

# ENVIRONMENTAL BIOLOGY

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AGRO BOTANICAL PUBLISHERS (INDIA)

**ENVIRONMENTAL BIOLOGY**

**1987**

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Rs. 300.00/ US \$ 40.00

ISBN 81-85031-19-3

Copy right: Dr. K. C. Agarwal

First published in India

by Agro Botanical Publishers (India)

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Published by Mrs. Saraswati for Agro Botanical  
Publishers (India), Old Ginnani, Bikaner and Printed  
at Shakun Printers, Delhi 110 032.

## PREFACE

Environmental crisis which is confronting the world, will profoundly alter the future destiny of our planet. No one amongst us, whatever our status, strength or circumstance, can remain unaffected. This made man to think over the issue of environmental problems seriously and to find out solutions to preserve the nature and natural resources without impairing the developmental programmes for Human survival and benefit. The present text is an attempt to make the man acquainted thoroughly with the knowledge of ecosystem, and the factors concerned with the deterioration of the environment with the view to plan and manage the development programmes in such a way so that exploitation of natural resources may not upset the balance of nature. It is difficult to consider all the aspects of such a vast discipline. Nevertheless, the most important issues related to the subject have, however been touched.

The plan of this book is a simple one. Its backbone is provided by what one would like to think of as basic knowledge of ecosystem, productivity, system analysis, and natural resources, notwithstanding this, there is an introductory chapter dealing with the concept of environment, ecology and environmental biology. Chapter 6 and 8 deal with environmental problems and protection of environment through law. Chapter 7 very well illustrates the importance, objectives and guidelines of environmental education. The last chapter deals with the man and biosphere programmes and the International agencies concerned with eco-development-programmes. Important measures and conversions, well explained glossary, abbreviations and a list of references are also appended to the text.

The use of library facilities of Indira Gandhi Centre for Human Ecology, Environmental and population studies, Department of Botany, University of Rajasthan, Jaipur is gratefully acknowledged.

The author wishes to place on record his gratitude to Agro Botanical Publishers (India), Bikaner, who spared no efforts to make the book in the best form, available to the readers.

Inevitably the text must include errors and omissions for which the author is responsible and shall very much appreciate criticism, comment, objection and suggestions from the readers for the improvement of the book.

The author takes great pleasure to dedicate the book to his parents.

**K C Agarwal**

October, 1987  
Bikaner

# CONTENTS

## Preface

- 1. ENVIRONMENTAL BIOLOGY: 1-4**  
**AN INTRODUCTION**
- 2. ECOSYSTEM 5-98**  
Introduction 5, Characteristics of ecosystem 7, Kinds of ecosystem 9, Structure of the ecosystem 10, Ecosystem functioning 15, Ecological pyramids 23, Ecological energetics 33, Energy flow in the ecosystem 37, Biogeochemical cycles 52, Hydrologic (water) cycle 54, Carbon cycle 57, Oxygen cycle 62, Nitrogen cycle Sulphur cycle 66, Phosphorus cycle 71, Calcium cycle 72, Cycle of toxic elements 74, Mercury cycle 74, Arsenic cycle 76, Lead 79, Cadmium 79, Fluorine 80, Homeostasis, management and optimization of ecosystem 81, Evolution of ecosystem 84, Preliminary studies of major ecosystems 84, Forest ecosystem 85, The desert ecosystem 88, The mountain ecosystem 89, Cave ecosystem 90, Tundra ecosystem 90, The pond ecosystem 91, Coral reef ecosystem 96, Space craft as an ecosystem 98.
- 3. PRODUCTIVITY 99-121**  
Introduction 99, Productivity 99, Primary productivity 99, Secondary productivity 101, Primary production process 103, Productivity of different ecosystems 107, Measurement of primary productivity 112, Harvest method 112, Oxygen measurement 114, Carbon dioxide method 115, Bomb calorimetry method 115, Radioisotope method 118, Leaf index method 118, Chlorophyll estimation method 119, pH method 120, Disappearance of raw material method 121, Numerical estimation 121.
- 4. SYSTEM ANALYSIS 122-137**  
Introduction 122, Ecosystem and feedback mechanism 124, Tools of system analysis 126, The system analysis

approach and ecomodelling 127, Ecomodelling 128, The development of an ecosystem model 130, The compartment system approach 131, The experimental components approach 135, Applications 137, Limitations 137.

## **5. NATURAL RESOURCES 138-191**

Introduction 138, Biotic resources 141, Forest resources 141, Silviculture 151, Agriculture 155, Fisheries and wildlife 157, Fisheries 157, Pisciculture 158, Wildlife 159, Physical resources 179, Energy resources 179, Fossil fuels 179, Natural gas 180, Coal 180, Solar energy 181, Biogas and biomass plants 183, Wind power 184, Hydropower 184, Atomic energy 185

## **6. POLLUTION 192-305**

Introduction 192, Air pollution 196, Carbon compounds 199, Carbon monoxide 203, Sulphur compounds 207, Sulphur dioxide 207, Hydrogen sulphide 210, Nitrogen oxides 211, Nitrous oxides 212, Nitric oxide 212, Nitrogen dioxide 213, Acid rains 213, Fluoride compounds 222, Hydrocarbon 223, Metals 224, Cadmium 225, Lead 225, Mercury 226, Particulate matter (or aerosol) 227, Photochemical products 230, Photochemical smog 231, Toxic substances 235, Arsenic 235, Asbestos 236, Chromium 237, Nickel 238, Nitrosamines 238, Polycyclic aromatic hydrocarbons (PAHs) 239, Causes, prevention and control of air pollution 239, Vehicular pollution 240, Industrial chimney waste 242, Cyclone collector 243, Water pollution 246, Sewage and other oxygen demanding waste 249, Industrial waste 252, Pesticides and biocides 253, Agricultural waste 258, Physical pollutants 260, Eutrophication 261, Mercury pollution 265, Fluoride pollution 267, Lead pollution 270, Ground water pollution 271, Marine pollution 272, Prevention and control of water pollution 274, Solid waste pollution 277, Radio active pollution 281, Natural sources, cosmic rays 282, Environmental, terrestrial radiations 282, Man made sources 283, Types of radiations 288, Measurement of radioactivity

289, Biological effects of radiations 290, Radiation protection 291, Noise pollution 289, Sources 294, Properties 295, Effect of noise pollution on human beings 298, Control of noise pollution 303.

**7. ENVIRONMENTAL EDUCATION 306-326**

Introduction 306, Job opportunities 310, Goals, objectives and guiding principles of environmental education 311, Classification of environmental education programmes 316, Formal environmental education 317, Non-formal environmental education 324, Environmental education for professional groups 325.

**8. CONTROL OF ENVIRONMENTAL POLLUTION THROUGH LAW 327-338**

Introduction 327, Demerits 336.

**9. INTERNATIONAL ENVIRONMENTAL ORGANIZATIONS, AGENCIES/ PROGRAMMES 339-358**

Organizations / Agencies 339, programmes 343.

**REFERENCES 359-369**

**GLOSSARY 370-428**

**ABBREVIATIONS 429-434**

**MEASUREMENTS AND CONVERSIONS 435-436**

**SALIM ALI 437-439**

# ENVIRONMENTAL BIOLOGY ; AN INTRODUCTION

The term environment etymologically means surroundings and is generally used for an abstract concept. The surroundings may be natural or man-made, and may be physical, chemical or biotic. The environment is thus, a complex of so many things surrounding an organism that interact not only with the organisms but also among themselves. As a result of this it is difficult to isolate or alter any one of them without affecting other components. The growth, behaviour and life history of an organism, are therefore, influenced by the environment in which they live. The preferred environment of an organism is usually referred to as **habitat**. The term, habitat denotes a more specific meaning of the surrounding than environment. On our planet earth, we find two major types of habitats, terrestrial ( $\sim 174$  million  $\text{km}^2$ ) and aquatic ( $\sim 480$  million  $\text{km}^2$ ) with different environmental complexes. Both of these habitats support innumerable forms of life, the nature and concentration of which vary considerably, although certain forms (amphibians) are dependent on both of them for completing their life cycle.

The term **ecology** (Greek- **Oikos** = home, habitat; **logos** = study ) was coined to denote relationship between the organisms and their environment. Etymologically, ecology is the study of organism "at home", i.e. in their natural habitats. There is some controversy about the author who coined the term ecology and first used it in the literature. For instance, Kormondy (1969) tried to give credit for the first use of the term ecology to Henry David Thoreau in



1858. There are however, references in literature to the German biologist, H. Reiter also, who is said to have used this term for the first time in 1868 (Reiter, 1885; Macmillan, 1897). Ernst Haeckel, another German biologist, although appears to have used the term in 1886, defined it for the first time in 1869, as "the body of knowledge concerning the economy of nature- the investigation of the total relations of the animals to their inorganic and organic environment. This definition still holds true if we simply replace the words "relations of the animals" by "relations of the organisms", to include also the plants and man. Since then, ecology has been defined in various ways. Warming (1895, 1909), defined it, as " the study of the organisms in relation to their environment". The American ecologist Frederick Clements (1916) considered ecology to be "the science of community" whereas, British ecologist, Charles Elton (1927) defined it as "Scientific natural history" concerned with sociology and economics of animals. Woodbury (1954) treated ecology as "science which investigates organisms in relation to their environment, and a philosophy in which the world of life is interpreted in terms of natural processes". Taylor (1936) defined ecology as " the science of all the relations of all organisms to all their environments". Andrewartha (1961), Petrides (1968) and Krebs (1972) defined it as "the scientific approach to the study of environmental interactions which control the welfare of living things, regulating their distribution, abundance, reproduction and evolution". Recently, with the recognition of orderly functioning of the abiotic and biotic components of the nature. The American ecologist, Eugene P. Odum defined ecology as " the study of structure and functions of ecosystem" (Odum, 1959, 1963), and "the science of totality of man and environment" (Odum, 1971). Another ecologist,

R. Margalef of Spain (1968) treats ecology as "the study of ecosystems". R. Misra (1967), taking into consideration the triangular concept of nature defined ecology as "interaction of form, function and factors". All these definitions have much in common and simply suggest the wide scope of ecology.

With the advancement in the knowledge of environment, explosive increase in human population, scarcity of space, food problems, deterioration of hygienic conditions, threatening depletion of natural resources and socio-economic problems, one needs extensive and exhaustive study of the environment, particularly in relation to human survival and benefit. The subject is gaining more popularity with its name as "**environmental biology**". However, the environmental biology is not a new discipline but simply an extension of ecological approach which stresses the study of the environment in its totality with special emphasis on the welfare of man and his comfort as the man has been considered the most evolved and an intelligent component of the ecosystem. Environment is not merely the atmosphere and other physical factors surrounding us, but is the complex of all factors which not only affect "one organism, one time, but all organisms all the time". In a larger sense, environment constitutes the various physical, mental, social, spiritual, educational, economic and intellectual aspects of whole humanity and when kept healthy and inspiring, it promotes the progress and development that acts as saviour and is a boon to mankind. Dimensions of environmental biology are enormously increasing and the understanding of the subject needs an adequate knowledge of geography, climatology, pedology, microbiology, bio-chemistry, physiology, biophysics, biometry, sociology, economics, etc.

The environmental problems with which now we are concerned embrace diverse aspects ranging from the economic, social, and psychological problems of human settlements to the management and use of natural resources, and the conservation of natural habitats. Since time immemorial, man has been, still is, and will always be exploiting nature without taking into consideration environmental deterioration. In fact, what he considers progress, in reality, is disturbing the environmental balance gravely, leading to breakdown of life-supporting system on the earth. The thoughtless exploitation is mainly on account of ignorance about environment and ecosystem, lack of concern amongst planners and ecologists about the side effects of the development projects, gaps in information and in training personnel, absence of multidisciplinary approach to development project, and lack of systematic information, data and feed back system. This calls for proper environmental strategy for maintaining the ecological balance and making preservation of nature, an integral part of developmental planning, together with the adoption of alternative means of livelihood for those dependent upon nature for survival. Environmental biology is a growing discipline which incorporates all these aspects of environment.

# ECOSYSTEM

## INTRODUCTION

The term **ecosystem** was first proposed by A. G. Tansley (1935), who defined it as the system resulting from the integration of all the living and non-living factors of the environment. Since then a great deal has been written on the subject (Lindeman, 1942; Odum, 1963 and 1971; Billings, 1964; Misra, 1969, 1969a; Mac Fadyen, 1964). Although the term ecosystem is of recent coinage (1935); yet concept is by no means so recent. Möbius (1877), Forbes (1887), Dokuchaev and Morozov (see Sukachev, 1944), Friederichs (1930), Thiernann (1939), Vernadsky (1944), and Misra (1968) used terms biocoenosis, microcosm, biocoenosis or geobiocoenosis, holocoen, biosystem, bioinert body and ecocosm, respectively to express similar ideas. However, the term ecosystem is most preferred, where **eco** refers the environment, and **system** implies an **interacting** and **interdependent complex**. Barrett (1978) advocates the restriction of the term ecosystem for its structural and functional aspects and proposed the new term **noosystem** to define a basic unit of study encompassing biological, physical, social, economic and cultural influences on the total system.

The organisms of any community besides interacting among themselves, always have functional relationship with the environment. This structural and functional system of communities and environment is called ecological system or **ecosystem**. It

is the basic functional unit in ecology, since it includes both biotic and abiotic environment, influencing each other for maintenance of life. According to A Dictionary of Botany written by George Usher (1965) the complete ecological system of an area, including the plants, animals and the environmental factors is known as ecosystem. According to Woodbury (1954) the ecosystem as that approach, in which habitat, plants and animals are all considered as one interacting unit; materials and energies of one passing in and out of the others. According to Odum (1971), any unit that includes all of the organisms (i.e. the **community**) in a given area interacting with the physical environment, so that a flow of energy leads to clearly defined trophic structure, biotic diversity and material cycles (i.e. exchange of materials between living and non living components) within the system, is called an ecosystem. According to A Dictionary of the Environment written by Michael Allaby (1983) a community of interdependent organisms together with the environment is known as ecosystem. Interdependence has been regarded as the first basic theme of ecology. Ecosystem includes interacting and interdependent components that are open and linked to each other. An ecosystem, may in its simplest form, be defined as a self sustained community of plants and animals existing in its own environment. An ecosystem may be as small as a drop of pond water (**microecosystem**) or as large as ocean. It can be of temporary nature, e.g., a fresh pool, a field of cultivated crops or permanent e.g., a forest or an ocean. A balanced aquarium may be thought of as an artificially established self-sustained ecosystem. It must be noted that a completely self-sufficient ecosystem like aquarium is rarely found in nature, rather, all these unit ecosystems are simply separated from each other with time and space,

but functionally they all are, infact, linked forming as integrated whole. Keeping this in view, we may think of the earth, we live upon as a giant ecosystem where abiotic and biotic components are constantly acting and reacting upon each other. The vast ecosystem, the biosphere (Fig.2.1) is however, difficult to handle and thus for convenience studied under various smaller ecosystems, e.g., forest, desert, grassland, cropland, freshwater, marine, etc.

An ecosystem is thus an overall integration of white mosaic of interacting organisms and their environment. It is normally an open system with a continuous, but variable influx and loss of materials and energy. It is thus a basic functional unit of variable size, consisting of both biotic and abiotic components interacting with each other to sustain the life upon earth. An ecosystem represents the highest level of ecological intergration which is energy based and capable of energy transformation, accumulation and circulation. Its main function in ecological sense is to emphasize obligatory relationship, interdependence and causal relationships, i.e. coupling of components to form functional units. Ecosystem may also be regarded as energy processing unit which is restrained or limited by the amount of nutrients and water available to it.

## **CHARACTERISTICS OF ECOSYSTEM**

According to Smith (1966), the ecosystem has the following general characteristics:

1. It is a major structural and functional unit of ecology.
2. Its structure is related to its species diversity; the more complex ecosystems have high species diversity and vice versa.

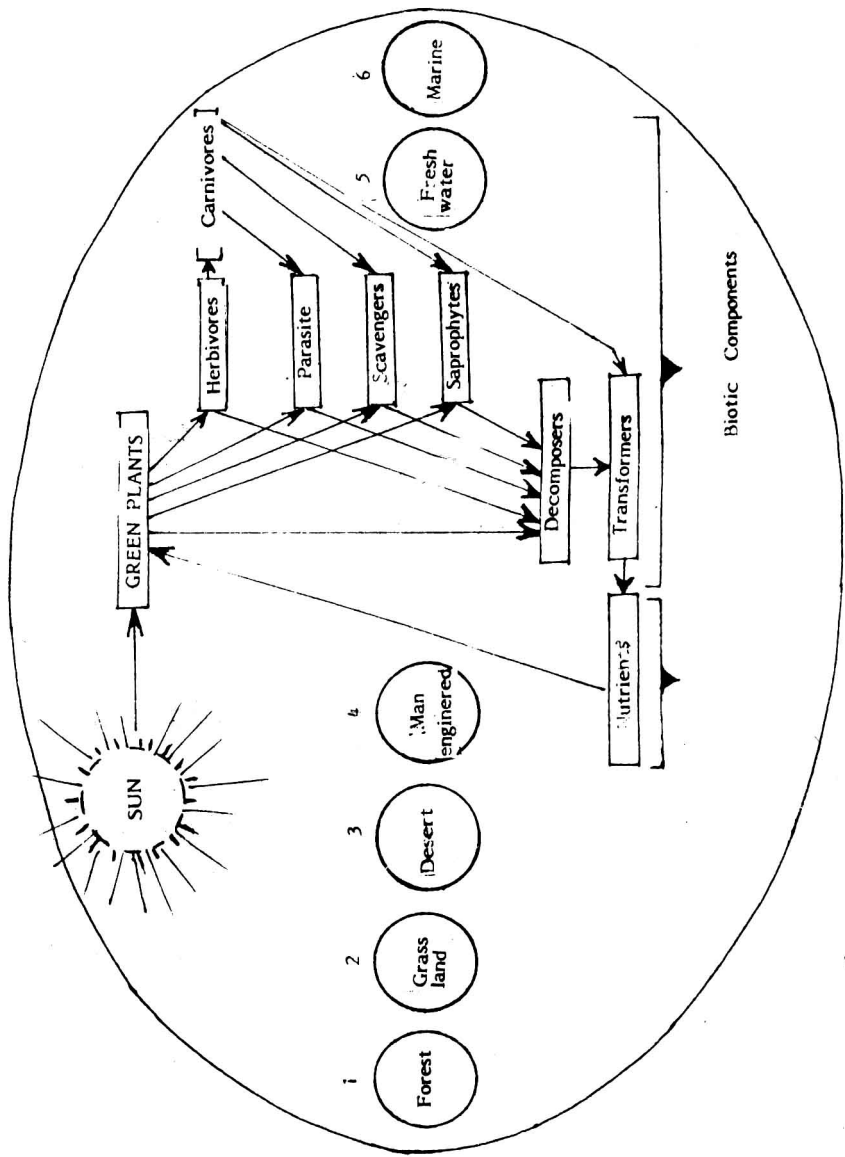


Fig. 2.1 Diagrammatic representation of biosphere.

3. Its function is related to energy flow and material cycling through and within the system.

4. The relative amount of energy needed to maintain an ecosystem depends on its structure. The more complex the structure, the lesser the energy it needs to maintain itself.

5. It matures by passing from less complex to more complex states. Early stages of each succession have an excess of potential energy and a relatively high energy flow per unit biomass. Later (mature) stages have less energy accumulation and its flow through more diverse components.

6. Both the environment and the energy fixation in any given ecosystem are limited and cannot be exceeded without causing serious undesirable effects.

7. Alternations in the environment represent selective pressures upon the population to which it must adjust. Organisms which are unable to adjust to the changed environment must need vanish.

## **KINDS OF ECOSYSTEM**

Artificially ecosystems may be classified as follows:

1. **Natural Ecosystems:** These operate under natural conditions without any major interference by man. On the basis of type of habitat these may be further divided as :

i. **Terrestrial:** Forest, grassland, desert, etc.

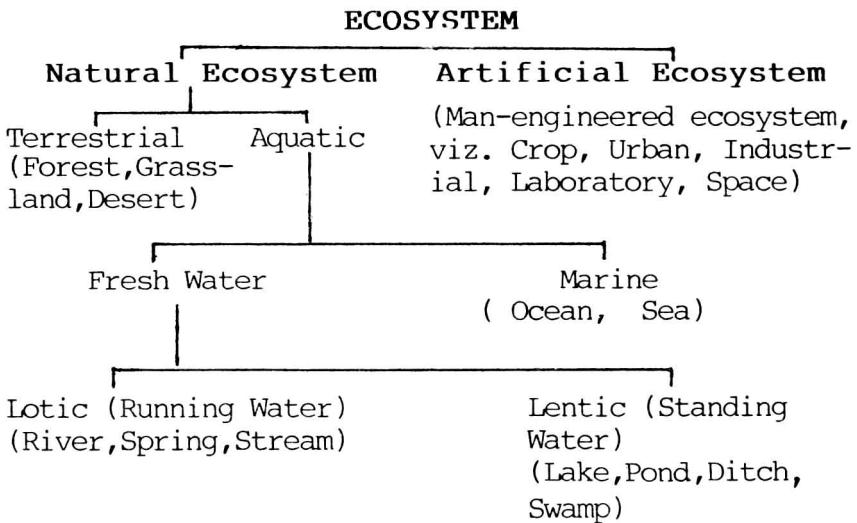
ii. **Aquatic:** (a) **Fresh water-** which may be lotic (e.g., running water as spring, stream or rivers) or lentic (e.g., standing water as lake, pond, pools, puddles, ditch, swamp, etc.). (b) **Marine-** such deep bodies as ocean or shallow ones as seas or an estuary, etc.



**2. Artificial (Man-engineered) Ecosystems:** These are maintained artificially by man where by addition of energy and planned manipulation, natural balance is disturbed regularly, e.g. cropland ecosystem.

In addition to above types, some other types such as **spacecraft** and **microecosystem** have also been recognised.

An outline of classification of the ecosystems is as follows:



A detailed account of the various major ecosystems may follow in the later part of this chapter.

**STRUCTURE OF THE ECOSYSTEM**

All ecosystems, whether terrestrial, freshwater, marine or man-engineered, consist of two major components: