



## THE ROLE OF MICROORGANISMS IN BIOLOGICAL WASTEWATER TREATMENT PROCESSES

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**ABSTRACT.** *This article examines the role of microorganisms in biological wastewater treatment processes. Biological treatment is considered one of the most effective and environmentally friendly methods for removing organic pollutants from wastewater. The study discusses the metabolic activities of microorganisms such as bacteria, fungi, protozoa, and algae, which decompose organic matter and convert it into simpler and less harmful substances. Special attention is given to widely used biological treatment technologies, including the activated sludge process and biofilm-based systems such as trickling filters and moving bed biofilm reactors. The article also highlights the role of microorganisms in nitrogen and phosphorus removal through nitrification and denitrification processes. In addition, the influence of environmental factors such as temperature, pH, oxygen concentration, and nutrient availability on the efficiency of biological treatment is analyzed. The results emphasize the importance of understanding and optimizing microbial processes to improve the performance and sustainability of modern wastewater treatment systems.*

**Keywords:** *wastewater treatment, biological treatment, microorganisms, activated sludge process, biofilm technology, nitrification, denitrification, environmental sustainability.*

**ANNOTATSIYA.** *Ushbu maqolada oqova suvlarni biologik tozalash jarayonlarida mikroorganizmlarning roli yoritilgan. Biologik tozalash oqova suv tarkibidagi organik ifloslantiruvchi moddalarni samarali bartaraf etishning eng ekologik xavfsiz va iqtisodiy jihatdan maqbul usullaridan biri hisoblanadi. Tadqiqotda bakteriyalar, zamburug'lar, protozoalar va suv o'tlari kabi mikroorganizmlarning metabolik faoliyati natijasida organik moddalar parchalanib, oddiy va kamroq zararli birikmalarga aylanish jarayonlari tahlil qilingan. Shuningdek, faol loy (activated sludge) jarayoni hamda biofilm asosidagi tozalash texnologiyalari — tomchilatib filtrlar va harakatlanuvchi biofilm reaktorlari kabi tizimlarning ishlash prinsiplari ko'rib chiqilgan. Maqolada mikroorganizmlarning nitrifikatsiya va denitrifikatsiya jarayonlari orqali azot va fosfor birikmalarini chiqarib tashlashdagi ahamiyati ham yoritilgan. Bundan tashqari, harorat, pH, kislorod miqdori va ozuqa moddalari kabi omillarning biologik tozalash samaradorligiga ta'siri tahlil qilingan. Tadqiqot natijalari mikrobiologik jarayonlarni chuqur o'rganish va optimallashtirish zamonaviy oqova suvlarni tozalash texnologiyalarining samaradorligini oshirishda muhim ahamiyatga ega ekanligini ko'rsatadi.*

**Kalit soʻzlar:** oqova suvlarni tozalash, biologik tozalash, mikroorganizmlar, faol loy jarayoni, biofilm texnologiyasi, nitrifikatsiya, denitrifikatsiya, ekologik barqarorlik.

Wastewater treatment is an essential process for protecting natural water resources and maintaining environmental sustainability. Among various treatment methods, biological wastewater treatment plays a crucial role due to its efficiency, cost-effectiveness, and environmental compatibility. Microorganisms are the key agents in biological treatment systems, as they are responsible for the decomposition and transformation of organic pollutants present in wastewater.

Biological wastewater treatment is based on the metabolic activities of microorganisms such as bacteria, fungi, protozoa, and algae. These microorganisms utilize organic matter contained in wastewater as a source of energy and nutrients for their growth and reproduction. During this process, complex organic compounds are converted into simpler and less harmful substances such as carbon dioxide, water, and biomass. As a result, the concentration of organic pollutants in wastewater is significantly reduced.

One of the most widely used biological treatment technologies is the activated sludge process. In this system, a mixture of wastewater and microbial biomass is aerated in a biological reactor. The supply of oxygen promotes the growth and activity of aerobic microorganisms that degrade organic pollutants. The microbial flocs formed during the process settle in secondary clarifiers, allowing treated water to be separated from the biomass. Part of the activated sludge is recycled back to the aeration tank to maintain a stable microbial population.

Another important biological treatment process is biofilm-based treatment, which occurs in systems such as trickling filters, rotating biological contactors, and moving bed biofilm reactors. In these systems, microorganisms grow as a biofilm on the surface of solid media. The biofilm structure provides a stable environment for microbial communities and enhances the degradation of organic substances and nutrients in wastewater.

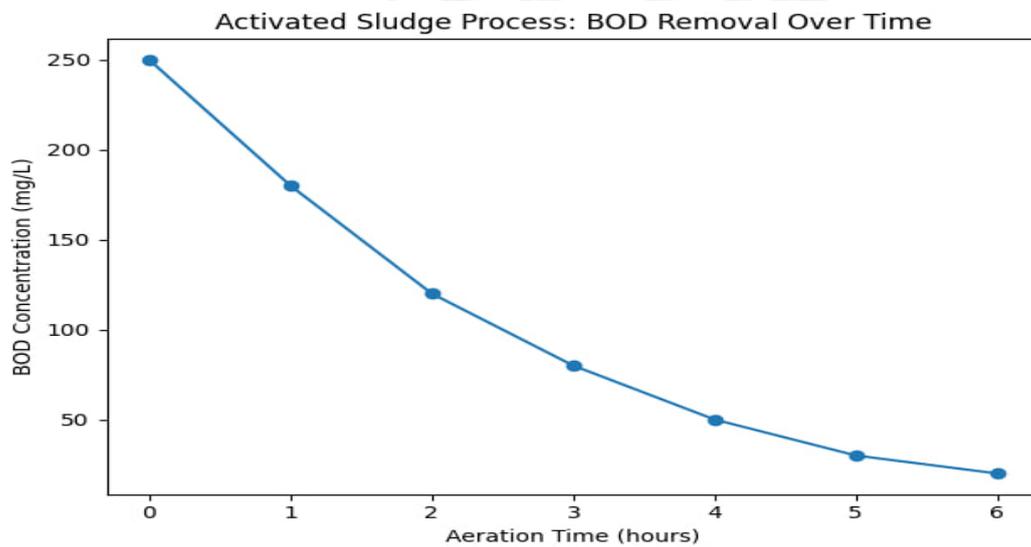


## Biological Wastewater Treatment Process



**Figure 1. Technological scheme of biological wastewater treatment.**

Microorganisms also play a significant role in the removal of nitrogen and phosphorus from wastewater. Nitrifying bacteria convert ammonia into nitrites and nitrates in the nitrification process, while denitrifying bacteria reduce nitrates to nitrogen gas during denitrification. These biological transformations help prevent eutrophication in natural water bodies.



**Figure 2. BOD removal during the activated sludge process.**

The efficiency of biological wastewater treatment processes depends on several factors, including temperature, pH, oxygen concentration, and the availability of nutrients. Maintaining optimal environmental conditions is essential for ensuring the stability and activity of microbial communities in treatment systems.





In conclusion, microorganisms are fundamental to the successful operation of biological wastewater treatment processes. Their metabolic activities enable the removal of organic pollutants and nutrients from wastewater, contributing to environmental protection and sustainable water management. Therefore, understanding and optimizing microbial processes is a key aspect of improving the performance of modern wastewater treatment technologies.

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