Biodiagnostic survey of salt soils of the desert zone of Uzbekistan

Biodiagnostic survey of salt soils of the desert zone of Uzbekistan

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Abstract. The unfavorable climatic conditions of the desert territory are the reason for the reduced biological activity of the studied soils; the highest BA was observed mainly in spring. This is due to the presence of favorable hydrothermal conditions and nutrients for the occurrence of biological processes at this time, in summer there is a slight decrease and by autumn a slight increase in the biological activity of the soil. Also, it was found that the change in the general biological activity of soils depends on the content of humus and nutrients in them, the mechanical composition, the duration of irrigation and the degree of salinity. Thus, the results show that the integral indicator of soil biological activity can be widely used in assessing the response of the region's soils to external influences, as well as the effectiveness of measures taken to preserve and increase soil fertility.

1. Introduction

Today, in the world, saline soils occupy vast areas which is about 25% of the entire land surface. Clearly, significant massifs of saline soils are located in Central Asia, in the western United States, in especially arid regions of South America and Australia, and in North Africa. At the same time, the soils of desert and semi-desert zones, in arid and arid climates, are distinguished by a particularly high degree of salinity [1-3]. The occurrence of salinization processes is associated with the level of occurrence and mineralization of groundwater. But it should be noted that salinization is not just a consequence of irrigation, but it is a natural process characteristic of the alluvial conditions of the arid zone. It is known that salinized soils largely lose their natural properties [4-7]. Therefore, the determination of the factors causing salinization, its prevention, as well as the preservation, restoration of the fertility of saline soils and their rational use in agriculture are urgent tasks at a time when the area of saline lands is increasing as a result of natural processes and anthropogenic impact [8-11].

The saline soils of different regions have been the subject of attention of many eminent scientists. In this regard, large-scale and research on the study of properties, ameliorative state and biological activity, improvement and increase in the fertility of saline soils common in different regions of the world in different years were carried out by N V Kimberg [8], V G Popov [12], V A Kovdym [9], A M Rasulov [13], E I Pankova [10, 11], L T Tursunov [14] , I T Turapov [15] , S A Abdullaev [16]. Obviously, scientific research is being carried out in the world to prevent salinization processes that occur in the context of global climate change and mitigate its consequences, to identify the influence of external

factors on soil properties, taking into account natural and climatic conditions [17-19]. In this regard , special attention is paid to the use of biodiagnostic methods for assessing the degree of resistance of saline soils to external factors based on informative indicators of soil biological activity [20-22].

In this regard, the diagnosis of the ecological and biological state of saline soils using modern methods is important for the correct characterization of the course of soil processes and the determination of their relationships, the management of soil processes, the development of optimal agro-reclamation measures to improve the state of saline soils in the face of climate change, and their rational use and prevention of negative factors [23]. The objective of this research is to research degrees of salinization in old-irrigated and newly irrigated meadow-alluvial soils and salt marshes common in the Amudarya and Chimbai districts of the Republic of Karakalpakstan.

2. Materials and Methods

In this research field and laboratory studies were carried out according to generally accepted standard methods. The analyzes were performed according to the guidelines, such as “Methods of soil microbiology and biochemistry”, “Methods of soil enzymology”, “Biodiagnostics and indication of soils: methodology and research methods”, “Guidelines for the chemical analysis of soils” [4-7, 20-23].

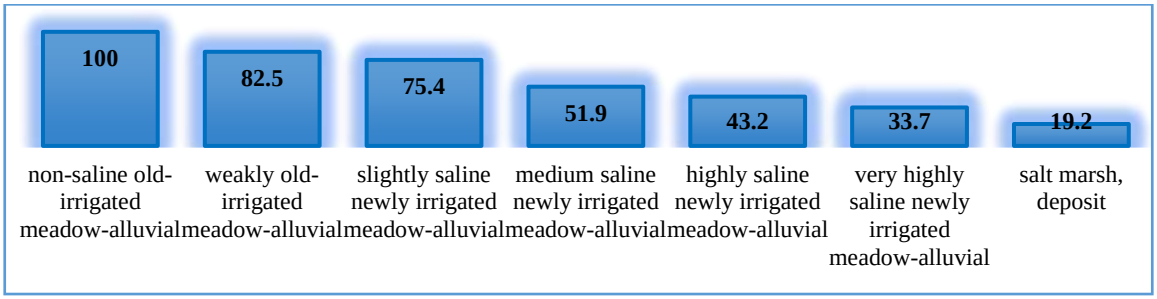

Figure 1. The value of the integral indicator of the ecological and biological state of soils in the Aral Sea region (IPEBSP), %

In modern conditions, biological research methods are also used to assess and diagnose the level of soil fertility. In this regard, during the research, in order to identify IPEBSP, a number of informative indicators were used, such as the content of humus, the number of microorganisms, enzyme activity and soil respiration (Figure 1).

This method makes it possible to assess the general biological activity of soils, conduct a comprehensive and comparative analysis under conditions of desert soil formation, describe the influence of the main properties and the degree of soil salinity on its biological activity, have an idea of changes in microbiological and biochemical processes, and reveal the ecological and genetic features of soils. It should be noted that when assessing the ecological and biological state of the soil by biodiagnostic methods, a simultaneous and interconnected study of the most informative indicators reflecting various parameters of soil biological activity is required. Clearly, with this method, it is possible to reveal the value of the integral indicator of the ecological and biological state of soils based on the determination of the overall relative biological activity.

3. Results and Discussions

The diversity of physical and chemical properties of the studied soils is also reflected in the distribution of soil microorganisms. According to the research results, there was a significant change in the number of studied microorganisms depending on the degree of salinity (Figure 2). The largest number of microorganisms was found in non-saline and slightly saline old-irrigated meadow-alluvial soils. It was revealed that in the newly irrigated strongly and very strongly saline meadow-alluvial soils and salt marshes microorganisms are poorly developed, which can be explained by poor vegetation cover and a low amount of organic matter. Moreover, a greater number of microorganisms was noted in the upper

horizons of soils, sufficiently provided with humus and nutrients. Clearly, as they deepened along the soil profile, their number sharply decreased.

It was researched that unfavorable climatic conditions of the studied region, such as high summer temperatures, low relative air humidity, rapid evaporation of moisture from the soil, and low content of organic matter, lead to a decrease in the microbiological activity of these soils.

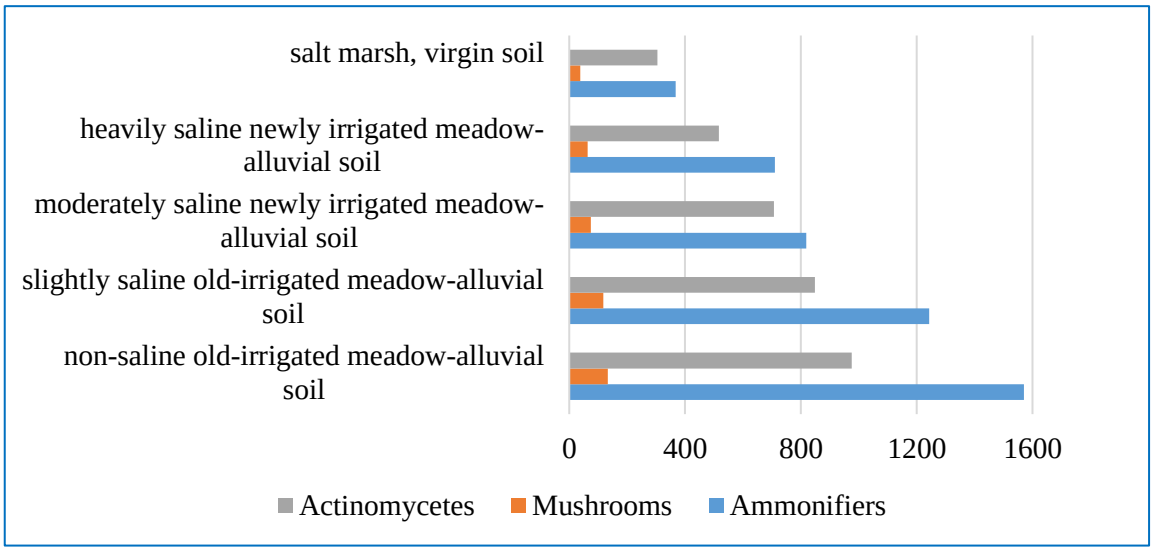

Figure 2. Change in the number of microorganisms under the influence of the degree of salinity (average seasonal dynamics, thousand/1g of soil)

Thus, the intensive activity of microorganisms falls on the spring period, in summer their activity was observed to be the weakest, and by autumn their number increased significantly. The formation of the enzymatic activity of soils occurs in conjunction with the environmental factors of soil formation. Due to the depletion in organic matter, low supply of nutrients, and salinity to varying degrees, the studied soils have low enzymatic activity [20, 22]. Redox reactions are the main link in the formation of humic substances in the soil. It was noted that the activity of oxidases in the studied soils was higher in non-saline and slightly saline meadow-alluvial soils, where the activity of catalase was 2.9-4.3 cm^3 O_2 1g/1 min., followed by the activity of peroxidase was 3.14-4.32 and polyphenol oxidase was 3.23-4.68 mg of purpurgallin 100g/24h. It was reported that in moderately saline soils, the activity of catalase was 2.2–2.5 cm^3 O_2 1g/1 min., the activity of peroxidase and polyphenol oxidase was 2.70–2.86 and 2.73–2.89 mg of purpurgallin 100 g/24h. The pertinent results depicted that their lowest activity was noted in strongly and very strongly saline soils, the activity of catalase was 1.2-2.0 cm^3 O_2 1g/1 min., the activity of peroxidase and polyphenol oxidase was 2.10-2.67 and 2.12-2 .70 mg purpurgallin 100g/24h. This is due to the low content of organic matter, the high content of water-soluble salts and the dominance of the content of sand particles among the mechanical fractions in the soil. According to the ratio of polyphenol oxidase and peroxidase activity, it was found that the value of the conditional humification coefficient in the soils of the region was in the range of 0.9-1.1.

The activity of hydrolytic enzymes (invertase, phosphatase, and urease) revealed the same value as that of oxidases. It was observed that the activity of redox and hydrolytic enzymes was directly proportional to the amount of humus, nutrients, mechanical composition of the soil and the hydrothermal regime of the region. According to the results, the limits of fluctuations in invertase activity in the studied soils were within 1.50-4.15 mg of glucose 1g/24h, urease activity was 1.06-2.76 mg NH_3 10g/24h and phosphatase activity was 0.57-2.38 mg P_2O_5 10g/24h. It was revealed that the studied soils had very weak, weak and medium activity in terms of availability of catalase and phosphatase enzymes, and only very low activity in terms of invertase and urease enzymes. The study of enzyme activity in seasonal dynamics made it possible to reveal changes in their activity under the influence of hydrothermal conditions, as well as general patterns for soils with different physicochemical properties

(Figure 3). The data obtained show that these soils had maximum activity in spring, minimum activity in summer, and average activity in autumn.

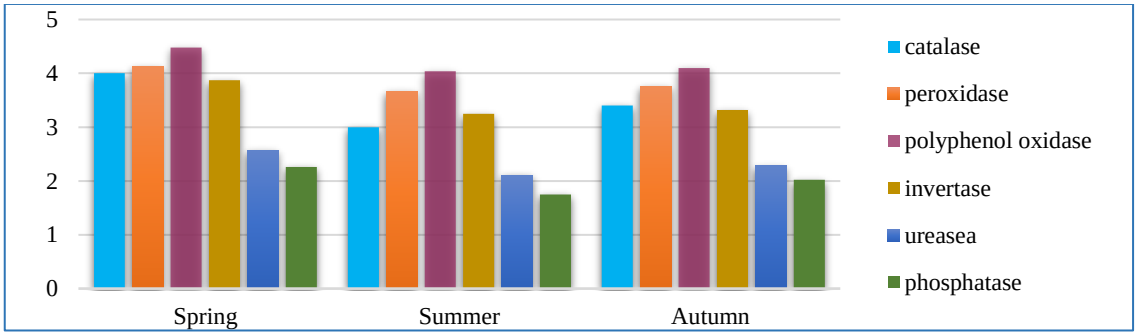

Figure 3. Seasonal dynamics of the enzymatic activity of newly irrigated meadow-alluvial soils (catalase - cm^3 O_2 1g/1 min.; peroxidase and polyphenol oxidase - mg purpurgallin 100g/24h; invertase - mg glucose 1g/24h ; urease - mg NH_3 10g/24h; phosphatase - mg P_2O_5 10g/24h)

The highest rates of enzyme activity corresponded to the upper layers; with depth, the enzymatic activity sharply decreases, and sometimes it is completely suppressed (saline soil), which can be explained by the direct inhibitory effect of salts on their activity and the low accumulation of organic matter in the soil profile. Clearly, soil respiration is one of the total indicators of biological activity. Based on the data obtained, it was established that the emission of CO_2 on the studied soils depends on the number of soil microorganisms, agrochemical and agrophysical properties, the degree of salinity, and the soil and climatic conditions of the region. In the spring months, when there was sufficient humidity and optimal temperature, followed by active CO_2 emission was observed, a decrease in CO_2 emission in summer under dry climate conditions and a slight increase in autumn was observed (Figure 4).

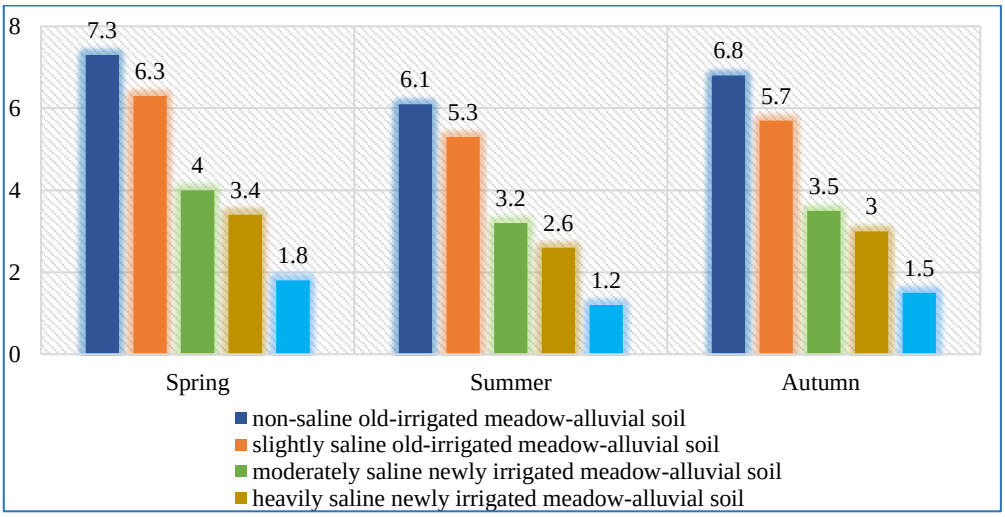

Figure 4. Seasonal dynamics of soil respiration in the region, mg CO_2/10g

It was noted that the intensity of respiration in the studied soils varied within 1.3-7.3 mg CO_2/10g. Its highest values are observed in old-irrigated and newly-irrigated non-saline and slightly saline soils. In the salt marsh, due to the high amount of toxic salts, a very weak respiration rate was revealed. The highest rates of CO_2 emission are characteristic of the upper horizons rich in organic and nutrient substances. During the research period, a close relationship between biological activity and humus content was noted, the correlation coefficients fluctuated within r=0.74-0.98. A relationship was also

found between the number of microorganisms, the content of total nitrogen was r=0.86-0.96, followed by phosphorus r=0.75-0.98, between the activity of enzymes and the content of total nitrogen r=0.92-0.96, phosphorus r =0.80-0.89, between soil respiration and nitrogen content r=0.96 and phosphorus r=0.88. Physical properties occupy an important place in the regulation of soil biological processes. According to this, a correlation was found between the intensity of soil respiration (r=0.72-0.78), the number of microorganisms (r=0.74-0.82, r=0.70-0.79), and the activity of enzymes (r=0.74-0.84) and total porosity and mechanical composition of the soil.

According to the value of the integral indicator of the ecological and biological state, the studied soils can be divided into the following decreasing series: old-irrigated non-saline meadow-alluvial > old- and newly-irrigated slightly saline meadow-alluvial > newly-irrigated medium-saline meadow-alluvial > newly-irrigated strongly saline meadow-alluvial > newly-irrigated very strongly saline meadow-alluvial > meadow salt marsh (Table 1). Based on the value of the integral indicator of the ecological and biological state of soils, criteria for biodiagnostics were developed to assess the level of the overall biological activity of the soil, and the soils were divided into appropriate groups (Table 1).

Table 1. Assessment of the level of general biological activity of the soil in the region based on IPEBSP value

The level of general biological activity of the soil	IPEBSP value,%	Soils
Very high	81-100	- this group includes non-saline and slightly saline old - irrigated meadow-alluvial soils
high	61-80	- this group includes newly irrigated slightly saline meadow-alluvial soils
Medium	41-60	- this group includes newly irrigated medium and highly saline meadow-alluvial soils
Weak	21-40	- this group includes newly irrigated very strongly saline meadow-alluvial soils
Very weak	twenty	- this group includes meadow solonchaks

4. Conclusions

It was reported that in moderately saline soils, the activity of catalase was 2.2–2.5 $cm^3 O_2$ 1g/1 min., the activity of peroxidase and polyphenol oxidase was 2.70–2.86 and 2.73–2.89 mg of purpurgallin 100 g/24h. According to the activity of catalase and phosphatase, the soils of the region are classified as very low, low and medium-supplied soils. According to the activity of invertase and urease enzymes, they are very low-supplied soils. High values of biological indicators are typical for old irrigated nonsaline and weakly saline meadow-alluvial soils. Due to the unfavorable climatic conditions of the study region, the highest biological activity in soils was observed mainly in spring. This is due to the presence of favorable hydrothermal conditions and nutrients for the occurrence of biological processes at this time, in summer there is a slight decrease and by autumn a slight increase in the biological activity of the soil.

A comprehensive study of the biological activity (BA) of the studied soils revealed their ecological and genetic features. The pattern of change in the value of the integral indicator of the ecological and biological state of the studied soils is determined by biological indicators, humus content, mechanical composition, degree and type of salinity, as well as soil and climatic conditions of the region. Thus, the research results show that the integral indicator of soil biological activity can be widely used in assessing the response of the region's soils to external influences, as well as the effectiveness of measures taken to preserve and improve soil fertility.

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