1.5	25
Hong Kong	1960-72	1.4	19
Singapore	1955-71	1.2	23
Costa Rica	1963-72	1.5	32
South Korea	1960-70	1.2	29
Egypt	1966-70	1.7	37

*Source : U.N.O. and U.S. Agency for International Development*

tudes, to ensure the universal availability of family planning services, and to reorient national and international economic policies towards meeting the basic social requirements of all people.

**FAMILY PLANNING PROGRAMME**

Pills, IUD, Voluntary sterilization and Abortion : A large part of the World's fertile population does not have ready access to family

Table 4

<b>A PROPOSED POPULATION STABILIZATION TIME-TABLE</b>						
	1970	1975	1985	2000	2005	2015
World population (billions)	3.6	3.9	4.5	5.3	5.5	5.8
Annual growth rate (percent)	1.9	1.7	1.1	1.0	9.0	0
Annual increase (millions)	69.0	65.0	50.0	52.0	49.0	0

*Source : L.R. Brown, 1976.*

planning services because the services are either very costly or not locally available. According to the report of International Planned Parenthood Federation (IPPF), 31% of all the couples of fertile age were practising family planning as on 1971. Of these 31%, roughly half, relied on traditional techniques, such as withdrawal, the condom, and the rhythm method. The other half relied on more modern methods, such as the pill, the IUD and sterilization. The family planning programme in India relies mainly on the condom, sterilization, principally vasectomy. Whereas the developed western countries now rely primarily on the use of the pill, the IUD, and sterilization, backed by abortion.

It is estimated (reliable data are not available) that 40 million unwanted pregnancies are terminated by induced abortions in the world each year. It is reported that an estimated 3.8 million induced abortions each year in India resulted in an estimated 180,000 maternal deaths. Taking such grave risks is an index of the desperation among women wishing to prevent unwanted births. In response to these and other factors, there has been a wide spread international effort to liberalize abortion. Almost all the countries permit abortion in the event of rape, incest, a threat to mother's life from child birth, or possible transmission of hereditary disease. To limit the human

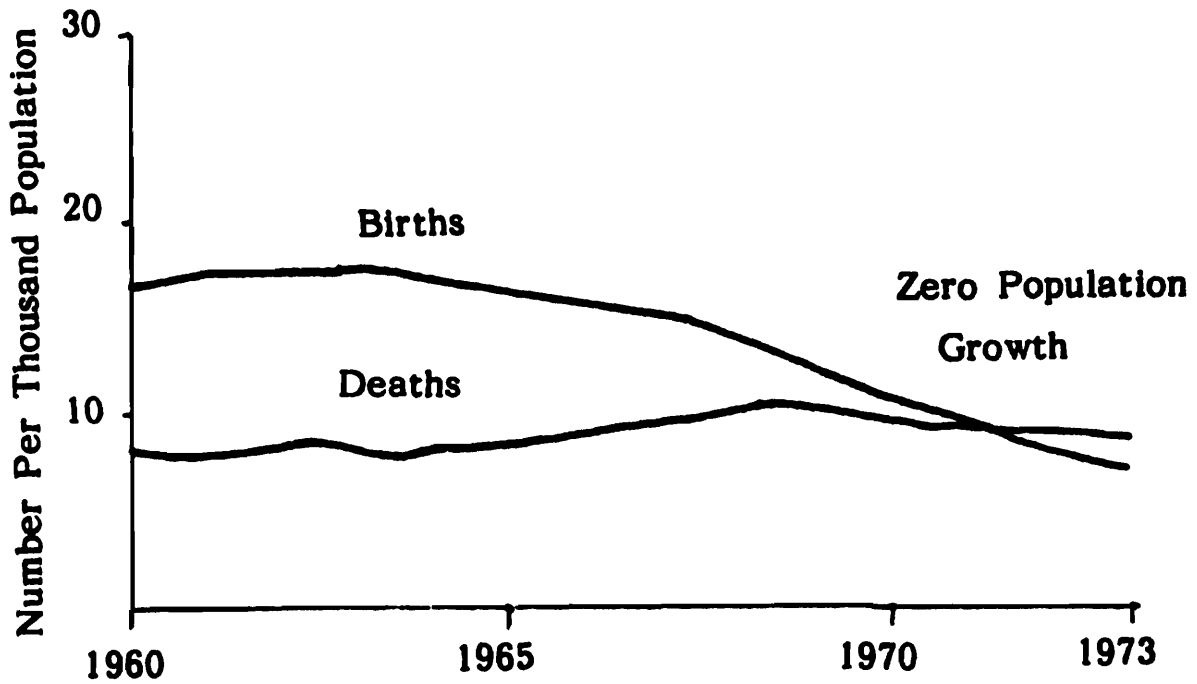


Figure 4. Birth and Death Rates in West Germany, 1960-1973; (after L.R. Brown, 1976)

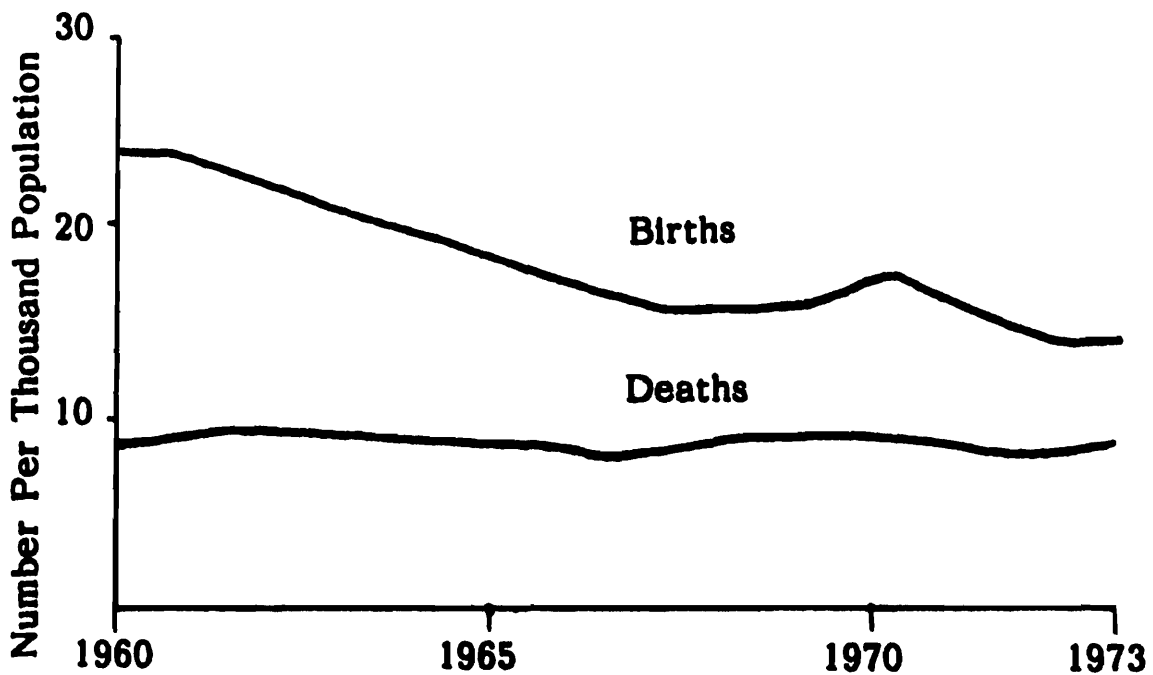


Figure 5. Birth and Death Rates in United States, 1960-1973; (after L.R. Brown, 1976)

growth it is possible only if legal, medically safe abortions are available to every woman, regardless of her ability to pay.

### ***ROLE OF WOMEN***

There are two factors which promise a change in the role of women in society.

1. Social and political rights and economical opportunities equal to those of men.
2. Pressure of population on earth's resources may not permit all women to bear children.

In western countries, abundant employment opportunities for women are beginning to compete with the traditional roles of child bearing and child rearing. The result is a drop in the level of fertility. Now, it is imperative for every society to create employment opportunities for women, sufficiently attractive, to induce many of them to opt for these rather than the child bearing.

### ***EDUCATION AND ROLE OF COMMUNICATIONS MEDIA***

Printing press was invented about 500 years ago, yet as of 1970 two-fifths of the world population lacked basic education. How are they to understand the accelerating pace of change, the consequence of the growing pressure of human activity on the ecosystem? Illiteracy is one of the greatest factor in global increase in human population. The developing countries should be committed to this goal. To achieve universal literacy the cost can not be precisely estimated. In the 1960s, UNESCO estimated the cost of enabling about a billion persons literate to 8 billion dollars. If the programme is spread over five years, the cost would come to 1.6 billion dollar per year. The benefits to become literate and to mankind as a whole is enormous, especially when taken into account the effect on economic health of the society and receptivity to family planning.

It is the educational system which can bring about the change in social attitudes on issues like family planning and life styles. But there is no time to train teachers and they in turn train a generation of children who will eventually enter the childbearing ages. The re-

quired changes must occur within a matter of years and there is a urgent responsibility of the communications media to play a positive role. These media can help us all, literate or illiterate to understand the full consequences of population growth on individual well-being, security and life styles. One of the urgent responsibilities of the communications media is to distinguish symptoms and causes of the problems we face. There is an urgent need to understand the relationship between population growth and its effects on pollution, traffic congestion, scarcity of resources, rising prices, malnutrition, etc. and to understand the remedial steps proposed to be taken to arrest such changes which are directly or indirectly effecting our ecosystem. This simple fact needs to be repeated again and again until it permeates the consciousness of people from policy makers to every individual couple contemplating another child.

The media must accept new responsibilities for the education of an audience ranging from illiterate farmer in village to housewives in suburbs. The basic task will fall on television and radio for the years immediately ahead. Radio and Television have an enormous educational potential. With the rise in literacy level, newspaper/magazines, and periodicals will become increasingly important as a means of disseminating information and understanding of the challenges, the humanity confronts on account of population growth.

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# **LAND AND SOIL—THEIR FORMATION AND BIOLOGICAL PROPERTIES**

**A.K. HAZRA**

## ***INTRODUCTION***

About one-fourth of the surface of our earth is occupied by the land. Soil can be said as the most important feature of the earth, as it plays the major role in determining the type and distribution of biomes. Besides influencing the types of vegetation, soil plays two other roles such as a source of nutrients and the incorporator of the food chain. Therefore, it would be useful to examine the basic processes involved in the formation of land and soil. The aim of this discussion is to show the complicated and a time consuming processes involved in the formation of soil as a valuable media, which now-a-days we are destroying by polluting them indiscriminately. It is essential to safeguard our land and soil from excessive pollution to keep the soil alive.

## ***FORMATION OF LAND***

Land forms develop through the combined influence of tellurically conditioned endogenous processes on one hand and solarly conditioned exogenous processes on the other. Because of these, complex mutual influences take place at the border of lithosphere, atmosphere and hydrosphere.

**I. Weathering and evolution of land forms :** Weathering is the break down and alteration of materials near the earth's surface. The processes involved in weathering are complex and can be categorized as (1) Physical or Mechanical weathering, (2) Biological weathering and (3) Chemical weathering. Many rocks are originally

formed at high temperature, high pressure and in the absence of air and water. Many kinds of alterations are possible : even a material that is an end product of weathering under one set of conditions may become the raw material of a weathering process under changed conditions. Basically there are three kinds of rocks (1) Igneous rocks formed by the hardening of various kind of lavas (granite), (2) Sedimentary rocks formed by the deposition of weathered materials derived from igneous rocks and (3) Metamorphic rocks which are formed from the exposure of first two kinds of rocks due to intense heat and very high pressure. The earth's crust comprises 95% igneous rocks and only 5% sedimentary and metamorphic rocks. The approximate proportions of mineral species exposed to weathering at the earth's surface are : Feldspar-30%, Quartz-28%, Clay minerals and Mica-18% Calcite and Dolomite-9%, Iron oxide-4%, Pyrozone and Amphibole-1%, and others-10%.

**II. Landforms made by rivers :** This is otherwise known as fluvial origin. Running waters in fixed channels are the most widespread agents working on earth's surface. Therefore, the landforms created are more important than those formed by other agents. Flow of water takes place in rivers under the influence of gravitation.

The following landforms are formed due to river system : (1) Meandering river, (2) Braided river, (3) Sand bar, (4) Channel bar, (5) Terraces, a. deposition, b. erosion, (6) Alluvial fans, (7) Point bars, (8) Meander cut off, (9) Chute cut off, (10) Natural lavae, (11) Back swamp, (12) Palaeochannel, (13) Flood plan and (14) Ox-bow-lake. (Figure 1)

**III. Glacial landforms :** Glaciers are masses of ice and granular snow formed by compaction of recrystallization of snow, lying largely or wholly on land and showing evidence of past or present movements. On the basis of size, shape and mode of occurrence the glaciers are classified as : (1) Alpine, (2) Piedmont and (3) Continental. The Greenland ice sheets about 5,100,00 feet in thickness at some places are enough to engulf entire mountain ranges and depress the earth's crust beneath their weight.

**IV. Aeolian landforms :** The wind acts upon the surface especially where it is dry and without vegetation, as the wind can sweep the fine

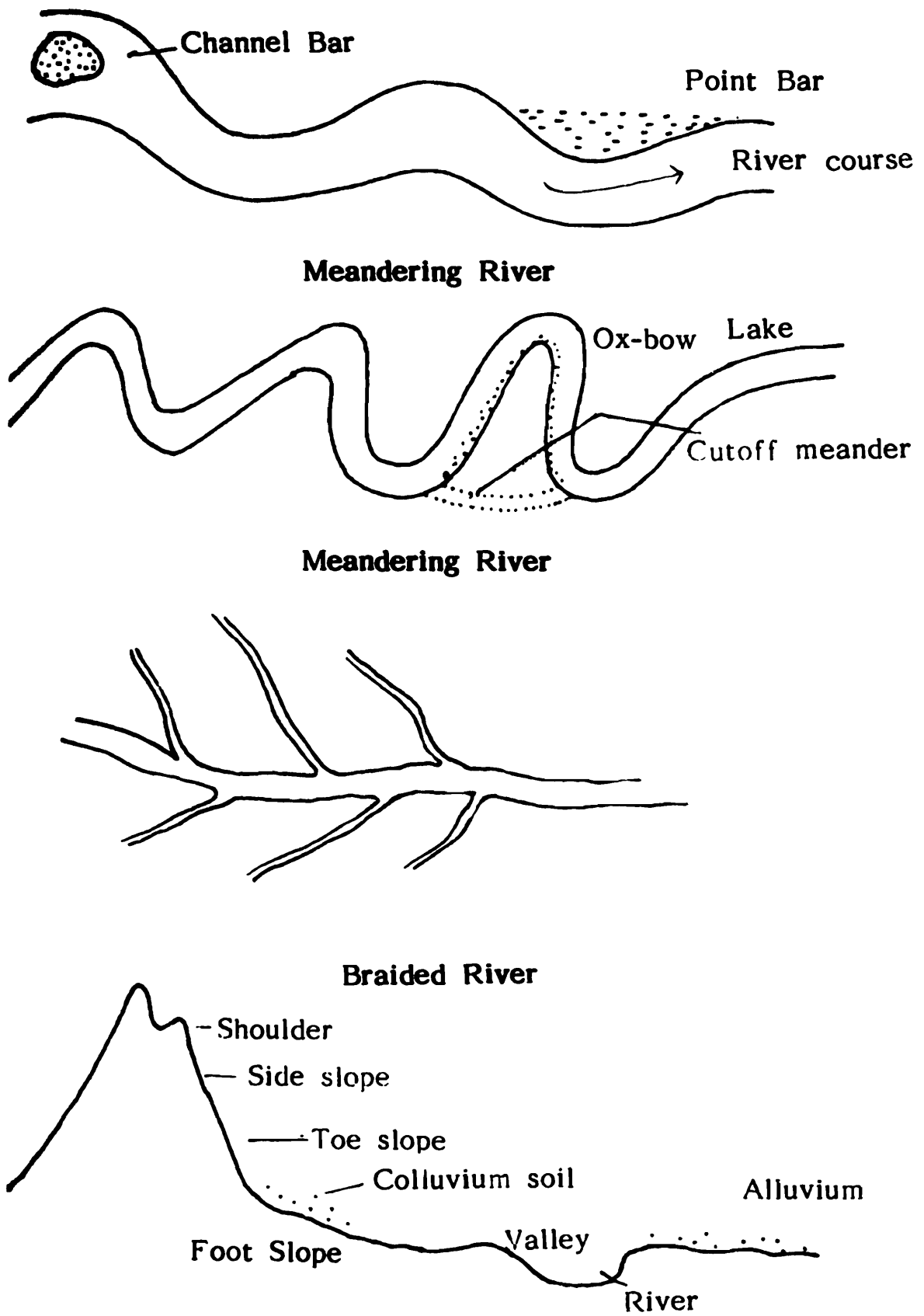


Figure 1 Landforms made by river systems

and loose materials and transport it. The difference between a landscape formed under the influence of water and one formed under the influence of wind is that the former is a landscape dissected by valleys and the latter is landscape with closed hollow forms. Water can only move down slope, whereas the wind moves in all directions.

### *FORMATION OF SOILS*

Soils comprise thin layers of earth's crust formed as a result of disintegration and decomposition of rocks as well as organic matter. If we pick up and examine a handful of soil, it appears inert and lifeless, but within every few grams of soil there may be millions of organisms, forming part of an active and complex web of life. Moreover, the soil forms an important part of the landscape, influencing and involved in the mechanisms of landscape development. It is similarly a major component of biogeographical systems, and is closely related to the growth and character of the vegetation. In addition, the soil is vital from agricultural point of view, and one of our main concerns is with the nature and maintenance of soil fertility. If we are to understand more clearly the way in which soil works—its relationship to the environment, its potential for exploitation by man, and its inherent sensitivity to interference and misuse, it is essential to know the formation of soil.

The soil genesis or the process of soil formation i.e. the transformation of rock material into soil, the soil formation can be expressed in a simple equation:

$$S = f(c, o, r, t, p)$$

Soil = function of (Climate, organisms, relief, time, parent rocks)

Climate and organisms are the active factors, but relief, time and parent rocks are passive factors.

$$\text{Climofunction} = f(c, o, r, t, p)$$

$$\text{Biofunction} = f(o, c, r, t, p)$$

$$\text{Topofunction} = f(r, o, c, t, p)$$

$$\text{Chronofunction} = f(t, c, o, r, p)$$

**Soils** are generally classified according to the degree of transfer of disintegrated parent material (transported soil) or which formed immediately over the parent rock (sedimentary soils). Transported soils are several kinds such as glacial, culluvial, alluvial, lacustrine (formed in bed of lakes), aeolian (by wind action).

**Soil texture** : Soil texture is defined as the relative proportion of sand, silt and clay in a soil material. The soil particles which are formed from weathering vary greatly in size. They are as follows :

1. Boulder	200 mm.
2. Cobbles	between 200 to 50 mm.
3. Pebbles	between 50 to 10 mm.
4. Gravel	between 10 to 2 mm.
5. Very coarse sand	between 2 to 1 mm.
6. Coarse sand	between 1 mm to 0.5 mm.
7. Medium sand	between 0.5 mm to 0.25 mm.
8. Fine sand	between 0.25 to 0.10 mm.
9. Silt	between 0.1 to 0.01 mm
10. Dust, mud and clay	0.01 mm.

The following textural classes are recognized depending up on the size of the particles most common in the soil :

1. Sand, 2. Loamy sand, 3. Sandy-loam, 4. Loam, 5. Clay-loam, 6. Sandy-clay-loam, 7. Silt and 8. Silty-loam.

**Soil profile** : The term used for the vertical section, generally up to a depth of 6 feet, to study soil in its undisturbed state and is made up of a succession of horizontal layers or horizons of varying thickness and differing in physical and chemical features. There are three distinct horizons—A, B and C (Figure 2), which are known as surface zone (A), sub-soil (B) and the layer next to the unweathered rock below (C). A and B horizons form true soil. Each zone has its own physical and chemical properties.

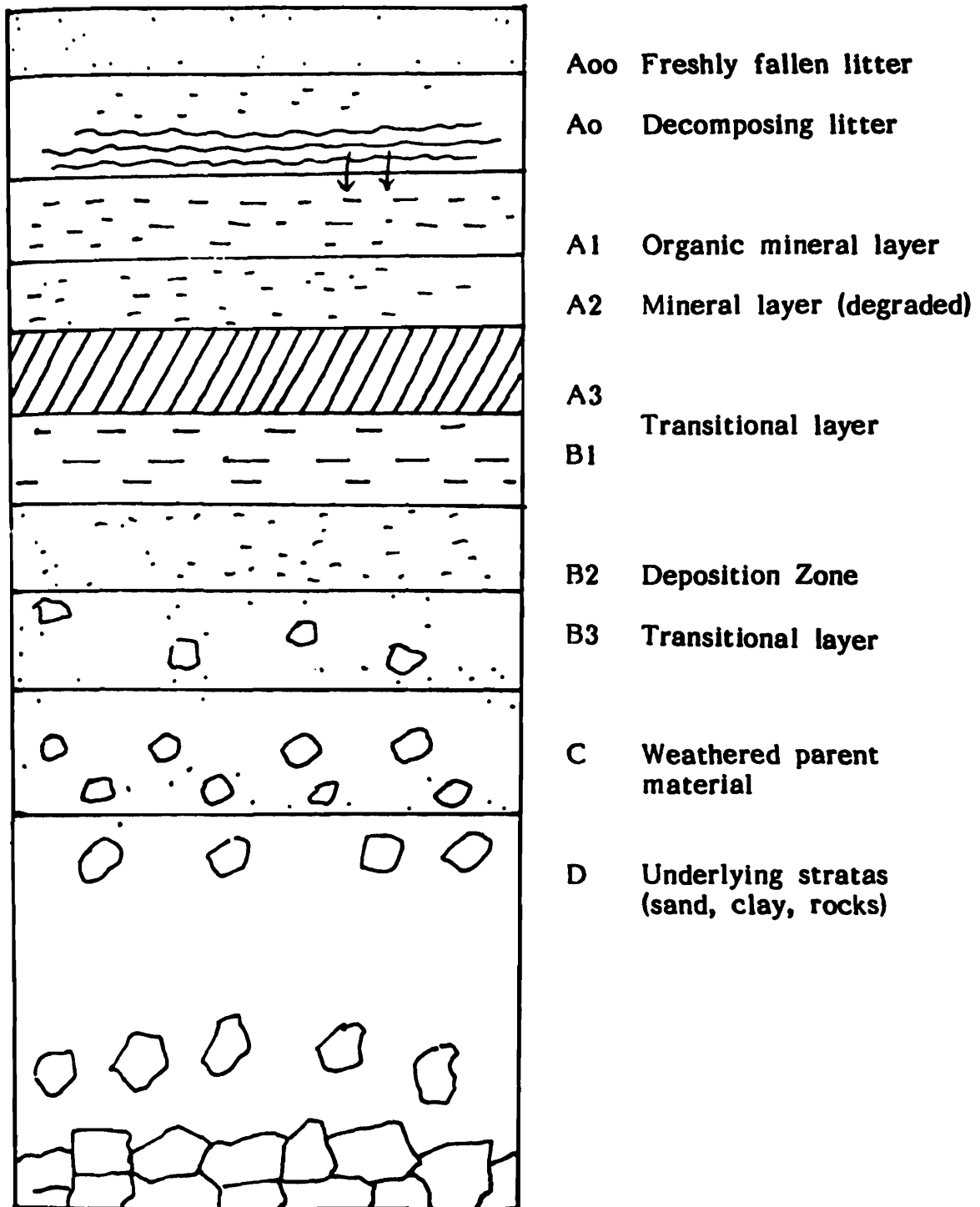


Figure 2. A Vertical Section of Soil Profile

The surface zone with undecomposed material is the L layer or **Fo** beneath which is the humus layer **AO**, composed of decomposing organic matter. Beneath this humus layer are varying number of layers of true soil. The dark coloured **A** layer with high organic content and **A<sub>2</sub>** below it consists of a light coloured layer often much leached. Below this is the **B** layer, dark coloured because of rich iron content, clay and humus, next to this is the **C** horizon, highly coloured and grading in to underlying parent rock. Such a soil nomenclature generally applied to the more acid soils (in the good drainage levels)- called *Podsols*.

When pH is low, microorganism activities are less. Generally under humid conditions soluble salts are leached away and this leached soils are termed *pedalfers*. The alkaline humus soil termed as *mull*, but crude humus giving acidic soils is called *mor* and the intermediate between these two is called *moder* soil. In the latter type of soil, maximum biological activities take place.

### IS SOIL LIVING ?

The answer is 'yes' A healthy soil is vibrantly active or 'alive' teeming with bacteria, fungi, moulds, yeasts, algae, protozoa, worms and insects living in the top soil. About 4 billion bacteria are estimated per/gm. of soil, and in good soils bacterial matter has been known to weigh about 56 lb/acre. More than 20 million actinomycetes occur in 1 gm. of dry soil. More than 200 species of moulds and fungi occur in the soil. The estimated number being one million fungi in one gramme of dry soil, their biomass per acre reaching 1,200 algal forms such as blue, blue-green, yellow and green occurring in high densities of 800,000 organisms/gm. of dry soil. What they do ? They help in soil aeration through release of oxygen, besides serving as food for other soil organisms. The varieties of living organisms present in the soil have been estimated as follows :

Group	Quantity
Bacteria	1,000,000,000/gm. of soil
Actinomycetes	5,000,000/gm. of soil
Protozoa	500,000/gm. of soil

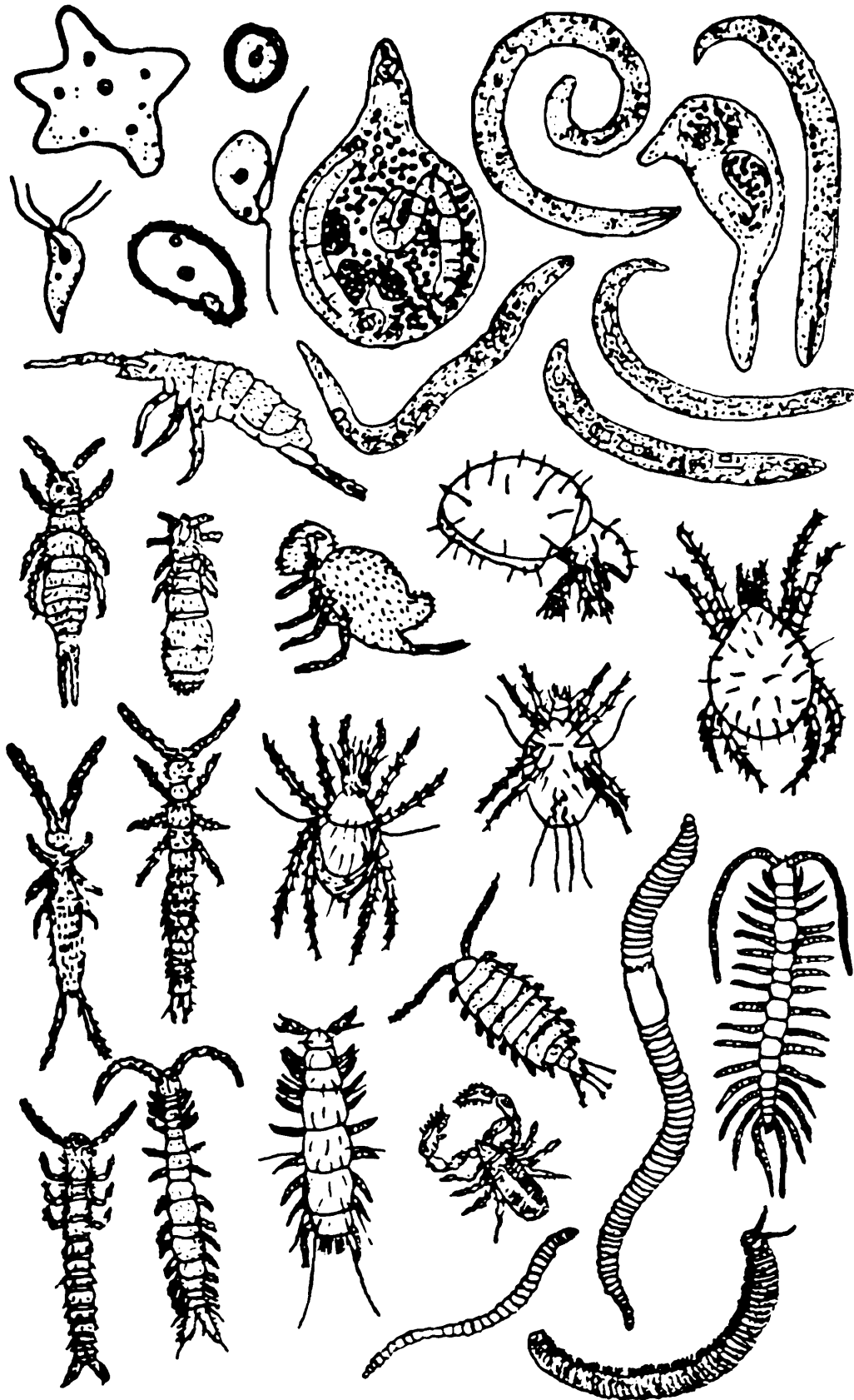
<b>Group</b>	<b>Quantity</b>
Algae	200,000/gm. of soil
Moulds	200,000/gm. of soil
Nematodes	175,000-20,000,000/acre
Molluscs	50,000/acre
Myriapods	1,000,000/acre
Annelids	1,000,000/acre
Arthropods	1,000,000/acre

*(After Southwick, 1976)*

### ***BIOLOGICAL PROPERTIES OF SOIL***

The biological component of the soil is extremely varied. It consists of both plant material and animals, living and dead. It includes the macroflora, the macrofauna and uncountable various species of micro-organisms. Besides these diversities of the soil biota, all these constituents are intimately interrelated. Actually the process linking them is the transfer of energy through the soil. It is well known that the energy is derived ultimately from the sun, but is fixed within the soil by autotrophic organisms i.e. the green plants by process of photosynthesis. This energy is then transferred in the soil, passing from one organism to another through a process known as food web. Some organisms, for example, obtain their energy directly from the autotrophic organisms, by eating the living plants. These herbivores may themselves be eaten by other organisms or carnivores. Thus, the original energy fixed by the plants is passed through the soil system. The close relationship between the various soil organisms, therefore, involves not only a transfer of energy, but also cycling of nutrients, and these processes are the very basis of the food chains within the soil. Each organism, therefore, obtains its food either directly or indirectly from neighbouring organism.

The soil organisms which are the constituents of soil biota can be classified on the basis of their size : Microfauna (0.20 mm), Mesofauna or meiofauna (0.2 mm–1 cm) and Macrofauna (more than 1 cm).



**MAJOR SOIL ORGANISMS**

Figure 3. Major Soil Organisms

It is observed from the foregoing account that the soil organisms are indispensable part of a living and fertile soil (Figure 3). Therefore, efforts should be made to adopt measures to prevent haphazard land use i.e. indiscriminate applications of pesticides, dumping of non-renewable garbage (polythene and plastic packets) and discharge of toxic industrial effluents on the land which otherwise will decrease the fertility and productivity of the soil—a disadvantage to Man.

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# **LAND POLLUTION**

**A.K. SANYAL**

## ***INTRODUCTION***

From time immemorial human beings are dependent on their external environment consisting of plants and animals, apart from land, water and air so essential to life. Land is the most important component of environment as most of the food consumed by man is grown on land. It is the soil that nourished the complicated ecological system of which man is a part. So our relationship with land goes beyond its use as a substratum for abodes, such as its productive purposes, namely agriculture and forestry, architecture, urban development, wildlife, recreation etc.

All over the world, air and water pollution have attracted much attention. The reason is that, the ill effects of polluted air and water become evident rather early. It is now adequately known that besides water and air, land is also being continuously polluted. Physical and chemical properties are being degraded, resulting in less production of food, fodder, fibre and shrinkage of habitable land.

The subject of land pollution can not be adequately discussed in isolation from water and air pollution. The pollution agents which contaminate the riverine systems as well as air commonly originate on land. On the contrary, water course carrying pollutants pollute the land through which they run and the air pollutants ultimately settle down on land.

## ***WHAT IS LAND POLLUTION ?***

The agent of any kind of pollution is a pollutant. The pollutant comprises of such solid, liquid or gaseous material which is not a part

of the natural ecosystem in any habitat and creates disturbances in the natural ecological balance and threatens healthy survival and renewal of the components of the environment. So the phenomenon by which the polluting agent singly or jointly degrades the productivity of the land, decreases the total usable land area and turn the land a source of pollution of other constituents, is known as land pollution.

Land is a living system with its self-replenishing property which is largely accomplished by myriads of soil fauna and microflora. The healthy soil must have pore space where water and air can circulate and there must be sufficient nutrients. Soil animals burrow in soil, produce a system of pore space and bring material rich in mineral nutrients. Soil animals and microflora also contribute to the chemical properties of soil through the process of decomposition of organic refuse. These living resources in soil are very much susceptible to pollutants.

### ***HOW THE LAND BECOMES POLLUTED***

All the activities of man are land based. Some of these activities generate pollutants and pollute the land. The important factors of land pollution are discussed below.

**A. Solid waste disposal:** Two major types of solid wastes are *municipal waste* and *industrial waste*.

(a). *Municipal waste* - In advanced countries and also in the metropolitan cities in India, refuse creates an acute environmental problem. The quantity of refuse produce per year in urban areas in India amounts to about 25 million tonnes. The studies in Calcutta have shown that this quantity is increasing at 1.5 percent per year. Removal of garbage costs several crores of rupees and composting is also rare. So the garbage is usually left lying in the open and cause unwanted occupation of land. The toxic material is also absorbed into the soil and kills soil inhabiting plants and animals. It also contaminates the surface as well as ground water. The refuse dump provides breeding ground for rats, flies and other disease carriers. It is also a source of poisonous gases which pollute air.

(b). *Industrial waste*—The industrial wastes containing toxic chemicals and heavy metals are in most cases dumped on land. The Sulphur dioxide and pulverized fly ash containing many trace elements, including arsenic, cadmium, chromium, mercury, lead, manganese, vanadium, fluorine and beryllium and other particulate matters are released from thermal power plants. Also the industrial and automobile emissions contain hydrocarbons, suspended particulate matters and metallic traces. All these toxic material settle on land and pollute it. The result is the disturbance in the biological acidity in soil and ultimately the land becomes unproductive.

The flooding of the land by industrial waste water containing unwanted chemicals and metals adversely affect the physiochemical properties of soil by killing the soil fauna and flora.

**B. Agricultural practices :** Man is dependent on agriculture from the Neolithic or New stone age, about 10,000 years ago. But only recently he has to change the conventional practices to modernize the system through irrigation and application of chemical fertilizers and pesticides to meet the growing demand of agricultural products. This is certainly a boon to the agriculturists but a bane to the land.

(a). *Unskilled irrigation*—Irrigation is certainly an essential practice in agriculture. But unskilled irrigation can cause serious problems like *waterlogging* and *salination*.

(i). *Waterlogging*—The canal water applied in the field is often far in excess of need. Due to lack of adequate drainage system the excess water is often logged in the field. Further, the canals and distributaries are usually not properly lined and they contribute to waterlogging through seepage. This results in rising up of water table up to or above the land surface and water stands for most of the year. The land which is permanently or periodically inundated by water and covered with vegetation like grasses and reeds is known as marsh.

Most of the major irrigation projects in India are re-

sponsible for waterlogging leading to damage to land. The well-known example in this respect is the 2,900 million Rupees worth project on the Tawa river in Madhya Pradesh. The badly built canals leaked and water flowed uncontrolled over the crops. The drainage system was also faulty and the result was waterlogging during cultivation.

In waterlogged land the pore space is filled with water and does not have enough air in it. Without the circulation of air, the oxygen level in the soil falls and carbon dioxide increases. The crops cannot grow on that land and the animals cannot survive there. It can be said that waterlogging turns healthy land into wet desert. The present estimate of waterlogged land in India is about 8.48 million hectares.

(ii). *Salination*—All water including rain water and underground water, contain dissolved salts mainly chlorides, sulphates and bicarbonates of calcium, sodium and magnesium. The lands brought under irrigation projects are affected by increased salinity because of the rising ground water table. Similarly in coastal areas the salinity of land is high due to periodic flooding and seepage of salt water. When the salt content exceeds 2,000–3,000 p.p.m. the water becomes toxic for most plants. Too much salt reduces the plant's capacity to absorb water.

The salt affected land is either saline or alkaline in nature. Saline land contains sufficient soluble salts—mainly sodium chloride and sodium sulphate. The saline soils are distributed throughout India and estimated at 5.5 million hectares. The land which contains excessive amount of sodium carbonate and sodium bicarbonate is called alkaline or sodic land. The soil is dense, compact and often with hard layer of calcium carbonate. In this hard soil plant roots can not grow and absorb nutrients. The alkaline soils are found mainly in the Indo-Gangetic plains and estimated at 3.58 million hectares.

(b). *Use of chemical fertilizers*—Indian soils are generally poor in plant nutrients particularly nitrogen, phosphorous and potash

(N, P and K). The recent studies show that some 7 million tonnes of N, P and K are used per year in India. The extensive use of chemical fertilizers is dangerous for the fertility of soils in long term. It particularly causes nitrate toxicity in soil which ultimately kills the fauna and microflora and pollute the ground water and water bodies.

(c). *Use of pesticides*—The discovery of toxic chemicals for management of animal and plant pests is certainly a blessing to farmers. But it is now being realized that the toxic chemicals or pesticides have some undesirable side effects and cause environmental pollution. Large amounts of pesticides reach the soil, either as direct applications, from fall out from aerial spraying, in rain or dust or from plant or animal remains which become incorporated with the soil. Thus soil acts as a reservoir for these toxic residues from which they move into the atmosphere, water or living organisms.

Of the 1000 pesticides which are in use in the world only nearly 250 are used in agriculture. The most common pesticide residues are either persistent inorganic chemicals, such as arsenic, copper or lead or persistent organochlorine insecticides. Among the pesticides normally used those which belong to the organochlorine group such as D.D.T., aldrin, dieldrin have attracted much attention and invited severe criticism for their adverse effects on soil.

Persistent insecticides in soil or forest litter may have a variety of adverse effects on soil fauna and flora as follows:

1. Serious disturbance of microbial activity in soil, affecting the soil fertility adversely.
2. Harmful effects due to killing of beneficial soil organisms such as predatory mites, centipedes and carabid beetles that prey on pests, and the myriads of invertebrates particularly earthworms, enchytraeid worms, collembola, diptera larvae and some acarina. All of these contribute to the breakdown of dead plant and animal organic matter, and thus ultimately increase the soil fertility.
3. Sufficient entry of toxic material into the systems of birds

and mammals through the food chain may acquire a lethal dose.

4. Sublethal effects on soil invertebrates through alteration of reproductive potential, behaviour and feeding habit.
5. The organochlorine insecticide residues seriously affect the growth of the crop.

The copper and mercury based fungicides have high toxicities and tend to remain in the soil. In higher concentration they can sterilize the soil and reduce the biological activity in the soil.

Herbicides have high residual toxicity. So repeated applications of herbicides result in harmful effects on soil fauna.

(d). *Shifting cultivation*—It is a traditional and popular method of cultivation in northeastern India. It is also practiced in the tribal areas throughout the country particularly in some parts of Orissa, Madhya Pradesh, Kerala and Andhra Pradesh. It is known as Jhum in Assam, Dahya in Madhya Pradesh and Podu in Orissa. Outside India e.g., in northern Burma, Sumatra, Borneo, New Guinea and the African continent similar cultivation practices are also known.

In this method of cultivation the forest is slashed and burnt. It adds to the mineral content of the soil, but it reduces the humus content in the soil. As a result the water holding capacity of the soil is lost and the biological activity is stopped. The productivity of the forest soils becomes poor and the shifting cultivators move on to a fresh patch of forest. The resulting exposure of the bare soil to rains and wind causes enormous soil losses through erosion, especially on hill slopes. After a few such cycles of cultivation on a particular hill slopes, the land is ultimately converted into a barren field. The recent figures show that over 4.35 million hectares of land are under the practice of shifting cultivation in India.

(e). *Over cultivation*—Intensive cropping removes the most important micronutrient elements like zinc, iron, copper, man-

ganese, magnesium, molybdenum, boron—these form only one percent of the weight of a plant but control various aspects of a plant's process.

**C. Deforestation :** The felling of trees causes less accumulation of organic matter. Due to absence of organic content soil loses its water-holding capacity and the soil organisms die. The other most important and adverse effect of deforestation is loss of nutrient rich topsoil due to erosion.

The National Commission on Agriculture estimated that India lost 3.4 million hectares of forest land due to various reasons between 1951 and 1972.

**D. Soil erosion :** Soil erosion is a natural and normal process, through which the earth's crust is constantly and gradually eroding away under the forces of weathering. This is geological or normal erosion and is extremely slow. But when human activities accelerate the disappearance of protective cover of natural vegetation and cause soil erosion, it is then called as accelerated or artificial erosion. The loss of top layers of soil through erosion turns the land unfertile, unproductive and wasted.

The most important types of erosion are gully and ravine erosion. When rain falls on land without stable vegetation cover, the rain drops mixed with soil flow down the slope and give rise to rills having a maximum depth of 3 metres. These steep slopes and undulating terrain are gullied land. The gullies are the first step of land dissection. They gradually become bigger and lead to the formation of ravines. So the ravines are the deep gorge containing systems of running gullies parallel to each other. The soil in the ravinous land is continuously eroded due to rainfall and the land becomes more deep. In India the growth of ravines is estimated to be 0.5 percent annually and total loss of land is nearly 8,000 hectares to ravines every year. Four million hectares of land in India have already been transformed into ravines. The top soil is also removed and flown away by wind.

An estimate in 1972 shows that the amount of soil lost due to erosion contained nutrients priced at Rs. 700 crores in that year

in India. It is also known from another report that total amount of soil washed away in India in every six months was higher than the amount of soil required to build brick houses during the period in the country.

Deforestation and overgrazing are the most important factors for soil erosion. Due to absence of stable vegetation cover on the land the soil becomes loose resulting in erosion of surface layers. Besides loss of nutrient rich top soil and/or formation of unproductive gullied and ravinous lands, the large quantities of soils washed or flown away are deposited in tanks, reservoirs, streams and river beds and reduce their water holding capacity, resulting in heavy flood.

**E. Overgrazing :** India with just a fortieth of the total land area of the world supports more than half of its buffaloes, 15 percent of its cattle, 15 percent of its goat and 4 percent of its sheep. This large number of livestock is the source of fuel, power, nutrition and raw material for industries. But these animals are underfed and malnourished as the fodder needed is not enough. Only about 13 million hectares in the country are recorded as permanent grazing lands. This amount is sufficiently less in comparison to the demand. The result is over grazing on fallow, uncultivated and forest lands. The absence of ground vegetation causes soil erosion, gradual depletion of soil organisms and ultimately the land is transformed into wasteland.

**F. Mining :** Mining causes land pollution both directly and indirectly. There are two methods of mining such as open cast mining and underground mining.

(a). *Open cast mining*—This method follows complete removal of top soil and other strata, called overburden for excavation and lifting of material. The result is the destruction of the whole land area, with large void and scars and loss of productive area.

(b). *Underground mining*—In this method the mineral is directly mined by making access to it through tunnel. The roof of the underground passages is supported by timber and pillars of ore. When the mine is abandoned the timbers are removed and depil-

**laring is done.** This leads to subsidence of land, making the whole area a big depression and it becomes a wasteland.

In both the mining operations the ore is deposited at site adjacent to the mine. It causes unwanted occupation of land. Further, the mining wastes dumped on the land are washed out to the adjoining agricultural fields and pastures. The debris blocks drainage channels resulting in waterlogging. The waste material often hardens on drying turning the fields infertile. Much of the mining activity is carried out in forested areas. Mining operation needs deforestation and the obvious result is land degradation followed by erosion. Unless proper measures are taken, mining activities in hilly areas cause landslides.

The loss of agricultural land due to mining of building sand and brick clay is a serious menace in India and other countries. Valuable agricultural lands have already been wasted in Mogra-Pandua belt of Hooghly district, West Bengal for mining of building sand. Use of agricultural land for brick fields is also universal. Bricks made of nearly 120 tonnes of soil are needed to build a modest house of five members. So for 156 million of urban population in India nearly 300 million tonnes of soil, mostly top soil, would have to be excavated.

**G. Radioactive fallout :** The explosion of nuclear bomb releases nuclear elements which become attached to tiny particles of dust. Eventually, the contaminated dust falls to earth, often in rain or snow. These deadly products pollute soil to a great extent. It considerably reduces the productivity of the soil through eradication of microfauna and microflora. It also affects the higher plants and animals, including man.

### ***HOW TO SOLVE THE PROBLEM OF LAND POLLUTION***

Land is the most fundamental natural resource. The land pollution affects people in a number of ways, leading to acute scarcities of food, fodder, fire wood, organic fertilizer, small timber, industrial wood, herbs and medicines and water.

With a population growth rate of 2.2 percent in India the population will be nearly 1000 million in the year 2000. So it is the high time to take measures to check land pollution and reclamation of polluted or wasted lands. To prevent land pollution, actions in the following lines can be taken up.

1. Recycling of wastes.
2. Rational utilization of irrigation water and proper planning and management of irrigation projects.
3. Maximum use of organic manure.
4. Use of non-persistent pesticides.
5. Change of cultivation pattern in hilly areas.
6. Restoration of forest lands.
7. Building of protective bunds and plantation of trees to reclaim ravinous land.
8. Areas not suitable for agriculture and kept fallow can be moderately developed for cultivation of fodder and fuel-wood.
9. Use of modern technological devices to reduce emission of pollutants from industry, automobiles etc.
10. Reclamation of land wasted due to mining by extensive plantation programme.
11. Planting of selected tree species for reclamation of different kinds of wastelands.
12. Programmes like ecodevelopment camps to create awareness for conservation among people.
13. Strict implementation laws to protect environment.

### **CONCLUSION**

A satisfactory and lasting solution of the problem of land pollution, a source of pollution of other components of environment, requires understanding, active effort and cooperation of all nations of the world. The governmental and non-governmental agencies of different countries including India have already taken definite and con-

crete steps to minimize these hazards. The government of India has constituted in the year 1985 the National Wastelands Development Board in the Ministry of Environment and Forests. The non-governmental organizations in India are also being patronized by the Central and State governments. They are already in the field to develop the polluted lands through technical help and making the people aware of the problems. Let us hope for the best and it is sure that the crisis is not yet so bad and we will certainly be able to make a healthy environment of our own and for the future generations.

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# WETLANDS

S.Z. SIDDIQUI

Often closely associated and indeed related to *lentic* (Standing) and *lotic* (Flowing) water ecosystems, there exists a more fertile and productive ecosystem—the Wetlands. Simply stated, wetlands are areas where water is near, at or above the level of land. Biologically, they are among the most fertile and productive ecosystems. Indeed, Maltby, a noted authority has rightly named them 'Water-logged wealth', waiting to be tapped for their immense potential as a productive ecosystem.

Their biological significance apart, wetlands are essential life-systems playing vital role in regulating water cycles (hydrological cycle) and cleaning the environment. Further, by effectively absorbing the flood water, they act as effective barrier against sudden surge of storm waters, containing its havoc and protecting coastal belts from seasonal inundation (floods).

The traditional general belief that wetlands are sheer wastelands, therefore, needs serious review; so also man's attitude to wetlands. Wetlands are the most fertile and productive of all ecosystems in the world. They are of environmental importance, especially when left to their own. According to Maltby, wetlands are capable of producing about eight times the plant (organic) matter on an average in a wheat field, promising large food harvests if only their soil fertility can be harnessed through prudent conservation and management. The potential of coastal wetlands in supporting premium fisheries (pisciculture and prawn fishery) needs no emphasis.

Unfortunately, the immense biological import and crucial environmental role the wetlands play have been far from realized by the

scientific community and public alike. Wetlands, therefore, are the first casualty in the name of development. They are destroyed, wiped and eroded through filling and or draining for various developmental needs. The Sunderbans delta in West Bengal is unique in that it is the longest remaining contiguous area, spanning near a million hectare area in the Gangetic delta. Not surprisingly, it accounts for over 80% of Indian fisheries in the Ganga-Brahmaputra estuary (Maltby, 1986). The world's longest delta holds a unique wetlands complex playing hosts to a number of significant ecosystems—the dense brackish water forest, the mangroves or mangrove system and others. It is also the home of the famous Royal Bengal Tiger, affording the beast its biggest natural habitat. In addition, it also plays host to a number of species of mammals, reptiles and amphibians and lower forms of animal life, for mangroves are a crucial link in an ecological chain. No less significant are the wide varieties of timber products and livelihood it generates on the commercial front.

Sadly, like other natural ecosystems, wetlands too are fast facing a threat and general deterioration following the onslaught of development in not only developed countries but the trend continues unabated in the third world nations. In the U.S. alone, wetlands measuring around 1,85,000 hectares were lost between 1950-70. The wetland losses all around the globe are, therefore, on the increase and they are being continuously destroyed in the developing countries by draining and converting them into agricultural land to feed their teeming populations. No less damage results from expansion of ports, indiscriminate setting of industries along the coast line, land reclamation for housing or developmental needs in metropolises and discharge of waste and industrial effluents with total disregard to ecological considerations.

### *THREAT TO WETLANDS*

Nearer home, it is not surprising to find the unique, notable Sunderbans in West Bengal languishing and longing for prudent conservation and management. There are also forests being threatened, since, during the lean or dry period, discharges down the river Ganga stand drastically reduced following constructions of barrages (Farakka Barrage), irrigation dams and large-scale groundwater obstructions (drawl) (Maltby, 1986). No less different has been the case

of mangrove ecosystem. The real environmental impact and biological utility of the wetlands including the mangroves has not been made public in the right perspective to the lay or the elite. Wanton destruction of these unique ecosystems are fraught with serious repercussions. The high price that Bangladesh pays in terms of colossal loss of human lives and crops due to indiscriminate conversion of mangroves to agricultural land is no grim reminder. With huge loss of mangrove, Bangladesh is fast losing its once natural barrier to tropical storms facing recurrent devastations from cyclones.

### ***RAMSAR CONVENTION, IRAN 1971, WWF & IUCN***

The first large scale endeavour to educate public about the impact of wetlands was initiated jointly by Worldwide Fund (WWF) and International Union for Conservation of Nature (IUCN) in 1985. Earlier, International Conservation on Wetlands in Ramsar, Iran, 1971 had called upon its signatories to initiate efforts to conserve wetlands as a planning priority through prudent conservation and management.

Happily, man and society's attitude to wetlands are changing and the day is not far off when society will learn to reap harvest from wetlands, one of the most fertile, productive ecosystems in the world.

### ***CLASSIFICATION OF WETLANDS***

By their very nature, wetlands are intermediate in structure and composition between terrestrial and aquatic ecosystems. They, therefore, exhibit some basic characteristics of each. A good many types of wetlands exist the world over and as with the classification of any other systems, there exist inherent problems in their classification (Sather, 1976). Nevertheless, an older but useful classification is followed (Shaw & Ferdine, 1936).

Wetlands dominated by emergent vegetation, with roots always under water and leaves above water are marshes. Growing of reeds, sedges, grasses, cattails and marshes are essentially wet prairies, developing along margins of lakes in shallow basins with an inflow or outflow of water and along slow moving rivers and tidal flats.

Wetlands retaining considerable water and accumulating partially decayed organic matter are peatlands or mires. Wooded wetlands are swamps and may be dominated by such trees as cypress, tulips and swamp oaks or by shrubs like alder or willow. Shrubby swamps are known as Carrs.

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# FRESHWATER POLLUTION

S.Z. SIDDIQUI

Ironically, our freshwaters are most vulnerable of all habitats of Man, and indeed society, at large, has taken this precious natural resource for granted, using and abusing it to an unprecedented scale and magnitude. Only lately has realization gained ground that man and society should learn to treat this scarce resource with prudence.

This albeit slow change in attitude is not without reasons. Solar energy and water, above all else, are the prime resources so crucial to sustenance of life support systems on earth. No civilization has prospered without ample water around it. Indeed scientifically speaking, history has been shaped by water such as the great Indus Valley Civilization (arose on the banks of river Indus) and Mesopotamia (on rivers Tigris and Euphrates). When water ran out or became scarce, civilizations extinguished. A more recent case fresh in memory is the unprecedented drought in Ethiopia (Africa) that brought in its wake disaster and crisis, threatening the very human survival, despite all world aid.

On the biological scale or front too, water was crucial in the evolution of life. The complex biochemical systems of all living organisms are inherently built for functioning in an aqueous medium. On a more higher evolutionary level, even to this day, all developed societies reflect their inherent dependence on water in an interesting parallel manner. Down on the individual scale, we all use on an average  $5\text{m}^3$  (cubic metres) of water per day, i.e. above 6 times the volume of our own body. Indeed the quantity of water used by a nation or society affords an index of development advance—developed nations consuming more water than less developed ones. Not surprisingly, we also have on the global scale ‘water rich’ and ‘water poor’

nations, about 13 each, with Canada and Malta topping the lists respectively. The Sub-Saharan Africa and Middle East countries have chronic water shortage and often in an interesting parallel most water poor countries also are the one falling under the hunger belt on a global scale. Availability of water, therefore, is a very critical developmental input.

Of the total water volume on the planet's ecosystem, about 1.4 billion km<sup>3</sup>, over 97%, is ocean water unfit for human use. The balance, a mere 3% of the earth's water, is freshwater and further analysis of this vital component makes interesting reading. Of the total 3% of earth's fresh water, 72.2% is locked in cold storage, frozen in ice caps and glaciers—Antarctica, for instance, is also a good reservoir. The remaining fraction—22.4% is ground water and soil moisture. This leaves a further meagre fraction—0.35% as freshwater that is contained in lakes or swamps the world over and a little less than 0.01 percent in rivers and streams. This critical analysis makes at once clear the stark fact that our freshwaters are a limited resource and in ecological parlance they have been often rightly regarded as finite resources. Unfortunately, unlike some of our other natural resources, freshwaters can be augmented only marginally (through desalination, at a tremendous cost). In India, Tamil Nadu is contemplating this measure (Saline water conversion) to tide over the series of droughts it is facing in recent years.

Freshwater-use by societies or nations may be broadly categorized as : i) Irrigation, ii) Industry, and iii) Public use (drinking water and sanitation). As a result the earth's resources continue to be severely taxed, resulting in serious degradation of water quality. Some major environmental impacts resulting from irrigation are general salinization (increase in salinity), alkalization (alkaline soils) and waterlogging of fertile agricultural land resulting mainly from improper design or execution of major irrigation projects. Yet another damage from irrigation projects in major river-valleys is the loss of precious forest, associated flora and fauna and related environmental problems.

Modern civilization has an uncanny way of imposing heavy demands on water and in fact on all fresh-water resources. One basic type of water pollution quite rampant in developed and developing countries is the pollution caused by discharge of untreated or inade-

quately treated waste waters into their rivers, lakes and reservoirs. Our lakes and reservoirs readily serve as 'sinks' for discharging products of human activities in their catchment and we unwittingly regard rivers as 'nature blessed drains' for eventual removal of water to the final discharge point—the sea. The wanton discharge of untreated, domestic, municipal waste waters, industrial effluents, toxic chemicals and pesticides into our rivers and lakes taking for granted their self-purification (Homeostasis) ability, has led to serious organic (biological) and industrial pollution—the two major/basic types of water pollution plaguing the developed and developing nations the world over. The third world nations such as India, China, Indonesia, Tanzania and Kenya face serious industrial pollution of their freshwater ecosystems.

While industrial pollution possesses a variety of problems in view of its inherently complex nature, the discharge of untreated sewage (estimated at 33 m<sup>3</sup> per day in India) together with sullage from town and cities is no less alarming, causing organic (biological) pollution responsible for spread of water-borne diseases (diarrhoea, typhoid fever, intestinal helminths, cholera, jaundice, etc.). According to a recent report (NEERI, Nagpur), over 70% of our waters are polluted, being, in turn, directly responsible for more than 15 lakh infant deaths per year in India alone. In fact, according to a WHO report, over 80% of illnesses in India can be prevented if safe potable water is made available.

River Ganga offers a classic case where these twin maladies assume gigantic proportions, each outstripping the other in scale and magnitude. The main sources of pollution in Ganga are the urban and industrial liquid wastes flowing in from 52 major cities and 48 towns in UP, Bihar and West Bengal. The Ganga Action Plan (GAP) is a matching response to cleanse Ganga at a cost of about Rs. 300 crores.

### *EUTROPHICATION*

Yet another malady, less discerning to a casual observer but potentially more forbidding is the increasing eutrophication trends plaguing our freshwater resources—the lakes or reservoirs. In contrast to the industrial pollution (concerted/discrete), eutrophication results mainly from surface run-offs from forests in watershed (catch-

ment) areas of the river, fertilizers, pesticides run-off from agricultural fields, etc., and above all from the whole gamut of anthropogenic activities resulting from human usage.

In nature, eutrophication or simply the loading (input) of nutrients in an aquatic ecosystem—river, lake or swamp, may be classified as natural (resulting from processes, not initiated by man's activities) or artificial or cultural eutrophication (result of man's activities). Further, eutrophication (simple or nutrient loading) results both from autochthonous and allochthonous loading and encourages growth of nuisance algae and other macrophytes (plants/weeds) gradually transforming the lake into a swamp. Indeed, one singular factor behind increasing deterioration of water quality of our inland waters (rivers and lakes) is their ever increasing or accelerated enrichment (nutrients loading), attendant mass growth of nuisance algae (algal blooms), increased productivity (fertility) and such undesirable changes which influence the overall water quality of the system. In the final stages, eutrophication not only affects the growth of biota (living organisms)—replacing 'clean water species' by 'pollution-tolerant species', but also gives rise to appreciable hydrobiological problems, influencing storage water quality of potable waters, propensity for borne diseases, fish yield, etc.

### ***WATER POLLUTION CONTROL MEASURES***

For well past a century, water pollution control measures for the treatment of domestic, municipal wastes (sewage) have been based on two principles : (i) infinite dilution of wastes and (ii) sewage treatment. The latter may be divided into (a) Preliminary treatment, (b) Primary treatment (sedimentation), (c) Secondary (Biological) treatment and (d) Tertiary treatment. However, the treatment of wastes emanating from different industries or industrial processes is not simple in view of the inherently complex nature of their effluents (Dairy, Distillery, Paper and Pulp, Tannery, Food Processing, Paints, etc., to quote a few). Their waste water treatment calls for specific low-cost technology for not only treatment (breakdown) but also for waste-water recycling, biogas generation, fodder/manure, land irrigation or waste-water farming (sewage-fed fish culture). Ironically, water pollution control measures on a cost-benefit scale are extremely prohibitive.

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## AIR WE BREATHE

R.A. KHAN

Air, water, land, flora and fauna—are the five basic constituents of the Life Support System on the earth and they are mutually inter-related, interconnected and interdependent, and form the intricate balance of the nature. Deterioration in one inevitably affects the other four constituents. Man has realized since time immemorial that he is inseparable from this system of nature. However, in his eagerness or we may call it selfishness and greed, he has been constantly and indiscriminately exploiting the various constituents of this system and destroying this intricate balance for petty short term gains with no realization of future consequences. The problem was not severe as long as the population was primitive and small, and needs were limited as natural recovery of the balance took place without significant impact. With the advent of civilization and enormous increase in population during recent decades followed by industrial, technological, agricultural and medical revolutions, the system or environment has so vigorously been exploited that the natural recovery could not keep pace with the destruction processes. Man has not only destroyed the plant cover built up meticulously by nature over millions of years but also polluted the air which he breathes, the water which he drinks and the land on which he lives and obtains his food.

Air, which he breathes, is one of the most important constituents of the life support system and is available in plenty in the atmosphere. Man—as a matter of fact, most of the living beings—can live several days without food and water, but only for few minutes without air, because lack of vital component of air—oxygen—for more than five minutes causes irreparable damage to brain and consequent death. Air constitutes nearly 80% by weight of man's daily intake and he breaths 22,000 times a day. Therefore, the air—clean and un-

polluted—is vital for the survival of animals and plants and human beings.

The normal composition of the dry air at sea level is : Nitrogen 78.03%, Hydrogen 00.01%, Oxygen 20.99%, Carbon-dioxide 00.30%, Methane and other inert gases, in minute quantities.

The presence of any other solid, liquid or gaseous substances in the atmosphere in certain quantities, characteristics and durations as to make it actually or potentially injurious to human being, animals and plants constitute the **pollution of the air**. It has been worked out that the maximum rate of air contamination acceptable to man is 1:3000.

### ***SOURCES OF AIR POLLUTION***

The hazards and nuisance of air pollution in urban and industrial areas have been recognized in varying degrees for quite some times. It is contributed by domestic, power, industrial and automobile sectors. Burning of low grade coal in power, industrial and domestic sectors is by far the greatest source of pollution followed by automobile exhausts. The fast expanding petrochemical, fertilizer, pesticide, synthetic fibre, metallurgical, pharmaceutical, ceramic and other chemical industries are also continuously adding huge amount of toxic pollutants in the atmosphere. However, the recent studies have shown that the worst kind of air pollution problem could be the wood-smoke inhaled by poor rural women while cooking.

### ***AIR POLLUTION — INDIAN SCENE***

The problem of air pollution in India is of recent origin, and therefore much detailed informations are not available on its quantum and impact. Different estimates have been given by different workers. As per NEERI report (Sunderesan, 1982) some 23.5 million tons of air pollutants are emitted annually, out of which 63% is contributed by industries, 29.82% by domestic sectors and 6.76% by automobiles. Rao (1985) reports that about 800 to 1000 tons of pollutants are ejected into atmosphere daily in big cities, out of which 50% is accounted by automobiles, 15-20% by domestic sectors and rest by industries.

By now it has been definitely realized that air pollution is increasing rapidly in the country and has already attained serious dimensions in certain big urban centres like Calcutta and Bombay. In these cities large number of industries are located near densely populated areas. These industries along with the pollutants generated by large number of people cooking on coal or wood have already posed serious problems of air pollution. Calcutta has acquired the reputation of "highest polluted urban centre"

Reports of frequent gas leak and high intensity of unbearable contamination of air in Chembur area of Bombay have become a regular feature. Chembur, on account of two big oil refineries, a big chemical and fertilizer factory, five thermal power plants and huge industrial complexes, is perhaps the most industrially polluted area of the country and has earned the name and fame of 'Gas Chamber'

Industrial complexes elsewhere have also been planned and located in adjoining residential or sensitive areas without realizing future consequences. Recent Bhopal tragedy, where a pesticide factory released accidentally huge quantities of highly toxic Methyl-Iso-Cyanate gas, killing more than 2000 people and injuring many more, is a glaring example of such faulty planning. According to some experts, the location of Mathura refinery near Taj Mahal is also not a wise decision as it is likely to cause damage to the monument. Sulphur-dioxide liberated may increase the acidity from 100 to 200  $\mu\text{g}/\text{m}^3$  and may cause stone cancer to Taj, if proper control measures are not adopted.

As already stated, the burning of low grade coal in both industrial and domestic sectors causes severe pollution. The thermal power plants are by far the biggest consumers of the coal. The country needs power immediately and increasingly turning to superthermal power plants served by captive coal mines. These superthermal power plants (STP) under implementation are :

<i>Place</i>	<i>Ultimate target (MW)</i>	<i>Investment (Crore Rs.)</i>
Singrauli	2000	1332.2
Korba	2100	1635.8
Ramagundam	2100	1885.1

<i>Place</i>	<i>Ultimate target (MW)</i>	<i>Investment (Crore Rs.)</i>
Farakka	2100	610.4
Vindhyachal	2260	1110.4
Rehand	3000	1033.0

(Source : N T P C)

The availability of low grade coal in certain areas and transmission facilities have prompted the concept of 'Energy Parks'—cluster of high transmission lines around a central reservoir. Rehand reservoir is one such example where five big thermal plants have come up or are coming up with ultimate capacity of more than 7000 MW, in area of 30 sq km.

<i>Place</i>	<i>Target</i>	<i>Agency</i>
Singrauli	2000 mw	NTPC
Vindhyachal	1260 mw	NTPC
Rehand	1000 mw	NTPC
Anpara	3130 mw (ult.)	UPSEB
Renusagar	185 mw	BIRLA
Obra	—	UPSEB

(Source : *The state of India's Environment 1984-85*)

These power plants generate multiple pollution. Open cast coal mines produce huge clouds of coal dust. The burning leads to production of enormous amount of sulphur-dioxide and fly ash leaving residual ash.

Domestic sector also contributes significantly to air pollution in both urban and rural areas. The large number of coal *chulhas* in Calcutta add miserably to pollution of the air which is visible in almost every locality. 90% of household in India, specially in rural areas, use firewood and cowdung cake as fuel. The smoke filled huts in countryside are a common feature. The use of inefficient *chulhas* in poorly ventilated kitchens has created considerable health hazards. The

burning of cooking fuel envelops the indoor environment with heavy smoke and women who have to do all the cooking may be daily exposed to more pollutant than even industrial workers in extremely polluted conditions on extremely polluted days. A recent study carried out by East-West Centre of Hawaii in Gujarat villages revealed shocking results. It reports that average exposure of women to Total Suspended Particulate (TSP) in their cooking period ranged from 1110-56600 with an average of 7000  $\mu\text{g}/\text{cum}$  as compared to 260 and 120-160 as recommended in US and by WHO respectively (for 24 hrs.). The proposed Indian standard for industrial workers (8 hrs.) is 500  $\mu\text{g}/\text{cum}$ . The highest levels are noticed during monsoon months when all ventilations are closed. The estimation of benzo(a)pyrene (BaP), a carcinogen compound in cigarette smoke is also shocking. The BaP concentrations were found to be 3850  $\mu\text{g}/\text{cum}$ . The average exposure time of three hours in Gujarat village was equivalent to smoking roughly 20 packs of cigarettes per day in terms of BaP (20  $\mu\text{g}/\text{cigarette}$ ).

The increasing number of automobiles in metropolitan cities and some other urban centres have considerably added to air pollution. The last two decades have witnessed enormous growth of road transport. A decade ago road transport hauled 77 billion freight km and 250 billion passenger km. Now the figures must have tripled. The emissions from these vehicles contain huge amount of toxic substances like Carbon-monoxide, hydrocarbons, oxides of Nitrogen and Sulphur and aldehydes. The typical and (maximum) composition of exhaust gases from a petrol driver vehicle is as follows.

CO	30,000 (135,000) ppm
Aldehydes	40 (300) ppm
SO <sub>2</sub>	60 (80) ppm
Hydrocarbons	5,000 (40,000) ppm
Oxides of Nitrogen	600 (2,000) ppm

*(Source—American conference of G.I.H.)*

The concentration of pollutant gases in diesel vehicles is far less. Though the number of vehicles in India are far less than in developed countries (1,251,360 in 1980, majority in few urban centres), emissions are significantly high. This is due to (1) Low grade fuel,

(2) overaged and poorly maintained vehicles, (3) defective engine performance, (4) multiplicity of fast moving and slow moving vehicles on same road and (5) traffic jams due to narrow carriageways and lack of traffic planning. The last factor has added considerably to the problem of Calcutta and Bombay. It is observed that average concentrations of CO at traffic junctions of these cities is around 350 ppm. In Delhi some 400 tons of pollutants are emitted by 50,000 odd vehicles daily which amount to 34% of total smoke and dust emitted in the city.

In Calcutta, a survey carried out by NEERI some time back revealed the following results :

Suspended particulates	560 tons/day	44%
Carbon monoxide	450 tons/day	34%
Sulphur dioxide	123 tons/day	9%
Hydrocarbons	102 tons/day	8%
Nitrogen (Oxides)	70 tons/day	5%

(Source : NEERI Survey 1979)

A recent study on the ambient air quality in selected urban centres in India revealed that the concentrations of SPM and SO<sub>2</sub> were highest in Calcutta. In respect of SO<sub>2</sub>, Bombay was next, followed by Kanpur.

### **AIR POLLUTION IN CALCUTTA**

A separate study reports following concentrations of pollutants in Calcutta atmosphere.

CO	35	mg/cum
SPM	340.7	mg/cum
H <sub>2</sub> S	0.052	mg/cum
SO <sub>2</sub>	32.9	mg/cum
Oxides of Nitrogen	0.017	mg/cum
Other comp.	0.023	mg/cum

**PAH (POLYNUCLEAR HYDROCARBONS)  
INDEX 0.20**

The SPM carry a large number of toxic metals. Like other places, the automobile exhausts form the major pollutants. A few years ago the report of the motor vehicle deptt. revealed that there are 250,000 vehicles plying on 2,000 km of the city's roads.

On the basis of the pollution level, the city may be divided into a number of zones :

<i>Zone</i>	<i>Pollution index</i>	<i>Localities</i>
1. Pollution-free zone	0-14	Residential areas of Ballygunge, Salt Lake, Alipur.
2. Comparatively clean zone	15-20	Lake Town.
3. Tolerably Polluted zone	21-24	Park Circus, Entally, CIT, Garia, Maniktola.
4. Considerably polluted zone	25-30	Kasba, Dhakuria, Jadavpur, Taratala, Hyde Road, Esplanade, B.B.D. Bagh.
5. Highly Polluted zone	31-40	Shyambazar, Dum Dum, Bhowanipur, Cossipore, Sova Bazar, Tollygunge, Behala, Kidderpore, Watgunge.
6. Alarmingly Polluted zone	above 40	Burrabazar, Beliaghata, Garden Reach, Paharpur, Sealdah and Tangra.

**TYPES OF AIR POLLUTANTS**

Primary pollutants which are emitted from industrial, power, domestic and automobile sectors, chiefly consist of (1) suspended particulate matter (SPM), (2) Sulphur dioxide (SO<sub>2</sub>) and other Sulphur compounds, (3) Carbon-monooxide (CO), (4) Oxides of Nitrogen, (5) Hydrocarbons, (6) Fluorides and (7) Heavy metals and other toxic gases.

Some primary pollutants get themselves manifested in the atmosphere by the action of solar radiation to form more hazardous photochemical pollutants. Weather plays an important role in increasing the impact of primary pollutants, by forming the smog. Finer particulate matters get mixed with air and form aerosol, which remains suspended in air for quite long time. SO<sub>2</sub> reacts with water vapour of the atmosphere and culminates in acid rain.

### *Suspended Particulate Matter*

It rises chiefly from the burning of coal in the form of smoke and fly ash, followed by mining operations and dust storm. In India it constitutes the major part of the air pollutants. As compared to some developed countries, Indian atmosphere presents a different picture. The SPM and SO<sub>2</sub> ratio is 4-5:1 as compared to 1-1.5:1 in other countries. It has been estimated that out of some 2.2 million tons of fly ash produced, nearly 1/3 goes in the air.

SPM contributes nearly 560 tons daily in Calcutta. The sampling of air quality in some other parts of South Bengal areas revealed that its level always exceeds the standard annual mean of 7 µg/cum (EPA). It chiefly consists of Silica, Alumina, Oxides of iron, Titanium, Sodium, Calcium, Magnesium and Phosphorous. Besides, there are trace metals like Arsenic, Beryllium, Vanadium, Selenium, Lead, Zinc, Mercury, etc. These are more harmful. The size of SPM varies from 2 (or less) to 20 (or above)µ. The finer particles take considerably longer to settle, or even do not settle at all and form aerosols. The importance of aerosols in the modification of climate and heat balance of the earth has well been realized.

**Sulphur-dioxide** : This is produced by combustion of fossil, like coal and petroleum, all of which are sulphur compounds, smelting of sulphur ore and metallurgical operations. The other sulphur compound, Hydrogen Sulphide is produced by the biological decomposition of organic wastes. Besides, petroleum refineries are also of SO<sub>2</sub>. About 2.1 million tons of gas were said to have been released into the atmosphere in 1979 by refineries.

SO<sub>2</sub> is readily soluble in water. It acts with the vapours of the atmosphere and forms sulphurous and sulphuric acids and precipitates as ACID RAIN, which has caused far greater hazards than any

other pollutant in certain parts of the world, specially Scandinavia and Canada, which periodically face problems from the pollutants generated and released by Britain, Germany and U.S. respectively. The strange aspect of the acid rain is that the culprit is in one locality and the sufferer in another, because pollutants are carried away by prevailing winds elsewhere, where it precipitates. Acid rain knows no geographical boundaries. 90% of the acid rain of Norway and 75% of Sweden are due to drift of pollutants from Britain and Germany. This has become a political issue.

**Oxides of Nitrogen** : These are chiefly produced by combustion of fossil fuel. Nitrogen peroxide is mainly liberated from automobile exhausts. Under the circumstances in which they occur in the environment, they are not dangerous to plants, animals or men. However, when they exceed the limit, a chain of photochemical reactions sets in, and more hazardous compounds are produced. Nitric oxide and Nitrogen dioxide play an important role in such photochemical reactions. Under the influence of solar radiation, nitric oxide reacts with hydrocarbons and produces aldehydes, and nitrogen dioxide produces organic nitrates like Peroxyacyl-nitrates (PANS) and Ozone. These are highly poisonous compounds. Further nitrogen dioxide absorbs in ultra violet region and dissociates into atomic oxygen which, after reacting with  $O_2$ , produces  $O_3$ .

**Hydrocarbons** : The chief source of this is again fossil fuel, specially petrol. It consists of a wide variety like ethane, methane, acetylene etc. Their role in the production of photochemical pollutants has already been discussed.

**Carbon-monoxide** : It is the biggest source of pollution in cities where it is mainly produced by incomplete combustion of petrol in motor vehicles. Recent studies point out that it is available in plenty in fuelwood in villages too.

**Carbon-dioxide** : It is generated by burning of all type of organic matter and also by respiration of plants and animals. Though it is not considered a serious pollutant, its role in maintaining the heat balance of the earth is well recognized.

**Fluorine/Fluoride** : The source of air born fluorides is a variety of chemical and metallurgical industries like petrochemical, fer-

tilizer, aluminium, fluorinated hydrocarbons, uranium and plastics. Its concentration is very high in certain localities specially in the vicinity of aluminium factories.

**Toxic Chemicals :** During the last 40 years, there has been enormous expansion of chemical industry throughout the world. Nearly 5 million chemicals are produced. In India too, some 4000 chemical factories produce a large number of chemicals. This industry mainly includes petrochemical, fertilizer, pesticide, which either use or produce highly toxic chemicals. The deadly action of Methyl-Iso-Cyanate gas on living beings has become clear only after the Bhopal disaster in December, 1984. There are many more such chemicals whose action is not yet known. Release of such chemicals may cause havoc greater than that of Bhopal. Many of the chemicals are proven carcinogen and genotoxicants.

**Smog :** This is formed when pollutants are unable to disperse when there is an inversion of temperature gradient in the atmosphere or lack of wind. The pollutants remain suspended in the atmosphere for quite sometime and therefore aggravate the effects of primary pollutants. Occurrence of smog during winter is a regular feature in some industrialized cold countries like U.K. In Calcutta the inversion occurs daily for about three months in winter, developing at about 6 p.m. and lifting at 6 a.m. next morning. The reduced visibility is the result of the smog.

### ***Biopollution***

Besides above mentioned man made pollutants, there are some natural bioparticles which also cause pollution of the air and affect human health. A large number of pollen of plants, fungal spores, bacteria and algae etc. always occur in the air. These cause allergy in human being which includes nasobronchial allergy and disorder of upper respiratory tracts. Bronchial asthma, rhinitis, hay fever, eczema etc. are well known allergic diseases caused by bioparticles.

### ***Mode of Action***

Production, emission transfer, contact and damage—this is the cycle of atmospheric pollution. Air pollutant emitted from a point, area or line source, get infused, diluted or deposited in the air shed.

The fall-out pattern of ambient ground level concentration of pollutants in any given area is the function of the topography direction and velocity of wind and vertical and horizontal thermal gradient of the region. Under favourable condition of dispersal, they may trespass local, national or international boundaries. Weather plays an important role in the dispersal of the pollutants.

### ***EFFECTS OF POLLUTION***

The atmospheric pollution adversely affects the life and material on earth. It affects plants and crops, animals and human health, buildings and materials, soil and water bodies, and weather and climate. It brings overall change in habitat.

**Effects on Plants and Crops :** Plants, the natural purifier of the air, are more sensitive to air pollution than man and animals. They are affected in four ways :

1. *Restriction of photosynthesis :* The SPM in the air and also the tarry deposits on the leaf surface reduce the amount of light available to plants. This reduces photosynthetic activity and food production and results in reduced growth, delayed maturity and reduced yield.
2. *Direct effects of gases :* The gases, specially SO<sub>2</sub> and other toxic gases, have great detrimental effects on vegetation. Reduced yield of crops in many areas has been related to large quantities of SO<sub>2</sub> present in those regions. It alters the stomatal opening mechanism, destroys pigments (chlorosis), disturbs the water relation and also causes disturbance in the enzyme system. The leaf damage due to the impact of this gas is well known. In higher doses, it may cause necrosis and death of the plant. Fluorides are also known to inhibit the plant metabolism.

The effect of MIC gas in Bhopal on plants was surveyed. It was found that vegetation in an area of 3.5 sq km around the factory was severely affected, 5 sq km was badly affected, 6 sq km moderately and 10.5 sq km mildly. The results of studies on some plants are summarized below :

*List of Plants Damaged by MIC*

<i>Completely damaged</i>	<i>Partially damaged</i>	<i>Undamaged</i>
Methi (Fenugreek)	Alfalfa	Mint
Radish	Mustard	Arvi
Spinach	Cabbage	Cuscuta
Brinjal (Fruits turned yellow)	Cauliflower (only leaves scorched)	Parthenium Kaitha
Tomato	Water hyacinth	Wild rice
Chenopodium	Marigold	Bougainvillea
Castor	Coriander	Moringa
Datura	Rose	Date palm
Jasmine	Bottlegourd	Jamun
Calotropis	Wild spinach	Mango
Lantana	Lemon	Kaner
Ber	Guava	Banana
Neem		

(Source : ICAR)

It was noticed that several wild plants were less damaged than cultivated plants and leaves bore the brunt of the damage.

3. *By altering soil conditions* : Rainfall in industrial areas dissolved the predominantly acidic pollutant gases and leaches bases from the soil. This results in poor growth of plant.
4. *By reducing the natural resistance to pests and diseases* : Increased physiological stress imposed by pollution further reduces their natural capacity to resist disease and pest infections.

**Effects on Animals** : One of the most important effects of atmos-

pheric pollution on terrestrial wildlife and livestock is fluorosis. The fluorides liberated from different sources get deposited on plants and grasses and transmitted to feeders. Lameness, bone abnormalities and dental deterioration have been reported as a result of fluorosis. The impact of the acute toxicity of MIC after Bhopal disaster was assessed. It was found that animals died within 3 minutes after inhaling the gas. In clinically ill animals there was an immediate drying of milk after exposure and milk production came down from 8–10 kg to 0.5 kg or nil. Over a thousand cattle, sheep and goats died and some 7000 received therapeutic care. Poultry was relatively less affected for reasons not yet known. Fish in affected areas were found to be suffering from anaemia.

**Effect on Human Health :** The effects of air pollution on human health are both acute and chronic. Acute effects occurred during temperature inversion and smog formation during winter and also due to accidental release of toxic gases. Heavy smog kills the older people and respiratory cripples. The famous smog of London in 1954 which lasted for 4 days and killed 4000 people is well known in the history of pollution. The worst ever acute impact of pollutants was by MIC in Bhopal. Over 2500 died in the world's worst chemical industry disaster. Many more among the survivors are still feeling the effects, three years after. The known figures are as high as 10,000. Results of the KEM College Medical survey 1000 days after the exposure revealed that out of 2,550,000 people affected, who acquired medical disability were as follows :

Mild to moderate – 43,864;      Severe – 63,385

The chronic impact includes basically the diseases of the respiratory tract and lung. SPM and dust particles are known to cause pneumoconiosis like silicosis due to silicon and anthrosis due to coal, etc. Acute irritation of skin is caused by SO<sub>2</sub> and PANS. The inflammation of lungs by PANS and chronic bronchitis by SO<sub>2</sub> are also known. Carbon dioxide destroys the oxygen carrying capacity of the blood. It reacts with the haemoglobin of the blood and forms stable compound carboxyhaemoglobin which decrease the amount of uncombined haemoglobin available for oxygen transport. There is growing body of evidence that points to a strong link between chronic CO exposure and both heart disease and impaired foetal development. The impact is severe in Indian women who are generally anaemic

and more so during pregnancy. They are exposed to greatest hazards of CO exposure during cooking on fuelwood and cowdung. A 15-year study on the patients of Delhi hospitals of cor-pulmonate (a kind of heart disease) revealed surprising similarity in the incidence of disease in men and women even though 75% men were smokers of tobacco as compared to only 10% of women.

**Effects on Buildings/Materials :** Corrosive effects of some of the atmospheric pollutants like SO<sub>2</sub> in the form of acid are well known. It affects stones and buildings and causes stone cancer. It also affects leather, metal and even timber. It is said that many monuments in the world particularly Taj Mahal and Red Fort of India are facing such problems due to high incidence of SO<sub>2</sub> pollution in the area, formally due to Mathura refinery and a large number of foundries in Agra and latter by the Indraprastha Thermal Power Plant in Delhi.

**Effects on Lakes and Ponds :** The impact of acid rain on fresh-water lakes and ponds has been drastic. Increased acidity of these water bodies due to acid rain makes them highly acidic and infertile leading to their death. It has been estimated that 4000 of Sweden's lakes, 1500 of Norway's and 1200 of New York are almost dead due to acid rain. Many of the Canadian lakes are unable to support trout and cod. The problem of acid rain in India has yet not become noticeable but symptoms are there and it may not take much time if proper measures are not adopted in advance.

### **ASSESSMENT AND MONITORING OF AIR POLLUTION**

Increased awareness of the potential hazards of large scale contamination of air with toxic substances from urban and industrial sources has highlighted the need of continuous assessment and monitoring of the level of these substances. This is particularly important for determining the impact of different pollutants tolerance limit of different groups of plants and animals and assessment of the general quality of the air.

Air quality monitoring is carried out both by physicochemical and biological methods. Physicochemical methods involve the continuous measurement and determination of some selected parameters of air quality. Generally the level of SPM or TSP, SO<sub>2</sub> and

sulphation rate and CO are taken into consideration for the purpose and periodic determination are done at selected sites. Under the National Air Quality Monitoring Network, a total of 75 monitoring stations in 21 districts have been set up.

**Biological Monitoring :** It has been recently realized that physico-chemical methods of pollution monitoring are not as reliable as biological methods. This is due to the fact that the physicochemical methods give the idea of the condition at the time of sampling only, while biomaterial are able to show conditions both in the past and at present.

Methods for biological monitoring are based on the differential sensitivity of different species of plants to different types of pollution. Plant species are classified as resistant/tolerant or sensitive/susceptible depending upon the impact of the pollution upon them. The susceptible or sensitive species are generally used for monitoring purpose. The criteria for the selection of a species for biological monitoring are :

1. Pollution indicative symptoms (visible injury) should be definitive and specific.
2. It should have the capacity to absorb and concentrate the pollutant.
3. It should also be sensitive to low concentrations of the pollutants.
4. It should retain the toxic laden parts.

A large number of species belonging to all groups of plants have been tried and it has been found that cryptogamic epiphytes, lichens and mosses are the best indicators as they fulfill all the above criteria. They are now widely being used throughout the world for biological monitoring of the air pollution.

The impact of lead emitted from petrol-driven automobiles exhaust on roadside plants in Delhi has been studied by the Central Board for the Prevention and Control of Water Pollution (CBPCWP). Four important plant species, viz., Jamun (*Igonia sp.*), Kaner (*Nerium sp.*), *Alstania sp.* and grass (*Cenodon sp.*), grown under the same ecological conditions in nursery were kept at 6 important

road crossings and the quantity of the accumulated lead was determined at three months' intervals and compared with the control species kept in the nursery of the National Physical Laboratory. The results show :

1. The quantity of the accumulated lead varied between 90-324  $\mu\text{g}/\text{cum}$  as compared to 82  $\mu\text{g}/\text{cum}$  (max.) in controlled plant species.
2. Three varieties of jamun and kaner could absorb and accumulate lead without any apparent impact. Further studies are in progress.

### *CONTROL MEASURES*

The purpose of the pollution control is to limit the pollutants to allowable maxima. The allowable maxima are determined by the individual and the combined characteristics of the principle pollutants and the degree of inconvenience and damage that can be tolerated. The effects of long exposure to low concentrations and immediate exposure to high concentrations should be considered in relation to damage. The control of the pollutants is effective only at source—chiefly in industries. A number of methods have been in use for long time for the control of pollutants at source (industry). These are both mechanical and chemical. These are :

- A. For suspended particulate matter :
  - (1) Gravity settling chamber—based on gravity and centrifugal principles.
  - (2) Cyclones based on centrifugal and impaction principles.
  - (3) Scrubbers—based on impaction and direct interception principles.
  - (4) Filter bags—based on filtration and retention principles.
  - (5) Electrostatic precipitators—based on the principles of electrostatics.
- B. For industrial gases :
  - (1) Absorption in liquid.
  - (2) Absorption on solid surface.

- (3) Combustion of gases to change into harmless products.

### *Monitoring of Air Pollution*

The pollution control measures are adopted both at point source and after it is discharged in the environment. The following measures are adopted for the prevention and control at source :

**1. For Industries :**

- (a) Laying down of emission standards for different industries and compliance.
- (b) New industries should be allowed after careful study of the impact and should be located away from habitation, conservation areas and other sensitive places.
- (c) Installation of pollution control equipment obligatory for new industries.
- (d) Incentive from the government for pollution control.
- (e) Thorough check up of the existing industries.

**2. For Automobiles :**

- (a) Laying down emission standards and appropriate legislation.
- (b) Enforcement of standards during annual licensing.
- (c) Re-registration of the vehicle after every 15 years.
- (d) New fuel efficient engines.
- (e) Proper traffic planning.

**3. Domestic Sector :**

- (a) Fuel conservation and use of non polluting fuels : This is a very acute and unmanageable problem because of poor condition of the majority of people and also the shortage of cleaner fuel. The electricity and gas are out of question in rural areas. Over 90% of the household in the country are using fuelwood, dung and crop refuse. It is suggested that for fuelwood tree species should be selected on the basis of their relative smokiness and this be included in social forestry programmes. It has been observed that Acacia are less smoky

while Neem most smoky. The much publicized biogas unfortunately has yet not spread far and wide. This requires attention.

(b) Smokeless *chulhas*: A number of smokeless *chulhas* have been designed by a number of workers/institutions. The basic principle is that there should be a chimney fitted in the *chulha* which can take the smoke out.

For the control of pollution beyond source the best way is by the natural purifier, the plants. The importance of green belt in the abatement of air pollution has long been recognized and it is said that a green belt in the heart of a big industrial urban area dilutes considerably the pollutants and mitigates the impact. The basic criterion for the formation of the green belt is that it should be based on the ability of the plants to remove significant quantities of pollutants without sustaining any damage. It has been recommended that the plant species of the following categories may be planted :

1. Species with high dust trapping capabilities.
2. Species with proven ability to absorb SO<sub>2</sub>.
3. Species resistant to the type of pollutant in the area.

Under Indian conditions, where SPM is considerably high, the dust trapping plants are required. An experiment has been carried out to study which genera of tree exert greater filter pressure. It has been found that evergreen trees with simple leaves are better dust collector than those of deciduous trees. Actively growing herbaceous plants also absorb significant quantities of gaseous pollution. It has been observed that a continuous cover of alfalfa under optimal conditions can remove nearly 0.2 of NO<sub>2</sub> or SO<sub>2</sub> per sq km per day from air. The vegetation may be scavenger or a sink for many airborne substances like HF, SO<sub>2</sub>, NO<sub>2</sub>, O<sub>3</sub>, etc.

### **ACTION TAKEN**

The Government of India, Department of Environment, through Central Board for Prevention and Control of Water Pollution, who have been assigned the job of air pollution control too, have laid down emission standards (Minimum National Standard, MINAS), for a number of industries which include Chlor alkali (caustic soda),

Table 1

NATIONAL AMBIENT AIR QUALITY MONITORING STATIONS						
S. No.	CITY/TOWN	NUMBER OF STATIONS SANCTIONED			Stations in operational state as at the end of Dec. 1986.	Stations yet to be made operational
		1984-85	1985-86	1986-87		
<b>Uttar Pradesh</b>						
1.	Agra	5	—	—	5	—
2.	Anapara	3	—	—	3	1
<b>Gujarat</b>						
3.	Baroda	—	5	—	5	—
4.	Surat	3	—	—	3	—
<b>Kerala</b>						
5.	Cochin	—	5	—	5	—
6.	Delhi (U. T.)	5	1	—	6	—
<b>Bihar</b>						
7.	Dhanbad	—	3	—	3	2
<b>Haryana</b>						
8.	Faridabad	—	2	—	2	2
9.	Goa	—	—	2	2	2
<b>West Bengal</b>						
10.	Haldia	3	—	—	3	—
11.	Howrah	5	—	—	5	—
<b>Andhra Pradesh</b>						
12.	Hyderabad	—	3	—	3	—
<b>Rajasthan</b>						
13.	Kota	5	—	—	5	—
<b>Punjab</b>						
14.	Ludhiana	—	3	1	4	4
<b>Tamil Nadu</b>						
15.	Madras	—	—	5	5	5
<b>Karnataka</b>						
16.	Mysore	—	—	3	3	3
<b>Madhya Pradesh</b>						
17.	Nagda	—	—	3	3	3
18.	Pondicherry (U. T.)	—	—	2	2	2
<b>Maharashtra</b>						
19.	Pune	—	3	—	3	3
<b>Himachal Pradesh</b>						
20.	Simla	—	—	2	2	2
<b>Orissa</b>						
21.	Talcher	—	—	3	3	3
<b>Total</b>		<b>29</b>	<b>25</b>	<b>21</b>	<b>75</b>	<b>32</b>

Source: DOE's Annual Report 1986-1987.

man-made fibre, oil refinery, sugar, thermal power plant, cotton, textile, composite woollen, cement, electroplating, dyes and dye industry, asbestos, iron foundry, petrochemical and paper & pulp, etc. The industries have been asked to adhere to the standards CBPCWP also initiates legal proceedings under Air (Prevention and Control) Act, 1981, in case of defaulting industries. It has been continuously monitoring the quality of air at about 75 stations in 21 districts under National Ambient Air Quality Monitoring (Table 1). New Industries are cleared only after thoroughly examining its future impact under Environmental Impact Assessment. Projects may be rejected on grounds of incompatibility. It has also undertaken the monitoring of emissions from the motor vehicles in selected areas of Delhi.

Besides Central Government, almost all States and Union Territories have undertaken steps to control the pollution. The Department of Environment, Government of West Bengal, has been involved actively since its inception. Recently it has been notified that vehicles of certain year of manufacture are required to undergo the pollution test.

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# **SUSPENDED PARTICULATE MATTER IN THE ENVIRONMENT**

**S.K. BHOWAL \***

Air pollution is not a new problem. It has been around for centuries and scientific literature records that air pollution and its effects have been described by scientist as early as 1661. John Evelyn in his complaint to King Charles II wrote about the city of London that "Her inhabitants breathe nothing but an impure and thick mist, accompanied with a fuliginous and filthy vapour, which renders them obnoxious to a thousand inconveniences, corrupting the lungs and disordering the entire habit of their bodies ... Is there under heaven such coughing and snuffing to be heard as in the London churches and assemblies of people?" Almost every responsible citizen of the developed and industrialized countries is aware of the adverse effects of the air pollutants and air pollution is also causing concern in a developing country like ours. Much has been said about the toxic gases in the environment but along with these the role of particulate matter is no less important in producing health hazards in urban and industrial locations.

Solid and liquid aerosols suspended in the atmosphere are referred to as particulate matter. Smoke, which is frequently observed in big cities, is basically particulate matter mixed with gases and is classified as solid condensation aerosols. Dust is solid dispersion aerosol and mist is liquid aerosol. Whether the particulate matter would be settling down to the ground or would remain suspended in air is determined by the size of the particles (Table-1). Most particles having diameter larger than one micrometer are removed from the atmosphere by gravity and others remain suspended. It has been

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observed that if the settling speed of the particles is  $10^{-6}$  m/sec then a distance of 32 m (100 ft.) is traversed in a year's time.

Table 1

SETTLING VELOCITIES OF SPHERICAL PARTICLES OF UNIT DENSITY IN STILL AIR		
	Diameter ( $\mu\text{m}$ ).	Settling velocity (m/sec).
Suspended particulate matter (SPM)	0.1	$8 \times 10^{-7}$
	1.0	$4 \times 10^{-5}$
	10	$3 \times 10^{-3}$
	100	0.25
Deposited matter	1000	3.9

0.1 to 110  $\mu\text{m}$  particulate remain suspended, while those from 10-1000  $\mu\text{m}$  are deposited.

## SOURCES

The particulate matters originate from natural as well as from man-made sources. Due to the maintenance of an ecological balance by nature, the natural sources do not pose problem, but man-made sources cause a local increase in the concentration of particulate matter and the entire machinery of the ecological balance is disturbed. This is manifested in the form of a pollution problem. The different sources of the particulate matter are given below.

### SOURCES OF PARTICULATE MATTER

#### Natural Sources

Erosion and spraying of soil.

Volcanic eruptions.

Release of organic compounds like terpenes from plants.

Spraying of salts from sea water.

### **Man-made Sources**

*Burning of fossil fuels* : Steel Industry, Thermal Power plants, Brick manufacturing.

*Other Industrial sources* : Cement Industry, Phosphate fertilizer industry, Mining of ores, coal and asbestos.

*Automobile exhausts* : Lead and cadmium compounds, hydrocarbons like benzopyrene and derivatives, asbestos, Zn, Fe compounds, Photochemical smog produced from hydrocarbons, sulphur dioxide and nitrogen oxides.

However, in the city of Calcutta, one of the important sources of particulate matter is the domestic burning of coal on a large scale. Though the emission from man-made sources seems to be insignificant in comparison to the natural ones, yet they pose problem due to sudden local increase in concentration in industrial or urban areas. The topography and meteorological conditions of these areas determine the extent to which these particulates will remain suspended in air. The global emission of all particulate matter is given in Table 2.

The suspended particulates in the environment have different characteristics, i.e., shapes and sizes. All these characteristics depend on the chemical nature of the particulates. The electron micrograph of particles from London air shows that many of the particles have complex shapes. There are a number of "smoke aggregates" originating from incomplete combustion of hydrocarbons consisting of small spherical particles of carbon or higher hydrocarbons having diameters of the order of  $0.05 \mu\text{m}$  clustered together to form the aggregates. Some truly spherical material may be present mainly as aqueous droplets containing dissolved salts, sulphuric acid or occluded solid particles. Many other types of particles including small flakes and fibres (mainly asbestos fibres) can also be seen. It is important to recognize that the suspended particulates generally make a heterogeneous mixture, which can differ in characteristics from one location to another and even at a particular site at different times. Concentrations of smoke and suspended particulates in some cities of the world are given in Table 3. This table clearly shows that the concentration of suspended particulates happens to be the highest in Calcutta.

Table 2

GLOBAL EMISSION OF ALL PARTICULATE MATTER (10 <sup>6</sup> tonnes per year)	
<b>Man-made</b>	
Particles	92
Gas-particle conversion: Sulphur dioxide	.147
Oxides of nitrogen	30
Photochemical compounds from hydrocarbons	27
	<hr/>
	296
<b>Natural</b>	
Soil dust	.200
Gas particle conversion H <sub>2</sub> S and NO <sub>x</sub> , NH <sub>3</sub>	.905
Photochemical compounds from terpenes	.204
Volcanic	4
Forest fibres	3
Sea salt	1000
	<hr/>
	2312

Table 3

CONCENTRATIONS OF SMOKE AND SUSPENDED PARTICULATE MATTER (WHO Report)		
Site	Concentration (µg/m <sup>3</sup> )	
<i>Smoke (Reflec.)*</i>	Annual mean	Max. daily mean
Brussels	37	—
London	26	149
Madrid	190	908
Rome	60	160
<i>Sus. Part. High Vol. Dust Sampler</i>		
Calcutta	519	1090
St. Louis	87	189
Vancouver	64	134
Zagreb	167	806

\*Reflec. = Reflectance measurement

## ***CHARACTERISTICS***

Generally speaking it is not possible to discriminate on the basis of either particle size or chemical composition of particulate matter for routine monitoring processes. The characteristics of the sample are determined by the types of sources in the Vicinity, the weather conditions and the sampling procedures adopted. When considering measurements of suspended particulate matter it is essential to specify the method used and to recognize that even then, results obtained in one set of circumstances will not necessarily be applicable to others. Thus it is recommended that smoke and total suspended particulate measured by the various methods should be regarded as separate entities. However, now-a-days the particulate concentration measurement is expressed in terms of total suspended solids (TSS) and these data are much higher than that of smoke measurements. During a high pollution episode in London in 1956, the TSS was found to be  $5111 \mu\text{g}/\text{m}^3$  measured by the high volume dust sampling method.

As has been mentioned before, the suspended particulate matter in fact manifests itself in the form of different kinds of aerosols. Aerosols have been classified as dispersion aerosols and condensation aerosols. Dispersion aerosols are formed due to grinding or atomization of solids or liquids in to a suspension. Dust is a dispersion aerosol. Condensation aerosols are formed when supersaturated vapors are condensed or when gases react chemically to form a non-volatile product. Condensation aerosols with a solid or with solid and liquid disperse phase are smoke, smog or photochemical smog. Condensation aerosols and dispersion aerosols with liquid particles are mists. The photochemical smog formation has led to a number of disasters in the world. The most serious smog episodes are those in which atmospheric conditions permit a buildup of high pollutant levels if the episode lasts for several days. Mention may be made of the great London disaster which occurred from December 5 to 9, 1952. The formation of photochemical smog is an intricate photochemical process which is still not fully understood. There are several mechanisms put forward involving free radical formation in presence of ultraviolet radiation having wavelengths ranging from  $0.3$  to  $0.4 \mu\text{m}$ . Two such mechanisms involving aerosols and photochemical oxidation of gases and particulates are shown in Table 4. The suspended particulates play a key role in the formation of aerosols and photochemical

Table 4

<b>Aerosol Formation</b>				
NO <sub>2</sub>	+	hν	→	NO + O
O	+	O <sub>2</sub>	→	O <sub>3</sub>
SO <sub>2</sub>	+	hν	→	SO <sub>2</sub> *
SO <sub>2</sub> *	+	O <sub>2</sub>	→	SO <sub>4</sub> *
SO <sub>4</sub> *	+	O <sub>2</sub>	→	SO <sub>3</sub> + O <sub>3</sub>
SO <sub>3</sub>	+	H <sub>2</sub> O	→	H <sub>2</sub> SO <sub>4</sub>
<b>Photochemical Oxidation Mechanism</b>				
NO <sub>2</sub>	+	hν	→	NO + O
HC	+	O	→	HCO*
HC	+	O <sub>3</sub>	→	HCO <sub>3</sub> *
HCO*	+	O <sub>2</sub>	→	HCO <sub>3</sub> *
HCO <sub>3</sub> *			→	ALDEHYDE + RO* + RCO*
RO*	+	NO	→	RO <sub>2</sub> * + NO <sub>2</sub>
RO*	+	NO <sub>2</sub>	→	RONO <sub>2</sub> (ALKYL NITRATE)
RCO*	+	O <sub>2</sub>	→	RCO <sub>3</sub> *
RCO <sub>3</sub> *	+	NO <sub>2</sub>	→	RCO <sub>3</sub> NO <sub>2</sub> (RCO <sub>2</sub> NO <sub>3</sub> ) (PEROXYACYL NITRATE)
<i>HC = Hydrocarbon</i>				

smog. The particulates lead to the formation of these through their catalytic effects or acting as nuclei or by direct involvement in the photochemical reaction. The main reactants are SO<sub>2</sub>, NO<sub>x</sub>, hydrocarbon particles and salts of Fe, Zn, Pb, Cd and Mn present in the urban environment. The cause of the great London smog was due to H<sub>2</sub>SO<sub>4</sub>-particulate combination and that in Los Angeles due to the photochemical smog in an oxidizing atmosphere. The methods of monitoring of suspended particulates are shown below.

## Monitoring of Suspended Particulates

<i>Method</i>	<i>Principle</i>
Smoke Measurement	Deposited on white filter paper and determined by measuring reflectance and transmittance.
High volume dust sampler	Deposited on glass fibre filter and determined by weighing.
Beta ray sampler	Deposited on filter paper and mass determined from the attenuation of energy of beta ray.
Light scattering	Determination by passing a light beam directly through the particulate.
Electrostatic samplers	Particles precipitated with the help of high voltage and weighed.
Personal sampler	Deposited on small glass fibre filter and weighed or determined by beta ray method. Applicable to industrial environments.

### **ADVERSE EFFECTS ON DIFFERENT SYSTEMS**

Particulate matter causes damage to both living and nonliving world. The suspended particulates reduce the solar radiation causing reduction of visibility. In general due to the presence of suspended particulates the cities receive 15-20% less radiation than rural areas. It may be mentioned that during the Great Depression in U.S.A. in 1932, many cities showed higher sunlight levels than in the previous year because of reduced industrial activity. Besides this aesthetic damage, suspended particulates cause material damage and also cause damage to living objects like plants and human beings. A brief account of these damages may be seen below. Although the tests have been carried out with different animals, nevertheless there is every reason to believe that respiratory illness like bronchitis and emphyse-

ma show the most pronounced association with levels of particulate matter. Moreover, asbestos and benzopyrene may play an important role in higher cancer rate in urban areas. The plants are damaged by aerosols and also dust particles.

### **Adverse effects of particulate matter**

#### *Aesthetic Effects :*

Reduction in visibility, annoyance etc.

#### *Effects on living systems :*

*Plants :* Disturbance in photosynthesis.

*Animals and Human Beings :* Deposition in the respiratory tract, damage of the tract and lungs due to intrinsic toxicity of the particles, interference with clearance mechanism in the respiratory tract. Respiratory illness—Enhancement of bronchitis and emphysema.

#### *Effects on Materials :*

Corrosion of metals (aerosols), soiling of buildings, sculpture, painted surfaces, clothing, draperies. Corrosion and damage of electronic equipments and electrical contacts.

#### *Toxic particles :*

Sulphuric acid, zinc ammonium sulphate, iron (III) sulphate, zinc sulphate, ammonium sulphate, Non-reactive particles—iron (II) sulphate, manganese sulphate (Based on studies made on guinea pigs, dogs, monkeys, rats and human volunteers).

### **CONTROL MEASURES**

The particulate matters having very small size generally remain suspended in air for a long time and hence people who live in the industrial areas or cities are compelled to inhale them. Much attention has been paid for controlling the emission of these particulates from their sources. The control techniques for particulate matter may be classified as industrial emission control and automobile exhaust control as shown below:

### **Industrial emissions of Particulate matter**

- (a) Cyclone separators.
- (b) Wet scrubbers.
- (c) Electrostatic precipitators.
- (d) Fabric filtration.

### **Motor vehicle emissions**

- (a) Instituting controls on the internal combustion engine—changing engine design, changing air-fuel ratio and *via* catalytic routes, etc.
- (b) Developing new fuels—propane, natural gas, alcohol, hydrogen etc.
- (c) Developing new engines and electrochemical devices—battery operated engines.
- (d) Reducing motor vehicle uses—development of better mass transport system, governmental controls (auto exhaust emission control, extra fuel taxes).

The industrial emissions are controlled by devices which remove the particles before the flue gases are released into the atmosphere. Particles larger than 50  $\mu\text{m}$  may be removed satisfactorily by cyclone separators and simple wet scrubbers and particles smaller than 1  $\mu\text{m}$  are handled effectively by electrostatic precipitators, high energy scrubbers and fabric filters. Cyclone separators are designed so that incoming gas stream produces a vortex from which particulate matter is removed by centrifugal forces and then collected. They are very simple in design and easy to maintain. They handle large particles very well but the collection efficiency of small particles is low. Efficiencies on a total weight basis may range from 50% to 95%. Wet scrubbers consist of a large metal chamber through which the flue gas is passed and is sprayed with water. The gas is cleaned by wetting with water and the particles are removed in the wastewater. Efficiencies on a total weight basis range from 75 to over 99% and can be varied. However, there may be corrosion problems with this process. The electrostatic precipitator removes solid and liquid particles from a gaseous stream by passing the gas between pairs of electrodes. The negative electrodes have a voltage high enough with respect to the

grounded collection electrodes to produce a corona discharge. The gas ions in the corona are attracted to the collection electrode but they may collide with solid and liquid particles and transfer charge to them. The particles are then attracted to and deposited on the collection electrode. Collection efficiencies by weight are from 80% to over 99.5%. The initial costs of electrostatic precipitators are relatively high but their power requirements are small and little maintenance is usually needed. This device is especially suitable for the removal of fly ash. Fabric filters remove particulate matter from gas streams by filtration with woven fabrics, paper, fibrous mats or aggregates such as sand, gravel or coke. Large dust collectors may contain several thousand filter bags, each several meters long. Removal efficiencies may be 95 to 99.9% but high temperature gases must first be cooled to a lower temperature. In some cases when the particulate matter to be removed is combustible, it is possible to burn it with direct flame or catalytic after burners. This method is particularly suitable for hydrocarbon emissions.

The particulate matters present in automobile emission are mainly hydrocarbons and lead compounds. The lead comes from the antiknock compound, lead-tetraethyl, added to the petrol. In order to get rid of the lead particles, lead free petrol has been introduced in the market and is being increasingly used in the developed countries. The possible ways to reduce motor vehicle emission are already given above. One promising control method is the "exhaust manifold thermal reactor" Here the exhaust gases are allowed enough reaction time at high temperature with sufficient air to permit more complete oxidation of the hydrocarbons and carbon monoxide. The thermal reactors may require expensive metals capable of withstanding high temperature and may cause some decrease in fuel economy. These problems may be avoided if catalytic reactors operating at lower temperatures are used. These reactors may be placed in the usual muffler position and would contain a catalyst like platinum or one of the platinum group metals or various mixtures of oxides of chromium, iron, copper etc. promoting the oxidation of hydrocarbons and carbon monoxide. Catalytic reactors were thoroughly researched in the period from 1957 to 1964 and are now making a 'come back' since they may be the most economical solution to the exhaust emission problem. But there is also a disadvantage because the lead compounds resulting from the tetraethyl lead antiknock

additive will poison the catalyst. However, with the advent of lead-free petrol, this problem seems to have been nearly solved.

In conclusion, it may be mentioned that the particulate matter emission has been identified to be the most serious problem in Calcutta. There are claims made by the physicians that the cases of bronchitis and emphysema are increasing at an alarming rate in Calcutta and its neighbourhood. If the cause of increasing cases of the said diseases is attributed to the high concentration of toxic particulate matter in the city atmosphere, it would not possibly be at all far from the truth. So it is high time the citizens of Calcutta be aware of the imminent health hazard.

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# NOISE POLLUTION

I. J. GUPTA

With the progress of Man's activities in various spheres of life, certain problems have also been cropped up which have become hazards in leading his comfortable life. Such a challenging situation is his immediate environment which is deteriorating and, thus, pollution free environment has become a topic of the day. The increasing concern of environmentalists about the polluting environment is expressed as follows :

- ☞ Pollution kills health
- ☞ Pollution is a devil to mankind
- ☞ Pollution is a menace to mankind
- ☞ Pollution is a slow poison
- ☞ Grow more trees, control pollution
- ☞ Pollution prevention better than cure

and lastly, in the tone of warning,

- ☞ 'Pollution control now or never'

Like air and water pollution, noise pollution has also assumed an alarming position. It has been recently recognized as posing a serious threat to the health of human being. Noise is an inescapable part of the machine civilization in which we live. Noise comes within the scope of the definition of a pollutant adopted by a Committee of the National Academy of Sciences(USA), '... any undesirable change in the physical, chemical or biological characteristics of our air, land and water that may or will harmfully affect human life or that of any

other desirable species or industrial process, living conditions or cultural assets, or that may or will waste or deteriorate our raw material resources'

There are historical examples on the effects of noise e.g. 'gunfire deafness' on battlefields in 1591; reports in 1713 referring that persons engaged in hammering copper got their ears injured by the perpetual din to the extent that they became hard of hearing and in 1830, a doctor reported frequent occurrence of deafness among black-smiths. In 1886, deafness was also reported among boiler-makers. Further idea of destructive effect of thunder of sound can be had from 'Joshua said unto the people, Shout; for Jehovah hath given you the city ... So the people shouted, and the priests blew the trumpets; and it came to pass, when the people heard the sound of the trumpet, that the people shouted with a great shout and the wall fell down flat ...' [*Joshua 6 : 16-20*]. In 211 BC, the Chinese police Chief Ming Ti issued the following order : 'He who reviles our rulers shall not be hanged, beheaded nor speared but pipers, drummers, and noisemakers shall bombard him without pause until he sinks dead to earth'

Noise is usually defined as 'Unacceptable Sound' or Unwanted Sound' Noise is annoying as well as irritating to all of us and interferes with our activities. Apart from causing hearing loss, noise seems to impair various other body functions, and, in general, lowers the quality of life.

From a physical point of view, sound may be defined as any pressure variation in a medium having density and elasticity which may be detected by the human ear. The two most important characteristics to evaluate a sound are its frequency and amplitude. The frequency of sound means the number of times the pressure variations occur per second and it is measured in Hz (Hertz). The human ear responds to frequencies ranging from about 20 Hz to 20 kHz. The auditory sensitivity to frequency is not uniform for the entire frequency range. The ear is insensitive to low frequencies but most sensitive to frequencies in the range of 2000-8000 Hz. The amplitude of a sound wave is a measure of the strength of the pressure variations creating the sound. The unit of measurement of this pressure is Pascals (Pa). As sound pressure range ( $2 \cdot 10^5$  Pa to 200 Pa) of audible sound is very large, it is common to express sound pressure level in terms of dB

aware the people to have restraint in using loud speakers and fire-works at social and religious celebrations. The holding of seminars in public, distribution of pamphlets and public display of placards against noise pollution may prove useful.

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# FOREST AND VEGETATION

P.K. MAITI

## *INTRODUCTION*

Since the inception of man, the plant community or the forests including the Wildlife, have been his inseparable and constant companion. Right from the stone age to this era of scientific and technological advancement, the forests have provided food, clothing and shelter to man, besides being witness to his advancement of civilization and maintenance of our rich biological diversity, consequently, maintaining the environmental balance. However, forest is made up of a variety of plant species which change rapidly in space and time. The natural vegetation of an area depends primarily on variations in climate, soil, elevation and other local factors. India, with its vast and contrasting land, has great variety in respect of these factors. Consequently, there are infinite varieties of plant community in this sub-continent. To understand the vegetation pattern, these factors have been discussed briefly, followed by the major forest types.

## *FACTORS DETERMINING FOREST TYPE*

(i) **Temperature** : It is the most obvious factor of climate. It is broadly related to latitude giving a rough differentiation in four zones :

1. Tropical : Very hot and with mild winter.
2. Subtropical : Hot with a cool winter.
3. Temperate : Warm summer and a pronounced winter.
4. Arctic : With a short summer and long severe winter.

It is however, obvious that no hard and fast line can be drawn and that the relation of climate to latitude is greatly influenced by factors, mainly the distribution of land and sea, the altitude, prevailing winds and ocean currents and by their indirect effects. It is necessary to substitute suitable temperature ranges for latitude to make such a classification of any practical value.

On the basis of temperature, India may be divided as follows:

<i>Zone</i>	<i>Mean Annual temperature</i>	<i>Mean January temperature</i>	<i>Winter</i>
1. Tropical	Over 24°C	Over 18°C	None, no forest
2. Subtropical	17 to 24°C	10 to 18°C	Definite but not severe, forest rare
3. Temperate	7 to 17°C	-1 to 10°C	Pronounced, with forest and some snow
4. Alpine	Under 7°C	Under 1°C	Severe with much snow

Such a classification will obviously result in certain localities falling in one zone in January temperature but in another on mean annual temperature; thus Jodhpur is subtropical on the former criterion and tropical on the latter. The vegetation itself will then indicate to which it more properly belongs.

(ii) **Effect of altitude** : From the known relation between latitude and temperature, the upper altitudinal limits of the zones might be expected to fall considerably higher in Peninsular India than in the Himalayas. Thus a mean annual temperature of 17°C is experienced in the Nilgiri Hills at about 1,830m, in the West Himalayas at about 1,700m and in Assam at 1,500m. The effect of altitude varies with conditions, a rise in the hills of 270m corresponding on the average to a fall of 1°C in mean temperature up to about 1,500m above which the fall is more rapid. In general, this fall is also more pronounced on the lee side of hills than on the windward side.

(iii) **Rainfall** : As regards total annual rainfall, India exhibits an extremely wide range of conditions from less than 150mm in the Thar

desert to nearly 5,000mm locally in the Khasi hills of Assam. Precipitation over 2,500mm is met with in three different parts of the country, viz., W. Ghats, North Bengal and Assam and locally in the Western Himalayas at Dharmsala. Total annual fall may be an important factor in determining the nature of the vegetation, but its seasonal distribution exerts an equally far-reaching influence.

(iv) **Wind** : The effect of wind as such on forest type is limited and localized. On exposed sites, it has a stunting effect which may be quiet marked as can be found in the hill-top vegetation in the Andaman islands and the ridge crest forest along the western ghats. Height is sufficiently reduced, and crowns tend to be relatively low, branchy and dense.

(v) **Topography** : In relatively flat country, this factor must be affecting the vegetation in the minor differences of levels determining the movement of water both over and through the soil. Even a difference of a few feet or less may influence moisture conditions favourable or the reverse.

(vi) **Soil** : It appears that the physical conditions of the soil, above all those affecting moisture supply root aeration and availability of chemical nutrients, are much more influential on species and forest type distribution than the chemical composition of soil as such.

Considering all the climatic factors, the climo-vegetational outline in India may be shown as in Table 1.

### **MAJOR FOREST TYPES**

The type of vegetation of India is mainly determined by the climate, elevation and other local factors. Accordingly, the following are the principal types of natural vegetation in the Indian sub-continent.

1. **Tropical Evergreen Rain Forests** : These forests are found in the areas where rainfall is more than 200 cm. Thus, they are found chiefly on the slopes of the Western Ghats (the Western parts of Maharashtra, Karnataka and Kerala States) and on the lower slopes of the Eastern Himalayas, the hilly parts of Assam up to a height of 1,500 m above sea-level. They are also found in the wetter parts of the Anda-

Table 1

<b>Climate</b>	<b>Wet Evergreen</b>	<b>Semi- Evergreen</b>	<b>Moist Deciduous</b>	<b>Dry Deciduous</b>	<b>Thorn Forest</b>
<b>Mean Annual Temp. (°C)</b>	23-27	23-27	20-29	20-29	24-29
<b>Mean January Temp. (°C)</b>	15-21	17-25	12-26	16-25	13-26
<b>Annual Rain- fall (mm)</b>	2400	1800-3000	1200-3000	750-1400	250-900
<b>No. of dry Months</b>	3-5	4-6	4-8	5-8	7-10
<b>Vegetational Evergreeness</b>	Entirely or nearly so	Dominants include some deciduous elements but evergreen predominates	Dominants predominan- tly deciduous; subcanopy evergreen	Entirely deciduous or nearly so	Entirely deciduous
<b>Species richness</b>	Entirely rich	Rich	Rich	Poor	Extremely poor
<b>Canopy height (m)</b>	40	25	25	8-20	10

man and Nicobar Islands, Bangladesh and Sri Lanka. Lofty, dense, evergreen forests 45m or even more high, characterized by the large number of species of trees which occur together. Some species of the top storey are trees with clear boles of 30 m long and 5m or more in girth and may be chiefly deciduous. The canopy is extremely dense. Epiphytes are numerous, specially ferns, mosses and orchids. The undergrowth is often a tangle of canes, creeping bamboos and palms. The leaves are thick and glossy, and very often white or pink when young. Dipterocarps (*Callophylum*, *Artocarpus*, *Dipterocarpus*, etc.,) are the predominant trees.

**2. Monsoon or Deciduous Forests :** These forests are found in the areas where the amount of rainfall is between 100cm and 200cm. They cover nearly half of the area of the Indian sub-continent, and are found in the three tracts : (i) A strip along the Wetter Western sides of the Deccan Plateau, (ii) the north-eastern part of the Deccan Plateau and (iii) the lower slopes of the Himalayas. The trees of these forests shed their leaves during very hot season in order to check the excessive transpiration. The main types of trees are teak, sal, sandal wood, ebony, deodar, blue gum, wattle, sisam, jack fruit, mahua, khair and bamboo. Teak, the most important tree, grows mainly in the Western part of the Deccan Plateau; Sal grows along the lower slopes of the himalayas and in the north-western part of the Deccan Plateau.

**3. Dry jungles or Shrub Forests :** These forests grow in those areas where the rainfall is less than 100 cm. The trees have long roots, small fleshy leaves, and have often sharp spines. They are stunted and widely scattered. The main trees are species of acacia, bamboo, banyan, wild date, etc. These types of forests are mainly found in the drier parts of the north-west India (Rajasthan, Punjab, Western U.P. and Gujarat) and on the Peninsular plateau.

**4. Semi-Desert and Desert Vegetation :** This type of vegetation is found in those regions where the rainfall is less than 25 cm. In this kind of vegetation, mostly thorny bushes, wild berries and babool grow. These plants grow apart from each other, and have very deep roots and thick fleshy stems in which they can store water to survive the long draught. This kind of vegetation is mostly found in some parts of Rajasthan, Rann of Kutch, the drier part of the south Punjab,

the Ladakh area of Jammu and Kashmir and in the very dry parts of the Deccan Plateau.

5. **Mountain Forests** : These forests grow usually at an altitude of 1,500m in the hills of southern India and at an altitude of about 100m in Himalayas. They grow up to a height of about 3,600m. They include both deciduous and coniferous types of trees. These forests are of different types, changing according to altitude up to snow-line. The lower slopes of Eastern Himalayas are covered with broad-leaf evergreen trees. Here, the main trees are oak and laurel. Above this belt of vegetation, there is a belt of deciduous forests and then higher up there is a belt of coniferous forests. The coniferous forests grow mainly in those high hilly regions where the rainfall is between 125-200 cm and the temperature conditions are like those of the temperate regions. Among the conifers, the main trees are spruce, cedar, poplar, silver fir, pine, chestnut and walnut. Besides these, birch, elm and bamboo also grow. Among these, cedar, blue pine, chir pine, silver fir and spruce are commercially most important. On the Western Himalayan foot-hills broad-leaf evergreen forests occur in restricted areas, it is because, in this part, the amount of rainfall is not much. These forests have a few varieties of trees and plants. The large coniferous forests, at higher altitudes thrive only in limited areas, and are devoid of the dense undergrowth as found in the Eastern region. At higher altitude of the Himalayas, are found thickets of rhododendrons with bushes and shrubs. Beyond the height of about 6,000m the mountains remain snow-clad and no vegetation grows.

6. **Tidal or Mangrove Forests** : These forests are found along the sea coasts at the edges of large deltas of the rivers, such as the deltas of the Ganga, Mahanadi, Godavari and Krishna rivers. These are called "Tidal Forests", because their dense growth depends upon the tidal waters which submerge the deltaic lands during the time of high tides. In West Bengal and Bangla Desh, these forests are called "Sunderbans" as the 'Sundri' tree is the most dominant tree there. Other important tree of these forests is casuarina. The trees are of hard wood variety, their wood is commonly used for building boats.

### **FOREST SUCCESSION**

The natural vegetation of a given place is influenced by environmental factors. The process by which the vegetation establishes itself

is called 'Succession' It generally begins with small pioneering plants entering the new soil and paving the way for bigger and complex varieties. The new plant varieties increase slowly and then set on a downward trend because they themselves alter the conditions which had attracted them to the spot. The altered conditions invite new plants which hasten the exit of the previous ones. But once the forest is formed, the vegetation reaches a biological steady state — also called the climatic climax. Botanically, two types of succession can be named : the hydrarch which starts in water — either ponds or lakes and ends in xeric vegetation, and the xerarch, which starts on rocks and ends in mesic forests. In either case, the initiating factor is most likely the creation of new soil for new plants to gain foothold. This is influenced by biotic factors as well as topographic and climatic changes. Volcanic eruption brings on the most important topographic change by completely destroying the earlier vegetation and soil. Biotic changes can be brought about by animal and human activity. Grazing, for example reduces the fertility and moisture content of the soil. Besides secondary succession, what happens when the steady state is disturbed, say, by cutting down of forests ? A forest clearing, unless kept under continuous cultivation, is bound to be invaded by a secondary succession. The first invaders are weeds, tall grasses, vines and seeding trees. These form a dense ground cover, but the trees soon begin to overtop the other vegetation. The first colonizing trees are of those species whose seeds are dispersed more efficiently than those of the permanent forest trees by wind or of those edible fruits attractive to birds or fruit bats.

### *FLORISTIC REGIONS*

The flora of India varies considerably in different parts of the country both in specific identity and in number of species. Some species occur throughout whilst others are restricted to quite small areas. Comparative studies have led to the differentiation of a number of floristic regions, the following nine being now recognized are:

1. Western Himalayan
2. Eastern Himalayan
3. Indus Plain
4. Gangetic Plain

5. Central India
6. Western coast (Malabar)
7. Deccan plateau
8. North-East India (Assam)
9. Andaman and Laccadive Islands.

The Western Himalayan flora differ from the Eastern Himalayan one in the greater representation of conifers. While the European element is conspicuous in the former, the Malayan, Chinese and Burmese are prominent in the latter. The Indus plain flora have received important North African components. All the regions have the majority of their species in common, but also an appreciable number that is peculiar to them or in common with only some of the other regions.

### ***FOREST DEGRADATION***

Growing population and its activities have generated numerous stresses which have directly or indirectly caused reduction of forests in India. These are as follows :

1. The demand for more land to grow more food, has accelerated the reduction of forests.
2. The demand of land for cattle raising has expanded open forest area, and excessive grazing has caused land deterioration, particularly soil erosion and suppression of the regeneration of useful species.
3. Heavy demand for domestic fuel supply, largely fuel wood, has reduced the species richness and has made the woodland diminutive.
4. Development projects, such as, reservoirs for irrigation and hydroelectric power, thermal power stations, road network, industries based on renewable and non-renewable raw materials, etc. Gaseous and liquid effluents from the industries have their own adverse effects on the forest vegetation up to several kilometers from the point of discharge.

Changes in closed tropical forest area (million ha) in certain Indian states are as follows :

<i>State</i>	<i>Geographical Area</i>	<i>Forest area</i>		<i>% Reduction</i>
		<i>1972-75</i>	<i>1980-82</i>	
Andhra Pradesh	27.68	4.02	3.18	20.89
Bihar	17.38	1.82	1.37	24.72
Karnataka	19.17	2.62	2.09	20.22
Kerala	3.88	0.77	0.62	22.23
Madhya Pradesh	44.20	8.86	6.89	22.23
Maharashtra	30.77	2.90	1.86	35.86
Orissa	15.57	3.73	2.88	22.78
Rajasthan	34.22	1.83	0.32	61.44
Tamilnadu	13.00	1.34	0.94	29.85
Other States & Union Territories	122.90	19.53	15.87	18.73
<b>Total</b>	<b>328.77</b>	<b>46.42</b>	<b>36.02</b>	<b>22.40</b>

### **FOREST MANAGEMENT**

The National Forest Policy framed in 1952 advocates the maintenance of 60% of the area in the hilly tracts and 20% of the area in the plains or 33% of the entire geographic area of India under forest cover. As against this not more than 12% of the country is actually under forest cover. The most alarming fact is that while deforestation is taking place at the rate of at least one million hectares, new plantation does not account for more than 0.5 million hectares per annum. However, to check the rapid disappearance of forest in our country, some vital needs can be recognized as follows :

1. The need for the maintenance of environmental stability through preserving and restoring the ecological balance that has

been adversely disturbed by an insufficient insight into the role of forest in environmental balance.

2. The need to conserve what remains of the natural heritage of the country through preserving the existing natural forests along with their vast variety of flora and fauna.

3. The need for checking denudation and soil erosion in the catchment areas of rivers in the interest of soil and water conservation, the prevention of floods as well as draughts and for the control of premature siltation of water bodies.

4. Forests need to be particularly protected on hill slopes, catchment of rivers, and in areas which form the major habitats of the country's biological resources such as wildlife.

5. The management of all forests should be regulated to ensure the maintenance of minimum tree density with constant monitoring of regeneration, growth, and mortality of the crop. Integrated and comprehensive forestry, hydrological, soil, botanical, geological and zoological surveys should be periodically undertaken to form the basis of a regular revision of management policy in the State Forests.

### ***FOREST AND WILDLIFE***

India is remarkable for the variety of its large mammals, a richness in species exceeded by few countries in the world. From the rain forest of Assam to the snows of the Himalayas and the deserts of Rajasthan, from the deciduous forests of the central highlands to the mangrove swamps of the Sundarbans, India presents a great diversity of vegetation types, each with its unique faunal assemblage. The immense sweep of the Himalayas harbour sheep such as the bharal and urial as well as wild goats — the markhor, tahr, and ibex; and there are takin and goat antelopes such as the serow, snow leopards, musk deer in the rocky gorges, and black bears prowl the forested slopes. Many of these species belong to the palaeartic faunal region, and the mountains represent the most southern part of their range in India. The peninsula has its own distinctive mammals, with some, such as the black buck, nilgai, and chital, being almost wholly confined to it. The thorn forests and other open habitats are or were the home of the Asiatic lion, cheetah, Indian gazelle, and others; the

grass jungles of the Gangetic basin hold wild buffalo, barasingha, hog deer, and the great Indian rhinoceros; the forests harbour elephant, sloth bear, leopard, gaur, barking deer, sambar, pig, and the unique fourhorned antelope. Many of the forests afford shelter to the tiger, an animal which perhaps more than any other over the years has become the symbol of India's wildlife heritage.

These herds are no more. The cheetah is extinct in India, the last ones having been shot in 1951 (Talbot, 1960). The great Indian rhinoceros, which was hunted in the Indus valley by the Moghuls as late as 1519 (Rao, 1957), survives only in a few isolated sanctuaries in India and Nepal. The population of Kashmir stag has been reduced to fewer than two hundred fifty individuals (Gee, 1962). The Asiatic lion, once found throughout the dry open forests north of the Narmada River, now occurs only in the Gir Forest of Gujarat, where fewer than three hundred animals remain (Gee, 1962). Probably no more than two thousand wild buffaloes exist in scattered remnants. Of the 'herds of thousands' of barasingha seen by Pollock and Thom (1900) in Assam and Bhutan only some four thousand survive in the country and in the world. Where Forsyth (1889) observed herds of black buck 'which must have numbered a thousand or more individuals', none are now seen and this species once so abundant is reaching a critical stage in its survival. The other large mammals, the Indian gazelle, nilgai, chital, gaur, and forth-which were exceedingly common have all declined drastically in number. The ubiquitous tiger has become scarce in most parts of the country. The Himalayan fauna have suffered a similar fate. What has been the cause for the decline?

Direct shooting has been an important factor in the decrease of wildlife. Animals of any age and sex were bagged indiscriminately. Hunting was not just a sport but a symbol of status, the criterion for the latter being the number of animals, especially tiger, shot. By the end of the past century the decline had accelerated to such an extent that some hunters grew concerned. The rhinoceros was gone from most of its former haunts, and the lion was nearly exterminated, although one was shot in central Madhya Pradesh as late as 1851. Attempts were made to regulate the shooting, with acts for the preservation of animals were passed in 1887, 1912, and 1935. The Nilgiris Game Association was founded in 1877 and the Bombay Natural History Society in 1885, both designed to promote the conservation of wildlife. A number of reserves were established, promi-

ment among them are the Banjar Valley Reserve, Corbett National Park, and Kaziranga Sanctuary. However, the decline of the wildlife continued. Yet, in spite of the apparent apathy with which the government viewed the protection of the large mammals, and the great amount of damage done by army personnel during the Second World War, India retained a considerable amount of its wildlife until 1947.

After Independence, the rapid rate of Forest destruction has led the wildlife vanishing fast. In order to save our wildlife, the conservation and management of natural and artificial forests are urgently needed which will surely provide much insight into the strategies of safeguarding the major wildlife still existing to-day.

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# **HABITAT AND WILDLIFE CONSERVATION**

**S.S. SAHA**

## ***INTRODUCTION***

Much is talked about wildlife these days. But the uses of the term 'wildlife' do not signify any uniform meaning. In fact, the term is expressed in different way by different people.

## ***WILDLIFE***

Philosophically, wildlife should include all the biotic elements of the world that evolved and flourished as a consequence of the phenomenon of evolution. Technically, it includes every form of life, plant and animal that is called a species. However, although man has also appeared as an evolutionary consequence we exclude man and his breed of domesticated animals that essentially need human support in their life. In actual practice when we use the term wildlife we restrict only to a fraction of total species of fauna and flora. During the last few decades or so the term wildlife has become a fashionable expression giving value to those species of animals that enjoy the pride and prestige of being the game animal of sports and also some species of plants that are favourites of the curious horticulturists. Yet, there is awakening of realization that the wildlife is a valuable resource that has been serving mankind from time immemorial by replenishing food, clothing, medicines, materials for utility goods or for use in any small and large industries. It is also a source of inspiration and recreation.

## ***HABITAT***

Our planet, the earth is unique in whole of the universe for its

dynamic properties that helped in evolution of life in its myriads of forms. Perhaps the unique proportion of matter and energy in their dynamic manifestation has found the only space in this little planet out of the vast expanse of the cosmosphere. The environment in the planet Earth with its five principal items of scriptures namely, Kshiti or Earth, Ap or water, Marut or air, Tej or energy, and Byom or space, in a dynamic phase helped to evolve the living matter which in course of time, evolved and flourished in an immense magnitude of forms during the past millions of years to create yet another sphere of its own called biosphere. This biosphere is the homeland of the living world. Be it a microbe, a plant species or an animal species, each and every species of the biosphere evolved as a consequence of the interaction with the environment. The environment becomes congenial when it can provide food, shelter and partner for biological functions.

If we try to elaborate those five principal items, the earth should include rocks and minerals in which scores of essential elements of chemistry and their compounds and mixtures that are needed not only for the formation of the body but also for the function of the organic systems and for the living creature as a whole. The water again like the earth is an essential item for the formation and for almost every chemical reaction needed for the function of the organism. In fact, all living body has the composition with the water in proportion that is found in the land and water proportion in the planet Earth. The air is yet another compound which envelopes the entire biosphere and protects it from the outer cosmos and is used for the vital function of living every moment by the organism. The energy is on the one end of the eternal swing of the pendulum while matter is on the other end. The conversion of matter to energy and vice versa, is expressed in the manifestation of the cosmosphere. Naturally the biosphere within it also gets its share of conversion. Each organism ultimately owes to matter and energy for its form and functions. The space is important because the entire space within the planet Earth available for the biosphere incidentally is not furnished with uniform amount of matter and energy and their derivatives. Therefore, it is important to know about the location of space on the Earth surface.

The steady energy source in the immediate vicinity of the planet is the Sun. The amount of solar energy available to a part of the

planet will govern grossly the temperature and radiation, these in turn will effect on the earth and water of the area. Interactions in due course will give rise to the shape of the land, its rocks and minerals, its contour or its topography. The topography together with its position in a particular area will give rise to the geographical features, its climate and vegetation. Vegetation is important because the green plant can convert and store the trapped solar energy into food by photosynthesis. This food can be broken again to release the trapped energy required for the function of the organism. All other creatures those do not possess the mechanism of photosynthesis are essentially dependent on the green plants directly or indirectly.

Broadly the globe has three principal belts of biomes namely, the Boreal or Arctic on either of the polar caps which is a cold place and only during half of the year it gets the direct solar radiation. The amount of radiation is much less than the radiation in the Equatorial or Tropic belt which lies either side of the Equator stretching up to the Tropic of Cancer in the north and Tropic of Capricorn in the south. In between the Tropical belt and the Arctic belt lies the Temperate belt which is a compromise between the two extremes of cold and hot, on either of the north and south hemispheres. Within these three principal climate zones there are variations. Proportion of land and water and their relative geographical positions; contour of the land with its altitude, because higher altitudes have many other manifestations in climate and related phenomenon; rocks and soil; climate particularly temperature, humidity, rainfall, wind pressure, wind current and its direction, all help in sustenance of certain communities of green plant and other vegetation in turn. Thus, the nursery is set where a species can carry out its functions of life. Only the food and shelter can not make the living of a species in totality. It needs some thing more and that some thing will include association of other fellow members of its own species and also many other species which play a definite role in the act of great drama of life of a species.

All these biotic and abiotic components in an area make the home or habitat of a species. However, a habitat of a species, as we single out is not necessarily meant for a single species alone. In fact it forms a system of interdependence of each of the components in a given habitat. Absence of any of the component has an impact to change the pattern of living of one species or more, even to the en-

tire system. And if any of the vital components becomes absent from the system the function of the system as a whole jeopardizes and unless the system can successfully adopt a different pattern to sustain it becomes fragile and ultimately destined to be doomed. It is therefore each and every component in the habitat, be it a particular element or a species that is important for the smooth function of the system of the habitat.

The edaphic factors and the biotic assemblages in different combinations and proportions form different kinds of habitats. In India some of the principal habitats have been identified as Nival habitats in the higher altitudes of the Himalayas; Sub-tropical Temperate habitats below the Nival habitat again in the higher altitudinal areas of the Himalayas; Tropical Rain forest habitats in the very rainfall prone areas; Arid and Desert habitats; Mangrove habitat; Terai Grassland habitat; Fresh water habitat and Marine habitat. These habitats are often referred to as ecosystems. Besides these, there are many other types of habitats coined for particular aim and objective.

### **CONSERVATION NEEDS**

Man, technically known as *Homo sapiens*, a species to which we belong, evolved as natural consequence of evolution. But, the way of function it has created yet another sphere of its own called the biosphere within the biosphere. Perhaps no other form of life has so far resulted such an impact and has attained the power to enhance changes in those established spheres, so much so, that this consequential evolution of man can not only mutilate but also can bring disaster in those spheres. This power of man is rather attained in a very short spell of time compared to the geological age of the Earth. Man has made landmarks in the flourishing civilization. Human civilization flourished at the expense of the Nature and the natural resources. The biosphere in retrospect, has changed and ever been changing with each spell of the rotation of the Earth. Many a forms in course of evolution appeared on the global arena. They have changed their form and function in compliance with the dynamic environment and in the process many forms failing to cope up with the change have become extinct.

In the immediate context, the changing environment on the planet Earth has created a critical situation and future of many

species if not the whole of the biosphere largely depending on the mode of function by a single species *Homo sapiens*, because man is the only species who can evaluate not only his own past but that of other species also. It is also in his power to charter his own future together with that of others with the help of his knowledge of science and technology.

The evils of human activities particularly in the last two centuries and specially during the last several decades have caused deliberate damage to the environment and the biosphere. Wildlife with their habitats are at stake. Human activities have annihilated many of the habitats so that many species are on the verge of oblivion and some are already lost. It is estimated that about thousand species of animals and over two thousand five hundred species of plants are becoming rare and endangered every year and it is feared that about half a million species of living forms are going to be extinct by the turn of the century, if the state of affairs continue to the present way.

Viewing the importance of role of every species in the biosphere there is an urgent need to prevent such loss. Protection, preservation and conservation are the remedies. Protection is aimed to stop slaughter, preservation is to protect and preserve the remaining individuals in an area so that they can renew on their own into a healthy population, and conservation is aimed to institute knowledge and its application to protect and preserve the species as a whole.

### **INDIAN CONTEXT : OLD**

The conception of conservation has been dramatized very recently. The theme of protection, preservation and conservation is not a new idea in the Indian context. Norms ritual and taboos practised from old age are directed for the protection of wildlife. Tapovana, Mrigadab, Avayaranya and Game Reserves were made to help protection and preservation. Philosophy of the doctrine of peaceful coexistence and Ahimsa formulated the part of conservation of wildlife and their habitats.

During the historic period protection and preservation of wildlife had been extended by the royalty in their kingdom. During the British rule Game Laws regulated hunting. Forests, which are eventually the home and habitat of most of the important wildlife species,

were protected under different categories, like Reserved Forests, Protected Forests, unclassified State Forest, etc., where different kinds of habitats were allowed to flourish. In the princely states, private reserves for the dignitaries to hunt used to be maintained. Sanctuaries were also established in order to protect and preserve the wildlife species.

During the post independence period, the Game Laws enacted during the British period were remodelled and enforced. Wildlife Board was established in 1952 to review the state of wildlife and to advise the Government on the matter. Each state had its own set of regulations for the protection of wildlife. But, in fact, no uniform regulation was covering whole of India. During this period, besides the categories of the forests, more sanctuaries were declared, so also National Parks. In sympathy for the cause of wildlife and conservation Government policy regulated hunting and trade for both domestic consumption and export of wildlife produces, reviewing the advice of the Wildlife Boards in the State level as well as in the National level.

### *INDIAN CONTEXT : CURRENT*

But in 1972, protection, preservation and conservation policies were dramatically renovated with the promulgation of the Wildlife (Protection) Act No. 53 and also by India becoming a member of the Convention of International Trade in Endangered Species (CITES). The Act defined categorically various groups of animals and the nature of importance for the cause of conservation up to the species level prescribed in different Schedules. It elaborately mentioned the limitation of hunting, trapping and trade. It also curbed illegal possession of trophy and other produces of the wildlife species.

Like Schedules of the Wildlife Act, the appendices of the CITES categorically defined the regulations on trade of different species of wildlife. The aim of the act was to seal the loopholes of the previous Game Laws and also bring whole of India under uniform regulation. In 1973 yet another dramatic step was taken by the launching of Tiger Project. Many Tiger habitats in different states were identified and brought under the project to ensure the survival of the Indian Tiger. The Tiger project areas not only helped conservation of Tiger but it extended conservation of the habitat which in a chain of reac-

tion helped conservation of the many species in those areas which deserved equal care and protection as Tiger, and the various ecosystems scattered in different parts of the country.

At present fifteen such Tiger Reserves cater in different states and have become successful in conservation of Tiger along with its biocommunities in different kind of ecosystems. Reorganization of forest management, practice of forestry and establishment of wildlife cell are many of the steps taken in the forest frontier. A forestation programme in a massive scale in the forest land and beyond, specially the Programme on Social Forestry will create green belt which in course of time minimize the burden on the forest for fuel and fodder. Steps being taken for the meaningful utilization of the Wetland and Wasteland of the country. This will help in creation of new habitats for the wildlife.

Management programme directed towards individual species in the way of captive breeding or translocation is one side for the direct action taken for conservation. Reservation of habitats in the form of sanctuary, national park and biosphere reserve and maintenance of them are another side of conservation which will take care of the Habitat and Wildlife Conservation in India. But people's participation in all the steps and actions government have taken becomes absolutely necessary. After all, everything is for the people and by the people.

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# **CONSERVATION STRATEGIES**

**V. C. AGRAWAL**

**Conservation is the management of the natural resources, both living and nonliving, in such a way as to yield the greatest sustainable benefit to the future needs and aspirations of the mankind.**

**Natural resources are of two kinds :**

- i) Nonliving resources :** These resources, if once used, can not be replaced, for example fossil fuel, minerals, etc. Hence, it is advisable to use them judiciously for worthwhile purposes, so that these may last long. Also attempts should be made to find out alternative sources, so that the pressure on the depleting non-living resources may be minimized. As for example, the increased use of bio-gas or solar and nuclear energy is being suggested as a substitute of fossil fuel.
- ii) Living resources :** Conservation of living resources has three main objectives — (a) maintenance of essential ecological processes and life support system, (b) preservation of genetic diversity and (c) ensuring sustainable utilization of species and ecosystems.

**The human population explosion in the last few decades, demanding developments in various spheres like the urbanization, construction of dams and hydro-electric projects, encroachment of forest land for extension of agriculture, industry and mining operation, etc., has brought severe imbalances in several natural ecosystems in India. This, coupled with unplanned exploitation of several species of wild animals and plants for trade and medical purposes have threatened not only the survival of wildlife but also the existence of human beings.**

The primary concern of conservation is to preserve balanced ecosystem. If total ecosystems are preserved, animal species contained in these systems will have greater chances of survival. The areas preserved should be of such size and diversity in habitat as to include several successional stages with animal populations large enough to be genetically viable and variable.

It is heartening to note that the Government administrators have lately started to feel the pinch of the disturbances in our ecosystems and are being conscious of the threat to the biosphere and its living components.

The Indian Board for Wildlife, which is the apex advisory body in the field of wildlife conservation in India, outlined a list of aims in 1982, on which is based a strategy and an action programme for wildlife conservation in the country. These aims provided the basis for the formulation of National Wildlife Action Plan. The Plan adequately covers the three basic objectives of conservation. It incorporates a National Conservation Strategy which covers the management of different ecosystems in the country. The preservation of genetic diversity is fulfilled through establishment of network of protected areas in representative biogeographical regions of India, restoration of degraded habitats, rehabilitation of endangered species of wild animals and plants in suitable areas, captive breeding programme, etc.

To check the exploitation of wild animals for trade, the export policy has been made more stringent by restructuring the CITES appendices and Wildlife (Protection) Act.

### ***MAINTENANCE OF LIFE SUPPORT SYSTEM***

Major life support systems centre around four main ecosystems, namely, Agriculture, Forest, Aquatic and Mountain, which provide us food, water, fodder, timber and fisheries. These ecosystems have been overexploited in the past in an unplanned manner, so that these have become degraded. Hence, the action plan envisages that a proper management policy may be evolved for each ecosystem so that these ecosystems may be restored and conserved to yield sustainable benefits to the future needs of the mankind.

One way of achieving this is by minimizing pressure on the above

mentioned ecosystems by exploiting the underutilized or alternative resources, so that the ecosystem as a whole and the overexploited species in particular may get a chance to restore themselves. Let us examine these ecosystems one by one.

i) **Agriculture** : To meet the challenge of increased demand of food, the National Policy has emphasized on the proper use of land and water. To achieve this objective, it is essential to increase the acreage of land under cultivation, to improve the quality of soil and to use the high-yielding, disease resistant variety of seeds.

To look after the management problems, a number of Bodies have been constituted by the Government. The Wasteland Development Board has been entrusted with the job of reclamation of wastelands in the country; the Ground Water Board is supposed to map the ground water resources, and to plan for its sustainable utilization, and preservation from seepage; and the Soil Conservation Department takes measures to protect the valuable top soil and to maintain its fertility. The Indian Council of Agricultural Research has been experimenting and has also developed some high yielding variety of seeds which brought green revolution in the country in 1968.

ii) **Forests** : Forests provide us timber and fuel wood. In addition, it indirectly controls the rainfall and soil erosion. Hence, our National Forest Policy (Forest Act, 1980) emphasizes the need of total conservation of Reserve Forests in the Himalayas, in the Eastern and the Western Ghats and in Conservation Areas, as also to raise mixed plantation of indigenous species in denuded areas.

In a developing country like India, about 80% of wood in the forest is used as fire-wood. Hence, this need can only be met through additional forestry programmes, like social forestry, plantation under wasteland development plan, etc. However, the demand for fuelwood can be minimized, if alternative sources of energy like solar energy, biogas, etc., are tapped.

iii) **Aquatic** : A vast majority of population in India depend on fish as their source of protein. Hence, Fishery Development programmes emphasize the need of extensive survey of fishery resources and to draw up a conservation-cum-management plan. It is being, further, suggested to minimize fishing in already exploited areas and to de-

velop more specialized areas of fisheries production, like the brackish water fishery, deep sea fishery, etc. In addition, efforts should be made to exploit the underutilized aquatic animal resources like edible molluscs, marine turtles, frog-legs, etc., by establishing marine turtle hatcheries, developing frog seeds in place of natural harvest, etc.

In view of the fast disappearing wetlands for human settlement and other developmental projects, a 'Wetland Board' has been constituted to collate the data and to draw up a national policy for wetland management and to make an inventory of its biological resources.

iv) **Mountain:** The mountain ecosystem especially the Himalayas, is endowed with a wide range of economically important plant-and animal-species as well as water resources. Considering the potentiality of the mountain ecosystem in India (the Himalayas, the Eastern and the Western Ghats), the National Conservation Policy has laid emphasis on the conservation of the same for sustainable utilization. The Doon Valley Development Board, Western Ghats Eco-development Board, the Eastern Ghats Eco-development Board, etc., have been constituted to achieve these objectives.

### ***ESTABLISHMENT OF A REPRESENTATIVE NETWORK OF PROTECTED AREAS***

To protect varied ecosystems, there is need for the establishment of effectively protected areas where any type of exploitation is prohibited.

The modern concept of wildlife conservation in their natural habitat was recognized in 1952 when the Indian Board for Wildlife was constituted. Since then, National Parks and Wildlife Sanctuaries have been established. The first step was to redesignate the Game Reserve of the erstwhile Princely States as Sanctuaries and National Parks.

In India, at present, there are 66 National Parks and 368 Sanctuaries constituted under the Wild Life (Protection) Act, 1972 (List appended). These are now spread over 25 States and 3 Union Territories. The total area covered by these protected places is approxi-

mately 1,41,298 sq.km or 4.3% of the geographical area of the country. There has been tremendous progress between 1980 and 1985 when the number of National Parks has increased three-fold. Still these protected areas do not cover representative and viable samples of all significant biogeographical subdivisions within the country, and also quality of management is still to be improved. Recently adopted Action Plan seeks to remove these deficiencies.

A biogeographical classification of the country has been attempted by the Wildlife Institute of India, and independent consultants have been assigned regions for the identification of areas and species that need protection. The future network of protected areas in the country would also include Biosphere Reserves which will be set up under the UNESCO's Man and Biosphere Programme. The objectives of the Biosphere Reserves are : i) To conserve for present and future use, the diversity and integrity of biotic communities of plants and animals within natural ecosystems and to safeguard the genetic diversity of species on which the continuous evolution depends, and ii) to provide areas for ecological and environmental research, particularly baseline studies, both within and adjacent to these reserves.

Under this programme, seven areas (Manas, Nokrek, Sunderbans, Nanda Devi, Nilgiris, Gulf of Mannar and Great Nicobar) have already been declared as Biosphere Reserves, and seven more are under consideration.

### ***WILDLIFE PROTECTION OUTSIDE THE CONSERVATION AREAS***

A major part of our wildlife exists outside the conservation areas. These areas fulfil many essential requirements of the local people, such as animal protein, timber, fodder, fuelwood, agriculture, etc. Hence, any conservation effort in these areas directly conflicts with the economic interests of their inhabitants. Therefore, conservation and management can become effective only with the cooperation of the local people. For this, the welfare of the tribals must be ensured by satisfying their needs of animal protein and various forest products, and that priority should be given to the question of giving them direct employment in forestry operations. They should be made conscious of the fact that wild animals are more valuable alive

than dead. Protection of interest of the tribals is envisaged in the recent Forest Management Plan (1980). This will enable such areas to function as corridors between protected areas and contribute towards maintenance of genetic continuity.

### ***DOMESTIC LEGISLATIONS AND INTERNATIONAL CONVENTIONS***

In order to conserve whatever remains of our wildlife, the Government of India has taken various steps aimed at prohibiting killing, trapping or collecting by any other means, of such species of animals which are endangered or rare, and at regulating exploitation of those species which, though apparently in abundance at present, may become rare, if utilized excessively.

A general Legislation was enforced in 1972, under the name Wild Life (Protection) Act, 1972 for providing protection to the wildlife, particularly to endangered species of fauna. This act has been adopted by all the States and Union Territories of the country except Jammu & Kashmir and Nagaland. The former has created her own legislation mainly on the same lines as the Central Act, while the latter has been asked to adopt it. As per 42nd amendment of the Indian Constitution in 1976, the preservation of wild animals and forests have been included in the Concurrent list. By this provision, the Central Government has not only acquired the power of control for the preservation of National Parks and Sanctuaries but also of the acquisition of property.

The Wild Life Act has seven chapters, dealing with definitions, rules regulating hunting of wild animals, authorities to be appointed or constituted under the Act, formation of Wildlife Sanctuaries, National Parks, Game Reserves and Closed Areas, regulation of trade or commerce in wild animals, animal articles and trophies, prevention and detection of offences, miscellaneous regulations, and Schedules from I to V.

Schedule I lists the rare and endangered species which are totally protected throughout the country, live or dead or part thereof. Schedule II lists Special Game species which deserve more stringent protection for which licences can be issued under special circumstances. Schedules III and IV comprise Big and Small Games, and V deals with

**Vermin.** In total 75 species of mammals, 46 species of birds and 18 species of reptiles are included in Schedule I of the Wild Life Act, 1972, as amended up to 1986 (List appended). Of late, 130 species of butterflies have also been included in Schedule I, and 36 species of beetles and 289 species of butterflies in Schedule II.

An expert Committee set up by IBWL considers and frames necessary amendments to the Wild Life Act. The Schedules of the Act are reviewed from time to time and the species are either added or deleted according to their status. The recent amendments have been made in November, 1986.

The Action Plan seeks to undertake a review of these legislations with a view to improve their effectiveness as also to examine the need for new legislations on the matter.

To control the trade in endangered species of animals, four Wildlife Offices have been established at Delhi, Bombay, Calcutta and Madras, from where wildlife and their products can now be exported or imported only after proper inspection. At present, all the export of the wildlife articles through major airports and sea-ports are allowed only after getting clearance from the Regional Offices of Wildlife. A 'No Objection Certificate' is issued after thorough checking, taking care of all legal aspects. Trade in wild animals and animal articles is regularized as per rules dealt with in Sections 39-49 in Chapter V of the Wildlife (Protection) Act, 1972, as amended up to November, 1986. The export of specified wild animals and their articles as per annual export policy (Department of Customs, Ministry of Finance) is allowed only under a valid licence and by producing necessary documents. The exporters are required to submit monthly returns to the Chief Wildlife Warden. The stock in hand is verified from time to time by the officers of the Regional Wildlife Office.

In recent years many of the international bodies, like the International Union for Conservation of Nature and Natural Resources (IUCN, 1948), World Wildlife Fund (WWF, 1961), International Council for Bird Preservation (ICBP, 1922), etc., have come up for wildlife conservation, and India is signatory to all these bodies. The Convention on International Trade in Endangered Species of wild Fauna and Flora (CITES, 1973) regulates the international trade in

wildlife and their products, and India became a party to it in 1976. The success of the convention depends on the effectiveness in implementation of the rules and recommendations of CITES by the member countries. The Action Plan specifically provides for examining the need for bilateral treaties and conventions for the protection of migrating species of wild animals (including birds) and their habitats. The new Indo-USSR Migratory Birds Treaty exemplifies the need. These are very important and timely steps to protect wildlife on a global scale.

In India, under CITES, the Inspector General of Forests and the Director, Wildlife Preservation are the Management Authorities, and the Director, Zoological Survey of India, Director, Botanical Survey of India and the Director, Central Marine Fisheries Research Institute are the Scientific Authorities. The representatives of the Parties meet every two years to review the convention and its implementation. This convention has framed rules and regulations to control the worldwide trade in endangered species of wildlife and their products. It consists of 25 articles. Three levels of protection have been given to species to be covered by the Convention.

Species believed to be threatened with extinction, which are or may be affected by trade, are listed on Appendix I of the Convention. The trade of specimens of these species is particularly restricted so as not to further endanger the survival of the species in the wild. An export permit is required from the country of origin of a specimen of any species listed on Appendix I. This permit is to be issued only after the Scientific Authority of the State has certified that export of the specimen will not be detrimental to the species in the wild and the Management Authority of the State is satisfied that the specimen was taken in accordance with the laws of the State. The import of any specimen of a species on Appendix I requires an import permit. The import permit will be issued only when the Authorities in the importing country agree with the decisions of the exporting country. Re-exporting a specimen requires a re-export permit under the same conditions as the original export permit.

Appendix II contains species that are not immediately threatened by extinction but may become threatened unless trade is restricted. This list may also contain certain look-alike species. The export of specimens of species on Appendix II requires an export

permit under the same conditions as those listed on Appendix I, but an importation permit is not required. Re-exportation does require a permit.

Appendix III includes all species which any Party to the Convention identifies as needing regulation within its jurisdiction for the purpose of controlling exploitation, particularly as the result of international trade. The export of a specimen of a species included in Appendix III from any State which has included that species in Appendix III requires an export permit. An import permit is not required, but a re-export permit is required.

### ***REHABILITATION OF ENDANGERED SPECIES***

Under this objective, it is proposed to rehabilitate some of the threatened species of animals as well as plants in some protected habitats of its erstwhile distribution. The recent translocation of Great One-horned Rhinoceros from Assam to Dudhwa National Park is an example to cite with. On the recommendation of the IBWL a second house of Gir Lion was established in Chandraprabha Sanctuary in southern Uttar Pradesh as back as 1957. A lion and two lioness were released in the sanctuary, which is said to have increased to 11 by 1964. But due to the lack of proper monitoring by the State Forest Department all the animals either died or were killed by the local people.

A Central Wildlife Translocation Unit is in the process of being established to assist such projects.

### ***CAPTIVE BREEDING PROGRAMME***

It has been proposed to take up captive breeding programmes for species whose survival in the wild is severely threatened on account of impaired natural breeding. The objective here again is to rehabilitate the concerned plant or animal species in its natural habitat under conditions that will promote growth. The efficacy of captive breeding programme for saving gravely threatened species in the wild is borne out by the success of Crocodile Breeding Project in India. The Brow-antlered deer is another example which needs captive breeding. The recent estimate of its number in the wild is only about two dozen. However, it is breeding successfully in captivity in

different zoos in India, where its number has arisen to 49. These animals should be trained to capture their own prey, defend themselves from predators and acclimatize to natural conditions before they may be rehabilitated in suitable areas.

### ***WILDLIFE EDUCATION***

Public understanding and support is crucial for wildlife conservation. Hence, efforts should be directed to educate children, visitors to zoos and wildlife reserves, and most importantly, to people living in and around the protected areas about the importance of conservation.

A faculty of wildlife education is being developed at the Wild Life Institute of India to train personnel for handling nature education, interpretation, etc. The Zoological Survey of India also imparts training on wildlife conservation and environmental awareness to persons attached to Nature clubs and educational institutions from time to time.

### ***RESEARCH AND TRAINING***

The first requirement of any programme on animal conservation and management is the basic data on the status and distribution of the species involved. Surveys and long term studies are required to determine the habitat requirements, dietary needs, status, population dynamics, etc. There is also an urgent need for careful study and monitoring of the habitats.

There is increasing need for trained personnel (both professional and non-professional) for the development and operation of programmes in wildlife conservation and management. Two levels of training should be imparted. Some persons should be trained in scientific research and management while others may undertake special courses in practical aspect of wildlife management.

The Wild Life Institute of India undertakes training and career development of the wildlife staff at different levels. Manuals containing technical information on the planning and management of protected areas for the use of wildlife officers, are also being developed by the Institute.

## ***COLLABORATION WITH VOLUNTARY BODIES***

Collaboration with non-governmental organizations and voluntary bodies is one of the major objectives outlined in the Plan, for their support is crucial for the implementation of the Plan. The various ways in which voluntary organizations can help are—to aid and advise the government in conservation matters, and to educate the people and create awareness in them for the cause of conservation.

The World Wildlife Fund–India = World Wide Fund for Nature–India is one such voluntary organization in India. The WWF–India was formed in 1969. It has a Board of eight trustees with the Headquarters in Bombay and three regional offices in Calcutta, Delhi and Madras. It focuses the attention of the Government of India and of the State Governments on the problems of concern in the field of wildlife conservation. It organizes Conservation Education Programmes both in educational institutions and for general public. As a part of youth movement, more than 400 Nature Clubs have been set up in four different regions of India. It also publishes a quarterly bulletin and sells wildlife posters, calendars, greeting cards, etc. with message of conservation printed over them.

WWF–I supports research projects on wildlife conservation in India. The foremost being the Project Tiger (1973), Gir Ecological Research Project (1968), Project Hangul (1970), Manipur Thamin (1977), the Himalayan Musk Deer Project (1979), and the Lesser Cats Project (1981). The last one was taken up in collaboration with the Zoological Survey of India.

With the technical assistance of FAO and UNDP, a major project for the breeding and management of crocodiles was started in India, in 1975, with emphasis on all the three species occurring in the country, namely, the Gharial, the Mugger and the Estuarine Crocodile. As a result, a total of 34 crocodile rearing centres and 12 sanctuaries have come up in the country. In 1978, the Government of India has also set up a Central Crocodile Breeding and Management Institute at Hyderabad to impart training in live crocodile handling, crocodile husbandry, sanctuary management and wildlife management in general.

***CONTRIBUTIONS BY THE ZOOLOGICAL SURVEY  
OF INDIA***

The Zoological Survey of India has also taken up projects on the faunal assessment of the Tiger Reserves (Sunderbans, Similipal, Buxa, Manas, Namdapha, Palamau and Nagarjuna Sagar) and of some of the Sanctuaries and National Parks (Namdapha, Dudhwa, Corbett, Nada Devi, Neora valley, Keoladeo Ghana, Kanha, Kalakad, Chail, Rajaji, Balphakram, etc.). In addition, the status survey of many of the endangered species of reptiles, birds and mammals (Golden Langur, Phayre's Leaf Monkey, Hoolock Gibbon, Nilgiri Langur, Lion-tailed Macaque, Indian Swamp Deer, Indian Wild Ass, Indian Elephant, Hispid Hare, Lesser Cats, Manipur Thamin, Great Indian Bustard, White-winged Wood Duck, Nicobar Megapode, Large Whistling teal, different species of pheasants, Mugger, etc.) and the population census of Rhesus Macaque, Bonnet Macaque and Hanuman Langur has also been done.

It is hoped that the National Conservation Policy will fulfil the major objectives and requirements of conservation and will offer a better quality of life.

<b>NUMBER OF NATIONAL PARKS AND SANCTUARIES IN INDIA (STATEWISE) UPTO 1985</b>				
<b>S. N.</b>	<b>Name of State</b>	<b>No. of Sanctuaries<sup>1</sup></b>	<b>No. of National Parks<sup>2</sup></b>	<b>Total</b>
1.	Andaman & Nicobar	94	6	100
2.	Andhra Pradesh	16	—	16
3.	Arunachal Pradesh	4	2	6
4.	Assam	8	2	10
5.	Bihar	14	1	15
6.	Chandigarh	1	—	1
7.	Delhi	1	—	1
8.	Goa	4	1	5
9.	Gujarat	12	4	16
10.	Haryana	6	—	6
11.	Himachal Pradesh	28	2	30
12.	Jammu & Kashmir	13	4	17
13.	Karnataka	18	5	23
14.	Kerala	11	3	14
15.	Madhya Pradesh	31	11	42
16.	Maharashtra	11	5	16
17.	Manipur	—	2	2
18.	Meghalaya	3	2	5
19.	Mizoram	1	—	1
20.	Nagaland	4	—	4
21.	Orissa	16	1	17
22.	Punjab	5	—	5
23.	Rajasthan	21	4	25
24.	Sikkim	4	1	5
25.	Tamil Nadu	10	2	12
26.	Tripura	2	—	2
27.	Uttar Pradesh	14	5	19
28.	West Bengal	16	3	19
	<b>Total Number</b>	<b>368</b>	<b>66</b>	<b>434</b>

**1 WILDLIFE SANCTUARY**  
*Place where some rare, wild, indigenous mammals, birds, reptiles and any other form of wildlife in good numbers and representative of a region are considered to be in need of protection together with the natural environment, the area is declared as a WILDLIFE SANCTUARY. It is created by the State Government by Notification. Its control and management are the responsibility of the State Government. In a sanctuary, private ownership rights may be allowed to continue and forestry and other usages may be permitted to the extent that they do not adversely affect wildlife conservation.*

**2 NATIONAL PARK**  
*An area dedicated by statute (legislation) for all times to come, to conserve the natural or historical objects of national significance and to conserve wildlife therein, in such a manner, and by such means, as will leave them unimpaired for the enjoyment of future generations, with such modifications as local conditions may demand. A National Park has a permanent status, and is entitled for financial support from the Central Government. In a National Park all private rights are extinguished and all forestry operations and other usages such as grazing of domestic animals are prohibited.*

**Wild Life (Protection) Act, 1972**  
**(as on 24 November, 1986)**

*Schedule I*

*Part I : Mammals*

Andaman Wild Pig	<i>(Sus scrofa andamanensis)</i>
Bharal	<i>(Pseudois nayur)</i>
Binturong	<i>(Arctictis binturong)</i>
Blackbuck	<i>(Antelope cervicapra)</i>
Brow-antlered Deer or Thamin	<i>(Cervus eldi)</i>
Brown Bear	<i>(Ursus acrtos)</i>
Capped Langur	<i>(Presbytis pileatus)</i>
Caracal	<i>(Felis caracal)</i>
Cheetah	<i>(Acinonyx jubatus)</i>
Chinese Pangolin	<i>(Manis pentadactyla)</i>
Chinkara or Indian Gazelle	<i>(Gazella gazella bennetti)</i>
Clouded Leopard	<i>(Neofelis nebulosa)</i>
Crab-eating Macaque	<i>(Macaca irus umbrosa</i> <i>= M fascicularis umbrosa)</i>
Desert Cat	<i>(Felis silvestris ornata)</i>
Desert Fox	<i>(Vulpes leucopus</i> <i>= Vulpes vulpes pusilla)</i>
Dugong	<i>(Dugong dugon)</i>
Ermine	<i>(Mustela erminea)</i>
Fishing Cat	<i>(Felis viverrina)</i>
Four-horned Antelope	<i>(Tetracerus quadricornis)</i>
Gangetic Dolphin	<i>(Platanista gangetica)</i>
Gaur	<i>(Bos gaurus)</i>
Golden Cat	<i>(Felis temmincki)</i>
Golden Langur	<i>(Presbytis geei)</i>
Giant squirrel	<i>(Ratufa macroura)</i>
Himalayan Ibex	<i>(Capra ibex)</i>

Himalayan Tahr	( <i>Hemitragus jemlahicus</i> )
Hispid Hare	( <i>Caprolagus hispidus</i> )
Hog-Badger	( <i>Arctonyx collaris</i> )
Hoolock Gibbon	( <i>Hylobates hoolock</i> )
Indian Elephant	( <i>Elephas maximus</i> )
Indian Lion	( <i>Panthera leo persica</i> )
Indian Wild Ass	( <i>Equus hemionus khur</i> )
Indian Wolf	( <i>Canis lupus pallipes</i> )
Kashmir Stag	( <i>Cervus elephus hanglu</i> )
Leaf Monkey	( <i>Presbytis phayrei</i> )
Leopard or Panther	( <i>Panthera pardus</i> )
Leopard Cat	( <i>Felis bengalensis</i> )
Lesser or Red Panda	( <i>Ailurus fulgens</i> )
Lion-tailed Macaque	( <i>Macaca silenus</i> )
Little Indian Porpoise	( <i>Neomeris phocaenoides</i> )
Slender Loris	( <i>Loris tardigradus</i> )
Lynx	( <i>Felis lynx isabellinus</i> )
Malabar Civet	( <i>Viverra megaspila</i> )
Malayan Sun Bear	( <i>Helarctos malayanus</i> )
Marbled Cat	( <i>Felis marmorata</i> )
Markhor	( <i>Capra falconeri</i> )
Mouse-Deer	( <i>Tragulus meminna</i> )
Musk Deer	( <i>Moschus moschiferus</i> )
Nilgiri Tahr	( <i>Hemitragus hylocrius</i> )
Nilgiri Langur	( <i>Presbytis johni</i> )
Nayan	( <i>Ovis ammon hodgsoni</i> )
Pallas's Cat	( <i>Felis manul</i> )
Pangolin	( <i>Manis crassicaudata</i> )
Pygmy Hog	( <i>Sus salvanius</i> )
Ratel	( <i>Mellivora capensis</i> )
Rhinoceros	( <i>Rhinoceros unicornis</i> )
Rusty-spotted Cat	( <i>Felis rubiginosa</i> )
Serow	( <i>Capricornis sumatraensis</i> )

Slow Loris	<i>(Nycticebus coucang)</i>
Small-clawed Otter	<i>(Aonyx cinerea)</i>
Small Travancore Flying Squirrel	<i>(Petinomys fuscocapillus)</i>
Snow Leopard	<i>(Panthera uncia)</i>
Snub-nosed Dolphin	<i>(Orcaella brevirostris)</i>
Spotted Linsang	<i>(Prionodon pardicolor)</i>
Swamp Deer	<i>(Cervus duvauceli)</i>
Takin or Mishimi Takin	<i>(Budorcas taxicolor)</i>
Tibetan Antelope or Chiru	<i>(Pantholops hodgsoni)</i>
Tibetan Gazelle	<i>(Procapra picticaudata)</i>
Tibetan Wild Ass	<i>(Asinus kiang)</i>
Tibetan Fox	<i>(Vulpes ferrilata)</i>
Tibetan Wolf	<i>(Canis lupus chanco)</i>
Tiger	<i>(Panthera tigris)</i>
Urial or Shapu	<i>(Ovis vignei)</i>
Wild Buffalo	<i>(Bubalus bubalis)</i>
Wild Yak	<i>(Bos grunniens)</i>

### ***Part II: Amphibians and Reptiles***

Agra Monitor Lizard	<i>(Varanus griseus)</i>
Barred, Oval or Yellow Monitor Lizard	<i>(Varanus flavescens)</i>
Crocodiles	<i>(Crocodylus porosus and C. palustris)</i>
Gharial	<i>(Gavialis gangeticus)</i>
Ganges Soft-shelled Turtle	<i>(Trionyx gangeticus)</i>
Green Sea Turtle	<i>(Chelonia mydas)</i>
Hawksbill Turtle	<i>(Eretmochelys imbricata)</i>
Indian Egg-eating Snake	<i>(Elachistodon westermanni)</i>
Indian Flap-shelled Turtle	<i>(Lissemys punctata punctata)</i>
Indian Tent Turtle	<i>(Kachuga tecta tecta)</i>
Large Bengal Monitor Lizard	<i>(Varanus bengalensis)</i>

Leathery Turtle	( <i>Dermochelys coriacea</i> )
Logger Head Turtle	( <i>Caretta caretta</i> )
Olive-back Logger Head Turtle	( <i>Lepidochelys olivacea</i> )
Peacock-marked or Soft-shelled Turtle	( <i>Trionyx hurum</i> )
Pythons	( <i>Python spp.</i> )
Water Monitor Lizard	( <i>Varanus salvator</i> )

### ***Part III: Birds***

Andaman Teal	( <i>Anas gibberifrons albogularis</i> )
Assam Bamboo Partridge	( <i>Bambusicola fytchii</i> )
Bazas	( <i>Aviceda jerdoni and Aviceda leuphotes</i> )
Bengal Florican	( <i>Eupodotis bengalensis</i> )
Black-necked Crane	( <i>Grus nigricollis</i> )
Blood Pheasants	( <i>Ithaginis cruentus tibetanus, Ithaginis cruentus kuseri</i> )
Cheer Pheasant	( <i>Catreus wallichii</i> )
Eastern White Stork	( <i>Ciconia ciconia boyciana</i> )
Forest Spotted Owlet	( <i>Athene blewitti</i> )
Great Indian Bustard	( <i>Ardeotis nigriceps</i> )
Great Pied Hornbill	( <i>Buceros bicornis</i> )
Hawks	( <i>Accipitridae</i> )
Hooded Crane	( <i>Grus monacha</i> )
Hornbill	( <i>Ptilolaemus tickelli austeni, Aceros nipalensis, Rhyticeros undulatus ticehursti</i> )
Houbara Bustard	( <i>Chlamydotis undulata</i> )
Hume's Bartailed Pheasant	( <i>Syrmaticus humiae</i> )
Indian Pied Hornbill	( <i>Anthracoceros malabaricus</i> )
Jerdon's Courser	( <i>Cursorius bitorquatus</i> )
Lammergeier	( <i>Gypaetus barbatus</i> )

Large Falcons	( <i>Falco peregrinus</i> , <i>Falco biarmicus</i> and <i>Falco chicquera</i> )
Large Whistling Teal	(Anatidae)
Monal Pheasants	( <i>Lophophorus impejanus</i> , <i>L. sclateri</i> )
Mountain Quail	( <i>Ophrysia superciliosa</i> )
Narcondam Hornbill	( <i>Rhyticeros narcondami</i> )
Nicobar Megapode	( <i>Megapodius freycinet</i> )
Nicobar Pigeon	( <i>Caloenas nicobarica</i> )
Osprey or Fish-eating Eagle	( <i>Pandion haliaetus</i> )
Peacock Pheasant	( <i>Polyplectron bicalcaratum</i> )
Peafowl	( <i>Pavo cristatus</i> )
Pink-headed Duck	( <i>Rhodonessa caryophyllacea</i> )
Sclater's Monal	( <i>Lophophorus sclateri</i> )
Siberian White Crane	( <i>Grus leucogeranus</i> )
Tibetan Snow Cock	( <i>Tetraogallus tibetanus</i> )
Tragopan pheasants	( <i>Tragopan melanocephalus</i> , <i>T. blythii</i> , <i>T. satyra</i> , <i>T. temminckii</i> )
White-bellied Sea Eagle	( <i>Haliaeetus leucogaster</i> )
White-eared Pheasant	( <i>Crossoptilon crossoptilon</i> )
White Spoonbill	( <i>Platalea leucorodia</i> )
White-winged Wood Duck	( <i>Cairina scutulata</i> )

### Schedule II

#### Special Game

##### Part I

Assamese Macaque	( <i>Macaca assamensis</i> )
Bengal Porcupine	( <i>Atherurus macrourus assamensis</i> )
Bonnet Macaque	( <i>Macaca radiata</i> )
Whales, dolphins and porpoises	Cetacean sp. (other than those in Schedule I and II)
Common Langur	( <i>Presbytis entellus</i> )

Ferret Badgers	( <i>Melogale moschata</i> & <i>M. personata</i> )
Himalayan Crestless Porcupine	( <i>Hystrix hodgsoni</i> )
Pig-tailed Macaque	( <i>Macaca nemestrina</i> )
Rhesus Macaque	( <i>Macaca mulatta</i> )
Stump-tailed Macaque	( <i>Macaca arctoides</i> )
Wild Dog or Dhole	( <i>Cuon alpinus</i> )
Chameleon	( <i>Chamaeleon zeylanicus</i> )
Spiny-tailed lizard	( <i>Uromastix hardwickii</i> )
Himalayan Newt	( <i>Tylototriton verrucosus</i> )
<b>Part II</b>	
Civets	(All species except Malabar Civet)
Common Fox	( <i>Vulpes bengalensis</i> )
Flying squirrels	( <i>Hylopetes, Petaurista, Belomys, Eupetaurus</i> )
Giant squirrels	( <i>Ratufa indica, R. bicolor</i> )
Himalayan Black Bear	( <i>Selenarctos thibetanus</i> )
Jackal	( <i>Canis aureus</i> )
Jungle Cat	( <i>Felis chaus</i> )
Marmots	( <i>Marmota bobak himalayana, M. caudata</i> )
Martens	( <i>Martes foina intermedia, M. flavigula, M. gwatkinsi</i> )
Otters	( <i>Lutra lutra, L. perspicillata</i> )
Pole cats	( <i>Vormela peregusna, Mustela putorius</i> )
Red Fox	( <i>Vulpes vulpes</i> )
Sperm Whale	( <i>Physeter macrocephalus</i> )
Sloth Bear	( <i>Melursus ursinus</i> )
Weasels	( <i>Mustela sibirica, M. kathia, M. altaica</i> )
Checkered Keelback	( <i>Xanochrophis piscator</i> )

Rat Snake	( <i>Ptyas mucosus</i> )
Dog-faced Water Snake	( <i>Cerberus rhynchops</i> )
Indian Cobra	( <i>Naja spp.</i> )
King Cobra	( <i>Ophiophagus hannah</i> )
Olivaceous Keelback	( <i>Artretium schistosum</i> )
Russel Viper	( <i>Vipera ruselli</i> )
Monitor Lizard, (excepting those mentioned in Schedule I)	<i>Varanus spp.</i>

**Schedule III****Big Game**

Barking Deer	( <i>Muntiacus muntjak</i> )
Chital	( <i>Axis axis</i> )
Goral	( <i>Naemorhedus goral</i> , <i>Naemorhedus hodgsoni</i> )
Hog Deer	( <i>Axis porcinus</i> )
Hyena	( <i>Hyaena hyaena</i> )
Nilgai	( <i>Boselaphus tragocamelus</i> )
Sambar	( <i>Cervus unicolor</i> )
Wild Pig	( <i>Sus scrofa</i> )

**Schedule IV****Small Game**

Five-striped Palm Squirrel	( <i>Funambulus pennanti</i> )
Hares	( <i>Lepus nigricollis and Ochotona sp.</i> )
Hedgehog	( <i>Hemiechinus auritus</i> )
Indian Porcupine	( <i>Hystrix indica</i> )
Birds (other than those mentioned in Schedule I)	
Avadavat	(Estrildinae)
Avocet	(Recurvirostridae)
Babblers	(Timaliinae)
Barbets	(Capitonidae)
Barn Owls	(Tytoninae)

<b>Bitterns</b>	(Ardeidae)
<b>Brown-headed Gull</b>	( <i>Larus brunnicephalus</i> )
<b>Bulbuls</b>	(Pycnonotidae)
<b>Buntings</b>	(Emberizidae)
<b>Bustards</b>	(Otididae)
<b>Bustard-Quails</b>	(Turnicidae)
<b>Chloropsis</b>	(Irenidae)
<b>Comb Duck</b>	( <i>Sarkidiornis melanotos</i> )
<b>Coot</b>	(Rallidae)
<b>Cormorants</b>	(Phalacrocoracidae)
<b>Cranes</b>	(Gruidae)
<b>Cuckoos</b>	(Cuculidae)
<b>Darters</b>	(Phalacrocoracidae)
<b>Doves including the Emerald Dove</b>	(Columbidae)
<b>Drongos</b>	(Dircuridae)
<b>Ducks</b>	(Anatidae)
<b>Egrets</b>	(Ardeidae)
<b>Fairy Blue Bird</b>	(Irenidae)
<b>Falcons, excepting those mentioned in Schedule I.</b>	(Falconidae)
<b>Finches including the Chaffinch</b>	(Fringillidae)
<b>Flamingos</b>	(Phoenicopteridae)
<b>Flowerpeckers</b>	(Dicaeidae)
<b>Flycatchers</b>	(Muscicapidae)
<b>Geese</b>	(Anatidae)
<b>Goldfinch and allies</b>	(Carduelinae)
<b>Grebes</b>	(Podicipedidae)
<b>Hérons</b>	(Ardeidae)
<b>Ibises</b>	(Threskiornithidae)
<b>Ioras</b>	(Irenidae)
<b>Jays</b>	(Corvidae)

Jacanas	(Jacanidae)
Kingfishers	(Alcedinidae)
Larks	(Alaudidae)
Lorikeets	(Psittacidae)
Magpies including the Hunting Magpie	(Corvidae)
Mannikins	(Estrildinae)
Megapodes, excepting the Nicobar Megapode	(Megapodidae)
Minivets	(Campephagidae)
Munias	(Estrildinae)
Mynas	(Sturnidae)
Nightjars	(Caprimulgidae)
Orioles	(Oriolidae)
Owls	(Strigidae)
Oystercatchers	(Haematopodidae)
Parakeets	(Psittacidae)
Pelicans	(Pelecanidae)
Pheasants	(Phasianidae)
Pigeons, excepting the Blue Rock Pigeon	(Columbidae)
Pipits	(Motacillidae)
Plovers	(Charadrinae)
Quails	(Phasianidae)
Rails	(Rallidae)
Rollers or Blue Jay	(Coraciidae)
Sandgrouses	(Pteroclididae)
Sandpipers	(Scolopacinae)
Snipes	(Scolopacinae)
Spurfowls	(Phasianidae)
Starlings	(Sturnidae)
Stone Curlew	(Burhinidae)
Storks	(Ciconiidae)

Stilt	(Recurvirostridae)
Sunbirds	(Nectaridae)
Swans	(Anatidae)
Teals	(Anatidae)
Thrushes	(Turdinae)
Tits	(Paridae)
Tree Pies	(Corvidae)
Trogons	(Trogonidae)
Vultures	(Accipitridae)
Waxbills	(Estrildinae)
Weaver Birds or Bayas	(Ploceidae)
White-eyes	(Zosteropidae)
Woodpeckers	(Picidae)
Wrens	(Troglodytidae)
Snakes : (other than those listed in other Schedules)	Amblycephalidae Anilidae Boidae Colubridae Desyptidae Elaphidae Glaucnidae Hydrophiidae Tyliidae Leptotyphlopidae Typhlopidae Uropeltidae Viperidae Xenopeltidae
Fresh Water Frogs	( <i>Rana sp.</i> )
Three-keeled Turtle	( <i>Melanochelys tricarinata</i> )
Tortoise	(Testudinidae, Trionychidae)
Viviparous Toads	( <i>Nectophrynoides sp.</i> )
Voles	

**Schedule V**

Common Crow

Fruit Bats

Mice

Rats

**Convention On International Trade  
in Endangered Species of Wild Fauna and Flora (CITES)  
(as on 22 October, 1987)**

**APPENDIX I****MAMMALIA****PRIMATES**

- |                              |                                   |
|------------------------------|-----------------------------------|
| 1. <i>Macaca silenus</i>     | (Lion-tailed Macaque)             |
| 2. <i>Presbytis entellus</i> | (Common Langur or Hanuman Langur) |
| 3. <i>Presbytis geei</i>     | (Golden Langur)                   |
| 4. <i>Presbytis pileatus</i> | (Capped Langur)                   |
| 5. <i>Hylobates spp.</i>     | (Gibbons)                         |

**LAGOMORPHA**

- |                               |               |
|-------------------------------|---------------|
| 6. <i>Caprolagus hispidus</i> | (Hispid Hare) |
|-------------------------------|---------------|

**CETACEA**

- |   |                            |
|---|----------------------------|
| 7. <i>Platanista gangetica</i>                          | (Gangetic Dolphin or Susu) |
| 8. <i>Physeter catodon</i><br>(= <i>macrocephalus</i> ) | (Sperm Whale)              |
| 9. <i>Neomeris phocaenoides</i>                         | (Black Finless Porpoise)   |
| 10. <i>Balaenoptera musculus</i>                        | (Great Blue Whale)         |
| 11. <i>Balaenoptera physalus</i>                        | (Common Rorqual)           |
| 12. <i>Balaenoptera borealis</i>                        | (Sei Whale)                |

**CARNIVORA**

- |                                     |                          |
|-------------------------------------|--------------------------|
| 13. <i>Canis lupus</i>              | (Wolf)                   |
| 14. <i>Helarctos malayanus</i>      | (Malayan Sun Bear)       |
| 15. <i>Selenarctos thibetanus</i>   | (Asian Black Bear)       |
| 16. <i>Ursus arctos isabellinus</i> | (Himalayan Brown Bear)   |
| 17. <i>Lutra lutra</i>              | (Common or Indian Otter) |
| 18. <i>Prionodon pardicolor</i>     | (Spotted Linsang)        |
| 19. <i>Acinonyx jubatus</i>         | (Cheetah)                |
| 20. <i>Felis bengalensis</i>        | (Leopard Cat)            |
| 21. <i>Felis caracal</i>            | (Caracal)                |
| 22. <i>Felis marmorata</i>          | (Marbled Cat)            |
| 23. <i>Felis rubiginosa</i>         | (Rusty-spotted Cat)      |
| 24. <i>Felis temmincki</i>          | (Golden Cat)             |
| 25. <i>Neofelis nebulosa</i>        | (Clouded Leopard)        |
| 26. <i>Panthera leo persica</i>     | (Asian Lion)             |
| 27. <i>Panthera pardus</i>          | (Leopard or Panther)     |
| 28. <i>Panthera tigris</i>          | (Tiger)                  |
| 29. <i>Panthera uncia</i>           | (Snow Leopard)           |

**PROBOSCIDEA**

- |                            |                  |
|----------------------------|------------------|
| 30. <i>Elephas maximus</i> | (Asian Elephant) |
|----------------------------|------------------|

**SIRENIA**

- |                         |                     |
|-------------------------|---------------------|
| 31. <i>Dugong dugon</i> | (Sea Cow or Dugong) |
|-------------------------|---------------------|

**PERISSODACTYLA**

- |  |                   |
|--|-------------------|
| 32. <i>Equus (=Asinus)<br/>hemionus khur</i> | (Indian Wild Ass) |
| 33. Rhinocerotidae                           | (Rhinoceroses)    |

**ARTIODACTYLA**

- |                                     |                                |
|-------------------------------------|--------------------------------|
| 34. <i>Sus salvanius</i>            | (Pygmy Hog)                    |
| 35. <i>Cervus duvauceli</i>         | (Swamp Deer or Barasinga)      |
| 36. <i>Cervus elephus hanglu</i>    | (Hangul or Kashmir Stag)       |
| 37. <i>Cervus eldi</i>              | (Thamin or Brow-antlered Deer) |
| 38. <i>Moschus moschiferus</i>      | (Musk Deer)                    |
| 39. <i>Bos gaurus</i>               | (Indian Bison or Gaur)         |
| 40. <i>Bos mutus</i>                | (Yak)                          |
| 41. <i>Capra falconeri jerdoni</i>  | (Suleiman Markhor)             |
| 42. <i>Capricornis sumatraensis</i> | (Serow)                        |
| 43. <i>Naemorhedus goral</i>        | (Goral)                        |
| 44. <i>Ovis ammon hodgsoni</i>      | (Nayan or Great Tibetan Sheep) |
| 45. <i>Ovis vignei</i>              | (Shapu or Urial)               |
| 46. <i>Pantholops hodgsoni</i>      | (Tibetan Antelope or Chiru)    |

**AVES****PELECANIFORMES**

- |                            |                                 |
|----------------------------|---------------------------------|
| 1. <i>Fregata andrewsi</i> | (Christmas Island Frigate Bird) |
|----------------------------|---------------------------------|

**CICONIFORMES**

- |                                    |                       |
|------------------------------------|-----------------------|
| 2. <i>Ciconia ciconia boyciana</i> | (Eastern White Stork) |
|------------------------------------|-----------------------|

**ANSERIFORMES**

- |                                     |                          |
|-------------------------------------|--------------------------|
| 3. <i>Cairina scutulata</i>         | (White-winged Wood Duck) |
| 4. <i>Rhodonessa caryophyllacea</i> | (Pink-headed Duck)       |

**FALCONIFORMES**

- |   |                                |
|---|--------------------------------|
| 5. <i>Aquila heliaca</i>  | (Imperial Eagle)               |
| 6. <i>Falco peregrinus peregrinoides</i> , <i>F. p. babylonicus</i> | (Red-capped or Barbary Falcon) |

**GALLIFORMES**

- |                                     |                                       |
|-------------------------------------|---------------------------------------|
| 7. <i>Catreus wallichii</i>         | (Cheer Pheasant)                      |
| 8. <i>Crossoptilon crossoptilon</i> | (Eared Pheasant)                      |
| 9. <i>Lophophorus impejanus</i>     | (Impeyan or Himalayan Monal Pheasant) |
| 10. <i>Lophophorus sclateri</i>     | (Sclater's Monal Pheasant)            |
| 11. <i>Syrmaticus humiae</i>        | (Mrs. Humes Barbacked Pheasant)       |
| 12. <i>Tetraogallus tibetanus</i>   | (Tibetan Snow Cock)                   |
| 13. <i>Tragopan blythii</i>         | (Grey-bellied Tragopan)               |
| 14. <i>Tragopan melanocephalus</i>  | (Western Horned Tragopan)             |

**GRUIFORMES**

- |                                  |                                 |
|----------------------------------|---------------------------------|
| 15. <i>Grus leucogeranus</i>     | (Siberian or Great White Crane) |
| 16. <i>Grus monacha</i>          | (Hooded Crane)                  |
| 17. <i>Grus nigricollis</i>      | (Blacknecked Crane)             |
| 18. <i>Chlamydotis undulata</i>  | (Houbara Bustard)               |
| 19. <i>Ardeotis nigriceps</i>    | (Great Indian Bustard)          |
| 20. <i>Eupodotis bengalensis</i> | (Bengal Florican)               |

**COLUMBIFORMES**

- |                                |                  |
|--------------------------------|------------------|
| 21. <i>Caloenas nicobarica</i> | (Nicobar Pigeon) |
|--------------------------------|------------------|

**STRIGIFORMES**

- |                            |                      |
|----------------------------|----------------------|
| 22. <i>Athene blewitti</i> | (Forest Spotted owl) |
|----------------------------|----------------------|

**CORACIIFORMES**

- |                                    |                       |
|------------------------------------|-----------------------|
| 23. <i>Buceros bicornis homrai</i> | (Great Pied Hornbill) |
|------------------------------------|-----------------------|

**REPTILIA****TESTUDINATA**

- |   |   |
|---|---|
| 1. <i>Batagur baska</i>                       | (Batagur)   |
| 2. <i>Geoemyda (=Nicoria)<br/>tricarinata</i> | (Three keeled Turtle)                                       |
| 3. <i>Kachuga tecta tecta</i>                 | (Indian Tent Turtle)  |
| 4. <i>Cheloniidae spp.</i>                    | (Marine Turtles)  |
| 5. <i>Dermochelys coriacea</i>                | (Leathery or Leatherback<br>Turtle)                         |
| 6. <i>Lissemys punctata</i>                   | (Indian Flapshelled Turtle)                                 |
| 7. <i>Trionyx gangeticus</i>                  | (Gangetic Soft-shelled Turtle)                              |
| 8. <i>Trionyx hurum</i>                       | (Peacock-marked Turtle or<br>Ocellated Soft-shelled Turtle) |

**CROCODYLIA**

- |                                |                             |
|--------------------------------|-----------------------------|
| 9. <i>Crocodylus palustris</i> | (Marsh Crocodile or Mugger) |
| 10. <i>Crocodylus porosus</i>  | (Estuarine Crocodile)       |
| 11. <i>Gavialis gangeticus</i> | (Gharial)                   |

**RHYNCHOCEPHALIA**

- |                                |                         |
|--------------------------------|-------------------------|
| 12. <i>Varanus bengalensis</i> | (Common Indian Monitor) |
| 13. <i>Varanus flavescens</i>  | (Yellow Monitor)        |
| 14. <i>Varanus griseus</i>     | (Indian Desert Monitor) |

**SERPENTES**

- |                                   |                 |
|-----------------------------------|-----------------|
| 15. <i>Python molurus molurus</i> | (Indian Python) |
|-----------------------------------|-----------------|

**AMPHIBIA****SALIENTIA**

- |                                |                               |
|--------------------------------|-------------------------------|
| 1. <i>Nectophrynoides spp.</i> | (Webbed-footed or Tree Toads) |
|--------------------------------|-------------------------------|

**APPENDIX II****MAMMALIA****PRIMATES**

1. *Primates spp.* (Apes, monkeys & lemurs excepting those mentioned in Appendix I)

**PHOLIDOTA**

2. *Manis crassicaudata* (Indian Pangolin)
3. *Manis pentadactyla* (Chinese Pangolin)

**RODENTIA**

4. *Ratufa spp.* (Giant squirrels)

**CETACEA**

5. *Cetacea spp.* (Whales, dolphins & porpoises)

**CARNIVORA**

6. *Cuon alpinus* (Asian Wild dog or Dhole)
7. *Ailurus fulgens* (Red Panda)
8. *Lutrinae spp.* (Otters)
9. *Felidae spp.* (Desert, Fishing, Jungle & Pallas' Cats & Lynx)

**PERISSODACTYLA**

10. *Equus hemionus (=Asinus kiang)* (Tibetan Wild Ass)

**ARTIODACTYLA**

11. *Capra falconeri* (Markhor)

**AVES****PELECANIFORMES**

1. *Pelecanus crispus* (Dalmatian Pelican)

**CICONIFORMES**

2. *Ciconia nigra* (Black Stork)  
3. *Platalea leucorodia* (White Spoonbill)

**ANSERIFORMES**

4. *Cygnus bewickii jankowskii* (Jankowskis or Eastern Whistling Swan)  
5. *Sarkidiornis melanotos* (Comb Duck or Nukta)

**FALCONIFORMES**

6. Falconiformes spp. (Eagles, falcons, hawks & vultures)

**GALLIFORMES**

7. *Gallus sonneratii* (Grey Jungle Fowl)  
8. *Ithaginis cruentus* (Blood Pheasant)  
9. *Polyplectron bicalcaratum* (Peacock Pheasant)

**PSITTACIFORMES**

10. Psittaciformes spp. (Parrots)

**STRIGIFORMES**

11. Strigiformes spp. (Owls & owlets)

**CORACIFORMES**

12. *Aceros narcondami* (Narcondam Hornbill)

**REPTILIA****TESTUDINATA**

1. *Testudinidae spp.* (Tortoises)
2. *Pedocnemis spp.* (River Turtles or Sideneck Turtles)

**SAURIA**

3. *Uromastix spp.*

**SERPENTES**

4. *Boidae spp.* (Sand Boas)
5. *Elachistodon westermanni* (Indian Egg-eating Snake)

**AMPHIBIA****ANURA**

1. *Rana hexadactyla* (Green Frog)
2. *Rana tigrina* (Indian Bull Frog)

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