LECTURE NOTES

Degree and Diploma Programs
For Environmental Health Students

Introduction to Ecology

Ethiopia Public Health
Training Initiative

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Jimma University

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Preface

The combination of rapid population growth, industrialization and its associated urbanization has placed an ever-increasing pressure on life supporting systems of developing countries such as Ethiopia.

There is evidence that natural resources of Ethiopia such as rivers and lakes are threatened by pollution discharged from towns/cities, institutions and industries. Indeed the problem becomes more acute in the river systems flowing through major cities. In the face of world climate change polluting such scarce natural resources may become a limiting factor in future development of the nation. In situations where treated water supply is still unaffordable it may also expose the communities to water-borne diseases.

Soil erosion is another eco-disaster affecting may countries. In this respect Ethiopia is believed to be the global spot where the worst soil erosion problem occurs as it is thought to lose 2 billion metric tons of soil each year to erosion. Anecdotal example such as Haiti can also be given where the topsoil has been absolutely removed by soil erosion. Some authorities believe that it may never recover from this eco-disaster.

Improper solid waste disposal such as household refuse and plastics is another area of environmental concern in Ethiopia and it is becoming more acute in urban and sub urban areas. Plastics in use for various purposes at present are not biodegradable and will greatly affect the ecology of health and disease in the region.

Although no authoritative sources exist regarding air pollution status in Ethiopia, use of biomass fuels, congested traffic coupled with excessive dependence on old imported cars is becoming a matter of great concern. The precursors for air pollution formation, at least in Addis, are observed although the problem is not systematically quantified and the problem is not yet put in place.

To achieve sustainable development in Ethiopia, it is vital that the above problems should be properly addressed and ecological integrity of the nation be properly maintained. One mechanism of achieving this could be to incorporate a course in ecology into the curricula of teaching institutions at various levels. This course is thus, and attempt to introduce ecological principles and concepts for students specializing in health profession at intuitions of higher learning in Ethiopia so that they can contribute their share to safeguard our environment.

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Content

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INTRODUCTION

1. Learning Objectives:

At the end of this chapter, the student will be able to:

- Define the term ecology and discuss the levels of biological organization at which ecological interactions occur.
- Discuss the scopes of ecology.
- Describe the causes and ways of preventing environmental diseases.
- Mention the effects of human activities on health and the environment.

2. Definition and Scope of Ecology

Man has been interested in ecology in a practical sort of way since early in his history. In primitive society every individual, to survive, need to have definite knowledge of his environment, i.e., of the force of nature and of the plants and animals around him.

Ecology is one of the popular areas of sciences in biology. It is a pluralistic science in the sense that it depends on a wide variety of methods and approaches rather than on a limited range of techniques and concepts. Even if, it is thought as part of biology, one important way in which ecology differs from most other branches of biology is that it can be properly appreciated or studied only through a multidisciplinary approach involving close cooperation from expertise in several disciplines.

Definition

The word 'Ecology' was coined from the Greek word 'oikos' meaning 'house' or ' a place to live' to designate the study of organisms in their natural homes. Specially, it means the study of interactions of organisms with one another and with the physical and chemical environment. The term “logy” is to mean study.

Another way of defining Ecology is to look at the levels of biological organizations. The molecules of life are organized in specific ways to form **cells**; cells are grouped in to **tissues**; and tissues are arranged to produce functional organs. The body organs are integrated to produce **organ system**, and the entire array of these systems constitutes an **organism**. Organisms exist not just as a single individual, but in-groups called population. The various populations of organisms that interact with one another to form a **community**; interdependent communities of organisms interact with the physical environment to compose an ecosystem. Finally, all the ecosystems of the planet are combined to produce a level of organization known as the **biosphere**. Ecology is concerned with the levels of organization beyond that of individual organism; i.e. population, community, ecosystem, and biosphere.

Scope

Whether we are talking about humans or any other kind of organisms, certain principles govern the growth and stability of their populations over time. These principles influence the pattern of relationships of organisms with one another and their environment. These patterns, in all their varied forms, are the focuses of ecology. As a science, ecology seeks to treat the world of nature including its human component with a single set of concepts and principles.

Ecology deals with such questions as:

- Why natural communities are composed of certain organisms and not others;
- How the various organisms interact with each other and with the physical environment; and
- How we can control and maintain these natural communities.

3. Human Activities Affecting Health and the Environment

Human activities in an ecosystem have many drawbacks, unless we are approaching it in an environmental friendly way. The atmosphere, fertile soils, freshwater resources, the oceans and the ecosystems they support, play a key role in providing humans with shelter, food, safe water and the capacity to recycle most wastes. However, pressures exerted by humans, on the environment, in the form of pollution, resource depletion, land use changes and others affect environmental quality. Degradation of environmental quality can, in turn, lead to adverse human exposures and eventual health effects.

The pressures excreted by the driving forces are in many instances increasing. They relate to household wastes, freshwater use, land use and agricultural development, industrialization and energy use.

Household wastes

Gaseous household wastes arise mainly from heating and cooking. They contribute substantially to both outdoor and indoor air pollution. Liquid wastes are the by-products of domestic activities. In most areas of developing countries, feces are recycled for use in agriculture or deposited on land without prior destruction of pathogens. Not surprisingly, infectious disease such as diarrheal diseases, schistosomiasis and hepatitis are endemic, and some times epidemic, in such areas.

Solid waste can also create environmental health problems. It consists mainly of non-hazardous materials such as paper and plastic packaging material, glass, food scraps and other residues. However, it generally also contains small quantities of hazardous substances such as paints, medicines, solvents, cleaning materials and batteries, leading to potential chemical exposures. Production of household and municipal solid waste continues to increase worldwide, both in absolute and *per capita* terms.

Fresh Water

For a large percentage of the world's population, water supplies are neither safe nor adequate. Currently, over 1000 million people do not have access to an adequate supply of safe water for household consumption. Moreover, the world's freshwater resources are limited and unevenly distributed over the global land mass. Demand for water is nevertheless increasing in several sectors: for drinking water (domestic needs), food production (agriculture) and product manufacturing (industry).

Global freshwater resources are threatened not only by overexploitation, however, but also by poor management and ecological degradation. Untreated sewage is discharged into rivers and lakes; industrial wastes are dumped into water bodies; and run-off from agricultural fields treated with herbicides and pesticides is leading to water contamination.

Industrial development, the exponential growth of human settlements and the ever-increasing use of synthetic organic substances are also having serious adverse impacts on freshwater bodies. Many surface and ground waters are now contaminated with nutrients, heavy metals and persistent organic pollutants.

For instance, the River Awetu has been degraded by untreated liquid and solid waste discharge from Jimma Town, southwestern Ethiopia. The water is pungent and turns black just before the confluence point with the River Gilgel Gibe and no macroinvertebrates were found at this site (Worku et al., 2001).

Land use and agricultural development

Competition for land appears to be intensifying between sectors and production systems. Agriculture, in particular, can be expected to become an even more dominant form of land use. Population increases and the finite extent, to which further land can be converted to agricultural uses, mean that *per capita* arable land availability is becoming an issue.

Agricultural production carries several risks. Thus extension and intensification of agricultural production systems, together with fluctuation in the supply of and demand for agricultural produce are causing shifts in the environmental determinants of the health status of local communities.

Erosion

Perhaps the worst erosion problem in the world, per ha of farmland, is in Ethiopia. Although Ethiopia has only 1/100 as much cropland in cultivation as the United States, it is thought to lose 2 billion metric tons of soil each year to erosion. Haitit is another country with severely degraded soil once covered with lush tropical forest; the land has been denuded for firewood and cropland. Erosion has been so bad that some experts now say the country has absolutely top soil, and poor peasant farmers have difficulty raising any crop at all. Economist Lester Brown of World Watch Institute warns that the country may never recover from this eco-disaster.

Industrialization

Industrialization is central to economic development and improved prospects for human well-being. But, if proper abatement technology is not used, industry becomes a major source of air, water and soil pollution, hazardous wastes and noise. Industrial workers are often at highest risk of health impacts. Furthermore, developed countries have exacerbated the environmental problems now being experienced by developing countries through transfer of hazardous wastes industries and technologies.

Major industrial impacts also arise from small-scale industry. In developing countries, small-scale industry contributes substantially to economic development, but can create problems for environment and health if environmental safeguards are not used.

Energy

Energy plays a critical role in basic human survival. Energy has important implications for health. Energy is also crucial to transportation and industrial processes. However, production and use of energy, if not properly controlled may be accompanied by adverse health and environment impacts.

In developing countries, biomass accounts for about one-third of all energy use, and in some of least-developed countries, for as much as two-thirds. Open fires impair indoor air quality, add to the risk of accidents and jeopardize food hygiene.

In general, the adverse effects on the environment of human activities are many and appear to be growing in intensity, and affecting larger and larger areas. Current and future potential pressures on the environment have major implication for health.

Environmental Threats to Human Health

Environmental threats to human health are numerous. These threats can be divided in to two:

a. ***Traditional hazard;*** i.e. associated with lack of development. Traditional hazards related to poverty and “insufficient” development are wide-ranging and include: lack of access to safe drinking-water; inadequate basic sanitation in the household and the community; indoor air pollution from cooking and heating using coal or biomass fuel and inadequate solid waste disposal.

b. ***Modern hazard,*** i.e. associated with unsustainable development. Modern hazards are related to development that lacks health- and environment safeguards, and to unsustainable consumption of natural resources. They include: water pollution from populated areas, industry and intensive agriculture; urban air pollution from motor cars, coal power stations and industry resulting in climate change, stratospheric ozone depletion and trans-boundary pollution.

Polluted air and water, excessive levels of noise, nuclear weapons fall-out, over crowded slums, toxic waste dumps, inadequate or overly adequate diet, stress, food contaminants, medical X-rays, drugs, cigarettes, unsafe working conditions and other can be regarded as causative agents of environmental diseases. In short environmental diseases are those diseases that are introduced to the environment by man due to his careless behavior. Most environmentally induced diseases, unlike those caused by bacteria or other pathogens, are difficult to cure but theoretically simple to prevent. Remove the adverse environmental influence and the ailment will disappear. This is simply to say that by:

- Preventing discharges of poisonous pollutants into water and food
- Avoiding exposure to radiation
- Keeping away from cigarette smoke
- Avoiding synthetic food coloring or material

One of the problems with environmental health concern is our limited knowledge on those toxic agents that are actually distributed over our earth, due to different activities by man in the ecosystem. For example, world wide, there are about 10 million chemical compounds that have been synthesized thus far. But only one percent is produced commercially and is regulated.

Review Question

1. Define the term ecology.
2. What are the levels of biological organizations at which ecological interactions occur?
3. Discuss the areas that ecology is concerned.
4. Have you observed, in your locality, any changes in pattern of disease occurrence that are related to changes in the environment?
5. What is environmental disease? Give examples in your setting.

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CHAPTER ONE

Introduction to Ecological Principles

1. Learning Objective:

At the end of this chapter, the student will be able to:

- Explain biotic community and ecological succession.
- Explain habitat and ecologic niche of organisms.
- Mention the major biomes of the world and the dominant species.
- Discuss the factors that affect the distribution of organisms.

2. Definition of Terms

1. **Biomes**: a large, relatively distinct terrestrial region characterized by a similar climate, soil, plants, and animals regardless of where it occurs on earth.
2. **Ecosphere**: The interrelation among and between all the earth's living organisms and the atmosphere, lithosphere and hydrosphere that they occupy.
3. **Limiting factor**: An environmental factor that restricts the growth, distribution, or abundance of a particular population.
4. **Tolerance**: Decreased response to a specific factor in the environment over time.
5. **Niche**: The totality of organism's adaptation and the life style to which it is fitted in its community.

1.1 Introduction

A biological community consists of several to many populations each containing all the members of a single species in a given area. Species are not fixed or unalterable, however. They evolve and adapt in response to the environment in which they live. Because, environmental conditions also are dynamic and constantly changing, the process of evolution and adaptation of living organisms is never complete. And yet many biological communities are self-perpetuating, resilient, and stable over relatively long times.

A. Biotic Community

The most familiar classification system used for grouping plants and animals is one based upon presumed evolutionary relationships. However, ecologists tend to arrange species on the basis of their functional association with each other.

A natural grouping of different kinds of plants and animals within any given habitat is termed as a **biotic community.** Biotic community like ecosystem is a broad term, which can be used to describe natural groupings of widely different sizes, from the various microscopic diatoms and zooplankton swimming in a drop of pond water to the hundreds of species of trees, wild flowers, insects, birds, mammals etc.

Biotic communities have characteristics trophic structure and energy flow patterns and also have a certain taxonomic unity in the sense that certain species tend to exist together.

Individual of the same species living together within a given area is collectively called **population**. Such population constitutes groups more or less isolated from others. A population within a biotic community in certain region is not a static entity but it is continuously changing in size and reshuffling in hereditary characteristics in response to environmental changes and to fluctuations in the population of other members of the community.

The community concept is one of the most important ecological principles. Because:

1. It emphasizes the fact that different organisms are not arbitrarily scattered around the earth with no particular reason as to why they live where they do together in an orderly manner.
2. By illuminating the importance of the community as a whole to any of its individual parts, the community concept can be used by man to control a particular organism, in the sense of increasing or decreasing its numbers.

The realization that the success of any particular species is dependent on integrity of its biotic community as a whole has profound implications for human welfare.

B. Ecological Dominance

Although all members of a biotic community have a role to play in the life of a community, it is obvious that certain plants or animals exert more of an effect on the ecosystem as a whole than do others.

Those organisms, which exert a major role in having controlling influence on the community, are called" **Ecological Dominants**." Such dominants comprise those keystone species, which largely control the flow of energy through the community, if they were to be removed from the community, much greater change in the ecosystem would result than if a non-dominant species were to be removed.
Example: If farmers chop down dominant forest trees for cultivation, the changes produced by the removal are:

- Loss of animal species, which depend on the trees for food and shelter
- Loss of shade loving plant
- Change in soil micro biota
- Raising of soil temperature
- Increase in soil erosion

Consequently, the stability of the ecosystem would be disturbed. In most terrestrial biotic communities certain plants comprise the dominant role because not only do they provide food and shelter for other organisms but also directly affect and modify their physical environment. That is: -

1. They build up topsoil
2. Moderate fluctuation of temperature
3. Improve moisture retention
4. Affect the pH of the soil.

C. Biomes

The species composition of any particular biotic community is profoundly affected by the physical characteristics of the environment particularly temperature and rainfall. For instance, the kinds of plants and animals one will find in Simen Mountains in Ethiopia would differ significantly from those found in the Awash Park.

Ecologists have divided the terrestrial communities of the world into general groupings called **Biomes,** which are areas that can be recognized by the distinctive life forms of their dominant species. In most cases, the key characteristic of a biome is its dominant type of vegetation. It could also be said that a biome is a complex of communities' characteristic of a regional climatic zone. Each biome has its pattern of rainfall, season, temperature and changes of day length all of which combine to support a certain kind of vegetation.

Starting at the polar region the major biomes of planet earth are:

i. Tundra

Tundra is the northern most of the world's landmasses. It is characterized by permanently frozen subsoil called Permafrost, which has low rainfall. These are bogs and lakes, which propagate mosquitoes more than any thing else.

Dominant vegetation is moss grass and some small perennials *ii.* *Taiga*

Taiga is a Russian world meaning " Swampy forest". Taiga is mostly identified with its abundant coniferous forest.

The trees available, mostly conifers are less diverse in number of species than those in the deciduous trees forests found further south from Taiga and the soil has different kind of humus which is more acid. Precipitation is low, but like Tundra there are a number of bogs and lakes available.

iii. *Temperate deciduous forests*

This occurs in a belt south of the Taiga where climate is milder and where rainfall is abundant relative to the amount of evaporation. The deciduous forest has a great variety of mammals, birds, and insects as well as modest number of reptiles and amphibians. Because of the annual leaf drop deciduous forest generate soils rich in nutrients, which in turn supports a multitude of soil microbes.

iv. *Grassland*

In regions where annual rainfall is not sufficient to sustain the growth of trees and evaporation rates are high we find the grassland of the world. Example of such a biome is the Savannah. The dominance of grass and herds of grazing animals characterize all. Carnivores are also abundant. Such biome has a higher concentration of organic matter in its soil than does any other biome, the amount of humus being 12 times greater than that in forested soils.

v. *Desert*

This is an area, which is receiving less than 10 inch of rainfall per year. Lack of moisture is the essential factor that shapes the desert biome.

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vi. Tropical Rain forest

It is characterized by high temperature and high annual rainfall (100 inch or more). Year round temperature variations is slight.

Tropical rain forest is characterized by a great diversity of plants and animal species and by four distinct layers of plant growth:

a. Top canopy of trees reaching 60 meters,
b. Lower canopy reaching 30 meters,
c. Sparse under story and
d. Very few plants growing at ground level.

Both plants and animal species exist in greater diversity in the tropical rain forest than anywhere else does in the world. Tropical rain forest soils in general are exceedingly thin and nutrient poor relative to temperate regions. As a result nutrients are locked in the biomass in the tropics and removal of vegetation may severely disrupt nutrient cycling leading to ecological disaster.

This brief survey of biome characteristics should make it obvious that various regions differ in their ability to return to an ecologically stable condition once they have been disrupted by human activities.

D. Ecological Succession

The process by which organisms occupy a site and gradually change environmental conditions so that other species can replace the original inhabitants is called **ecological succession or development**.

Primary succession occurs when a community begins to develop on a site previously unoccupied by living organisms, such as on island, a sand or silt bed, a body of water or a new volcanic flows.

Secondary succession occurs when an existing community is disrupted and a new one subsequently develops at the site. The disruption may be caused by some natural catastrophe, such as fire or flooding, or by a human activity, such as deforestation, plowing or mining.

Both forms of succession usually follow an orderly sequence of stages as organisms modify the environment in ways that allow one species to replace another.

Eventually in either primary or secondary succession a community develops that seemingly resists further change. Ecologists call this a **climax community**, because it appears to be the culmination of the succession process. The different biomes of our planet discussed earlier are examples of climax community.

1.2 Concepts of Range and Limits

Probably no species of plant or animal is found everywhere in the world; some parts of the earth are too hot, too dry or too something else for the organisms to survive there. Even if the environment does not kill the adult directly, it can effectively keep the species from becoming established by preventing its reproduction, or it kills off the egg, embryo or some other stage in the life cycle.

Most species of organisms are not even found in all the region of the world where they could survive. The existence of barriers prevents their dispersal.

Law of the Minimum (Liebig's Law)

An organism is seldom if ever exposed to a single factor in its environment. On the contrary, it is exposed or subjected to various factors simultaneously in its surroundings. However, some factors play greater role than the others do.

In general, each species requires certain materials for growth and reproduction, and can be restricted if the environment does not provide a certain minimum amount of each one of these materials. This phenomenon is governed by what is known as the law of the minimum, which states, "the rate of growth of each organism is limited by whatever essential nutrient is present in a minimal amount". The law can also be stated as "the functioning of an organism is controlled or limited by essential environmental factor or combination of factors present in the least favorable amount in the environment".

Example: The yield of crops is often limited not by a nutrient required in large amounts, such as water or carbon dioxide, but by something needed only in trace amounts, such as boron or manganese.

Law of Tolerance (Shelford's Law)

For each species, there is a range in an environmental factor within which the species function near or at optimum. There are extremes both lower and upper towards which the function of the species is curtailed or inhibited. Shelford pointed out that too much of a certain factor would act as a limiting factor just as well as too little of it as has been stated in the Liebig's law. This leads to a concept of range of tolerance, which states, **"** the distribution of each species is determined by its range of tolerance to variation in each environmental factor."

1.3 Habitat and Ecologic Niche

In describing the ecological relation of organisms, it is useful to distinguish between where an organism lives and what it does as part of its ecosystem. The term habitat and ecological niche refers to two concepts that are of prime importance in ecology.

Habitat

The habitat of an organism is the place where it lives, a physical area, and some specific part of the earth's surface, air, soil or water. It may be as large as the ocean or a forest or as small and restricted as the underside of a rotten log or the intestine of a termite. However, it is always tangible, physically demarcated region. More than one animal or plant may live in a particular habitat.

Ecologic Niche

Diverse assortment of Organisms can live in a habitat. Every organism is thought to have its own role within the structure and function of a community. This status or role of organism in the community or ecosystem is termed as ecologic niche. Ecologic niche depends on the organism’s structural adaptations, physiologic response and behavior.

An ecologic niche is difficult to define precisely; it is an abstraction that includes all the physical, chemical, physiologic and biotic factors that an organism requires to live; but not physically demarcated space. To describe an organism's ecologic niche, we must know what it eats, what eats it, what organism competes with, and how it interacts with and is influenced by abiotic component of the environment (like light, temperature, and moisture).It is helpful to think of the habitat as an organism's address (where it lives) and of the ecologic niche as its profession (what it does biologically). One of the important generalizations of ecology is that no two species may occupy the same ecologic niche.

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Review Questions

1. What is biotic community?
2. What are the major biomes of our planet?
3. Describe the different kinds of ecological successions.
4. What do we mean by climax community?
5. Explain the difference between habitat and ecologic niche of organisms.
6. Define the law of the minimum and give an example from your area.
7. Define the law of tolerance and give an example from your area.

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CHAPTER TWO

Ecosystem

1. Learning objectives

At the end of this chapter, the student will be able to:

- Define the term ecosystem.
- Describe the components of ecosystem.
- Explain the concept of food chain and energy flow in ecosystems.
- Explain how materials cycle in the biosphere.
- Describe the laws of thermodynamics.
- Distinguish between food chain and food web.
- Explain the effect of human intervention on material cycling.

2. Definition of Terms

1. **Ecosystem:** a community and its physical and chemical environment. An ecosystem has living (biotic) and nonliving (abiotic) components.
2. **Biotic factors:** all living organisms in an ecosystem.
3. **Abiotic factors:** all environmental conditions required to support life, e.g. rainfall, sunlight, moisture, soil, temperature, organic matter, etc.
4. **Autotrophs:** organisms that synthesize their own organic compounds from simple inorganic substances with the aid of energy from the sun (photosynthetic autotrophs) or from the inorganic substances themselves (chemosynthetic autotrophs).
5. **Heterotrophs:** organisms that ingest other organisms to obtain organic nutrients.

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6. **Decomposers:** heterotrophic bacteria and fungi that obtain organic nutrients by breaking down the remains or products of organisms. The activity of decomposers allows simple compounds to be recycled back to the autotrophs.
7. **Food chain:** linear sequence of who eats whom in an ecosystem.
8. **Food web:** network of many interlocked food chains, encompassing producers, consumers, decomposers, and detritivores.
9. **Biogeochemical cycle:** the cycling of materials through living system and back to the earth.
10. **Nitrification:** a process by which certain soil bacteria strip ammonia or ammonium of electrons, and nitrite (NO_2^-) is released as a reaction product, then other soil bacteria use nitrite for energy metabolism, yielding nitrate (NO_3^-).
11. **Ammonification:** decomposition of nitrogenous wastes and remains of organisms by certain bacteria and fungi.
12. **Denitrification:** reduction of nitrate or nitrite to gaseous nitrogen (N_2) and a small amount of nitrous oxide (N_2O) by soil bacteria.
13. **Eutrophication:** a process by which a body of water becomes over-enriched with nutrients, and as a result produces an over-abundance of plant life.
14. **Biomass:** the total dry weight of all organisms at a given trophic level of an ecosystem.
15. **Community:** the populations on all species that occupy a habitat.
16. **Population:** group of individuals of the same species occupying a given area.
17. **Trophic level:** all organisms that are the same number of energy transfers away from the original source of (e.g. sun light) that enters an ecosystem.
18. **Nitrogen Fixation:** among some bacteria, assimilation of gaseous nitrogen (N_2) from the air; through reduction reactions, electrons become attached to the nitrogen, thereby forming ammonia (NH_3) or ammonium (NH_4^+).

2.1 Introduction

An ecosystem is a community of organisms functioning together and interacting with their physical environment through; a flow of energy and a cycling of materials, both of which have consequences for the community structure and the environment **(Fig.2.1).**

Any area can be considered as an ecosystem as long as living and non-living elements are present and interacting to achieve functional stability. An ecosystem may be as large as the ocean or a forest, or it may be as small as an aquarium jar containing tropical fish, green plants and snails.

It is important to understand that ecosystems are open systems, hence they are not self-sustaining: they require an energy input (as from the sun), and often a nutrient input (as from minerals carried by erosion into a lake); because energy cannot be recycled, all ecosystems have energy output, most often as low-grade heat lost to the environment during each energy transfer between organisms; although nutrients typically are recycled, the process is not 100% efficient, and some loss occurs from the system (as though soil leaching), so there also is a nutrient output.

In describing an ecosystem, it is convenient to recognize and tabulate the following components:

i. The inorganic substances, such as carbon dioxide, water, nitrogen and phosphorus, that are involved in material cycling;
ii. The organic compounds such as proteins, carbohydrates and lipids that are synthesized in the biotic phase;
iii. The climate, temperature and other physical factors;
iv. The producers, autotrophic organisms (mostly green plants) that can manufacture complex organic materials from simple inorganic substances;

v. The macro-consumers, or phagotrophs, heterotrophic organisms (mostly animals) that ingest other organisms or chunks of organic matter; and

vi. The micro-consumers, or saprotrophs, heterotrophic organisms (mostly fungi and bacteria) that breakdown the complex compounds of dead organisms, absorb some of the decomposition products, and release inorganic nutrients that are made available to the producers to complete the various cycles of elements.

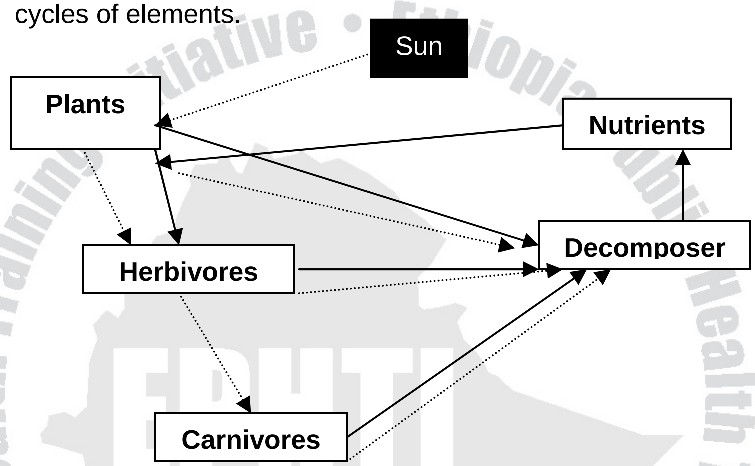

Fig.2.1. Movement of energy (broken line) and materials (continuous line) in the ecosystem. (Adopted from Modern concepts of ecology, 1995)

2.2 Structure of Ecosystem

In the ecosystem, a flow of energy, derived from organisms-environment interaction, leads to a clearly defined trophic structure with biotic diversity and to the cycling exchange of materials between the living and the non-living part.

2.2.1 Trophic organizations

Ecosystem has a layered structure based on the number of times energy is transferred from one organism to another, away from the initial energy input into the system. Thus, all organisms that are the same number of transfer steps away from the energy input are said to be at the same trophic level. From the trophic standpoint, an ecosystem has two components. These are:

- Autotrophic part: - in which light energy is captured or "fixed" and used to build simple inorganic substances in to complex organic substances such as carbohydrates, lipids, proteins, etc.
- Hetrotrophic part: - in which the complex molecules undergo rearrangement, utilization and decomposition.

Food chain

The transfer of food energy from plants to animals and then to other animals by successive stages of feeding (trophic level) is called food chain.
Example:

Grass → Grasshopper → Frog → Snake → Hawk

All food chains start with an autorophic organisms. These organisms are called producers, because they can manufacture food from inorganic raw materials using sunlight for energy source. Any Organism that feeds dirrectly upon plant (in this case grasshopper) is a herbivore or primary consummer; and are in the second trophic level. Carnivores (like frog of the above example) that feed on herbivores are called secondary consumers; and those which feed on these carnivores are tertiary consumers, and so on. Each level of consumption in a foodchain is called a trophic level.

At each transfer (in the food chain), a large portion of potential energy present in the chemical bonds of the food species is lost as heat. Because of this prograssive loss of energy (in the food chain process) as heat, the total energy flow at each succeding level is less and less obeying the second law of thermodynamics. This limits the number of steps in a food chain, usually, to four or five. A final attribute of food chains is that the shorter the food chain (or the nearer the organism is to the beginning of the chain), the greater the available energy that can be converted into biomass (living weight) and utilised in cellular respiration.

In some cases, the relationship between organisms involved are so complex that the chain is in the form of a highly complicated and branching net work called a foodweb, which is the actually existing feeding relationship in an ecosytem.

2.2.2 Energy Flow and Material Cycling

The existence of the living world, including human life, depends upon the flow of energy and the circulation of materials through the ecosystem. Both influence the abundance of organisms, the rate at which they live, and the complexity of the community. Energy and materials flow through the community together; one can not very well be separated from the other. But, the flow of energy is one way; once used by the community, it is lost. Material on the other hand re-circulates. An atom of carbon or calcium may pass between the living and the non-living many times or it may even exchanged between the ecosystems.

Laws of Thermodynamics

Energy flows in a one-way path through biological systems and eventually into some low-temperature sink such as outer space.

Two laws of thermodynamics describe the behavior of energy. The first law of thermodynamics states that energy is conserved; that is, it is neither created nor destroyed under normal conditions. It may be transferred from one place or object to another, but the total amount of energy remains the same. Similarly, energy may be transformed, or changed from one form to another (e.g. from the energy in a chemical bond to heat energy), but the total amount is neither diminished nor increased.

The second law of thermodynamics states that, with each successive energy transfer or transformation in a system, less energy is available to do work.

A. Energy Flow

Living things are dependent for their existence not only on proper soil and climate conditions, but also on some forms of energy. Ultimately, most organisms depend on the sun for the energy needed to create structures and carry out life processes.

The transfer of energy through a biological community (or an ecosystem) begins when the energy of sunlight is fixed in a green plant by photosynthesis. Photosynthesis coverts radiant energy into useful, high-quality chemical energy in the bonds that hold together organic molecules. The transfer of this captured energy from organism to organism is basic to the functioning of ecosystems.

At each transfer of energy within a food chain, approximately 90% of the chemical energy stored in organisms of the lower level are lost, and therefore unavailable to the higher level (second law of thermodynamics). Since the total amount of energy entering the food chain is fixed by photosynthetic activities of plants, more useable energy is available to organisms occupying lower positions in the food chain than to those at higher trophic level. Expressing this concept in simpler terms, one might say, for example:

Corn →	**Beef** →	**Human**
10,000 unit of energy	1000 unit of energy	100 unit of energy

By moving man one step lower in the food chain, ten times more energy becomes directly available.

Corn →	**Human**
10,000 unit of energy	1000 unit of energy

The unidirectional flow and efficiency of energy transformation account for the need for a continuos source of energy to prevent collapse of an ecosystem.

B. Material Cycling

Living organisms require at least 30 to 40 elements for their growth and development. Most important of these are carbon, hydrogen, oxygen, phosphorus, potassium, nitrogen, sulfur, calcium, iron, magnesium, boron, zinc, chlorine, cobalt, iodine, and fluorine. These materials flow from the non-living to the living and back to the non-living again, in a more or less circular path known as the **biogeochemical cycle**. Biogeochemical cycles are important because they help retain vital nutrients in forms useable plants and animals, and because they help to maintain the stability of ecosystems.

If nutrient cycling did not occur, the amount of necessary elements would constantly decrease, and would make the development of stable plant and animal population impossible, since there is no constant addition to the source of nutrients from outside (as there is of energy in the form of sunlight).

There are basically two types of biogeochemical cycles- gaseous and sedimentary- depending on the primary source for the nutrient involved happens to be air and water (gaseous cycle) or soil and rocks (sedimentary cycle). The elements moved about by gaseous cycle recycle much more quickly and efficiently than do those in the sedimentary cycle. Carbon, nitrogen, oxygen and hydrogen are included in the gaseous cycle. Iron, calcium and phosphorus are examples of nutrients whose cycling occurs via the basic sedimentary pattern.

2.3 The Carbon Cycle

Carbon is a basic constituent of all organic compounds. Since energy transfer occurs as the consumption and storage of carbohydrates and fats, carbon moves through the ecosystem with the flow of energy. The source of nearly all carbon found in living organisms is carbon dioxide (CO_2), free in the atmosphere and dissolved in waters of the earth

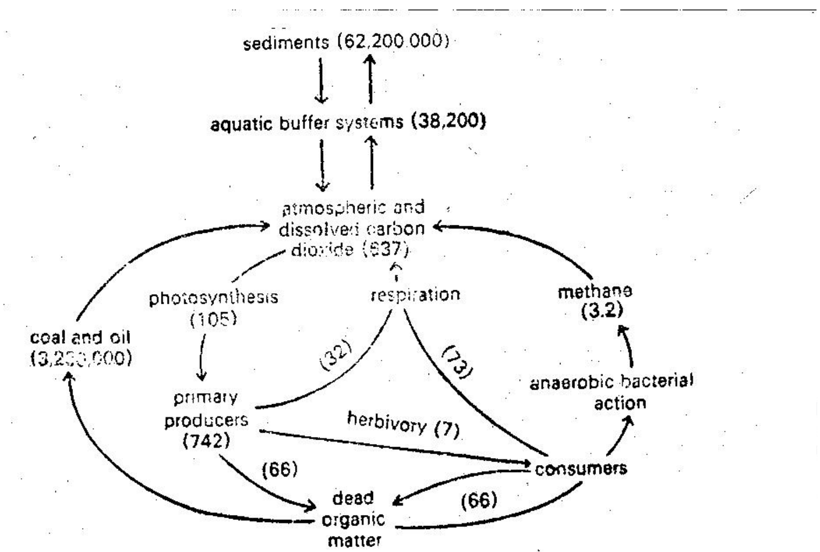

Fig.2.2. The carbon cycle. Estimated pool size is presented, the numbers representing 10^6gm (Source: Kumar, 1997).

The first step in the utilization of CO_2 by living organisms is photosynthesis by green plants. Carbon together with oxygen and hydrogen, in the presence of sunlight, is converted to simple carbohydrates. These in turn are synthesized by plants into complex fats and polysaccharides. The polysaccharides and fats stored in plant tissues are eaten by animals, which digest and resynthesize these carbon compounds into others. Meat-eating animals feeding on the herbivores and the carbon compounds again are re-digested and re-synthesized into other forms. Some of the carbon is returned to the atmosphere directly, since CO_2 is a by-product of respiration of both plants and animals. The carbon locked up in the animal waste and in protoplasm of plants and animals is released eventually by organisms of decay. Bacteria and fungi attack and feed up on plant and animal remains, break down the complex compounds into simpler substances, which are then available for another cycle. After their work, most of the organic carbon is CO_2 once again.

Part of the organic carbon becomes incorporated in the earth's crust as coal, gas, petroleum, limestone and coral reefs. Such deposits are removed from circulation for long periods of time, often permanently. Some of them are liberated by industrial and agricultural use of these products; and some CO2 are released from limestone through weathering. But, the circulation of carbon through the ecosystem depends upon living organisms.

Green house effect

The amount of carbon dioxide in the atmosphere is critically important in maintaining the earth's temperature. Carbon dioxide absorbs infrared rays, and allows heat to stay in the atmosphere, rather than escaping into space. How much heat is retained depends on how much CO_2 is in the air. The greater the amount of CO_2 in the atmosphere, the warmer the earth becomes, because of the greenhouse effect. The greenhouse effect occurs because CO_2 in the atmosphere acts as do the glass wall of a greenhouse. The glass walls transmit sunlight in to the greenhouse, where it is absorbed and reradiated as heat that does not readily exit through the glass; as a consequence the temperature inside the greenhouse becomes higher than the outside.

Carbon dioxide is released in large quantities when wood and such fossil fuels as coal, oil and natural gas are burnt. This release of CO_2 is faster than plants and oceans, which absorb the gas, could handle it. If CO_2 (and other greenhouse gases) levels in the atmosphere were to increase (due to burning of fossil fuels), the atmospheric temperature would increase (global warming). This leads to a rise in sea level (because of glacial melting), submergence of coasts, change in pattern of precipitation, change in the habitable ranges of organisms.

2.4 The Nitrogen Cycle

Nitrogen is crucial for all organisms because it is an essential part of proteins and nucleic acids. About 78% of the atmosphere nitrogen gas (N_2), the largest gaseous reservoir of any element. In its gas form, N_2 is useless to most organisms. However, certain nitrogen-fixing bacteria and algae found in soil and wet habitats can convert inorganic nitrogen into forms, especially nitrates, which are immediately useable by plants **(Fig .2.3)**.

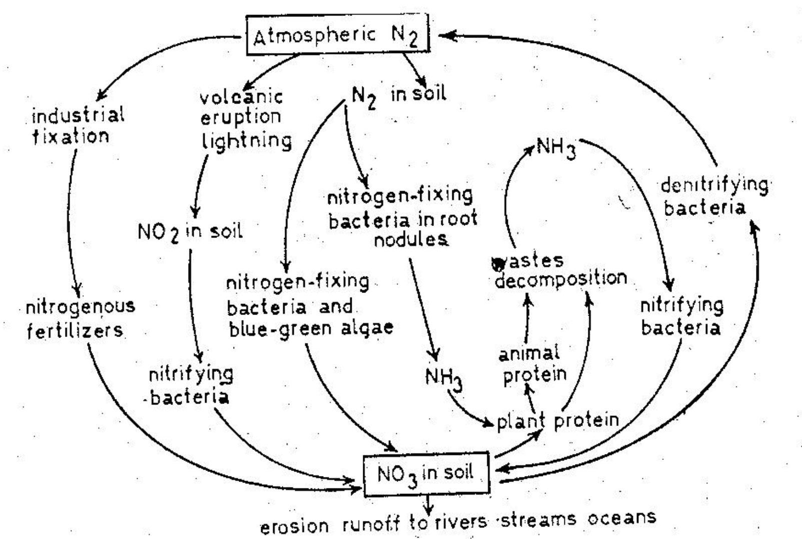

Fig.2.3. The Nitrogen cycle (Source: Kumar, 1997).

When the plant or animal dies, decomposing bacteria and fungi cause the body to decay so that the nitrogen-containing amino acids are broken down, releasing ammonia gas (NH_3). Nitrite bacteria can convert the ammonia into nitrite ($NO_{2)}$ molecules, and still other bacteria (nitrate bacteria) in the soil can add a third oxygen atom to nitrites to produce nitrates. At this point, we have gone full cycle, because plants in the area now have a useable form of nitrogen again.

Nitrogen may be removed from the nitrates in the soil by denitrifying bacteria, and returned to the atmospheric reservoir, from which it can be released again by either nitrogen-fixing bacteria or electrification by lighting. In the latter case, the energy of a lightning bolt passing through the atmosphere binds nitrogen and oxygen together into nitrate, which precipitate onto the soil from the air during electrical storms.

2.5 The Phosphorus Cycle

Phosphorus cycle is an excellent example of a sedimentary cycle. Phosphorus is necessary element in the hereditary material DNA, in other vital cellular molecules, and in the structure of bone on vertebrate animals.

The principal reservoir for the cycle is phosphate rock formed in past geologic ages, although excrement deposits (guano) by fish-eating sea birds and fossil bone deposits contribute substantial phosphate in certain areas of the world. Erosion by rainfall and the runoff of streams dissolves phosphate out of these reservoirs, forming phosphorus 'pool' in the soil **(Fig.2.4)**.

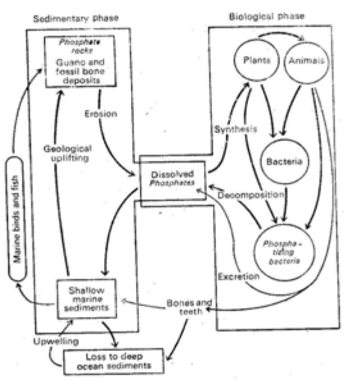

Fig.2. 4. The phosphorus cycle (Source: Kumar, 1997).

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This makes phosphorus available to plants, which absorb it through their roots for use in cellular synthesis. Animals obtain phosphorus from plants; upon death or through normal excretion of waste products from the body, they return phosphorus to the dissolved phosphorus pool. However, in the dissolved state, much phosphorus is lost by downhill transport into shallow marine sediments. Some of this phosphorus is returned to land by sea birds that deposit excrement on the shores.

The phosphorus cycle is leaky or incomplete, in that there is, on land, some loss of phosphate into insoluble forms, and there is a slow loss of phosphate from; and into the oceans, from which there is only poor natural return, except over geologically long periods of time.

Human intervention is a significant factor in the phosphorus cycle. Large quantities of phosphates are mined and used as fertilizers and for other uses, such as in detergents. The result is that some fresh water streams and lakes have a great excess of biologically available phosphate from runoff and sewage. Since, in such bodies of water, phosphate is often a limiting factor in photosynthesis; excessive growth of aquatic plants ensues.

This process, called **eutrophication**, can totally disrupt aquatic ecosystems with serious consequences.

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Review Questions

1. Give brief description of ecosystem.
2. What are the components of ecosystem?
3. What is food chain? What are the differences between food chain and food web?
4. Define the trophic level. Name and give examples of some trophic levels in ecosystem.
5. What are the two laws of thermodynamics?
6. How does energy flow in ecosystems?
7. What is the importance of material cycling in the biosphere?
8. Discuss the difference between sedimentary cycle and gaseous cycle.
9. What are the effects of releasing large amount of CO_2 to the atmosphere?
10. What will happen when a waste that contains large amount of phosphorus is discharged to water bodies?

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CHAPTER THREE

Population Dynamics

1. Learning Objectives

At the end of this chapter, the student will be able to:

- Explain the factors that affect population size.
- Describe environmental resistance and biotic potential in terms of population growth.
- Explain the difference between the J-shaped and S-shaped population growth forms.
- Discuss the idea of carrying capacity in influencing population growth.
- Explain the factors that regulate population growth.
- Discuss the factors that contribute to human population growth.
- Discuss the impact of unchecked human population growth.

1.2 Definition of Terms

1. **Natality:** the production of new individuals by birth.
2. **Biotic potential:** the maximum rate at which an organism or population could increase under ideal conditions.
3. **Environmental resistance:** the environmental pressure which limit a population's inherent capacity for growth.
4. **Carrying capacity:** a sustainable supply of resources (including nutrients, energy, and living space) defines the carrying capacity for a particular population in a particular environment.
5. **Age structure:** the relative number of individuals in a population at different ages.
6. **Emigration:** individuals leave the population.
7. **Immigration:** individuals from other populations of the same species join the population.

8. **Exponential growth:** pattern of population growth in which the number of individuals increases in doubling increments (2,4,8,…).
9. **Survivorship:** the proportion of individuals in a population that survive to a particular age.
10. **Density-dependent factor:** any environmental factor whose effect on a population varies with the density.
11. **Density-independent factor:** any environmental factor that affects the size of a population but is not influenced by changes in population density.
12. **Doubling time:** the time required for a population to double in size.

3.1 Introduction

Individuals are part of a larger organization- a group composed of members of the same species that live together in the same area at the same time. Such a group is called a population.

Populations of organisms tend to increase as far as their environment will allow. As a result, most populations are in a dynamic state of equilibrium. Their numbers wax and wane in a delicate balance that is influenced by limiting factors of the physical environment and interactions with other populations in the community.

3.2 Factors Affecting Population Size

The sizes of any population increase or decrease with change in one or more of the following factors:

A. Natality (Births)

Natality is the production of new individuals by birth, hatching, germination, or cloning. Natality is the main source of addition to most biological populations. Natality is usually sensitive to environmental conditions so that successful reproduction is tied strongly to nutritional levels, climate, soil or water conditions, and-in some species-social interactions between members of the species.

B. Immigration

Organisms are introduced into new ecosystems by a variety of methods. Seeds, spores, and small animals may be floated on winds or water currents over long distances. Sometimes organisms are carried as hitchhikers in the fur, feather, or intestines of animals traveling from one place to another. Some animals travel as adults flying, swimming, or walking.

C. Mortality

An organism is born and eventually it dies; it is mortal. Mortality, or death rate, is determined by dividing the initial population (the number alive at the beginning of a period) by the number that died during a given interval. If more organisms in a population die than are replaced in a given time, the population will decrease. If mortality is low compared to natality, on the other hand, the population will grow.

D. Emigration

Emigration, the movement of members out of a population, is the second major factor that reduces population size. The dispersal factors that allow organisms to migrate into new areas are important in removing surplus members from the source population.

E. Age Structure

Age structure is an important factor, which influences both natality and mortality. Consequently, the ratio of the various age group (age and sex ratio) in a population determines the current reproductive status of the population and indicates what may be expected in the future. In particular, the number of women of childbearing age in a population is crucial in evaluating its growth rate. Usually, a rapidly expanding population will contain a large proportion of young individuals, a stationary population a more even distribution of age classes, and a declining population a large proportion of old individuals. However, a population may pass through changes in age structure without changing in size.

Example: In 1970, more than 44% of the population in India was under 15, but in Britain only 23% of the population was in this age group. What does the preadolescent bulge in the population of India mean?

1. Birth rates are high and infant mortality is low;
2. A society so constituted is burdened with a relatively large number of non-productive individuals.

As the children of the bulge reach reproductive age, an astronomical rise in population size will occur if the birth rate remains the same, and this, in turn, will once more inflate the preadolescent group. Thus, the population bulge tends to be self-perpetuating.

Together, the above factors dictate the rate of change in the number of individuals in the population over a given period of time. Basically, assessing dynamic changes within a population largely revolves around keeping track of additions to that population from births and immigration, and of losses from the same population due to death and emigration.

3.3 Population Growth and Regulation

Population growth is the increase in number of individuals comprising an aggregation. It is not necessarily the result of more births than deaths, but may be caused by increased survivorship, movement into the area of new organisms of the species under consideration, or other factors.

Growth of a population without increase in emigration or removal by other means does cause an increase in density, which is simply the size of the population within a particular unit of space.

Biotic Potential

The maximum growth rate, which a population could achieve in unlimited environment, is referred to as that population's biotic potential. In reality, of course, no organism ever reaches its biotic potential, because of one or more factors which limit growth long before population size attains its theoretical maximum. Such limiting factors include: food shortage, disease, competition, predation, accumulation of toxic wastes, etc.

Environmental Resistance

The environmental pressure which limits a population's inherent capacity for growth rate termed as environmental resistance. Environmental resistance is generally measured as the difference between the biotic potential of a population and the actual rate of increase as observed under laboratory or field conditions **(Fig.3.1).**

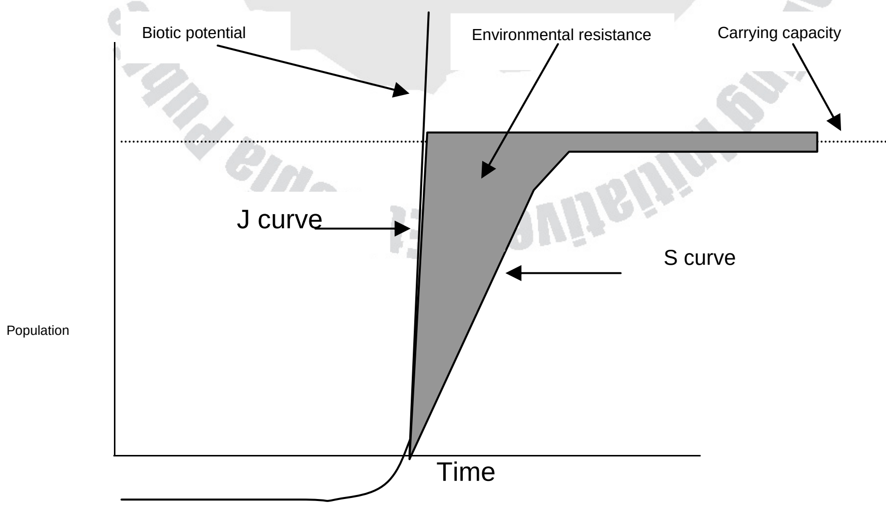

Fig.3.1 J and S population curve. The vertical J represents theoretical unlimited growth. The S represents growth and stabilization in response to environmental resistance.

3.3.1 Population Growth Forms

As a result of the interaction of the biotic potential and environmental resistance, populations tend to have a characteristic pattern of increase or population growth form.

A. J-shaped or Exponential Growth Curve

In species or situations where this type of growth form is permitted, population density increases rapidly, in exponential form (It is called exponential because the rate of increase can be expressed as a constant fraction, or exponent, by which the existing population is multiplied). The more individuals are added to the population, the faster it increases, because all those that are added also breed and hence increase the total growth rate of the population.

This exponential J-shaped growth rate may stop abruptly, as environmental resistance becomes effective more or less suddenly. The population suffers a crash in number regardless of population density. This kind of population growth pattern is characteristic of insects with short life span and most annual plants.

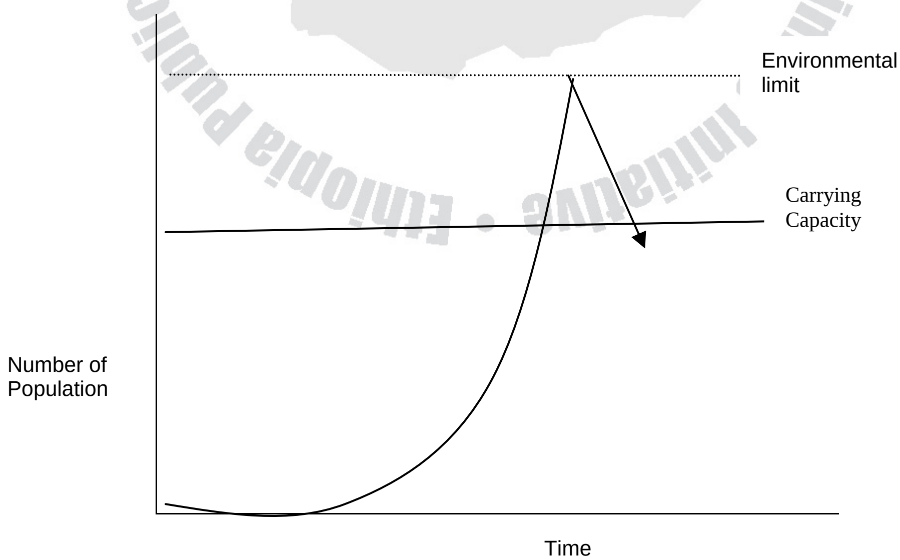

Fig.3.2 J- shaped Population growth form

B. S-Shaped or Sigmoid Growth curve

A more frequently encountered pattern of population growth is S-shaped or sigmoid growth form, where growth starts slowly, accelerates rapidly in exponential form, and then decelerates and continues thereafter at a more or less constant level.

The deceleration phase is a slowdown of population growth caused by the gradual increase of the environmental resistance present in the system. The deceleration continues until a more or less equilibrium level is reached and maintained. The upper asymptote of the sigmoid curve is often referred to as the carrying capacity of that environment- the limit at which that environment can support a population. This growth curve is characteristic of larger organisms with larger life cycles and lower biotic potential.

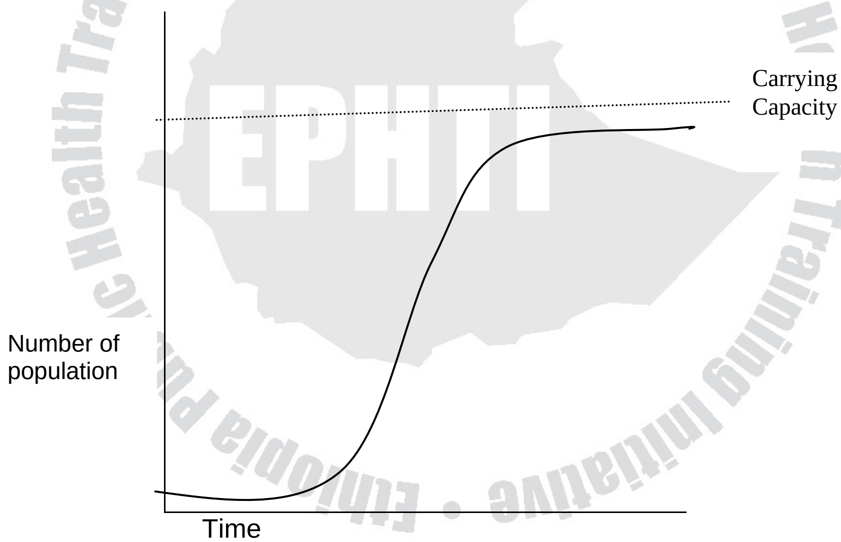

Fig.3.3 S- shaped population growth form

3.3.2 Population Regulation

The regulatory factors can act in a density-dependent manner (effects are stronger or a higher proportion of the population is affected as population density increases) or density-independent manner (the effect is the same or a constant proportion of the population is affected regardless of population density).

Density-independent Factors

In general, the factors that affect natality or mortality independently of population density tend to be abiotic components of the ecosystem. Often weather or climates are among the most important of these factors. Extreme cold, high heat, drought, excess rain, severe storm, and geologic hazards-such as volcanic eruptions, landslides, and floods-can have devastating impacts on particular populations.

Density-dependent Factors

Density-dependent mechanisms tend to reduce population size by decreasing natality or increasing mortality as the population size increases. Most of them are the results of interactions between populations of a community (especially predation), but some of them are based on interaction within a population.

3.4 Human population Growth

Human population has grown rapidly during the past three centuries. By the year 2000, the world population has reached 6 billion, and it is doubling about every forty-one year. About 92 million more people are added to the world each year, making us now the most numerous vertebrate species on earth. There is good reason to fear that this population explosion, unless checked immediately, will bring disaster of an unknown scale.

Many people share a conviction that overpopulation inevitably will bring crowding, poverty, violence and environmental degradation. In this view, too many people are trying to share limited resources in ways that surpass the earth's carrying capacity and over-stress life-support systems on which we all depend. These fears lead to demands for immediate, worldwide birth control programs to reduce population growth.

3.4.1 Human Population History

For most of our history, humans have not been very numerous compared to other species. Studies of hunting and gathering societies suggest that the total world population was probably only a few million people before the invention of agriculture and the domestication of animals around ten thousand years ago. The larger and more secure food supply made available by the agricultural revolution allowed the human population to grow, reaching perhaps 50 million people by 5000B.C. For thousands of years, the number of humans increased very slowly.

Until about Middle Ages, human population was held in check by diseases, famine, and wars that made life short and uncertain for most people. Among the most destructive of natural population control were bubonic plagues that periodically swept across Europe between 1348 and 1650. During the worst plague years, between 1348 and 1350, it is estimated that at least one-third of the European population perished. However, this did not retard population growth for very long. In 1650, at the end of the last great plague, there were about 600 million people in the world.

Human population began to increase rapidly after 1600A.D**. (Fig.3.4).** Many factors contributed to this rapid growth. Increased sailing and navigating skills stimulated commerce and communication between nations. Agricultural developments, better sources of power, and better health care and hygiene also played a role. We are now in an exponential or J curve pattern of growth.

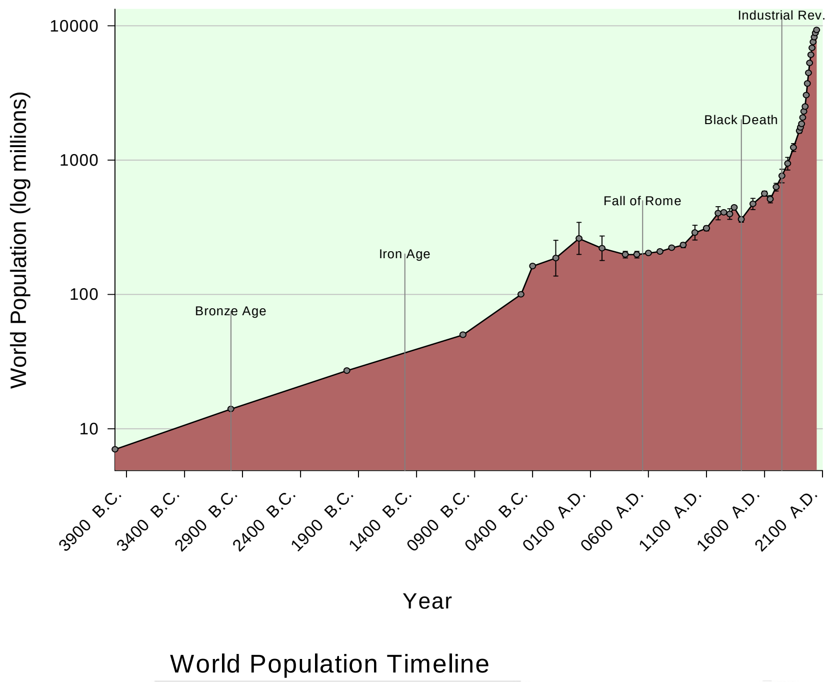

Fig. 3.4. Human population levels through history
(source: Cunningham & Saigo, 1995).

Doubling Time

Perhaps the best way to describe growth rate is in terms of 'doubling time'-the time required for a population to double in size, assuming that its current growth rate did not change. A look at a country's doubling time can identify it as a highly, moderately or less developed country: the shorter the doubling time, the less developed the country.

Thus, for example, with the annual growth rate of 3.0%, the population of Ethiopia will double in a mere 23 years.
In human terms, this means that just to maintain present standard of living, everything in Ethiopia needs to be doubled in 23 years-food production, provision of jobs, educational facilities, medical personnel, public services, and so forth.

3.4.2 Impact of Human Population Growth on Resources and Ecosystem

There are already 1.9 billion people who are very poor, and who always think not of the food they are eating but of their next meal. Population growth unless matched with corresponding natural resources, growth of economy and development will create:

a. Unemployment
b. Low literacy rate
c. Shortage of housing
d. Resource depletion
e. Shortage of food
f. Shortage of social services
g. Political and social unrest
h. Unstable ecosystem (environmental pollution)

Of all these problems, creation of unstable ecosystem is the worst. In a natural state, earth's life forms live in equilibrium with their environment. The resources available to them govern the number and activities of each species. Species interaction is common, with the waste product of one species often forming the food supply of another. Humans alone have the ability to gather resources from beyond their immediate surroundings and process those resources into different, more versatile forms. These abilities have made it possible for human population to thrive and flourish beyond natural constraints. But the natural and manufactured wastes generated and released into the biosphere by these increased numbers of human beings have upset the natural equilibrium.

Experience over the last couple of decades in Ethiopia has shown that as human number increased, the population carrying capacity of the environment decreased. A high population growth rate induces increased demand for resources and the rate at which these resources are exploited. In Ethiopia where technology has not kept pace with the demands for greater productivity, environmentally harmful and economically counter-productive methods of exploiting land and associated resources (forests, animal resources, etc.) are resorted to in order to meet immediate needs. As a consequence of this, climatic conditions are becoming erratic and soil quality is declining at an alarming rate.

Review Questions

1. Define each of the followings, and explain its effect on population size:
   - Natality
   - Mortality
   - Immigration
   - Emigration
   - Age structure
2. Explain differences between density-dependent and density-independent factors that regulate population growth. Give examples for each factor.
3. Discuss the J-shaped and S-shaped population growth forms in terms of biotic potential and environmental resistance.
4. What defines the carrying capacity of a particular environment?
5. What are the factors that contribute for the rapid growth of human population?
6. What does age structure indicate in human population growth?
7. Define 'doubling time' in terms of human population growth.
8. Discuss the impacts of uncontrolled human population growth on the biosphere.

CHAPTER FOUR

The Biosphere and its Pollution

Learning Objectives

At the end of this chapter, the student will be able to:

- Describe the components of the biosphere.
- List the types and sources of water pollution.
- Explain the effect of water pollution on human health and on the environment.
- Mention the major air pollutants and their sources.
- Discuss the effects of air pollutants on human health and on the environment.
- Discuss the effects of solid wastes on human health and the environment.
- Explain the benefits and problems of pesticides.

Definitions

1. **Biosphere**: narrow zone that harbors life, limited to the waters of the earth, a fraction of its crust, and the lower region of the surrounding air.
2. **Pollutant**: any substance with which an ecosystem has had no prior evolutionary experience, in terms of kinds or amounts, and that can accumulate to disruptive or harmful level.
3. **Pollution**: Addition of some exogenous substances in the environment, which are harmful for organisms including human beings.
4. **Biological concentration**: increasing concentration of a relatively non-degradable(stable) substance in body tissues, beginning at low trophic levels and moving up through those organisms that are diners, than are dined upon in food web.
5. **Environmental pollution:** the introduction of undesirable changes such as the constitution or quality, of water, air and soil.

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6. **Point-source pollution:** pollutants which enter waterways from a specific point through a pipe, ditch, culverts, etc.
7. **Non-point source pollution:** pollutants those which runoff or seep into waterways from broad areas of land rather than entering the water through a discrete pipe or conduit.
8. **Biochemical Oxygen Demand (BOD):** the amount of oxygen required degrading (stabilize) wastes.

4.1 Introduction

The Planet Earth along with its living organisms and atmosphere (air, land, and water), which sustains life, is known as the Biosphere. The biosphere extends vertically into the atmosphere to about 10Km, downward into the ocean to depth of about 35,000ft, and into about 23,000ft. of the earth surface itself where living organisms have been found.

The biosphere, a thin shell that encapsulates the earth, is made up of the atmosphere (a mixture of gases extending outward from the surface of the earth), lithosphere (the soil mantle that wraps the core of the earth) the hydrosphere (consists of the oceans, the lakes and streams, and the shallow ground water bodies that inter-flow with the surface water.

4.2 Water Pollution

Water is one of the most important and most precious of natural resources, and a regular and plentiful supply of clean water is essential for the survival and health of most living organisms. As a consequence of rapidly expanding industrialization and excessive population growths, and most of our rivers, lakes, stream and other water bodies are being increasingly polluted. Water is regarded as " polluted " when it is changed in its quality or composition, directly or indirectly as a result of human's activities so that it becomes less suitable for drinking, domestic, agricultural, and recreational, fisheries or other purposes.

Sources of Water pollution

Pollutants can enter waterways by a number of different routs. Sources of pollution can be categorized into two: **point source pollution** and **non-point source pollution**. Factories, power plants, sewage treatment plants, latrines that are directly connected to water bodies are classified as **point sources**, because they discharge pollution from specific locations. In contrast, non-point sources of water pollution are scattered or diffuse, having no specific location where they discharge into a particular body of water. Non-point sources include runoff from farm fields and feedlots, construction sites, roads, streets and parking lots.

Types and Effects of Water pollution

Although the types, sources and effects of water pollutants are often interrelated, it is convenient to divide them into major categories for discussion **(Table 4.1).** The followings are some of the important sources and effects of each type of pollutant.

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Table 4.1. Major water pollutants: source, effects, and possible controls

Pollutant	Main source	Effects	Possible control
Organic oxygen demanding waste	Human sewage, animal wastes, decaying plant life, industrial waste	Overload depletes dissolved oxygen in water: animal life destroyed or migrates away: plant life destroyed	Provide secondary and tertiary waste-water treatment; minimize agricultural runoff
Plant nutrients	Agricultural runoff, detergents industrial wastes inadequate waste water treatment	Algal blooms and excessive aquatic plant growth upset ecological balances: eutrophication	Agricultural runoff too widespread, diffuse for adequate control
Pathogenic bacteria & virus	presence of sewage and animal wastes in water	Outbreaks of such diseases as typhoid infectious hepatitis	Provide secondary and tertiary waste-water treatment; minimize agricultural runoff
Inorganic chemicals	Mining manufacturing irrigation, oil fields	Alter acidity, basicity, or salinity: also render water toxic	Disinfect during waste-water treatment; stop pollutants at source
Synthetic organic chemicals (plastics, pesticides)	Agricultural manufacturing, and consumer uses	Many are not biodegradable; chemical interactions in environment are poorly understood many poisonous	Use of biodegradable materials; prevent entry into water supply at source
Fossil fuels (oils particularly)	Machinery, automobile wastes; pipeline breaks, offshore blowout and seepage, supertanker accidents, spills, and wrecks; heating transportation, industry; agriculture	Vary with location, duration, and type of fossil fuel; potential disruption of ecosystems; economic, recreational, and aesthetic damage to coasts	Strictly regulate oil drilling, transportation, storage; collect and reprocess engine oil and grease; develop means to contain spills
Sediments	Natural erosion, poor soil conservation practices in agriculture, mining construction	Fill in waterways, reduce fish populations	Put soil conservation practices to use

<u>Source</u>: Starr & Taggart, 1978.

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i. Infectious Agents

The most serious water pollutants in terms of human health are pathogenic organisms. Among the most important waterborne diseases are typhoid fever, cholera, bacterial and amoebic dysentery, polio, hepatitis and schistosomiasis.

The main source of these pathogens is from untreated or improperly treated human wastes. Animal feedlots or fields near waterways and food processing plants with inadequate waste treatment facilities also are sources of disease causing organisms.

ii. Oxygen Demanding Wastes

The amount of dissolved oxygen (DO) in water is a good indicator of water quality and the kinds of life it will support. Oxygen is added to water by diffusion from the air, especially when turbulence and mixing rates are high, and by photosynthesis of green plants and algae. Oxygen is removed from water by respiration and chemical processes that consume oxygen.

The addition of certain organic materials, such as sewage, paper pulp, or food processing wastes, to water stimulates oxygen consumption by decomposers. The impact of these materials on water quality can be expressed in terms of **biological oxygen demand (BOD)-** a standard test of the amount of dissolved oxygen utilized by aquatic microorganisms over a five-day period.

iii. Plant Nutrients and Eutrophication

Aquatic plants require certain nutrients for health growth and metabolism. An excess of these essential elements (from such sources as sewage treatment plants, runoff from animal feedlots or fertilized agricultural lands), however, can result in a plant population explosion which leads to serious degradation of water quality and radical changes in the species composition of the over-fed lake, pond or stream. The process by which a body of water becomes over-enriched with nutrients and as a result produces an over-abundance of plant life is known as **eutrophication**. Boye Pond, can be a classic example of eutrophication, which has been receiving a sustained solid and liquid waste discharge from inhabitants of Jimma Town, Southwestern Ethiopia, and now on the process being converted to a marshy area.

Although eutrophication can occur in sluggish streams, bays, and estuaries, it is most common in lakes and ponds. This is because lakes, unlike flowing bodies of water, flush very slowly; thus nutrient-laden wastewaters or runoffs introduced into a lake tend to remain there for many years.

iv. Toxic Inorganic Chemicals

Toxic, inorganic chemicals introduced into water as a result of human activities have become the most serious forms of water pollution. Among the chemicals of greatest concern are heavy metals, such as mercury, lead, tin, and cadmium. Other inorganic materials, such as acids, salts, nitrates and chlorine that normally are not toxic in low concentrations may become concentrated enough to lower water quality or adversely affect biological communities.

V. Organic Chemicals

Thousands of different natural synthetic organic chemicals are used in the chemical industry to make pesticides, plastics, pigments and other products. Many of these chemicals are highly toxic. Exposure to very low concentrations can cause birth defects, genetic disorder, and cancer. They also can persist in the environment because they are resistant to degradation and toxic to the organisms that ingests them. Contamination of surface waters and groundwater by these chemicals is a serious threat to human health.

Important sources of toxic organic chemicals in water are improper disposal of industrial and household wastes and runoff of pesticide from farm fields, forests, roadside and other places where they are used in large quantities.

VI. Thermal Pollution

Many industrial processes create problem of thermal pollution by discharging heat (in the form of hot water, air or effluent) into the environment. Such industries use a lot of water for cooling purposes and return this water to a stream at a higher temperature.

The adverse effects of thermal pollution include:

- Change in species composition;
- Fish may migrate or be killed by suffocation (because warm water holds less oxygen than cold water);
- The BOD of the water rises;
- Increase the susceptibility of aquatic organisms to disease;
- Reproductive cycles of fish and other aquatic organisms may be disrupted.

4.3 Air Pollution

Air pollution occurs through enrichment (contamination) of the atmosphere or air with noxious gases and other undesirable substances; caused largely as a result of burning fuels and through release of gases by various industries and automobiles.

Sources of air pollutants

Air pollutants come from many sources and contain diverse chemicals. All air contains natural contaminants such as pollen, fungi spores, and smoke and dust particles from forest fires and volcanic eruptions. It contains also naturally occurring carbon monoxide (CO) from the breakdown of methane (CH_4); hydrocarbons; and hydrogen sulphide (H_2S) and methane (CH_4) from the anaerobic decomposition of organic matter. In contrast to the natural sources of air pollution, there are contaminants of anthropogenic origin. Coal-burning power plants, factories, metal smelters, vehicles are among the main anthropogenic sources of air pollutants.

Major Air Pollutants and Their Effects

The most common and well-identified air pollutants are: -

a. Suspended Particulate

This includes all particulate matters such as soot pollen, dust, ash, smoke etc. Such pollutants are easily seen and the common man could very easily be made to be aware of them. Major and visible damages of suspended particulates are:

1. Damage to buildings paints
2. Dirt into clothing
3. Obscure visibility
4. Corrode metals
5. When inhaled, suspended particulate irritates the respiratory tract.

b. Sulfur dioxide (SO_2)

Sulfur dioxide is a colorless pollutant mostly released from industries and power-generating plants. Once in the atmosphere, SO_2 can be further oxidized to sulfur trioxide (SO_3), which reacts with water vapor or dissolves in water droplets to form sulfuric acid (H_2SO_4) which is the cause of acid rain. Sulfur dioxide:

1. Irritates respiratory system
2. Corrodes metals and statues
3. Impairs visibility
4. Kills or stunt growth of plants
5. Is a precursor of acid precipitation

c. Carbon monoxide (CO)

Carbon monoxide, odorless, colorless, non-irritant but highly toxic gas is found at high concentrations in urban areas. It is mostly released from motor vehicles, fuel wood combustion and industry. CO is a product of incomplete combustion. Its effect is that it:

- Binds to hemoglobin in the blood, displacing oxygen and thereby reducing the amount of oxygen carried in the blood stream.
- Slow down mental processes and reaction time

d. Nitrogen Dioxide (NO_2)

This is a colored gas than any other gas. It is formed when combustion occurs at high temperatures. The sources of NO_2 are power plants and automobile emission.

Nitrogen dioxide:

- Stunt plant growth
- Reduce visibility by its yellow brown smog it forms
- Contribute to the formation of acid rain.

e. Ozone (O_3)

This is one of the constituents of photochemical oxidant. Photochemical oxidants are formed from a complex series of chemical reaction when NO_2 and hydrocarbons react with O_2 and sunlight to produce photochemical smog.

Ozone formed on the upper part of the atmosphere (stratosphere) provides a valuable shield for the biosphere by absorbing incoming ultraviolet radiation. In ambient air (troposphere), however, ozone is a strong oxidizing agent and damages vegetation, building materials (such as paints, rubber, and plastics), and sensitive tissues (such as eyes, and lungs).

f. Hydrocarbons

Those compounds containing hydrogen and carbon atoms in various combinations are the hydrocarbon groups. Examples are benzene, and benzo(a)pyrene, which is potent carcinogen. Apart from their long time effect, they being catalysts for photochemical smog is the most felt problem.

g. Lead

Lead is a toxic metal, which is traced to automobile emissions from leaded gasoline. Lead is a metabolic poison and a neurotoxin that binds to essential enzymes and cellular components and inactivates them.

4.4 Land/Soil Pollution

Humans and animals used resources that earth could supply for existence for millions of years. Earth (Land) being natural resources is also used for disposal of the wastes we generate. Even in the primitive society the hunters and gathers dispose their waste near and by their caves.

Solid wastes are the wastes arising from human and animal activities that are normally solid and that are discarded as useless or unwanted. It encompass the heterogeneous mass of throw away from mostly urban communities as well as the more homogenous accumulation of agricultural, industrial and mineral wastes.

The problem of solid waste was not as bad as it is now. In the past, the number of population in urban and rural communities was not so populated. But, the problem of solid waste began when first humans congregate in tribes, villages and communities. The practice of throwing waste into the streets, galleries, any where in the yard, and vacant areas led to the breeding of rats and flies. For example, in Europe because of waste accumulation at the time of formation of large communities resulted in increment of the rat population. It was during that time that the great plague pandemic killed hundreds of thousands of people in the world.

Present public health science proved that those rats, flies and other diseases vector breed in open dumps, in food storage facilities, and in other areas and houses. One study in USA revealed that there is 32 human diseases which have relationship to improper solid waste management.

Ecological impacts of solid waste include:-

a. Water and air pollution.
b. Liquid that seeps from open dumps or poorly engineered landfills will contaminate surface water and ground water found in the vicinity.
c. In mining areas, the liquid leached from waste dump may contain toxic elements such as copper, arsenic or may contaminate water supplies from unwanted salts of calcium and magnesium.

Some substances such as DDT, and mercury are relatively stable; they are non-degradable and insoluble in water. They are neither used nor eliminated, but are stored in the body, where they may exert a cumulative damaging effect on a variety of physiological processes **(Box 5.1.).** For example, DDT is soluble in fat. It tends to accumulate in the fatty tissues of organisms. For this reason, like mercury, DDT is a prime candidate for biological concentration. The DDT that becomes concentrated in tissues of herbivores (such as insects) becomes even more concentrated in tissues of carnivores that eat quantities of the DDT-harboring herbivores. The concentration proceeds at each trophic level.

Pesticides

Pesticides are substances, which kill pests and disease vectors of agriculture and public health importance. Pesticides are subdivided into groups according to target organisms:

- Insecticides; kill insects
- Rodenticides; kill rats and mice
- Herbicides; kill weeds
- Nematicides; kill nematodes

Insecticides: the largest numbers of pesticides are employed against a wide variety of insects, and include: stomach poison (taken into the body through the mouth); contact poisons (penetrate through the body wall); and fumigants (enter insects through its breathing pores).

Inorganic insecticides

These insecticides act as stomach poison. Lead arsenate, Paris Green, and a number of other products containing copper, zinc, mercury, or sulfur are examples of inorganic insecticides. Many of these products are quite toxic to man as well as to insects.

Botanical

Certain plant extracts are very effective contact poisons, providing quick knockdown of insects. Most botanical preparations are non-toxic to humans, and can be safely used.

Chlorinated hydrocarbons

These are contact poisons. DDT, chlordane, lindane, endrine, alderin are some of the chlorinated hydrocarbons. These insecticides are broad-spectrum, and act primarily on the central nervous system, causing the insect to go through a series of convulsions prior to death. They are also persistent in the environment, breaking down very slowly, and therefore, retaining their effectiveness for a relatively long period after application.

Organophosphates

Organophosphate are broad-spectrum contact poisons. Unlike chlorinated hydrocarbons, organophosphates are not persistent, usually breaking down two weeks or less after application. They are nerve poisons, which act to inhibit the enzyme cholinesterase, causing the insect to lose coordination and go into convulsion. Methyl parathion, phosdrin and malathion are examples of this group.

Carbamates

These are contact poisons, which act in a manner similar to the organophosphates. Carbamates are widely used in public health work and agriculture because of their rapid knockdown of insects and low toxicity to mammals.

Pesticide Benefits

Disease control

Insects, rodents and ticks serve as vectors in the transmission of a number of disease-causing pathogens and parasites. Malaria, yellow fever, trypanosomiasis, onchocerciasis and plague (Black Death) are some of human diseases that are transmitted by disease vectors (insects and rodents). All of these diseases can be reduced by careful use of insecticides.

Crop protection

Plant diseases, insects, bird predation, and competition by weeds reduce crop yield worldwide by at least one-third. Post-harvest losses to rodents, insects, and fungi may as much as another 20 to 30 percent. Without the use of pesticides, these losses might be much higher.

Pesticide Problems

While synthetic chemical pesticides have brought us great economic and social benefits, they are also causing a number of serious problems. Some of the problems are:

- Killing of beneficial species;
- Development of resistance;
- Environmental contamination
- Hazards to human health especially workers who do not use personal protection equipment during application (See **Fig 4.1**).

Fig 4.1. A Farmer in Jimma Zone ready to spray a herbicide with out wearing any form of personal protective equipment.

Radioactive Materials

There are various kinds of atoms of each elemental substance, each with a slightly different make-up, some radioactive, some not radioactive.

When radioactive materials are released into the environment, they become dispersed and diluted, but they may also become concentrated in living organisms and during food chain transfers by a variety of means. Radioactive substances may also simply accumulate in water, soils sediments, or air if the input exceeds the rate of natural radioactive decay.

Radioactive materials have the same chemical properties as the non-radioactive forms. Thus, radioactive iodine (I^{131}), for example, can be incorporated into thyroxin, the thyroid hormone, as easily as non-radioactive iodine (I^{127}). Strontium 90 is a radioactive substance. It is chemically very similar to calcium, and thus tends to be accumulated in the bones and other tissues rich in calcium. It can also damage the blood-forming center in the bone marrow.

Prevention and Control of Pollution

As in disease, pollution prevention is far better and more desirable than its cure. There are various measures that can be taken for preventing pollution. The followings are some of the measures:

a. Recycling and reuse of waste materials;
b. Waste reduction;
c. Control the use of chemicals;
d. Proper disposal of wastes;
e. Treatment of wastes before discharge;
f. Use of "cleaner" energy sources, such as sun energy, wind, etc.;
g. Reduce emission of air pollutants using different techniques;
h. Formulation of rules and regulations.

Box 4.1.

Minamata Disease

In the early 1950s, people in the small coastal village of Minamata, Japan, noticed strange behavior that they called dancing cats. inexplicably, cats would begin twitching, stumbling, and jerking about, as they were drunk. Many became "suicidal" and staggered off docks in to the ocean. The residents didn't realize at the time, but they were witnessing an ominous

warning of an environmental health crisis that would make the name of their village synonymous with a deadly disease. Their cats were suffering from brain damage that we now know was caused by methyl mercury poisoning. In 1956, the first human case of neurological damage was reported. A five-year old girl who had suddenly lapsed in to a convulsive delirium was brought into the local clinic. Within a few weeks there seemed to be an epidemic of nervous problems including numbness, tingling sensations, headaches, blurred vision, slurred speech, and loss of muscle control. For an unlucky few, these milder symptoms were followed by violent trembling paralysis and even death. An abnormally high rate of birth defects also occurred. Children were born with tragic deformities; paralysis and permanent mental retardation. Lengthy investigations showed that these symptoms were caused by mercury from fish and seafood that formed a major part of the diet of both humans and their cats. For years, the Chisso chemical plant (Plastic Manufacturer) had been releasing residues containing mercury into Minamata Bay. Since elemental mercury is not water soluble, it was assumed that it would sink into the bottom sediments and remain inert. Scientists discovered, however, that bacteria living in the sediments were able to convert metallic mercury into soluble methyl mercury, which was absorbed from the water and concentrated in the tissues of aquatic organisms. People who ate fish and shellfish from the Bay were exposed to dangerously high levels of this toxic chemical. Altogether, more than 3,500 people were affected and about fifty died of what became known as Minamata disease.

Review Questions

1. What are the three main components of the biosphere?
2. What are the types and sources of water pollution?
3. What are point-source and non-point source of pollution? Give examples for each.
4. Give some examples of diseases that are related to water pollution.
5. What is eutrophication? What causes it?
6. What are the major air pollutants and their effects on the environment and human health?
7. What are the main anthropogenic sources of air pollutants?
8. Discuss the impacts of indiscriminate disposal of solid wastes on human health the environment.
9. What will happen when a large amount of oxygen- demanding waste is discharged to water bodies?
10. What are the effects of thermal pollution?
11. Discuss the benefits and disadvantages of pesticides

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CHAPTER FIVE

Natural Resources and their Conservation

Learning Objective:

At the end of this chapter, the student will be able to:

- List the different types and groups of resources
- Discuss the different conservation methods
- Mention environmentally friendly/ safe/ energy sources

Definition of terms:

1. **Energy:** The capacity to do work
2. **Mineral:** Inorganic nutrient, which is mostly found in the earth's crust.
3. **Mulch**: A layer of organic material applied to the ground surface to the ground surface to retain and conserve moisture.
4. **Renewable resource:** Resource normally replaced or replenished by natural processes; resources not depleted by moderate use.
5. **Recycling:** Processing of discarded materials into new, useful products; not the same as reuse of materials for their original purpose, but the terms are often used interchangeably.
6. **Composting: T**he Process of making compost by decomposition of vegetable and other degradable organic wastes.

5.1 Introduction

A Resource is any useful information, material, or service. Within this generalization, we can differentiate between natural resources (goods and service supplied by our environment, including sinks for wastes) and human resources (human wisdom, experience, skill, labor, and enterprise). It is useful to distinguish between **exhaustible (non-renewable)**, **renewable (non-exhaustible)** and **intangible** resources.

Modern civilization entails the high risk of irreversible deterioration of the environment, which accompanies overpopulation, overproduction, over wastage and the exploitation of ever-increasing amounts of natural resources such as source rocks for ever-declining proportions of useful products, e.g., Minerals. Any perturbation in the broad framework of the inter-relationships between living organisms and their environment may influence the availability of resources to human societies.

Natural resources can be broadly classified into biological and non-biological, and includes such resources as minerals and industrial, agricultural, forestry and food resources, power and energy, plant and animal, range and water. As explained above, resources may be renewable or non-renewable. Biological resources such as fish are of course, can be replenished, but such resources as nitrogen, iron and energy may also some time be renewable through not to the same extent as forests and fisheries.

Abstract or intangible resources include open space, beauty, serenity, genius, information, diversity and satisfaction. Unlike tangible resources often are increased by use and multiplied by sharing. These non-material resources can be important economically.

5.2 Types of Natural Resources

The functioning of ecosystems, including man's survival and happiness, depends on the availability, preservation and recycling of natural resources such as minerals, water, land and energy sources. These resources are, however, not unlimited and many countries still continue to dream of an ever increasing Gross National Product based on obsolescence and wasteful practices.

Any perturbation in the broad framework of the inter-relationships between living organisms and their environment may influence the availability of resources to human societies.

5.2.1 Forest Resources

Forests are unevenly distributed over the earth. Large and densely inhabited areas are sometimes poorly covered with forest, whereas sparsely populated areas of the humid tropics and the boreal forest belt are dominant woodland. Some 20 % of the forested area belongs to the former USSR,

Africa, central and South America each; about 16% are shared between North America and Asia and the remaining 4% occur in Europe.

It is being destroyed rapidly all over the world. In South-east Asia the forest is being cleared at an estimated rate of 5 million/ha/yr., in Africa 2 million/ha/yr., in South America 8 million/ha/yr.

To a great degree, the type and density of the natural forest (vegetation) of Ethiopia reflect its rainfall and temperature distribution patterns, although human use (and misuse) has drastically altered its structure and composition. It has been estimated that the natural vegetation of the country, before manmade changes became significant, consisted of 34% forest (covering most of the highlands), 20 % woodland and tree savanna, and 32% grassland and steppe. Today only 3-4% of the land is in forest, 8% in woodland. Cultivated land has largely replaced forest and development projects contributed their share by clear felling as is the case for the Gilgel Gibe Hydroelectric dam construction (See **Fig 5.1**).

Fig 5.1. Forest clearance at the site of Gilgel Gibe Hydroelectric dam construction, Region 4, Southwestern Ethiopia. Trees measuring up to 1.6 m in diameter have been removed.

Consequences of Forest Destruction

Forests are important regulators of ecosystem. They exert significant effects on the water budget and the hydrological cycle. In areas of heavy rainfall, forest plants intercept a large fraction of the rain. This water evaporates quickly and returns to the hydrological cycle.

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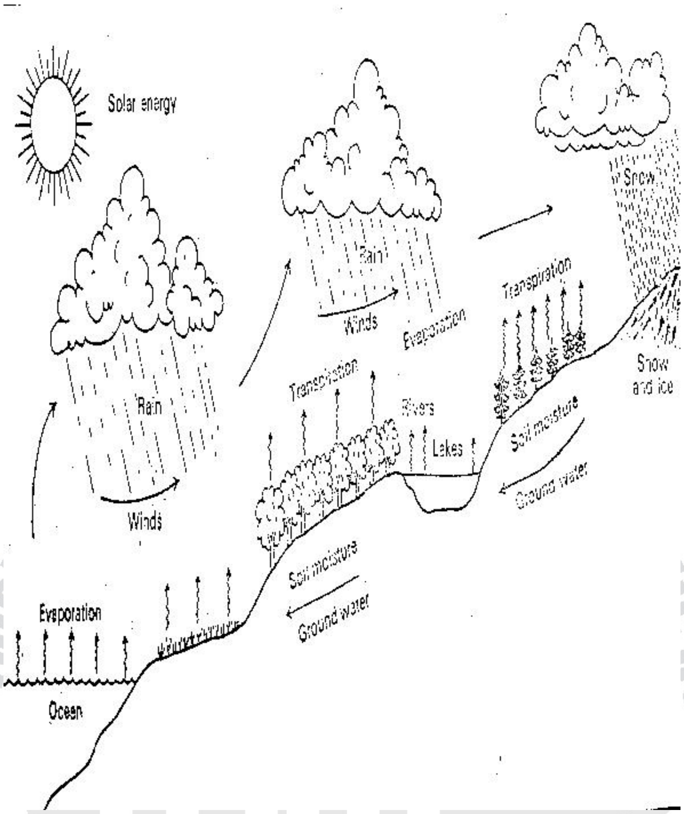

Fig 5.2. The Hydrologic Cycle (Source: Kumar, 1997).

Some of the water reaching the forest floor penetrates into the soil through the litter and the loose soil surface, and there is little surface run-off. It is only after some period of time that the seeped water reaches the streams and rivers. This time lag is an important device to regulate the water discharge into rivers, and in this way, flooding is prevented or minimized. On the other hand, in dry periods also the forest soil continues to supply water slowly to the streams and rivers.

Destruction of forest changes the above situation immediately. The hydrological cycle is disrupted and the water level of the rivers cannot be properly regulated. This causes flooding. In dry periods, the rivers tend to dry up, affecting irrigation and power generation. In deforested areas, erosion of soil occurs fairly briskly, especially on steep slopes. This removes the fertile topsoil and also loads the rivers with much suspended matter. Deforestation thus greatly increases the quantity of detritus in many tropical rivers. This detritus causes premature filling up of water reservoirs, etc.

Large-scale forest destruction often produces grave climatic consequences, especially desertification and aridity. This result from reduction of evaporation as the tree canopies (cut and removed) no longer intercept rainwater, and also because rapid run-off of precipitation occurs in the absence of the forest cover.

5.2.2 Mineral Resources

A Mineral is a naturally occurring, inorganic, crystalline solid that has a definite chemical composition and characteristic physical properties. There are thousands of known and described minerals in the world. Most economically valuable minerals exist everywhere in small amounts; the important thing is to find them concentrated in economically recoverable levels.

Until recently little attention was paid to conservation of mineral resources because it was assumed that there were plenty for centuries to come and that nothing could be done to save them anyway. But this assumption is dead wrong.

World industry depends on about eighty minerals, some which exist in plentiful supplies. Three-fourth of the eighty minerals are abundant enough to meet all of our anticipated needs or have readily available substitutes. At least eighteen minerals, including tin, platinum, gold, silver, and lead, are in short supply.

5.2.3 Soil Resources

Of all the earth's crust resources, the one we take most for granted is soil. It can be considered an ecosystem by itself. We are terrestrial animals and depend on soil for life, yet most of us think of it only in negative terms. Soil is a marvelous substance, a living resource of astonishing beauty, complexity and frailty. Half of the soil content is mineral, and the rest is air and water together with a little organic matter from plant and animal residue.

We face a growing scarcity of good farmland to feed the world's rapidly growing human population. Only about 10% of the earth's land area (14.78 million sq. km of a total of 144.8 million sq. km) is currently used for agricultural production.

With careful husbandry, soil is a renewable resource that can be replenished and renewed indefinitely. Agriculture is the area in which soil is most essential and also most often lost through erosion. Therefore, the greatest potential for soil conservation and rebuilding lies on agricultural practices. The most important considerations in a soil conservation program are topography, ground cover, climate, soil type, and tillage system.

Due to mismanagement, in Ethiopia about 2 billion tons of soil is eroded annually, reducing the country's food production capacity by 2-3% per annum. About 50% of the highlands had been significantly eroded by the mid 1980s, 4% had already been lost to agriculture due to erosion, and only 18% were relatively free from erosion.
These days terracing and plantation activities made by the extension program in different parts of the country is a good measure for soil conservation.

5.2.4 Energy resources

Energy is the ability to do work such as moving matter over a distance or causing a heat transfer between two objects at different temperatures.

Oil, natural gas and other petroleum products constitute major sources of energy to fuel our economy. Other resources of energy are heat from the sun, heat from the earth, and the harnessing of wind, ocean and tides. Water wheels, windmills and hot water from thermal springs have been used as energy sources in some countries, and of course coal has been a major source of energy for a century or more in England.

Renewable energy resources like Hydropower, the sun, wind, tides and biomass are nor likely to make significant contributions to the world's energy for the developed nations. But these renewable sources are expected to play an increasingly important role in the energy use pattern of many developing countries like Ethiopia. It is not environmentally friendly to completely shift the hunger for petroleum to the more abundant but still finite coal, shell and heavy oil reserves; because it will increase the level of CO_2 which is the known greenhouse gas.

In this case, biomass conversion has unique advantages over the commonly used energy technologies. Unlike petroleum or coal, biomass resources are renewable. Conversion of municipal and industrial wastes in to useful fuels amounts to killing two birds with one stone; the energy supplies are increased, and the environment is cleaned up.

Many developing countries have a substantial reliance up on wood fuel (e.g. charcoal) and, to a lesser extent, crop wastes as their source of energy. **Table 5.1** shows the percentage degree of reliance on this “traditional” fuel. Countries with the highest reliance on traditional fuels or energy sources tend to be the poorest.

Table 5.1. Developing countries dependence on traditional fuels (traditional fuels as a percentage of total primary energy)

Country	Percentage	Country	Percentage
Nepal	93	Senegal	60
Malawi	92	Yemen	58
Tanzania	91	Fiji	55
Guinea-Bissau	89	Indonesia	49
Ethiopia	89	Sri Lanka	45
Sudan	83	Botswana	45
Paraguay	83	St Vincent	44
Niger	80	St Lucia	39
Uganda	71	Costa Rica	38
Kenya	71	Bolivia	35
Gambia	70	Morocco	35
Haiti	70	Zambia	35
Bangladesh	70	Zimbabwe	30
Solomon Islands	66	Turkey	24
Liberia	64		

Source: World Bank /UNDP energy assessment for developing Countries.

Indeed, in many ways, the extents to which traditional fuels are used as an indicator of the stage of economic development.

Case study:

The primary use of wood fuel is cooking. As wood become scares, so cooking habits may change, sometimes to the detriment of nutrition. Fuel scarcity also inhibits the introduction of new nutritious foods such as Soya beans, due to the extra cooking time required. The cost of such dietary changes, and the foregone benefits from the inability to introduce new foods, is obviously complex to estimate and no empirical work appears to be available. But it is a positive cost, which must be debited to resource mismanagement. Apart from collection time and nutrition effects, fuel wood scarcity has a third impact. As the wood becomes scarce, animal dung and crop residue are used as energy source rather than being applied to the soil as fertilizer and soil conditioners. Study conducted in Ethiopia in 1984 estimates that up to 90% of cattle dung produced in Eritrea, and 60% in Tigrai and Gondar, Ethiopia, is used as fuel. This estimate is about 7.9 million tones of dung per year. In Ethiopia, dung is sold to urban markets.

5.3 Conservation of Natural Resources

Conservation in the broadest sense has always been one of the most important applications of ecology. Conservation broadly means sound land or water use planning. It is concerned with the maintenance of natural systems with their moderate, systematic, planned and regulated utilization and exploitation for the long-term benefit of mankind.

Unmodified natural ecosystem as well as those ecosystems that have been changed to differing extents through human activity may be expected to play an important role in the future development of environmental biology. The unmodified ecosystems constitute a kind

of protected area and characteristically contain a rich variety of organisms, some of which can serve as reliable indicators for disturbance in the system. As a consequence of increasing tampering of nature by man, natural reserves are greatly dwindling and are becoming the main sanctuaries for
wild plants and animals.

The aim of conservation is twofold:

1. To ensure the preservation of a quality environment that considers esthetic and recreational as well as product needs and
2. To ensure a continuous yield of useful plants, animals, and materials by establishing a balanced cycle of harvest and renewal.

In addition to conservation of natural resources, man is also greatly concerned with as much preservation of environmental quality as is reasonably possible. The last two decades has shown and realized that man is capable of inducing significant alterations in the environment either internationally or inadvertently. Lose of life by floods, droughts, cyclones, etc. can witness this.

Concerning mineral conservation, there is great potential for extending our supplies of economic minerals and reducing the effect of mining and processing through **recycling**. For scare and or valuable metals, their waste products are exploited as resource using recycling methods. On the other hand, new materials can reduce mineral consumption or new technologies developed to replace traditional minerals and mineral uses, by **substitution**.

Composting is one way of recycling materials. The composting process has always occurred in nature. If organic materials are subjected to aerobic microbacterial decomposition, the end product remaining after is humus material commonly known as compost.

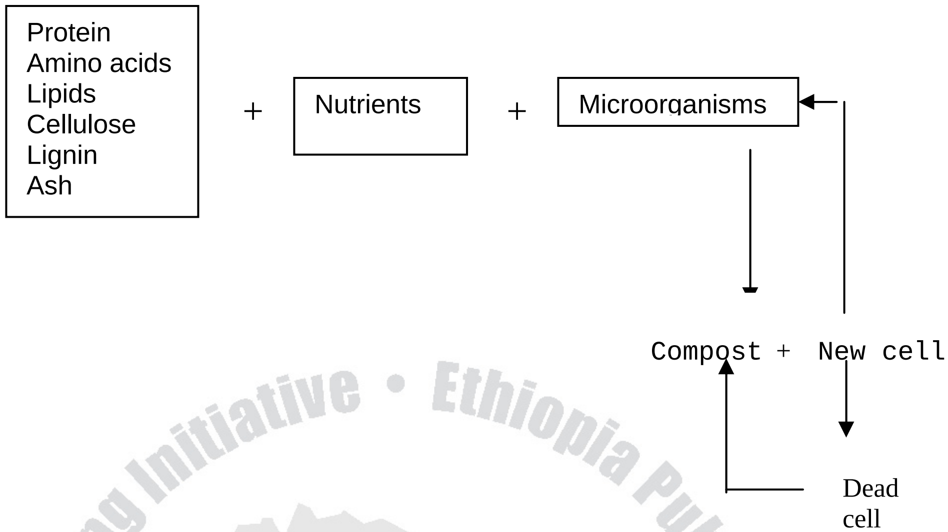

Fig.5.3. Composting process (Ehlers and Steel, 1965)

The other method of resource conservation is by forestation, which is actually important for soil, wildlife and plant conservation. In fact, wild life is often a reliable indicator of the state of health of an environment.

The historical record of resource management in much of Ethiopia, particularly in the area of seed/plow agriculture, has been rather dismal, characterized by exploitation, crises, and lack of a harmonious relationship between man and the environment. Formulated in 1990, the National conservation strategy tries to develop a more integrated and participatory approach to natural resources issues. Integrated, participatory planning is essential if Ethiopia's renewable and nonrenewable resources are to be utilized in a rational and sustainable manner and ecologically sound agricultural systems are to be developed to support the rapidly growing population.

In general the conservation of natural habitats and the protection of biological diversity is important for sustainable development at levels ranging from the global to the local.

Review questions:

1. Define the following terms
   - Resource
   - Exhaustible and non-exhaustible resource (give examples for each).
2. What are the current activities that are undertaking in our country regarding resource conservation?
3. What is the importance of recycling and reuse of resources other than conservation of a specific resource? Give example.
4. What are clean/environmentally friendly/ energy sources? Which one is feasible to our country, Ethiopia?
5. Discuss the impact of poor resource handling practices in Ethiopia.

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