# Microbiological activity of soils with difficult ecological conditions

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**Abstract**. This article presents data on irrigate d meadow-alluvial soils of the Takhtakupyr region of the Karakalpak Republic. The microbiological activity (ammonifiers, spore, oligonitrophils, nitrogen fixers, actinomycetes, microscopic fungi) of meadow-alluvial soils is studied, depending on the degree of salinity. The degree of enrichment with microorganisms of highly saline, medium and slightly saline soils is determined.

## 1. Introduction

The territory of the Republic of Karakalpakstan covers the ancient, old and relatively young regions of the Amu Darya delta, and partially the Kyzyl Kum, the Ustyurt plateau and the Aral Sea. At the beginning of 2017, the area of irrigated land in the Republic of Karakalpakstan amounted to 509.6 thousand hectares (3.1%) at a total land area of 16.7 million hectares. The planted area of Karakalpakstan is mainly cultivated with cotton and grain crops. Cotton is cultivated in all southern regions of the republic, except for Muinak. Under the conditions of a wide variety of natural and geomorphological conditions, typically desert automorphic soils and azonal hydromorphic soils were formed. They consist of gray-brown, desert sandy, takyr soils and takyrs, residual-hydromorphic, meadow and bog-meadow soils, as well as continental and coastal salt marshes. The study of the microbiological activity of desert soils under the influence of climate change and the degree of salinity is of great interest for soil scientists, microbiologists, ecologists and climatologists.

Biodiversity loss has become a global concern as evidence accumulates that it negatively affects the ecosystems on which human societies depend. So far, most research has focused on the environmental impacts of the loss of terrestrial biodiversity; however, much of the earth's biodiversity is literally hidden under the ground. The problem of whether the decline in biodiversity in soil communities affects the overall productivity of the ecosystem remains unresolved. It is important to investigate this considering recent observations on the reduction of soil biodiversity and changes in soil communities under intensive land use [1].

The microbiological activity of soils is a bio-indicator of soil fertility. Soil microorganisms are the key driving forces of aboveground biogeochemical cycles; however, it is still unclear how variations in the composition of the soil microbial community affect ecosystem processes [2, 3].

Hansel, C. M. et al have studied the spatial heterogeneity of the physical, chemical and biological properties of soil, which allow the spread of a variety of microbial communities [4]. Factors affecting the structuring of microbial communities, including nutrient and water availability, pH and soil structure, can vary significantly with soil depth and subsurface aggregates. They have investigated changes in microbial and functional communities in soil aggregates obtained along the soil profile.

A number of researchers refer to the correlation network analysis to study the combined presence of fungi and bacteria in soil; the differences and the coincidences in the ecosystem of these groups were found [5]. These results contradict the concept that fungi and bacteria are two separate functional groups that can be studied as isolated issues. A better understanding of the relationship between soil properties, biogeochemical cycles and interactions between fungi and bacteria is an important step towards better predicting and managing soil ecosystem functions [5].

The aim of the research is to study the number of physiological groups of microorganisms and the degree of soil

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enrichment with microorganisms on irrigated meadow-alluvial soils, depending on the degree of salinity.

## 2. Methods

The quantitative account for individual physiological groups of microorganisms was conducted by the generally accepted method of dilutions followed by sowing on solid elective nutrient media [6]. The accounting and study of the functional diversity of microbial communities in soils were traditionally evaluated at the level of physiological groups on the appropriate media: ammonifying bacteria on meat-peptone agar (MPA), spore bacteria on MPA with the addition of wort (1:1), oligonitrophils and nitrogen fixers on Ashby's medium, actinomycetes on starch-ammonia medium, microscopic fungi on Czapek's medium. The number of bacteria was expressed in colony-forming units per 1 g of soil (CFU/g).

## 3. Results and Discussion

The cycle of transformations of nitrogen-containing compounds in soil is inextricably linked with the development and biochemical activity of ammonifying microorganisms. Ammonifiers decompose nitrogen-containing compounds into simpler ones, which then penetrate osmotically into the cells of microorganisms and undergo deamination under the action of intracellular enzymes. All protein substances contained in soil undergo ammonification. Ammonifiers, as a rule, decompose readily available nitrogen-containing organic matter in soil. If the content of nitrogen in organic matter is less than 2%, it will be completely immobilized in the cells of microorganisms, and at a higher content, it will be assimilated with the release of ammonia [6, 7, 8, 9, 10, 11]. The ammonification process is not specific; it can be realized by groups of microorganisms belonging to different taxonomic groups: bacteria from the genera Bacillus, bacterium, Pseudomonas; fungi of the genera *Penicillium, Trichoderma, Aspergillus;* streptomycetes [12, 13]. It was found that the number of ammonifying microorganisms is greatly influenced by the modes of aeration, humidification - drying, temperature, cultivation culture, application of mineral and organic fertilizers, and especially manure [14, 15].

**Table 1.** The number of physiological groups of microorganisms in soil (CFU/g of soil)

| **Depth, cm** | **Ammonium fixers** | **Spore** | **Oligonitrop hils** | **Nitrogen fixers** | **Actino mycetes** | **Microscopic fungi** |
|---|---|---|---|---|---|---|
| 403-section (highly saline soils) | | | | | | |
| 0-15 | 1800000 | 69000 | 780000 | 15000 | 30000 | 13000 |
| 15-30 | 1000000 | 51000 | 600000 | - | 70000 | 7000 |
| 30-50 | 800000 | 23000 | 420000 | - | - | 2000 |
| 2449-section (medium saline soils) | | | | | | |
| 0-15 | 4200000 | 18000 | 1300000 | - | 40000 | 13000 |
| 15-30 | 2800000 | 60000 | 1400000 | - | 90000 | 3000 |
| 30-50 | 2500000 | 7000 | 1000000 | | 90000 | 3000 |
| 2448 -section (highly saline soils) | | | | | | |
| 0-15 | 2100000 | 45000 | 790000 | - | 40000 | 3000 |
| 15-30 | 400000 | 13000 | 250000 | 40000 | 40000 | 3000 |
| 30-50 | 1200000 | 3000 | 480000 | 10000 | 60000 | 4000 |
| 404-section (slightly saline soils) | | | | | | |
| 0-15 | 8400000 | 45000 | 1600000 | - | 30000 | 10000 |
| 15-30 | 2800000 | 40000 | 1400000 | - | 40000 | 2000 |
| 30-50 | 1300000 | 15000 | 600000 | | 40000 | 2000 |
| 1193-section (slightly saline soils) | | | | | | |
| 0-15 | 2400000 | 27000 | 1600000 | 60000 | 600000 | 12000 |
| 15-30 | 1800000 | 42000 | 1000000 | 40000 | 40000 | 3000 |
| 30-50 | 800000 | 9000 | 1000000 | 30000 | 50000 | 3000 |
| 1187-section (medium saline soils) | | | | | | |
| 0-15 | 3900000 | 16000 | 1500000 | 30000 | 30000 | 4000 |
| 15-30 | 1600000 | 19000 | 1200000 | 40000 | 70000 | 4000 |
| 30-50 | 1300000 | 6000 | 500000 | 30000 | 70000 | 3000 |

Oligonitrophilic microorganisms mineralize nitrogen-free organic matter of the soil. They are weak fixers of atmospheric nitrogen, and after the death of these microorganisms, the soil is enriched with protein nitrogen. Oligonitrophils, settling on fresh plant material, mineralize mainly the carbohydrate part of organic matter and reduce the ratio of carbon to nitrogen in the decomposed substrate [16]. The ability of oligonitrophils to develop at a very low nitrogen level provides the possibility of their development in conditions unfavorable for other microorganisms, and due to this, allows them to participate in soil processes [17]. Since, in the soil, these microorganisms almost constantly develop with an acute nitrogen deficiency, then from an environmental point of view, two features of oligonitrophils are of greatest interest: the ability to develop at a low level of bound nitrogen in the environment and to use atmospheric nitrogen. In addition, according to Makhkamova et al [18], oligonitrophils participate in soil structuring, forming cementing mucus.

In slightly saline soils (404-1193 s), the number of ammonifiers is twice as large and ranged from 2800000 to 8400000, spore from 27000 to 45000, oligonitrophils from 10000 to 1600000, nitrogen fixers from 40000to 60000, actinomycetes from 30000 to 40000, microscopic fungi from 10000 to 12000 CFU/g of soil. In medium saline soils (2449-1187 s), the number of ammonifiers ranged from 2500000 to 4200000, spore from 7000 to 18000, oligonitrophils from 18000 to 1300000, actinomycetes from 40000 to 90000, microscopic fungi from 3000 to 13000 CFU/g of soils. In highly saline soils (403-2448 s), the number of ammonifiers ranged from 1800000 to 2100000, spore from

69000 to 45000, oligonitrophiles from 780000 to 790000, nitrogen fixers from 4000 to 15000, actinomycetes from 30000 to 40000, microscopic fungi from 3000 to 13000 CFU/g of soils. The number of microorganisms from the upper horizons to the lower horizons decreased gradually (Table 1).

The results of the study showed that in highly saline soils, bacteria-ammonifiers, according to the level of enrichment by the Zvyagintsev scale [19], are depleted in 0-15, 15-30 cm layers and very depleted in 30-50 cm. In medium saline soils in 0-15 cm layer, the number of bacteria is at an average level, and the layers of 15-30 cm and 30-50 cm are depleted and very depleted, respectively. In slightly saline soils in the 0-15 cm layer, the number of bacteria is at an average level, and 15-30 cm and 30-50 cm layers are depleted.

In highly saline and slightly saline soils, actinomycetes, according to the level of enrichment by the Zvyagintsev scale, in the layers of 0–15, 15–30, 30–50 cm, the number of bacteria is at an average level. According to the results of the study, microscopic fungi (by the Zvyagintsev scale) in highly saline soils in 0-15, 15-30, 30-50 cm layers are depleted, in medium saline soils in 0-15, 15-30 cm layers, the number of bacteria is at an average level, in 30-50 cm layer it is depleted. Slightly saline soils in 0-15 cm layer are medium supplied, in 15-30, 30-50 cm layers they are depleted.

The formation and development of soils in the desert region are characterized by constant variability associated with environmental conditions. The process of salinization of these soils affects not only the properties of soil but also the flora; this leads to a decrease in microbiological activity. We know that the study of microflora in soils is an important diagnostic index of soils (Figure 1).

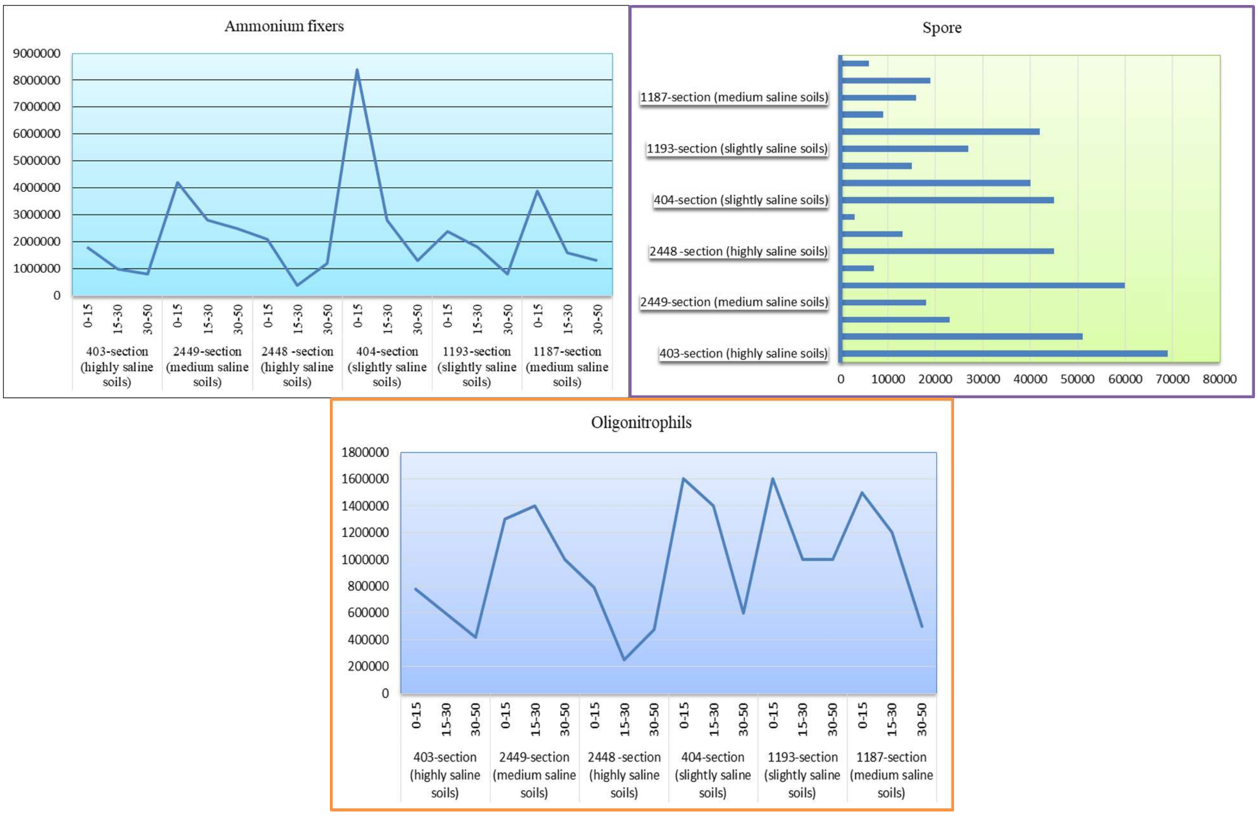


**Fig. 1.** The number of physiological groups of microorganisms in soil: Ammonium fixers, Spore, and Oligonitrophils

The study revealed the presence of agronomically important groups of microorganisms, including *ammonifiers, spores, actinomycetes, microscopic fungi* in the composition of irrigated soils in Bukhara district of Bukhara region (Figure 2).

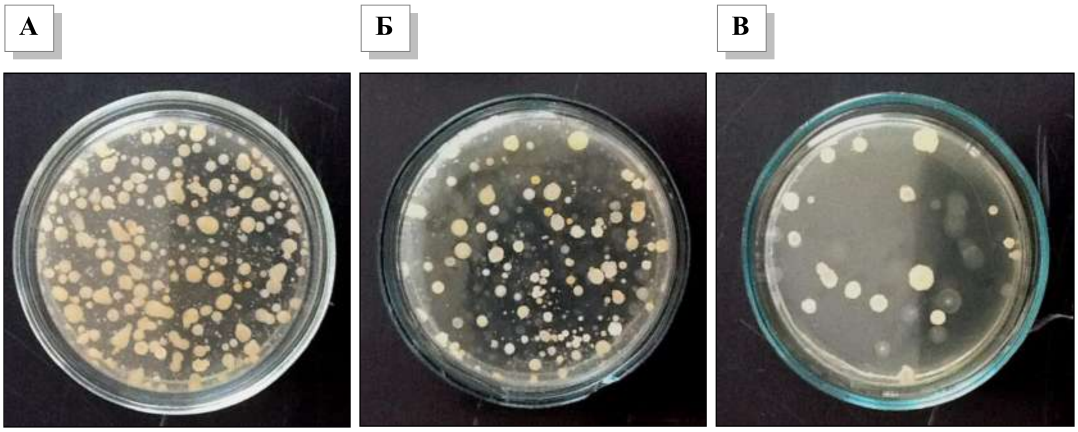


**Fig. 2.** Groups of microorganisms in irrigated soils of the experimental field (Note: *A. Ammonifiers; Б. Spores; B.Colonies of actinomycetes.)*

According to the diagnostic indices obtained, from an environmental point of view, soil microbiology is severely damaged, which negatively affects the entire process in soil, leading to a long-term decrease in soil fertility and the loss of generations of microorganisms, as well as to a complete loss of fertility in some areas.

## 4. Conclusion

The number of ammonifiers (8400000- 4200000) and spore (45000 -18000) in slightly saline soils is twice as high as in medium saline soils. The number of oligonitorophiles in slightly saline soils is 1600000, in medium saline soils, it is 1300000; the lower number of nitrogen fixers is explained by the lack of nutrients and extreme conditions in the area under study. The number of actinomycetes in slightly saline soils is 30000; in medium saline soils, it is $4x10^4$, microscopic fungi in slightly saline soils is 10000; in medium saline soils, it is 13000 CFU/g of soil.
In highly saline soils, ammonifying bacteria are depleted in terms of enrichment by the Zvyagintsev scale, medium saline soils are moderately supplied, and slightly saline soils are enriched. In highly saline, medium and slightly saline soils, actinomycetes in terms of enrichment by the Zvyagintsev scale turned out to be moderately supplied, while microscopic fungi in highly saline soils are depleted; slightly saline soils are moderately supplied, and in 15-30, 30-50 cm layers they are depleted.

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