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THE INFLUENCE OF ENVIRONMENTAL FACTORS ON MICROORGANISMS

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Abstract

This article examines the effects of physical, chemical, and biological environmental factors on microorganisms. Environmental factors have a decisive influence on the distribution, adaptation, survival, and biological activity of all living organisms, including microorganisms. The article highlights the specific features of how ecological factors affect the microbial world, as well as their significance for ecosystems and medicine.

Objective: To study the influence of environmental factors on microorganisms.

Keyword

microorganisms, environmental factors, temperature, desiccation, antagonism, symbiosis.

Relevance of the topic: Microorganisms are among the first to respond even to minor fluctuations in environmental parameters—whether changes in temperature, humidity levels, chemical composition of the environment, or the degree of anthropogenic impact. Due to such high sensitivity, they serve as bioindicators reflecting the state of ecosystems. Therefore, a deep understanding of how environmental factors affect microbial communities is of practical importance in developing measures to regulate and reduce the negative impact of anthropogenic factors on various natural systems.

Microorganisms represent the most numerous and widespread form of life on the planet. They inhabit all natural environments—soil, water, and air—as well as the bodies of animals, plants, and humans. Their жизнедеятельность, reproductive capacity, and metabolic activity directly depend on environmental conditions. Environmental factors determine not only the preservation and size of microbial populations but also their role in biogeochemical cycles, the development of epidemiological processes, and the formation of stable microbial communities.

Physical, chemical, and biological environmental factors exert the greatest influence on microorganisms. Key physical factors include temperature, humidity, and the effect of light, including ultraviolet radiation, which can significantly alter the activity and survival of microbial cells [2].

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Fig. 1. Classification of environmental factors affecting microorganisms

The temperature regime of the environment is one of the key factors influencing the intensity of metabolism in microorganisms. Each species is characterized by its own temperature range, including a minimum, an optimum, and a maximum growth limit. When permissible values are exceeded, protein molecules are destroyed, enzymes are inactivated, and cellular structures are damaged, leading to cell death. Vegetative forms of bacteria are especially sensitive to heating, whereas spores are significantly more resistant and can withstand boiling during sterilization and pasteurization processes.

Low temperatures, as a rule, do not destroy microorganisms but slow down or temporarily stop their metabolic processes. Under cold conditions, cells enter a state of anabiosis, maintaining viability. When favorable conditions are restored, their activity resumes, which is of great importance in the storage of food products and microbiological cultures.

According to temperature preferences, microorganisms are divided into psychrophilic, mesophilic, and thermophilic forms.

Psychrophiles are organisms adapted to exist at low temperatures. They are capable of growing at temperatures close to 0 °C or even lower; their optimum development range is between 10–20 °C, and the upper limit usually does not exceed 30 °C. Such microorganisms are widely distributed in cold natural environments—polar seas, glaciers, deep soil layers, and wastewater. Their enzyme systems function efficiently in cold conditions but become unstable when heated [1].

Mesophiles constitute the most numerous and ecologically significant group. The most favorable temperature for them lies within the range of 28–37 °C; the lower growth limit is around 10 °C, and the upper limit can reach 45 °C. This category includes most saprophytic forms and almost all microorganisms pathogenic to humans. Their temperature optimum

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coincides with human body temperature, creating conditions for active reproduction in the body and determining their importance in medical microbiology.

Thermophiles, on the contrary, are adapted to elevated temperatures. Their development begins at around 30 °C, with optimal values of 50–60 °C, and maximum limits reaching 70–75 °C or higher. These organisms inhabit hot springs, self-heating organic substrates (compost, manure), as well as the upper layers of soil exposed to intense heating. Their proteins and membranes are highly thermostable, ensuring survival under conditions unfavorable for most other microbes [1].

Water and humidity are also important physical environmental factors and are essential for maintaining the structural integrity of cells. They ensure the normal course of chemical (biochemical) reactions within cells, acting as a universal solvent. Desiccation leads to dehydration of the cytoplasm, disruption of membrane structures, and death of microorganisms. However, resistance to this factor varies significantly among different species. Bacterial spores and mold spores exhibit the highest resistance to drying and can remain viable for many years. This is of great importance in the epidemiology of infectious diseases and explains the long-term persistence of pathogens in the external environment.

Solar radiation, especially its ultraviolet component, has a pronounced bactericidal effect. UV rays damage nucleic acids and enzyme systems of microorganisms, leading to the cessation of reproduction and cell death. This property is widely used for the disinfection of air, water, and medical facilities. Additional physical factors affecting microorganisms include ultrasound and high pressure. Ultrasound causes the destruction of cell membranes, while extreme pressure can lead to cell death, although some microorganisms exhibit high resistance to such conditions [6].

Chemical environmental factors exert diverse effects on microorganisms, directly influencing them as well as the biochemical processes occurring within them. Depending on concentration and duration of exposure, chemical substances may serve as nutrients or exert toxic effects. For example, low concentrations of sugars stimulate microbial growth, whereas high concentrations inhibit reproduction. Many chemical compounds, such as salts of heavy metals, phenols, alcohols, acids, and alkalis, possess strong bactericidal properties.

Fig. 2. Groups of chemical compounds with bactericidal effects

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The listed chemical compounds are actively used in medicine and the sanitary field as disinfectants and antiseptics. Their main purpose is to suppress or eliminate pathogenic microorganisms and prevent the spread of infectious diseases [4].

Under natural conditions, microorganisms do not exist in isolation; they form complex communities in which various forms of biological interactions develop. These include symbiosis, metabiosis, commensalism, parasitism, and antagonism. The most common are symbiotic, antagonistic, and parasitic relationships. All these forms of interaction act as important biological environmental factors that significantly influence the number, activity, and structure of microbial populations.

Symbiosis is a mutually beneficial coexistence of organisms of different species. In microbial communities, such relationships increase resistance to unfavorable conditions—nutrient deficiency, temperature fluctuations, and changes in the chemical composition of the environment. An example is the interaction between nitrogen-fixing bacteria and higher plants, as well as the functioning of microorganisms within the normal human microflora. Through symbiotic relationships, metabolism is optimized, resources are used more efficiently, and ecosystem stability is maintained [3].

Metabiosis is characterized by the fact that the metabolic products of one microorganism create favorable conditions for the existence of another. Direct contact between organisms may not occur. Metabiotic relationships are widespread among soil and aquatic microorganisms and play a key role in the cycling of chemical elements in nature. For example, the decomposition of organic matter by putrefactive bacteria leads to the accumulation of compounds used by nitrifying bacteria. Thus, metabiosis ensures the sequential involvement of microorganisms in chains of substance transformation and maintains the continuity of biogeochemical processes.

Antagonism is a form of biological interaction in which one microorganism inhibits the growth and development of another or causes its death. Antagonistic relationships arise as a result of competition for nutrients, space, and other environmental resources. Mechanisms of antagonism include the production of organic acids, bactericides, antibiotics, and other biologically active substances. Antagonism has important practical significance in the human body, where normal microflora suppresses the growth of pathogenic microorganisms, providing natural protection. Moreover, the discovery and application of antibiotics in medical practice are based precisely on the antagonistic properties of microorganisms.

The above-mentioned biological communities of microorganisms are among the most important factors determining the structure of microbial communities, ecosystem stability, and the efficiency of matter cycling in nature. Their study allows for a deeper understanding of the mechanisms of self-regulation in microbial systems and enables the application of this knowledge in medicine, ecology, and biotechnology.

Environmental factors exert a complex influence on the жизнедеятельность of microorganisms, determining their survival, adaptive capabilities, and ecological role. Physical, chemical, and biological factors act in an interconnected manner, forming dynamic microbial communities. The study of these processes has significant theoretical and practical importance for ecology, medicine, sanitation, and biotechnology, and allows for more effective management of microbiological processes in the environment [3].

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