

Microbiological Characteristics of Promising Endemic Plants Adapted to the Conditions of the Southern Aralkum

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Abstract: The article discusses the issues of ensuring environmental safety and environmental protection in the Aral Sea, rational use of natural resources, combating the negative consequences of climate change, highlights the results of an innovative approach to combating soil degradation by expanding the area of natural areas, especially the effective use of water resources, promising endemic plants adapted to the ecological conditions of the Southern Aral Sea in combating soil degradation.

As a result of the anomalous phenomena occurring in nature today and the increased anthropogenic pressure, climate change has become a global problem for the entire world community. Water-scarce regions are rapidly developing desertification processes that are the result of climate change. The rapid drying of the Aral Sea led to a global change in all natural conditions.

Desertification caused by the drying of the Aral Sea is the reason for the aggravation of the environmental situation. On these lands, the role of representatives of the local flora in strengthening mobile sands, reducing the process of desertification and positively solving existing environmental problems in the development of saline soils is great. And this is due to the fact that the bioecology of plant species common in this area is the study of plant species with high salt resistance, the creation of plantations of these plants is one of the urgent environmental problems today.

Key points: Aral Sea, biodiversity, soil degradation, innovative approaches, promising endemic plants, adapted plants, environmental factors, soil microbiological activity, halophyte communities, salinity levels, south Aralkum.

Introduction.

The consequences of this environmental catastrophe have become a problem not only in Uzbekistan and the Central Asian region, but already on a global scale. The approach to the problem has radically changed in terms of achieving concrete results.

On May 18, 2021, during the plenary meeting of the 75th session of the United Nations General Assembly, at the suggestion of President of the Republic of Uzbekistan Shavkat Mirziyoyev, a special resolution was unanimously adopted declaring the Aral Sea region a zone of environmental innovation and technology. The resolution was co-sponsored by about 60 states from various regions of the world, including Azerbaijan, Algeria, Afghanistan, Bangladesh, Belarus, Hungary, Vietnam, Georgia, Egypt, India, Jordan, Iran, China, Morocco, Nepal, Oman, Pakistan, Paraguay,

Russia, Rwanda, Romania, Senegal, Singapore, Tajikistan, Turkmenistan, Turkey, Japan and others [11].

The ecological crisis in the Aral Sea led to a violation of the dynamic equilibrium of the region's ecosystems, the degradation of natural complexes, and a reduction in the biodiversity of the plant and animal world.

During the visit of the President of the Republic of Uzbekistan SM Mirziyoyev to the Republic of Karakalpakstan on February 22-23, 2022, the corresponding tasks were set to mitigate the negative impact of the island problem, improve the living conditions and quality of the region's population, and most importantly to expand the territories of vegetation adapted to the soil and climatic conditions of the arid bottom of 3.5 million hectares. Reducing the negative impact of the island problem, increasing the efficiency of land use in the drained depths of the Aral Sea, developing optimal scientific solutions for the introduction of water-saving and salt-containing technologies require the involvement of the existing scientific and innovative potential in our country [3].

Materials and methods of research

The purpose of the research is to determine the type of salinization of areas planned for experiments in the South Orolkum; selection of critical and threshold salt concentrations for germination of seedlings based on testing seeds in various concentrations of salt solutions.

The main objectives of the study are: collection of biomaterials for laboratory tests in local endemic plant species growing in saline and degraded areas of South Aralkum; determining the soil type of sites planned for experiments in South Aralkum; selection of critical and limiting salt concentration in seedling germination; improve the condition of degraded soils with the help of promising endemic plants adapted to the environment of South Aralkum; development of scientific and practical recommendations to prevent soil degradation by promising endemic plants common in the climatic conditions of Southern Aralkum.

In the course of the research work, the degree of uniqueness of rare and endemic plant species included in the Red Book of the Republic of Uzbekistan growing in the territory using floristic, geobotanical, ecological and botanical geographical methods, as well as the International Union for Conservation of Nature (IUCN) (<https://www.iucn.org>) was assessed based on categories. The results of scientific studies conducted in the areas of the Southern Aral region were also used [2; 3; 6; 7; 8; 9].

Results and discussion

We conducted research a) on the drained bottom of the Aral Sea on the "0" plots of the International Innovation Center; b) at the plots of the International Innovation Center "Tik-uzek" in the Muynak region (for experimental testing), studies were carried out on field sites and in the laboratory of INNOVATIVE IDEAS LLC.

During the 2021-2022 field expedition, soil sections were excavated from salt marshes, and soil samples from strata were taken for chemical analysis.

At the beginning of our research, the natural geographical description of the areas that were initially freed from the Aral Sea water and the interpretation of scientific literary sources on the subject were carried out based on the scheme presented in Figure 1 below.

Collection of plant species belonging to different taxonomic units and preparation of herbarium specimens from them was carried out on the basis of generally accepted guidelines.

To determine the amount of chemical elements in the samples, plant organs were collected in separate polyethylene bags of at least 100 g. During the collection of samples in field conditions, special attention was paid to the type of soil where the plants grow, the season of the year, and taxonomic-ecological characteristics. Each plant sample was first wrapped in clean white papers and carefully dried in the shade. In this, serious attention was paid to the fact that biomaterials do not become moldy until they dry. Also, in the process of working with samples (drying and primary grinding), special emphasis was placed on not using tools of a metallic nature.

To determine the amount of chemical elements in soil samples, at least 200 g of different types of soil samples were collected in separate laboratory containers. In this case, a thin part of the surface soil of the sampled area (dried plant organs, soil eroded by sunlight and wind) was removed, and the sample was taken from its lower part.

In order to determine the amount of elements in residual rock samples, at least 500 g of samples with different morphological shapes were collected in strong polyethylene bags. During the collection of samples in field conditions, rocks scattered in areas less exposed to external natural influences were taken.

For the purpose of comparing the amount of elements in plants, soil, and residual rock, samples were proportionally collected from an area of 1 m² (10 m² in areas with few plant species).

The location, date and coordinates of all collected samples (herbarium, biomaterial, soil and residual rock) were recorded. The herbarium specimens collected during the scientific expeditions from the Southern Archipelago in 2022-2023 are kept at the Faculty of Ecology of the National University of Uzbekistan.

In the drained part of the Aral Sea there are more halophytic plants, the vegetation of which develops singly, these include such plants as, *Suaeda salsa*, *Halostachys caspica*, *Lythrum salicaria*, *Sophora alopecuroides*, *Halothamnus subaphyllus*, *Salsola orientalis*, *Halimodendron halodendron*, *Kochia scoparia*, *Ceratoides ewersmanniana*, *Climacoptera lanata* adapted to development in harsh conditions, these plants having a large depth of the root system, a high content of ash matter.

The ash content in plants found on saltmarsh soils is relatively high in relation to the elements of sodium, sulfur, chlorine. If the content of chlorine salts in the soil exceeding its "toxicity threshold" (> 0.01%) negatively affects the yield, quality and biomass of cultivated plants, then the species of salt-resistant plants growing in natural conditions gradually change, they are replaced by halophytes, representatives of various families of "salt-loving" plants, and gradually plants belonging to the salt-tolerant family with anatomical-morphological specific appearance are formed [1; 5]. These endemic halophytic plants grow well even on typical salt marshes, where the content of total salts in the soil is 5-8%, and some of their salts up to 15-20%.

Despite the fact that soil salinization is considered a state that occurs under the influence of certain factors, the issue of assessing soils and processes of general salinization by degree and type of salinization is quite complex, the main reason for this is the formation of salts, not only changes in time and space, but salts and ions of their components pass from one phase of the soil to another and in different ways succumb to reclamation effects [1; 4; 5].

During the expedition, 42 soil sections were laid in typical selected areas. Soil description was carried out on genetic horizons with photographs of soil profiles, soil samples were taken. Samples were analyzed to determine the chemical and physical properties of soils for the content of organic matter, humus, qualitative and quantitative composition of water-soluble salts, as well as gypsum and carbonates.

The main part of the residual salt marshes in the study area is saline by chloride type, to the low side (17-56 cm) - by chloride-sulfate type, and in the interval (88-120 cm) - by sulfate-chloride type. In the soils of the main part of the section profile, the content of water-soluble salts is at a very high level and is salt marshes. Chloride-type salts predominate in all these layers. In the qualitative composition of salts of chloride-sulfate and sulfate types of salinization, salts of CaSO₄, NaSO₄, MgSO₄ prevail. They are found in the form of chlorides in the soil NaCl, KCl, MgCl₂, CaCl₂. The solubility of a number of salts contained in the soil also increases or decreases under the influence of other salts, and one of the salts can neutralize the other.

Plant groups depending on soil moisture level. The issue of which representatives of the plants are the first to enter the areas emptied of water as a result of the drying up of the sea is of great theoretical and practical importance. Of course, the plants that initially appear on the dry bottom of the sea are formed depending on the salinity of the soil, salt-water regime, lithological composition, and the depth of underground water.

It is known that *Salicornia europaea* is the first to occupy many areas around saline lakes, ponds, and areas freed from sea water. After it, xerophytes adapted to grow in soils with relatively low salinity enter.

During the drying up of the Aral Sea, the moisture level in the soil decreases due to the year-on-year drawing of underground water in the areas emptied of water.

As a result of observations carried out in different seasons of the year in the southern bottom of the Aral Sea, the requirement of the plant species common in the area in relation to the level of soil moisture was studied.

It takes at least 5-10 years for the areas freed from sea water to be covered with plants (15-25% coverage level), and 10-15 or even more years for the enrichment of the flora composition. It should be noted that the vegetation of one-year salt marshes deteriorates due to excessive salt content (15-25, sometimes 35 %) in salt marshes. Therefore, in the first areas freed from sea water, plants are very sparse or do not grow at all.

In short, most of the plants distributed in the South Aralkum region are species adapted to grow in soils and sands with varying degrees of salinity. This situation makes it possible to choose promising species in the development of saline soils, in carrying out phytoremediation works, and in strengthening mobile sands and dunes.

Representatives of each group gradually occupy areas freed from sea water due to their adaptation to growth in specific ecological and soil conditions. Covering of saline soil areas with plants is carried out through the natural law, such as the replacement of halophilous plants with representatives of psammophilous plants.

Various biometals and minerals in nature play an incomparable role in the implementation of biochemical processes occurring in the tissues and cells of a living organism. Living organisms, especially plants, accumulate in their tissues and organs elements that are important for the normal functioning of physiological, biochemical and genetic processes.

Taking this into account, when studying the chemical composition of plants, determining their elemental composition is the main factor in finding solutions to theoretical and practical problems. Studying the role of such vital elements allows a deep understanding of the molecular mechanisms of biological and ecological characteristics of species (taxa) belonging to a certain group.

Plant-indicators can control the modification of their external structure and change the chemical composition of their cells due to environmental changes.

Taking into account the large amount of salt in the soil around the Aral Sea, not only ecological groups of promising plant species distributed in this area, but also the amount of chemical elements in their composition were studied.

Quantitative proportions of biogenic elements in plant species also play a major role in the speed of physiological and biochemical processes taking place in them.

The high or low concentration of each chemical element is one of the most important indicators of the unique geographical distribution and typical characteristics of the soil.

The change in the concentration of most trace elements in different soil analysis samples is directly related to the humus level of the soil, changes in the pH environment, granulometric composition and, of course, the level of biological diversity in the studied area, that is, in the ecotope.

Depending on the microflora of the ecosystem, plant and animal species and their life cycle, the composition of chemical elements in the soil changes seasonally or over the years under the general control of natural processes. Most of these chemical elements were also detected in plant samples. The source of trace elements in the soil is the parent rock of the earth. At the same time, the concentration of chemical elements changes depending on various natural processes (under the influence of water flow, rain, wind, weathering or falling of heavenly bodies as powder, etc.), anthropogenic and man-made factors (enriched or reduced)).

The study of the presence of chemical elements at different levels depending on soil types and geographical areas provides the opportunity to widely use this area in soil-geochemical zoning and geological prospecting. The reason is that the analysis of the elements in living and dead nature components, and the scientific justification of their interrelationship are among the great practical researches.

To determine the degree of salinity of areas planned for experiments in arid areas of the Aral Sea; based on the tests of seeds in different concentrations of salt solutions, work was carried out to select the critical and maximum salt concentration during germination of seedlings in the laboratory of LLC INNOVATION IDEAS. Microbiological activity of soils is determined by protease activity of soil-living microorganisms.

Microbiological activity of soils is determined by protease activity of soil-living microorganisms. Proteins decompose most intensively in soils, which account for up to 50% of the dry mass of the cell. Proteins are decomposed by ammonium inhibitors, actinomycetes, micromycetes (microscopic fungi). When proteins are decomposed by microorganisms, nitrogen is released as ammonia. Ammonification is of great importance for plant nutrition. Ammonification is of great importance for plant nutrition. Oligonitrophilic bacteria have the ability to transfer humus carbon into available forms, nitrogen-fixing - to absorb atmospheric nitrogen. Their accumulation in the soil can significantly contribute to its enrichment with nitrogen. In this regard, a comprehensive study of this group of microorganisms is of great importance for increasing soil fertility. Phosphomobilizing microorganisms - convert mineral (tricalcium phosphates) and organic (phytin, complexes with humus) phosphorus into forms accessible to plants, delivering calcium and phosphorus, potassium-mobilizing bacteria to plants - convert potassium aluminum silicates into potassium and silicon available to plants. Micromycetes also include phytopathogenic fungi, which cause various diseases of agricultural cultures, and actinomycetes suppress the incidence of cultures. Cellulosic decomposing aerobic and anaerobic microorganisms decompose plant residues, straw, weeds, plant roots, turning them into humus. Phase 1 and 2 nitrifiers decompose soil nitrogen-containing compounds and convert nitrogen to plant-accessible forms [1; 3; 6].

Minerals such as sulfate, chlorine, sodium, and magnesium are increasing in Orolqum soil year by year. The process of soil formation in this area is still ongoing. According to the annual retreat of sea water to a certain distance from the bottom coast and the lithological composition of the bottom deposits, as a result of the relief-forming activity of the wind, its surface structure has become more complicated over the past 50 years. The area drained from the water of the Aral Sea mainly consists of saline sandy, saline and clayey soils. Most of this territory, i.e. 82%, is occupied by soils with a heavy clay content, 1-3% strong and 16-20% highly saline soils with unfavorable aeration regime. Seaside clay-saline soils are mainly saline with sulfate-chloride salts (Fig.1).



Fig.1 Study of the effect of active strains of rhizobacteria on germination, growth and development of seeds in laboratory conditions and the choice of optimal options

Therefore, it is very important to determine the content of soil microorganisms, since the fertility of soils and, therefore, the yield of crops, the accumulation of humus in the soil and the water-retaining capacity of the soil depend on their amount and bioarray (Fig.2).



Fig.2 When adding NaCl and MgSO₄ salts 3.5 and 10% to the timing medium growth of dominant bacteria

When studying the rhizospheric soil of 12 plants of endemic plants above the indicated ones, it was revealed that the soil microflora pattern is represented by 3 groups of microorganisms, namely ammonium stabilizers, oligonitrophils and micromycetes. It was found that the number of ammonium finifiers and oligonitrophils was 2-4 orders of magnitude less than normal, and no ammonium finifiers were detected in the rhizospheric soil of Sample N. 5, the number of micromycetes (microscopic fungi) in the rhizospheric soil of Samples N. 1,2,3 and 5 was within normal limits (10³ CFU/g of soil), and no micromycetes were detected in Sample No. 4, and in the remaining samples thereof the amount was 1-2 orders of magnitude higher than normal. Nitrogen-fixing and phosformobilizing bacteria and actinomycetes were not detected.

The above data on the decrease in the number of ammonium and oligonitrophils, the increased number of micromycetes, as well as the non-detection of nitrogen fixators, phosformobilizing bacteria and actinomycetes indicate a decrease in fertility in the rhizospheric soils of the studied plants.

Conclusion

More than 90% of soils formed on the drained bottom of the studied Aral Sea are soil covers subject to various degrees of salinity and degradation. The state of these soil cover is determined by the ecological-reclamation, soil-climatic state of the Aral Sea. Saltwater areas formed in areas previously remote from the water are currently partially covered with salt-loving halophytes, but moisture-loving plants have been preserved in the territories adjacent to the surface of soil waters and on residual swamp soils in the sediments. In addition, saltmarsh areas were subjected to degradation processes and destruction (erosion and deflation) under the influence of wind, which ultimately led to a reduction in plant distribution areas.

It was predicted that the covering of saline soils with plants will proceed gradually according to the natural law due to the fact that the areas are first occupied by halophytic plants and then covered by psammophytic plants. It was confirmed that the degree of formation (number and diversity) of vegetation cover, including the landscape, decreases from the foreshore to the water (Aral Sea) [1; 2; 4; 6; 7; 10].

When studying different physiological groups of rhizosphere microorganisms of different halophyte plants growing in the dry bottom of the Aral Sea, the number of ammonifiers and oligonitrophils is less than normal, micromycetes are more than normal, nitrogen fixers, phosphorus-decomposing bacteria and actinomycetes were not detected. It was found that the studied soils have low fertility and weak beneficial microflora. When the resistance of isolated pure cultures of rhizobacteria of desert plants to 3%-5%-10% concentrations of MgSO₄ and NaCl salts was studied, culture K-35 from among the cultures was found to have good resistance to 2 salts in one week. For further studies, this K-35 culture was screened for tolerance to MgSO₄ and NaCl salts.

According to the biochemical characteristics of plant adaptability to specific environmental conditions, promising endemic plant species (*Suaeda salsa*, *Halostachys caspica*, *Lythrum*

salicaria, *Sophora alopecuroides*, *Halothamnus subaphyllus*, *Salsola orientalis*, *Halimodendron halodendron*, *Kochia scoparia*, *Ceratoides ewersmanniana*, *Climacoptera lanata*) are recommended for use in phytomelioration.

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