PRIORITY PARAMETERS: ABIOTIC AND BIOTIC COMPONENTS

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Contents

Summary

Organisms respond to factors in the environment in which they live. These environmental factors are part abiotic (nonliving) and part biotic (living). The abiotic factors are usually the governing forces of the environment, one organism ordinarily affecting others by its ability to modify the abiotic environment. The abiotic and biotic factors function to maintain a continuous energy flow and nutrient cycling. The abiotic factors influence the distribution of organisms. Abiotic factors include fire, light, moisture, soil, temperature, wind, and chemical factors as salinity and acidity while the biotic components are living organisms and the interactions among them. The living organisms form the biological or living resources. The most valuable aspect of the living resource is the diversity of organisms on Earth—known as biodiversity. Human survival is utterly dependent on biodiversity. Human activities are adversely impacting on most of these factors. Humans have injected materials into the biosphere in large quantities that have affected the functioning of the ecosystems and have an adverse effect on life on Earth. Humans, through uncontrolled exploitation of living resources, are depleting those resources faster than nature can replace them. Because some of these factors are essential for the continued existence of life on Earth and because human activities are adversely affecting these factors thereby threatening the existence of life on Earth, these factors could be considered as priority abiotic and biotic environmental components.

1. Introduction

Organisms respond to factors in the environment in which they live. These environmental factors are part abiotic (nonliving) and part biotic (living). The abiotic factors include fire, light, moisture, soil, temperature, wind, and such chemical factors as oxygen levels, salt concentrations, the presence of toxins, and acidity. The biotic factors are living organisms which include competing species, parasites, predators, and humans. Each organism can tolerate a wide range of environmental factors and can only live where these factors lie within its tolerance limits.

The abiotic factors are usually the governing forces of environment, one organism ordinarily affecting others by its ability to modify the abiotic environment. The abiotic factors of the environment influence the well-being and distribution of organisms and the functions of the ecosystem. For example, temperature and moisture acting together determine in large measure the climate of a region and the distribution of plant and animal life. Light is essential to plants, without it, ecosystems could not function. Light also influences the reproductive and activity cycles of plants and animals. Soil is the site of decomposition of organic matter and of the return of mineral elements to the nutrient cycle.

Human activities are adversely impacting on most of the environmental factors. Humans have injected materials into the biosphere in large quantities that have affected the functioning of the ecosystems and have an adverse effect on plants, animals, and humans. These substances have affected the process by which Earth dissipates absorbed solar radiation, leading to global warming; have led to depletion of the ozone layer, resulting in greater penetration of ultraviolet radiation in the atmosphere; and have polluted water bodies and soil, thereby reducing the suitability of the environment for the survival of humans and other organisms. Humans, through uncontrolled exploitation of living resources, are depleting those resources faster than nature can replenish them and are already threatening the continued existence of the resources. Because some of the environmental factors are essential for the survival of organisms on Earth and because human activities are adversely affecting these factors thereby threatening the existence of life on Earth, these factors can be considered as priority abiotic and biotic environmental factors.

2. Priority Abiotic Factors

2.1. Temperature

Temperature is an indication of the amount of heat energy in a system; the higher the heat content, the higher the temperature. On a worldwide basis, temperature is perhaps the dominating factor affecting plant and animal distribution. The arctic, the temperate zones, and the tropics are largely delimited by temperature differences. The environmental temperatures experienced by most organisms result directly or indirectly from solar radiation reaching any point on Earth at any time and varying with the time of year, slope, aspect, cloud cover, time of day, and other factors.

Temperature is one of the most critical factors of the environment and exerts a profound influence on all physiological activities by controlling the rate of chemical reaction. Every physiological function has temperature limits above and below which it ceases and an optimum temperature at which reactions proceed at a maximum rate. As the temperature deviates from this optimum, the rate of reaction decreases, stopping completely beyond a critical limit. The temperature at which organisms can exist is referred to as the physiological range. It varies in different organisms depending on local adaptations. A temperature of 52 °C is about as high as any animal and protozoan can still grow and multiply. The thermal limit for the survival of metabolically active vascular plants ranges from about +60 °C to –60 °C in different species. Some bluegreen algae and other prokaryotic organisms are known to exist from slightly below 0 °C to about 70 °C.

Human activity is warming Earth through a phenomenon known as the "greenhouse effect." Scientists are concerned that patterns of temperature may be altered by global warming much too rapidly for human societies and especially for agricultural systems to adjust. Increased concentration of greenhouse gases are almost certainly going to raise global average temperature substantially with the attendant consequences. Current projections estimate an increase in global average temperature of 3–5 °C by the year 2050. Associated with global warming will be regional and local changes in average temperature, changes in the distribution of hot and cold periods, and changes in a number of other chemical and physical variables including precipitation, evaporation rates, sea level, and soil and water chemistry. Because of global warming, some regions will see dramatic increases in rainfall and others will loose their present vegetation because of drought.

R.E. Smith has reported that the role of temperature and its relationships with moisture in the distribution and abundance of species is the subject of intensive research relating to global climate change and has raised the following questions. How will organisms respond to increasing temperature? What effect will global climate change have on flora of the tundra and taiga? Will ranges of temperate plants shift northward? What plants and animals will succumb or be supplanted by competitors better adapted to warmer temperatures? What effect will such changes in plant communities have on associated animal and microbial life? How will increasing temperature affect agricultural plants? According to him, these and hundreds of other questions about the effects of global warming beg for answers.

2.2. Moisture

Water is the major constituent of the planet, covering about 71% of Earth’s surface. It is the most abundant compound in all living matter. Water and temperature, in a large measure, determine the climate of a region and the distribution of animals and plants. While temperature determines the global distribution of animals and plants, on a smaller geographical scale, moisture is more important. Moisture relationships within an ecosystem are clearly related to rainfall. In determining what kinds of animals and plants an area can support, the actual amount of rainfall is less important than the ratio of rainfall and evapotranspiration (evaporation from soil and plant surfaces plus plant transpiration). This is because areas of equal rainfall may have different evapotranspiration and this accounts for the differences between forest, grassland, and desert.

About 97% of Earth's volume of water is found in the oceans and is too salty for drinking and growing crops and for most industrial uses except cooling. The remaining 3% is freshwater. Of this, more than 75% (about 2% of Earth's total volume) is locked up as ice at the poles and in glaciers leaving less than 1% of the world's water available as fresh liquid water. Only about 0.003% of Earth's total volume of water is easily available to us as freshwater in lakes, soil moisture, exploitable ground water, atmospheric water vapor and streams.

There are two sources of freshwater, namely surface water and groundwater. Surface water is precipitation that does not infiltrate the ground or return to the atmosphere by evapotranspiration. It is the freshwater that is on Earth's surface in streams, lakes, wetlands, and artificial reservoirs. Water flowing off the land into bodies of surface water is called surface runoff and water flowing in rivers to the oceans is called river runoff. Groundwater fills the pores and hollows within Earth's crust. The main natural source of this is precipitation, which percolates downward through soil and rock in what is called neutral recharge. Some of the groundwater is inherited as in aquifers in desert regions, where the water has been in the aquifer for thousands of years and still another portion of it is fossil water, which lies below 100 m and it is often saline and does not participate in the hydrologic cycle. Though there is about 40 times as much groundwater below Earth's surface as there is in surface water in all the world's streams and lakes, it is unequally distributed, and only a small amount of it is economically exploitable. Heavy use of groundwater for irrigation and other purposes at a rate greater than it is recharged by hydrologic cycle is depleting the groundwater supply. Overuse of groundwater can also cause subsidence in relatively unconsolidated land overlying an aquifer and intrusion of saltwater into aquifers near a coast.

Earth's water moves through hydrologic cycle, involving precipitation, interception, surface flow, and evaporation. The key to this cycle is the atmosphere. Evaporation into and precipitation from the atmosphere, retention in oceans, and land and atmospheric transport maintain the global water balance. The hydrologic cycle connects every place on Earth. However, humans are disrupting the water cycle by polluting the water, overloading it with slowly degradable and nondegradable wastes, and withdrawing it from underground supplies faster than it is recharged by the hydrologic cycle. Because of these human impacts, the natural usable water resources have decreased and water quality had declined. The natural water cycle has not been able to compensate for these destructive human actions.

The abundance of water divides the environment into aquatic and terrestrial habitats. In nature, there are three types of habitats as regards water content, namely hydric, mesic, and xeric habitats. For the most part, water is a problem in two environments, the marine and salt environment and the desert. The saltwater environments are physiological deserts in which the concentration of salts outside the body of the organism can osmotically dehydrate the organism. In the deserts, an absolute lack of moisture exists. In the course of evolution, many species of animals and plants have become adapted in both structural and physiological features to the water concentration in their environment. Plants are grouped into xerophytes, hydrophytes, and mesophytes according to the adaptation they show to water concentration in their environment. Xerophytes are plants that live in arid regions like deserts where rainfall is insufficient and drains through the soil very quickly. In such areas, the available water is often limited, and because the air is dry, the rate of transpiration is very high. Since the rate of transpiration is very high, reduction of water loss is an important physiological adaptation. Xerophytic adaptations enable the plants to retain enough water to keep their protoplasts wet, thus avoiding desiccation to survive the drought. Hydrophytes are plants that are adapted to existence under water or with their roots in water in swampy or marshy soil containing a quantity of water that would prove supraoptimal or excessive for the average plant. Plants of both fresh- and saltwater belong to this group. Their usual problem is lack of oxygen for respiration. The adaptations are chiefly in response to excessive water content, which allows them to increase their oxygen supply. Mesophytes are land plants adapted to a moderate water supply. They grow in habitats that are neither extremely dry nor wet. The oxygen supply around the roots is moderate; the solutes are neither extremely dilute nor too concentrated.

Animals show responses to different moisture regimes. In arid regions, terrestrial animals are faced with the problem of water shortage and their challenge is how to conserve water. For example, desert-dwelling animals face the problem of water shortage as well as high daytime temperature. They overcome these problems in several remarkable ways.

Many desert animals go into estivation or some other stage of dormancy during periods of extreme drought and resume activity when the rains arrive. This dormant stage is characterized by temporal failure of growth and reproduction, by reduced metabolism and enhanced resistance to drought and other climatic conditions. Others resist drought by evolving ways of circumventing acidity through physiological adaptations or by modifying their feeding and activity patterns. Animals such as reptiles and some insects are "pre-adapted" to deserts by their impervious integuments and dry excretions, which enable them to get along on a small amount of water. Mammals, as a group, are poorly adapted to desert but some have become secondarily adapted.

In marine environments, animals are faced with water of high salt content. In most cases, the osmotic pressure of the saltwater is higher than that of the animal cells. In order to survive in this environment, animals have evolved adaptations to inhibit the loss of water by osmosis through the body wall and prevent an accumulation of salts in their system. Under extreme moisture conditions, such as flooding or severe drought, animals move to more favorable environments to survive.

Humans through our activities are increasingly polluting water bodies throughout the world, altering the chemical, physical, and biological quality, which has resulted in the depreciation of the water value. Humans are exploiting groundwater for irrigation and other purposes faster than hydrologic cycles recharge it. These impacts have adversely affected the multiple uses of water bodies by humans and as habitats for plants and animals.

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