MIRZO ULUG'BEK NOMIDAGI
O'ZBEKISTON MILLIY UNIVERSITETINING
JIZZAX FILIALI

# ZAMONAVIY INNOVATSION TADQIQOTLARNING DOLZARB MUAMMOLARI VA RIVOJLANISH TENDENSIYALARI: YECHIMLAR VA ISTIQBOLLAR

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***mavzusidagi Respublika ilmiy-texnik anjuman materiallari to‘plami***

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# ECOLOGICAL AND BIOLOGICAL CHARACTERISTICS OF BACTERIA OCCURRING IN THE RHIZOSPHERE OF PLANTS IN THE ARAL SEA REGION

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**Abstract:**This article describes the diversity, ecological adaptability, and biological characteristics of rhizosphere bacteria associated with plants of the Aral Sea region. The rhizosphere is considered an important biological zone where microorganisms actively develop under the influence of organic compounds released by plant roots. Rhizosphere bacteria play a significant role in plant nutrition, mineral cycling, biological nitrogen fixation, phytohormone synthesis, and protection against phytopathogens.

The extreme environmental conditions of the Aral Sea region, characterized by high salinity, drought, and ecological degradation, have contributed to the formation of halotolerant and salt-resistant microorganisms. Studies have revealed the widespread occurrence of bacterial genera such as Bacillus, Pseudomonas, Enterobacter, Arthrobacter, Rhodococcus, Micrococcus, and Streptomyces. These microorganisms are important biological resources for enhancing plant stress tolerance, restoring soil fertility, and supporting bioremediation and phytomelioration processes.

Modern molecular-genetic methods, including 16S rRNA sequencing, metagenomics, and MALDI-TOF MS technologies, are increasingly used to investigate the functional and taxonomic diversity of the Aral Sea microbiome. The results demonstrate that rhizosphere microorganisms of the Aral Sea region represent a promising source for maintaining ecological stability and developing environmentally safe biopreparations.

**Keywords:** Aral Sea region; rhizosphere; rhizobacteria; halotolerant bacteria; saline soils; bioremediation; phytomelioration; biopreparations

Microorganisms are widely distributed on aerial plant surfaces, inside plant tissues, on root surfaces, and in the root-associated zone, where they are closely connected with plant physiological activity. In particular, the rhizosphere — a narrow biologically active zone surrounding plant roots — is considered one of the most favorable ecological environments for microorganisms. Plant roots release various

organic compounds into the rhizosphere in the form of root exudates, including monosaccharides, polysaccharides, amino acids, organic acids, vitamins, enzymes, and proteins. These substances serve as nutrient sources for bacteria and other microorganisms, promoting their active colonization around the roots. As a result, the number of microorganisms in the rhizosphere is several times higher than in bulk soil, leading to the formation of a complex microbial community [3].

Rhizosphere bacteria play an essential role in nutrient exchange between plants and soil. They decompose organic residues, accelerate nutrient cycling in the soil, and improve the efficiency of mineral uptake by plants. Certain bacteria are capable of biological nitrogen fixation, phosphate solubilization, siderophore production, and phytohormone synthesis, thereby stimulating plant growth and development. In addition, many rhizobacteria produce antifungal and antibacterial compounds that provide biological protection against phytopathogenic microorganisms [4;7].

The Aral Sea region is considered one of the world's most ecologically challenging territories. As a result of the desiccation of the Aral Sea, extensive saline and degraded soils have formed. The region is characterized by severe drought, high temperatures, increased ultraviolet radiation, and wind erosion. Although such extreme conditions are unfavorable for most organisms, certain halophytic and xerophytic plants have adapted and survived in this environment. Their rhizosphere hosts a specialized microbiome with high ecological adaptability [2;5].

Studies have shown that halotolerant and salt-resistant bacteria dominate the rhizosphere of plants in the Aral Sea region. In particular, bacterial genera such as Bacillus, Pseudomonas, Enterobacter, Arthrobacter, Rhodococcus, Micrococcus, and Streptomyces are widely distributed. These bacteria are adapted to high salinity and water deficiency conditions and play an important role in increasing plant tolerance to environmental stress. For example, some Bacillus and Pseudomonas species produce phytohormones such as indole-3-acetic acid (IAA), which enhance root system development. Certain strains also produce the ACC-deaminase enzyme, reducing the level of ethylene — a stress hormone in plants — thereby facilitating adaptation to saline and drought conditions [1].

Furthermore, rhizobacteria of the Aral Sea region are considered valuable biological resources for bioremediation and phytomelioration processes. They contribute to soil fertility restoration, acceleration of organic matter mineralization, and reduction of the toxic effects of salts on plants. Particularly in degraded soils, biopreparations based on rhizobacteria are recognized as promising ecological technologies for restoring vegetation cover. Biofertilizers and biostimulants developed from halotolerant bacteria may improve agricultural productivity in saline soils [6].

In recent years, advances in molecular-genetic techniques have enabled deeper investigation of the microbiome of the Aral Sea region. Modern methods such as 16S rRNA sequencing, metagenomics, and MALDI-TOF MS are used to identify both cultivable and uncultivable microorganisms. Metagenomic studies make it possible to determine the functional diversity of the rhizosphere microbiome, including genes associated with stress resistance, antibiotic synthesis, metabolic adaptation, and biochemical activity. This significantly expands the prospects for evaluating the

ecological importance of microorganisms in the Aral Sea region and applying them for biotechnological purposes [8].

The findings indicate that the rhizosphere of plants in the Aral Sea region contains a unique and highly adaptable microbiome. These microorganisms have considerable scientific and practical importance in maintaining ecological balance, restoring degraded ecosystems, and ensuring sustainable plant growth in saline soils. Future in-depth studies of rhizosphere bacteria may enable the development of a new generation of environmentally safe biopreparations.

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## ТОЧНОЕ РЕШЕНИЕ СИСТЕМЫ ДИРАКА С ПОТЕНЦИАЛОМ СПЕЦИАЛЬНОГО ВИДА.


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**Аннотация:** В данной статье рассматривается задача нахождения точного решения системы Дирака с потенциалами специальнго вида. Предложенное аналитическое решение (выраженное через элементарные функции) может быть полезно для верификации численных схем, анализа влияния каждой гармоники, а также для построения управляющих протоколов в квантовых, социальных или биологических технологиях.