FUNDAMENTALS OF ECOLOGY

Meenakshi Jhanwar
Dr. Krishnappa Venkatesharaju

ALEXIS PRESS
JERSEY CITY, USA

FUNDAMENTALS OF ECOLOGY

FUNDAMENTALS OF ECOLOGY

Meenakshi Jhanwar
Dr. Krishnappa Venkatesharaju

ALEXIS PRESS

ALEXIS PRESS

Published by: Alexis Press, LLC, Jersey City, USA
www.alexispress.us

First Published 2022

A catalogue record for this publication is available from the British Library

Library of Congress Cataloguing in Publication Data

Includes bibliographical references and index.

Fundamentals of Ecology by *Meenakshi Jhanwar, Dr. Krishnappa Venkatesharaju*

ISBN 978-1-64532-948-0

CONTENTS

CHAPTER 1

THE FEATURES OF ECOLOGY: A COMPREHENSIVE REVIEW

Ms. Meenakshi Jhanwar
Assistant Professor, Department of Environmental Science,
Presidency University, Bangalore, India.
Email Id: meenakshi@presidencyuniversity.in

ABSTRACT:

Biology's field of ecology focuses on the investigation of interactions between living things and their surroundings. It includes both the physical environment of living things and the complex interactions and interdependencies among them. An overview of ecology is given in this chapter, emphasizing its significance for comprehending the natural world and resolving urgent environmental issues. Ecology is a branch of science that studies how organisms interact with their surroundings. It includes the investigation of living things, their interactions with one another, and their natural environments. The goal of ecological research is to comprehend the dynamics, structure, and function of ecosystems as well as the mechanisms that control the quantity and distribution of organisms. Ecology explores multiple levels of biological organization, including populations, communities, and ecosystems in addition to individual species. Behavioral ecology, population ecology, community ecology, and ecosystem ecology are only a few of the many sub-disciplines that it comprises. To understand the intricacies of ecological systems, ecologists employ a variety of instruments and approaches, such as field observations, experimentation, modeling, and data analysis.

KEYWORDS:

Ecology, Environmental Issues, Local Adaption, Low Elevations, Sickle Cell.

INTRODUCTION

Ernest Haeckel coined the term "ecology" in 1869. According to Haeckel, ecology is the scientific study of how organisms interact with their surroundings. The word comes from the Greek word oikos, which means "home." Therefore, ecology may be described as the study of the "home life" of living things. Krebs (1972) offered a less ambiguous definition of ecology, saying that it is "the scientific study of the interactions that determine the distribution and abundance of organisms." It is important to define the word "environment" in order to understand why Krebs' definition omits it. All external elements and occurrences, whether they are physical and chemical (abiotic) or other creatures (biotic), that have an impact on an organism are collectively referred to as the organism's environment. Naturally, interactions with these same components are what Krebs refers to as "interactions" in his definition. As a result, the environment continues to have the central place that Haeckel assigned to it. Krebs' definition offers the advantage of focusing on the core concept of ecology: the distribution and abundance of species, including where they are found, how many are there, and why. Given this, it could still be preferable to describe ecology as the scientific study of the distribution and abundance of species as well as the interactions that affect these factors. The phrase "the distribution and abundance of organisms" is wonderfully brief when referring to the topic of ecology [1]–[3].

The biological hierarchy of the living world can be thought of as ascending from subcellular particles to cells, tissues, and organs. The individual organism, the population (which consists of individuals of the same species), and the community (which consists of a higher or fewer number of species populations) are the next three levels that ecology works with. Ecology examines how people interact with their environment at the organismal level, including how they influence it and how it influences them. Ecology is concerned with the presence or absence of specific species, their abundance or rarity, and the trends and variations in their numbers at the population level. Then, community ecology focuses on the structure and makeup of ecological communities. Ecologists also study the paths that matter and energy take as they flow between living and nonliving components of the ecosystem, which is made up of a community and its physical environment. In light of this, Likens (1992) would broaden our definition of ecology to encompass "the interactions between organisms and the transformation and flux of energy and matter." However, we consider energy/matter conversions to fall under the description of "interactions" in our definition.

At each level of ecological organization, ecologists can choose one of two major strategies. First, there is much to be gained from using properties at a lower level. For example, physiology can be used to study organismal ecology, individual clutch size and survival rates can be used to study the dynamics of individual species populations, food consumption rates can be used to study interactions between predator and prey populations, and limits to the similarity of coexisting species can be used to study communities. Another strategy deals directly with the characteristics of the relevant level of interest, such as niche breadth at the organismal level, relative importance of density-dependent processes at the population level, species diversity at the level of communities, and rate of biomass production at the level of ecosystems, and attempts to connect these to biotic or abiotic aspects of the environment. In each of the three sections of this book, Organisms, Species Interactions, and Communities and Ecosystems—both techniques will be employed. Each has their advantages and disadvantages.

Description, prediction, and control: We can attempt a variety of various things at all levels of ecological organization. First, we can make an effort to explain or understand. This is a pursuit of knowledge in the strictest sense of the word. However, it is first required to describe in order to do this. This also broadens our understanding of the living world. It goes without saying that in order to understand something, we must first have a description of it. The most useful descriptions are also those that are written with a specific issue or "need for understanding" in mind, albeit this is less visible. All descriptions are selective, but an unfocused description that is done for no other reason is frequently found to have chosen the wrong items after the fact.

Ecologists frequently make predictions about what will happen to a population, an ecosystem, a community, or an organism under a specific set of conditions, and we use these forecasts to try to influence the situation. By anticipating when locust plagues are likely to occur and taking the necessary precautions, we aim to reduce their negative impacts. By anticipating when conditions will be favorable to the crop and unfavorable to its adversaries, we attempt to protect crops. We work to protect threatened species by forecasting the conservation measures that will ensure their survival. To sustain ecosystem "services" like the preservation of the chemical integrity of natural waters, we work to safeguard biodiversity. Certain types of prediction and control can be executed without justification or comprehension. But only when we can understand what is happening can we make certain predictions, exact predictions, and predictions of what will happen in unique circumstances. In particular, mathematical modelling has been and will continue to be essential to our capacity for outcome prediction as ecology advances. But since we are interested in the real world, the value of models must always be assessed in terms of the insight they provide into how natural systems function.

It's crucial to understand that proximal and ultimate explanations fall into two distinct categories in biology. In terms of the physical environment that a specific species of bird can endure, the food that it eats, and the parasites and predators that attack it, for instance, the current distribution and abundance of that species of bird may be "explained." This serves as a nearby explanation. We can also wonder how this particular type of bird acquired the characteristics that now seem to guide its existence. A rational evolutionary explanation is required to address this query. The ecological experiences of this bird's ancestors are ultimately responsible for its current distribution and abundance. The question of "How have organisms come to possess particular combinations of size, developmental rate, reproductive output, and so on?" is one of many in ecology that calls for evolutionary, ultimate explanations. What influences predators' choice of specific foraging behavior patterns? How does it happen that coexisting species are frequently similar but infrequently the same? These issues are as much a part of contemporary ecology as the eradication of diseases, the safeguarding of crops, and the conservation of endangered species. Understanding and being able to explain things would undoubtedly help us be better at managing and utilizing ecosystems. We must mix both proximal and ultimate explanations in our quest for understanding [4]–[6].

DISCUSSION

Pure and applied ecology: In addition to communities, populations, and organisms found in nature, ecologists are also interested in man-made or human-influenced environments (such as plantation forests, wheat fields, grain bins, nature reserves, and so forth), as well as the effects of these influences on nature (such as pollution, overharvesting, and global climate change). We would struggle to locate an environment that is completely unaffected by human activities since our influence is so pervasive. Ecologists undoubtedly play a key role in addressing environmental issues, which are currently high on the political agenda. A sustainable future is largely dependent on ecological knowledge and our capacity to foresee or create results under many situations. The majority of ecologists would have classified themselves as pure scientists when the first edition of this work was released in 1986. They would have defended their right to research ecology for its own sake and not wanted to be diverted into projects that were only narrowly applied. In the past 20 years, the situation has drastically changed, in part due to governments shifting the focus of grant-awarding bodies towards ecological applications, but more importantly because ecologists themselves have responded to the need to focus much of their research on the numerous environmental issues that have grown more urgent over time. This is reflected in the new edition's methodical consideration of ecological applications, which includes an applied chapter at the end of each of the book's three sections. We firmly think that a profound understanding of pure science must serve as the foundation for the application of ecological theory. Our chapters on ecological application are structured on the earlier chapters of each section's prior chapters on ecological understanding.

Organism with its environment: It is obvious that the link between species and their habitats lies at the core of ecology from our definition of ecology in the Preface and even from a layperson's understanding of the term. This first chapter explains how this relationship is primarily one of evolution. Theodosius Dobzhansky, a notable Russian-American biologist, is credited with saying: "Nothing in biology makes sense, except in the light of evolution." This holds true for all aspects of biology, including ecology. As a result, we attempt to both explain how various species' characteristics enable them to survive in particular settings as well as why they are unable to do so in other situations. Many of the issues that are covered in detail in following chapters will be introduced as we lay out this evolutionary context for the topic.

The phrase "organism X is adapted to" followed by a description of the environment the organism is located in is the one that is used most frequently in daily speech to express the compatibility between organisms and environment. Thus, we frequently hear statements like "fish are adapted to live in water" and "cacti are adapted to live in drought conditions".Simply put, this may mean that cactus have traits that enable them to survive in arid climates or that fish have traits that enable them to exist in water (perhaps excluding them from other settings). The word 'adapted' in this context doesn't specify how the traits were attained.

However, "X is adapted to live in Y" for an ecologist or evolutionary biologist indicates that environment Y has given forces of natural selection that have impacted the lives of X's ancestors and as a result have shaped and specialized the evolution of X. The term "adaptation" denotes a genetic modification. Unfortunately, the phrase "adaptation" connotes that creatures are matched to their current circumstances, which can be interpreted as "design" or even "prediction." However, organisms have been shaped (by natural selection) by previous environments rather than being made for or adapted to the present. Their traits are a reflection of their predecessors' accomplishments and failures. Only because current environments frequently resemble earlier ones do they seem appropriate for the ones they currently inhabit.

An ecological theory is the hypothesis of evolution by natural selection. It was first developed by Charles Darwin (1859), however Alfred Russell Wallace, Darwin's contemporary and correspondent, also understood the essence of it. It is supported by a number of hypotheses.

1. The individuals that make up a population of a species are not all exactly the same; they differ in terms of size, rate of development, reaction to temperature, and other factors, though sometimes only slightly.
2. At least some of this variation is inherited. In other words, a person's traits are influenced by their genetic makeup to some level. People tend to share the traits of their ancestors since they inherit their DNA from them.
3. All populations have the capacity to occupy the entire planet, and they would if every person lived and produced their maximum number of offspring. But they don't since a lot of people pass away before having children, and the majority of people only reproduce at a little below-average pace.
4. Numerous descendants are left behind by various ancestors. This includes the likelihood of offspring living to reproductive age, the survival and procreation of these offspring, the survival and procreation of these offspring's progeny, the survival and procreation of these offspring's offspring in turn, and so on.
5. Last but not least, the interaction between a person's traits and its surroundings plays a key role in determining how many descendants that individual leaves.

In any ecosystem, some people will often outlive, reproduce, and leave behind more offspring than others. It is considered that evolution by natural selection has taken place if as a result, the heritable traits of a population change from generation to generation. In a loose sense, nature can be regarded of as selecting in this manner. But unlike plant and animal breeders, nature does not use selection. Breeders want to produce larger seeds or a racehorse that runs faster. Nature, however, does not actively select in this manner; rather, it only creates the context for the evolutionary game of differential survival and reproduction to take place. The population members who produce the most offspring are the fittest members of the population. In reality, the phrase is frequently used to refer to a type or an average person rather than a specific person. For instance, we may claim that yellow-shelled snails are more physically fit than brown-shelled snails in sand dunes. Thus, fitness is a relative phrase rather than an absolute one. A population's most fit members are those who produce the most offspring in comparison to the offspring produced by other members of the population. There is a temptation to view each situation as an illustration of evolutionary perfection when we are astounded by the variety of intricate specializations. But that would be incorrect. Utilizing the existing genetic diversity, evolution takes place [7]–[9].

It follows that the emergence of ideal, "maximally fit" people is unlikely to occur through natural selection. As opposed to being "the best imaginable," organisms instead adapt to their conditions by being "the fittest available" or "the fittest yet." some of the Lack of fit occurs because an organism's current traits did not all develop in a common environment courtesy to the one it currently resides in. An organism's distant ancestors may have developed a set of traits during the course of their evolutionary history (phylogeny), known as evolutionary "baggage," that subsequently limit subsequent evolution. The evolution of vertebrates has, for many millions of years, been constrained to what is possible for creatures with a vertebral column. Koala bears can survive on Eucalyptus foliage, but from another angle, koala bears cannot survive without Eucalyptus foliage. This and other precise fits between a creature and its environment may be considered as limitations.

Specialization within species: We can distinguish between one type of organism and another in the natural world, which does not consist of a continuous gradient of different creature types. However, there is frequently significant variation within what we classify as species (described below), some of which is heritable. After all, natural selection and plant and animal breeders both depend on this intraspecific variation. We may anticipate natural selection to have favoured various species variants at various sites as the surroundings that a species encounters in different portions of its range are itself varied (at least to some extent). The term "ecotype" was initially used to characterise genetic variations between populations of plants within a species that reflect local adaptations between the organisms and their environments (Turesson, 1922a, 1922b). However, evolution only forces populations' traits to diverge from one another if (i) there is enough heritable variation for selection to act on, and (ii) the forces favouring divergence are powerful enough to overcome the mixing and hybridization of individuals from different sites. If individuals (or, in the case of plants, pollen) from two populations are continuously moving between them and mingling their genes, the populations will not totally diverge.

Among creatures that are sedentary for the majority of their life, local, specialised populations become most pronouncedly differentiated. Motile organisms have a great deal of control over the environment in which they exist; they can actively seek out another environment by recoiling or retreating from a harmful or unfavourable one. Organisms that are sessile and immobile lack this independence. They must adapt to the surroundings where they settle or perish. Sessile organism populations are thus unusually intensely exposed to the forces of natural selection. On the seaside, where the intertidal habitat alternately shifts between the terrestrial and the aquatic, this difference is underlined. All of the fixed algae, sponges, mussels, and barnacles interact with each other and can survive in either extreme. But the mobile while shore-feeding birds track their terrestrial habitat, prawns, crabs, and fish track their aquatic habitat as it moves. The adaptability of these species permits them to adapt to their circumstances. The stationary organism needs to adapt to its surroundings.

Geographic variation within species (ecotypes): Arabis fecunda, also known as sapphire rockcress, is a rare perennial herb that is only found on calcareous soil outcrops in western Montana (USA). There are only 19 known populations, which are divided into two groups ('high elevation' and 'low elevation') by a distance of around 100 kilometres. The existence of local adaptation is crucial for conservation since four of the low elevation populations are threatened by urban sprawl and may need to be reintroduced from elsewhere if they are to survive. If local adaptation is too pronounced, reintroduction may not succeed. We could not determine whether there was local adaptation in the sense of evolution by seeing plants in their native habitats and comparing them to one another. Differences could simply be the outcome of plants that are fundamentally the same responding differently in an instant to different conditions. In order to eliminate the influence of the differing local habitats, high and low elevation plants were grown together in a "common garden" (McKay et al., 2001). Due to the warmer and drier air and soil conditions, the low elevation locations were more vulnerable to drought. In fact, the common garden's low elevation plants were noticeably more drought tolerant.

On the other hand, hybridization is not always trumped by local selection. For instance, plants from the 'home' site or transplants from distances of 0.1, 1, 10, 100, 1000, and 2000 km were grown in a common garden for a study on Chamaecrista fasciculata, an annual legume from disturbed habitats in eastern North America. Three times in Kansas, Maryland, and northern Illinois the study was reproduced. Germination, survival, vegetative biomass, fruit output, and the number of fruits produced per seed planted were the five variables that were measured. However, except at the largest spatial scales, there was little to no evidence of local adaptation for all features in all replicates. 'Local adaptation' does exist, but it is obviously not local. By contrasting an organism's performance while it is grown "at home," that is, in its native habitat, with its performance when it is grown "away," that is, in the habitat of another, we can evaluate if an organism has evolved to become specialised for life in its local environment through reciprocal transplant studies. The subsequent section provides details of one such experiment that involved white clover.

Genetic polymorphism: It might be able to identify levels of variation within populations on a finer scale than ecotypes. Polymorphism is the name for this kind of variety. Genetic polymorphism, according to Ford (1940), is "the coexistence in the same habitat of two or more discontinuous forms of a species in such proportions that the rarest of them cannot merely be maintained by recurrent mutation or immigration. Not all of this variety reflects a compatibility between the environment and the organism. In fact, part of it might indicate a mismatch if, for instance, environmental conditions change and one form is being replaced by another. We refer to these polymorphisms as transitory.

Many of the polymorphisms we detect in nature may be temporary because all communities are always evolving, illustrating how the genetic response of populations to environmental change will always lag behind. This is demonstrated in the case of the peppered moth in the following paragraph. But many polymorphisms are actively preserved in a population by natural selection, and this can happen in a variety of ways.

1. Although heterozygotes may be more fit than homozygotes, due to the workings of Mendelian genetics, they constantly produce less fit homozygotes within the population. In cases of human sickle-cell anaemia where malaria is common, this 'heterosis' is present.

Red blood cells are attacked by the malaria parasite. Red blood cells with the sickle-cell mutation are biologically flawed and irregularly shaped. However, sickle-cell heterozygotes are the healthiest since they have the least anaemia and malaria risk. However, they frequently produce homozygotes that are either dangerously anaemic (having two sickle-cell genes) or malaria-prone (having no sickle-cell genes). Nevertheless, the heterozygote's greater fitness keeps both gene types (i.e., a polymorphism) present in the population.

2. There could be gradients of selection pressures that favour one form (morph) at one end and another form at the other. In the study of the peppered moth, this can also result in polymorphic populations at intermediate places along the gradient.

3. According to Clarke and Partridge (1988), there may be frequency-dependent selection, where each of a species' morphs is most suitable when it is most uncommon. This is thought to be the case when prey species have unusual colour variations because their predators fail to recognise them and, as a result, disregard them.

4. Within various patches of the population, selective forces may act in various directions. A study on white clover (Trifolium repens) reciprocal transplants in a field in North Wales (UK) offers a startling illustration of this. Turkington and Harper (1979) took plants from designated locations in the field and multiplied them into clones in the shared habitat of a greenhouse to see if the traits of individuals matched local elements of their environment. The samples from each clone were then transplanted into the location in the vegetation sward where they had initially been taken (as a control), as well as to the locations from which all the others had been taken (a transplant). A year of growth was given to the plants before they were taken out, dried, and weighed. The mean weight of clover plants sent back to their original locations was 0.89 g, compared to only 0.52 g at distant locations, a statistically highly significant difference. This offers solid, clear proof that the pasture's clover clones had evolved to become specialised so they could flourish in their particular habitat. But all of this was occurring inside a single, polymorphic population.

In reality, it's not always easy to tell local ecotypes from polymorphic populations. Agrostis stolonifera, a common plant, was found in several of the habitats in a different study conducted in North Wales, where there was a gradient in habitats at the edge between seaside cliffs and grazed pasture. Additionally, it displays the outcomes of growing plants from the sampling spots along this transect in a public garden. To compare the growth of different plants, the lengths of the stolons that the plants used to spread themselves along the ground were measured. Cliff plants only produced short stolons in the field, but pasture plants produced long stolons. Even though the sampling locations in the experimental garden were often only 30 m apart, well within the range of pollen dissemination between plants, these disparities persisted there. In fact, the stolon length changed gradually along the transect, matching the environment's slow changes. Since this change was also present in the communal garden, it is likely genetic in origin. The question of whether to refer to this as a small-scale sequence of local ecotypes or a polymorphic population maintained by a gradient of selection is moot because the forces of selection appear to overcome the mixing forces of hybridization despite the tiny spatial scale.

Variation within a species with manmade selection pressures: Perhaps it is not unexpected that man-made ecological processes, particularly those caused by environmental contamination, have been the driving force behind some of the most striking examples of local specialisation within species (indeed, of natural selection in action). These have the ability to change quickly when subject to strong selection pressures. For instance, industrial melanism is the situation where populations of organisms with black or blackish shapes have taken over in industrial regions. A dominant gene is normally in charge of producing an excess of the black pigment melanin in people with dark skin. The majority of industrialised nations are aware of industrial melanism, and more than 100 species of moth have developed variants of it. The peppered moth (Biston betularia) was the first species to be known to undergo this type of evolution; in an otherwise pale population, a single black individual was discovered in Manchester, United Kingdom, in 1848. Nearly all of the Manchester peppered moth population by 1895 was dark. After many more years of pollution, a thorough examination of the pale and melanic variants of the peppered moth in Britain between 1952 and 1970 yielded more than 20,000 specimens. Britain's typical westerly winds carry industrial pollutants (particularly smoke and sulphur dioxide) in the direction of the east. The majority of melanic forms were found in the eastern regions, completely lacking in the unpolluted western regions of England and Wales, northern Scotland, and Ireland. However, the picture shows that many populations were polymorphic, coexisting with both melanic and nonmelanic forms.

As a result, it appears that polymorphism results from a gradient of selected pressures moving from the less polluted west to the more polluted east, as well as from environments changing (getting more polluted) to the extent that polymorphism is transient. Birds that feed on moths appear to exert the majority of the selective pressure. In field tests, both melanic and pale (or "typical") moths were raised in huge numbers and released simultaneously. The majority of those collected by birds in a rural, highly unpolluted region of southern England were melanic. Most people in an industrial district close to Birmingham were stereotypes (Kettlewell, 1955). However, the assumption that melanic forms were preferred simply because they blended in better with smoke-stained backdrops in polluted locations (while typicals were preferred in unpolluted areas because they blended in better with pale backgrounds) may just be part of the picture. The moths spend the day resting on tree trunks, and nonmelanic moths blend in nicely with their moss and lichen-covered surroundings. Industrial pollution has darkened the moths' surroundings, but sulphur dioxide in particular has also largely eliminated the moss and lichen covering the tree trunks. As a result, smoke and sulphur dioxide pollution may have played a similar role in the selection of melanic moths.

As oil and electricity began to replace coal in the 1960s and legislation was established to impose smokefree zones and decrease industrial emissions of sulphur dioxide, industrialised surroundings in Western Europe and the United States began to shift once more. The frequency of melanocytic forms then abruptly decreased to levels similar to those before the Industrial Revolution. Transient polymorphism occurred once more, but this time populations were moving in the opposite way.

Speciation: Therefore, it is evident that populations of plants and animals can be forced by natural selection to change, or evolve. However, the development of a new species has not occurred in any of the examples we have looked at. What therefore explains the designation of two populations as distinct species? And how do two or more new species emerge from a single original species? This process is known as speciation. Cynics have asserted, perhaps accurately, that a species is what a skilled taxonomist considers to be a species. In contrast, two American biologists named Mayr and Dobzhansky established an empirical test in the 1930s that could be used to determine whether two populations belonged to the same species or to two separate species. They classified organisms as belonging to the same species if they had the potential to mate in nature and result in viable offspring. A species that was tested and defined in this manner was referred to as a biological species or biospecies. We know that melanic and regular peppered moths can mate and that the progeny are totally viable from the examples we studied previously in this chapter. This is also true of plants from the various varieties of Agrostis. They are all distinct species within one species, not different species.

However, in reality, biologists don't use the Mayr-Dobzhansky test before classifying every species because there isn't enough time or money, and in any case, a strict interbreeding criterion is inappropriate for a significant portion of the living world - most microorganisms, for example - where sexual reproduction isn't present. More importantly, the test acknowledges a key aspect of the evolutionary process that we have already encountered while thinking about species specialisation. Natural selection cannot truly separate two populations if their individuals are able to hybridise, combining and redistributing their genes in the offspring. Sexual reproduction and hybridization combine a population once it has evolved into two or more separate forms, despite the fact that natural selection may have a tendency to do so.

According to Schluter (2001), "ecological" speciation is speciation caused by divergent natural selection in various subpopulations.

The most common scenario for this includes several steps (Figure 1.7). First, natural selection drives genetic adaptation to their respective surroundings when two subpopulations become geographically isolated. Next, a degree of reproductive isolation develops between the two as a result of this genetic divergence. This could be "pre-zygotic," which tends to discourage mating altogether (for example, different wooing rituals), or "post-zygotic," which affects the viability or even inviability of the children themselves. The two subpopulations later re-engage each other during a time of "secondary contact". Due of their literal lack of differentiation, the hybrids formed by people from the various subpopulations currently have low fitness. Therefore, any trait in either subpopulation that strengthens reproductive isolation, especially pre-zygotic traits, will be favoured by natural selection, avoiding the generation of low-fitness hybrid offspring. The separation between what are now distinct species is then cemented by these breeding barriers.

To assume that every instance of speciation, however, complies with this conventional view would be incorrect (Schluter, 2001). First off, there might never be a second meeting. This would be a case of pure "allopatric" speciation, in which all divergence took occurred in distinct subpopulations. Second, both in the allopatric and the secondary-contact periods, there is unquestionably potential for substantial variation in the relative weights of pre- and post-zygotic mechanisms. Perhaps most importantly, there has been growing evidence to support the idea that an allopatric phase is not required; rather, "sympatric" speciation—in which subpopulations diverge despite not being physically isolated from one another—is feasible.

Where insects feed on multiple host plant species and each necessitates specialisation by the insects in order to defeat the plant's defences, this seems to be most likely to happen (see Drès & Mallet, 2002). Drès and Mallet's discovery of a continuum between populations of insects that feed on multiple host plants, populations that have differentiated into "host races" (defined as sympatric subpopulations exchanging genes at a rate greater than or equal to 1% per generation), and coexisting, closely related species is particularly persuasive in this regard. This serves as a reminder that a species' origin, whether sympatric or allopatric, is a process rather than an event. There is some room for disagreement regarding the point at which the creation of a new species, like the boiling of an egg, is complete.

The remarkable instance of two species of sea gulls serves as an illustration of how species evolve and how natural selection and hybridization coexist in harmony. A chain or cline of several variants of the smaller black-backed gull (Larus fuscus), which started in Siberia and gradually colonised the west, extended from Siberia to Britain and Iceland. Although the neighbouring forms along the cline are unique, in nature they often hybridise. Therefore, taxonomists only classify nearby populations as "subspecific" and consider them to be a component of the same species (e.g., L. fuscus graellsii, L. fuscus fuscus). However, gull populations have also expanded eastward from Siberia, once more producing a cline of freely hybridising species. The populations that are migrating east and west completely encircle the northern hemisphere. Northern Europe is where they collide and overlap. There, the smaller black-backed gull (L. fuscus) and the herring gull (L. argentatus) are recognised as two distinct species because the eastward and westward clines there have diverged so far that it is simple to tell them apart. Additionally, because the two species have separated into real bio species, they do not hybridise. Therefore, we can see in this exceptional example how two different species have evolved from a single primary population and how the stages of their divergence are preserved in the cline that connects them [10]–[12].

CONCLUSION

Finally, ecology is crucial to our comprehension of the intricate network of life on Earth. Ecologists can understand the mechanisms that control ecosystems and foretell how they will react to environmental changes by studying the interactions between organisms and their surroundings. Addressing urgent environmental issues like climate change, habitat devastation, and biodiversity loss requires this understanding. By using ecological principles, we may work towards conservation and sustainable practises that will protect our planet's rich biodiversity and provide a safe and stable environment for coming generations.

REFERENCES

[1] Abdissa Ayana Biftu, "Introduction to cultural ecology," *Choice Rev. Online*, 2005, doi: 10.5860/choice.42-2898.

[2] D. E. Davis and G. E. Hutchinson, "An Introduction to Population Ecology," *J. Wildl. Manage.*, 1980, doi: 10.2307/3808396.

[3] N. M. Singh, "Introduction: Affective Ecologies and Conservation," *Conservation and Society*. 2018. doi: 10.4103/cs.cs_18_33.

[4] M. B. Jones, "An Introduction to Marine Ecology," *J. Exp. Mar. Bio. Ecol.*, 2000, doi: 10.1016/s0022-0981(99)00146-x.

[5] N. J. Royle, "An Introduction to Behavioural Ecology," *Anim. Behav.*, 2013, doi: 10.1016/j.anbehav.2013.01.003.

[6] T. E. Essington, *Introduction to Quantitative Ecology*. 2021. doi: 10.1093/oso/9780192843470.001.0001.

[7] K. A. With, "An Introduction to Landscape Ecology," in *Essentials of Landscape Ecology*, 2019. doi: 10.1093/oso/9780198838388.003.0001.

[8] J. C. Emberlin, "Introduction to ecology.," *Introd. to Ecol.*, 1983, doi: 10.2307/3545.

[9] A. Jelaso, "An Introduction to Molecular Ecology," *Bioscience*, 2005, doi: 10.1641/0006-3568(2005)055[0376:gfe]2.0.co;2.

[10] L. L. Eberhardt and E. C. Pielou, "An Introduction to Mathematical Ecology," *J. Wildl. Manage.*, 1971, doi: 10.2307/3799632.

[11] M. J. Lemke, J. W. Walk, A. M. Lemke, R. E. Sparks, and K. D. Blodgett, "Introduction: The ecology of a river floodplain and the Emiquon preserve," *Hydrobiologia*. 2017. doi: 10.1007/s10750-017-3335-8.

[12] S. C. CAIRNS, "Introduction to Population Ecology," *Austral Ecol.*, 2006, doi: 10.1111/j.1442-9993.2006.01674.x.

CHAPTER 2

SCIENCE OF THE ENVIRONMENT AND SUSTAINABILITY

Dr. Krishnappa Venkatesharaju
Assistant Professor, Department of Environmental Science and Engineering,
Presidency University, Bangalore, India.
Email Id: venkateshraju.k@presidencyuniversity.in

ABSTRACT:

A broad area of research called "environment and sustainability science" looks at the intricate connection between human cultures and the natural world. This chapter discussed the science of the environment and sustainability. It integrates aspects of the scientific, social, and humanities disciplines to comprehend and address the urgent environmental issues that the world is currently confronting. The objective of science is to reduce pollution and make clean the environment. Sustainability and the environment are essential components of the health and destiny of our planet. The term "environment" refers to all of the physical, chemical, and biological components of our natural surrounds, such as the land, water, air, and living things. Contrarily, sustainability refers to the wise and sensible use of resources to satisfy current needs without endangering the ability of future generations to satisfy their own. In order to solve the urgent global concerns of climate change, biodiversity loss, pollution, and resource depletion, it is essential to understand the relationship between the environment and sustainability. Sustainability demands a multifaceted strategy that takes into account social, economic, and environmental factors. It entails striking a balance between human advancement and preservation of the natural world.

KEYWORDS:

Environmental Science, Environment Sustainability, Fossil Fuels, Living Things, Environmental Concerns, Sustainability Science, Environmental Issues.

INTRODUCTION

The study of the natural environment, human impact on the environment, and the creation of sustainable solutions to environmental problems are the main objectives of the interdisciplinary area known as the science of the environment and sustainability. Environmental science, ecology, geology, climatology, biology, chemistry, and social sciences are among the many scientific fields it embraces. The goal of environmental science is to comprehend the intricate relationships that exist between human activity and natural systems like ecosystems, climate, and geology. It entails researching the physical, chemical, and biological processes that take place in the environment and how human behavior affects them. Contrarily, sustainability refers to the idea of satisfying current demands without compromising the capacity of future generations to satisfy their own wants. Finding methods to preserve natural balance, conserve resources, and advance societal well-being are central to the study of sustainability [1]–[3].

The Sun, Fossil Fuels, and Back to the Sun: According to an ancient Chinese saying, "If we do not change course, we are likely to arrive where we are going." The New Millennium has brought with it evidence that we have been on a path that, if changed, will have substantial, unfavorable impacts on humanity and the Earth, which is the only home for this species and all other living creatures. The attacks on the World Trade Centre on September 11, 2001, as well as subsequent attacks on the London underground system, Madrid trains, Mumbai hotels, and other locations around the world, highlighted how susceptible our civilization is to the evil deeds of those who feel compelled to commit evil deeds and sparked worries about the likelihood of even more destructive attacks using chemical, biological, or radioactive agents. The first half of 2008 saw skyrocketing prices for important commodities like grain, copper, and metals like oil.

When crude oil prices nearly hit $150 per barrel in July 2008, it was predicted that petrol costs in the US will continue to rise above $5 per gallon for the foreseeable future. With the occurrence of the biggest economic collapse the world had seen since the Great Depression of the 1930s, these tendencies were reversed in the latter part of 2008. Housing prices crashed and several commodities saw their prices fall to levels that were unaffordable for those with average salaries. Early in 2009, global leaders were battling to find answers to dire economic issues. As people and their governments battle economic hardships, mounting evidence has shown that their actions are destroying the Earth's life support system, which is essential to their survival. Global warming is almost certainly being caused by the release of greenhouse gases into the atmosphere, including carbon dioxide.

The Arctic ice cap shrank to a level never before seen in historical records in the early 2000s. In industrialized areas, pollution discharge has harmed the geosphere, hydrosphere, and atmosphere. Minerals, fossil fuels, fresh water, and biomass are among the natural resources that are under stress and being depleted. Water and soil erosion, deforestation, desertification, pollution, and conversion to non-agricultural uses have all reduced the productivity of agricultural land. Wildlife habitats, such as wetlands, estuaries, grasslands, and woods, have been lost or harmed. Half of the world's population, or 3 billion people, survive in extreme poverty on less than the equivalent of $2 per day in the United States. Most of these individuals don't have access to sanitary sewers, and the environments in which they live are conducive to the development of malaria and other severe viral, bacterial, and protozoa infections.

At the other end of the standard of the living spectrum, a relatively small portion of the global population leads a lifestyle that involves living too far from their places of employment, in energy-wasting homes that are much larger than they need, traveling long distances in large "sport utility vehicles," and overeating to the point of unhealthy obesity with accompanying issues of heart disease, diabetes, and a host of other health issues. In a way, the history of humankind and its relationship to Planet Earth is a story of "from the sun to fossil fuels and back again," since humans have been mostly reliant on the sun's resources for the entirety of their existence on Earth. The warmth needed for humanity to survive was provided by solar radiation, which was supplemented by fire from burning material produced by photosynthesis. And by clothing made from the skins of animals that had consumed biomass created through photosynthesis[4], [5].

Humans eat meat generated by animals that eat plants, as well as plants that transform solar energy into biomass chemical energy. As human societies advanced, indirect solar energy harvesting techniques were also developed. Windmills and sailboats used for transportation were propelled by the wind created by the sun heating of the atmosphere. Humans discovered how to contain water and use waterwheels to transform the energy of flowing water into mechanical energy. This water was moving as a result of the hydrological cycle propelled by solar energy. Basically, the sun was the source of everything that humanity utilized and relied upon to survive.

The short-but-spectacular age of fossil fuels: Humans learned how to use fossil fuels as an energy source as civilizations advanced. While coal had been utilized as a heat source for centuries in the few places where it could be easily accessed from the surface, the development of this energy source took off around 1800, notably with the invention of the steam engine as a useful power source. As a result, there was a significant transition from solar and biomass energy sources to fossil fuels, starting with coal and moving via petroleum and eventually natural gas. As a result, massive heavy industries, train, automobile, and aviation transportation systems, as well as tools for much-enhanced food production, were developed, causing a massive upheaval in human society. The method for converting atmospheric elemental nitrogen to ammonia (NH3) was created in Germany at the beginning of the 20th century by Carl Bosch and Fritz Haber. This high-pressure, energy-intensive process required a significant amount of fossil fuels. The vast amounts of very cheap nitrogen fertilizer that could be produced as a result of this discovery and the subsequent boost in agricultural output may have prevented widespread hunger in Europe, which at the time had a fast-growing population. As a result, starting around 1800, the "fossil sunshine" period of fossil fuels allowed humanity to experience unprecedented material wealth and grow from a little over 1 billion people to over 6 billion. However, it is now clear that the fossil fuel era will no longer be viable as the foundation of industrial society if it does not already come to an.

DISCUSSION

The study of the environment and sustainability is a multidisciplinary subject that covers a wide range of academic specialties and tackles the complicated problems associated with the environment, ecosystems, and sustainability. It entails the investigation of the natural environment, human impact on the environment, and the creation of long-term ecological balance-promoting sustainable solutions to environmental issues.

Sustainability Science: Environmentalists, including those who practice environmental chemistry, are sometimes accused of having a negative outlook. Such an opinion can most definitely be supported by a comprehensive examination of the status of the world. However, the human will and ingenuity that has been used to exploit resources around the world and create circumstances that are causing Planet Earth to deteriorate can be—and are being—harnessed to preserve the planet, its resources, and its characteristics that are favorable to healthy and productive human life. The crucial concept is sustainability, also known as sustainable development, which was defined by the Brunt Land Commission in 1987 as industrial progress that satisfies present demands without jeopardizing the capacity of future generations to satisfy their own needs.2 The preservation of the Earth's carrying capacity, or its capability to support a sustainable level of human activity and consumption, is a crucial component of sustainability [6]–[8].

Dr. Steven Chu, a physicist, and Nobel Prize winner, was interviewed in February 2009 after being named Secretary of Energy in U.S. President Barack Obama's new administration. He identified three key areas that need Nobel-level innovations to achieve sustainability: solar energy, electric batteries, and the creation of new crops that can be used as fuel. He argued that there was a need to significantly increase the efficiency of solar energy capture and conversion to power. For electric vehicles to have practical driving ranges and to store electrical energy produced by renewable resources, better electric batteries are required. It is necessary to develop crops that are more efficient than present crops at converting solar energy to chemical energy stored in biomass. Since just 1% of the solar energy falling on most plants is converted to chemical energy through photosynthesis, there is significant room for improvement in this situation. This efficiency may probably be doubled by genetic engineering, which would greatly enhance the production of biomass. Undoubtedly, achieving sustainability while utilizing cutting-edge scientific advancements will be a fascinating development in the coming decades.

Ecological Science: This book is about the chemistry of the environment. It is crucial to have some understanding of environmental science and sustainability science overall to comprehend that subject. In its broadest definition, environmental science is the study of the intricate interactions that take place between the terrestrial, atmospheric, aquatic, biological, and anthropological systems that make up Earth and the environment that may have an impact on living things. It encompasses all the academic fields that have an impact on or characterizes these interactions, including chemistry, biology, ecology, sociology, and politics. Environmental science shall be defined for this book as the study of the earth, air, water, and living environments, as well as the effects of technology thereon. Environmental science has significantly developed from studies of the processes and environments that living organisms use to complete their life cycles. Ecology is the study of environmental elements that impact organisms and how they interact with these factors and with one another. Originally known as natural history, this field subsequently changed its name to ecology.

Green Technology and Science: The focus of the environmental movement has shifted recently from being focused on pollution, its impacts, and how to combat these negative effects to a more comprehensive understanding of sustainability. The more contemporary perspective is frequently referred to as "green." Green chemistry, which is used to describe the application of chemical research that is naturally safer and more ecologically friendly, is a subject covered in greater detail later in this book. Green engineering is a branch of green chemistry that applies to engineering, particularly chemical engineering. The practice of sustainable science and technology can be referred to as "green science and technology" in the broadest sense. The application of green science and technology has assumed significant significance as humanity struggles to meet the needs of populations that are already very vast in a world with finite resources.

Environmental and chemical issues: Chemistry plays a significant part in understanding the environment and maintaining its quality since it is the science of all matter. In the past, erroneous and uneducated applications of chemical science and engineering caused serious harm to the environment. Chemical wastes were typically disposed of using the cheapest, most practical methods, which typically involved throwing them up a stack, down a drain, or onto the ground. As a result of these practices, biologists have noticed an increase in kills, a decline in bird populations, and malformed animals. Medical professionals began to identify illnesses brought on by air and water pollution, such as respiratory issues from breathing contaminated air. Additionally, regular people without specialized scientific knowledge could see obstructed visibility in polluted atmospheres and waterways choked with overgrown plants caused by nutrient runoff; eyes and noses alone were frequently sufficient to detect significant pollution issues.

However, chemistry has a crucial part to play in preserving and enhancing the environment as the science of matter. Chemists have created methods for focusing chemical science towards environmental betterment as they have grown more knowledgeable about the chemical processes that take place in the environment. Environmental chemistry, the subject of this book, has arisen as a powerful and dynamic science that has significantly advanced our understanding of the environment and the chemical and biological processes that take place there since around 1970. A field of study called toxicological chemistry has emerged that connects the chemical makeup of chemicals with their hazardous consequences. Disciplines that guide the way to actions that are more ecologically friendly are evolving.

Sustainable development, industrial ecology, and green chemistry are all efforts to help human civilizations and industrial systems coexist more peacefully with the Earth's support systems, which are ultimately what all living things eventually rely on for their survival. Later in this book, these topics all of which depend on environmental chemistry are developed in greater detail.

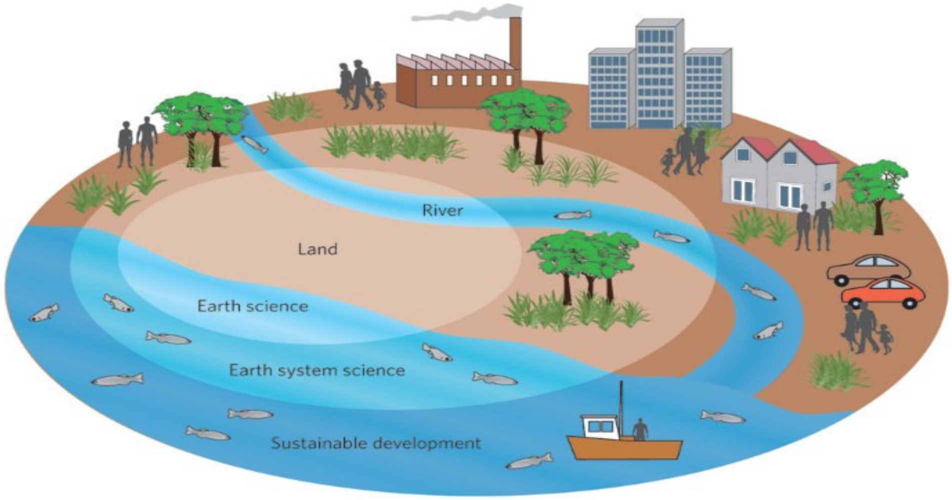

Figure 1: The Environment and Sustainability Science, [Nature]

Technology, Water, Air, Earth, Life Figure 1. This in a sense summarizes and explains the concept of the remainder of this book, and illustrates the deep connections between water, air, earth, life, and technology. The traditional division of environmental science into the studies of the hydrosphere, geosphere, atmosphere, and biosphere. However, technology has permanently changed the environment in which all humans must live, for better or ill. In light of how technology affects the environment and how it can be used wisely by those who are knowledgeable about environmental science to benefit rather than harm this Earth, upon which all living things depend for their welfare and existence, technology is strongly considered within a separate environmental sphere known as the astrosphere in this book. Cycles of matter, which include biological, chemical, and geological processes and occurrences, are the finest descriptions of the complex interactions between living things and the many realms of the abiotic (nonliving) environment. These cycles are known as biogeochemical cycles and other parts of this book. As shown in Figure 1, it is now possible to think about environmental chemistry from the perspective of the interactions between water, air, earth, life, and the anthroposphere in light of the aforementioned definitions. This section provides a summary of these five environmental "spheres" and how they interact. The chapters that go into more detail on each of these subjects are also indicated below.

Hydrosphere and Water: Water, which is essential to all aspects of the environment and is found in the hydrosphere, is present on Earth. All biological systems depend on water, which is also the medium from which life arose and in which life exists, and environmental chemistry. Exists. 70% of the Earth's surface is covered by water. Oceans hold more than 97% of the world's water. The Atmosphere and Air: By absorbing energy and harmful UV radiation from the sun and regulating the Earth's temperature to within a range favorable to life, the atmosphere acts as a thin protective blanket that sustains life on Earth and shields it from the hostile environment of outer space. It is the source of both oxygen for respiration and carbon dioxide for plant photosynthesis. It provides the elemental nitrogen needed by microorganisms that fix nitrogen and by industrial plants that make ammonia.

The Geosphere, Earth: The solid earth, which includes soil, makes up the geosphere, which is covered in general discussion. The crust, mantle, liquid outer core, and solid, iron-rich inner core make up the geosphere. The most significant component of the geosphere in terms of interactions with the other spheres of the environment is the crust, a thin outer skin that is just 5–40 km thick and mostly made up of lighter silicate-based materials. It is the region of the planet where people reside and obtain the majority of their food, minerals, and fuels. Geology, which is the science of the geosphere, is crucial when thinking about the environment. It mostly applies to the areas of the Earth's crust made of solid minerals.

The Biosphere, Life: The biosphere is made up of all living things on Earth. Biogenic refers to living things and the aspects of the environment that directly affect them, whereas abiotic refers to everything else in the environment. The study of life is known as biology. It is based on chemical species that have been produced by biology, many of which are big molecules known as macromolecules. The interaction of the environment with life is the primary concern of humans with their environment as living things. As a result, environmental science and environmental chemistry both depend heavily on biological research.

The Environment and Technology: Technology describes the methods through which people work with materials and energy to create and maintain the anthroposphere. Engineering built on science, which describes how energy, matter, time, and space interact naturally, produces technology. Engineering uses science to give the strategies and tools necessary to carry out particular practical goals. These plans are used by technology to accomplish desired goals. Because of the significant environmental impact that technology, engineering, and industrial operations have, they must be taken into account when studying environmental science. To ensure their wellness and survival, humans will use technology to provide the food, shelter, commodities, and transportation they require. The issue is to reconcile technological advancements with ecological and environmental concerns so that they complement rather than compete with one another.

Ecology: Ecology is the branch of science that examines how living things interact with one another and with their physical surroundings. An ecosystem is made up of a group of creatures that interact with one another (a community) and the environment in which they live. Materials are exchanged in an ecosystem generally in a cyclical fashion. Along with energy sources and pathways for the exchange of materials and energy, an ecosystem also consists of physical, chemical, and biological components. The habitat of a particular creature refers to its living conditions. An organism's niche is what it does in its habitat. A biome is a large group of organisms that have adapted to their environment and are the primary producers of biomass within the community.

Pollution caused by humans: Worldwide pollution is developing dramatically as a result of the needs of a growing population and the desire of the majority of people for a greater material quality of living. Each of the five main environmental domains is susceptible to pollution, and they are all interconnected in terms of the phenomenon. For instance, certain gases released into the atmosphere may undergo chemical changes that result in the formation of powerful acids, which then fall to Earth as acid rain and taint water. Hazardous wastes that are not disposed of properly can leak into the groundwater and then release contaminated water into streams.

A Few Pollution-Related Definitions: Pollution can be a definite reality in some situations while being entirely subjective in others. Often, the context of an event determines what qualifies as a pollutant. Chemically speaking, the phosphate that the operator of a sewage treatment plant must remove from wastewater is identical to the phosphate that a farmer a few miles away must purchase for fertilizer at expensive prices. Since most pollutants are actually resources that have been wasted, economic forces can function as a catalyst for finding solutions when resources become more expensive and scarcer. The reuse of materials in pollution is a crucial component of sustainability. A material existing in larger than natural concentration as a result of human activity that has a net negative impact on its environment or upon something of value in that environment is an acceptable definition of a pollutant. Contaminants cause variations from the typical makeup of an environment but are not classified as pollutants until they have some negative impact.

Fate and Transport of Chemicals: An important factor in determining the effects of environmental toxins is how they migrate and end up. The field of chemical destiny and transport or environmental fate and transport deals with this issue. The main chemical fate and transport pathways are shown in Figure 2. Polluting substances usually always come from the atmosphere, though they can sometimes come from other places, such as sulfur-containing volcanic gases. They could travel through the air, land, water (surface or groundwater), sediments, and biota (plants and animals).

Performance Transport: Depending on the medium in which the pollutants are present, there are many different physical transport methods; nonetheless, they can be grouped into two groups. The first of these is advection, which occurs when large quantities of fluids simply transport contaminants. Convection is the term for vertical air or water advection. Diffusive transport, also known as Fickian transport or molecular diffusion, is the second form of movement of chemical species. It is the natural propensity of molecules to migrate randomly from areas of higher concentration to areas of lower concentration. Turbulent mixing also provides a good estimate of diffuse transport. A flowing stream's eddies show evidence of turbulent mixing, and the same thing happens in the air. Diffusive transport is also used to describe the mixing that takes place when water flows underground, passing through and among microscopic particles.

Ecological Forensics: The science that examines the judicial and medical ramifications of environmental pollution is known as environmental forensics. It is a crucial subject because of the negative health impacts of pollutants and the frequently significant financial stakes in legal actions meant to identify those accountable for environmental contamination, such as hazardous waste sites. Furthermore, those responsible for terrorist attacks that employed chemical agents can be identified through environmental forensics. In order to identify those accountable for pollution and adverse environmental occurrences, this field investigates the origins, movement, and impacts of pollutants. The origin, timing, or severity of an environmental incident are significant factors. In situations where hazardous chemical wastes are inappropriately disposed of, soil and groundwater are typically analyzed to learn more about the history of the site through modeling, groundwater flow investigations, and chemical and physical analyses.

Advantages of Science of the Environment and Sustainability

There are several benefits to using the Science of the Environment and Sustainability to address and resolve urgent environmental issues. Among the principal benefits are:

1. Holistic Approach: This field integrates natural sciences, social sciences, and humanities to comprehend environmental concerns holistically. It acknowledges the complexity and interconnectedness of environmental issues, which calls for interdisciplinary solutions that take ecological, social, economic, and cultural factors into account.
2. Environmental and sustainability systems thinking, which recognizes that environmental events are a component of bigger systems with numerous interdependencies and feedback loops, is embraced by science. This method makes it possible to comprehend environmental concerns completely, including their sources, effects, and potential remedies.

3. Collaboration across other disciplines' researchers, decision-makers, communities, and stakeholders is encouraged in this area. This cooperation makes it easier to share knowledge, skills, and viewpoints, which produces more substantial and efficient solutions.
4. Environmental and sustainability evidence-based decision-making Science places a strong emphasis on using data and evidence from the field to guide decisions. Policymakers and stakeholders can make better decisions that are supported by empirical evidence by relying on thorough research, analysis, and modeling.
5. The notion of sustainable development, which aims to meet present-generation requirements without compromising the capacity of future generations to meet their own, is promoted by the science of the environment and sustainability. To build a sustainable and resilient future, it attempts to strike a balance between social fairness, environmental conservation, and economic prosperity.
6. Policy and Governance: Sustainability and the Environment Science offers vital insights for establishing policies and governing frameworks. Decision-makers can design and execute more effective rules, incentives, and strategies to solve environmental concerns by understanding the environmental effects of various policies and practices.
7. The promotion of ecosystem conservation and restoration, as well as biodiversity restoration, is a key function of this field. Researchers can pinpoint problem regions, create conservation plans, and restore degraded landscapes to their natural conditions by understanding ecological systems and how they function.
8. Environmental and sustainability-related public awareness and participation Science aids in educating the public about environmental challenges and encouraging a sense of duty and engagement. This field helps individuals and communities make informed decisions and engage in sustainable practices by disseminating scientific results and fostering environmental education.
9. Building resilience and adaptation to environmental changes and disruptions is a key component of environmental science and sustainability. Researchers can create strategies to aid populations and ecosystems in adapting to and thriving in a changing environment by researching the effects of climate change, natural disasters, and other stressors.
10. Global Cooperation: Sustainability and the Environment Science promotes international cooperation and coordination to handle transnational environmental problems. International cooperation is crucial to create shared solutions, share best practices, and advance sustainability because environmental concerns cross national boundaries[9], [10].

CONCLUSION

Environmental science and studies are a highly interdisciplinary discipline that examines problems related to the world's population growth, the use of natural resources and their depletion, harm from pollution and disturbance, and impacts on biodiversity and the biosphere. These are significant problems, but they entail intricate and obscure systems. Conflicts between direct human interests and those of other animals and the natural world are another issue they deal with. In order to handle the present and future difficulties facing our world, the environment and sustainability must be taken into account. In this article, we have looked at the importance of the environment and sustainability, how they are related, and what has to be done to ensure a sustainable future.The natural resources and systems that sustain life on Earth are collectively referred to as the environment. It offers habitats for several species and gives us access to clean water, food, and air. However, due to human activity, the environment is under tremendous pressure, which has resulted in pollution, habitat destruction, and climate change. In order to preserve and restore our environment for the benefit of both current and future generations, it is essential that we acknowledge its value.

REFERENCES

[1] D. Mequanent and M. Mingist, "Potential impact and mitigation measures of pump irrigation projects on Lake Tana and its environs, Ethiopia," *Heliyon*, 2019, doi: 10.1016/j.heliyon.2019.e03052.

[2] J. Oliveira, L. Neves, and S. Lanceros-Mendez, "Kit 'energy, environment and sustainability': An educational strategy for a sustainable future. a case study for guinea-bissau," *Educ. Sci.*, 2021, doi: 10.3390/educsci11120787.

[3] R. W. Kates *et al.*, "Environment and development: Sustainability science," *Science*. 2001. doi: 10.1126/science.1059386.

[4] L. R. Rivkin *et al.*, "A roadmap for urban evolutionary ecology," *Evol. Appl.*, 2019, doi: 10.1111/eva.12734.

[5] D. M. Szpakowski and J. L. R. Jensen, "A review of the applications of remote sensing in fire ecology," *Remote Sensing*. 2019. doi: 10.3390/rs11222638.

[6] E. F. Moran, *Environmental Social Science: Human-Environment Interactions and Sustainability*. 2010. doi: 10.1002/9781444319057.

[7] W. C. Clark and A. G. Harley, "Annual Review of Environment and Resources Sustainability Science: Toward a Synthesis," *Annu. Rev.*, 2020.

[8] R. Effendi, H. Salsabila, and A. Malik, "Pemahaman Tentang Lingkungan Berkelanjutan," *MODUL*, 2018, doi: 10.14710/mdl.18.2.2018.75-82.

[9] A. Loftus, "Political ecology I: Where is political ecology?," *Prog. Hum. Geogr.*, 2019, doi: 10.1177/0309132517734338.

[10] P. McManus, "Ecology," in *International Encyclopedia of Human Geography, Second Edition*, 2019. doi: 10.1016/B978-0-08-102295-5.10007-1.

CHAPTER 3

APPLICATION OF THE IMPORTANCE OF ECOLOGY

Ms. Meenakshi Jhanwar
Assistant Professor, Department of Environmental Science,
Presidency University, Bangalore, India.
Email Id: meenakshi@presidencyuniversity.in

ABSTRACT:

Ecology is a branch of science that examines how animals interact with their surroundings and how these interactions and interdependencies influence ecosystems. This chapter examines the value of ecology in comprehending and regulating the natural world, emphasizing its applicability to solving current environmental problems. Ecology is a branch of science that is essential for comprehending and addressing the intricate relationships that exist between organisms and their surroundings. It offers insightful information on the distribution and quantity of organisms as well as the structure, function, and dynamics of ecosystems. Ecology is significant because it may help with resource conservation and sustainable management, guide environmental policy decisions, and tackle major environmental problems. Ecology aids in our understanding of the complex interactions between species and their surroundings. Ecologists learn about the workings and resilience of ecosystems by researching how species interact with one another and their surroundings.

KEYWORDS:

Application of Ecology, Ecology Scientific Study, Importance of Ecology, Living Things Environment, Scope of Ecology.

INTRODUCTION

Ecology is characterized as the branch of science that investigates the interactions between living things, their habitats, and all other living and non-living elements found there. The term "ecology" was first used by the scientist Reiter. To describe these interactions between species and their environment, the Greek terms oikos, which means "house" or "dwelling place," and logos, which means "the study of," were combined to form the term ecology. Although there is debate about who first used the phrase, many biologists give credit to German naturalist Ernst Haeckel, who used the term "oenology" to describe the interactions between living things and their environment in 1866. Numerous scientists have given various definitions of ecology, including Allee et al. (1949), who defined it as "the science of the interrelation between living organisms and their environment, including both the physical and biotic environments and emphasizing inter-species as well as intra-species relations".

The father of contemporary ecology is Eugene Odum (1963). He defines ecology as the composition and operation of ecosystems. Ecology is "the study of how particular organisms, populations of some species, and communities of populations respond to these changes," according to Lewis and Taylor (1967). According to Smith (1977), ecology is "a multidisciplinary science that deals with the organisms and their environment and is centred on the ecosystem". Ecology, or the scientific study of interactions between organisms and their environment, can be defined as a field of biology. Both physical (abiotic) and biological (biotic) elements make up the environment. Environments and organisms are interdependent and intimately related. Living things are affected by environmental changes, and vice versa. Understanding the distribution of biotic and abiotic elements of living things in the environment is the primary goal of ecology. Ecology is a comprehensive biological field. It is studied at different levels, including The Biosphere, Ecosystem, Community, Population, and Organism are the main ecological research levels. It alludes to biodiversity in whatever form. The sciences of physiology, genetics, evolution, and behaviour are all closely tied to the study of ecology. Investigating the food chain in a wetland area is one example of ecology.

The emergence of a collection of creatures known as an ecological hierarchy or ecological levels of organization results from the interaction of organisms with their environment. It refers to how the ecological members are ranked. Ecology is made up of every species that exists in the universe. An ecological system's fundamental building block is an individual organism. Following is a list of the several ecological system hierarchies. H. Reiter first used the term ecology in 1868, but it wasn't until 1869 that German biologist Ernst Haeckel gave it its correct definition. The Greek words "oikos" (home) and "logos" (study) are the origins of the word ecology (old spelling: ontologies). The study of living things in their natural environment or habitat is what ecology means in its literal sense. Various ecologists have provided definitions of ecology.

Eugene Odum (1963) described ecology as the study of the composition and operation of the natural world, among other things. According to Allee et al. (1949), ecology is "the science of the interactions between living organisms and their environments, including both the physical and biotic environments, and emphasizing both inter- and intra-species relations." According to Taylor (1936), ecology is the study of how each organism interacts with its environment. Ecology is the scientific study of interactions that influence the distribution and abundance of species, according to Charles J. Krebs (1972). It is "the scientific natural history concerned with the sociology and economics of animals," according to Clements Elton (1927). Ecology was defined by Pinaka (1974) as "the study of relationships between organisms and the sum of the biological and physical factors affecting them or influenced by them." Ecology is the scientific study of the interactions between living things and their environment, according to Southwick (1976).

The study of plant and animal populations, plant and animal communities, and ecosystems are all included in the field of ecology. The term "ecosystem" was first used by British ecologist Arthur Tansley in 1935. The ecosystem is shorthand for "ecological systems." The study of ecosystems is what is meant by ecology. Ecologists research how different animals in an ecosystem interact with one another. The web or network of relationships between species at various organizational scales is referred to as an ecosystem. Ecologists study everything from small bacteria's involvement in nutrient recycling to the effects of tropical rainforests on the Earth's climate since ecology refers to any form of biodiversity. Ecology examines a wide range of elements of nature, including climate, plants, animals, soil, litter on top of the soil, production, dominance, decomposition, variety, etc.

History of Ecology: The concepts of ecology were deeply ingrained in human history, even if contemporary ecology has largely developed since 1900. Prehistoric man used environmental knowledge to find food, shelter, medicines, and other things. Theophrastus, who is considered to be one of the earliest ecologists, wrote detailed descriptions of the interactions between animals and their environment as early as the fourth century BC (Ramalay, 1940). Early in the eighteenth century, two schools of thought dominated the expanding field of ecology research. First, the idea of Arcadian ecology is credited to Gilbert White, a "Parson-naturalist" who developed and supported it. Arcadian ecology promotes a "simple, humble life for man" and a positive coexistence between humans and the natural world. The "imperial ecology" worldview of Francis Bacon, on the other hand, stands in opposition to the Arcadian viewpoint. According to Imperial Ecology, man can dominate nature by using reason and putting forth a lot of effort. Through the early 18th century, the two points of view remained at odds until Carl Linnaeus came out in favour of imperialism. As a result of Linnaeus' fame, imperial ecology quickly rose to the top of the discipline. The work of Swedish scientist Carl Linnaeus (1707–1778) with taxonomy the discipline of naming and classifying organisms—is well known. In his book "Systema Naturae," Linnaeus described the numerous new species of animals and plants that he had discovered. His concepts contributed to the development of contemporary ecology. Charles Darwin put forth his hypothesis of adaptation and evolution in 1859. This idea states that inherited features and personalities cause organisms to change over time. Then, as a result of such evolutionary modifications, they can better adapt to their surroundings. Ernst Haeckel first used the term "ecology" in 1869, and ever since then, ecology has been the study of how organisms interact with their surroundings. The term "biosphere" was first used by Eduard Seuss in 1875 to refer to the system made up of living things and their surroundings. Le Cog Sendtner and Kerner introduced the plant community in ecology, whereas Karl Mobius (1877), Warming (1909), Elements (1916), Cowles (1899), etc. brought the animal community. The term "Synecology" was first used in literature by Schroeter and Kirchner in 1896. The term "ecosystem" was first used by Arthur Tansley in 1935 to describe the biological community of interdependent species and their physical environment. Ecology consequently evolved into the science of ecosystems. The first ecology textbook was written by Eugene and Howard Odum in 1953, and ecology was later made into a university course.

The relevance of climate and other factors in determining population number was emphasized by Andrewartha and Birch in 1954. The unifying principles of ecology have been highlighted by Margolef (1968), who also takes into account the energetic, 1970s James Lovelock concept of Gaia, which holds that the entire earth is one living entity and will ensure its survival even if humans destroy themselves, and the maturity of ecosystems as measured by diversity. Conservation, 1978 Biology has a history of emphasizing environmental management.

The study of ecology first became a separate academic field at the turn of the 20th century, and it came to public attention in the 1960s as environmental concerns became more widespread. In the 1950s and early 1960s, regional floristic and vegetation studies were replaced with ecosystem approaches. After passing through a gestation period of several hundreds of years, the science of ecology has now emerged as a developed, revered, and academic field within biology. In India, Prof. Ramdeo Mishra (1908–1998) is regarded as the founding father of ecology. His studies lay the groundwork for knowledge of tropical communities and their succession, how plant populations respond to the environment, and how productivity and nutrient cycling affect tropical grasslands and forests. F.R. Bharucha (Royal Institute of Science, Bombay) and G.S. Puri, who focused on forest ecology and formed the International Society for Tropical Ecology and the journal Tropical Ecology with Ramdeo Misra, were other early ecologists in India.

The approach of the Zurich-Montpellier School of vegetation study was introduced to India by F.R. Bharucha. Writings from the Vedic, Epic, and Pauranic periods of Indian history contain several allusions to ecological theory. In order to control life, Vayu (air and gas), Desha (topography), Jata (water), and time are all significant, according to Chakra. British ecologists achieved the earliest advancements in modern ecology in India's forests and grasslands. Because most of the labourers were Europeans, the early ecological studies were inspired by European philosophy. Winfield Dudgeon presented an ecological analysis of the upper Gangetic plains in 1921 and used the idea of seasonal succession to do so. This was the first comprehensive ecological contribution. Later, Saxton (1922) and Mishra (1946, 1958, and

1959) expanded on this. Agharkar (1924) conducted the first phytosociological analysis of plant communities, mostly for grasslands. Using the Braun-Blanquet approach, Bharucha and Shankarnarayana (1958) made the most significant contributions to the Phytosociology of the grassland vegetation of the Western Ghats. The autecological studies of Pant and Champion (1931), Champion and Griffith (1947), Jagat Singh (1925), and Phadnis (1925) on a variety of forest trees. The publication of G.S. Puri's book "Indian forest ecology" in 1960 offers a thorough analysis of the plants and surroundings in this region. Indian vegetation was given a thorough taxonomy by Champion and Seth in 1965. Bhatia (1954, 1955, 1956), Sharma (1955), Puri (1949, 1950), Mohan and Puri (1955, 1956), Arora (1961–1964), Misra and Joshi (1952), and Rao (1967) have all conducted autecological and synecological investigations of forest populations. Misra (1969), Singh (1971), Raman (1970), Sharma (1972), Bandhu (1971), and Faruqui (1971), among others, conducted studies on the productivity of forests [1].

DISCUSSION

Branches of Ecology: Ecology can be divided into two primary branches: (i) autecology, which studies organisms alone or in groups, and (ii) synecology. "The two types of study, autecology and synecology, are interrelated," wrote C.F. Harried II in 1977. "The synecologist paints with a broad brush the outline of the picture and the autecologist stroking in the finer details."

Autecology: The study of a single species or its population that takes into account how other living things and the environment affect each stage of a species' life cycle is known as autecology. Additionally known as species ecology. Studies on certain species were initially conducted once humans began using agriculture. According to Misra and Puri (1954), agriculture and silviculture are divisions of agroecology. Even though autecology research has been done widely, only a small number of species have been studied in depth. The physiology of the plant, taxonomy and nomenclature of the species, environmental complex (germination, flowering, seed output reproduction capability, the shape of the plant, etc.), and others are significant factors in the autecological studies of a single organism. At Banaras Hindu University in Varanasi, Prof. R. Mishra and his colleagues have researched the autecology of many plants.

Synecology: Community ecology, also known as synecology, is the study of the interactions between the various species of plants and animals that make up a natural community. Aquatic ecology and terrestrial ecology are further divisions of synecology.

(a) Marine ecology, aquatic ecology, and estuary ecology are all included in aquatic ecology.

(b) Terrestrial ecology is the study of terrestrial (land) ecosystems, including their microclimate, soil chemistry, nutrient hydrological cycle, and productivity. It is further separated into sections like grassland ecology, forest ecology, farmland ecology, and desert ecology. Numerous ecologists have classified ecology into various categories, some of which include the following:

(i) Fossil ecology (paleoecology): It deals with animals and their interaction with the ancient geological environment.

(ii) Cytoecology: This field looks at the cytological specifics of a species in connection to populations in various environmental settings.

(iii) Conservation ecology: This field is concerned with the wise management of natural resources for human benefit, including plants, soil, water, land, and mineral resources.

(iv) Ecological energetics and production ecology are both still in the early stages of development. These cover the mechanism of energy conversion, its movement through living things, production processes, and the rate at which the weight of organic matter increases relative to both space and time for both animals and green plants.

(v) Space ecology: This field focuses on the creation of partially or entirely self-regenerating ecosystems for sustaining life during protracted space missions.

(vi) Microbial ecology: This field of study examines how organisms that are a part of every natural environment function.

(vii) Habitat ecology: It is reliant on the habitat's characteristics. This comprises ecosystems of grasslands, freshwater bodies of water, the ocean, and the desert, among others.

(viii) Ecosystem ecology: creatures get their energy by eating other creatures or from photosynthesis. The motions of materials within and between organisms as well as between them and the physical environment are connected to these energy transformations.

Ecosystem ecology is a branch of ecology that studies the interplay between biotic and abiotic components, which is referred to as an ecosystem. How human activity affects energy flow, the global nutrient cycle, and food webs are among the topics of interest at this scale.

Importance of Ecology: grasp the underlying relationships of the natural community and the disciplines that focus on particular environments, such as soil, ocean, forest, and inland waters, begins with a grasp of ecological principles. This topic has numerous practical applications in forestry, agriculture, horticulture, fishery, biology, etc. The field of plant ecology studies the interactions between plants and their surroundings and describes domestic plants. It highlights the physiological connections between plants and their surroundings. The practice of agriculture and forestry is based on scientific ecological principles. The health and prosperity of humans depend on the environment. It offers fresh insight into the interdependence of organisms with their natural surroundings, which is crucial for the production of food, the preservation of resources like land and water, and the maintenance of biodiversity in a changing climate. The foundation of nature conservation is ecology. The significance of ecology is explained by the following factors.

1. Aids in environmental preservation: Ecology studies help us comprehend the detrimental effects of human activities on the ecosystem. We can direct conservation efforts by first determining the main causes of the issues we face with our environment. We demonstrate where the greatest impact of our efforts will be made by using this identifying procedure. Protecting the environment entails preserving its natural resources, preserving the world, and enhancing the standard of living for all living beings.

2. Appropriate resource allocation: Within the context of ecological knowledge, resource allocation refers to the process of planning, managing, and allocating resources. We can learn what resources different species need to survive. Ecology serves as the foundation for creating effective conservation policy. especially when persons who are in charge of managing natural resources have ecological expertise in fields like forestry, wildlife, agriculture, land management, and fisheries.

3. Promotes energy conservation: Energy conservation refers to lowering energy consumption by changing human behaviour and routines. Energy is a necessity for all living things to thrive and flourish. Lack of ecological knowledge causes overuse of energy sources like food, light, and radiation, which causes their depletion. A proper understanding of ecological requirements eliminates needless energy resource waste and conserves energy for later uses.

4. Eco-Friendliness: This phrase is most frequently used to describe things that support environmentally friendly lifestyles or actions that reduce resource use, such as energy, and noise, air, and water pollution. Ecology encourages species coexistence and the adoption of lifestyle choices that preserve the ecology of life.

5. Promotes pest and disease: Insects and diseases are a normal component of ecosystems. The vectors that spread many diseases. In addition to giving people the information and skills to combat pests and diseases, the ecological study offers the globe new perspectives on how vectors and pests act.

Application of Ecology: The broad topic of ecological applications is the application of ecological research to environmental issues. Ecology is an extremely significant subject with numerous applications, including:

(i) Wild Life Management: In the 1920s and 1930s, the field of applied science known as wildlife ecology was born. The science behind the practice of wildlife management, which aims to control wildlife populations for the benefit of people, is known as wildlife ecology. In the beginning, maintaining populations and habitats to sustain recreational hunting was the main focus. In Sinclair et al. (2006), modern viewpoints are clearly described. They continue to value wildlife for human use while also embracing the conservation of biodiversity, non-consumption uses of wildlife, and ecosystem management.

(ii) Soil Conservation: Preventing soil loss through erosion or diminished fertility due to excessive use, acidification, salinization, or other chemical soil contamination constitutes soil conservation. Because it supplies food, filters air and water, and aids in the breakdown of biological waste into nutrients for new plant life, soil conservation is crucial. Certain human activities are causing soil disturbance. In many cases, the cultivation of certain lands is affected by the building, agricultural, or logging industries.

(iii) Watershed Management: The term "watershed" refers to the process of putting land use practices and water management practises into place to safeguard and enhance the quality of the water and other natural resources contained within a watershed by managing the use of those land and water resources comprehensively. Watershed management has undergone a paradigm shift in recent decades, moving from primarily supply-based considerations of water quantity and quality to more comprehensive considerations of the ecological services provided by watersheds, as well as a more holistic perspective interested in understanding and managing feed-backs between hydrological and ecological processes.

(iv) Agriculture: A significant worldwide human endeavour, agriculture has a significant impact on ecosystems. Looking ahead, ecologists will continue to play a significant role in the creation of sustainable agricultural systems. Understanding ecological agriculture gives one a comprehensive understanding of how agroecosystems function as well as the science behind sustainable agriculture. Ecology places a focus on the interactions between soils, insects, plants, animals, people, and other agroecosystem components, such as food crop agroecology, ecosystem dynamics, and the place of agriculture in both rural and urban landscapes. Ecologists study each of these characteristics, thus it would be very impossible to grow a plant without knowledge of every facet, which could lead to a financial loss. Sustainable food production is difficult, but agriculture ecology offers alternatives [2], [3].

(v) Aquaculture: Directly or indirectly related to human consumption, aquaculture is the production of aquatic organisms such as fish, crabs, prawns, molluscs, and aquatic plants. Contrasted with commercial fishing, which is the capture of wild fish, aquaculture involves the controlled cultivation of populations in both freshwater and saltwater. Although the seafood market is enormous and expanding quickly, fish stocks are declining as a result of overfishing, pollution, and other human activities. Overall, to maintain its contribution to the world's fish supplies, the expanding aquaculture industry must increase its use of environmentally friendly management techniques. The importance of temperature and soil conditions in fish culture can't be overstated [3], [4].

(vi) Land Utilisation: Humans are the primary agent of change in the world, modifying the land to produce food, shelter, and useful items. Time, species, place, disturbance, and landscape are all addressed in ecological principles for land use and management. The ideas lead to many recommendations that function as useful generalisations for incorporating ecological ideas into decisions regarding the land. On the road to ecologically based land use, defining ecological principles and comprehending their implications for land use and land-management choices are crucial.

(vii) Air Pollution: Pollution is the unfavourable alteration of the natural environment brought on by the introduction of contaminants. Pollution can overwhelm an ecosystem's natural stability and cause irreversible changes and losses. For instance, air pollution and acid deposition cause forests to decline and lose their ability to grow new trees. Pollution also reduces fish production by killing invertebrates with copper, which causes nutrient losses in soil insects and microbes. We must research the causes of pollution if we are to control it. Ecological research can be used to control these causes [5], [6].

(viii) Forestry: Forestry is the management of forests. A significant and extremely diversified area of ecological research is forest ecology. The scientific study of the interconnected patterns, processes, flora, fauna, and ecosystems in forests is called forest ecology. In addition to providing numerous priceless ecosystem services and benefits, forests are a major supplier of wood products used in global commerce. Experts and scientists take into account the economic, social, and environmental objectives while assessing the efficacy of forest management strategies [6], [7].

Scope of Ecology: Ecology has a vast range, encompassing all living things on Earth as well as their physical and chemical environments. Because of this, the subject is typically separated into various levels of study, such as organismal ecology, population ecology, ecosystem ecology, and community ecology. The study of organismal ecology examines how people engage with their surroundings. The study of population ecology looks at the variables influencing population dispersion and density. In community ecology, population interactions are examined. Organismal, population and community ecology are all subsets of ecosystem ecology. All the biotic and abiotic elements of that area make up the ecosystem. An ecosystem biologist studies how nutrients and energy are stored, how they are transferred between organisms, and how they interact with the air, soil, and water around them. The focus of ecological research includes the following:

1. It examines the movement of materials and energy throughout the ecosystem.

2. It is concerned with the study of nature and how it works.

To describe ecology, Taylor (1936) pointed out the scope of the field by defining ecology as the science of all interactions between ecosystems, all organisms, and their environments.

As people's awareness of environmental issues has grown, the field of ecology has significantly broadened. People have been warned by ecologists about the effects of humans gradually destroying and removing natural resources from the environment. With the right and informed understanding of ecological studies, man can use ecological studies and management to create a healthy and long-lasting balance between living things and their environment, which may solve many significant problems.

In his address on ecology and development at the "All India Symposium on Advancement of Ecology" in Muzaffarnagar in 1976, Prof. R. Misra noted that attempts to apply the science to India's economic development and the development of ecological concepts in redressing or reversing the progress of environmental degradation will lead to significant advances in ecology. Many of the issues brought on by overuse of the resources can be solved with the help of environmental expertise. Ecology has numerous subcategories. The study of differences and similarities among distinct plants in varied climatic and ecological conditions is known as plant ecology. The study of plants in their natural habitat has produced a vast amount of knowledge that supports the science of resource conservation. Agriculture, food production, and horticulture all need ecological knowledge. Since its inception on July 1, 1967, the International Biological Programme (IBP) has been researching the biological underpinnings of organic productivity and resource conservation concerning human welfare. With a focus on birds, the Bombay Natural History Society (a science-based NGO) has carried out admirable long-term ecological studies in the wetlands of Bharatpur, Bhitarkanika, and Point Calimer [8]–[10].

CONCLUSION

In summary, ecology is vital to our understanding of the natural world and is essential for resolving urgent environmental issues. Ecologists learn more about the operation and dynamics of ecosystems by examining the complex connections between living things and their surroundings. This information is essential for creating successful strategies to protect biodiversity, sustainably manage natural resources, and lessen the effects of human activity on the environment. Ecology also provides the groundwork for comprehending the effects of environmental change, such as habitat loss and climate change, and provides direction for creating resilient and adaptable solutions. A healthy relationship between human civilization and the environment can be fostered by embracing ecological concepts and incorporating them into decision-making processes, providing a sustainable and prosperous future for future generations.

REFERENCES

[1] S. Mayanja, J. M. Ntayi, J. C. Munene, J. R. K. Kagaari, and B. Waswa, “Ecologies of innovation among small and medium enterprises in Uganda as a mediator of entrepreneurial networking and opportunity exploitation,” *Cogent Bus. Manag.*, 2019, doi: 10.1080/23311975.2019.1641256.

[2] J. A. Byrne and D. Houston, “Urban Ecology,” in *International Encyclopedia of Human Geography, Second Edition*, 2019. doi: 10.1016/B978-0-08-102295-5.10760-7.

[3] E. A. Newman, “Disturbance ecology in the anthropocene,” *Front. Ecol. Evol.*, 2019, doi: 10.3389/fevo.2019.147.

[4] A. van der Hoeven and E. Hitters, “The social and cultural values of live music: Sustaining urban live music ecologies,” *Cities*, 2019, doi: 10.1016/j.cities.2019.02.015.

[5] C. Scaramelli, “The delta is dead: Moral ecologies of infrastructure in Turkey,” *Cult. Anthropol.*, 2019, doi: 10.14506/ca34.3.04.

[6] J. Ortiz, H. Ren, K. Li, and A. Zhang, "Construction of open innovation ecology on the internet: A case study of Xiaomi (China) using institutional logic," *Sustain.*, 2019, doi: 10.3390/su11113225.

[7] G. J. Williams *et al.*, "Coral reef ecology in the Anthropocene," *Funct. Ecol.*, 2019, doi: 10.1111/1365-2435.13290.

[8] A. Bernd, D. Braun, A. Ortmann, Y. Z. Ulloa-Torrealba, C. Wohlfart, and A. Bell, "More than counting pixels – perspectives on the importance of remote sensing training in ecology and conservation," *Remote Sens. Ecol. Conserv.*, 2017, doi: 10.1002/rse2.27.

[9] F. A. Champagne, "Interplay between paternal germline and maternal effects in shaping development: The overlooked importance of behavioural ecology," *Funct. Ecol.*, 2020, doi: 10.1111/1365-2435.13411.

[10] D. Foster *et al.*, "The importance of land-use legacies to ecology and conservation," *Bioscience*, 2003, doi: 10.1641/0006-3568(2003)053[0077:TIOLUL]2.0.CO;2.

CHAPTER 4

FEATURES OF THE EARTH ENVIRONMENT

Dr. Krishnappa Venkatesharaju
Assistant Professor, Department of Environmental Science and Engineering,
Presidency University, Bangalore, India.
Email Id: venkateshraju.k@presidencyuniversity.in

ABSTRACT:

The physical, chemical, and biological elements that support life on our planet are all included in the environment of the Earth. The Earth's environment is examined in this chapter along with its characteristics and interconnections, emphasizing the role that it plays in sustaining a variety of ecosystems and human well-being. The significance of protecting and managing this complex system for a sustainable future is emphasized as it discusses important variables and processes that shape the Earth's ecosystem. The atmosphere, hydrosphere, lithosphere, and biosphere are only a few of the many linked parts that make up the ecosystem on Earth. Understanding the Earth's environment is essential for understanding the planet's natural processes, how its elements interact, and how human actions affect the environment. By controlling temperature, sustaining weather patterns, and delivering the oxygen required for respiration, the Earth's atmosphere is an essential component that keeps life on the planet alive. The water on Earth, including the seas, rivers, lakes, and groundwater, is referred to as the hydrosphere and is crucial for many natural processes as well as human needs. The soil, rocks, and minerals that serve as the basis for terrestrial life are all part of the lithosphere, which is the solid portion of the Earth.

KEYWORDS:

Atmosphere, Biosphere, Chemical Biological Elements, Environmental Earth, Hydrosphere, Lithosphere.

INTRODUCTION

The physical, chemical, and biological elements of our planet are all included in the environment of the Earth, which is a complicated and interrelated system. It is a dynamic, ever-evolving system that offers the prerequisites for the existence of life. The ecology of the Earth is examined in this article in all of its facets, including its elements, functions, and difficulties. It emphasizes how crucial it is to comprehend and protect the environment on Earth for the welfare of ecosystems and human society. Physical Elements of the Environment on Earth: Multiple physical elements that make up the Earth's environment influence it physically and lay the groundwork for life. The planet's atmosphere, a gaseous envelope, is crucial in controlling temperature, weather, and the distribution of gases necessary for life, like oxygen and carbon dioxide. It serves as a barrier, shielding the planet from space debris and damaging solar radiation. All of the Earth's water features, including the oceans, rivers, lakes, and groundwater, are included in the hydrosphere.

It is an essential part of the environment on Earth, sustaining a variety of aquatic habitats and supplying water for drinking, farming, and other uses. Through processes including evaporation, condensation, and precipitation, the hydrosphere is also essential in controlling climate and weather patterns. The solid outer layer of the Earth, which also includes the continents, oceanic crust, and subsurface mantle, is referred to as the lithosphere. It works as a storage area for priceless resources including minerals, fossil fuels, and groundwater while also providing a habitat for terrestrial ecosystems. Geological processes like plate tectonics and erosion, which aid in the formation of mountains, valleys, and other landforms, continuously sculpt the lithosphere. All living things on Earth, including plants, animals, and bacteria, are included in the biosphere. It is the most varied elements of the ecosystem on Earth, supporting complex ecological networks and being a key player in the control of numerous biogeochemical cycles. The other physical elements provide resources like air, water, and nutrition that the biosphere depends on.

Processes and interactions: The environment of the Earth is characterized by an intricate network of interactions and activities that support life and mold the ecosystems of the planet. Sunlight, which is collected by plants through photosynthesis and distributed to other organisms through food chains and food webs, moves energy through ecosystems. Through several biogeochemical processes, including decomposition, nutrient uptake by plants, and nutrient consumption by animals, nutrients are cycled. An important component of the Earth's ecology is its climate, which is controlled by elements like solar radiation, the makeup of the atmosphere, and ocean currents. Ecosystem distribution and organism adaption are influenced by climate trends. However, human activities like the burning of fossil fuels and deforestation have made a significant contribution to climate change, which has resulted in increased frequency of extreme weather events, rising temperatures, and changing rainfall patterns.

The difficulties and conservation: Numerous threats to the ecology of the Earth pose a risk to both its delicate equilibrium and the welfare of its inhabitants. As a result of ecosystem disruption, habitat loss, increasing sea levels, a rise in the frequency of natural disasters, and changing agricultural patterns, climate change is a major cause for concern. Another serious problem is the loss of biodiversity, which is being caused by human activities including habitat destruction, pollution, and overexploitation of natural resources. As a result, species are vanishing at an alarming rate. Sustainable management and environmental preservation are essential to addressing these issues. Adopting sustainable behaviors that minimize pollution, encourage resource efficiency, and lower greenhouse gas emissions is part of this. Protecting endangered species, preserving and repairing ecosystems, and promoting sustainable resource use should be the main objectives of conservation initiatives.

To promote sustainable behaviors and build a sense of responsibility, education, and awareness are crucial. Individuals and societies can take action to reduce their ecological footprint and support a sustainable future by making educated decisions and acting following their knowledge of the interdependence and significance of the Earth's environment. The environment of the Earth is a dynamic and complex system that offers the ideal surroundings for life to develop. It includes all of our planet's physical, chemical, and biological elements and is characterized by complex interactions and processes. The environment of the Earth, however, suffers several difficulties, such as pollution, biodiversity loss, and climate change. We must comprehend and value the Earth's ecosystem, work to preserve it, and manage it responsibly if we want to secure a sustainable future. We can safeguard the Earth's ecology and guarantee a healthy planet for future generations by adopting sustainable practices, encouraging conservation initiatives, and increasing awareness [1], [2].

The French term "Environ" (which means "to encircle") is the source of the word "environment." An organism's life is influenced by the physical, chemical, and biological elements of its surroundings. The totality of all biotic (living) and abiotic (non-living) elements that surround and have an impact on an organism is the environment. The availability of food organisms, the prevalence of biological specialization, predators, parasites, and rivals are examples of biotic factors. Sunlight intensity, air temperature, and soil pH all fall under the category of abiotic variables. Any external force, material, or circumstance that is present around an organism and has any impact on its life counts as a component of that organism's environment. Environmental factors are those things. an environmental element that restricts the growth, metabolism, or spread of organisms through its decrease, rise, presence, or absence. Depending on demands and age, different species have varying environmental requirements. The maximum and minimum levels of environmental factors, including water, light, nutrients, space, temperature, and humidity, have an impact on an organism's ability to live.

The "law of the minimum," developed by German scientist Justus Von Leibig, holds that any plant will grow badly if it lacks one of its basic elements, even if it has an abundance of all other important nutrients. But a limiting factor can also be too much of something, which might restrict an organism's ability to develop and spread. American zoologist Victor Ernest Shelford (1931) included the idea of the influence of maximum as well as minimum into the law of tolerance. According to the Law of Tolerance, each organism has specific minimum, maximum, and optimal factors or combinations of elements that affect its success. The success of an organism is based on a complicated set of conditions. Only a very erratic layer (5–20 km deep) of the planet is home to the world's environment that can support life. The biosphere is the name given to this thin layer of life on Earth. The biosphere, atmosphere, hydrosphere, and lithosphere are the four spheres that make up the Earth [3], [4].

DISCUSSION

Biosphere: There is just a very thin, erratic veil or film that covers the entire planet that can support and contain life. The ecosphere and biosphere are two names for this thin layer of biological matter that covers the world. The Greek words "bios" for "life" and "sharia" for "sphere" are the origin of the word "biosphere." A region where life exists on, above, and below the surface of the earth is referred to as the biosphere. The term "biosphere" was originally used to refer to the region of the earth that supports life in 1875 by the Austrian geologist Eduard Suess (1831–1914). The biosphere, according to Hutchinson (1970), is the region of the world where life is present. The entire populated area of the earth, including its atmosphere and all living things, is referred to as the biosphere. It reaches the deep-water vents of the Ocean from a few kilometers above in the sky [5]–[7].

The biosphere provides the ideal conditions for survival. It is the region of the earth where interactions between biotic and abiotic components, including air, water, and land, support life. The abiotic (non-living) and biotic (life) elements that make up the entire world's environment are fundamentally what makes it up. The biosphere is made up of all of these elements. The lithosphere (earth), the hydrosphere (water), and the atmosphere (air) make up the abiotic global environment. The biotic component is made up of numerous types of life that exist in the abiotic environment.

The lithosphere (rocks), the outer surface of the globe made of solid and rock, the atmosphere, the surrounding gaseous envelope, and the hydrosphere, the body of liquid water on earth, including the oceans, lakes, and rivers, are the other three layers that surround it. The biosphere is one of these layers. The Biosphere can be broken down into numerous large land-based groupings called Biomes. A biome is a sizable area of the planet with a particular climate and a specific kind of living organism. There are five main types of biomes: grassland forests, deserts, forests, and tundra. Some of these biomes, such as savanna, freshwater, marine, taiga, tropical rainforest, and temperate, can be further subdivided into more focused groups. Zones are the smallest, most basic divisions of biomes. For instance, the canopy zone and ground zone of a woodland biome can be separated. Each biome's native flora and animals have characteristics that enable them to thrive there. Terrestrial biomes are those that are found on land. Aquatic biomes are those that are found near water. The world's biomes differ in terms of temperature, amount of precipitation, and the kind of creatures that live there[8], [9].

The biosphere is made up of various ecosystem kinds. For the creation and maintenance of life, living things need inorganic metabolites such as water, minerals, oxygen, nitrogen, and carbon dioxide. All of these inorganic materials come from the abiotic counterparts of the biosphere, which are living things. The biosphere serves as the planet's life support system by maintaining soil health, controlling the hydrological (water) cycle, and regulating the composition of the atmosphere. The three additional major parts of the earth, in addition to the biosphere, are listed below.

Atmosphere: The atmosphere is a gaseous layer that surrounds the world. The atmosphere is a layer of gases that covers the whole surface of the globe and is held there by the gravitational pull of the planet. The atmosphere's constituent gases cannot escape into space due to gravity. Water vapor, carbon dioxide, methane, ozone, and sulfur dioxide are present in very small levels in the atmosphere, which is made up of 78% gas, 21% oxygen gas, and 0.9% argon. Four primary layers make up the atmosphere. From sea level, we begin measuring these and work our way up to space. The troposphere is the uppermost layer, followed by the stratosphere, mesosphere, and thermosphere. The exosphere is the layer above the thermosphere when the atmosphere and space are one. These layers each include many characteristics. For instance, variations in temperature density, gas composition, etc. Up to an altitude of roughly 80 km, the atmosphere's composition is essentially uniform. The gas is lighter the greater the level. Closer to the Earth, the atmosphere is heavier, while farther away, it is thinner. When compared to distances from the Earth, atmospheric pressure is higher nearby. A layer of ozone exists in the atmosphere between 32 and 48 kilometers in altitude. The ultraviolet rays from the sun, which are fatal to living things, are blocked from entering the earth by this layer. Because they operate as metabolites of living organisms, the three gases oxygen, nitrogen, and carbon dioxide are crucial for the correct operation of living things.

Structure of atmosphere: The five concentric layers that make up the atmosphere can be identified based on temperature. The following are these layers:

(i) Troposphere: The term "troposphere" refers to the lowest layer of the atmosphere, where humans and other living things can be found. This is an illustration of the 20 km above-ground, linear part of the atmosphere. It is thin at around 10 km from the surface of the planet in the Polar Regions. More than 90% of the gases in the atmosphere are present there. The troposphere is where significant occurrences like cloud formation, lightning, thundering, thunderstorm formation, etc. take place. The troposphere is characterized by weather variations and a gradual decline in temperature with increasing amplitude; in the highest layers, this temperature decrease may reach -60 ^{o}C. Near the soil surface, the temperature is around 150 c. Tropopause refers to the upper layers of the troposphere that progressively meld with the stratosphere above. The troposphere is a crucial component of the atmosphere because it produces oxygen that humans can breathe, maintains a livable temperature on Earth, and permits the occurrence of weather.

(ii) Stratosphere: The second layer of the air mass, commonly known as the ozone layer, is located about 30 km above the tropopause. The stratopause is the term for the stratosphere's top layer. The temperature in this region rises, rising from a minimum of roughly -60°C to a maximum of 5°C. Ozone is created by the sun's UV (ultraviolet) rays, which is what is causing the temperature to rise. Ozone is created from oxygen through a photochemical reaction in which solar energy, represented by the symbol hv, divides the oxygen molecule into atomic oxygen and atomic oxygen, which then reacts with oxygen to create ozone. The aforementioned reactions can be undone. The stratosphere's ozone content is constant, meaning that ozone is being created from oxygen at the same rate as it is being converted to molecular oxygen. The ozonosphere is the region of the stratosphere that has the highest concentration of ozone (90%) and is located 20–25 km above the earth's surface. It is crucial because it blocks the sun's UV rays from reaching the earth's surface, where they could endanger living things.

(iii). Mesosphere: The term "mesosphere" refers to the third atmospheric layer after the stratopause. It is approximately 40 kilometers high. Low air pressure and low temperature are characteristics of the mesosphere. At an elevation 80 to 90 kilometers above the surface of the earth, the temperature reaches a minimum of roughly -95oC before starting to decline from the stratopause. The term "mesopause" refers to the mesosphere's upper boundary.

(iv). The thermosphere, which sits next to the mesosphere and rises 500 km above the surface of the globe, is entirely cloudless and devoid of water vapor. The consistent temperature increase with a height from mesopause that characterizes the atmosphere. The thermosphere is made up of the areas where cosmic rays and UV radiation ionize molecules like oxygen and nitric oxide. The ionosphere is the name of this area. Gas molecules in the ionosphere are so far apart that the atmosphere is unable to carry high-frequency audible sound.

(v). Exosphere: The area of the atmosphere above the thermosphere is known as the exosphere, also known as outer space, and it is devoid of all elements but hydrogen and helium. Up to 32190 km are covered by this. Solar energy causes the exosphere to be highly hot. Given that the earth has a magnetic field, gravity no longer has as much of an impact on how atomic particles are distributed in the exosphere.

Importance of atmosphere: 1. The atmosphere and sound: Sound is a wave-based kind of energy. While sound waves can pass through gases, they cannot pass through space. Birds, insects, and airplanes can all fly through the atmosphere thanks to its gases, which also serve as a conduit for sound.

2. The environment and life forms: Oxygen and carbon dioxide, two gases in the atmosphere, are necessary for life to exist on Earth. Carbon dioxide is required for photosynthesis in plants. Plants may use carbon dioxide to make sugar for food through photosynthesis. The photosynthesis reaction is :

$$6CO_2 + 6H_2O + \text{solar energy} \rightarrow C_6H12O_6 \text{(sugar)} + 6O_2$$

The mechanism that Animals go through enables them to utilize oxygen to turn sugar into useful energy. This technique is also used by plants to ingest part of the sugars they create. The reaction for respiration is:

$$C_6H_{12}O_6 \text{(sugar)} + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{usable energy}$$

3. The atmosphere and the earth's temperature: The atmosphere maintains the earth's temperature at a level that is conducive to life. The lowest layers of the atmosphere's water vapor and carbon dioxide absorb the heat emitted by the earth's surface, keeping the atmosphere warm even at night. Some of the daytime heat from the Sun is reflected by gases in the atmosphere.

4. The atmosphere and the water on Earth: The atmosphere plays a crucial role in facilitating the circulation of water. Water is stored in the atmosphere, which also serves as a significant water reservoir. It has a big part in the water cycle. It makes it easier for clouds to form and stay in the air until they are heavy enough to fall as rain or snow on the ground.

5. The atmosphere and solar radiation For the earth, the atmosphere functions as a blanket or a greenhouse. The earth's atmosphere serves as an insulating barrier to shield the surface from the sun's strong heat and light. It shields us from ultraviolet (UV) and other short-wavelength radiation that might otherwise cause significant harm to living things' DNA. By reflecting the UV rays of the Sun, the ozone layer's existence accomplishes this. Strong sunlight is reflected or absorbed by gases, which also receive solar energy but prevent it from escaping into space. As a result, the earth remains heated.

Hydrosphere: The hydrosphere is the collective name for all surface-level bodies of water, including ice, snow, rivers, ponds, oceans, and lakes. The Greek term hydro, which means "water," and "sphere," which denotes a "round," "ball-like," spherical shape, are the roots of the word hydrosphere. The hydrosphere, which makes up 73% of the earth's surface, is the watery portion of the biosphere. The oceans make up about 97 percent of the world's total water supply, while the remaining 3 percent is made up of water from ponds, lakes, rivers, and snow and ice. Water is necessary for all life since it is the primary inorganic nutrient required by all living things. In water, life first appeared. Water serves as both a medium for many different ecosystems and one of the primary factors in pedogenesis. A single molecule of water is made up of two hydrogen atoms and one oxygen atom, according to the chemical formula for water, H2O. A cycle known as the hydrological cycle governs how water circulates inside the hydrosphere. It is essential to the hydrosphere's survival. It consists of the many steps listed below.

Environmental Cycle: The ecosystem's form and function are determined by water, a key ecological component. The atmosphere, ocean, and land are all regularly exchanged for water. This process is known as the water cycle or hydrological cycle because it happens continually throughout the cycle. This cycle is a crucial procedure that keeps life on Earth alive. Water is also necessary for the cycling of all other nutrients since it transports them through various processes. It serves as a solvent medium for the organisms' absorption of nutrients. The following processes make up the continual movement of water in the earth's atmosphere: evaporation, transpiration, sublimation, condensation, precipitation, runoff, infiltration, and percolation, as well as groundwater flow.

The sun provides the energy that powers the water cycle. Water from other bodies of water (such as rivers, ponds, lakes, etc.) and the ocean, which is the largest reservoir of water, evaporated due to solar heat. Evapotranspiration is the term for the smaller amount of water that evaporates from the surface of the land and plants. Sublimation is the direct transformation of soil (ice and snow) into vapor. All of this vaporized water condenses into clouds that are carried by winds and may cross land where they cool sufficiently to cause precipitation of water in the form of rain or snow. When it rains, some of the water soaks into the soil while some run off into streams before returning to the seas. After that, it evaporates into the atmosphere to restart the cycle. Water undergoes three states of matter transformations during the water cycle: solid, liquid, and gas. The Cryosphere is the term used to describe the portion of the hydrosphere that is frozen, such as glaciers, icecaps, icebergs, etc. The cycling of water and energy between the ocean, atmosphere, and land is a major factor in the climate of Earth and its variability.

Elements of the Hydrosphere:

1. Glaciers: The liquid that runs down glaciers.
2. Oceans: The majority of the earth's water, 97% of its salt water, is found in the sea.
3. Groundwater: A small fraction of the fresh water on earth is made up of rainwater that seeps through rocks and soil into the earth's surface.

4. Only about 3% of the water on Earth is freshwater, which can be found in some locations including rivers, lakes, underground, etc. Surface Water: Lakes, rivers, and streams are examples of surface sources of freshwater.

Hydrosphere importance: The hydrosphere is essential to the survival of all life.

1. A component of living cells: The hydrosphere is a component of living cells and is the source of water. At least 75% of every living cell is made up of water, which supports the cell's proper operation. The vast majority of chemical reactions occurring in living things involve substances dissolved in water. No cell could exist or perform its usual functions without water. Water is stored in the hydrosphere, which also acts as a source and reservoir for living things.

2. Home to a range of life forms: Water dissolves several nutrients, including nitrite, nitrate, and ammonium ions, as well as gases like oxygen and carbon dioxide, making it a haven for a diversity of plants and animals. These substances are essential to the continued existence of life in water.

3. The presence of the atmosphere: The hydrosphere considerably influences how the atmosphere is right now. The Earth's atmosphere was extremely thin when it was first created. Due to its high helium and hydrogen content, this atmosphere was similar to that of mercury today. Later, the atmosphere was cleared of helium and hydrogen. The current atmosphere was created as gases and water vapor was formed as the planet cooled.

4. Manage the weather: Water has a high latent heat, which means it collects or releases a lot of heat when it freezes or evaporates, and a high specific heat, which means it absorbs or loses a lot of heat when temperatures shift slightly. These characteristics support the stabilizing of environmental conditions, including plant temperatures. It plays a significant part in maintaining Earth's temperatures within a range that is favorable for life. The qualities of latent heat of water play a crucial part in the hydrological (water) cycle by causing water to evaporate and precipitate (condensate) as rain and dew, in addition to regulating the temperature of the biosphere.

5. Requirements of people: There are several ways that the hydrosphere benefits people. Water is utilized for domestic and industrial reasons in addition to drinking. In addition, it can be used for transportation, agriculture, and electricity production through hydropower.

Lithosphere: Earth's lithosphere is its solid portion. The Greek words 'lithos', which means stone, and'sphaira', which means ball or globe, are combined to form the phrase lithosphere. It is the part of the biosphere that is terrestrial. The pedosphere is the topmost layer of the lithosphere, which interacts chemically with the biosphere, atmosphere, and hydrosphere to generate soil. Living things can find food, cover, anchoring, and protection from predators in the soil. The asthenosphere, the weaker, deeper, and hotter portion of the mantle, is located under the lithosphere. It is a layer of solid rocks under which the heat and pressure are so intense that the rocks flow like liquid. The rocks of the asthenosphere are less dense than those of the lithosphere.

The most well-known aspect of the lithosphere of the earth is tectonic activity. A tectonic plate, sometimes referred to as a lithospheric plate, is a large, erratic slab of solid rock that typically consists of both the oceanic and continental lithospheres. The size of these tectonic plates varies. At the boundary of the plates, where they might collide, split apart, or slide against one another, the majority of tectonic activity takes place. Tectonic plate movement is made possible by thermal energy (heat) from the mantle of the lithosphere. Rocks in the lithosphere are more elastic due to thermal energy. Some Earth's most dramatic geologic occurrences, such as earthquakes, volcanoes, and deep ocean trenches, are caused by tectonic activity in the lithosphere.

Tectonic action can shape the lithosphere: Both oceanic and continental lithospheres are the thinnest near rift valleys and ocean ridges, where tectonic plates are shifting apart from one another. The lithosphere is composed of the three primary layers listed below.

1. Crust: The crust is the earth's top layer, located 8 to 40 km above the mantle. Its surface is coated in soil that supports diverse and abundant biotic communities where people, animals, and plants can live. The two main constituent minerals are silica (Si) and aluminum (Al). So, it is frequently referred to as SIAL.

2. Mantle: This layer sits between the crust and the core. It is the earth's second stratum. It rises 2900 kilometers or so above the core. This is molten at the moment. Iron and magnesium-rich silicates make up its composition. It serves as the primary conduit for the magma that rises to the surface during volcanic eruptions.

3. Core: The core is located underneath the mantle. The core, which has a diameter of roughly 2500 km from the center and may be made of nickel-iron, is the central fluid or vaporized sphere. A core is separated into two smaller zones:

The earth's center and warmest layer are represented by its solid inner core (figure 1a). The solid inner core has a thickness of 1,250 km and a temperature range of 5500–7000 C. It is made of nickel and iron and is solid because of great pressure.

(b) The liquid outer core, which is composed of molten iron and nickel, has a temperature range of 6100 to 4400 degrees Celsius. The earth's magnetic field, which shields it from the solar wind, is created by the outer core's spinning.

Lithosphere can be broadly categorized as the oceanic and continental lithosphere.

1. Oceanic lithosphere: The oceanic lithosphere is connected to the oceanic crust and is found in ocean basins. It is denser than the continental lithosphere and predominantly made up of mafic crust (oceanic crust) and ultramafic mantle. Because new oceanic lithosphere is continually being created at mid-ocean ridges and recycled back into the mantle at subduction zones, the oceanic lithosphere is far younger than the continental lithosphere. As the oceanic lithosphere ages, it thickens and drifts farther from the mid-ocean ridge. Age-related thickening of the oceanic lithosphere is brought on by conductive cooling, which transforms the heated asthenosphere into the lithospheric mantle.

2. Continental lithosphere: The continental lithosphere is in close contact with the atmosphere and is connected to the continental crust. Rock strata made up of sedimentary and igneous material formed the continents and continental shelves. The majority of the rock in this layer is granite.

Relevance of the Lithosphere

1. The lithosphere contains a variety of rocks, including sedimentary, igneous, and metamorphic rocks.

2. Lithosphere aids in giving plants the essential nutrients they need. It offers forests, and pastures, and is a significant mineral supply. The biosphere, or the living organisms on earth, occupies the lithosphere, which is why it is so significant.

3. The primary source of fuels including petrol, coal, and natural gas is the lithosphere. Organic chemicals can become buried in the crust as a result of interactions between the biosphere and the lithosphere and then be unearthed as fuel-producing coal, oil, and natural gas.

4. Mountains, earthquakes, and volcanoes can form when tectonic plates shift as a result of convection currents deeper in the mantle. As they create fertile soil and lands, earthquakes, and volcanoes aid in the emergence of fresh plants and life.

5. Minerals and elements like copper, magnesium, iron, and aluminum are found in the lithosphere [10]–[12].

CONCLUSION

In conclusion, the ecosystem of the Earth is a complicated and interrelated system that offers the prerequisites for life. A delicate balance is created by the interactions between the physical elements—such as the atmosphere, hydrosphere, lithosphere, and biosphere—and the chemical and biological elements. This equilibrium allows for the creation of various ecosystems, which in turn improve human welfare by supplying necessary resources and services. However, the Earth's ecosystem and capacity to support life are seriously threatened by human activities including pollution, deforestation, and climate change. Prioritizing the preservation and appropriate management of the Earth's environment is essential to ensuring a sustainable future. Adopting sustainable practices that reduce pollution, encourage conservation, and lessen the effects of climate change is necessary to achieve this. Making informed judgments and putting effective policies in place requires raising awareness and understanding of how environmental issues and human activities are intertwined. By protecting the ecology of the Earth, we can ensure the health of both the present and future generations, enabling a peaceful coexistence between people and nature.

REFERENCES

[1] E. J. Pedersen, D. L. Miller, G. L. Simpson, and N. Ross, "Hierarchical generalized additive models in ecology: An introduction with mgcv," *PeerJ*, 2019, doi: 10.7717/peerj.6876.

[2] T. Osawa, "Perspectives on biodiversity informatics for ecology," *Ecol. Res.*, 2019, doi: 10.1111/1440-1703.12023.

[3] D. Schimel and F. D. Schneider, "Flux towers in the sky: global ecology from space," *New Phytologist*. 2019. doi: 10.1111/nph.15934.

[4] N. Bocken, F. Boons, and B. Baldassarre, "Sustainable business model experimentation by understanding ecologies of business models," *J. Clean. Prod.*, 2019, doi: 10.1016/j.jclepro.2018.10.159.

[5] Rashid Khan, "Earth environments: past, present, and future," *Choice Rev. Online*, 2010, doi: 10.5860/choice.48-2096.

[6] K. Kawamura, "Hydrothermal microflow technology as a research tool for origin-of-life studies in extreme earth environments," *Life*. 2017. doi: 10.3390/life7040037.

[7] S. Hegde and L. Kaltenegger, "Colors of extreme exo-earth environments," *Astrobiology*, 2013, doi: 10.1089/ast.2012.0849.

[8] S. L. Rasmussen, T. B. Berg, T. Dabelsteen, and O. R. Jones, "The ecology of suburban juvenile European hedgehogs (Erinaceus europaeus) in Denmark," *Ecol. Evol.*, 2019, doi: 10.1002/ece3.5764.

[9] A. M. Santana-Cordero and P. Szabó, "Exploring Qualitative Methods of Historical Ecology and Their Links With Qualitative Research," *Int. J. Qual. Methods*, 2019, doi: 10.1177/1609406919872112.

[10] F. Reith, S. G. Campbell, A. S. Ball, A. Pring, and G. Southam, "Platinum in Earth surface environments," *Earth-Science Reviews*. 2014. doi: 10.1016/j.earscirev.2014.01.003.

[11] E. S. C. Emmanuel, V. Vignesh, B. Anandkumar, and S. Maruthamuthu, "Bioaccumulation of cerium and neodymium by Bacillus cereus isolated from rare earth environments of Chavara and Manavalakurichi, India," *Indian J. Microbiol.*, 2011, doi: 10.1007/s12088-011-0111-8.

[12] T. Zhang *et al.*, "The technology of lunar regolith environment construction on Earth," *Acta Astronaut.*, 2021, doi: 10.1016/j.actaastro.2020.08.039.

CHAPTER 5

FEATURES OF ECOLOGICAL ABIOTIC FACTORS

Ms. Meenakshi Jhanwar
Assistant Professor, Department of Environmental Science,
Presidency University, Bangalore, India.
Email Id: meenakshi@presidencyuniversity.in

ABSTRACT:

The term "ecological factors" refers to the different components and mechanisms that affect how ecosystems are organized and function. The significance of ecological factors in determining the distribution and abundance of organisms as well as the general dynamics of ecological communities is examined in this chapter. In order to understand and manage ecosystems, it examines important ecological elements like climate, habitat, resource availability, and species interactions. The distribution, quantity, and diversity of species in an ecosystem are influenced by ecological abiotic variables, which are non-living elements of the ecosystem. These elements include environmental physical and chemical characteristics like temperature, sunlight, water accessibility, soil composition, and nutrient levels. For one to understand ecosystem dynamics, species interactions, and ecosystem reactions to environmental changes, one must understand and research these abiotic elements. An important abiotic element that influences biological processes, species ranges, and community makeup is temperature.

KEYWORDS:

Abiotic Factors, Climatic Factors, Importance of Light, Physiographic Factors, Physiological Impact, Soil (Edaphic Factor).

INTRODUCTION

A community of living things interacting with their non-living surroundings is referred to as an ecosystem. The ecosystem, the fundamentally useful ecological unit, is the focus of contemporary ecology. Ecosystems are made up of species that interact with one another and their environment in a way that transfers energy and leads to the emergence of system-level processes like the cycling of elements. The term "ecosystem" was first used by A.G. Tansley in 1935 to refer to a group of living things that coexist with their surrounding physical environment and are situated in a particular location. Chemical, physical, and biological components all make up the environment. A component becomes a factor when it has an impact on an organism's quality of life [1], [2].

A living creature in any environment is impacted by a variety of forces and factors known as eco-factors or ecological factors. There are two main categories of environmental influences on behavior, development, distribution, abundance, and ultimately the survival of organisms: abiotic (non-living) environments that control population interactions, and biotic (living) environments that include population interactions with other populations as well as internal instinctive control mechanisms.

The following three categories can be used to classify all of these ecological factors:

1. Abiotic elements
2. Biotic elements
3. human-made Causes

Abiotic factors: Abiotic variables are inanimate, chemical, and physical components of the environment that are necessary to preserve life as we know it. Abiotic influences include things like climate, graphics, and geography. The environment of an organism is made up of all of these components in total [3], [4]. The range between two limitations is known as the limit or zone of tolerance, and every organism has an ecological minimum and maximum for each factor. Various scientists have offered several rules and principles to describe how various limiting conditions affect living things. Victor Ernest Shelford, an American zoologist, introduced the law of tolerance, sometimes known as Shelford's law of tolerance, in 1911. According to the legislation, where levels of these factors surpass the maximum or lowest limits of tolerance of that organism, the abundance or distribution of that organism can be influenced. Examples of these elements include the climatic, topographic, and biological requirements of animals and plants [5], [6].

For instance, all soil nutrients are equally needed for the appropriate development and growth of plants, but anything in excess may prevent the uptake of another nutrient, which would prevent proper growth. In 1840, German biochemist Justus Liebig proposed the Law of Minimum, which argues that an organism's growth is based on the amount of food that is provided to it in the smallest possible quantity. For instance, if the soil lacks one nutrient, it will render the other nutrient biologically inactive and limit the plant's ability to grow properly. The Laws of Limiting Factors proposed by British Physiologist F.F. Blackman (1905) also integrate Liebig's Law of Minimum. According to the rule of limiting factors, a biological process is regulated by a variety of variables, and a lack of any one of these variables will have an impact on the process as a whole [7], [8]. Taking photosynthesis by plants as an example. Blackman identified five variables that affect the rate of photosynthesis, including the amount of water, carbon dioxide, chlorophyll, solar radiation intensity, and chloroplast temperature. Animal functions follow the same rules of limiting factors. The following list includes the abiotic variables or influences that have an impact on living things:

Climatic factors: Climate refers to a region's long-term pattern of weather. The climatic conditions of a region are determined by several major natural elements, including climate, which also has an impact on plant life. Climatology is the field's research. The following categories are used to classify the climatic factors:

1. Light
2. Thermometer
3. Water (Precipitation and Humidity)
4. Wind
5. Fire

1\. Light: One of the most crucial abiotic elements required for the existence of life is light. Sunlight, moonlight, starlight, and the light emitted by luminescent creatures are the main sources of natural light. The primary source of light is the sun. The region of the electromagnetic spectrum that is visible to the human eye is called light. Scientists refer to the complete range of visible light as the electromagnetic spectrum. The electromagnetic spectrum is typically divided into seven sections: radiowaves, microwaves, infrared, visible light, ultraviolet, x-rays, and gamma rays. These regions are arranged in decreasing wavelength and increasing energy and frequency order. A photon, a unit of electromagnetic radiation, has a specific amount of energy. High-energy photons are present in short-wavelength radiation types, while low-energy photons are present in long-wavelength radiation types. The electromagnetic spectrum is divided into three groups by scientists. Cosmic rays, x-rays, and ultraviolet rays are all classified as short waves and have wavelengths between 0.4 and 0.7 mm. It is often referred to as PAR or photosynthetically active radiation [9], [10].

On a clear day, there is around 10% ultraviolet, 45% visible light, and 45% infrared energy that reaches the surface of the planet. Infrared waves are medium-sized waves (longer than 0.740 mm). It is a type of solar kinetic energy that flows in waves in the form of minuscule particles known as photons or quanta. Vibrant, indigo, blue, green, yellow, orange, and red (VIBGYOR) are seven various colors that are displayed when sunlight passes through a prism. These hues together make up the visible spectrum of light, which has an impact on plant physiological activities including photosynthesis. There are three different forms of UV radiation based on wavelength. These include UV-A rays (320–400 nm), The UV-B spectrum (280–320 nm), and the UV-C spectrum (100–280 nm).

Out of these three radiation kinds, UV-C is toxic to living things whereas UV-B is damaging. The angle of incidence, latitude and altitude, season, time of day, the amount absorbed and diffused by the atmosphere, and several climatic and topographical variables all affect how much light reaches the earth's surface.

DISCUSSION

Importance of light: The influence of light on soil temperature, photosynthesis, transpiration, rate of water absorption, and other processes has an impact on plant development and distribution. The production and operation of chlorophyll depend on light. There are three aspects of this climatic factor—light intensity, light quality, and day duration or photoperiod—that have an impact on plant growth and development. The unit of measurement for light intensity is the foot-candle or 10.76 Lux, and it changes depending on the latitude and time of year. A higher rate of photosynthesis results from lighter, and a lower rate of photosynthesis results from less light. The rate of photosynthesis would rapidly decrease at very high light levels when the light began to harm the plant. The color or wavelength that reaches the plant surface is referred to as the light quality. The duration of a plant's exposure to sunlight during the nighttime hours is known as the day length or photoperiod. Numerous plant physiological processes are influenced by light. The following effects of light on plants:

(i) Photosynthesis: The most important source of energy for plants is sunlight. Since photosynthesis depends on light for success, plants are autotrophic creatures. In the presence of chlorophyll, photosynthesis is the process by which plants transform light energy into chemical energy, which is then used to create carbohydrates from carbon dioxide and water. Sunlight's varied wavelengths are not all equally utilized during photosynthesis. Instead, pigments, which are light-absorbing compounds found in photosynthetic organisms, only absorb some wavelengths of visible light while reflecting others. The range of wavelengths that a pigment absorbs is known as its absorption spectrum. The best visible light wavelengths for photosynthesis are in the blue (450–500 nm) and red (600–700 nm) ranges. To promote photosynthesis, light sources should ideally emit light in the blue and red regions. The least efficient light is green (500–570 nm). Because chlorophyll molecules in plants absorb blue and red light and reflect other hues, giving plants their characteristically green appearance. In contrast to continuous light, intermittent light speeds up photosynthesis.

(ii). Respiration is the process by which cells obtain chemical energy through the consumption of oxygen and the release of carbon dioxide. To provide energy for plant growth, plants use oxygen and the sugar created during photosynthesis during the process of respiration. The respiration mechanism is illustrated as follows:

$$C6h12O6 + 6O2\ 6CO2 + 6H2O + 32\ ATP\ (energy)$$

All living cells breathe, which is commonly referred to as cellular respiration. The breakdown of glucose molecules releases energy during a process called cellular respiration, which happens inside the cells. Both aerobic (using oxygen) and anaerobic (without using oxygen) processes can be used for cellular respiration.

No of the time of day or night, plants continually breathe. Respiration is not directly impacted by light. Because the respiratory substrates are created while the light is present, the indirect effect is crucial. The light compensation point is the level of illumination at which photosynthesis and respiration are equal. This indicates that the amount of carbon dioxide emitted during respiration is equal to the amount absorbed during photosynthesis. As the light intensity rises, the adjustment point is achieved. after the point of compensation, increasing the light intensity causes a proportional rise in the rate of photosynthesis, which continues until the point of light saturation, after which the rate of photosynthesis is unaffected by light intensity.

Effect on stomata opening and closing and transpiration: Transpiration is the biological process by which water is lost from aerial portions of plants, such as stems, flowers, and leaves, as water vapor. Lack of transpiration will cause excess water to build up inside plant cells, which will eventually cause the cells to explode. Stomata open in the daylight and close at night. The rate of transpiration directly relates to the presence of light.

Stomata's opening and closing, the permeability of the plasma membrane, and the heating effects are all influenced by light. All of these have an impact on transpiration, which has an impact on water absorption.

(iii) Plant growth and flowering: The most significant variables influencing plant growth and flowering are the length of the day, the quality of the light, and its intensity (photoperiodicity). Plants can be categorized into three classes based on their photoperiodic reactions:

(a) Short-day plants: When the days are fewer than 12 hours long, the short-day plants typically bloom. Examples include Xanthium strumarium (cocklebur), Glycine max (soybean), and Saccharum officinarum (sugarcane). Day length is important and differs between species.

(b) Plants that grow flowers on lengthy days: These plants bloom when the days are longer than 12 hours. Examples include Spinacea oleracea (spinach), Lactuca sativa (lettuce), and Daucus carota (carrot).

(c) Day-neutral plants: Day-neutral plants are those whose flowering is influenced by factors other than day length, such as age, the number of nodes, past exposure to cold temperatures, etc. Tomatoes (Lycopersicon lycopersicum) are a good example of a plant that is "day neutral" and does not blossom based on the duration of the day or night. Instead, after reaching a particular developmental age, tomato plants simply blossom. Other examples are Gossypium hirsutum (cotton), Helianthus annuus (sunflower), and Cucumis sativus (cucumber).

Heliophytes are plants that grow in direct sunlight, and sciophytes are plants that grow in shade. Some heliophytes can thrive in the shadow and are referred to as facultative sciophytes, while those that cannot are referred to as obligate sciophytes. Similar to how obligate heliophytes are sciophytes that do not grow in intense sunlight, facultative heliophytes are sciophytes that may grow in light. The heliophytes are negatively impacted by shadow, whereas shade plants continue to photosynthesize at a high rate even in low light intensities.

Sunlight has an impact on how plants travel. Heliotropism or phototropism refers to the effect of sunlight on plant movement. Positive phototropism is the term for the movement of plant components in the direction of the light source. For instance, a plant's stem will grow upward in reaction to sunshine, but negative phototropism is the movement of plant parts away from light. For instance, as roots descend into the earth, they are negatively phototropic.

Germination: Most plants require light to develop and stay healthy, but not all plants require it for germination. Some seeds grow best in complete darkness, while others thrive under constant sunlight. According to experts from Thompson and Morgan, blue light inhibits germination whereas red light encourages it. The reason for this is that red light has an impact on the plant pigment phytochrome, which is found in seeds and regulates processes including seed germination (otoplasty), chlorophyll synthesis, seedling elongation, leaf size, shape, quantity, and movement, as well as the time of flowering in adult plants. But blue light might also be required if the plants are surrounded by a dense layer of leaves. Yellow light, on the other hand, has been discovered to encourage seed germination in the Typha species and to counteract the inhibitory effects of blue light.

Effect of light on animals: Light has an impact on several aspects of animal life, including growth, development, reproduction, and diapause (the resting period), as well as migration, movement, metabolism, and other processes. Below are some of the main impacts of light on animals:

(i) Impact on metabolism: The amount of light has a significant impact on the metabolic rate of several species. Enzyme activity, overall metabolic rate, and the solubility of minerals and salts in the protoplasm all increase as the light intensity rises. Animals that live in caves are not greatly impacted by light. Gases become less soluble in high light levels.

(ii) Impact on pigmentation: Light is necessary for pigment formation. It has been discovered that pigmentation increases with light intensity. For instance, people with darkly colored skin in tropical areas have skin with higher melanin concentrations. Many creatures that live in deep water and in caves, where light has no ecological value, lack eyes altogether.

(iii) Impact on development: Light can either speed up or slow down development depending on the situation. For instance, insufficient light, salmon larvae develop normally whereas mytilus larvae grow larger.

(iv) Impact on reproduction: Light's inoculating action over the gonads causes many animals and birds to begin reproducing. Birds' gonads have been discovered to become more active in the summer (when there is lighter) and regress in the winter (when there is less light).

(v) Effect on animal movement: In some lesser species, light controls the rate of mobility. The condition is referred to as photokinesis. They come in two varieties:

(a) Phototaxis: This term refers to oriented locomotory motions towards and away from a source of light. Positive photoacoustic movement refers to an animal moving in the direction of the light source. Examples of creatures that are favorably photoactive include Euglena and Ranatra. An animal is said to be negatively photogenic when it travels away from the light source. These animals include earthworms, planarians, copepodites, slugs, and siphonophores.

(b) Phototropism: Phototropism is the movement of a portion of an organism in response to light. Animals that are sessile exhibit it.

2. Temperature: One of the most significant biological elements is temperature. The climate of a region and the distribution of plant and animal life is largely determined by the moisture and temperature acting together (Smith, 1977). The temperature around a plant determines its development and pace of growth, and each species has a defined temperature range that is represented by a maximum, lowest, and optimum. All of the metabolic processes required for life to begin in organisms begin at a specific minimum temperature. The term "optimum temperature" refers to the temperature at which physiological systems operate with the greatest efficiency. The temperature below which none of the vital metabolic processes can start and can only move slowly is known as the minimum temperature. The temperature at which no biological activity can be seen is known as the maximum temperature. Cardinal temperatures are the minimum, ideal, and maximum temperatures that vary from species to species and within the same individual from part to part. For instance, some arctic algae may complete their life cycles in locations where the temperature hardly rises above 0°C, and some hot-spring algae can live in water as warm as 73°C given the right circumstances. At temperatures above 90ºC, non-pathogenic bacteria that live in hot springs can actively develop (Bott and Brock, 1969).

Eurythermal organisms, such as jasmine, roses, conifers, daisies, Ashoka trees, and other plants, may grow despite very high-temperature swings. Stenothermal organisms are those that can only withstand a slight temperature change. Plants that produce stenosis include plumeria, bougainvillea, and eucalyptus. fungus has also been divided into the following three groups based on their ability to tolerate different temperatures: mesophilic, thermotolerant, and thermophilic fungus (R. Emerson, 1968). Thermophilic fungi need a temperature of 450C or higher to grow. The majority of plant activities, such as respiration and transpiration, are influenced by temperature.

(a) Temperature and cell: Cells and the parts that make them up are fatally affected by the minimum and maximum temperatures. Cell proteins may turn to ice at extremely low temperature. However, heat causes proteins to coagulate (Lewis and Taylor, 1967). Protein denaturation at high temperatures makes it difficult for most organisms to endure temperatures beyond 45°C. While some species can survive at slightly lower temperatures by employing antifreeze like glycerol and salts, others can survive at slightly higher temperatures thanks to heat-stable proteins.

(b) Temperature and metabolism: Normally, different types of enzymes regulate the various metabolic processes of plants, animals, and microbes, and enzyme activity is influenced by temperature. As a result, an increase in temperature, up to a certain point, results in an increase in the rate of metabolism. When the temperature rises more quickly, the metabolic rate could fall.

(c) Temperature and reproduction: The aggregate of a plant's reactions, particularly to correctly varying temperatures, determines its thermoperiodism, which influences flowering in plants. In terms of a plant's phenology, temperature is crucial. The study of periodic phenomena in plants, such as when flowers bloom with the climate, when leaves change color and fall from the trees in the fall, etc., is known as phenology.

(d) The relationship between temperature and sex ratio: In some animals, the ambient temperature affects the sex ratio. For instance, temperature affects the copepod Macrocyclops abide sex ratio. There is a huge increase in the number of men as the temperature rises. In Daphina, parthenogenetic eggs that mature into females are generated under normal circumstances. They do, however, produce sexual eggs when the temperature is elevated, and these eggs, once fertilized, can either produce females or males.

(e). Temperature and parasitic infection: Unfavourable temperatures, such as high temperatures combined with wind and high humidity, can promote the spread of bacterial illnesses on plants.

(f). Temperature and growth: The temperature in the area around a plant affects its growth and development. There is a defined temperature range for each species. Extremely low and high temperatures both have the potential to harm plant growth. Cold and heat are the two primary causes of high-temperature stress in plants. Due to the membrane's lipids' excessive fluidity at high temperatures, membrane stability declines. The membrane and cell compartment are damaged, which causes functional issues. Dehydration, chills, and freezing injuries are among the cold-related illnesses that can result from low temperatures. Desiccation occurs when tissues get dehydrated and harmed owing to winter's rapid evaporation and delayed absorption. Chilling injury can happen at a variety of low but not freezing temperatures for that species. Cellular growth, function, and coloration are all harmed by freezing. Additionally, it may cause tissue death. When the temperature falls below the freezing point of water, freezing injury happens. This causes protoplasts to shrink, chlorophyll to be destroyed, and ice to form in the spaces between cells, which causes cellular water to migrate in the direction of ice.

(g). Temperature and coloration: Many creatures, including birds, insects, and mammals, have darker pigmentation in warm, humid conditions than in cool, dry ones. The Gioger rule is the term for the phenomenon.

(h) Temperature and respiration: For poikilothermic species, the rate of respiration typically doubles with a temperature increase of 100 C, according to Vant Hoff's law. The ideal temperature for photosynthesis is lower than the ideal temperature for respiration, according to Smith (1974).

(i). Temperature and transpiration in plants: Plants lose water through transpiration from their aerial surfaces. A higher temperature increases the air's ability to contain more moisture in the form of vapor, which causes differences in vapor pressure defects and a rise in the rate of transpiration. In addition to speeding up transpiration when temperatures exceed safe levels, plants may also go dormant and form choruses.

Organism classification based on tolerance to temperature (j) The entire vegetation can be categorized into four classes according to how plants react to environmental temperature, as follows:

(i). Megatherms: Plants that demand year-round temperatures that are nearly constant at a high level. for instance, desert vegetation and tropical rainforests.

(ii). Mesotherms: Plants that thrive in environments that are neither extremely hot nor cold. Extreme heat or cold is not tolerated by these plants. Examples include aquatic flora and tropical deciduous woodlands.

(iii). Microtherms: These plants need a cool environment to flourish. High temperatures are not suitable for these plants. This group includes all high-altitude plants from tropical and subtropical areas.

(iv). Hekistotherms: Plants that can withstand extremely low temperatures. They can endure the chilly, protracted winters. for instance, alpine vegetation.

3. Water: All life on earth depends on water for survival. Animals and plants have a high amount of water; for example, the cytoplasm contains between 70 and 80 percent of water.

Two hydrogen atoms and one oxygen atom make up the molecule known as water. All living things contain the greatest amount of this substance. Water is always moving around the world and can be found in ice, snow, sleet, hail, liquid rain, and gaseous water vapor. The sun's energy controls the hydrological cycle, also known as the water cycle. By evaporating water from lakes, rivers, oceans, and even the soil, this solar energy powers the cycle. Through the process of transpiration, more water is transferred from plants to the atmosphere. By condensing, the water vapor creates clouds in the atmosphere and returns to Earth as rain and snow. The amount of water that is accessible to plants affects their ability to absorb nutrients, photosynthesis, respiration, growth, and other metabolic activities.

Water has many functions in plants. The transpiration process cools the leaves when it evaporates from the leaf tissue. It is also a key element in respiration and photosynthesis. For nutrients and carbohydrates passing through the plants, water serves as a solvent. Water is present in the atmosphere in the form of water vapor. The term for this is atmospheric humidity. The amount of solar radiation, wind, water, soil condition, temperature, altitude, and other factors all have a significant impact on humidity. The primary causes of atmospheric humidity are plant transpiration and water evaporation from the earth's surface. Many mosses, lichens, filmy ferns, and epiphytic orchids can directly absorb moisture from the air, although the majority of plants cannot. The visible manifestations of humidity are clouds and fog. A psychrometer and hygrometer are used to measure humidity, which is expressed as a percentage. Three separate terminologies are used to describe humidity:

(a). Humidity relative: The ratio of the actual amount of water vapor in the atmosphere to the maximum amount that can be held in the air at a given temperature and pressure is known as relative humidity.

(b). The "amount of water vapors present per unit weight of air" is referred to as specific humidity.

(c) Absolute humidity: The "amount of water vapors present per unit volume of air" is what is meant by this term.

Humidity has an impact on organisms in several ways, including how quickly plants transpire water. Lower transpiration rates are associated with higher humidity levels. Low relative humidity hinders plant growth by causing more water to be lost through transpiration. It also affects how quickly people sweat. Thus, sweating is increased under high humidity. Lichens and mosses that are epiphytes depend on it for water. It is crucial to the fungi's spores' ability to grow.

Precipitation: Rain, snow, sleet, or hail are all examples of precipitation, which is the discharge of water from clouds and falls to the ground. When the relative humidity of the atmosphere reaches 100%, a region of the atmosphere becomes saturated with water vapor, causing the water to condense and "precipitate" or fall. Pressure, season, wind, and temperature all affect precipitation. The productivity and species diversity of a community or perennials, as well as the vegetation of a specific region, are greatly influenced by precipitation. In many dry and semi-arid habitats, precipitation can change germination, seedling growth and survival, and phenology (the study of recurring occurrences). This can change annual production and species diversity.

The amount of precipitation as well as the timing of the precipitation at a specific location affect plant productivity. Since water is the scarcest resource in arid and semiarid ecosystems, seasonal precipitation has a greater impact on productivity than total precipitation. In addition to rain, snow, and hail, there are a few less frequent types of precipitation, including ice pellets, diamond dust, and freezing rain. Because the water vapor does not enough condense to precipitate, mist and fog are instead suspensions rather than precipitation. The most frequent type of precipitation is rainfall.

Instead of strong rains, which cause soil erosion and significant amounts of water to be lost from the soil's surface as runoff, moderate and consistent rainfall is preferable. Rainfall is used to differentiate between tropical forest zones, desert regions close to the tropics, and temperate forest zones. With 100 inches of rainfall, tropical evergreen forests can be found in India. The tropical dry deciduous forests of Sal and Teak are found in areas with just 40–50 inch rainfall, while the tropical moist deciduous forests of the Western Ghats, Chota Nagpur correlate to a rainfall of 60–68 inches. Deserts make the areas with little rainfall. Precipitation is the only source of water available to most plants in terrestrial settings for growth.

4. Wind: The invisible gas combination that makes up the troposphere is called air. The wind is the air that is moving. The uneven heating of the earth by the Sun and the earth's rotation are what generate wind, which is the movement of air. Different forms of patterns and storms can be produced by a wind that is traveling at various speeds, at various altitudes, and over either land or sea. They are a massive tropical storm that is spiraling. Hurricanes developed over warm oceans and receive their power from the latent heat of water evaporation that is drawn into the center of the low-pressure system. In the western Pacific Ocean, these tropical storms are referred to as cyclones, typhoons, and hurricanes, respectively. The wind is the world's greatest equalizer of the atmosphere, carrying heat, contaminants, moisture, and dust at tremendous distances.

Aeolian landforms are defined as the processes, landforms, and effects of wind. Wind affects trees and other species as an ecological provider and a promoter of disturbances. The effect of wind on plants is greatly influenced by its strength, duration, and ability to penetrate the canopy layers. Strong winds have a significant abrasive effect on the ground and plants because they can carry sand and snow particles. Following is a list of the effects of wind on plant life and the environment:

Physiological Impact

(i) Wind has an impact on the rate of transpiration. In areas with strong winds, there is more transpiration, which causes their tissues to lack water.

(ii). Wind increases atmospheric turbulence, which increases the amount of carbon dioxide available to plants, resulting in faster rates of photosynthesis. The rate of photosynthesis becomes constant until the wind speed reaches a particular point.

(iii). The generation of ethylene in rice and barley is increased by wind, which also alters the hormone balance.

(iv). Dwarfing: Turgidity aids in the correct sizing of a plant's growing cells. The plants that are growing in arid environments never get turgid enough to enlarge their maturing cells. As a result, all organs are little because their cells grow smaller than normal.

(v). Desiccation of the plants occurs in hot winds because dry air replaces the humid air in the intercellular spaces. For instance, the rice harvest during June and July exhibits tip drying.

(vi). Transpiration is accelerated by the wind. Plants can only develop successfully as long as they can maintain a balance between their water intake and usage. The stomata may partially or completely close if transpiration outpaces water absorption, which will impede the flow of carbon dioxide into the leaves. The pace of photosynthesis will slow down, as will growth and yield.

Mechanical impact of wind

(i). Plants may lose their leaves in strong winds, and in the worst cases, stems may break or plants may be uprooted. Typically, delicate woods from plants like cottonwoods and river maple experience similar shattering.

(ii). With lodging, agricultural plants (such as wheat, maize, and sugarcane) are flattened against the ground as a result of a strong wind. However, if the stems are not overly developed, differential development at the lower node allows the prostrate plants to partially revert to an upright position.

(iii). Because of the influence of wind, plants growing at higher altitudes have underdeveloped growth.

(iv). Deformation: The form and position of emerging shoots may change permanently when they are subjected to intense wind pressure coming from a certain direction. Deformation is the term for this. On ridged, trees with slanted trunks are frequently seen. While certain trees, like oaks, grow flattened against the ground, other trees expand their branches in a leeward orientation.

Other Wind Effects

(i). Wind erosion occurs when the soil is moved by the wind from one location to another. The transfer of soil by wind from one place to another occurs naturally. It may seriously harm the economy and ecology.

(ii). A surface of coarse-grained sand and boulders is left behind when wind causes the lifting and movement of lighter particles from dry soil.

(iii). Given that seeds, insects, and birds can move thousands of miles on wind currents, the wind is an essential mode of transportation for these items. Gymnosperms are mostly pollinated by the wind, a phenomenon known as anemophily. Anemophily is the process through which pollen is moved from one plant to another by air currents.

(iv). Strong winds along the seaside bring salt and render the soil unfit for plant growth.

(v). Many different sorts of particles, including pollen, disease-causing organisms, and moving gas molecules, including carbon dioxide and pollutants, are also dispersed by wind.

5. Fire: Fire is the stage of heat where things burn and heat and light rays are released that have an impact on the environment. Three things are required for a fire: heat, fuel, and oxygen. There are three potential causes of the fire: biological origin, illumination, and volcanic activity. The fire is typically started by humans, such as by campfires, arson, dumping lighted cigarettes, improperly burning rubbish, playing with matches or fireworks, or occasionally, most frequently in forests, by reciprocal friction between tree surfaces (such as bamboo). The following types of fire may impact plants:

(i) Ground Fire: This subterranean, flameless fire typically develops in dense accumulations of humus, peat, and other kinds of dead plants that have dried out enough to ignite. These fires are especially hazardous because they can "hibernate" below the surface during a warm winter and then reemerge when the weather warms up.

(ii) Surface Fire: This type of fire spreads over the surface of the ground, consuming any litter, living plants, shrubs, and trees that come into touch with it. The easiest type of fire to extinguish is a surface fire.

(iii) Crown fires: A fire that spreads from one plant's canopy to another by starting in dense, wooded vegetation. Crown fires present by far the greatest risk owing to their rapid spread.

Fire has a fatal direct effect on plants. Fire has a direct impact on many plant organs, including leaves, stems, and others. Higher temperatures cause protoplasm to be destroyed, which causes the death of plant organs. Large amounts of biomass can be quickly consumed by fire, which can also have detrimental effects such as air pollution, post-burn soil erosion, and water runoff. Once trees have been eliminated through logging or fire, infiltration rates increase and erosion decreases to the extent that the forest floor is unharmed. If there is a period of heavy rain after a severe fire, significant further erosion may result.

Both biological things and inanimate objects in the environment are affected by fire. Fire can endanger the local population and infrastructure. Destroying vegetation can lessen the quantity of precipitation that plants can absorb. Major fires can destroy soil humus and lower soil fertility. The following effects of fire on plants occur indirectly: Fire regulates the age of the forest by disrupting and changing succession. The number of seedlings that survive and, consequently, the number of trees per hectare are constrained by recurrent fire.

1. Fire impacts ecosystems, promoting species' flowering and fruiting while increasing the availability of seeds and berries. Fire aids in the removal of competition between surviving species. Following a fire, both the quantity and quality of browse as well as the population of wood-boring insects rise. Woodpeckers and Quail both value this.
2. Lessen competition, allowing mature trees to expand. to prevent the spread of unwanted food plants, such as shrubs or legumes that can be used for both forage and soil improvement.
3. It encourages the generation of seeds or the opening of cones and gets seedbeds ready for either naturally occurring or artificial seeding. The development of some plants, such as Populus tremuloides, is accelerated by fire.
4. Some plants, like the Banksia, lodge pole pine, and eucalyptus, produce serotinous cones or fruits that are entirely encased in resin. Only when the resin has been physically melted by the heat from a fire will these fruits or cones open to release their seeds.
5. When there is little green pasture, fire removes unappealing vegetation that has remained from previous seasons and stimulates development. Aristida stride, Cynodon dactylon, and other grasses are spurred by fire to generate vast numbers of seeds.
6. Fires frequently eliminate undergrowth, which lets sunlight reach the forest floor and supports the growth of native species, as well as alien plants that compete with native species for nutrients and space.
7. Fire clears the forest floor of trash, exposes it to sunshine, and enriches the soil by removing low-growing underbrush. Existing trees can get stronger and healthier by lessening this competition for resources.

Soil (Edaphic Factor): One of the most significant ecological elements, or edaphic factor, is soil. According to Treshow (1970), the soil is a complicated physical and biological system that gives plants food, water, and oxygen. A mixture of mineral and organic matter, the soil is the loose, friable, unconsolidated top layer of the earth's crust and contains air, water, and microorganisms. The soil is the consequence of the actions and reciprocal influences of parent rocks, climate, topography, plants, animals, and the age of land, according to Dokyachev (1879), the first soil scientist. The base for the development of terrestrial plants, including the provision of nutrients, water, temperature, and moderation, is soil. It is the topmost layer of the earth's surface, where roots develop, attach plants, and get their water and nutrients. Pedology is the study of soil science.

Soil formation: Formation of soil Minerals, water, air, organic debris, and numerous organisms that are the decomposing remains of once-living beings make up the complex blend of elements that make up soil. In addition to the action of soil organisms like fungi, bacteria, etc., and the interactions of different chemical components present in the soil, soil is generated through the disintegration and decomposition of rocks through fragmentation, break-down, or weathering.

Species of soil: The vertical cross-section of soil made up of strata that run parallel to the surface is referred to as a "soil profile." Soil horizons are the name for these strata. Each one differs from the others in terms of porosity, acidity, structure, texture, color, thickness, and composition. The letters O, A, E, B, C, and R stand in for these vistas or strata. These horizons make it easy to see the following strata from the surface downward (Figure 1):

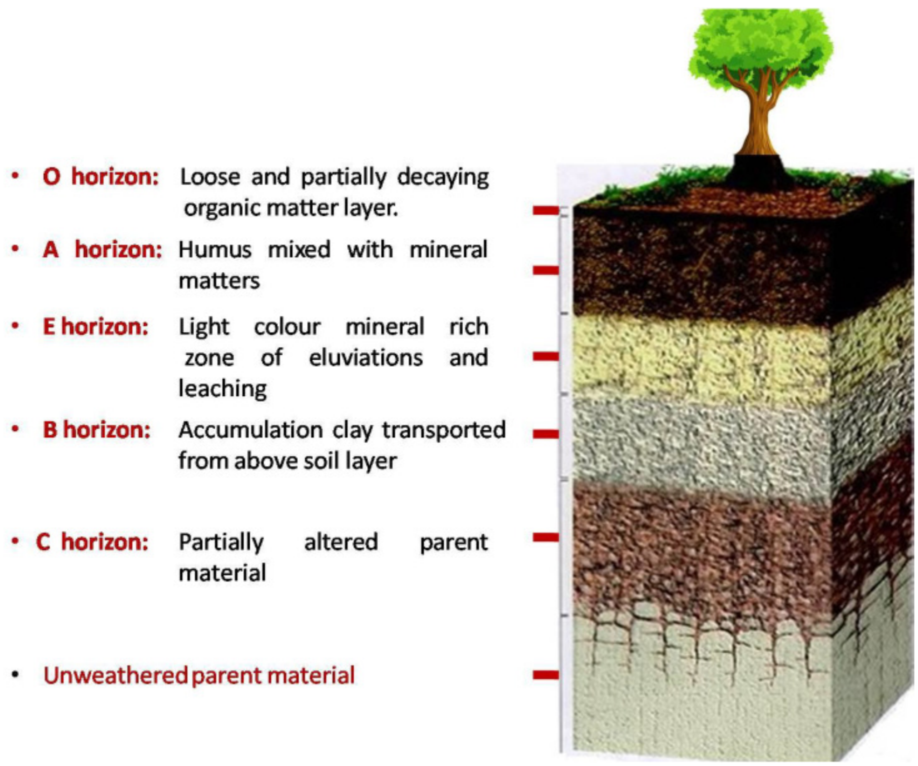

Figure 1: Species of soil [Google].

O horizon: The O horizon, also known as the litter zone, is the top horizon of the soil profile. Grass, dried leaves, dead leaves, small rocks, twigs, surface creatures, and other organic materials that have degraded make up the majority of its composition. It has the two following sublayers:

horizon O1: The topsoil layer is primarily made up of organic elements including dead leaves, bark, dried leaves, grasses, small rocks, twigs, fallen trees, fruits, flowers, animal excrement, etc. Due to the presence of organic matter, the soil is typically black or dark brown in hue.

O2 horizon: Underlying the O1 or litter horizon, the O2 horizon is made up of blackened, undetectable decomposing litter. The Duff layer refers to the upper region of the O2 horizon, which comprises partially degraded debris. Humus, a light, amorphous organic material that has entirely dissolved, is found in its lower region. Humus enriches the soil with nutrients, increasing its fertility. This layer contains a variety of live creatures, including worms, beetles, and other creatures.

A horizon: A horizon, sometimes known as topsoil, lies beneath the litter zone. A horizon encompasses the three following subzones:

(i) A1 Horizon: This is the area where soil minerals and humus are combined. The top layer of soil is made up of dark decomposed matter that has been fully mixed with the mineral soil. It is also rather rich in organic compounds. Microorganisms like bacteria, earthworms, fungi, etc. make up this stratum.

(ii) A2 horizon: The highest leaching occurs in the A2 horizon, which is located under the A1 horizon. It is a horizon with less humus and a light hue from which materials like aluminum, silicates, clays, etc. are extracted most quickly.

(iii) A3 horizon: It connects to the adjacent B horizon. It is a zone of transition between horizons A and B.

E horizon: Leached nutrients from the O and A horizons make up the E horizon. Only the oldest soils and forest soils contain it.

B horizon- The subsoil beneath A horizon is referred to as B horizon. In this region, roots do not grow well. Rich in minerals that accumulated here after leaching (moving down) from the A horizons. Additionally, it is separated into zones B1, B2, and B3. The actual soil is represented by horizons A and B taken together.

C horizon: Below the B horizon is the C horizon. The parent material for the mineral fraction of the soil is found in this layer, which is made up of weathered rock or silt. It is transparent and devoid of any organic material. Saprolite is another name for this stratum.

R horizon: Unweathered bedrock, often known as R horizon, lies beneath C horizon. It is a tightly packed, cement-bonded layer. Here, many types of rocks, including limestone and granite, are present.

The following are some significant edaphic elements that influence vegetation:

1. Soil moisture: Soil moisture is the water that is held in the soil and is influenced by temperature, precipitation, soil properties, etc. Precipitation is the principal source of soil water. water types in the soil:

(a) Gravitational water: This is a form of free water that seeps downhill via the pore spaces between soil particles and collects there as groundwater. Ecologically speaking, the leaching of nutrients depends on this soil water.

(b) Capillary water: Capillary water is the volume of water that is held in tiny interstitial spaces in the form of thin films covering the soil particles. This is easily available to plants and has a favorable water potential.

(c) Hygroscopic water: Hygroscopic Water generates an incredibly thin, tightly held layer over soil particles. It's referred to as hygroscopic water. Because the soil is holding the water so firmly, roots cannot absorb it.

(d) Water vapor: This is airborne water vapor that epiphytes' hanging roots can absorb thanks to the velamen's spongy tissue and hygroscopic hairs.

(e). Combined water: A little amount of soil water that is chemically bonded to soil constituents in the soil is known as combined water. The plants cannot get this type of water.

The term "hoard" refers to the total amount of water in the soil. The quantity of water that plants can use is referred to as chard or accessible water. Echard, or non-available water, is the term used to describe the quantity of water that plants are unable to absorb. The size of soil particles, the amount, duration, and intensity of rainfall, the distribution of precipitation throughout the year, and the pace at which water percolates are only a few of the numerous factors that affect the availability of soil moisture. A significant deciding factor of the nature, composition, and stature of vegetation wherever is the amount of soil water available to plants.

2. Soil pH: A measure of the alkalinity or acidity of the soil solution or the number of active hydrogen ions present in the soil is the soil reaction or pH. Some soils are acidic, whereas others are neutral or basic. Any pH value less than 7 is acidic, and any pH value more than 7 is alkaline. A soil with a pH of 7.0 is considered neutral. The pH range for soils is typically between 2.2 and 9.6. The availability of crucial nutrients is influenced by the PH value of the soil. For instance, some plants (Calciphytes) grow best in basic soils since they need a lot of calcium to survive. Oxylophytes are plants with minimal calcium requirements. Extremely acidic, saline, or alkaline soils frequently harm plant growth and other organisms. Zinc, copper, manganese, aluminum, and iron typically become poisonous at low pH levels. The majority of plants, however, thrive on soils that are neutral or slightly acidic in pH.

In India, places with significant rainfall such as the Western Ghats, Kerala, Eastern Orissa, Manipur, Assam, and Tripura have acidic soils (pH below 5.5 to 5.6). In India, the states of Uttar Pradesh, Punjab, Bihar, Orissa, Maharashtra, Madras, Andhra Pradesh, Madhya Pradesh, Gujarat, Delhi, and Rajasthan have saline, alkaline, or basic soils.

3. Soil Nutrients: A significant source of nutrients for plant growth is soil. Ion exchange at the surface is the process through which roots absorb nutrients. Ionic types of inorganic solutes are typically absorbed by plants. The compounds of aluminum, silica, magnesium, calcium, sodium, potassium, and iron are the main inorganic components of soil. Trace elements like manganese, copper, boron, zinc, iodine, cobalt, and molybdenum are also present in the soil. Humus, an amorphous dark-colored substance created by the partial decomposition of dead organic remnants, is the predominant organic component of soil. Chemically, the humus is composed of proteins, aromatic compounds, pyrimidines, hexose sugars, sugar alcohols, methyl sugars, oil, fat, and waxes, among other things.

4. Soil atmosphere: The soil atmosphere is made up of gases that are found in the pore spaces of soil profiles. If the solid soil particles do not contain water, the spaces between them are occupied by air. Three primary gases, namely nitrogen, carbon dioxide, and oxygen, make up the soil atmosphere. Soil air is different from atmospheric air in that it contains more CO_2, more moisture, and less oxygen. Wind, temperature, rainfall, and other factors all have an impact on the soil atmosphere. Most crops do well in loam soils with humus because they have a normal amount of water and air (about 66% water and 34% air).

5. Soil temperature: The temperature of the soil is measured, and it can be found with the aid of a soil thermometer. Soil receives thermal energy from a variety of sources, including solar radiation, the heat produced by the earth's interior, and the decomposition of organic matter. Solar radiation, soil color, soil mulching, the slope of the land surface, vegetation cover, organic matter content, and evaporation are some of the variables that determine the quantity of heat delivered to the soil surface. The temperature of the soil is lowered and made cooler by the evaporation of water from it. More radiant heat is absorbed by dark-colored soils than by

light-colored soils. The chemical, physical, and biological processes in the soil are controlled by its temperature.

6. Soil organism: The term "soil organism" refers to any living thing found in the soil. Macrofauna (earthworms, moles, and millipedes), mesofauna (mites and springtails), and microfauna (protozoan and nematodes) are the different sizes of soil organisms (fauna). Higher plant roots, soil fungi, algae, bacteria, and soil actinomycetes are all included in the category of soil plants (flora). In addition to decomposing animal and plant waste, soil organisms also fix nitrogen in the soil, decay, and cycle organic matter, break down toxic materials, aerate the soil (especially done by earthworms), break down toxicants like pesticides, produce humus, and produce polysaccharides to improve soil aggregation and increase plant nutrients in available forms. Some soil bacteria release compounds like organic acids and aldehydes in the absence of oxygen, which may have harmful effects on a variety of plants.

Physiographic factors (Topographic factors): Physiographic factors are those that relate to an area's physical characteristics. The topography of the area, the slope of the land, the height of the land above sea level, sandblasting, and silting, the degree of erosion, etc. are some of these factors. These elements affect flora, which in turn can affect how a region's climate varies. Consequently, a localized microclimate is created. The local climate, such as the immediate surroundings of plants and animals, is represented by the microclimate. Below is a discussion of a few of the significant physiographic characteristics.

1. Location altitude: The height of the land above sea level is referred to as altitude. Faster winds, lower temperatures and pressure, more humidity, and stronger light are all effects of higher altitudes. Together, these elements produce a distinct pattern of vegetational zone. As the altitude rises, wind speed also rises, accelerating the rate of transpiration. Higher-altitude plants have stunted development as a result of the effects of wind.

2. The slope's exposure and steepness: A slope is the gradient or steepness of a specific Earth surface. It has an impact on how much solar energy is absorbed during the day. The amount of solar radiation is increased by the steep slopes, especially at higher altitudes. Southern slopes in the northern hemisphere are exposed to more solar radiation than northern slopes. This is likely because during the day, sunlight strikes the steep southern slope practically vertically, but only obliquely so on the high northern slope. The qualities of soil are greatly influenced by slopes. The direction of the rain's descent Water takes soil down a hill where it may deposit in a valley after being removed from the slope. The topsoil is eroded by the water flowing down the slopes, which causes the vegetation to vanish from the region.

3. The direction of mountain chains: The amount of rainfall in a location is significantly influenced by the direction of mountain ranges. Mountain ranges influence the wind's flow, trap moisture carried by the wind on some of their sides, and condense water vapor into clouds and rain in higher elevations. This could be the cause of the high mountain's uneven distribution of vegetation, with dense vegetation on some slopes and sparse vegetation on others[1], [11].

CONCLUSION

To sum up, ecological factors are very important in defining the dynamics and properties of ecosystems. Climate affects how organisms are distributed and impact how they adapt, whereas habitat offers the ideal physical and biological circumstances for species to flourish. The quantity and interactions of species within an ecosystem are influenced by the availability of resources, such as food, water, and shelter. Additionally, interactions between species, such as rivalry, predation, and mutualism, have a significant impact on the makeup of communities and the health of ecosystems. For efficient ecosystem management and conservation, these ecological aspects must be understood and taken into account. We can create plans to safeguard and restore ecosystems, maintain biodiversity, and lessen the effects of human activity on the environment by understanding the significance of climate, habitat, resource availability, and species interactions. Studying ecological elements also helps us foresee and control ecological reactions to environmental changes like habitat loss and climate change. We can encourage sustainable practices, preserve the long-term health and resilience of ecosystems, and ensure that decisions are made using ecological principles.

REFERENCES

[1] L. R. Rivkin *et al.*, “A roadmap for urban evolutionary ecology,” *Evol. Appl.*, 2019, doi: 10.1111/eva.12734.

[2] J. Lai, C. J. Lortie, R. A. Muenchen, J. Yang, and K. Ma, “Evaluating the popularity of R in ecology,” *Ecosphere*, 2019, doi: 10.1002/ecs2.2567.

[3] L. Y. Zanette and M. Clinchy, “Ecology of fear,” *Current Biology*. 2019. doi: 10.1016/j.cub.2019.02.042.

[4] E. A. Newman, “Disturbance ecology in the anthropocene,” *Front. Ecol. Evol.*, 2019, doi: 10.3389/fevo.2019.147.

[5] M. Walker and S. Humphries, “3D Printing: Applications in evolution and ecology,” *Ecology and Evolution*. 2019. doi: 10.1002/ece3.5050.

[6] H. Lambers and R. S. Oliveira, *Plant physiological ecology*. 2019. doi: 10.1007/978-3-030-29639-1.

[7] P. Baldrian, “The known and the unknown in soil microbial ecology,” *FEMS Microbiology Ecology*. 2019. doi: 10.1093/femsec/fiz005.

[8] R. L. Putland, J. C. Montgomery, and C. A. Radford, “Ecology of fish hearing,” *Journal of Fish Biology*. 2019. doi: 10.1111/jfb.13867.

[9] L. Valera, “Human ecology. New challenges for ecology and philosophy,” *Arbor*, 2019, doi: 10.3989/arbor.2019.792n2010.

[10] S. K. Lowerre-Barbieri, I. A. Catalán, A. Frugård Opdal, and C. Jørgensen, “Preparing for the future: Integrating spatial ecology into ecosystem-based management,” *ICES J. Mar. Sci.*, 2019, doi: 10.1093/icesjms/fsy209.

[11] H. Yu, X. Liu, B. Kong, R. Li, and G. Wang, “Landscape ecology development supported by geospatial technologies: A review,” *Ecological Informatics*. 2019. doi: 10.1016/j.ecoinf.2019.03.006.

CHAPTER 6

BIOTIC AND ANTHROPOGENIC FACTORS: AN ANALYSIS

Ms. Meenakshi Jhanwar
Assistant Professor, Department of Environmental Science,
Presidency University, Bangalore, India.
Email Id: meenakshi@presidencyuniversity.in

ABSTRACT:

Ecosystem structure and function are significantly influenced by both biotic and human causes. Anthropogenic variables include the effects of human behaviour on natural systems, whereas biotic factors are concerned with living things and how they interact within an ecosystem. The significance of biotic and anthropogenic variables in forming ecosystems is examined in this chapter, with a focus on their contributions to biodiversity, ecological processes, and ecosystem services. To ensure the sustainability and resilience of ecosystems, it emphasizes the necessity of comprehending and managing these aspects. The distribution, abundance, and interactions of organisms within ecosystems are greatly influenced by biotic and human causes. The living elements of an ecosystem, including as plants, animals, microorganisms, and their interactions, are referred to as biotic factors. On the other hand, anthropogenic factors are human-caused influences that have an impact on ecosystems and can have both good and bad effects on biodiversity and ecosystem performance. The composition and number of species are shaped by biotic variables like as competition, predation, mutualism, and disease.

KEYWORDS:

Anthropogenic Factors, Biotic Factors, Global Warming, Host Plant, Human Activities.

INTRODUCTION

Biotic factors: The term "biotic" refers to a biological element in an ecosystem. The words "bio" and "stick," which both indicate "like," are combined to make the phrase "biotic." The phrase so refers to everything that is living and connected to it in an ecosystem. The biotic elements of the ecosystem are all forms of life. Biotic refers to something alive, and biotic components include other living things like plants, animals, and microorganisms. Producers, or autotrophs, consumers, or heterotrophs, and decomposers, or detritivores, are the three categories used to classify biological factors. The grass is an example of a biotic factor because it is an autotroph. Earthworms act as decomposers (detritivores) and heterotrophic consumers (deer, mouse, owl, etc.). A community is the collection of various plants, animals, and microorganisms in any given ecosystem or physical habitat. The biotic communities can range in size from enormous, like grasslands, woods, and deserts, to small, like ponds, rivers, meadows, and so forth. All of the organisms in a community live together, share a common habitat, and have direct or indirect effects on one another's lives. The interactions between organisms have a significant role in many biological processes, including reproduction, dissemination, and so forth. Any society can experience both positive and negative interactions between species. It could either be advantageous to both partners or detrimental to both, advantageous to one partner but detrimental to the other, or neutral for all parties.

Inter-specific and intra-specific ecological interactions can be distinguished from one another. Interspecific rivalry is between members of different species, whereas intraspecific competition happens between members of the same species. These connections may be advantageous or detrimental. The (+) symbol denotes a positive interaction, the 'O' sign a neutral interaction, and the (-) sign a negative effect [1], [2].

Interspecific relationship: Any community will have interspecific relationships between two or more species. These relationships fall into one of two primary categories: symbiosis, mutualism, or antagonism. Symbiotic Connections: The word "symbiosis" refers to coexistence. It is a close association between two species where one or both of them gain from the other. Lichen is the ideal illustration of a symbiotic interaction between two plants.

Algae and fungi coexist in lichens in a close-knit symbiotic interaction. Both the algal and fungal components consume the organic food that the alga produces. The alga receives moisture and mineral components in exchange for the fungal component. Mutualism, commensalism, and proto-cooperation are examples of symbiotic interactions.

(a). Mutualism: An interspecific relationship between two species that is advantageous to both parties is known as mutualism [3], [4]. Consider the collaboration between microorganisms that fix nitrogen and legume plants. A greater variety of creatures, including 1) plant-plant, 2) animal-animal, or 3) plant-animal interactions, are involved in mutual relationships. Here are some instances of mutualism:

(i) Animal pollination: The pollen is transferred from an anther to a stigma by pollinators like butterflies, bees, moths, and others. The pollinators then eat the nectar that the flower secretes.

(ii) The role of animals in fruit and seed dispersal: In general, animals aid in the movement of fruits and seeds from one location to another. Ants are effective transporters of cereal grains and oily seeds.

(iii). Fixation of symbiotic nitrogen takes place when bacteria that fix nitrogen are associated with plant roots. The relationship between bacteria of the genus Rhizobium and legumes is the most well-studied example. The bacteria receive nutrients from the host plant, and in exchange, the bacteria fix atmospheric nitrogen into a form that the host plant can absorb.

(b). Commensalism: Commensalism is a partnership in which one species gains and another is unaffected. For shelter and sustenance, for instance, barnacles "ride" with whales, whereas epiphytes live on the host plant and get sunlight and nutrition from it. Lianas are yet another illustration. Lianas are woody vascular plants that have roots in the soil at ground level.

To reach the top of the plant canopy, they rely on trees as well as other types of vertical support. Examples of Lianas include Bauhinia valid, Tinospora, Entada gigas, etc. The relationship between lianas and trees is a form of commensalism because the tree only serves to support the plant.

(c) Proto-cooperation: This beneficial interaction, from which both species gain, is not necessary for the existence of either species. The removal of ectoparasites off the back of cows by birds that consume the parasites is an illustration of proto-cooperation. In this connection, the birds receive food from the cleaned-up cattle, and the cattle, in turn, get rid of parasites.

2. Antagonism or Negative Interaction: This term refers to an interaction between members of two different species in which either one or both suffer harm (Clarke, 1954). Antagonism in relationships includes:

(a). Parasitism: When one species (the parasite) benefits at the expense of another species (the host), this is known as parasitism. animals or plants that reside on or within their hosts and rely on those hosts for food. The stem or root of the host plant is where plants that receive all or a portion of their sustenance from another living plant grow. The haustoria, or specific sucking roots, of parasitic plants, enter the host plant and attach them to the conducting system, which may be the phloem, xylem, or both. Cuscuta (total stem parasites), Balanophora, Rafflesia, Orobanche (complete root parasites), Cassytha, Viscum, Loranthus (partial stem parasites), Striga, Santalum album (partial root parasites) are a few examples of parasitic plants.

(b) Predation: Predation is a type of biological interaction in which a predatory organism kills a prey organism to get nourishment. The prey is the living thing that is murdered for food. A carnivore typically preys on another carnivore or a herbivore for sustenance. Although most predatory creatures are mammals, like bats that eat insects and snakes that devour mice, there are some predatory plants as well, including nepenthes, Darlingtonia, Dionaea, Sarracenia, and Drosera. These plants all feed on insects and other tiny species. These plants are referred to as carnivorous plants. Fish, ducks, and other animals eat aquatic plants.

(c) Competition: Competition is the interaction of organisms and species when both have a simultaneous need for the same finite resources. Intraspecific and interspecific competition can take place between members of the same species. Plants compete with animals for resources like food and shelter, including nutrients, light, water, space, pollinators, etc. (i) Intraspecific competition: This refers to interactions between members of the same species. When it comes to habitat, food, pollination, etc., all species have comparable demands. There is a lot of rivalry. (ii). Competition between various species is known as interspecific competition. In grasslands, a diverse variety of grasses can grow since there is typically little competition for nutrients. Different species of grasslands compete with one another for life when there is water scarcity. The capacity to travel to new places, access to water, and availability of nutrients are essential for success in this battle. Trees, bushes, and other plant life found in forests fight with one another for sunlight, water, and nutrients. They compete for fruit and seed dispersion as well as pollination. Utricularia, a type of bladderwort, competes with microscopic fish for insects and crustaceans.

(d) Ammensalism: The 'O' symbol indicates commensalism, which is an ecological relationship in which one species suffers harm or extinction while the other either gain an advantage or is unharmed. For instance, Trichoderma inhibits the growth of the fungus Aspergillus, while Penicillium notatum generates penicillin, which prevents the growth of many bacteria, including staphylococci. Another illustration is the commensalism that exists between people and other creatures that are endangered by human activity. such as ecological mishaps, fires that destroy habitats, etc. In many instances, the negative consequences are caused by specific chemicals that one group releases into the environment as poisons.

Allelochemicals are the name for these substances. There are three different kinds of them: allomones, depressants, and kairomones. Chemicals called allomones provide organisms that make them with an adaptive benefit. Allomone production is a typical method of defense, especially by plant species against insect herbivores. Certain species release depressants that harm or hinder the recipient without providing any benefit to the releasing organisms. The red tide is an example. Red tide is an algal bloom that can cause fish and other aquatic animals to become intoxicated and die. Kairomones are substances that a live organism produces and releases; they are advantageous to the recipient but harmful to the donor. To protect the nematodes from predators, for instance, the chemical emitted by nematodes drives some fungi to develop traps for nematode worms.

DISCUSSION

Interspecific interactions/ Co-evolutionary dynamics:

1. Mimicry: Mimicry is a behavioral adaptation in which a living organism alters its form, behavior, structure, and appearance to resemble another living organism or item to protect itself from predators and survive. In plants, mimicry aids in pollination as well as providing defense against herbivores. types of plant mimicry

(i) Batesian mimicry: A predator would avoid a non-poisonous species (the mimic) because it resembles a poisonous species (the model), which is toxic.

(ii). Bakerian mimicry: In a kind of mimicry known as Bakerian mimicry, female flowers imitate males of the same species.

(iii). Mullerian mimicry: When two toxic species resemble one another, the predator avoids both out of uncertainty.

(iv). Dodsonian mimicry: Dodsonian mimicry is a type of mimicry in which plants imitate another species' flowers or fruits to entice pollinators. The false fruit used to disperse seeds fascinates the feeders of other species.

(v). Pouyannian mimicry: In this type of mimicry, flowers visually imitate a female mate, but the main stimuli are chemical and tactile.

(vi). Leaf mimicry: To stave off herbivory, climbing plants' leaves mirror the leaves of the trees that support them. For instance, the woody wine Boquila trifoliolata imitates the leaves of the trees that it is supported by.

(vii). Cryptic mimicry: The mimicking plant should resemble its host in cryptic mimicry; this can be accomplished by visual or textural alteration.

(viii). Pseudocopulation is the act of male insects bringing pollen to a female bug in an attempt to mate while pollinating plants, most notably an orchid.

(ix). Vavilovian mimicry is a type of mimicry in which an inadvertently artificially selected weed is made to resemble a crop plant. It is also known as weed mimicry or crop imitation.

Myrmecophily: The term "myrmecophily" refers to the advantageous interspecies relationships that exist between ants and a variety of other creatures, including plants, specific arthropods, and fungi. Ants occasionally seek refuge in trees (such as Litchi, Jamun, Mango, Acacia, etc.) and protect the plants from intruders by serving as their bodyguards. In exchange, the plants give these ants food and a place to live. Acacia and acacia ants, for instance.

Co-evolution: The contact between two or more species that last for generations results in reciprocal modifications to both species' genetic and physical traits. Co-evolution is the name for this process of evolution. One species' evolution is reliant on another species' evolution. Numerous types of pollinating insects have a tight interaction with flowering plants. For instance, bees and flowers have developed a tight symbiotic interaction over time. Bees acquire pollen and nectar from flowers, and while they fly around transferring pollen from blossom to flower, they are assisting in the reproduction of the blooms. The co-evolution of the fig wasp and the Ficus (fig tree) is a striking illustration of the co-evolution of plant and insect species [5]–[7].

Anthropogenic factors: Anthropogenic activities are those that are human-made. Any changes in nature brought on by people are referred to as anthropogenic changes. Humans play a crucial role in the complex ecosystem known as "the ecosphere," and anthropogenic activities interrupted ecological processes, which led to environmental deterioration that had an impact on people just as much as it did on other living things and animals, plants, and microbes. It resulted from human actions that restricted the environment and depleted the biosphere's natural resources.

The phrase is occasionally used to allude to pollution emissions brought on by human activities, but it more widely refers to significant environmental effects produced by humans. Agriculture, forestry, urbanization, and industry have all contributed to a range of ecosystem changes as a result of human activity.

The following factors contribute to anthropogenic activities:

1. Human overpopulation: The phrase "human overpopulation" describes how the world's population of people interacts with the environment. When a population's ecological footprint exceeds the amount of space that can support them in a given region, it is said to be overpopulated. Over farming, global warming, deforestation, water pollution, and eutrophication are only a few of the negative ecological and economic effects of overpopulation.

2. Overconsumption: When renewable natural resources are used more than they can replenish, this is referred to as overconsumption. Overconsumption over an extended time eventually results in the depletion of resource bases.

3. Technology: The use of technology frequently has unanticipated and inescapable effects on the environment. Technology-related environmental effects are frequently seen as inevitable for many reasons.

4. Light pollution is the presence of unwelcome, excessive, or unsuitable artificial lights. Commercial, residential, and industrial exterior lighting that is poorly designed has a substantial impact on light pollution. It interferes with wildlife's nocturnal behavior, raises atmospheric carbon dioxide levels, and blocks out the stars at night. Sky glow, glare, and light trespass are the three basic categories of light pollution.

5. Introduction of species: Any non-native species that significantly alters or disturbs the ecosystems it colonizes is considered an introduced species. Invasive species are newly introduced organisms that significantly alter their host environments. These implications include modifying ecosystem functioning and out-competing native species, sometimes leading to their extinction.

6. Energy: Harvesting and consumption: Harvesting and using energy For small wireless autonomous devices, such as those used in wearable electronics and wireless sensor networks, energy harvesting is the process by which energy is derived from external sources (such as wind energy, solar power, thermal energy, kinetic energy, and salinity gradients), captured, and stored. Examples of energy sources include pressure or vibration (captured by a Piezoelectric element), light (captured by photovoltaic cells), radio energy (captured by an antenna), temperature differences (captured by a thermoelectric generator), and even energy produced biochemically (such as by cells obtaining energy from blood sugar). Any energy utilized to act is referred to as being consumed, and the usage of fossil fuels contributes to climate change and global warming.

7. Mining: The process of mining involves the removal of usable resources from the soil. Potential harmful element accumulation from mining operations results in unnatural enrichment, ecological pollution, and environmental damage.

8. Transportation: Transportation systems, including infrastructure and vehicle operations, have an impact on the environment in a variety of ways, including noise, the discharge of pollutants, and climate change. For example, over the past few decades, vehicle pollution has led to an increase in the worldwide concentration of N2O, a particularly potent greenhouse gas.

9. Environmental degradation: Environmental degradation is the deterioration of the environment as a result of processes like improper land use and natural disasters, as well as the depletion of resources like the quality of the air, soil, and water; the destruction of ecosystems; the extinction of wildlife; the destruction of habitats; and the extinction of wildlife.

10. Human influence on the nitrogen cycle: Nitrogen undergoes many chemical transformations as it moves through the atmosphere, marine ecosystems, and terrestrial ecosystems in the nitrogen cycle, a biogeochemical cycle. The nitrogen cycle has been significantly impacted by anthropogenic activity. The amount of biologically accessible nitrogen in an environment can be significantly increased by burning fossil fuels, using fertilizers with nitrogen, and other practices. For instance, urea is a crucial nitrogenous fertilizer that replenishes the soil's depleted nitrogen reserves. In a laboratory, organic compounds are initially created. The nitrogen cycle in nature is impacted by the usage of nitrogenous fertilizers.

11. Ozone depletion: Ozone depletion is the steady lowering of the ozone layer over the earth's surface due to the production of chemical compounds from industry and other human activities that contain gaseous chlorine or bromine. The main factors that contribute to ozone molecule depletion include interactions with various anthropogenic and natural substances, the lack of solar radiation during the polar winter, a stable polar vortex that prevents ozone from polar regions from penetrating the atmosphere, and the development of polar stratospheric clouds (PSO). Particularly in the Antarctic region, these characteristics are noticeable.

12. Global warming: Global warming is the rise in atmospheric temperature brought on by an increase in certain gases. Although climatic change may be natural, human activities have been the primary cause of it. This is mainly because burning fossil fuels increases the amount of heat-trapping greenhouse gases in the earth's atmosphere.

13. Mass extinction, defaunation, and reduction in biodiversity: A mass extinction event occurs when a significant amount of the world's variety is lost and species disappear considerably more quickly than they are replaced. The global, local, or functional extinction of an animal or species from a biological community is known as defaunation. In terms of biodiversity reduction, species extinction is only one aspect. It also encompasses the extinction of ecosystems and the loss of genetic diversity within species. Invasive species, habitat loss, pollution, climate change related to global warming, and overexploitation (overfishing, overhunting, and overharvesting) for things like food, medicines, and lumber are the five main causes of biodiversity loss. Humans and their actions play direct roles in each situation.

14. Habitat destruction: Habitat destruction is the process by which native species cannot survive in their natural habitats, which leads to the eradication or destruction of biodiversity.

15. Land degradation: Land degradation is the loss or deterioration of the biological or economic productivity and complexity of grassland, forest, irrigated cropland, forests, and rainfed crops as a result of natural processes, land uses, or other human activities.

16. Ocean acidification: Ocean acidification is the term used to describe a long-term decrease in the pH of the ocean that is mostly due to the ingestion of carbon dioxide.

17. Manufactured goods: Items like pesticides, cleaning supplies, paper, paint, leather, plastics, pharmaceuticals, and personal care items are all manufactured goods that contribute to environmental pollution.

18. Agriculture: Depending on the many different agricultural practices used globally, agriculture's influence on the environment varies. The impact on the environment ultimately depends on the farming system's production methods.

Human activity's effects:

1. A non-native species can be unintentionally or purposefully introduced into an ecosystem by humans. They can destroy natural habitats, disperse illnesses, and bring about extinctions. Due to competition and displacement caused by introduced species, this may harm the environment.

2. As people move into cities, natural landscapes could be destroyed. As a result, fewer habitats and food sources are available, which is negative.

3. Numerous human activities near water sources, inadequate sanitation, and contaminated water from sizable factories all significantly contribute to water pollution. The pollution in rivers is caused by the direct discharge of sewage and industrial effluent. Additionally inhospitable to aquatic life, seas, and oceans occasionally experience oil spills that have long-lasting consequences on the water.

4. One of the biggest causes of air pollution is overpopulation. Hazardous manufacturing gases are discharged into the environment, causing us to breathe air that is contaminated and dangerous, which contributes to several illnesses, including cardiovascular and respiratory diseases.

5. Soil erosion, nutrient depletion, and deforestation are the main effects of agriculture. Enhance output, there have been both beneficial and bad environmental effects. Micronutrient imbalances are one of many fertilizing issues, and they are also the most prevalent. Both the overuse of fertilizers and nitrate contamination are issues. Herbicides, insecticides, fungicides, and biocides are just a few of the pesticides that can create a variety of issues.

6. Global warming is the rapid rise in the planet's average surface temperature over the past 100 years, which is mostly attributable to greenhouse gases produced when people consume the fossil fuels required for industrialization. This is thought to be the result of the Earth's warming brought on by human activities connected to the greenhouse effect. Tsunamis, storms, and other natural disasters are brought on by the melting of ice caps and rising sea levels.

7. Ozone is a harmful gas that is destructive on Earth and plays a significant role in the atmosphere. The sun's UV rays cause harm to both people and animals. Ozone shields the earth from UV radiation, protecting us from its harmful effects. Over time, the protective layers have been dissolved all across the world. Because CFCs (chlorofluorocarbons) were utilized in freezers and fire extinguishers, this severe deterioration was only detected in the 1980s. Today, manufacturers must produce CFC-free products all across the world.

8. Overfishing and biodiversity loss put marine life in danger. The longevity of marine life is still undetermined due to ongoing water deterioration.

9. It is becoming more challenging to protect wildlife because their habitat is continuously being threatened and destroyed. Water pollution and deforestation are the primary contributors to habitat loss. Although deforestation provides humans with plenty of lands, it causes animals to lose their habitats.

10. The residents' physical and mental health suffers as a direct and measurable result of inadequate housing conditions. Due to indoor air pollution, modern high-tech buildings might have negative health effects. VOCs, polyvinyl chloride, and carbon dioxide are among the greenhouse gases produced during the production of plastics. There are many environmental effects associated with the extraction of metals from their ores, some of which may be carcinogenic (cause cancer).

11. Extraction of rich minerals and metals from the earth is known as mining. In addition to deforestation and harm to the landscape, groundwater contamination, surface water pollution, air pollution, and workplace health risks can all be the results of mining operations.

12. Every year, the transportation sector's operations discharge millions of tonnes of gas into the environment. These include heavy metals (zinc, chromium, copper, and cadmium), particulate matter (ash, dust), carbon monoxide (CO), carbon dioxide (CO_2), methane (CH_4), nitrogen oxides (NO_x), nitrous oxide (N_2O), chlorofluorocarbons (CFCs), and perfluorocarbons (PFC). Construction is impacted, agricultural output is decreased, and forest health declines as a result of acid rain.

Ecology is the scientific study of how organisms interact with their environments. Any biotic or abiotic element that affects plants and other living things is considered an ecological factor. Climate-related variables, physiographic factors, edaphic factors, biotic factors, and anthropogenic factors are the five categories into which environmental factors can be divided. Light, temperature, precipitation and air humidity, wind, and fire are the different climatic elements that are categorized. Edaphic influences are those that affect plants by way of the soil. Physiographic factors are those connected to the region's physical characteristics. These variables include the local topography, the slope of the land, the elevation of the land above sea level, the silting and blowing up of sand, the level of erosion, etc. Other living entities, including plants, animals, and bacteria, are referred to as biotic factors. Anthropogenic factors refer to all human actions that have changed various ecosystems in various ways. The main deterministic causes of species reductions and extinction are anthropogenic forces [8]–[10].

CONCLUSION

The ability of ecosystems to support biodiversity and offer crucial ecosystem services is significantly impacted by both biotic and human causes. Ecosystem function and resilience are shaped by biotic factors such as species interactions, population dynamics, and community structure. For the purpose of managing invasive species, preserving biodiversity, and repairing damaged ecosystems, it is essential to comprehend these biotic aspects. On the other hand, anthropogenic influences are a product of human activity and have a significant impact on ecosystems. Environmentally harmful practices, such as habitat destruction, pollution, climate change, and resource exploitation, can impair ecosystem functions, reduce biodiversity, and disturb ecological processes. Ecosystem preservation and sustainable development depend on identifying and reducing the harmful effects of anthropogenic influences. It is essential to take into account and manage both biotic and anthropogenic elements in order to ensure the sustainability and resilience of ecosystems. Sustainable land and resource use practices, supporting biodiversity protection and restoration, and minimizing the ecological impact of human activity should all be the main goals of conservation initiatives. Additionally, promoting environmental stewardship and raising awareness might lessen the damaging effects that human activity has on ecosystems. We can work to achieve a more harmonious relationship between human society and the natural environment by comprehending and addressing the interactions between biotic and anthropogenic variables.

REFERENCES

[1] M. J. D. Ramstead, A. Constant, P. B. Badcock, and K. J. Friston, "Variational ecology and the physics of sentient systems," *Physics of Life Reviews*. 2019. doi: 10.1016/j.plrev.2018.12.002.

[2] S. Mayanja, J. M. Ntayi, J. C. Munene, J. R. K. Kagaari, and B. Waswa, "Ecologies of innovation among small and medium enterprises in Uganda as a mediator of entrepreneurial networking and opportunity exploitation," *Cogent Bus. Manag.*, 2019, doi: 10.1080/23311975.2019.1641256.

[3] A. L. Parachnowitsch, J. S. Manson, and N. Sletvold, "Evolutionary ecology of nectar," *Annals of Botany*. 2019. doi: 10.1093/aob/mcy132.

[4] A. Hegemann, A. M. Fudickar, and J. Å. Nilsson, "A physiological perspective on the ecology and evolution of partial migration," *Journal of Ornithology*. 2019. doi: 10.1007/s10336-019-01648-9.

[5] A. Kumar, S. Kumar, and B. Deshmukh, "Geoecological integrity index for assessment and prioritisation of watersheds in the Indian northwestern Himalayan region using geoinformatics," *J. Earth Syst. Sci.*, 2021, doi: 10.1007/s12040-020-01537-3.

[6] P. Zahradník and M. Zahradníková, "Salvage felling in the Czech Republic's forests during the last twenty years," *Cent. Eur. For. J.*, 2019, doi: 10.2478/forj-2019-0008.

[7] W. F. Morris, J. Ehrlén, J. P. Dahlgren, A. K. Loomis, and A. M. Louthan, "Erratum: Biotic and anthropogenic forces rival climatic/ abiotic factors in determining global plant population growth and fitness (Proceedings of the National Academy of Sciences of the United States of America (2019) 117 (1107-1112) DOI: 10.1073/pnas.1918363117)," *Proceedings of the National Academy of Sciences of the United States of America*. 2020. doi: 10.1073/pnas.2003371117.

[8] R. I. Alfaro *et al.*, "The role of forest genetic resources in responding to biotic and abiotic factors in the context of anthropogenic climate change," *For. Ecol. Manage.*, 2014, doi: 10.1016/j.foreco.2014.04.006.

[9] J. M. Schmack, M. Schleuning, D. F. Ward, and J. R. Beggs, "Biogeography and anthropogenic impact shape the success of invasive wasps on New Zealand's offshore islands," *Divers. Distrib.*, 2020, doi: 10.1111/ddi.13021.

[10] I. Dan Guimbo, B. Morou, H. Rabiou, and M. Larwanou, "Facteurs de pression sur les parcs agroforestiers à *Vitellaria paradoxa* et à *Neocarya macrophylla* dans le Sud-ouest du Niger (Afrique de l'Ouest)," *J. Appl. Biosci.*, 2017, doi: 10.4314/jab.v107i1.6.

CHAPTER 7

THE PRINCIPLES OF AQUATIC CHEMISTRY

Dr. Krishnappa Venkatesharaju
Assistant Professor, Department of Environmental Science and Engineering,
Presidency University, Bangalore, India.
Email Id: venkateshraju.k@presidencyuniversity.in

ABSTRACT:

The study of the chemical composition and processes that take place in water environments, such as lakes, rivers, seas, and groundwater, is the focus of the area of chemistry known as aquatic chemistry. In this chapter discussed about the fundamental of the aquatic Chemistry that is used for determining water quality, researching aquatic ecosystems, and solving various environmental problems, it is essential to understand the principles of aquatic chemistry. Studying the chemical processes and characteristics that take place in aquatic settings, such as rivers, lakes, oceans, and groundwater, is known as aquatic chemistry. Understanding the behavior and fate of chemicals in water, as well as their impact on the general health and sustainability of aquatic ecosystems, requires an understanding of the underlying concepts of aquatic chemistry. The study of diverse chemical characteristics and reactions particular to aquatic environments forms the basis of aquatic chemistry principles. The behavior of dissolved gases like oxygen and carbon dioxide, the ionization of acids and bases, redox processes, and the creation and dissolution of solids in water are a few examples.

KEYWORDS:

Aquatic Chemistry, Water Quality, Aquatic System, Water System, Chemical Process, Water Treatment.

INTRODUCTION

The study of the chemical makeup and behavior of compounds in aquatic environments is known as aquatic chemistry. It includes all of the chemical reactions that take place in different aquatic ecosystems, such as the seas, rivers, lakes, and groundwater. For assessing water quality, researching aquatic ecosystems, and addressing environmental problems involving water resources, it is essential to have a solid understanding of the foundations of aquatic chemistry. Let's go deeper into the main ideas and tenets of aquatic chemistry:

1. Water as Solvent: As a solvent, water is frequently referred to as the "universal solvent" because of its special characteristics. It is a polar molecule, which means that the hydrogen atoms at one end give it a slight positive charge, and the oxygen atoms at the other end give it a slight negative charge. Due to its polar properties, water molecules can interact with other polar molecules to form hydrogen bonds, which helps a variety of chemicals dissolve more easily in water.
2. Dissociation and Ionization: A small percentage of the water molecules that come into touch with each other go through the process of dissociation, which causes them to separate into charged particles known as ions. Particularly, water molecules have the ability to split into the negatively charged hydroxide ions (OH-) and positively charged hydrogen ions (H+). This procedure affects the pH and alkalinity of the water and is crucial to a variety of chemical processes that take place in aquatic systems.

3. Acidity and pH: The pH scale measures the amount of hydrogen ions (H+) in water. It is scaled from 0 to 14 on a logarithmic scale. While pH values below 7 imply acidity and pH values above 7 suggest alkalinity, pH 7 is regarded as neutral. The availability of nutrients, chemical interactions, and the general wellbeing of aquatic creatures are all significantly impacted by the pH of aquatic systems.
4. Acid-Base Equilibrium: Acid-base reactions are crucial to the chemistry of aquatic environments. While bases take hydrogen ions or release hydroxide ions (OH-), acids are compounds that emit hydrogen ions (H+) when dissolved in water. The pH and water's ability to act as a buffer are affected by the balance between acids and bases. In the face of the addition of an acid or a basic, buffers aid to maintain stability by resisting pH fluctuations.
5. Dissolved Solids and Salinity: Salinity is the measure of the total amount of dissolved salts in water. It is an important parameter in aquatic chemistry and is affected by things like evaporation, runoff, and local geology. Various ions, including sodium (Na+), chloride (Cl-), calcium (Ca2+), and magnesium (Mg2+) are examples of dissolved solids. These ions have an impact on the density, freezing point, and osmotic balance of aquatic systems as well as their chemical makeup and behavior.
6. Redox Reactions: In redox (reduction-oxidation) reactions, electrons are transferred from one material to another. Redox reactions are essential for the transformation of pollutants and the cycling of nutrients (such as nitrogen and phosphorus) in aquatic environments. An illustration of a redox reaction is the transformation of nitrate (NO3-) into nitrogen gas (N2) during DE nitrification.
7. Bioavailability and Speciation: The accessibility and potential for uptake by aquatic organisms of chemical species in water is referred to as bioavailability. The speciation, or physical and chemical forms, of the compounds in water affect it. According on variables like pH, temperature, and the presence of ligands (molecules that attach to metal ions), substances can exist as distinct chemical species. The toxicity and possible effects on aquatic species of chemicals depend on their speciation and bioavailability.

Future Scope: The future of aquatic chemistry is crucial for tackling current environmental issues and improving our knowledge of water systems. The following areas present promising chances for fieldwork in terms of both research and application [1]–[3].

1. Emerging contaminants: There is growing worry about the presence of emerging contaminants in aquatic habitats, such as pharmaceuticals, personal care items, micro plastics, and nanoparticles. Future research in aquatic chemistry can concentrate on comprehending how these toxins are transported, changed, and perhaps affected aquatic ecosystems and human health.
2. Impacts of Climate Change: Ocean acidification, rising temperatures, altered precipitation patterns, and altered nutrient dynamics are all affecting the chemistry of aquatic systems. Research on aquatic chemistry can aid in understanding and foreseeing the effects of climate change on ecosystem functioning, species distribution, and water quality. To lessen the negative effects, it can also investigate adaptation and mitigation options.
3. Water quality, ecosystem health, and human activities like drinking water supplies and fisheries are all seriously threatened by harmful algal blooms (HABs), which are brought on by the excessive growth of specific algae species. Future aquatic chemistry research can concentrate on comprehending the chemical triggers, the elements driving bloom development, and the creation of mitigation and management measures for HABs through improved nutrient management and early detection techniques.
4. Restoration and remediation: The development of successful restoration and remediation solutions for damaged water bodies depends heavily on aquatic chemistry. Future research

can examine novel methods to clean up contaminants and improve the water quality in polluted aquatic systems, including the use of nanomaterial's, enhanced oxidation processes, and bioremediation procedures.

5. Ecosystem Services: Research on aquatic chemistry can help us understand how ecosystem services such as carbon sequestration, nutrient cycling, and water purification relate to water quality. We can decide how to manage water resources and where to focus conservation efforts by quantifying and valuing these services.
6. Development of environmentally friendly and energy-efficient water treatment systems is a burgeoning field of study. Aquatic chemistry can help with the design and optimization of water treatment procedures such membrane filtration, sophisticated oxidation, and electrochemical techniques. This entails experimenting with novel materials, comprehending fouling processes, and reducing the production of disinfection byproducts.
7. Integration of Big Data and Modelling: New methods for data gathering and modelling offer opportunity to combine extensive datasets and create forecasting models for aquatic chemistry and water quality. This can improve our capacity to foresee contamination episodes, monitor and manage water resources effectively, and optimize remediation tactics.
8. Ecotoxicology and risk assessment: By comprehending the connections between pollutants, aquatic animals, and ecosystems, aquatic chemistry studies can contribute to the subject of ecotoxicology. This information can be used to create rules and frameworks for risk assessment that will safeguard aquatic life and human health.

DISCUSSION

Importance of the water: Aquatic chemistry's future is essential for addressing today's environmental problems and expanding our understanding of water systems. Prospective areas for fieldwork exist in the following fields for both research and practical purposes:

1. Emerging pollutants, including drugs, cosmetics, personal care products, micro plastics, and nanoparticles, are causing increasing concern in aquatic environments. Understanding how these toxins are carried, modified, and perhaps affected aquatic ecosystems and human health can be the focus of future study in aquatic chemistry.
2. Impacts of Climate Change: The chemistry of aquatic systems is being impacted by ocean acidification, warming temperatures, changing precipitation patterns, and altered nutrient dynamics. Understanding and predicting the effects of climate change on ecosystem functioning, species distribution, and water quality can be aided by research on aquatic chemistry. It can also look into possibilities for adaptation and mitigation to decrease the negative consequences.
3. Harmful algal blooms (HABs), which are caused by the overgrowth of certain algae species, pose a major threat to water quality, ecosystem health, and human activities including drinking water supply and fisheries. Future research in aquatic chemistry can focus on understanding the chemical triggers, the factors influencing bloom formation, and the development of HAB mitigation and management strategies through enhanced nutrient management and early detection methods.
4. Aquatic chemistry plays a significant role in the development of effective restoration and remediation strategies for harmed water bodies. Future studies can look at cutting-edge techniques including the use of nanomaterial's, increased oxidation processes, and bioremediation procedures to remove toxins and boost the water quality in contaminated aquatic systems.
5. Ecosystem Services: Studies on aquatic chemistry can aid in our understanding of the connections between water quality and ecosystem services like carbon sequestration,

nutrient cycling, and water purification. By quantifying and valuing these services, we can decide how to manage water supplies and where to concentrate conservation efforts.

6. A growing area of research is the creation of water treatment technologies that are both energy and environmentally friendly. The design and optimization of water treatment processes like membrane filtration, advanced oxidation, and electrochemical approaches can be aided by aquatic chemistry. To do this, it is necessary to test out new materials, know the mechanisms of fouling, and cut back on the creation of disinfection byproducts.
7. Integration of Big Data and Modelling: New approaches to data collection and modelling provide the chance to combine significant datasets and produce forecasting models for aquatic chemistry and water quality. This can increase our ability to anticipate episodes of contamination, efficiently monitor and manage water resources, and maximize remediation strategies.
8. Ecotoxicology and risk assessment: Aquatic chemistry studies help advance the field of ecotoxicology by understanding the relationships among contaminants, aquatic species, and ecosystems. Using this data, procedures and standards for risk assessment can be developed to protect aquatic life and human health.

From Molecules to Oceans, Water: The Hydrological Cycle: Sources and Uses of Water: The five components of the hydrologic cycle are where the world's water supply is located. Oceans contain almost all of the water on Earth (97%). Water vapor makes up an additional portion of the mixture. Clouds, or the atmosphere. Snowpack’s, glaciers, and polar ice caps all include some water in the solid form as ice and snow. In lakes, streams, and reservoirs, surface water can be found. Aquifers underneath store groundwater [4]–[6].

The lithosphere, the region of the geosphere that is accessible to water, and the hydrosphere, where water is located, have a close relationship. Both are impacted by human behavior. For instance, altering the terrain through conversion of grasslands or forests to agricultural land or intensifying agricultural production may result in a reduction in vegetation cover, which will have an impact on the microclimate by reducing transpiration the loss of water vapor by plants. As a result, there is more erosion, rain runoff, and silt buildup in bodies of water. The nutrient cycles may be expedited, resulting in nutrient enrichment of surface waters. In turn, this may have a significant impact on the chemical and biological makeup of water bodies. Humans typically consume fresh surface water and groundwater, the sources of which might be very different from one another. A minor portion of the water supply in arid areas comes from the ocean; this source will become more important as the world's freshwater supply declines relative to demand. In some locations, brackish or saline groundwater’s can also be used.

The average amount of water that falls as precipitation each day in the continental United States is 1.48 1013 L, or 76 cm/yr. About 1.02 x 1013 L/day, or 53 cm/year, of that total is lost by evaporation and transpiration. Thus, just 23 cm/year, or around 4.6 1012 L/day, of water is theoretically accessible for usage. Currently, the United States uses 8 cm, or 1.6 1012 L/day, of the average annual precipitation. This represents an almost 10-fold increase from a daily usage of 1.66 1011 L in 1900. The per capita growth from around 40 L/day in 1900 to about 600 L/day today is even more astounding. High agricultural and industrial use, which together make up around 46% of overall consumption, is largely responsible for this increase. The final 8% is used for municipal purposes. But after 1980, the rise in water consumption in the US significantly decreased. The success of water conservation initiatives, particularly in the industrial (including power generation) and agricultural sectors, has been credited for this trend. Most of the lower use in the industrial sector can be attributed to conservation and recycling. By switching from spray irrigators, which lose a lot of water to the action of the wind and to evaporation, to irrigation systems that apply water, irrigation water has been used far more effectively.

Characteristics of Water Body's: The chemical and biological processes that take place in water are greatly influenced by the physical state of the water body. Streams, lakes, and reservoirs are the main habitats for surface water. Wetlands are floodplains where the water is shallow enough to support the growth of plants with roots that extend below the surface. Estuaries are the ocean's outflow channels for streams. Estuaries have special chemical and biological characteristics due to the mixing of fresh and salt water. The fact that many marine species spawn in estuaries makes it crucial to protect them.

The peculiar temperature-density connection of water causes the creation of separate layers inside no flowing bodies of water. In the summer, heat from the sun causes an upper layer, known as the epilimnion, to warm up and float on top of the lower layer, known as the hypolimnion. Thermal stratification is the term for this process. The two layers do not mix when there is a significant temperature differential between them; instead, they react independently and have highly different chemical and biological characteristics. The epilimnion may have a dense bloom of algae if it is exposed to sunlight. The epilimnion has significantly greater amounts of dissolved oxygen (DO) and is often aerobic as a result of exposure to the atmosphere and (during the day) because of the photosynthetic activities of algae. Water in the hypolimnion may become anaerobic (lacking DO) due to bacterial action on biodegradable organic material. In the hypolimnion, chemical species in a relatively reduced form hence tend to prevail.

The metalimnion, also known as the thermocline, is the shear plane, or layer, that lies between the epilimnion and hypolimnion. When the epilimnion cools during the autumn, the temperatures of the epilimnion and hypolimnion converge at this location. Overturn is the term for the resulting mixing that occurs when thermal stratification vanishes and the entire body of water behaves as a single hydrological unit. Additionally, an overturn typically happens in the spring. Numerous chemical, physical, and biological changes may happen as a result of the overturn, which causes the water body's chemical and physical features to become considerably more consistent. The blending of nutrients may result in an increase in biological activity. Processes for treating water may be interfered with if the composition of the water changes during overturn.

Marine Life: An aquatic ecosystem's living creatures (biota) can be categorized as either autotrophic or heterotrophic. Autotrophic organisms convert simple, nonliving inorganic material into the complex life molecules that make up living organisms using solar or chemical energy. The most significant autotrophic aquatic creatures are algae since they are solar-powered producers who produce biomass from CO2 and other basic inorganic species. The organic compounds created by autotrophic organisms are used by heterotrophic organisms as energy sources and as the building blocks for the production of their own biomass. Decomposers (or reducers) are a subclass of heterotrophic organisms that are primarily made up of bacteria and fungus. They eventually break down biological material into the simple molecules that the autotrophic organisms initially fixed. Productivity is the capacity of a body of water to generate living things. Physical and chemical components combine to produce productivity. A sufficient supply of carbon (CO2), nitrogen (nitrate), phosphorus (orthophosphate), and trace elements like iron are necessary for high productivity. Low productivity water is typically preferred for swimming or water supply.

In an aquatic ecosystem, the foundation of the food chain and the maintenance of fish require relatively high productivity. A phenomenon known as eutrophication is the outcome of excessive productivity, which causes the biomass generated to degrade, consume DO, and emit odors. In most aquatic systems, life forms other than algae and bacteria like fish, for instance make up a relatively modest portion of the biomass. These higher living forms barely have any impact on the chemistry of the water. However, the physical and chemical characteristics of the body of water in which it dwells have a significant impact on aquatic life. The three main physical factors influencing aquatic life are temperature, transparency, and turbulence. While most organisms are killed by extremely high temperatures, very low water temperatures cause biological processes to proceed very slowly. The growth of algae is significantly influenced by the transparency of the water. The mixing processes and the movement of nutrients and waste materials in water are both significantly influenced by turbulence. Plankton are tiny organisms that rely on water currents for movement.

The main factor in influencing the quantity and types of life in a body of water is DO often. Many aquatic animals, including fish, die from oxygen deficiency. Numerous types of anaerobic bacteria can also die in the presence of oxygen. The amount of oxygen used during the biological degradation of organic matter in a given volume of water is known as the biochemical oxygen demand, or BOD. This pollutant is treated as a water pollutant in Section 7.9. In addition to being created by respiration in sediments and water, carbon dioxide can also enter water from the atmosphere. Algae need carbon dioxide to produce biomass through photosynthetic processes, and in some situations, this gas might be a limiting factor. Excessive algal growth and biomass productivity can be brought on by high concentrations of carbon dioxide released by the degradation of organic materials in water. The kind of living forms that are present also depend on the salinity of the water. Water used for irrigation may absorb dangerous amounts of salt. Many freshwater creatures are salt-intolerant, whereas marine life obviously needs or tolerates salt water.

An Overview of Aquatic Chemistry: To comprehend water contamination, one must first have a basic understanding of the chemical processes that take place in water. Aquatic acid-base and complexation phenomena are covered in the subsequent sections of this chapter. In Chapter 4, oxidation-reduction reactions and equilibria are covered solubility calculations and interactions between liquid water and other phases are covered in more detail. Provides an illustration of the primary classifications of aquatic chemical phenomena. Acid-base, solubility, oxidation-reduction, and complexation reactions are among the chemical processes that are involved in aquatic environmental phenomena.1 Reaction rates (kinetics) are crucial in aquatic chemistry, even though the majority of aquatic chemical phenomena are described here from a thermodynamic (equilibrium) perspective.

Organisms, gas phases, and mineral phases: They are open, dynamic systems with changeable energy and mass inputs and outputs. As a result, a real equilibrium condition is rarely reached, even if an aquatic system that is roughly steady-state sometimes exists. The majority of metals discovered in natural waters do not reside there as straightforward hydrated captions, and oxyanions are frequently discovered as polynuclear species rather than as straightforward monomers. The behavior of these creatures has a significant impact on the chemical species in water containing bacteria or algae. As a result, it is impossible to accurately describe the chemistry of a natural water system using parameters such as acid-base, solubility, and complexation equilibrium constants, redox potential, pH, and other chemical variables. As a result, the systems must be characterized by simplified models, frequently built on the principles of chemical equilibrium. Such models can provide important generalizations and insights on the nature of aquatic chemical processes as well as guidance for the description and measurement of natural water systems, even though they are neither accurate nor totally realistic. Such models, despite being substantially simplified, are particularly useful for visualizing the factors that affect chemical species and their reactions in naturally occurring waters and wastewaters. Organisms, gas phases, and mineral phases. They are open, dynamic systems with changeable energy and mass inputs and outputs. As a result, a real equilibrium condition is rarely reached, even if an aquatic system that is roughly steady-state sometimes exists. The majority of metals discovered in natural waters do not reside there as straightforward hydrated captions, and oxyanions are frequently discovered as polynuclear species rather than as straightforward monomers.

The behavior of these creatures has a significant impact on the chemical species in water containing bacteria or algae. As a result, it is impossible to accurately describe the chemistry of a natural water system using parameters such as acid-base, solubility, and complexation equilibrium constants, redox potential, pH, and other chemical variables. As a result, the systems must be characterized by simplified models, frequently built on the principles of chemical equilibrium. Such models can provide important generalizations and insights on the nature of aquatic chemical processes as well as guidance for the description and measurement of natural water systems, even though they are neither accurate nor totally realistic. Such models, despite being substantially simplified, are particularly useful for visualizing the factors that affect chemical species and their reactions in naturally occurring waters and wastewaters [7]–[9]. Aquatic chemistry heavily relies on biological processes. As an illustration, algae engaged in photosynthesis can increase the pH of water by eliminating aqueous CO2, which changes an HCO3 - ion into a CO3 2-ion. This ion then interacts with the Ca2+ in the water to precipitate CaCO3. It is harder to characterize chemical events in natural water systems than it is in the well-regulated settings of the laboratory. Due to the complexity of these systems, numerous factors must be taken into account while describing their chemistry. These systems include water in addition to organisms, gas phases, and mineral phases. They are open, dynamic systems with changeable energy and mass inputs and outputs.

Water Gases: The health of aquatic life depends on dissolved gases, specifically O2 for fish and CO2 for photosynthetic algae. The mortality of fish due to bubbles of nitrogen generated in the blood brought on by exposure to water that is oversaturated with N2 is one issue that can be caused by some gases in water. In 1986, 1700 people in the African nation of Cameroon perished from suffocation caused by volcanic carbon dioxide that resulted from supersaturated dissolved CO2 in the lake's waters. As per Henry's law, which states that a gas's solubility in a liquid is inversely proportional to the partial pressure of that gas in contact with the liquid, the solubility's of gases in water are computed.

Advantage of Aquatic Chemistry:

1. Grasp of Chemical Composition, Behavior, and Processes in Water Systems: Aquatic chemistry offers a thorough grasp of the chemical composition, behavior, and processes taking place in water systems. It enables researchers to look at how water interacts with ions, minerals, contaminants, and organic compounds, leading to a comprehensive understanding of aquatic habitats.
2. Aquatic chemistry is essential for determining and keeping track of the water quality. It aids in the identification of possible hazards, pollution sources, and effects on aquatic ecosystems and human health by analyzing the chemical characteristics of water, such as pH, alkalinity, dissolved oxygen, nutrients, and pollutants. Making educated judgments about the management of water resources and the prevention of pollution requires the use of this knowledge.
3. Identification of contamination origins: Aquatic chemistry is useful in locating and identifying the origins of contamination in water bodies. It is possible to identify the origin

and pathways of contaminants by examining the chemical fingerprints and particular isotopic signatures of pollutants, assisting in pollution prevention and mitigation measures.

4. Environmental Impact Assessment: Conducting environmental impact assessments requires a thorough understanding of the chemical processes that occur in aquatic systems. The evaluation of potential ecological risks and the creation of effective mitigation strategies are made possible thanks to the insights provided by aquatic chemistry into the fate, transport, and transformation of pollutants.
5. Aquatic chemistry offers insights into nutrient cycling, ecosystem dynamics, and water treatment technologies, all of which are important to sustainable water management. It aids in the development of effective nutrient removal techniques, water treatment systems, and sustainable management practices that reduce their negative effects on the environment and maximize the advantages of water resources.
6. Policy Development and Regulation: The scientific foundation for policy development and regulation relating to water quality and pollution management is provided by the insights acquired from aquatic chemistry research. Decision-makers, stakeholders, and regulatory authorities can design efficient policies and standards for safeguarding water resources and aquatic ecosystems with the support of the data and knowledge acquired [10]–[12].

CONCLUSION

The foundational principles of aquatic chemistry offer a strong basis for comprehending the chemical make-up, behavior, and processes that take place in water settings. Scientists can learn a lot about how aquatic systems work by studying the fundamental ideas and principles of aquatic chemistry, such as the use of water as a solvent, dissociation and ionization, pH and acidity, acid-base equilibrium, salinity and dissolved solids, redox reactions, bioavailability and speciation, nutrient cycling, and equilibrium constants. Aquatic chemistry is essential for assessing water quality, locating pollution sources, doing environmental impact analyses, and creating plans for long-term water management. Predictive modelling is based on aquatic chemistry, which enables researchers to simulate and anticipate the behavior of water systems under various conditions. Models can assist in predicting changes in water quality, nutrient dynamics, and the effects of environmental stressors by incorporating chemical reactions, mass transport, and biological processes. Aquatic chemistry plays an important role in the preservation and restoration of aquatic ecosystems. Scientists can create efficient plans for habitat restoration, nutrient management, and the decrease of negative effects, such algal blooms and eutrophication, by understanding the chemical processes that affect ecosystem health.

REFERENCES

[1] R. Max Ferguson, "Principles of aquatic chemistry," *Aquaculture*, 1986, doi: 10.1016/0044-8486(86)90301-7.

[2] J. Wangersky, "Principles and applications of aquatic chemistry," *J. Hydrol.*, 1994, doi: 10.1016/0022-1694(94)90170-8.

[3] L. He *et al.*, "Applications of computational chemistry, artificial intelligence, and machine learning in aquatic chemistry research," *Chem. Eng. J.*, 2021, doi: 10.1016/j.cej.2021.131810.

[4] L. Hildebrandt, F. L. Nack, T. Zimmermann, and D. Pröfrock, "Microplastics as a Trojan horse for trace metals," *J. Hazard. Mater. Lett.*, 2021, doi: 10.1016/j.hazl.2021.100035.

[5] A. S, M. K, Chidambaram.S, Prasanna.M.V, M. M, and T. C, “A study on the Land use pattern change along the coastal region of Nagapattinam , Tamil Nadu,” *Int. J. GEOMATICS Geosci.*, 2011.

[6] T. Neumann, “Fundamentals of aquatic chemistry relevant to radionuclide behaviour in the environment,” in *Radionuclide Behaviour in the Natural Environment: Science, Implications and Lessons for the Nuclear Industry*, 2012. doi: 10.1533/9780857097194.1.13.

[7] F. Morel, “Principles and applications of aquatic chemistry,” *Choice Rev. Online*, 1993, doi: 10.5860/choice.31-0941.

[8] N. V. Veríssimo *et al.*, “From green to blue economy: Marine biorefineries for a sustainable ocean-based economy,” *Green Chem.*, 2021, doi: 10.1039/d1gc03191k.

[9] M. J. Eckelman *et al.*, “Applying green chemistry to raw material selection and product formulation at The Estée Lauder Companies,” *Green Chem.*, 2021, doi: 10.1039/d1gc03081g.

[10] A. P. Shinn, R. Wootten, C. Sommerville, and D. Conway, “Aquaculture Science,” *Trout News*, 2001.

[11] R. Nisticò, “Aquatic-derived biomaterials for a sustainable future: A European opportunity,” *Resources*. 2017. doi: 10.3390/resources6040065.

[12] C. J. Newcomb, “Humic Matter in Soil and the Environment, Principles and Controversies,” *Soil Sci. Soc. Am. J.*, 2015, doi: 10.2136/sssaj2015.0004br.

CHAPTER 8

FEATURES OF THE ECOLOGICAL ECOSYSTEM

Ms. Meenakshi Jhanwar
Assistant Professor, Department of Environmental Science,
Presidency University, Bangalore, India.
Email Id: meenakshi@presidencyuniversity.in

ABSTRACT:

An ecological ecosystem is an intricate web of living things, their relationships, and the surroundings they live in. This abstract examines the idea of ecological ecosystems and emphasizes their significance for preserving the harmony and efficiency of natural systems. It examines the numerous elements and procedures that makeup ecosystems and the functions they perform to sustain life on Earth. Ecological ecosystems are sophisticated, linked systems made up of living things, their physical surroundings, and the complex interactions and relationships that exist between them. Understanding biological ecosystems is essential for knowing how natural systems operate, change, and are resilient as well as for guiding conservation and management initiatives. Individuals, populations, communities, and the whole ecosystem are only a few of the several organizational levels that make up an ecological ecosystem. Through several ecological processes, including energy flow, nutrient cycling, and species interactions, these levels are tightly interrelated.

KEYWORDS:

Ecological Pyramid, Food Chain, Food Web, Organic Matter, Primary Energy Source.

INTRODUCTION

An ecosystem is described as a naturally occurring, functional ecological unit made up of living things and non-living surroundings in which they coexist to create a stable, self-sustaining system. Earnst Hackel first used the term ecology in 1869. Its origins are two Greek terms, "oikos" (home, dwelling, or place of life) and "logos" (study). Ecosystems are made up of both living and non-living things. All biotic and abiotic organisms depend on one another to survive, so living things cannot exist separately from their non-living surroundings since the latter supplies them with food and energy. Throughout millions of years, the natural ecosystem has evolved, resulting in the manifestation of numerous life forms that interact and coexist in harmony. For personal advantage, humans have altered the environment, and these changes have significantly altered the ecology. As a result of its deviation from natural patterns and testing of time and evolution, it is losing balance. The ecosystem may therefore become out of balance if any of the factors' functions are interrupted. To keep the ecosystem stable, they must constantly interact with one another.

Types of Ecosystems: The type of organism that can survive in a specific ecosystem depends on their physical and metabolic adaptations to that ecosystem's environment as well as on specific events in our planet's history that have influenced which species have been able to migrate to different parts of the globe. On Earth, there exist groups of ecosystems that are geographically separated from one another yet subjected to the same climatic circumstances.

These ecosystems are characterized by dominating species that have comparable life cycles, climatic adaptations, and physical structures. Biome is the name for this group of ecosystems. There are both natural and man-made biomes (ecosystems) in the biosphere.

1. Natural ecosystem (Biomes): Natural ecosystems function independently of human influence in the context of the natural world. For humans, natural ecosystems perform a wide range of public services. Drinkable water is frequently produced by converting wastewater from homes and businesses through filtering in natural ecosystems like soil. Air pollution from vehicles and businesses is frequently captured on leaves or changed by forests into harmless compounds. They are further separated into the following categories based on specific habitat types:

a) Terrestrial Biomes: These are frequently categorized based on the dominant vegetation type in the community. The many vegetation types influence the climate and soil composition, which define a particular biome. Oxygen, water, and carbon dioxide are rapidly exchanged by terrestrial vegetation. Terrestrial vegetation has an annual and seasonal impact on the carbon dioxide concentration. Tropical rainforests, grasslands, deserts, cultivated land, etc. are examples of terrestrial biomes.

b) Freshwater and marine aquatic biomes are the two subcategories of aquatic biomes. While marine biomes include the deep Sea and Oceans, freshwater biomes can be lotic (flowing water) like streams, rivers, and springs or lentic (standing water) like lakes, ponds, and swamps.

2. Artificial Ecosystem: They are artificially managed by people. An artificial ecosystem has been created as part of a wastewater treatment facility. Its maintenance can span a wide range of activities. Agriculture can be viewed as a limited form of ecological management. Here, energy addition and deliberate modification are used to disseminate natural balance regularly. Examples of places where man seeks to regulate the biotic community as well as the physiochemical environment include wheat, maize, and rice fields. Folsom bottles are the smallest artificial ecosystem that has failed to support life for an extended length of time. Professor Claire Folsom of the University of Hawaii built these physically isolated habitats by putting water, algae, bacteria, and sediment from Honolulu Bay in a liter flask and sealing the top. To allow the biotic components to use some energy throughout the day, the sealed bottles were positioned close to a window. Some of them have managed to keep people alive for almost twenty years.

DISCUSSION

Types of ecosystems based on energy resources: Ecosystems rely on the sun and chemical or nuclear fuels as their primary energy sources. So, there can be fuel- and solar-powered ecosystems depending on the primary input. The ecosystems are divided into the following categories based on their energy resources:

1. Ecosystems with a pure solar energy source: In these kinds of ecosystems, solar energy is the only energy source. Ocean, highland forests, meadows, etc. are a few examples.

These are unsubsidized in that no other energy source is available to complement solar energy or radiation.

2. Ecosystems that are naturally supported by solar energy: In these kinds of ecosystems, the sun, which was first created by natural non-solar energy, serves as the primary energy source. As a result, the system has access to additional energy that may be used to produce more organic matter, which can then be exported to other systems or kept within the system itself.

The tides, waves, currents, the wind, fierce rains, etc. are examples of auxiliary natural sources of energy.

3. Ecosystems powered by solar energy that is supported by man: In these kinds of ecosystems, man supplies auxiliary fuels or other energy, such as man and machine labor. The sun is once more the primary source of energy.

Aquaculture and agricultural habitats are two examples of these types of ecosystems. Man's contribution of power and energy can take the shape of sprays, machines, animals, and fertilizers, among other things.

4. Ecosystems that run on fuel: In these ecosystems, highly concentrated fuel, chemical, or radioactive fuel is used to replace the sun's energy. Cities, suburbs, industrial parks, and other structures are examples of these systems. These processes produce pollution and the wealth of the human race. Energy input in this system is unrestricted.

Ecosystem components: Each ecosystem consists of two primary parts:

1. Abiotic components: Abiotic components, first The physical environment that dominates an ecosystem is made up of abiotic components or the non-living factory. They significantly affect how organisms are arranged, behave, and interact with one another. Abiotic components mostly come in two varieties:

Climate-related issues and edaphic factors

The following list of significant abiotic component functions:

A mixture of worn rock fragments, highly changed soil mineral particles, organic matter, and living creatures make up soils, which act as a container for fragments and organisms as well as a source of nourishment, hydration, and structural support. Soils are significantly more complicated than basic sediments. Through nitrogen cycling, the plant that is observed growing on top of the soil is strongly related to this element of an ecosystem.

1. The atmosphere supplies oxygen for respiration and carbon dioxide for photosynthesis to organisms located in ecosystems. The exchange of water between the atmosphere and the earth's surface occurs through evaporation, transpiration, and precipitation [1], [2].

2. Biotic elements: The biotic components of an environment that support life, such as plants, animals, and microbes (bacteria and fungi). The biotic component can be divided into three primary types based on their function in the ecosystem [3], [4].

A. Producers: The chlorophyll of green plants allows them to capture solar energy and convert it into chemical energy in the form of carbohydrates utilizing only two simple inorganic components, namely water and carbon dioxide. As green plants produce their own food, they are often referred to as autotrophs. This process is known as photosynthesis. (Auto = self, Trophos = feeder, etc.).

The producer uses a portion of the chemical energy it has accumulated for its development and survival, while the remainder is stored in the various components of the plant for later use[5], [6].

B. Consumers: The animal cannot synthesize its own nourishment since it lacks chlorophyll. They, therefore, rely on the farmers to provide them with food. They're referred to as heterotrophs. (i.e., htros = other, trophos = feeder). The four different sorts of consumers are as follows:

i. Primary consumers or first-order consumers or herbivores: Herbivores, also known as primary consumers or first-order consumers, are the animals that devour the producers' plant matter [7], [8]. Rabbit, deer, goat, etc. are a few examples.

ii. Secondary consumers, second-order consumers, or principal carnivores: The term "primary carnivore" refers to an animal that eats herbivores. Cats, foxes, and snakes are some examples.

iii. Tertiary consumers or third-order consumers: Tertiary consumers, sometimes known as third-order consumers, are huge carnivores that eat secondary consumers[9], [10]. Wolves are a few examples.

iv. Quartinary consumer or fourth order consumer or omnivores: The greatest carnivores, known as quaternary consumers, fourth-order consumers, or omnivores, prey on tertiary consumers and are not eaten by any other creatures. These include lions, tigers, etc.

C. Decomposers or reducers: This category includes bacteria and fungi. The dead organic materials produced by producers (plants) and consumers (animals) are broken down by them. to release into the environment and for their meals. simple organic and inorganic chemicals that their metabolisms create as waste products. The producers recycle these simple elements, which leads to a cyclical flow of materials between an ecosystem's biotic community and abiotic environment. The term "decomposers" is "saprotrophs" (approx = rotten, trophies = feeder).

Food chain: The biotic community of living things in an ecosystem has a pattern of eating. The herbivores consume the producers. Carnivores consume herbivores thereafter. Larger predators may also devour smaller carnivores. This process involves the transmission of dietary energy from plants to herbivores, carnivores, and larger carnivores that consume them. A food chain is a network of apex predator species, detritivores, or decomposer species that extends linearly from producer organics to the end of the food web.

Characteristics of the food chain:

1. A food chain involves a nutritive relationship between biotic elements of an ecosystem because it involves recurrent feeding, with each group eating the smaller one and being eaten by the larger one.

2. The links of a food chain are the plants and animals that are successively dependent on one another.

3. In a food chain, energy moves in a single route from the sun to producers to many different sorts of consumers.

4. The food chain typically has 4 or 5 trophic levels. A shorter food chain will make energy more readily available, and vice versa.

5. In general, omnivores occupy higher trophic levels in the food chain than they do.

6. Some creatures, including the human race, occupy many trophic levels in various food chains.

7. On average, respiration cast rises with each trophic level of a food chain; it is around 20% at the producer level, around 30% at the herbivore level, and as much as 60% at the carnivore level. Therefore, as the trophic levels increase, the leftover energy decreases.

8. A food chain is made up of many people who eat and are eaten.

9. In general, a food chain is straight.

10. There are 3-6 trophic levels.

11. The amount of biomass energy that is accessible is gradually decreasing, while the number of people is increasing as the trophic level rises.

12. A significant amount of biomass is consumed at every trophic level, releasing energy.

13. Heat loss accounts for a large portion of the energy made accessible at each trophic level.

14. Some species, like humans, function at trophic levels higher than their own.

15. Producers and decomposers keep food chains alive.

Types of food chains: There are two fundamental types of food chains.

1. Grazing food chain (GFC): One is the grazing food chain (GFC) A straightforward food chain connects producers with herbivores and then with carnivores.

These kinds of food chains start with plants, pass through grazing animals, and finally end with animal consumers.

Characteristics:

(i) They are directly dependent on solar radiation as their main energy source, among other traits.

(ii) The first trophic level of the food chain is made up of green plants, also known as producers. These produce their plant biomass through the process of photosynthesis, in which color radiation's kinetic energy is trapped in the presence of chlorophyll, a green pigment containing Mg++, and transformed into the potential energy of organic food (i.e. glucose).

(iii) The second trophic level is made up of herbivores or main consumers, which consume the producers.

(iv) Different types of carnivores consume different types of herbivores.

(v) These always come to an end at the decomposer level.

2. Detritus food chain: The detritus food chain starts with dead creatures or organic materials, moves via soil organisms that consume detritus, and ends with species that consume detritus feeders. This kind of food chain starts with dead organic matter, moves via microbes, and then includes species that eat derivers and their predators. As a result, this system is less reliant on solar power.

Characteristics:

(i) Detritus, often known as dead organic debris, is the primary energy source of the detritus food chain.

(ii) Fallen leaves and dead animals are the main sources of organic stuff that are dead.

(iii) Detritivores, or people who eat trash, are the main consumers. These include bacteria, fungi, protozoa, and others that feed on the detritus naturally.

(iv) Secondary consumers, such as nematodes and insect larvae, ingest the detritivores.

(v) The food chain is typically shorter than that of grazing animals.

(vi) In nature, the detritus food chain is essential because the detritivores use the dead organic matter of grazing food chains to recycle inorganic materials into the ecosystem.

Food web: A food web (or food cycle) is a diagrammatic representation of what consumes what in an ecological community and is the result of the natural relationship between food chains. A consumer resource system is another similarity to the food web. For instance, grasshoppers as well as rabbits, cattle, and deer may consume plants or grains. Depending on how they consume, each of their herbivores may be devoured by a carnivore like a tiger, frog, bird, or crake.

Characteristics:

(i) No food chain in an ecosystem is independent, and food chains are rarely arranged linearly.

(ii) It is created by the fusion of three different food chains. Examples include saprophytic chains (beginning from dead organic materials), parasitic chains (proceeding from larger to smaller creatures), and predatory chains (proceeding from smaller to larger species).

The food network offers additional routes for food availability

(iii). For instance, if a specific crop is destroyed by a disease, the herbivores that live there will not perish since they can graze other kinds of plants or crops. Similar to cats, dogs (secondary consumers) may eat rats and mice if the number of rabbits they also eat declines. More pathways mean that the ecosystem is more stable.

(iv) They also aid in reducing the overpopulation of particular plant and animal species.

(v) An animal's position in a food web is influenced by its size, age, and species, as well as the availability of food sources.

(vi) Normally, a food web functions following the preferences of species at each trophic level for food, such as taste. Instead of their natural diet, Sunderbans tigers consume fish and crab.

(vii) Increasingly close relationships and reciprocal adaptations between plants and animals are made possible by the food web, which also aids in ecosystem evolution.

(viii) Food web is more realistic than the food chain.

(ix) It is made up of numerous food chains that are connected at different trophic levels.

(x) The food chain is crooked. The individual food chains are not parallel.

(xi) Food back checks function in food webs that hardly ever maintain a stable population of several species.

(xii) The sustainability of the ecosystem depends on it.

Ecological pyramid: The trophic structure and trophic function are graphically represented by an ecological pyramid. In an ecological pyramid, the foundation and peak are formed by the first level, which is comprised entirely of producers.

Charles Elton created the ecological pyramid concept in 1928. The Eltonian Pyramid is another name for the Ecological Pyramid. A spindle-shaped ecological pyramid (wider in the middle and narrower above and below) or an upright ecological pyramid (tapering towards the tip) showed that the producers outnumbered or outweighed the herbivores, which in turn outnumbered or outnumbered the carnivores.

There are three different types of ecological pyramids based on ecological parameters.

1. The Number Pyramid

2. The biomass pyramid

3. The Energy Pyramid

1. Pyramid of numbers: It is a graphic representation that shows how various levels of an ecosystem's organizations are arranged.

There are three different kinds of pyramids.

(A) An upright number pyramid.

(b) partially upright Number pyramid.

(c) Inverted Pyramid of Number.

(a) Upright Pyramid of Number: A Pyramid of Numbers standing upright Grasslands often have upright number pyramids like this one. The size of the aquarium grows as carnivores rise the food chain without the aquarium's size decreases.

(b) Pyramid of Number that is partially upright: These pyramids are prevalent where trees are present. In ecosystems, one giant tree (T.) is attacked by a large number of tiny, plant-eating, carnivorous insects (T3), which are then outnumbered by smaller (T4) and (T5) insects.

(c) Inverted Pyramid of Number: In a parasitic food chain, for example, a single oak tree sustains a huge number of fruit-eating birds and a big number of parasites. The largest in number and located at the top of the inverted pyramid of numbers are hyperparasites such as bacteria, fungi, and others.

2. Pyramid of Biomass: This diagram shows how much biomass—the total amount of living or organic matter present in an ecosystem at any one time—there is per square meter in various tropic levels. A typical biomass pyramid is more basic since it illustrates the quantitative correlations between the standing crop. The biomass pyramid can be upright or upside-down. The biomass of species at each tropic level, from producers to top carnivores (uprights or straight pyramids), gradually declines in grassland and forest ecosystems. On the other hand, predators are the largest species in the pond ecosystem, while producers are the smallest. As a result, the biomass of Aryanisms gradually increases at each subsequent tropic level, from producers to top carnivores, resulting in an inverted pyramid. There, the biomass of zooplankton will be lower than that of main predators (such as tiny fish), while that of phytoplankton will be smaller still. A small standing phytoplankton crop supports a huge standing zooplankton crop in such an inverted pyramid of biomass.

3. Energy Pyramid: "An energy pyramid is a graphic representation of the movement of energy in a community. The many layers depict various assemblages of creatures that could make up a food chain. They are as follows, starting from the bottom up: producers provide the community with energy from nonliving sources. when a community's output is expressed in terms of energy. We discover that each tropic level leads to the formation of a pyramid. After that, that was added. The energy pyramid provides the most detailed information on the types of states in which food mass passes through the food chain.

Energy content always gradually decreases at progressively lower levels, from producers to consumers.

The sun serves as the world's primary energy source. The sun currently emits 1366.75W/M2 of energy. When research on how energy is captured by producers (photosynthetic organisms) was conducted, the sun irradiance (SI) was 1365.45 W/m2. The energy required by photosynthetic organisms is 697.04 W/m2, but they only consume 0.65 W/m2. The remaining incident energy on the surface is transferred to the biotic environment (oceans, soil, atmosphere, etc.), from where it is released into space and the gravitational field. The atmosphere absorbs 191.345W/m2, keeping the earth's troposphere at a comfortable 35.40°C (95.720°F).

Energy flow: Energy flow is the transfer of energy from the external environment through a succession of creatures and back to the external environment within an ecosystem. Energy is a resource that every ecosystem needs to survive. The biotic structures and their functionality require a constant source of energy. The term "energy flow" describes a cyclical movement of energy that originates in an environment that is external to the ecosystem, travels through several organisms, and then returns to the original external environment. A very important requirement for an ecosystem is the movement of energy. The type and amount of energy flow determine how wealthy or poor and how long a life will last. The sun is the ultimate source of energy for the biosphere. Every ecosystem's energy flow serves as a support for life and imposes a cap on the quantity and variety of life. Due to the unidirectional flow of energy, the behavior of energy in an ecosystem can be referred to as energy flow. From an energetic standpoint, it is crucial to comprehend an environment.

1. How well producers can capture and transform solar energy.

2. The customers' usage of this chemical energy that has been converted.

3. The overall amount of energy consumed in the form of food and its absorption effectiveness.

4. Losses from breathing, heat, excrement, etc.

5. The total net output

A few generalizations can be drawn regarding how energy and inorganic nutrients move through the ecosystem.

1. The scene is the ultimate source of energy (for most ecosystems).

2. Heat loss is the ultimate fate of energy in an ecosystem.

3. Nutrients and energy are transferred from one creature to another. as one organism consumes another through the food chain.

4. Decomposers take the last of the organism's energy from its remains.

5. Energy can be produced by inorganic nutrients.

The continuous and one-way flow of energy: Different ecosystems experience periodic nutrient shortages. The non-energy-producing elements, such as carbon, nitrogen, and water, also calculate from abiotic to biotic segments and vice versa. But energy doesn't work that way; instead of circulating, it flows in all directions. In every ecosystem, energy moves continuously in a single direction depicts a unidirectional energy transfer from the "sun" to the decomposer. Before reaching the decomposer, the energy's journey passes via producers and major consumers. It cannot, however, flow the other way. It is due to the energy flow's unidirectional character.

Ecosystem: Ecosystems keep themselves going by recycling nutrients and energy from outside sources. Primary producers utilize sun energy to create organic plant material through photosynthesis at the highest tropic level. The second level of the tropics is populated by herbivorous creatures. If larger predators are present, they represent an even higher trophic level, and creatures that graze at survival trophic levels are categorized as the highest on the trophic levels at which they feed. Predators that consume herbivores threaten the third tropic level. Waste and dead organisms are broken down by decomposers, such as bacteria, fungi, worms, and insects, and then returned to the soil. Because consumers can convert high-quality food supplies into new living tissue more effectively than low-quality food sources, only around 10% of the energy produced at one trophic level is typically transmitted to the next level [11], [12].

In terms of energy blow, decomposers are typically more significant than producers due to the slow rate of energy transfers between trophic levels. Decomposers break down a lot of organic matter and then recycle it Can an ecosystem support a certain number of trophic levels? The answer is based on a variety of factors, such as the amount of energy entering the ecosystem, the energy transfer between trophic levels, and the developed structure and physiology of organisms at each level. Because they can only use a small portion of the energy produced at the level below them at higher trophic levels, predators must cover an ever-larger area to meet their caloric needs.

Most ecosystems contain no more than five levels due to energy losses, and marine ecosystems are probably different from terrestrial ecosystems in fundamental ways. The majority of phytoplankton's primary output is devoured and utilized for energy by grazing creatures that graze on them since they are tiny organisms with incredibly basic structures. However, a significant portion of the biomass that supports plant production, such as the roots, trunks, and branches, cannot be consumed by herbivores. The energy fixed by primary production, therefore, moves up the food chain proportionally less.

The food chain metaphor, in which energy moves from one trophic level to the next without taking into account other factors, is the simplest approach to explain the fluxes of energy through ecosystems. For instance, the ecosystem of the removed wind spot Taylor Valley in Antarctica consists primarily of bacteria and algae, which are more frequently consumed by nematodes. However, producers and consumers are connected in an intricate food wave, with some consumers breeding at multiple tropic levels. This is an example of a very simple ecosystem that may consist of a food chain with only a few tropic levels. Important effects of the bioaccumulation process, which occurs when toxins gather in animal tissue between tropic levels,

A well-known example of bioaccumulation is the insecticide DDT, which was used extensively in the USA from the 1940s through the 1960s. Fortunately, the population has bound over resources to the ecosystem in an organic form, which is subsequently taken up once again by primary producers. Fortunately, DDT builds up in eagles and other raptors to levels high enough to affect reproduction, causing the birds to lay thin-shelled Eggs that broke in their nests. During decompositions, energy is not regenerated but instead is primarily emitted as heat. Gross primary productivity measures the overall amount of organic matter produced by photosynthesis within an ecosystem. Net primary productivity measures the amount of energy left over for plant development after deducting the portion used for plant respiration. Up to 30 degrees Celsius, productivity in land ecosystems typically increases. Thereafter, it drops and is positively adjusted by moisture on the land. Primary productivity is therefore highest in tropical wet zones with tropical forest biomes present, while deserts have the lowest output. Light and temperature are crucial productivity-controlling elements in the oceans. Within and close to surface water, photosynthesis takes place. The harm posed by bioaccumulation extends to people and animals. For instance, numerous federal and state organizations in the USA today advise consumers to avoid or limit their eating of large predatory fish, such as shark and swordfish that contain high levels of mercury. To prevent birth abnormalities and neurological impairment caused by rest [13], [14].

CONCLUSION

Ecological ecosystems are crucial to the health and sustainability of our world, to sum up. They cover the complex interrelationships that exist between living things and their physical surroundings, leading to a sophisticated web of interactions and activities. Ecosystems provide crucial functions such as the supply of habitat, the cleaning of air and water, the cycling of nutrients, and the regulation of the temperature. For biological ecosystems to be conserved and managed sustainably, it is essential to comprehend their constituent parts and functional interactions. It enables us to comprehend how interdependent and interrelated different species and their habitat are. We can preserve biodiversity, lessen the effects of climate change, and guarantee that ecosystem services will be available to both current and future generations by protecting and restoring ecosystems. Ecological ecosystem integrity preservation calls for a comprehensive strategy that takes into account the wide variety of species, habitats, and ecological processes present within them. Additionally, it calls for the incorporation of scientific understanding, successful policies, and community involvement. We can encourage peaceful cohabitation between people and nature while also enhancing the long-term sustainability and resilience of our planet by appreciating and safeguarding ecological ecosystems.

REFERENCES

[1] L. A. Amaral-Zettler, E. R. Zettler, and T. J. Mincer, “Ecology of the plastisphere,” *Nature Reviews Microbiology*. 2020. doi: 10.1038/s41579-019-0308-0.

[2] J. I. Prosser, “Putting science back into microbial ecology: A question of approach,” *Philosophical Transactions of the Royal Society B: Biological Sciences*. 2020. doi: 10.1098/rstb.2019.0240.

[3] M. Wille, “Unravelling virus community ecology in bats through the integration of metagenomics and community ecology,” *Molecular ecology*. 2020. doi: 10.1111/mec.15306.

[4] C. Mony, P. Vandenkoornhuyse, B. J. M. Bohannan, K. Peay, and M. A. Leibold, “A Landscape of Opportunities for Microbial Ecology Research,” *Frontiers in Microbiology*. 2020. doi: 10.3389/fmicb.2020.561427.

[5] A. Herrel, D. Joly, and E. Danchin, “Epigenetics in ecology and evolution,” *Functional Ecology*. 2020. doi: 10.1111/1365-2435.13494.

[6] T. Romeu-Fontanillas, M. Guitert-Catasús, J. E. Raffaghelli, and A. Sangrà, “Mirroring learning ecologies of outstanding teachers to integrate ICTs in the classroom,” *Comunicar*, 2020, doi: 10.3916/C62-2020-03.

[7] M. Soga and K. J. Gaston, “The ecology of human-nature interactions,” *Proceedings of the Royal Society B: Biological Sciences*. 2020. doi: 10.1098/rspb.2019.1882.

[8] M. S. Helmberger, L. K. Tiemann, and M. J. Grieshop, "Towards an ecology of soil microplastics," *Functional Ecology*. 2020. doi: 10.1111/1365-2435.13495.

[9] N. G. Swenson *et al.*, "A reframing of trait–demographic rate analyses for ecology and evolutionary biology," *Int. J. Plant Sci.*, 2020, doi: 10.1086/706189.

[10] E. E. Beller, L. McClenachan, E. S. Zavaleta, and L. G. Larsen, "Past forward: Recommendations from historical ecology for ecosystem management," *Glob. Ecol. Conserv.*, 2020, doi: 10.1016/j.gecco.2019.e00836.

[11] E. Harvey, I. Gounand, C. L. Ward, and F. Altermatt, "Bridging ecology and conservation: from ecological networks to ecosystem function," *Journal of Applied Ecology*. 2017. doi: 10.1111/1365-2664.12769.

[12] F. T. Stori, C. M. Peres, A. Turra, and R. L. Pressey, "Traditional ecological knowledge supports ecosystem-based management in disturbed coastal marine social-ecological systems," *Front. Mar. Sci.*, 2019, doi: 10.3389/fmars.2019.00571.

[13] J. Trap, M. Bonkowski, C. Plassard, C. Villenave, and E. Blanchart, "Ecological importance of soil bacterivores for ecosystem functions," *Plant and Soil*. 2016. doi: 10.1007/s11104-015-2671-6.

[14] M. A. Cebrián-Piqueras *et al.*, "Scientific and local ecological knowledge, shaping perceptions towards protected areas and related ecosystem services," *Landsc. Ecol.*, 2020, doi: 10.1007/s10980-020-01107-4.

CHAPTER 9

ENERGY FLOW IN ECOSYSTEM AND BIOCHEMICAL CYCLE

Dr. Krishnappa Venkatesharaju
Assistant Professor, Department of Environmental Science and Engineering,
Presidency University, Bangalore, India.
Email Id: venkateshraju.k@presidencyuniversity.in

ABSTRACT:

Ecosystem energy flow and biochemical cycles are essential for preserving the sustainability and balance of Earth's ecosystems. This summary gives a general overview of these processes and emphasizes how important it is to understand how intricately connected ecosystems are. The term "energy flow" describes how energy moves through different trophic levels in ecosystems, from producers to consumers to decomposers. The biochemical cycles, on the other hand, entail the movement of vital substances like carbon, nitrogen, and phosphorus via biotic and abiotic aspects of ecosystems. Understanding these processes is necessary to comprehend how ecosystems work and how resilient they are to environmental change. This chapter explores the fundamentals of energy flow and biochemical cycles, highlighting the interdependence and significance of these processes for preserving ecological stability.

KEYWORDS:

Carbon Cycle, Energy Flow in Ecosystem, Nitrogen Cycle, Oxygen Cycle, Phosphorus Cycle, Productivity, Sulphur Cycle.

INTRODUCTION

Energy flow in Ecosystem: Due to the unidirectional flow of energy in ecosystems, the behavior of energy may be described as energy flow. From an energetics perspective, it is crucial to comprehend for an ecosystem (i) the efficiency of the producers in absorbing and converting solar energy, (ii) how the consumers use this converted chemical form of energy, (iii) the total input of energy in the form of food and its efficiency of assimilation, (iv) the loss through respiration, heat, excretion, etc., and (v) the gross net production[1], [2].

1. Single Channel Energy Flow Model: Energy is transferred unidirectionally from green plants, or producers, to herbivores and carnivores through a single channel. The energy flow model in Fig. 1 makes two things very clear:

(i) Energy flows in a single direction. The energy that autotrophs capture does not return to the sun's energy but instead passes to herbivores; what flows to herbivores does not return to the autotrophs but rather passes to consumers. The system would break down if the main energy source (the sun) were cut off since energy is only flowing in one direction[3], [4].

(ii) Energy levels gradually decline at each trophic level. The energy lost through metabolic processes (respiration) and wasted energy mostly account for this.

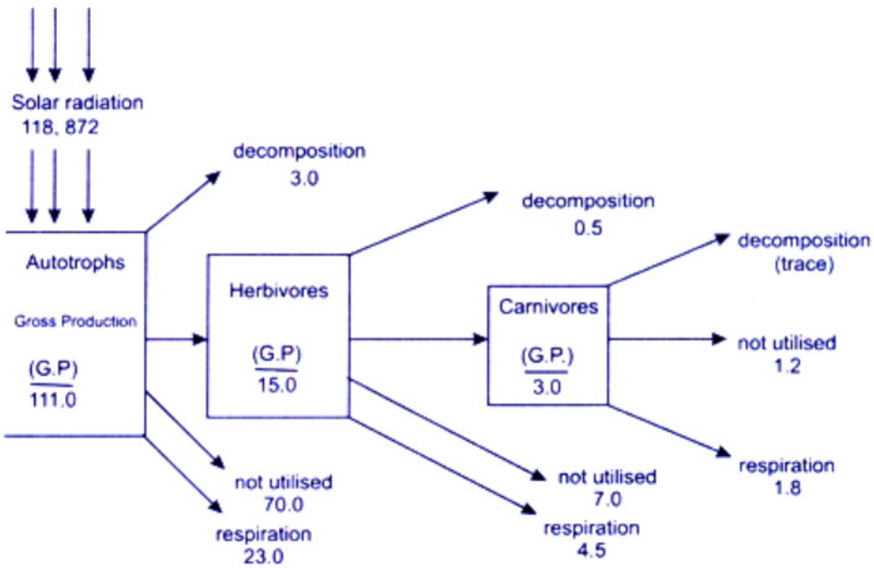

Figure 1: Energy flow diagram for a lake (freshwater ecosystem) in g cal/cm2/yr [brainly.in]

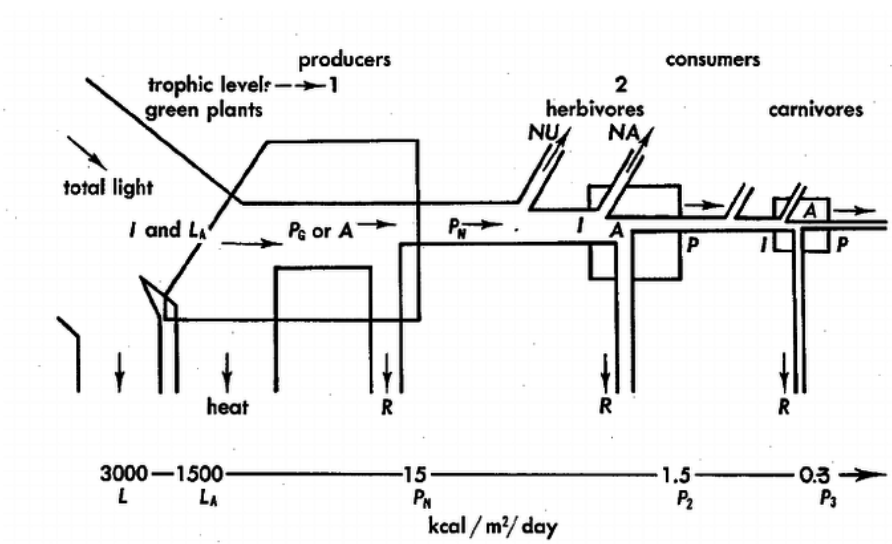

Figure 2: A simplified energy flow diagram showing three trophic levels [Research Gate].

Three trophic levels are shown in a simplified energy flow model in Fig. 2. It is evident that the energy flow significantly decreases from producers (autotrophs) to herbivores, then to carnivores, at each subsequent trophic level [5], [6]. The trophic levels are depicted in the Figure as boxes, and the energy flow into and out of each level is shown as pipes [7], [8]. The first rule of thermodynamics, which states that energy inflows and outflows must balance at each trophic level, and the second law, which states that energy transfer must be followed by the dissipation of energy into accessible heat, or respiration, are both vividly demonstrated in action. Thus, 1,500 kcal (or 50%) of the total 3,000 kcal of light that strikes green plants is absorbed at the first trophic level. At the autotroph level (the first trophic level), 1% (15 kcal) is transformed. So, the net output is just about 15 kcal. At successive consumer levels, i.e., at the herbivore level and the carnivore level, secondary productivity (shown as P2 and P3 in Fig. 2) typically ranges between 10% and 15%. As was previously established, energy flow decreases at each subsequent trophic level. Therefore, the amount of food energy accessible would increase the shorter the food chain[9], [10].

2. Y-Shaped or Double Channel Energy Flow Model: In 1956, H.T. Odum invented the Y-shaped energy flow model (Fig. 3). A shared border, heat and light fluxes, organic matter import, export, and storage are all depicted in this model. The trash and grazing food chains are partially separated by putting decomposers in a different compartment. Decomposers are a diverse group in terms of energy levels. The fact that the two food chains are connected in the Y-shaped model is important.

Because of the following reasons, the Y-shaped energy flow is more realistic and useful than the single-channel energy flow model:

(i) It complies with the fundamental stratified structure of ecosystems.

(ii) It creates a temporal and spatial separation between the two chains, the grazing food chain, and the debris food chain.

(iii) In the two models, the size-metabolism relationships between the macro-consumers (animals) and the microconsumers (e.g., bacteria, and fungus) are quite different.

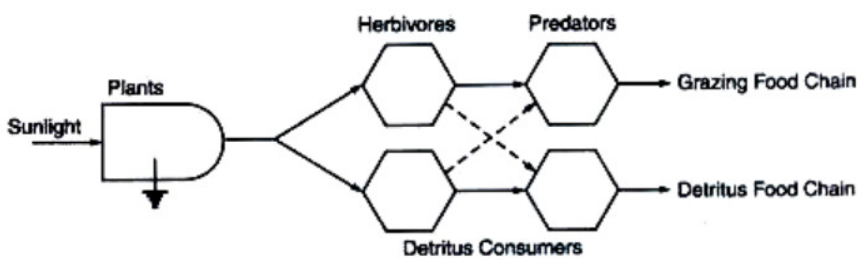

Figure 3: Y-shaped energy flow model showing a linkage between the grazing and detritus food chains [researchgate]

3. Universal Energy Flow Model: In 1983, E.P. Odum merged the single channel model and the Y-shaped model, which are both applicable to terrestrial and aquatic ecosystems, to create a generalized model that is now known as the Universal Energy Flow Model. In this model, I stands for incident solar radiation, A for assimilated energy, P for net production, G for growth, B for biomass, R for respiration, S for stored energy, E for expelled energy, and NU for unutilized energy. The model has two possible applications: (a) representing a species population, in which case the necessary energy inputs and connections to other species would be shown as a conventional species-oriented food level; and (b) representing a discrete energy level, in which case the biomass and energy channels represent numerous populations supported by the same energy source.

DISCUSSION

Productivity in an Ecosystem: Productivity is defined as the quantity of food energy generated, acquired, or stored by a specific tropic level per unit area, in a unit period. It is a rate function that is described in terms of the amount of dry matter and energy that is captured per unit of land area and per unit of time. The most common units of measurement are gm-2 year-1 or kcal m-2 year-1. Productivity or production in ecology refers to the pace at which biomass is produced within an ecosystem. Grams per square meter per day (gm-2d-2) is a common unit of measurement for this. It is also known as mass per unit surface (or volume) per unit of time. The mass unit might be related to the mass of dry materials or the mass of carbon produced. Primary productivity refers to the output of autotrophs like plants, whereas secondary productivity refers to the output of heterotrophs like animals.

1. Primary productivity: It describes the pace at which producers absorb solar energy for the synthesis of organic substances that are high in energy.

Synthesis of fresh organic material from inorganic molecules like water and carbon dioxide is referred to as primary production. Although chemosynthesis only accounts for a small portion of primary production, it is dominated by the process of photosynthesis, which uses sunlight to create organic compounds like sugar. Land, plants, marine algae, and certain bacteria (including cyanobacteria) are among the organisms that are involved in primary production.

The synthesis of organic molecules from air or aqueous carbon dioxide is referred to as primary production. It mostly happens as a result of photosynthesis, which utilizes light as its energy source, but it may also happen as a result of chemosynthesis, which gets its energy from the oxidation or reduction of inorganic chemical molecules. Almost all life on Earth is dependent on primary production, either directly or indirectly. The primary producers, also known as autotrophs, are the creatures that make up the foundation of the food chain. These are mostly plants in terrestrial ecoregions, whereas algae predominate in aquatic ecoregions. Ecologists distinguish between net and gross primary production, with the former taking into account losses from processes like cellular respiration and the latter not.

Primary production is again divided into two categories:

(a) Gross primary productivity (G.P.P.) or Total photosynthesis: Total photosynthesis or Gross Primary Productivity (G.P.P.) Gross primary production refers to the overall quantity of photosynthesis occurring during the measurement time, which includes the amount of organic matter consumed during respiration. The overall rate of photosynthesis throughout the measurement time is how it is defined. The number of producers, their level of activity, and the amount of solar energy available all have an impact on the gross production rate. It is related to creatures that are both photosynthetic and chemosynthetic. It consists of bacteria, phytoplanktons, and green plants. The quantity of CO2 fixed/g chl/hr, or the chlorophyll content expressed as chl/g dry weight/unit area, is used to assess the rate of primary productivity.

(b) Net primary productivity (N.P.P.): net primary productivity Gross production fewer losses from respiration and breakdown is referred to as net primary production (NPP) (GPP-losses). The process is known as apparent photosynthesis. It is described as the rate at which plants store more organic matter than they use up through respiration during the measuring time. Therefore, it is by definition the equilibrium between all photosynthesis and respiration. Net assimilation is another name for it. It is the energy that the following trophic level may have access to. Net primary production (NPP) is the difference between the rate at which plants in an ecosystem produce useful chemical energy (GPP) and the rate at which they use some of that energy during respiration. It is the rate at which all plants in an ecosystem produce net useful chemical energy.

2. Secondary Productivity: Secondary productivity is the rate of energy storage at the consumer level. It is important to distinguish between absorption and production when describing the overall energy flow at heterotrophic levels, which is similar to the gross production of autotrophs. This output is not constant. Any ecosystem's effectiveness is strongly influenced by the primary producers' output rates. Oceans are part of the world's biggest ecosystem, and their productivity varies by location. In extremely productive lakes, the productivity value may range from 5 to 10 g/m2/day and can even reach 50 g in particularly favorable conditions, compared to 2 to 3.5 g/m2/day on shares and just 0.5 g/m2/day in deep oceans. For wheat and rice crops, the net productivity of crop plants ranges from 0.25 to 1 kg or slightly more per m2/year. One of the best solar energy converters is sugarcane, which has an NPP value of 2 to 4 kg/m2/year or even more. On the other hand, secondary production pertains to all consumers and decomposers and is connected to the heterotrophic and saprophytic forms of feeding. The secondary productivity is still movable and can disperse while the primary productivity is still stubbornly in place.

3. Net Productivity: This is the amount of food energy per unit of area and time that heterotrophs do not use.

N.P.P.- Consumption of heterotrophs = N.P.

Biochemical cycle: Because these three minerals are physiologically accessible to plants, nitrogen, phosphorous, and potassium are the main plant nutrients acquired from the soil. As it builds up protein and several components of microorganisms, plants, and animals, nitrogen stands out as the element that has the most impact on microbial transformations. In terms of nutrients needed by both plants and microbes, phosphorus is only second to nitrogen. It is critical for the metabolism's release of energy. Potassium comes from the soil. In addition, plants, animals, and microorganisms all contain a variety of significant compounds.

Principle: Nutrients are neither generated nor destroyed; instead, they go from non-living things to living things and then back again in the form of waste or dead bodies.

Aspects of a Nutrient cycle:

Nutrient Input: In this scenario, an ecosystem takes in nutrients from outside sources and stores them for later use in biological processes that support the growth and development of living things. The output of Nutrients: In this case, nutrients are lost through soil erosion and runoff water, for example, losing nutrients like calcium and magnesium.

Internal nutrient cycling:

1. Regeneration of nutrients through the bacterial and fungal breakdown of debris.

2. Nutrient intake includes plants absorbing nutrients from the soil.

Nitrogen cycle:

Vitality of Nitrogen: The concentration of gaseous nitrogen in the atmosphere is 78%. It is a crucial component of the proteins, nucleic acids, and chlorophyll present in living things. A crucial component of protoplasm is nitrogen. Directly Linked to Soil: Conc. of Nitrogen In Soil Microbial Activity Directly Correlates With Fertility. The following topics make it easy to talk about the nitrogen cycle further:

Fixation of nitrogen: It is a process wherein certain bacteria and cyanobacteria mix the gaseous form of nitrogen with other forms, such as ammonia or organic nitrogen. These living things that fix N2 into proteins are both free-living and symbiotic. The phenomena of this activity are known as diazotrophs, and the nitrogen-fixing microorganisms are known as diazotrophs. Industrial fixation: Under extremely high temperatures of 400 degrees and high pressures of around 200 atmospheres, nitrogen, and hydrogen mix to form ammonia in the industrial setting. Ammonification is the process by which microorganisms such as ammonifying bacteria, actinomycetes, and fungi break down proteins, urea, uric acid, and other substances. They produce ammonia compounds by converting nitrogen-containing wastes, dead wastes, and decomposing carcasses. The process through which organic nitrogenous substances are transformed into ammonia ammonification

Bacilli that ammonize: Bacillus remosur and Bacillus vulgaris This process, also known as an exothermic reaction, produces energy.

PROTEINS ⟶ AMINO ACIDS ⟶ AMMONIA

Nitrification is the process by which ammonia or ammonium ions are converted to nitrate ions in the presence of nitrifying microorganisms. The nitrification process begins with the ammonium.

AMMONIA ⟶ Nitrosomonas Nitrates ⟶ Nitrobacteria nitrates

The plants take up these nitrates from the soil.

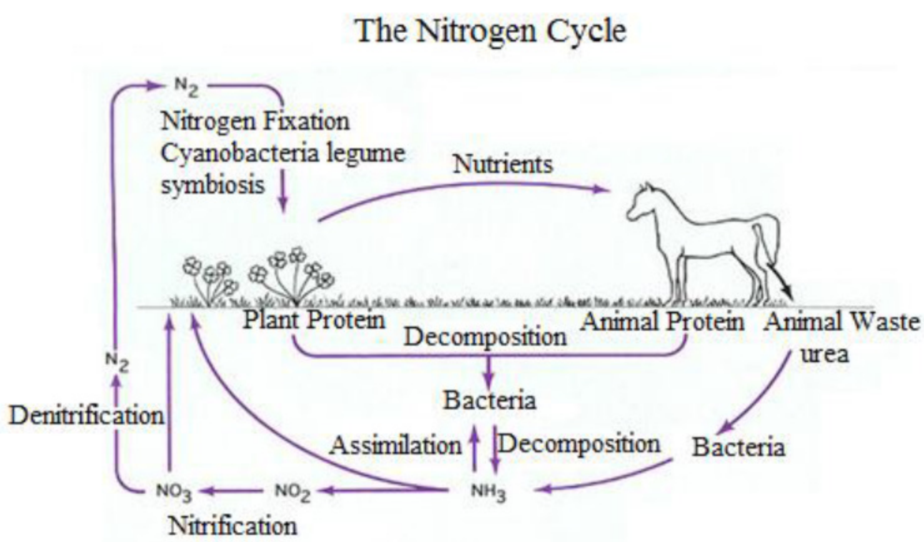

Figure 4: Nitrogen cycle [Google].

Denitrification: It is a biological process by which ammonium compounds nitrates are reduced to molecular nitrogen. Nitrogen in the presence of de nitrifying bacteria like bacillus subtilis etc. It reduces the soil fertility

It involves the following steps

NO3 ------NO2 (Nitrate)

NO2------ NO (Nitrous Oxide)

NO------N20 (Nitric Oxide)

N20-----N2 (Nitrogen)

Free nitrogen refers to the atmospheric poor and nitrous and nitric oxides are taken up by the plants.

Oxygen cycle:

Sources of oxygen: Of all the elements, oxygen is the most prevalent. It occurs naturally as O2 and contributes up to 21% of the atmosphere's total volume. The earth's crust contains 46.6%

by weight of oxygen. It combines 89% of ocean weight. In the high atmosphere, oxygen is found as ozone (o3) and is quite significant. In typical circumstances, oxygen is a gas that exists. When oxygen is present, aerobic respiration occurs. It forms water during respiration when it interacts with hydrogen. Utilisation of Oxygen Through respiration, wherein carbohydrates are oxidised to produce O2 and water, it enters plants and animals. In order to produce CO2, SO2, water, etc., it is also utilised in the burning of wood, coal, and other fuels. In the atmosphere, there is a dynamic equilibrium for oxygen. For respiration, organisms get it from the air or water.

Production of oxygen: In the light phase of photosynthesis, oxygen is primarily created through the proteolysis of water. CO2 and water vapour are released back into the environment as oxygen. During photosynthesis, it also enters the plant body as CO2 or H2O, and during the same process, it is expelled as a large product in the form of molecules for use in respiration. The cycle is therefore finished.

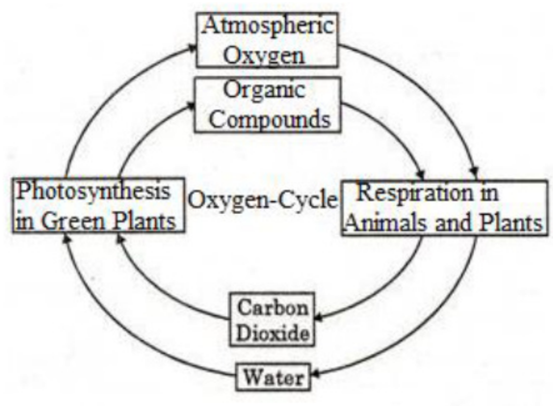

Figure 5: Oxygen cycle [Google].

Carbon cycle:

Importance of carbon: Carbon is the most significant component of protoplasm; hence it is crucial. It is a key component of the carbohydrates, proteins, lipids, and nucleic acids found in an organism's cells. Consequently, it is believed that carbon is the foundation of life. 49% of the dry weight of organisms is made up of carbon.

Sources of carbon: Carbon sources include There are four sources of carbon in the biosphere. Oceans and the atmosphere both contain carbon. They serve as carbon storage areas. Carbon makes up 0.034% of the atmosphere. It makes up around 1% of all c in the world.

2. Petroleum has the same carbon molecule as fossil fuels like coal.

3. As carbonates in the crustal rocks.

4-Oceanic bodies of water where it is still preserved as bicarbonates in limestone and marble rocks. As a result, the biosphere's three main carbon storage areas are the atmosphere, the seas, and fossil fuels.

Utilization of carbon: The atmosphere's carbon is the primary source of energy that enters living things through photosynthesis in plants or other producers, followed by herbivores, small and big predators, and eventually decomposers. O2 is emitted during photosynthesis as a byproduct.

Carbon production: A variety of sources, including, release CO2 back into the atmosphere.

1. During respiration, plants and animals emit carbon as CO2 into the atmosphere.

2-By decomposers, which are organisms that break down organic waste and dead corpses through the activity of bacteria and fungus.

3. Through the burning of wood and fossil fuels.

4-Hot springs and volcanic eruptions both produce CO2 into the atmosphere.

5-Weathering of carbonate-containing rocks also increases the atmospheric CO2 level.

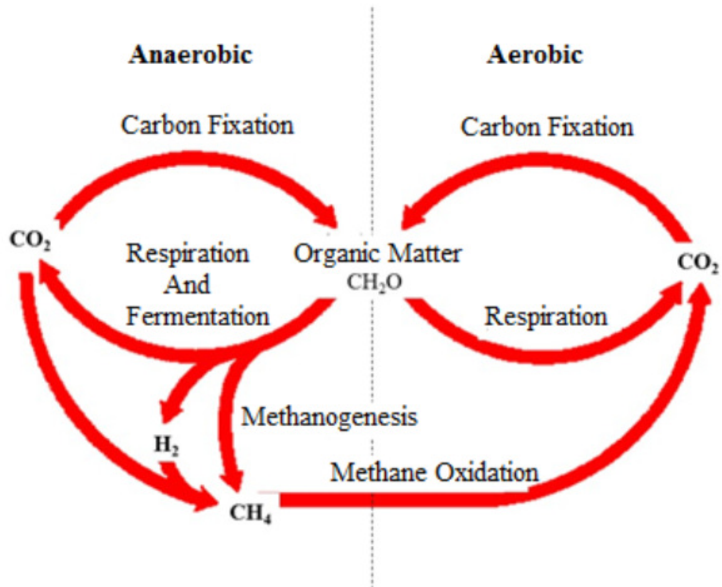

Figure 6: carbon cycle [Byjus].

Thus, the atmosphere's carbon cycle involves both living and extinct creatures. Insofar as carbon is necessary to atm. as soon as it is required, the "C" cycle is ideal. Carbon recycling fundamentally functions as a self-correcting feedback loop. However, excessive fossil fuel consumption and other human actions, such as deforestation and large fossil fuel burning, can disturb the system.

Sulphur cycle:

Importance of Sulfur: Sulphur is an important ingredient for both plants and animals. Cysteine, cysteine, and methionine are three amino acids that include Sulphur. It is hence a part of many proteins, several enzymes, and some vitamins.

Sources: It is scarce for plants and is most prevalent at low concentration in the earth's crust. Because it occurs naturally as an element and as sulphates in soil, water, and rocks, Sulphur is a sedimentary cycle. Consequently, the soil is an elemental reservoir.

Different transformation processes are used in the soil to microbiologically metabolize organic and inorganic forms of Sulphur compounds.

1. The breakdown of organic Sulphur compounds into smaller parts and then into organic compounds by microorganisms. 2. Incorporation of basic Sulphur compounds into the cells of bacteria, fungus, and actinomyctes

3. Inorganic ions or substances like sulphides, thio sulphate, and Sulphur, which is a necessary element.

4. The sulphate and other anions' reaction with Sulphur dioxide.

Utilization of Sulphur:

1. Producers (green plants need Sulphur from soil or water in the form of sulphates (SO_4) for their needs. Amino acids are a kind of Sulphur that some plants may absorb.

2. Animals get Sulphur through consuming plants or other animals.

3. Sulphur enters animals through the food chain.

Sulphur Production: Aspergillus neurospora and other aerobic and anaerobic microorganisms break down dead plants and animals to release hydrogen sulphide (H_2S).

1. Sulphur bacteria like thio bacillus convert some H_2S to soluble sulphates, whereas Beggiatoa (colorless Sulphur bacteria) oxidase some H_2S to necessary Sulphur.

2. SO_2 is emitted into the environment by several industries. Due of their extreme sensitivity to SO_2, lichens vanish in air pollution that contains SO_2.

3. When burning, fossil fuels release SO_2 into the atmosphere.

4. Soil and air are also made more sulfate-rich by volcanic eruptions.

5. The filamentous fungi, such as those in the asper genus and microsperm, create Sulphur from organic compounds like methionine and cysteine, among others.

The Sulphur cycle is the ideal illustration since Sulphur has the capacity to bind to cations such as iron and calcium in anaerobic environments to produce the very insoluble compounds ferrous sulphide (FeS), ferric sulphide (Ferric) sulfide (Fe_2S_3), or calcium sulphate ($CaSO_4$). A significant cause of atmospheric air pollution is SO_2. Acid rain from the land contains Sulphur in the form of sulfuric acid, which is created when Sulphur in the form of elemental Sulphur, H_2S, or SO_2 is oxidized to SO_3.

Phosphorus cycle:

Importance of phosphorus cycle: The phosphorus cycle is crucial for all living things' metabolisms and as a component of protoplasm. It is the source of energy in dense molecules like GTP, ATP, and ADP. Plasma membrane, bones, and teeth also contain it. Since P is a component of n.a. nucleotides, it is also necessary for the encoding of information in genes.

Phosphorus's sources: Rock deposits are the main repository for potassium. Between 0.05 and 0.5% of phosphorus can be found in the tissue of agricultural crops. 15 to 85% of the total "P" in soil is organic. A sedimentary cycle with its primary reservoir in rocks made of calcium phosphate and insoluble ferric is the potassium cycle. P is frequently utilized in the form of phosphate Pathway of the phosphorus cycle: Weathering has a major role in this process. Phosphorus weathering involves rocks and deposits. As a result of weathering, rocks release potassium into the soil. Man may add certain plants to the soil in the form of organic fertilizer. The plants absorb potassium from the soil, namely as ortho-phosphate PO_4 ions, which are subsequently passed through the food chain as organic phosphate to consumers and decomposers. Mycorrhizae are beneficial for the higher plants' ability to absorb potassium.

Decomposition: Dead and decaying organisms, particularly those that include phosphate-solubilizing bacteria, are broken down to return potassium to the soil. The "P" cycle is not ideal since significant amounts of phosphorus are lost to excretion and biological processes including the creation of teeth and bones. Eutrophication and pollution are brought on by a high phosphorus content in natural water.

CONCLUSION

The biochemical cycles and the energy flow in ecosystems are essential elements of the ecological systems on Earth. The maintenance and productivity of ecosystems are made possible through the transfer and transformation of energy across several trophic levels, from primary producers to higher-level consumers and eventually to decomposers. The carbon, nitrogen, and phosphorus cycles, for example, ensure that vital materials required for organisms to survive and grow are available and recycled simultaneously. Ecological stability depends on the interaction of energy flow and biochemical cycles, as any interruption of these processes can have serious effects on the health of the ecosystem. Therefore, more study and comprehension of these processes are necessary for efficient ecosystem conservation and management, especially in light of ongoing environmental changes. We may endeavor to promote sustainable practices and protect the fragile balance of the Earth's ecosystems for future generations by understanding the intricate relationships between energy flow and biochemical cycles.

REFERENCES:

[1] D. E. Reichle, "Energy flow in ecosystems," in *The Global Carbon Cycle and Climate Change*, 2020. doi: 10.1016/b978-0-12-820244-9.00008-1.

[2] E. J. Chapman, C. J. Byron, R. Lasley-Rasher, C. Lipsky, J. R. Stevens, and R. Peters, "Effects of climate change on coastal ecosystem food webs: Implications for aquaculture," *Mar. Environ. Res.*, 2020, doi: 10.1016/j.marenvres.2020.105103.

[3] P. Singh and D. K. Benbi, "Nutrient management impacts on net ecosystem carbon budget and energy flow nexus in intensively cultivated cropland ecosystems of north-western India," *Paddy Water Environ.*, 2020, doi: 10.1007/s10333-020-00812-9.

[4] Q. Wang *et al.*, "Evaluation of nutritional structure and energy flow of crab-rice complex ecosystem based on an ecopath model," *Shengtai Xuebao*, 2020, doi: 10.5846/stxb201905171011.

[5] T. D. Eddy *et al.*, "Trends in Ecology & Evolution Energy Flow Through Marine Ecosystems : Confronting Transfer Ef fi ciency," *Trends Ecol. Evol.*, 2020.

[6] D. Perrotti and S. Stremke, "Can urban metabolism models advance green infrastructure planning? Insights from ecosystem services research," *Environ. Plan. B Urban Anal. City Sci.*, 2020, doi: 10.1177/2399808318797131.

[7] A. E. Zimmerman *et al.*, "Metabolic and biogeochemical consequences of viral infection in aquatic ecosystems," *Nature Reviews Microbiology*. 2020. doi: 10.1038/s41579-019-0270-x.

[8] W. Zhao, L. Wang, and Z. Zhang, "Artificial ecosystem-based optimization: a novel nature-inspired meta-heuristic algorithm," *Neural Comput. Appl.*, 2020, doi: 10.1007/s00521-019-04452-x.

[9] D. Diella and R. Ardiansyah, "Pengembangan Four-tier Diagnostic Test Konsep Ekosistem: Validitas dan Reliabilitas instrumen," *BIODIK*, 2020, doi: 10.22437/bio.v6i1.8093.

[10] J. Konietzko, N. Bocken, and E. J. Hultink, "A tool to analyze, ideate and develop circular innovation ecosystems," *Sustain.*, 2020, doi: 10.3390/SU12010417.

CHAPTER 10

FEATURES OF POPULATION AND COMMUNITY ECOLOGY

Ms. Meenakshi Jhanwar
Assistant Professor, Department of Environmental Science,
Presidency University, Bangalore, India.
Email Id: meenakshi@presidencyuniversity.in

ABSTRACT:

Ecology's population and community ecology subfields concentrate on examining how organisms interact with one another within a specific ecosystem. The summary of population and community ecology in this abstract emphasizes the importance of these concepts for comprehending the dynamics and composition of ecological systems. While community ecology looks at interactions between various populations and how they affect the structure and function of communities, population ecology analyses the variables affecting the abundance, distribution, and dynamics of populations. Our knowledge of species interactions, rivalry, predation, mutualism, and how communities react to environmental changes is influenced by both subfields. This chapter explores important ideas in population and community ecology, highlighting their applicability to solving urgent ecological problems.

KEYWORDS:

Community Ecology, Ecological Succession, Ecological Stability, Population Ecology, Population Growth.

INTRODUCTION

We all worry about the population growth, but not at the appropriate moment. One of India's biggest issues is the country's growing population. It is posing serious issues for all of the world's developing nations in addition to India. Population requires food, housing, and other necessities of life in addition to education since it is growing faster than agricultural and other productivity. You may ask anyone in large cities like Bangalore, Delhi, or Mumbai how life is now compared to when they were born. He will convey the full picture; from the idyllic time he spent living it fifty years ago to the modern period he is now experiencing due to population growth. In India, there were about 361 million people according to the 1951 census. Over 1.21 billion people were counted in the 2011 census[1], [2].

The simple statement "the power of population is indefinitely greater than the power of the earth to produce substance for men" made by Thomas Malthus in the late 1700s means that the human population will always exceed the capacity of the earth to support it, resulting in famine, epidemics, and armed conflicts. Because of the widespread crowding condition, life has become terrible. Queues may be found anywhere. Around you, there is filth, and the air and water are becoming more and more polluted. We are deteriorating because of the alarming population growth. A demographic bomb is so developing. We must maintain control over this since failure to defuse it promptly might spell calamity for the country. A branch of ecology known as population ecology, or autecology, studies the dynamics of species populations and how they interact with their surroundings. It examines how species population numbers alter across time and space. Population dynamics, population biology, and population ecology are frequently used interchangeably. Demography and actuarial life tables had a significant role in the development of population ecology. Population ecology is crucial to conservation biology, particularly in the development of population viability analysis (PVA), which enables one to forecast the likelihood that a species will endure in a certain habitat patch over the long run. Despite being a branch of biology, population ecology poses challenging questions to statisticians and mathematicians who study population dynamics[3], [4].

Local population: A group of individuals frequently found within a population (as described above) and located within an investigator-delimited region that is smaller than the species' global range. A dispersed population might also be a local population[5], [6].

Subpopulation: A population's (as previously defined) arbitrary geographically bounded subset of persons. As long as everyone in the population experiences the same environment, the population will increase (or decrease) exponentially[7], [8]. This population ecology concept serves as the foundation for the following tests and theories of prediction: Death, birth, immigration, and emigration are the four main demographic processes that comprise simplified population models. In order to quantify changes in population demography and evolution, mathematical models use the assumption—also known as the null hypothesis—that no outside forces are at play. Where " multiple competing hypotheses are simultaneously confronted with the data," models might become more mathematically sophisticated. The rate of change in the population's size may be expressed, for instance, as follows in a closed system with no immigration or emigration: The area of ecology known as population ecology focuses on the dynamics and structure of populations. Individual traits and individual processes are studied in physiology. These serve as the foundation for population-level process prediction[9], [10].

The dynamics and organization of animal and plant communities are studied through community ecology. Modeling techniques for forecasting community structure and dynamics are provided by population ecology. Gene frequencies and microevolution in populations are investigated through population genetics. Selective advantages are reliant on an organism's capacity for competition, reproduction, and survival. In population ecology, these processes are also investigated. "Population biology" is a term that refers to the study of both population ecology and population genetics. One of the main subjects of population biology is evolutionary ecology. Systems ecology is a relatively recent field of ecology that examines how people interact with their environment. Optimization of ecosystem extraction and sustainable ecosystem management are two of the key ideas. Another recent field in ecology is landscape ecology. It uses computer-based geographic information systems to study regional large-scale ecosystems. The connection between population ecology and landscape ecology is that population dynamics may be examined at the landscape level.

Population Ecology: varied disciplines of science have varied definitions of "population": A population is a group of people in human demography who live in a certain location. A population is an isolated group of individuals from the same species that are interbreeding in genetics. A population is a collection of people belonging to the same species who live in the same region. In ecological studies of populations, interbreeding is rarely taken into account. Studies in population genetics and evolutionary ecology are the outliers. Different geographical scales can be used to define populations. Local populations may inhabit puddle-sized habitat areas. A metapopulational is a collection of local populations linked together by dispersed individuals. Regions, islands, continents, and seas can all be used as scales for populations. One can think of a population as being an entire species. The stability of different populations varies. Some of them have remained constant for countless years. Only ongoing immigration from other regions ensures the survival of other populations. Small islands frequently experience population extinction, yet these islands can later experience recolonization. Last but not least, there are transient populations made up of species that are at a certain stage of their life cycles. For instance, a hemi population of dragonfly larvae exists in the water.

Population Growth: The population size of any given species is not constant; it changes throughout time. Depending on many variables, such as the availability of food and the climate. These alterations help us determine if the population is increasing or decreasing.

Four fundamental mechanisms lead to population changes:

1) Natality is the "number of births in the population during a given period that are added to the initial density."

2) Mortality is defined as "the number of deaths in the population over a specified period."

3) Immigration is defined as "the number of individuals of the same species that have entered the habitat during the period under consideration from elsewhere."

4) Emigration: "The population's number of individuals who left their habitat and went elsewhere during the period under consideration."

DISCUSSION

Cause of population growth: Death rate decline for the environment to be in balance, birth and death rates must be equal. Therefore, a drop in the mortality rate causes a rise in the birth rate, which further contributes to population expansion.

Better medical facilities: Better medical facilities have made pregnancy much safer today than it was in the past. IVF is the finest illustration of population expansion brought on by technical improvement in reproductive therapy.

Immigration: Moving from underdeveloped nations to developed ones where the finest services in the fields of health care, education, security, and jobs are offered. In the end, wealthy nations become overpopulated.

Lack of Family Planning: People lack awareness of family planning due to illiteracy. Getting their kids married off young increases the likelihood of them having additional children.

Effect of Population Growth: Our planet, our nation, and our country are experiencing several issues solely as a result of the population growth that is increasing so quickly. Some of them are as follows:

(i) Natural resource depletion

(ii) A rise in illiteracy

(iii) Environmental degradation

(iv) Year-over-year increases in crime

(v) Conflicts and wars

(vii) High expense of living

(viii) Rich become richer and poor get poorer

(ix) Rise in Unemployment

Modeling Approach:

(i) Choose the ideal level of difficulty.

(ii) Never schedule the development of a model for more than a year.

(iii) Adhere to specified goals; avoid attempting to create a generalized model.

(iv) Resist the urge to include all accessible data in the model.

(v) If at all feasible, use pre-existing models.

Properties of the model and the system:

(i) This model disregards several system features.

As an illustration, neither the exponential nor the logistic models adequately capture age structure.

(ii) This model contains several model qualities that are not present in actual systems.

Example: While the trajectory of a physical system is always noisy, the solution to a differential equation is always smooth.

Does the population have an equilibrium density? Is a bad example.

(iii) The stable equilibrium is a condition in which all of the system coverage's trajectories endlessly converge over time.

(iv) The real situation may not have an equilibrium density, although the model (such as the differential equation) may have one because population density cannot be measured with infinite accuracy.

(v) Weather variations constantly introduce noise into the dynamics of the system.

(vi) Time series are never long enough to discuss convergence and limitations.

Ecological succession: Ecological succession is the process of change in an ecological community's species composition over time. After a major extinction, it may take decades or perhaps millions of years. The community begins with a small number of pioneering plants and animals and grows more sophisticated until it reaches a climax community when it becomes stable or self-sustaining. The effects of established species on their environments are what drive succession and lead to ecosystem change. The occasional modification of one's immediate environment is a result of life. A disturbance or the early colonization of a new environment might cause an ecological community to change in a way that is more or less predictable and orderly. A major landslip or the creation of a brand-new, uninhabited environment, such as one caused by lava flow, might start a succession.

Factors: Site characteristics, the nature of the events causing succession, interactions between the species present, and several additional factors, such as the accessibility of colonists or seeds or the weather at the time of disturbance, can all influence the course of succession change. Some of these variables help succession dynamics to be predictable, while others add more uncertain components. Fast-growing, widely distributed species will typically dominate ecosystems in the early stages of succession. These species tend to be replaced by more competitive (k-selected) species as succession progresses.

There have been some hypothesized trends in ecological and community traits in succession, but few seem to be widespread. For instance, when new species first appear, species diversity almost always rises; but, as opportunistic species are driven out by competition and are replaced by regionally superior competitors, species diversity may fall in later succession. Net Over succession, primary productivity, biomass, and trophic characteristics all exhibit varying patterns.

Types of Ecological succession: Different ecological successions exist. These are what they are:

A) Primary Succession: In any basic habitat, such as one that is freshwater, marine, or terrestrial, there is always one type of succession that begins in an area where the conditions for existence are initially unfavorable. This succession is known as primary succession. when the primary succession first began, for instance, on an exposed rock surface. The first to arise are lichens and mosses, which alter the physical environment to allow new species of autotrophs to flourish there. Heterotrophs also move into the area as a result. So long as succession continues, a community will be stable.

B) Secondary Succession: It typically begins on substrata that have already been developed and include living organisms. Because these places were once home to a well-established community, life conditions are favorable in this sort of succession. These successions happen more quickly in comparison.

C) Autotrophic Succession: Autotrophic species, such as green plants, exhibit early and persistent dominance throughout this kind of succession. These successions take place primarily in an inorganic environment, and their energy flow never stops.

D) Allogeneic Succession: Occasionally, an existing community is replaced by an existing organism for work by any other external conditions. Allogeneic succession is the name given to this kind of succession.

E) Autogenic Succession: After a succession has started in some circumstances, there are numerous communities that, as a result of their interactions with their surroundings, change their environments, which causes the original communities to be replaced by new communities.

Forest succession: As an ecological system, forests are subject to the process of species succession. Some "opportunistic" or "pioneer" plants may colonize large vacant stretches because they generate a large number of seeds that are spread by the wind. They can develop and germinate in direct sunshine. The absence of direct sunlight in the soil makes it difficult for their seedlings to grow once they have created a closed canopy. Then, under the shelter of the pioneers, shade-tolerant plants have the chance to establish themselves. The shade-tolerant species take over when the pioneers pass away. These plants may flourish below the canopy and will consequently persist in the absence of disasters. The stand is therefore deemed to have achieved its apex for this reason. When a disaster strikes, the pioneers have a new chance to succeed.

Succession is the gradual, natural replacement of a species or combination of species by another in a given region. Typically, when we talk about the replacement of three species or groups of trees, we are discussing forest succession. Each step in a sequence sets up the prerequisites for the subsequent level. As a form of balance between the plant and the environment is attained, transient plant communities are replaced by more stable communities. Foresters and ecologists have known for a long time that forests grow less as they become older, but until recently the reason for this age-related reduction was unknown. In the early stages of succession, a large amount of the litter is made up of leaf tissue, which, because of its higher nutrient concentration than branches and stems, is easier for decomposers to break down. Woody tissue, on the other hand, decomposes more slowly than foliage.

Ecological stability: Ecological stability is the capacity of an ecosystem to withstand changes in the presence of disturbances, which prompts consideration of the most efficient choice of energy flow paths. According to a different definition, ecological stability might refer to many forms of stability along a continuum, from regeneration to, for instance, resilience. The construction of an index from the qualitative ideas of information theory has naturally led to the function of variety and interdependence in determining stability.

Today, ecological stability has significant partial applicability for all of us.

(i) Ecosystem destruction caused by humans is a worry.

(ii) Knowing how stable things are naturally helps us determine how much harm they can take.

Ecological stability types: When we continue to look at the issues that threaten natural stability, it helps to remember that the word "stability" actually relates to two meanings. Resistance and resilience may now be defined.

1- Resistance gauges a system's level of resistance to change. A system with high resistance maintains its state despite disruption or changes in, for instance, nutrition intake.

2 - System resilience measures how quickly it bounces back after a shock and reverts to a stable state. Ecosystems are continuously undergoing regime shifts as a result of human activities that harm their resilience, such as the loss of biodiversity, the overuse of natural resources, land pollution, and anthropogenic climate change.

(a) Constancy: Constancy is a concept used in observational studies of ecosystems to define biological systems that can endure change.

(b) Amplitude: This term refers to the degree to which a system may be shifted from one state to another and yet return. Ecology borrows from dynamical systems theory the concepts of neighborhood stability and a zone of attraction.

Intermediate Disturbance Hypothesis: Some ecologists and scientists contend that the intermediate disturbance concept can explain both the persistence of widely dispersed big patches and the quick recovery of smaller ones. IDH can be attributed to an increase in local species variety brought on by a relatively infrequent ecological disturbance. The intermediate disturbance theory is illustrated graphically below. It states that as the scale of disturbance rises due to human-caused forest fires or deforestation, the habitat and the species are at risk of going extinct. Hence the conclusion of IDH is as follows: under two prime circumstances, succession will not form and will instead seize if the disturbance occurs frequently. According to the competitive exclusion principle, when disruption is infrequent, variety will decrease or lessen, and succession will take hold above the pioneer phase (gap phase).

Ecological Succession model of Connell and Slatyer: The process of shifting the species composition is known as ecological succession. Due to an ecological disturbance, within a community, and varies greatly depending on the original disturbances that caused the succession. Connell and Slatyer decided to concentrate on autogenic succession in 1997 because it start with changes inside the community rather than a geophysical shift and occurs on recently exposed landforms. Physical changes to the landscape might be made by the targeted plant immobile aquatic species that require a larger surface area inside a habitat. The group of creatures that coexist and have a substantial impact on one another's distribution and abundance is referred to as a community.

Model of facilitation: Predicated on the premise that only specific species with traits suited for "early succession" can colonize the newly exposed landforms following an ecological disturbance. The capacity to remain dormant for extended periods, a quick growth rate, and extremely efficient dissemination techniques are some examples of these "colonizing" characteristics. However, after a region has been densely occupied by neighboring species, the pioneer species frequently suffer later on owing to increasing shade, litter, concentrated roots in the soil, etc.

Cyclic Succession: Cyclic succession is a pattern of vegetation change in which, in the absence of significant disturbance, a small number of species gradually replace one another over time. The old Clementina theories of a fixed species composition in the end-state climax community have been refuted by observations of cyclic replacement. A concept in community ecology, cyclic succession is one of numerous types of ecological succession. When used specifically, "cyclic succession" indicates to processes that aren't started by extensive external disruptions or substantial environmental changes. In instances of secondary succession, however, when frequent perturbations like bug outbreaks may "reset" a whole population to a prior stage, wider cyclic patterns can also be seen. British ecologist Alexander Watt introduced the cycle concept of succession in 1947. Watt presents the plant community as a renewing entity made up of a "space-time mosaic" of species, whose cyclical behavior may be defined by patch dynamics, in a landmark article on vegetation patterns in grass, heath, and bog communities.

Community Ecology: A community is the collective name for all the species that coexist in one location. Community ecology is the study of how species interact with one another over a range of geographical and temporal dimensions, including population structure, dispersion, and interactions. "Ecology" is the study of social systems. a study of how one species interacts with its surroundings. European plant sociology is where community ecology first emerged. Modern community ecology looks at patterns like changes in species diversity, equity, productivity, and food web structure. It also looks at processes like succession, predator-prey population dynamics, and community formation. A collection of species that interact or have the ability to interact live in an ecological community. The way that local processes build an assembly age of species, such as how climate change is anticipated to influence the composition of grass communities, have typically been considered as communities on a fine scale.

Communities and their members: Communities are recognized and categorized in a number of ways by community ecologists. The majority of these are related to the numerous species that are present in the community. Community ecologists work with a variety of communities, including the following:

1. Using distinct habitat boundaries on a physical level

2. Taxonomically by a dominant indicator species' identity

3. Interactively by the existence of strong interactions among species on

4. Statistically, by patterns of associations among species

A collection of species that can be found in a certain location on a habitat is included in a physical defined community. The habitat's limits are clearly defined. These contain groups of creatures that are evenly spread, such as lakes and ponds. Basic groups of communities known as "biomes" vary in their physical settings and the predominant creatures that live there. The notion is that biomes are a good shorthand for defining particular kinds of communities and as such assist to simplify communication among ecologists. Here is a list of the major biomes of the world as recognized by Whittaker.

Communities' properties: There are several approaches of looking at communal properties. We can choose the ideal strategy for your needs and scenario by dividing the issue into a number of big themes.

Species Richness: According to Robert May's 1975 observation, the total number of species present, also known as species richness, which is connected to the fundamental concept of biodiversity, goes a long way toward describing a biological community. If we had the capacity to identify every species in a certain location, it would be difficult to assess if we had given the species there our best search effort. Richness in species is more than just a practical tool. Evidence supporting the crucial roles played by communities is growing. Recent experimental work has demonstrated that all-natural disturbance, resistance, and other factors rise along with species diversity.

Diversity: Although species richness plays a significant role in the community, it indicates nothing about the species or the distribution of individuals within the species. The Shannon Weavers Index of Diversity is one measurement. The total number of species present in the sample and the percentage of the sample's overall population that is made up of members of different species are both given. When diversity is compared to a community that varies in both species' richness and the distribution of individuals among the species, the comparison becomes more difficult. The degree of diversity present in a single habitat type; also known as alpha diversity. The species found in the various ecosystems will contribute to a region in a few years. Beta diversity is the term for this diversity's inter-habitat component.

Trophic pyramids and the flow of energy: A trophic pyramid is a basic kind of interaction seen in all biological societies. Trophic levels make up the tropical pyramid, and food energy is transferred from one trophic level to the next along the food chain. Species referred to as autotrophs, the ecosystem's primary producers, make up the pyramid's base. All other species are consumers known as heterotrophs, who rely on the producer for food and energy either directly or indirectly.

Food Chain and Food Web: Each trophic pyramid is made up of a number of interconnected feeding connections termed food chains since all species have specialized diets. However, many animal species eat various meals at various times throughout their lives and consume more than one variety of food. Food webs are made up of combinations of food chains. Mimicry: In evolutionary biology, we may define mimicry as the likeness of one creature to another that has developed because, if the similarity is selectively favored, it can be encouraged by the behavior of a common signal and receiver that can respond to both. This organism in question is often an animal. In other words, imitation might develop between members of the same species or between members of other species. A species frequently develops mimicry to fend off predators, turning it into an antipredator. Similarities that develop through imitation might be in terms of behavior, sound, smell, or appearance. Mimicry can be beneficial to both creatures that resemble one another, in which case it is a mutualism, or it can be detrimental to one, in which case it is parasitic or competitive. It is possible to state that imitation happens when a group of creatures, known as the mimics, develop to share observed traits with a different group, known as the models. The selective effect of a signal-receiver or dupe propels the evolutionary convergence between groups.

For instance, utilize sight to distinguish tasty insects from unpleasant ones. Insects that are edible may change through time to resemble those that are poisonous, creating a mimicry between the two. When mutualism occurs, both groups are referred to as "co-mimics" at times. We might claim that mimicry can encompass non-living models in the broadest sense. When the models are inanimate, the phrases masquerade and mimesis may be employed.

CONCLUSION

In order to understand the intricate dynamics and interdependencies that exist within ecological systems, population, and community ecology are essential. Population ecology sheds light on the variables affecting population numbers, geographic dispersion, and long-term population dynamics. Understanding how species react to environmental changes, foreseeing population fluctuations, and putting effective conservation measures into practice all need this information. While species interactions like competition, predation, and mutualism are examined in community ecology, interactions across many populations within a particular environment are not. Community ecology focuses on the structure and operation of communities in order to better understand the mechanisms behind ecological stability, biodiversity patterns, and community resilience to disturbances. Addressing urgent ecological issues including the preservation of endangered species, the control of invasive species, and the mitigation of ecological disturbances brought on by human activity requires the combination of population and community ecology. Making informed judgments and putting sustainable practices into practice need an understanding of the complex linkages between people and their interactions within communities. The dynamics, structure, and interactions of organisms within ecological systems may be studied using a framework provided by population and community ecology. We can improve our understanding of ecosystems, support biodiversity conservation, and create efficient management and protection plans for the natural world by learning more about these subfields.

REFERENCES:

[1] M. Wille, “Unravelling virus community ecology in bats through the integration of metagenomics and community ecology,” *Molecular ecology*. 2020. doi: 10.1111/mec.15306.

[2] B. P. Kotler and J. S. Brown, “Cancer Community Ecology,” *Cancer Control*, 2020, doi: 10.1177/1073274820951776.

[3] P. L. Thompson *et al.*, “A process-based metacommunity framework linking local and regional scale community ecology,” *Ecol. Lett.*, 2020, doi: 10.1111/ele.13568.

[4] H.-J. Hawkins, “Aboveground-Belowground Community Ecology,” *African J. Range Forage Sci.*, 2020, doi: 10.2989/10220119.2020.1758208.

[5] G. Tikhonov *et al.*, “Joint species distribution modelling with the r-package Hmsc,” *Methods Ecol. Evol.*, 2020, doi: 10.1111/2041-210X.13345.

[6] L. Ung, P. J. M. Bispo, N. C. Bryan, C. Andre, J. Chodosh, and M. S. Gilmore, “The best of all worlds: Streptococcus pneumoniae conjunctivitis through the lens of community ecology and microbial biogeography,” *Microorganisms*. 2020. doi: 10.3390/microorganisms8010046.

[7] O. Mottl *et al.*, “Spatial covariance of herbivorous and predatory guilds of forest canopy arthropods along a latitudinal gradient,” *Ecology Letters*. 2020. doi: 10.1111/ele.13579.

[8] P. Matos-Maraví, “An ‘omics’ approach to bridge community ecology and island biogeography,” *Molecular ecology*. 2020. doi: 10.1111/mec.15426.

[9] Y. Tang *et al.*, “A Tripartite Microbial-Environment Network Indicates How Crucial Microbes Influence the Microbial Community Ecology,” *Microb. Ecol.*, 2020, doi: 10.1007/s00248-019-01421-8.

[10] N. Nunan, H. Schmidt, and X. Raynaud, “The ecology of heterogeneity: Soil bacterial communities and C dynamics,” *Philosophical Transactions of the Royal Society B: Biological Sciences*. 2020. doi: 10.1098/rstb.2019.0249.

CHAPTER 11

IMPACT OF LAND DEGRADATION ON ECOSYSTEM

Dr. Krishnappa Venkatesharaju
Assistant Professor, Department of Environmental Science and Engineering,
Presidency University, Bangalore, India.
Email Id: venkateshraju.k@presidencyuniversity.in

ABSTRACT:

An important environmental problem, land degradation has repercussions for human communities, ecosystems, and the sustainability of the entire planet. The origins, effects, and potential remedies of land degradation are highlighted in this chapter. When the quality of the land declines, it loses its ability to support life and its ability to provide ecosystem services. This is referred to as land degradation. Deforestation, soil erosion, excessive grazing, urbanization, and poor land management techniques are frequently the causes of this process. Significant repercussions of land degradation include decreased agricultural output, biodiversity loss, desertification, and greater susceptibility to natural catastrophes. The main points of land degradation are explored in this chapter, which emphasizes the necessity for sensible tactics and laws to deal with this urgent environmental problem.

KEYWORDS:

Cause of Land Degradation, Control of Land Degradation, Effects of Land Degradation, Types of Land Degradation.

INTRODUCTION

Land degradation is any alteration that makes the land less productive. It is a process where a variety of human-induced processes occurring on the land alter the value of the biophysical environment [1], [2].

1. Loss of the soil's natural fertility as a result of nutrient loss is what is meant by "land degradation".

2. A lower amount of greenery.

Modifications in the climate brought on by imbalances in the environment [3], [4]. Pollution of soil where water seeps into the ground or runs off into water bodies, which contaminates water supplies. Any alteration or disruption to the land that is deemed unpleasant or negative. According to UN/FAO, land degradation typically denotes a temporary or long-term loss in the land's ability to support human habitation. It is a process, either natural or caused by people, that harms the land [5], [6]. Natural factors make certain places more susceptible to land degradation than others. The chance of deterioration is influenced by steep slopes, a lot of rain, and soil organic matter [7], [8]. In general, it refers to a process that has a detrimental impact on the land's inherent abilities to receive, recycle, and store water, energy, and nutrients, which causes a loss in land productivity. Different definitions of land degradation were offered by various scientists [9], [10]. These definitions offer a thorough understanding of the types of resources found on land, such as soil, plants, and water, as well as the variety of commodities and services that may be obtained from it. Barrow (1991) asserts that a precise description of land degradation is difficult. According to one definition, it may be described as "the loss of utility or the reduction, loss, or change of features or organisms that cannot be replaced." The land is said to be degraded when "it suffers a loss of intrinsic qualities or a decline in its capabilities" by Blaikie and Brookfield (1987). "Weathering down of the land surface" is what Winfried (1986) identified it as.

Young (1997) defined land degradation as the reduction of a land's productivity and capacity due to processes such as soil erosion, loss of soil fertility, and soil salinity. One of the most serious issues is the degradation of the earth's surface or land degradation. Land must be preserved in order to continue providing support since land degradation not only decreases capability but also hastens the process of turning productive land into a wasteland, which cannot support life. India is mostly a farming nation. Approximately 143 million hectares of India's total 305 million hectares of land are utilized for agriculture, of which roughly half is a wasteland. Nearly 18 million of the remaining hectares are used for urban production, 21 million are rocky or snowcapped, 17 million are cultural waste areas, 23 million are fallows, and 83 million are forested and used for grazing.

Land degradation: The term "land degradation" is broad and has several possible applications in this field. Land degradation was considered in four distinct ways, including how it affected the environment and soil productivity, how usable the land became over time, how biodiversity was lost, how ecological risk was moving, and how much less productive the land might be.

Since soil deterioration is the root of the idea of land degradation, the two terms are frequently used interchangeably. Given that soil deterioration hinders or interferes with plant development, it is obvious that soil degradation has a significant influence on both the land and landscape. The qualities and properties of the soil harm its fertility. Land degradation eventually puts a strain on the world's agricultural and grazing lands, which give everyone on the globe access to food, water, and clean air. More than only the degradation of the soil or land is meant by "land degradation." Food insecurity, climate change, environmental risks, the loss of biodiversity, and ecosystem services make it a worldwide problem that affects everyone. is the degradation or loss of the soils' future and present capacity for production.

There are both natural and artificial causes of land deterioration. A purely anthropogenic definition of land degradation is the loss of a sustained economic, cultural, or ecological function as a result of human activities in combination with natural processes. It is apparent that since humans first appeared on the planet, anthropogenic processes have become exponentially more significant. Land degradation is accelerated and made worse by global processes including climate change, changing land use, and changing land cover. Third-world nations are particularly affected by the processes of degradation. The overexploitation of natural resources in these nations' ecologically vulnerable regions hastens the process of deterioration. The impact of global warming on already damaged land intensifies the deterioration as well. Natural resources are threatened by land degradation, which has implications for food security, poverty, ecological stability, and political stability. In all parts of the world, the rising frequency of climate extremes, such as heat waves, droughts, and heavy rains, has an impact on processes that lead to land degradation, such as flooding, mass migrations, soil erosion by water and wind, and salinization.

DISCUSSION

Types of Land degradation: The effects of a land degradation process vary according to the natural qualities of the land, including the soil type, slope, flora, and climate. Because of variations in geography, climatic conditions, soil properties, and other factors, an activity that is not degrading in one place may be degrading in another. As a result, various soil types will experience variable rates of soil loss from equally erosive rainstorms. As a result, while evaluating the cause of land degradation, it is important to consider how various landscape components interact with one another as well as how deterioration varies depending on the location. Degradation of the land can take many different forms. Among the most common varieties are:

1. Soil erosion: Loss of the top, rich layer of soil, either partially or completely. It is the most well-known and prevalent type of land degradation. It consists of many processes, each of which is explained in more detail below, but any one of them may take place in the same location at different periods of the year or in combination. Water-induced soil erosion is a common problem that can happen everywhere in a dry environment when there is enough rainfall to cause surface flow. Processes including splash, sheet, rill, and gully erosion fall under this group. In drylands that are exposed to high winds, soil erosion caused by wind is also common. By wind action and the abrasive impacts of moving particles as they are carried, soil particles are both removed and redeposited.

2. Soil contamination: When pollutants are present in soil over a specific threshold, one or more soil functions may be compromised or lost. The deterioration of the land is facilitated by the presence of xenobiotic (human-made) substances and other modifications to the natural soil environment. Usually, industrial activity, agricultural chemicals, or inappropriate waste disposal are to blame. It affects soil biodiversity, lowers soil organic matter, and lessens soil's filtering ability. Additionally, it depletes the nutrients in the soil and contaminates groundwater and water held in the soil. Mining, oil spills, non-biodegradable waste dumps, and radioactive waste dumps all cause soil contamination or ecological damage.

3. Desertification: This process of land degradation is described as "a type of land degradation in which a relatively dry land region gradually becomes arid, typically losing bodies of water as well as vegetation and wildlife." Increased soil desertification is a hazard to agriculture. Due to causes including climate change, a decline in vegetation, and poor agricultural management, the land turns into a desert when it completely loses all of its water and green matter. It is quite difficult to repair the land in this situation.

4. Soil Acidification: A decrease in the pH of the soil is referred to as soil acidification. Too much acidity reduces the productivity of the soil. Acid rain, airborne nitrogen emissions, soil amendments, and other reasons can all contribute to its occurrence. The production of acid sulfate soil and soil acidification lead to barren soil.

5. Soil Salinity: An increase in the soil's salt content is referred to as soil salinity. Salinization significantly lowers plant cover and soil quality. Saline and sodic soils are more susceptible to erosion by wind and water because the soil structure has been destroyed. Salination causes impacts of desertification such as soil crusting, loss of soil fertility, deterioration of soil structure, compaction, etc. All forms of soil deterioration caused by an increase in salts in the soil are together referred to as salinization. The productivity of the soil decreases when it becomes too salinized. Ocean conditions, over-irrigation, water supplies with salt concerns, and other situations can all make use of it.

6. Loss of vegetation cover: The amount of soil that is covered by greenery is referred to as vegetation cover. The loss of air humidity and fluctuations in temperature during the day, night, or seasons are muted by vegetation. When the earth is covered with plants, the summers are cooler and the winters are warmer. As a result of soil erosion, there is less plant cover, which has the effect of regulating the climate. The benefits of vegetation are numerous. In addition to offering organic material to keep nutrient levels necessary for strong plant development at a constant level, it shields the soil from the erosive effects of wind and water. Plant roots support soil structure maintenance and aid in water infiltration. Land deterioration is significantly

influenced by vegetation cover. Reduced perennial cover is thought to be a key sign that desertification is beginning. Increasing soil organic matter, soil aggregate stability, water holding capacity, hydraulic conductivity, delaying and lowering surface water flow, and other benefits of vegetation cover are all highly essential.

Cause of land degradation: Natural processes connected to the features of the specific land resources and ecosystems may be the primary cause of land degradation. On the other hand, human actions frequently speed up these degrading processes. The quality and quantity of land resources as well as the ecosystem services that depend on them are rapidly declining due to pollution or degradation of the soil and ecosystem caused by mining, the dumping of oil and non-biodegradable trash on top of the soil, and radioactive wastes. Particularly delicate and susceptible to land deterioration are arid places. The degradation of the land is a result of several intricately interrelated degradation processes. Overuse of natural resources is one of the main factors contributing to rising land degradation. Degradation of the land is mostly caused by

1. Soil Erosion: Soil erosion is the loss of soil or disruption of the soil structure. The loss of the top soil, which is the soil's surface fertile layer, is referred to as soil erosion. Water, ocean waves, glaciers, rainfall, excessive grazing, excessive cropping, and incorrect tilling are the main causes. The primary factors that contributed to land degradation were plant cover deterioration and soil erosion brought on by wind and water.

2. Overgrazing: Overgrazing occurs when the stocking density of natural pastures exceeds the carrying capacity for animals. When plant and soil qualities do not fully recover after periods of regular rainfall, degradation has taken place. It can decrease ground cover, allowing wind and rain to erode and crush the soil. This makes it harder for plants to develop and for water to infiltrate the soil, which kills soil bacteria and causes significant land erosion. The productivity of our croplands is significantly impacted by overgrazing, which is also to blame for soil erosion. The extent of grazing land in India is shrinking daily as a result of the increase in agricultural land. Recent satellite images demonstrate the serious degradation of the region beneath pastureland. The reason pasture pastures are in such bad shape is because of overgrazing.

3. Desertification: This is the process through which deserts are formed. In arid, semi-arid, and dry sub-humid regions, desertification is a common process of land degradation brought on by a variety of reasons, including climate changes and human activity. Desertification is described as the "diminution or destruction of the biological potential of land can ultimately lead to desert-like conditions" by the UNO Conference on Desertification (1977). Desertification occurs on terrain that no longer has vegetation, in regions with obvious rainfall shortages, or as a result of human mistakes.

4. Shifting cultivation: Shifting cultivation is another factor in the deterioration of the soil. A large number of tribal people, especially in northern and eastern India, utilize jhum (shifting) farming. In jhum agriculture, a passage of ground is cleared by chopping down and burning trees, and crops are subsequently grown on the ash left behind. The cultivations continue to move from one area to another as additional land is cleared. Excessive jhuming cycles harm soil fertility and destroy forests.

5. Misuse of fertilizers: Fertilizers are a common tool for boosting food production. By using chemical fertilizers to maintain soil fertility, farmers utilize less organic manure. But using chemical fertilizers excessively has caused many issues, including substantial soil deterioration, soil compaction, nitrogen leaching, a decline in soil organic matter, and soil

carbon loss. The buildup of heavy metals in soil and plant systems may be impacted by fertilizers.

6. Mining: The most significant cause of land degradation is mining. The physical, chemical, and biological characteristics of the soil are disturbed by mining. Heavy amounts of dust are released during mineral processing, limestone grinding, and ceramic manufacturing. This dust eventually settles in the surrounding environment.

7. Water logging: Excessive irrigation of land contributes to water logging, soil deterioration, and an unsuitable soil environment for cultivation. Sodium bicarbonate-containing irrigation water causes soil alkalization, which results in poor soil structure and lower agricultural yields. The rise in the groundwater level is caused by faulty field drainage and excessive irrigation. As a result, water-logging is a condition that results from the mixing of groundwater with surface water utilized for irrigation. In order to address the detrimental impacts of soil waterlogging on irrigated land, subsurface land drainage is required.

8. Industrialization: The development of industries for economic expansion results in excessive deforestation and land use to the point where it has lost its natural capacity for improvement. Due to the encroachment of urban, industrial, and agricultural activities, the building of dams, canals, roads, trains, airports, mining, etc., large portions of fertile and productive lands are destroyed. The growth of businesses like coal mining, oil refineries, paper and pulp mills, chemical fertilizer manufacturing, and others affect the chemical and biological composition of the soil. Hazardous chemicals from these sectors may enter the food chain through soil during waste disposal, having negative impacts. Nuclear testing facilities or industries may release radioactive contaminants into soil and water, including uranium, thorium, radioactive radon, potassium, and carbon isotopes. Thus, all of these have made the issue of land degradation worse.

9. Urbanization: One of the causes of land degradation is the rising population and the desire for additional business and residential space. The demand for land resources for food production is increased by unchecked urbanization and the growing world population. This causes soil erosion and the disappearance of buildable ground.

10. Deforestation: Deforestation is the loss of forest areas for other land uses, such as urban development, mining, agricultural croplands, or other land uses, around the world. Deforestation occurs when trees are taken down and not replaced, destroying forests. Widespread erosion is brought on by the removal of trees, whose roots stabilize the soil. The land begins to lose its fertility and all of the nutrients it once contained as the soil progressively disappears. Numerous ecological issues, such as habitat loss, mass extinction, increased $CO2$ emissions, etc., have been brought on by deforestation.

11. Salination: Salination is the term used to describe an increase in the number of soluble salts in the soil. This might be either sonication, which is a rise in sodium cation ($Na+$) on the soil particles, or salinization, which is an increase in salt in the soil water solution. Poor irrigation management frequently coexists with salinization. The majority of the time, dissolved salts in the water supply are what cause salination. This water source may result from brackish groundwater seeping through the soil from below, seepage of seawater, or inundation of the land by seawater. Sodication often happens spontaneously; it may be more common in locations where the water table varies.

12. Siltation: Siltation is the buildup of the slit (fine sand, mud, and other material particles) in the reservoir. Water naturally contains some slit, however, tons of slit contaminate the water. Every river contains sand, but this does not always signify that the river is contaminated; sand

is simply carried by the water as a result of soil erosion. It may develop into a significant issue, particularly in water reservoirs when siltation happens as a result of ground erosion and the water has nowhere to go since it is not flowing.

Effects of land degradation: Any change in the state of the land that lessens its production capacity is referred to as land degradation. In this, topsoil loss, vegetation loss, and rising soil salinity are all included. It has more profound effects on receiving water supplies than just the productivity of the land. It is the process through which a piece of land loses its suitability for farming. A large amount of the fertile lands was harmed by various forms of land degradation, which harmed countries' prosperity and economic advancement. The following are the main effects of land degradation:

1. Loss of Soil Fertility: Physical, chemical, and biological aspects of soil are all impacted by land degradation, which lowers soil production. The impact of land degradation on soil's physical characteristics, such as declining soil structure, decreasing root zone depth, low porosity, decreasing moisture and nutrient retention capacity, decreasing aeration, etc., as well as its biological characteristics, such as decreasing microbial population, decreasing soil respiration rate, decreasing organic matter content because of the removal of vegetation from topsoil, decreasing land biodiversity, etc., and chemical characteristics, such as decreasing reduction Losing rich soil reduces the ability of a piece of land to be used for agriculture, generates new deserts, reduces the amount of vegetation that covers the soil, contaminates streams, and may increase the frequency of flooding.

2. Siltation: The deposition of soil particles on the plains from river water. Cropland land is destroyed by siltation over the flood plains on the river banks. Human activities that cause fine dirt to leak into surrounding rivers are the main source of siltation. This had the effect of leaving an exceptionally huge number of debris in that particular section of the river. These soils could go into other bodies of water after rainstorms. Sensitive marine animals and freshwater fish may be affected by suspended slits in their natural waterways. Benthic creatures like coral, oysters, shrimp, and mussels are particularly susceptible to slit because they are filter feeders. Waterways and irrigation canals may also suffer from the effects of slit accumulations. Concerns about human health, the disappearance of wetlands, modifications to coasts, and adjustments to fish migratory patterns are some other detrimental impacts of siltation. Silt is a significant problem because it makes the river bottom shallower, which reduces the capacity of river channels to hold water. In these places, floods are also typical.

3. Forest degradation: As a result of human activities, biotic resources are being depleted and the productive capacity of forests is being reduced. The forest flora of the highlands and foothills is destroyed by erosion on the slopes of the hills. One of the key causes of the rise in land degradation is overuse of the natural resources.

4. Climate change: Land degradation, which releases significant amounts of carbon (stored in soil) into the atmosphere, also contributes to climate change. The largest terrestrial carbon sink is soil. More carbon is stored in the world's soils than the planet's biomass and atmosphere put together. The carbon stored in soils across the world is known as soil carbon. This contains carbonate minerals made from both organic and inorganic carbon found in soil. One of the main indicators of land degradation is the loss of soil organic carbon, and land degradation is one of the biggest obstacles to sustainable development, biodiversity preservation, and mitigating and adapting to climate change.

5. Famine: Soil erosion affects the productivity of the land, the amount of water available for irrigation, and the amount of hydroelectric power produced during the year's dry seasons. There

isn't much water and other input available for supporting crops when the seasonal rains don't come. As a result, starvation grips the region.

6. Desert spread: Sand from a desert area is carried by the wind and spread onto nearby cropland, ponds, lakes, and irrigation canals. In addition to the soil being infertile, the vegetation is destroyed through abrasion and suffocation. Desert conditions are created as a result of water reservoirs and channels being filled with water.

Prevention and Control of Land Degradation: Because land resources are limited and non-renewable, it is important to ensure their sustainable management. Only fertile fields can support human existence. Land degradation has been caused by long-term, continuous usage of the land without the implementation of proper conservation and management practices. The effects on society and the environment are severe as a result. A severe issue on a worldwide scale, land degradation now threatens the viability of agricultural production and ecological services. The land is a finite resource, and we frequently overlook its significance in our daily lives. Sustainable land management is outlined as a fundamental prerequisite for long-term agricultural management and agricultural sustainability success given the world's growing population and finite natural resources. Land degradation is made worse by natural processes that are impacted by human activity, such as climate change and biodiversity loss. The harm brought on by erosion results from the loss of topsoil, plant nutrients, and subsoil water, clogging of waterways, decreased land productivity, and eventually a decline in quality of life. Protecting fertile areas can only be done via soil conservation. It also stops the ground from degrading while increasing agricultural output. The modern approach to soil conservation is based on sensible land use and management of the land using those flexible practical techniques that maintain the soil's ongoing productivity. Agrostological techniques and afforestation can be used to stop land deterioration. Trees that slow the wind are planted to prevent the expansion of sand dunes, desert conditions, or the blowing away of fertile topsoil. Grass strips placed between rows of crops in a field are very helpful for preserving soil, soil water, and soil productivity. Crop rotation, mixed cropping, or the development of plantation crops can replace shifting farming, improving fertility and supporting a bigger population. Here are some methods for preventing land degradation:

1. Reforestation: The woods, which are regarded as the nation's main source of income and which offer wood, fuel, pulp, gum, resin, and turpentine, among other things, are crucial for preventing floods and soil erosion. Soil erosion and flooding can be prevented by replanting grass and trees. The humus that the woods accumulate protects the soil from erosion. Plants' rocks act as natural dams to hold back dirt and water. Therefore, it is important to avoid forest fires and regulate soil degradation as well as timber harvesting.

2. Crop rotation: This agricultural method involves growing several crops in the same field following a rotation schedule. Leguminous and grain crops are alternately saved through a process called crop rotation. Crop rotation reduces soil depletion and is particularly useful in the management of erosion, weeds, and several plant diseases when combined with fern manures and commercial fertilizers. Crop rotation techniques can replace shifting cultivation. A bigger population might be supported by mixed farming or the development of plantations.

3. Contours plantation: This technique is used on incline hills. Instead of plowing up and down the hill, this approach works the ground against it. This inhibits the flow of water and causes across ridges to develop. So that crop rows are level, the log slopes are divided into many strips and put out across them. Sometimes the hill is split into many terraces, or little flat areas, using a technique called terracing. Each terrace consists of a waterway with a wide bottom and an

outlet. In other cases, low ridges are also constructed across the terraces to act as miniature dams, contain water, and prevent soil erosion.

4. Mulching: Mulching is the practice of covering a soil surface with any material, including grasses, straw, leaves, agricultural wastes, and other types of plant litter. With this technique, the earth is left untilled. Mulching prevents weeds from growing, promotes soil development, lowers runoff, boosts soil infiltration, offers thermal insulation, and increases humification. The protected soil is not in direct touch with the forces that cause erosion.

5. Control of grazing: Grazing destroys not only seedlings, herbs, and underbrush, but it also compacts and hardens the soil, making it unsuitable for plant growth. Different animals, such as buffaloes, horses, sheep, and goats, have clear ties to the kinds of flora they graze, and each species has a significantly different impact on the pasture. These animals' excessive grazing exacerbates desert conditions by spreading soil erosion. Years of continual grazing make the soil loose, making it vulnerable to wind and water erosion. A region shouldn't be permitted to be grazed for an extended time to regulate grazing. The management of fodder with grazing animals is known as control grazing. Separating pastures with both permanent and temporary fences, it restricts excessive grazing.

6. Organic farming: In organic farming, organic fertilizers are used to enrich the soil rather than chemical ones. The best supply of nitrogen is found in the nodules of legume roots, while agricultural wastes and natural fertilizers like cow dung help increase the soil's nutritional content.

7. Strip farming: Strip farming is the technique of planting two distinct crops in alternating rows. Crops like cotton, soybeans, corn, and others that allow for relatively wide plant spacing make up one set of rows. Plants that grow closely together, such as wheat, legumes, and other similar crops, are found in the second set of rows. This kind of farming causes water to flow along the land's contour rather than down its slope. Additionally, the crops in one row that are grown close together shield the exposed soil in the crops in the second row that are grown more widely apart. The length and steepness of the slope are two characteristics that affect strip farming. When there is no other way to stop soil erosion or when a slope is too steep, it is utilized. By building organic water dams, strip farming prevents soil erosion and maintains the stability of the soil. It aids in nutrient retention in the soil.

8. The development of ridges and furrows: This conservation farming technique involves planting seeds in ridges, which raises soil temperatures and collects precipitation in the furrows that separate the ridges. More infiltration time is provided by the developed ridges and furrows, which operate as a continuous barrier to the unrestricted downward passage of water. As a result, the loss of soil and nutrients is greatly reduced, increasing soil fertility and crop output. One of the many in situ soil and water conservation techniques for black and red soils is ridges and furrows. Mulched ridges and furrows provide microclimates that encourage soil microbial activity, boost soil biodiversity, and enhance environmental advantages.

9. Building of dams: To reduce the flow velocity, a check dam is a tiny dam built over a drainage ditch, swale, or channel. Stone, sandbags, or loss may all be used to construct check dams. Where temporary or permanent channels need velocity checks, channel lining is impractical, and neither temporary nor permanent channels have yet been vegetated, check dams can be employed. Check dams are frequently employed to stabilize sedimentation, minimize watershed erosion, decrease flow in tiny temporary channels that are already degrading, and boost reservoir storage capacity. They stop flowing water in active gullies and direct it to a safe location.

The following are some more strategies to prevent land degradation:

a) To prevent salt of the soil, adequate drainage should be established.

b) Lands damaged by salt can be restored by whitening them with more water.

b) Planting enough of the right kinds of plants, mulching, or covering the area with an artificial protective covering can all stop sand from moving.

b) Making use of lighter agriculture equipment.

e) Decrease the number of implement passes made during tillage operations.

f) Refraining from touching the ground while it's moist.

g) Occasional thorough plowing to lessen soil compaction.

h) Reducing soil crusting by mulching, light cultivation, and the use of gypsum ($CaSO_4$).

The loss in the land's ability to produce is referred to as "land degradation," and it can be either temporary or permanent. Since soil deterioration is the root of the idea of land degradation, the two terms are frequently used interchangeably. It is a process, either natural or caused by people, that harms the land. Common human activities that cause land degradation include trash disposal, agricultural practices, deforestation, mining operations, and urbanization. The top layer of the soil is the most crucial since it contains all of the nutrients that plants need. In addition to pollution, soil deterioration also causes many other issues. These include urban encroachment without proper planning, deforestation, erosion, floods, and salinization of the land.

Degradation is the term used to describe a change in the features and quality of soil that harms its fertility. It is a process, either natural or caused by people, that harms the land. Because soil degradation is the root of the idea of land degradation, the two terms are frequently used interchangeably. In this, topsoil loss, vegetation loss, and rising soil salinity are all included. Soil erosion, excessive grazing, desertification, shifting agriculture, improper fertilizer usage, mining, and water logging are the main causes of land degradation. Urbanization, salinization, deforestation, and industrialization. A large amount of the fertile lands was harmed by various forms of land degradation, which harmed countries' prosperity and economic advancement. Loss of soil fertility, siltation, loss of forest vegetation, climatic change, famine, or the expansion of the desert are the main effects of land degradation. Land degradation can take many different forms, including eroding soil, contaminating soil, desertification, soil acidification, soil salinization, losing plant cover, etc. Protecting fertile areas can only be done via soil conservation. Only fertile fields can support human existence. Some methods for preventing land degradation include reforestation, crop rotation, contour planting, mulching, grazing management, organic farming, strip farming, ridge and furrow creation, and dam building.

Land Degradation: Land degradation is the disruption of the natural composition and characteristics of soil as a result of anthropogenic (human) effects, either directly or indirectly.

Organic farming: Agriculture without synthetic pesticides or fertilizers.

Mulching: Mulching is the technique of covering the soil to create circumstances that are more favorable for plant development, growth, and effective crop production.

Siltation: Due to the presence of tiny mineral particles in the water, siltation is the process by which the water becomes tainted.

Shifting cultivation: This method of farming involves clearing and cultivating a plot of land for a brief time, after which it is left unattended and allowed to resume generating its usual vegetation while the cultivator shifts to another plot.

Jhum: It's the practice of cultivating crops by first removing all trees and plants from the area, then burning them.

Soil acidification: The process of soil acidification involves a gradual reduction in the pH of the soil.

Arable: Land that can support crop production is referred to as arable land.

Agnotological techniques: Grass is cultivated in this technique to stop soil erosion. By use of a process called humification, plant twigs, wood, etc. are converted into humus.

Wetland: A wetland is a region of land that is either completely or partially submerged in water.

CONCLUSION

Environmental sustainability, agricultural production, and human well-being are all severely hampered by land degradation. Deforestation, soil erosion, overgrazing, urbanization, and poor land management techniques are some of the factors that contribute to land degradation, which lowers the quality of the land and reduces ecosystem services. Wide-ranging effects of land degradation include decreased agricultural production, destruction of biodiversity and habitats, desertification, and heightened susceptibility to natural catastrophes. In conclusion, governments, organizations, and people all need to work together to address the urgent environmental challenge of land degradation. We can lessen the effects of land degradation, promote environmental sustainability, and protect the health and productivity of our lands for both current and future generations by putting into practice sustainable land management techniques, adopting sensible legislation, and encouraging community engagement.

REFERENCES:

[1] H. Xie, Y. Zhang, Z. Wu, and T. Lv, "A bibliometric analysis on land degradation: Current status, development, and future directions," *Land*. 2020. doi: 10.3390/LAND9010028.

[2] H. Xie, Y. Zhang, Z. Wu, and T. Lv, "A Bibliometric Analysis on Land Degradation :," *Land*, 2020.

[3] A. A. Adenle, S. Eckert, O. I. Adedeji, D. Ellison, and C. I. Speranza, "Human-induced land degradation dominance in the Nigerian Guinea Savannah between 2003 – 2018," *Remote Sens. Appl. Soc. Environ.*, 2020, doi: 10.1016/j.rsase.2020.100360.

[4] A. Gobin, L. T. T. Hien, L. T. Hai, P. H. Linh, N. N. Thang, and P. Q. Vinh, "Adaptation to land degradation in southeast Vietnam," *Land*, 2020, doi: 10.3390/LAND9090302.

[5] J. Wang *et al.*, "Spatio-Temporal Pattern of Land Degradation from 1990 to 2015 in Mongolia," *Environ. Dev.*, 2020, doi: 10.1016/j.envdev.2020.100497.

[6] G. Giuliani *et al.*, "Knowledge Generation Using Satellite Earth Observations to Support sustainable Development Goals (SDG): A Use Case on Land Degradation," *Int. J. Appl. Earth Obs. Geoinf.*, 2020, doi: 10.1016/j.jag.2020.102068.

[7] D. A. Menestrey Schwieger and M. Mbidzo, "Socio-historical and structural factors linked to land degradation and desertification in Namibia's former Herero 'homelands,'" *J. Arid Environ.*, 2020, doi: 10.1016/j.jaridenv.2020.104151.

[8] S. Erşahin, "A method for calculating land degradation neutrality," *MethodsX*, 2020, doi: 10.1016/j.mex.2020.100969.

[9] A. Almeida de Souza, L. S. Galvão, T. S. Korting, and J. D. Prieto, "Dynamics of savanna clearing and land degradation in the newest agricultural frontier in Brazil," *GIScience Remote Sens.*, 2020, doi: 10.1080/15481603.2020.1835080.

[10] M. Kiani-Harchegani and S. H. Sadeghi, "Practicing land degradation neutrality (LDN) approach in the Shazand Watershed, Iran," *Sci. Total Environ.*, 2020, doi: 10.1016/j.scitotenv.2019.134319.

CHAPTER 12

EXPLORING THE IMPACT OF POLLUTION ECOLOGY

Ms. Meenakshi Jhanwar
Assistant Professor, Department of Environmental Science,
Presidency University, Bangalore, India.
Email Id: meenakshi@presidencyuniversity.in

ABSTRACT:

The subject of pollution ecology focuses on how pollutants affect ecosystems and the environment. This chapter gives a general introduction to pollution ecology and emphasizes how crucial it is to comprehend how pollution affects natural systems. When dangerous compounds are introduced into the environment, including the air, water, and soil, this is referred to as pollution. Pollution ecology studies how pollutants are produced, dispersed, changed, and how they affect species, populations, communities, and ecosystems. It covers a variety of pollution types, including the effects of chemical pollutants on ecosystem health and biodiversity as well as air, water, and soil pollution. This chapter explores important facets of pollution ecology, highlighting the demand for efficient pollution control methods to safeguard and improve the health of our ecosystems.

KEYWORDS:

Air Pollution, Effects of Air Pollution, Green House, Ozone Layer Depletion, Pollutants.

INTRODUCTION

Pollution is defined as the presence or introduction of dangerous chemicals into the environment. Nature maintains a balance between the land, water, air, and living organisms in the biosphere and ecosystem, which are self-sustaining. Any type of biosphere imbalance leads to environmental contamination [1], [2]. The Latin verb polluter, which means "to contaminate any feature of the environment," is where the word pollution originates. The first global science conference on resource protection and exploitation, organized by the UN and held in Lake Sussess in 1949, was when the concept of pollution was first introduced. The National Academy of Sciences Pollution Committee declared in 1966 that pollution is the unwarranted alteration of soil, water, or air qualities [3], [4].

According to Odum (1971), pollution is "an unfavorable change in the physical, chemical, or biological characteristics of our air, land, and water that may or will adversely affect the lives of humans or other desirable species, our industrial processes, living conditions, and cultural assets." According to Southwick (1976), pollution is the unfavorable change in our environment that is mostly brought about by human activity. Some ecologists, like Smith (1977), Odum (1971), and Southwick (1976), claim that the pollution catastrophe on earth may have its roots in many reasons, including the exponential growth of the human population, uncontrolled urbanization and deforestation, profit-driven capitalism, and technological innovation[5], [6].

The natural environment becomes less favorable for organisms when toxins are added. Human activities including transportation, trash disposal, consumption, and energy production are connected to pollution [7], [8]. The biophysical environment, biodiversity, and other resources as well as the functioning of the ecosystem are all impacted by humans. Humans' disregard for their surroundings leads to pollution.

By burning fossil fuels, recycling chemicals and pesticides, causing sewage run-off, and other practices, humans damage the air, land, and water. Humans and other biological species are negatively impacted by pollution. People nowadays modify natural resources to make them more practical and put up with the waste they produce as a result of exploiting them. The environment is harmed by these waste products. The introduction of unwanted and harmful chemicals into the ecosystem harms the environment [9], [10].

Pollutants: Pollutants are substances that make the air, soil, water, or another natural resource harmful. The word "pollutant" describes a class of substances that are present in the environment at risky levels and behave as pollutants that harm both the environment and living organisms. Pollutants are a result of human activity. Any chemical, geochemical material, biological organism or product, or physical property (heat) that is purposefully or unintentionally released into the environment by a person and has real or prospective negative, harmful, or unpleasant impacts is said to be released into the environment. Important pollutants include the following:

1. deposited materials, such as smoke, tar, or dust

2. Gases, such as chlorine, fluorine, ammonia, hydrogen sulfide, carbon monoxide, nitrogen oxide, and sulfur dioxide.

3. Metals, including cadmium, lead, iron, mercury, zinc, and tin.

4. Pesticides, herbicides, fungicides, insecticides, fertilizers, etc. are examples of agricultural pollutants.

5. Organic contaminants, include benzopyrene, acetic acid, ether, and others.

6. Pollutants from photochemical oxidation caused by cars, such as photochemical smog, ozone, peroxyacetyl nitrates, nitrogen oxides, aldehydes, and ketones.

7. Heat and noise, etc.

8. Stable waste.

Pollutants are separated into two groups.

1. Biodegradable pollutants: These include household waste, textiles, paper, and wood, all of which can disintegrate quickly through microbial action and other natural processes. When their input into the ecosystem outweighs their decomposition, they may cause issues.

2. Non-biodegradable pollutants: Non-degradable pollutants include materials and poisons like aluminum, cans, mercuric salts, plastics, waste glasses, phenolics, DDT, etc. that do not disintegrate or degrade extremely slowly in the natural environment. They are not naturally recycled in an environment. These contaminants are transferred from one biological system to another, or they are "biologically magnified."

According to the forms that pollutants take after being released into the environment, they are also divided into the following two groups.

a) Primary pollutants: These are the pollutants that already exist in the environment as they are, such as nitrogen and sulfur oxides.

b) Secondary pollutants: These are the pollutants created when primary pollutants react, often in the presence of sunlight. For instance, when hydrocarbons and nitrogen oxides react in the atmosphere, they produce a class of nitrous compounds like peroxyacetyl nitrate (PAN), which is a secondary pollutant.

DISCUSSION

Types of pollution: Environmental pollution is the inappropriate release of mass or energy into the planet's natural resources, such as the air, water, and land, which has a negative long- or short-term impact on the environment and the health of its ecosystem, as well as a negative qualitative and quantitative impact on the living things and their existence. According to the type of environment being contaminated or the pollutant in question, different forms of pollution are categorized.

1. Air toxicity
2. Water contamination
3. Soil pollution
4. Noise pollution
5. Radioactive pollution
6. Solid waste pollution

Air pollution: For people and other living things to live and survive, there must be air pollution. A person cannot live without air. As time goes on, either naturally occurring or due to human activity, air pollution increases daily. The term "air pollution" refers to the tainting of the earth's atmosphere, typically brought on by human activity, which harms plants, living things, and property. The World Health Organization defines air pollution as the presence in the outer atmosphere of substances or contaminants introduced by man, in quantities and concentrations and of a duration that causes any, discomfort to a significant number of residents of a district and is harmful to the public health or to humans, plant or animal life, or property, or which interfere with the reasonable comfortable enjoyment of life and property throughout the territories o According to the Environment Perform Index 2014, India's air quality was among the five worst in the world. The atmosphere is polluted by things like smoke, dust, fire, exhaust, and pollutants from moving cars, among other things. One of the most serious and prevalent types of environmental issues is air pollution. The buildup of compounds in the atmosphere that, when present in high enough quantities, damages human health or have other measurable impacts on other materials and living things is referred to as air pollution. The introduction of substances such as chemicals, particulate matter, or biological elements into the air can hurt or threaten people, other living things, or the environment.

Air pollution is brought on by the addition of unwelcome elements to the atmosphere. The presence of substances in the air at levels that are hazardous to both the environment and people can be referred to as air pollution. Air pollution, according to the World Health Organization (WHO), is "limited to situations in which the outer ambient atmosphere contains materials in concentrations that are harmful to man and his environment." The calculated fact that air makes up roughly 80% of a man's daily intake in terms of weight may be used to determine the significance of air pollution. Average male breaths around 22,000 times each day, inhaling almost 16 kg of air. Currently, 91% of people live in locations where the air quality is below the standards set by the World Health Organization as being safe. The physiology and growth of plants and animals, human health, and the structure and functioning of ecosystems are all impacted by air pollution, either directly or indirectly. Pollutants come in two different categories: primary and secondary.

1. Primary Pollutant: Primary pollutants, such as CO2 and CO, are released into the atmosphere directly as a result of burning fossil fuels. Nitrogen oxides, hydrocarbons, carbon monoxide, particulates, photochemical oxidants, and Sulphur dioxide are the six main categories of primary pollutants.

a) Sulfur dioxide (SO2): Coal and petroleum burning are the main sources of sulfur dioxide. Sulfur compounds are frequently found in coal and petroleum, and their burning produces sulfur dioxide. Smelters, oil refineries, fertilizer manufacturers, paper and pulp manufacturing, sulphuric acid manufacturing, and other sectors all generate sulfur dioxide (SO2). Acid rain is created when sulphuric acid (H2SO4), which is created when Sulphur dioxide and moisture combine in the atmosphere, causes several respiratory illnesses. Acidic rain retards the development of forests.

b) Nitrogen oxides (NO2): Nitrogen oxides are the second most common type of air pollution. When fuel is burned at a high temperature, as in industrial facilities and transportation (automobiles), nitrogen oxides are produced. Sulfur compounds are frequently found in coal and petroleum, and their burning produces sulfur dioxide. Since nitrogen oxides may harm plants and irritate the eyes and lungs when inhaled directly, they are a contributing factor in many issues.

c) Carbon monoxide (CO): Carbon monoxide (CO) is a colorless, odorless, deadly gas that is neither unpleasant nor offensive. Incomplete combustion of fuels like natural gas, coal, and wood results in carbon monoxide, which makes up more than half of the total weight of pollutants released into the atmosphere.

d) Volatile organic compounds (VOCs): VOCs are odorless, tasteless, organic substances that easily evaporate at room temperature and include the element carbon in their molecular structures. They can be found in common home things including art supplies, paints, varnishes, fuels, garments that have been dry cleaned, pesticides, cigarette smoke, etc.

e) Particulates: Solid particle air pollutants include heavy metals, pesticides, photochemical haze, smoke, radioactive elements, etc. Liquid particulate air pollutants include solvents suspended in gases. Liquid aerosols and sprays are particles of a liquid form. Some particulates are produced naturally, such as by forest fires, volcanoes, and dust storms. Aerosols are also produced by burning fossil fuels in cars, fireplaces, and industry chimneys.

f) Radioactive Pollutants: Cooled powder reactors, atomic explosions, and nuclear weapon testing all release a significant amount of radioactive elements into the atmosphere. Atomic power reactors produce a significant amount of radioactive elements into the environment. The production and decommissioning of nuclear weapons, the mining of radioactive minerals, the handling and disposal of radioactive waste, accidents at nuclear power plants, and radioactive material released into the environment during nuclear explosions and nuclear weapon testing are all causes of this.

g) Aerosols: A suspension or dispersion of tiny solid or liquid droplets in air or another gas, such as smoke, mist, or fog, is referred to as an aerosol. Aerosols like fluorocarbons, which are fluorine-containing carbon compounds generated by jet aircraft emissions, cause the ozone layer, which serves as a screen against damaging UV radiation reaching the planet, to shrink.

h) Metals: These are mostly found in the air as solid particles, liquid droplets, or gases, and include lead, nickel, arsenic, beryllium, tin, vanadium, titanium, etc. They are mostly created by metallurgical operations, vehicles, sea spray, etc.

2. Secondary Pollutant: When primary pollutants interact or react with one another, secondary pollutants are created in the atmosphere. For instance, nitrogen oxides react with unsaturated hydrocarbons to generate peroxy acetyl nitrate, sometimes known as PAN.

Effects of Air Pollution: Air pollution has negative effects on people, animals, and plants.

1) In Plants: Over time, substances such as fluorides, peroxyacetyl nitrate, and sulfur dioxide injure plant leaves and cause tissue collapse owing to air pollution-induced plasmolysis of leaf cells. Carbon dioxide and SO2 in high quantities cause long-term damage to plants. Air pollution causes slowed growth, tiny fruit production, and leaf drop. NOx and Peroxy Acetyl Nitrate (PAN) impair chloroplast function, which impairs plant development, and hinder the Hill reaction, which kills forest trees. Plant foliage is harmed by photochemical pollution, severely affecting spinach leaves.

2) Impacts on people: Pollutants harm people's health. Headaches, vertigo, difficulty breathing, and mucous membrane irritation are among the symptoms of inhaling carbon monoxide, which interacts with blood hemoglobin to limit its ability to transport oxygen. Young children's brains can be harmed by lead and nitrogen dioxide (NO2). Inhalation can result in bronchitis, pulmonary congestion, eye discomfort, and even death. Ozone, for example, produces dry mouth mucous membranes, coughing, eye irritation, pain and coughing in the chest, pulmonary congestion, and edema, while cadmium is poisonous to the respiratory system and results in an oxygen shortage. Particulate air pollution causes bronchitis, asthma, and other respiratory issues in individuals all over the world. Numerous gaseous and particle contaminants have a detrimental impact on human health. Small, solid particles and liquid droplets carried by the air are referred to as particulates. They represent a severe hazard to air pollution issues since they are too prevalent in the air. When particle matter enters the human body, it causes blood clots and cardiac issues by increasing blood viscosity and blood flow. The size of the particles has a significant impact on the impacts of particulate pollution. Dust, soot, fumes, and mists are examples of airborne contaminants that might be harmful to human health. The likelihood that particles will harm your health is strongly correlated with their size. PM 2.5, or fine particles, present the biggest health danger. Some of these tiny particles could even enter the bloodstream and go deep into the lungs.

The lungs and heart of a person can be impacted by exposure to these particles. Even though coarse particles (PM 10-2.5) might irritate someone's eyes, nose, and throat, they are less dangerous. Some chronic illnesses, such as lung cancer, bronchitis, emphysema, and asthma, are mostly brought on by exposure to contaminated air. Sulfur dioxide severely irritates the respiratory system and eyes. H2S results in headache, nausea, conjunctivitis, mucous membrane irritation, collapse, coma, and ultimately death from respiratory failure. If breathed often, sulfur particles produced by SO2 can lead to bronchitis and asthma. When carbon monoxide is breathed, it interacts with the hemoglobin in the blood and results in an oxygen shortage. This causes difficulty breathing, headaches, and mucous membrane discomfort. Lung and heart damage as well as eye irritation are caused by nitrogen oxides and PAN (peroxyacetyl nitrate, formed photochemically in the environment containing olefins and nitrogen oxides). The most significant sources of fluoride consumption for humans are foods and beverages. Fluorosis is a condition brought on by long-term fluoride poisoning. Other inorganic gases that harm the lungs and respiratory system include ammonia, chlorine, and phosgene. Numerous ailments are brought on by airborne metal dust particles. Lead affects how the nervous system works in adults and can kill young children by killing their brains. Cadmium is a respiratory toxin that increases blood pressure and causes cardiac problems. In addition to causing headaches, weariness, anxiety, lethargy, and appetite loss, mercury exposure can harm the brain system, liver, and eyes. Asthma, bronchitis, and other respiratory conditions are brought on by atmospheric pollution brought on by smoke and grit. Byssinosis is a fairly frequent occupational illness in India that is caused by cotton dust. Many different biological particle materials, such as bacterial cells, spores, and pollens, can lead to allergies, bronchial difficulties, and other illnesses. In humans, strontium-90 is concentrated in tissue and damages bone and marrow cells, as well as having the potential to trigger tumor growth.

3) Effects on Construction Materials: Building materials are damaged by air pollution. Materials used to construct buildings erode due to smoke, dust, fog, grit, and sulfur oxides. Hydrocarbons, SO2, and Nitrogen Oxide (NOX) are produced during the burning of coal and petroleum. They can linger in the atmosphere or generate acids in the rainwater. Monuments, structures, and furniture are all damaged by acid rain. The Taj Mahal, a prominent landmark across the world, is severely harmed by acid deposition and is also dealing with corrosive issues from the SO2 gases generated by the Mathura refinery.

4) Climate change: The term "climate change" refers to modifications in the planet's climate that are brought on by human activity. The upper atmosphere becomes contaminated as a result of air pollution, which also changes the temperature. According to Ayyar (1973), when air pollutants such as dust, smoke, CO2, oxides of N2, and SO2 are present in larger concentrations, they scatter light, which results in a shift in the climate. When some gaseous pollutants and aerosols, including ammonium sulfate mists and sulfuric acid mists, reach the sky, they have an impact on how sunlight is absorbed and penetrated. The pH of rainwater is impacted by aerosol, SO2, and ammonium acid fume concentrations.

By obstructing sunlight, lowering vision, creating acid rain, and hurting forests, animals, and agriculture, air pollution harms the ecosystem. Sulfuric acid and nitric acid are created when sulfur dioxide and nitrogen dioxide, which are present in the atmosphere, combine with water droplets to generate acid rain. These contaminants can be transported by winds hundreds of kilometers before they finally arrive as acid rain at the surface of the planet. High levels of particle pollution alter the sky's look and diminish the quantity of sunlight that reaches the surface. Air pollution is to blame for the hole in the ozone layer. Chlorine atoms are present in substances that are employed as refrigerants, such as chlorofluorocarbons (CFCs). Ozone is destroyed when chlorine atoms are released into the atmosphere. The sun's dangerous ultraviolet-B (UVB) radiation is absorbed by the ozone layer.

Greenhouse gases like carbon dioxide and methane are part of air pollution. Climate change is being brought on by greenhouse gas emissions. It keeps the earth from being too cold. They provide a relatively warm climate that is suitable for the survival of living things by capturing a small amount of heat from the sun and preventing it from fleeing the ground. Global warming is a phenomenon caused by an increase in greenhouse gases, which will increase the amount of heat that is trapped on the earth. As these gases are produced in greater quantities, the amount of heat that is trapped will also increase, contributing to global warming. Extreme weather events, rising oceans, and melting ice sheets are a few instances of how greenhouse gas pollution affects the climate. As the planet warms, the polar ice cap will begin to melt, raising ocean and sea levels worldwide, resulting in disasters like floods and dramatic and severe climate changes as well as the submerging of islands and coastal regions.

Preventing and reducing air pollution: Environmental issues are so pervasive that they affect all aspects of human activity. Toxic chemical releases, automobile emissions, nuclear testing, and the depletion of natural resources are just a few of the factors that have contributed to the biosphere's rapid decline. Environmental goals include improving and developing the atmosphere in addition to reducing pollution-related issues. The following are some actions to reduce air pollution:

(i). In a designated industrial zone, factories and other businesses should be located as far away from the city borders as practicable.

(ii). To filter out the bigger particles of carbon pollution, manufacturers' chimneys should be connected with specific fittings like scrubbers, cyclone separators, or electric precipitators.

(iii). Using unleaded fuel, superior engines with minimal emissions, and adequate vehicle maintenance will help reduce automotive pollution.

(iv). More trees should be planted because they will purify the air by releasing oxygen and lowering carbon dioxide levels in the environment.

(v). It's important to monitor the indiscriminate use of biocides and insecticides.

(vi). Controlling air pollution from motor vehicles, industry, etc. calls for the proper actions. State and federal air pollution boards exist. They have the authority to grant and revoke permits to polluting businesses, enforce emission regulations, and establish guidelines for the management of air pollution.

(vii). Instead of producing gasoline or diesel-powered automobiles, the automotive sector could produce battery- and solar-powered vehicles.

(viii). It is necessary to stop excessive and undesired vegetation burning.

(ix). Avoid nuclear explosions at all costs.

Environmental education is the most crucial and fundamental strategy for addressing environmental issues. Environmental contamination issues should be brought to the attention of every individual.

Depletion of the ozone layer: The stratosphere, the second layer of the atmosphere, has a gas mixture with the ozone layer as its outermost layer. Between 15 and 35 kilometers (km) above the earth's surface, the ozone layer may be found. A naturally occurring gas called stratospheric ozone filters UV light from the Sun and shields the earth's surface from its detrimental effects. Most of the UV energy from the Sun is absorbed by ozone. Human activities are contributing to the ozone layer's weakening. Chlorofluorocarbons (CFCs) are substances made up of carbon, fluorine, and chlorine. These gases are utilized in polyurethane foams, aerosol spray cans, cleaning agents, fire extinguishers, and air conditioners and refrigerators (as coolants). One CFC molecule can harm 100,000 ozone molecules. The weakening of the ozone layer, sometimes known as the ozone hole, was first seen above Antarctica in 1985. Supersonic aircraft, space rockets, and rocket ships all contribute to the ozone layer's depletion. Radiation may reach the Earth's surface more easily when the ozone layer is thinner. For people, excessive exposure to UV rays can cause cataracts, immune system decline, and skin cancer, including melanoma. Plants with less chlorophyll have lower agricultural yields, which disrupt the oxygen cycle and change the weather. It causes mutations in living organisms' nucleic acids.

Green House Effect: The earth's surface heats naturally as a result of the greenhouse effect. Greenhouse gases absorb the remaining solar energy after it enters the earth's atmosphere and re-radiate some of it into space. The planet is kept warm enough for life to exist thanks to this mechanism. Greenhouse gases include carbon dioxide, methane, nitrous oxide, ozone, CFCs, CO, and SO2. Human activities including the combustion of fossil fuels, deforestation, agriculture, industrial processes, etc. are contributing to an increase in CO2 concentration. The heat cannot be reflected out into space due to a thick layer formed by an increasing CO2 concentration. Thus, this substantial CO2 layer serves as a greenhouse's glass panel. A greenhouse is a glass structure used to cultivate plants that need a high temperature to thrive. While allowing sunlight to enter a greenhouse, glass panels stop heat from being reflected into space. Similar to higher CO2 concentrations, other gases also restrict heat from radiating back into space while allowing sunlight to pass through. Thus, the atmosphere's CO2 layer and water vapor absorb the majority of the heat, which helps to warm the planet and raise its temperature. The alleged "Green House Effect" is this. CO2 concentration in the atmosphere was 275 ppm about 100 years ago. Currently 350 ppm, it is predicted to increase to 450 ppm by 2040. Global warming is caused by the greenhouse effect being amplified. Weather and climatic changes might result from global warming.

CONCLUSION

Understanding the damaging impacts of pollution on ecological processes and the environment depends heavily on pollution ecology. Pollutants have a tremendous influence on species, populations, communities, and entire ecosystems when they are introduced into the air, water, and soil. Pollution may impact human health, alter natural processes, decrease biodiversity, deteriorate air quality, and damage water quality. Finally, pollution ecology offers significant understanding of how pollutants affect ecosystems and the environment. We can create and put into practice measures to reduce pollution, safeguard biodiversity, and preserve the sustainability of our natural systems by understanding the origins, distribution, transformation, and impacts of pollutants. Prioritizing pollution control is essential if we want to achieve a cleaner, more sustainable future.

REFERENCES:

[1] J. Yuan *et al.*, “Ecology of industrial pollution in China,” *Ecosystem Health and Sustainability*. 2020. doi: 10.1080/20964129.2020.1779010.

[2] D. de M. Castro e Silva, R. M. N. Marcusso, C. G. G. Barbosa, F. L. T. Gonçalves, and M. R. A. Cardoso, “Air pollution and its impact on the concentration of airborne fungi in the megacity of São Paulo, Brazil,” *Heliyon*, 2020, doi: 10.1016/j.heliyon.2020.e05065.

[3] Y. Hao *et al.*, “How does ecology of finance affect financial constraints? Empirical evidence from Chinese listed energy- and pollution-intensive companies,” *J. Clean. Prod.*, 2020, doi: 10.1016/j.jclepro.2019.119061.

[4] K. S. Handayani, B. Irawan, and A. Soegianto, “Short-term mercury exposure in tilapia (Oreochromis niloticus) at different salinities: impact on serum osmoregulation, hematological parameters, and Na+/K+-ATPase level,” *Heliyon*, 2020, doi: 10.1016/j.heliyon.2020.e04404.

[5] A. Kumar, M. Cabral-Pinto, A. Kumar, M. Kumar, and P. A. Dinis, “Estimation of risk to the eco-environment and human health of using heavy metals in the Uttarakhand Himalaya, India,” *Appl. Sci.*, 2020, doi: 10.3390/app10207078.

[6] L. G. Akita, J. Laudien, M. Akrong, C. Biney, E. Nyarko, and S. Addo, "Physicochemical influence on the spatial distribution of faecal bacteria and polychaetes in the Densu Estuary, Ghana," *African J. Environ. Sci. Technol.*, 2020, doi: 10.5897/ajest2020.2830.

[7] A. Kendall and E. S. Spang, "The role of industrial ecology in food and agriculture's adaptation to climate change," *J. Ind. Ecol.*, 2020, doi: 10.1111/jiec.12851.

[8] H. Chandran, M. Meena, and K. Sharma, "Microbial Biodiversity and Bioremediation Assessment Through Omics Approaches," *Front. Environ. Chem.*, 2020, doi: 10.3389/fenvc.2020.570326.

[9] S. F. de B. Matheus, C. dos S. C. Tereza, S. S. Alberis, and V. dos S. Ewerton, "Ingestion of plastic debris affects feeding intensity in the rocky shore crab Pachygrapsus transversus Gibbes 1850 (Brachyura: Grapsidae)," *Int. J. Biodivers. Conserv.*, 2020, doi: 10.5897/ijbc2020.1391.

[10] L. Posthuma *et al.*, "Chemical pollution imposes limitations to the ecological status of European surface waters," *Sci. Rep.*, 2020, doi: 10.1038/s41598-020-71537-2.