INNOVATIVE SOLUTIONS FOR WASTE RECYCLING WITH THE HELP OF MICROORGANISMS

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Abstract: This thesis analyzes the role of microorganisms in waste recycling, their ecological and economic aspects. Microbial bioremediation is analyzed as a process of converting oil waste, plastics and heavy metals into environmentally safe substances through biological decomposition. The scientific basis of this technology, its practical application and innovative approaches proposed for sustainable development are considered. The advantages of bioremediation, including its effectiveness in converting waste into resources, producing biofuels and restoring the environment, are analyzed, and their future ecological and economic significance are highlighted.

Keywords: Bioremediation, biofuels, environmental friendliness, environmental safety, biodegradation, biofuels, microbiological technology, bioenergy.

Microorganisms are invaluable in solving the urgent problems of waste recycling in modern society. This method, while ensuring environmental safety, allows you to turn waste into renewable resources. For example, bacteria such as Bacillus and Pseudomonas are highly effective in reducing pollution in soil and water. Such technologies allow you to convert waste into safe products and contribute to maintaining climate balance[1]. Today, plastic waste is one of the global environmental problems. In 2016, Japanese scientists led by Shosuke Yoshida discovered the bacterium Ideonella sakaiensis. This bacterium was shown to be able to decompose PET plastics using enzymes. Fusarium fungi also have the ability to decompose plastic materials. As a result of studies conducted by the Indian Institute of Ecological Research, it was noted that the rate of decomposition of plastic waste by Fusarium fungi was increased by 60%[2]. The use of microorganisms such as Alcanivorax is also showing positive results in reducing oil spills and their environmental damage. In 2010, during the Deepwater Horizon oil spill, researchers led by Terry Hazen discovered the ability of the bacterium Alcanivorax borkumensis to break down oil. Alcanivorax bacteria were successfully used during the Deepwater Horizon disaster, which resulted in the spill of 4.9 million barrels of oil into the sea, and a large amount of oil was cleaned up from the sea surface in a natural way. This technology is very effective in preventing environmental disasters that may occur in nature and is also economically beneficial[3]. Today, Myxococcus xanthus bacteria have been proven effective in cleaning up areas contaminated with heavy metals. These microorganisms are used to absorb cobalt and zinc ions from soil. In 2020, studies conducted by the Fraunhofer Institute in Germany noted the high efficiency of these bacteria, which is an important practical solution for protecting the environment[4].

Microorganisms also play an important role in the biofuel production process, as they allow the creation of energy sources such as methane, bioethanol and biodiesel by recycling waste. This process, on the one hand, reduces the environmental damage of waste, and on the other hand, it is also

economically beneficial. The use of microorganisms in research for sustainable energy production has been widely considered. These technologies not only increase environmental safety, but are also economically efficient and play a crucial role in creating renewable energy sources. At the same time, the efficiency of microorganisms in biofuel production is being increased through genetic modification and biotechnology. Microbial engineering technologies are being used to speed up the process and optimize the efficiency of microorganisms. Therefore, this approach opens up great opportunities in the field of biofuel production. In addition, microorganisms are important in cleaning the ecological environment by recycling waste. This method helps to reduce waste, use resources efficiently and protect the environment from pollution. Thus, microorganisms play a special role in ensuring ecological sustainability and solving global energy problems[5].

Conclusion.

Waste processing technologies using microorganisms stand out as one of the most effective tools for solving today's environmental problems. These technologies help to clean the environment and reduce pollution, degrade plastic waste, reduce the harmful effects of oil and heavy metals. They also provide economic efficiency through the production of biofuels and allow the creation of renewable energy resources. For the further development and implementation of these technologies, it is necessary to expand scientific research, discover new types of microorganisms and increase their genetic efficiency. By using the potential of microorganisms in the field of waste processing, environmental and economic sustainability can be achieved. The widespread introduction of these technologies on a global scale and increasing the environmental literacy of the population will help ensure a healthy and sustainable environment for future generations.

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