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ACTINOMYCETES AS BIOINDICATORS OF SOIL DEGRADATION PROCESSES

Kodirova Dilrabo Abdukarimovna
PhD, Professor, Tashkent State Agrarian University
d.qodirova@inbox.ru

Jamolova Rukhshona Jaloliddin qizi
Anvarova Husnorakhon Akramjon qizi
Gulomova Bakhtinurbegim Husniddin qizi
2nd Year Students

Abstract
This article analyzes the patterns of quantitative changes in actinomycetes in soil types and sub-types with different degrees of degradation (eroded and saline). The study examines the indicator value of actinomycetes in assessing the ecological state of the soil, their sensitivity to degradation factors, and their relationship with the physicochemical properties of the soil. It was shown that with increasing soil degradation, the number of actinomycetes tends to decrease. It was also found that there are correlations between the amount of organic matter, humus level, and salinity indicators and the quantitative changes in actinomycetes. The data obtained justify the possibility of using actinomycetes as bioindicators in assessing soil degradation.

Keywords: Actinomycetes, soil degradation, erosion, salinity, soil microflora, bioindicator, soil fertility, microbiological analysis.

Introduction

It is known that biological and biochemical processes occurring in the soil ecosystem are largely determined by the activity of microorganisms. Among microorganisms, actinomycetes play an important role in soil fertility, mineralization of organic matter, plant nutrition and improvement of phytosanitary conditions. In the scientific literature, actinomycetes are recognized as one of the most active and ecologically important microbial groups in the soil (Gafurova and et al, 2023).

Actinomycetes are spore-forming, Gram-positive bacteria of the actinobacteria genus that are found in soil, aquatic environments, air, and even in extreme environments such as deserts, deep-sea sediments, and Antarctica (Arifiyanto et al. 2020; Selim et al. 2021; Su et al. 2022).

Actinomycetes – have the property of producing hydrolytic enzymes (protease, amylase, invertase, keratinase, chitinase, lipase) that break down complex organic substances resistant to bacterial decomposition into their components. They mineralize cellulose, hemicellulose, chitin, lignocellulose and other polymeric substances with the help of enzymes, accelerating the turnover of substances in the soil. As a result of this process, nitrogen, phosphorus, potassium and other elements necessary for plants are converted into a mobile form and serve to form humus in the soil. They also produce enzymes belonging to the group of polyphenol oxidases. Soils rich in organic matter and with a neutral or weakly alkaline environment are favorable environments for

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the active development of actinomycetes (Kodirova, 2022).
At the same time, it has been found that actinomycetes actively develop in the rhizosphere zone and synthesize substances that enhance plant growth - phytohormones, siderophores, enzymes and vitamins. Some strains have the ability to fix atmospheric nitrogen, dissolve insoluble phosphates and increase plant resistance to stress factors. Therefore, they are of great practical importance as biofertilizers (Nazari and et al, 2022)
Another important feature of actinomycetes is their antagonistic effect against phytopathogenic fungi, bacteria, and some pests. In particular, it is known that representatives of the genus Streptomyces produce many antibiotics, such as streptomycin, neomycin, tetracycline, and erythromycin. Modern research suggests that actinomycetes have high potential as biopesticides and biocontrol agents in sustainable agriculture (Diab and et al, 2024).
In addition, it is currently known for producing several important secondary metabolites for medicine, the food industry, and agriculture, which are widely used to obtain antibiotics against fungi, antiviral agents against viruses, immunosuppressants, compounds with anticancer and antioxidant activity, enzymes, bioinsecticides, biostimulants, and other substances and are widely studied by researchers (Arifiyanto and et al. 2020; Devi and et al., 2022). It is estimated that 45% of the approximately 23,000 secondary metabolites synthesized by microorganisms are produced by actinomycetes (Kim and et al., 2020; Olano et al., 2008). However, it is estimated that only 1% of actinomycete species have been cultivated (Kumar and et al., 2019).
Today, in the context of soil degradation, depletion of organic matter reserves, salinization, and climate change, the ecological and agronomic importance of actinomycetes is increasing. In particular, intensive research is being conducted to create new biopreparations from actinomycetes adapted to arid and extreme conditions, to improve soil health, and to increase crop productivity.
In this regard, this article analyzes the distribution of actinomycetes in soil under the influence of degradation processes, their participation in the cycle of substances, and their importance in increasing soil fertility based on research results.

Object of research. The soils of the mountain and foothill regions of the Surkhan-Sherabad valley (dark sierozem formed on loess and tertiary deposits, mountain brown carbonate and mountain brown typical soils), sierozem soils (old irrigated swamp-meadow, meadow, bog meadow, meadow-sierozem, light sierozem, newly irrigated typical sierozem, newly developed swamp-meadow soils) and desert regions (old irrigated gray-brown, old and newly irrigated barren-meadow, meadow-barren, swamp-meadow, meadow, barren-meadow, meadow sandy-desert, desert-meadow) are widespread.

Research style. During the research, systematic, profile-genetic, comparative-geographical methods were used to study the soil cover of the Surkhan-Sherabad oasis. Taking into account the type and subtype of soil erosion, salinity, and duration of irrigation of the study area, the main soil sections were taken from selected key farms, divided into genetic layers, and their morphological characteristics were studied in field conditions. To determine the microbiological activity, soil samples were taken from depths of 0-15, 15-30, 30-50, and 50-70 cm in sterilized boxes separately for each season (spring, summer, autumn). The number of physiological groups of microorganisms was determined by sowing on various nutrient media, including actinomycetes - starch-ammonia agar (KAA) nutrient media.

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Research results. Actinomycetes are actively involved in the decomposition of nitrogenous and non-nitrogenous organic matter in the soil. Their occurrence in almost all soils indicates that they play an important role in soil processes.

According to the results of the study, it was observed that actinomycetes are also well developed in mountain brown soils, where microbiological processes are deeply developed, and their number varies from 65 to 1,185 thousand cells per 1 g of soil according to the seasons along the profile (Figure 1).

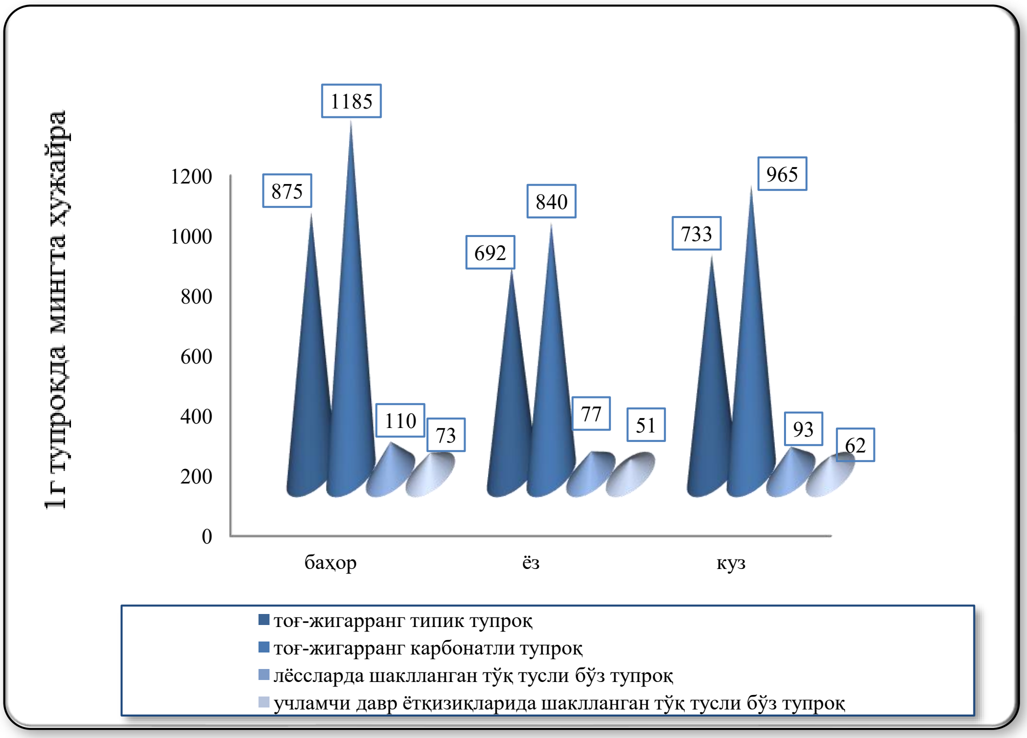

Figure 1. Seasonal dynamics of the amount of actinomycetes in mountain and foothill soils

This situation can be explained by the diversity of plant cover in the soils and their chemical composition. The high number of actinomycetes indicates that plant residues are rapidly decomposing in these soils. If we compare mountain brown soils formed under favorable soil-climatic conditions according to the law of vertical zoning with dark sierozem soils, actinomycetes, due to their ability to quickly adapt to adverse conditions, are not so small in these soils compared to other groups of microorganisms (95-110 thousand cells per 1 g of soil).

Actinomycetes are considered more drought-resistant than other groups of microorganisms due to their strong enzymatic apparatus. The ability of actinomycetes to develop even at the lowest soil moisture and highest soil temperature, that is, when bacterial activity has ceased, indicates their xerophilic properties.

It was observed that actinomycetes also developed well in irrigated soils of the sierozem soil region (Figure 2).

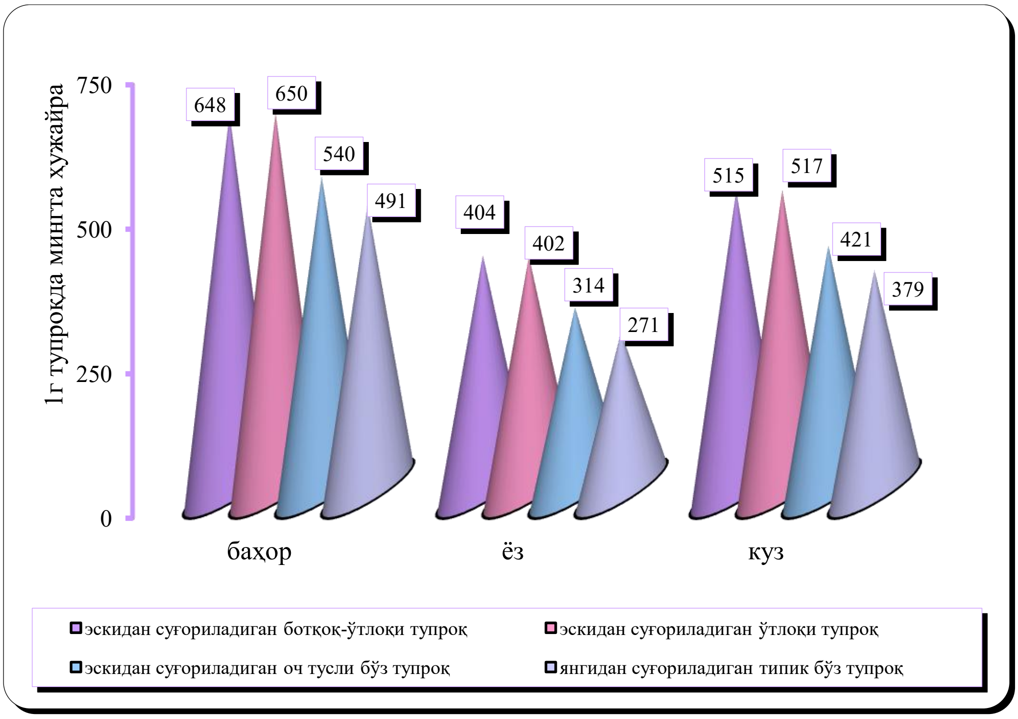

Figure 2. Seasonal dynamics of the amount of actinomycetes in irrigated soils of the sierozem soil region

We have already mentioned the resistance and rapid adaptation of actinomycetes to various adverse soil conditions, and these ideas are clearly reflected in the abundance of actinomycetes in saline soils of the desert region. We can see that the abundance of actinomycetes is higher in the soils of the desert region.

This can be explained by the succession of microorganisms, i.e., it is known that salinity has a significant impact on the development of bacteria and fungi, leading to a sharp decrease in their numbers. This is the same period for the development of actinomycetes.

The seasonal dynamics of actinomycetes is associated with the hydrothermal regime of the soils of the studied area and their physiological properties. Actinomycetes vary relatively little with the seasons compared to other groups of microorganisms.

The studied soils are not only rich in actinomycetes, but also differ in the color of their species composition. According to their color, it was observed that actinomycetes of gray, pink, yellow, brown, red, and dark red shades were found in the soils.

In general, the distribution of actinomycetes varies in different quantities in the studied soils depending on the conditions of soil formation, agricultural use, salinization and erosion processes, soil culture, and irrigation frequency. A certain pattern is also observed in their change along the soil profile. In dry and loamy soils, they develop mainly in the upper layers, while in irrigated soils they are evenly distributed along the profile.

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