The Effect of Agrobentofos on the Agrochemical   
Properties of Saline Soils

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**Abstract.** This article studies the effect of the innovative fertilizer "Agrobentophos" on the agrochemical properties of saline soils. During the study, experimental work was conducted on saline soils in the "Tik-uzik" massif in the Muynak district. The area of saline soils occupied 3.340 percent of the total area. The study measured changes in soil bulk density by applying these innovative fertilizers. The effect of Khaudag bentonite and Agrobentophos on soil properties was tested by applying 600, 900, and 1200 kg/ha. Initially, the soil bulk density was 1.35-1.36 g/cm3. According to the experimental results, the accumulation of chloride ions in the experimental variants treated with these fertilizers was lower than in the experiments treated with mineral fertilizers, equal to 2.320-2.511%. In addition, it was found that the density of the soil mass increased by 0.06 g / cm3 during the experiment.

**Keywords:** Saline soil, chloride ion, local fertilizer, mineral fertilizer, aqueous extract, Agrobentofos, bentonite, phosphorite mineral.

# Introduction

The Republic of Karakalpakstan is characterized by diverse soil types, with the reclamation status of irrigated soils being the most severe in the republic. Irrigated soils in all 15 districts of the Republic of Karakalpakstan are saline to varying degrees. Specifically, in the Tik-Uzik massif of the Muynak district, the plow layer of irrigated meadow-takyr soils is 25-30 cm thick, consisting of heavy, medium, and light loam in terms of mechanical composition. The humus content in these soils is 0.9-1.0%, nitrogen is 0.04-0.05%, decreasing to 0.5-0.7% in the lower horizons. Carbonates constitute 7.0-8.0%, gypsum 0.1-0.8%, reaching up to 1.5-4.6% in some highly saline horizons. Soils are predominantly moderately to heavily saline. Additionally, irrigated takyr-meadow soils have a 27-30 cm plow layer, composed of heavy and medium loam, with some areas of light loam and sandy loam. The humus content in light loam ranges from 0.4-0.6% and in heavy loam from 0.7-1.0%. Nitrogen content varies from 0.03 to 0.07%, while carbonates (CO2) range from 6.6 to 8.1%. These soils are classified as weakly to moderately saline [1].

Water-soluble salts have a significant impact on plant and soil properties. The presence of salts in the soil causes an increase in the osmotic pressure of the soil solution. If the osmotic pressure of the soil solution exceeds the osmotic pressure of plant tissue sap, then plants cannot absorb such moisture, and the phenomenon of physiological "drought" occurs, causing plants to gradually wither. Salts have a toxic effect on plants, making it difficult for them to absorb nutrients from the soil, leading to a decrease in yield and deterioration in the quality of agricultural products. Experiments have shown that determining the toxicity threshold of salts is considered a highly complex task. The "toxicity threshold" of ions involved in soil salinization, i.e., the criteria for negative impact on plants starting from certain levels, has been determined and recommended for reclamation soil science [2]. The established "toxicity threshold" standards are <0.05% (0.8 mg-eq) for HCO3 ions, <0.01% (0.3 mg-eq) for Cl, <0.08% (1.7 mg-eq) for SO4, and <0.023% (1 mg-eq) for Na ions.

In the process of soil salinization, three main cations (Ca2+, Mg2+, Na+) and four anions (CO32-, HCO3-, Cl-, SO42-) participate in natural waters and soil solutions. As a result of their interactions and the formation of hypothetical salts, 12 types of salts are formed in soil and groundwater. These 12 types of salts determine the degree of soil salinity and reclamation status.

Among these salts, calcium bicarbonate Ca(HCO3)2, sulfate(CaSO4), and carbonate(CaCO3) salts are harmless (non-toxic) for plants and are considered beneficial to some extent. The remaining 9 types of salts form the group of toxic salts, which include sodium and magnesium bicarbonate (NaHCO3, Mg (HCO3)2) and carbonate salts (Na2CO3, MgCO3), as well as chloride salts of sodium, magnesium, and calcium (NaCl, MgCl2, CaCl2).

The impact of salinization on plants depends on soil properties, plant age and species, moisture regime, salt composition, and their solubility. If we consider the toxicity level of moderately toxic sodium sulfate (Na2SO4) to plants as 1, then the toxicity level of NaHCO3 is 3, MgSO4 and MgCl2 salts are 3-5, NaCl is 5-6, and the toxicity level of Na2CO3 (washing soda) is 10. These figures demonstrate that the toxicity of Na2CO3 is 10 times higher than that of Na2SO4. When these salts dissolve, they form a strong alkaline salt of sodium (NaOH), which, as mentioned above, sharply increases the osmotic pressure of the soil solution. This strongly influences physiological processes, causing plants to stop nutrient uptake and gradually die.

Numerous types of phosphorus fertilizers have been synthesized by chemists worldwide. The main drawback of these fertilizers is their poor retention in soil and tendency to be absorbed into groundwater along with water [3-4]. A group of scientists from the scientific school of Academician Sh.S. Nomozov has produced various liquid and solid forms of phosphorus and mixed fertilizers by processing Kyzylkum phosphorite ores, recommending them for widespread and effective use in agriculture [5-6]. Additionally, they have created various fertilizers by modifying phosphorite minerals with local livestock waste, bentonite minerals, and underwater sediments [7].

Soil samples from the "Tik-uzik" massif area of Muynak district. Regularly used local and mineral fertilizers. The innovative fertilizer "Agrobentofos" developed by scientists at Termez State University of Engineering and Agrotechnologies.

# Methods

This research was conducted by scientists at Termez State University of Engineering and Agrotechnology as part of USAID's Aral Sea Regional Project on Water Resources and Environment. In addition to this research, university scientists have carried out several scientific studies focused on the synthesis and investigation of reactive polymer compounds containing nitrogen and phosphorus.

One of the primary methods for examining saline soils under laboratory conditions is water extract analysis. Data from water extracts are typically used to provide a comparative description of the quantity and composition of water-soluble substances in various soils and to determine the degree of soil salinity. Among water-soluble salts, the most commonly found in soils are calcium, magnesium, sodium and potassium sulfates, chlorides and bicarbonates. The water extract method involves briefly treating the soil by mixing it with water, followed by filtration of this liquid. The filtered liquid - the extract - is then subjected to further analysis. In addition, several scientists have developed research methods for determining the amount of organic humus in soil composition. In these studies, they utilized the "Walkley-Black" method, which is currently the most widely used approach.

The soil sample is passed through a 1 mm sieve, and 50 g of it is weighed on a technical scale. It is placed in a 500 ml flask, and 250 ml of distilled water is poured over it (soil to water ratio of 1:5). The mixture of soil and water is shaken for 5 minutes. After the specified time, it is filtered through a simple filter into a second flask. The solution filtered through is called an aqueous extract. When soil is treated with water, water-soluble compounds are transferred to the extract. It is generally accepted to determine the amount of dry residue, total alkalinity, alkalinity due to normal carbonates and bicarbonates, Cl', SO"4, Ca", Mg ", K', Na' water-soluble humus from the composition of the aqueous extract. In some cases, nitrates, nitrites, some oxides, and other compounds are also identified. When determining the amount and composition of water-soluble substances in the soil, a shortened or complete analysis of the aqueous extract is used. Due to the limited time allocated to students, it is usually recommended to perform a shortened analysis of the aqueous extract, i.e., to determine dry residue, total alkalinity, chloride ion, as well as to qualitatively determine SO4 and Ca ions.

Soil pH is one of the most frequently measured parameters in laboratories. This indicator shows whether the soil is neutral, alkaline, acidic, or saturated with bases, primarily reflecting the activity of hydrogen ions. The pH scale is such that if the reaction of the medium changes by one unit, the concentration of hydrogen ions in the solution increases tenfold. The pH of soil typically ranges from 3 to 9. The importance of pH lies in its influence on the form of nutrients in the soil, the solubility of toxic elements, the physical breakdown of root cells, cation exchange in the soil, and pH-dependent particle and biological activity. Among the soils of the world's semi-arid regions, acidic soils are very rare. They are mainly characteristic of humid tropical and temperate climate zones. To determine soil pH, a 50 g (1 mm) sample is weighed on a scale and poured into a 50 ml measuring flask. It is then thoroughly shaken with a glass rod and stirred intermittently for half an hour at 10-minute intervals. After one hour, the suspension is thoroughly mixed, the device electrode is immersed 3 cm deep into the suspension, and measurements are taken after 30 seconds. The electrode is then removed from the suspension, rinsed with distilled water, and wiped dry with a napkin.

The ratio of the weight of a certain volume of pure dry soil preserved in its natural state to the weight of the same volume of water is called the bulk density of the soil and is expressed in units of g/cm3 or t/m3. Determining the bulk density of the soil reveals its important agronomic properties. The bulk density of the soil depends on the soil type, composition, structural state, and consistency.

In this research study, the results of laboratory work on determining the amount of cations and anions in the experimental field soils, as well as the humus content and bulk density of the soil, are presented in a table. Water extracts were prepared from the soils, and both qualitative and quantitative analyses were conducted. Modern instruments used in physicochemical analysis, including photometers, spectrophotometers, and atomic absorption spectrophotometers, were extensively utilized.

# results And analysis

The easiest and most optimal method for calculating salt reserves in soils by separate layers (0−100, 100−200, 0−200 cm) is to express the average specific amounts of salts determined by genetic horizons of the soil for a specific layer (0−100 cm) by multiplying the thickness of the calculated layer and the bulk density of this layer. This approach allows for an objective assessment of the quantitative indicators of the identified salt reserves, the degree of salinity, and the reclamation and ecological condition of irrigated soils, enabling the development of specific proposals and recommendations aimed at improving these conditions.

The soils of the research objects are mainly weakly, moderately, and strongly saline, with some sections consisting of very strongly saline variations. The average salt content in the upper 0-1 meter layer of the soil ranges from 0.212−0.560% to 0.764−2.398% in dry residue, of which the chloride ion content is 0.016−1.084%. The salinity chemistry is highly diverse, consisting of chloride, chloride-sulfate, sulfate-chloride, and sulfate types.

Salt reserves in the soils of the studied areas were observed at various quantitative levels. The fluctuation ranges and average arithmetic values of the identified water-soluble (total), chloride ion, and toxic salt reserves calculated for different soil layers are presented in Table 1.

**TABLE 1.**Chemical analysis of salinized soils in the "Tik-uzik" massif of Muynak district

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Experimental field | | Ion ratio, %/millieq | | | | | | Degree of salinity | |
| Salinity type  Contour | Salinity type  Depth (cm) |
| Contour | Depth (cm) | HCO3 | Cl | Contour | Depth (cm) | HCO3 | Cl |
| 106(1) | 0-30 | 0,013 | 0,115 | 0,405 | 0,066 | 0,017 | 0,156 | С | Excessively salty |
| 30-50 | 0,271 | 3,345 | 8,537 | 3,487 | 1,722 | 6,944 | С | Excessively salty |
| 106(1) | 0-30 | 0,019 | 0,025 | 0,085 | 0,030 | 0,007 | 0,004 | С | Excessively salty |
| 30-50 | 0,388 | 0,831 | 1,873 | 1,740 | 0,981 | 0,372 | С | Excessively salty |
| 107(1) | 0-30 | 0,023 | 0,119 | 0,412 | 0,052 | 0,014 | 0,161 | С | Excessively salty |
| 30-50 | 0,253 | 3,294 | 7,125 | 3,723 | 1,252 | 6,442 | С | Excessively salty |
| 108(1) | 0-30 | 0,021 | 0,12 | 0,397 | 0,047 | 0,018 | 0,145 | С | Excessively salty |
| 30-50 | 0,265 | 3,117 | 6,911 | 2,678 | 2,172 | 6,249 | С | Excessively salty |

Table 2 presents a chemical analysis of the saline soils in the "Tik-uzik" massif of the Muynak district. In the table, the average salinity in the experimental plots of contours 106 and 107 is 4.26-4.28%. The layer with the highest degree of salinity is the 15-30 cm layer, while the lowest is the 45-50 cm layer.

TABLE 2.Agrochemical analysis report on soil salinity in the "Tik-uzik" area of Muynak district (Sample from contour zones k-106 and k-107)

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| № | Contour № | Depth (cm) | Dry residue, % | pH | Salt content, % | Humus, % | K2O, mg/kg | P2O5, mg/kg | DDT and its metabolites | Pesticides and their residues |
| 1 | 106 (1) | 0-15 | 4,08 | 6,2 | 4,28 | 0,87 | 348 | 26,92 | No | No |
| 2 | 106 (2) | 15-30 | 4,12 | 5,9 | 4,52 | 0,75 | 120 | 26,53 | No | No |
| 3 | 107 (1) | 30-45 | 4,04 | 6,3 | 4,42 | 0,81 | 112 | 18,91 | No | No |
| 4 | 107 (2) | 45-60 | 3,98 | 6,1 | 4,26 | 0,83 | 130 | 16,52 | No | No |
| 5 | 106 (1) | 60-75 | 2,32 | 5,9 | 4,23 | 0,79 | 145 | 15,54 | No | No |
| 6 | 106 (2) | 75-85 | 2,5 | 6,3 | 4,16 | 0,75 | 146 | 15,98 | No | No |
| 7 | 107 (1) | 80-90 | 2,5 | 6,4 | 4,18 | 0,73 | 134 | 14,97 | No | No |
| 8 | 107 (2) | 90-105 | 2,3 | 6,2 | 4,17 | 0,71 | 126 | 15,14 | No | No |

According to the results of agrochemical studies, failing to follow the recommendations of specialists in the field and using chemical preparations and mineral fertilizers irrationally leads to a decrease in soil fertility. Additionally, toxic chemical substances (pesticides, nitrates, etc.) in the soil negatively impact environmental pollution and public health. During the cultivation of agricultural products, insufficient provision of phosphorus and potassium fertilizers, along with the continuous absorption of nutrients from the soil by plants, results in a decrease in the amount of phosphorus, potassium, and trace elements in the soil composition. Therefore, it is necessary to conduct agrotechnical soil surveys and prepare cartograms once every four years for each cultivated area.

**TABLE 3.**Agrochemical analysis report on soil salinity in the "Tik-uzik" massif of Muynak district (Sample from contour area K-108)

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| № | Contour № | Depth (cm) | Dry residue, % | pH | Salt content, % | Humus, % | K2O, mg/kg | P2O5, mg/kg | DDT and its metabolites | Pesticides and their residues |
| 1 | 108 (1) | 0-15 | 4,08 | 6,2 | 4,28 | 1,01 | 352 | 27,02 | No | No |
| 2 | 108 (2) | 15-30 | 4,12 | 5,9 | 4,52 | 0,95 | 355 | 26,21 | No | No |
| 3 | 108 (3) | 30-45 | 4,04 | 6,3 | 4,42 | 0,87 | 347 | 25,41 | No | No |
| 4 | 108 (1) | 45-55 | 3,98 | 6,1 | 4,26 | 0,91 | 287 | 23,15 | No | No |
| 5 | 108 (2) | 50-60 | 2,32 | 5,9 | 4,23 | 0,82 | 264 | 22,01 | No | No |
| 6 | 108 (3) | 60-75 | 2,34 | 5,7 | 4,28 | 0,74 | 224 | 18,15 | No | No |
| 7 | 108 (1) | 75-85 | 2,32 | 5,9 | 4,37 | 0,49 | 135 | 14,2 | No | No |
| 8 | 108 (2) | 80-90 | 2,5 | 6,3 | 4,53 | 0,81 | 90 | 16,9 | No | No |
| 9 | 108(3) | 95-105 | 2,26 | 6,1 | 4,58 | 0,84 | 102 | 17,2 | No | No |

Table 3 shows that in the K-108 contour experimental field of irrigated soils in the "Tik-uzik" massif of Muynak district, the average content is 4.37-4.54%. The layer with the highest degree of salinization is the 90-105 cm layer, while the lowest is in the 60-75 cm layer.

The highest average content of total salts in the upper 0-1 meter layer of soils in the studied area was recorded in the experimental plot K-108 (3) of the irrigated soils in the "Tik-uzik" massif of the Muynak district (4.54%), while the lowest average values were observed in the experimental plot K-108 (1) (4.37%). The average chloride ion content in the saline soils of the "Tik-uzik" massif in the Muynak district is 3.340%. In the remaining experimental plots (contours), irrigated lands occupy intermediate positions in terms of salt reserves.

Local, mineral, and innovative fertilizers were studied in field experiments to determine the effects of different application rates (600, 900, and 1200 kg/ha) of Khaudag bentonite and Agrobentofos on soil properties. The experiment tested various doses of the innovative fertilizers Khaudag bentonite and Agrobentofos both with and without mineral fertilizers. In the experiment, different doses of innovative Khaudag bentonite and Agrobentofos were tested with mineral fertilizers and without mineral fertilizers, only Khaudag bentonite and Agrobentofos were tested.

Changes in soil bulk density under the influence of the innovative fertilizers Khaudag bentonite and Agrobentofos were measured at the beginning, middle, and end of the experiment. The initial soil bulk density before the experiment was 1.35-1.36 g/cm3. An increase in bulk density was observed in all experimental variants from the beginning to the end of the experiment. However, the overall decrease in soil bulk density from the start to the end of the experiment is attributed to the positive effects of Khaudag bentonite and Agrobentofos on improving soil structure. No significant difference (0.3-0.4 g/cm3) was observed when using Khaudag bentonite and Agrobentofos alone or in combination with mineral fertilizers. The highest soil compaction in the experiment was observed in the variant with pure mineral fertilizer application, which increased by 0.06 g/cm3 from the beginning to the end of the experiment. In variants where the non-traditional fertilizers Khaudag bentonite and Agrobentofos were applied in addition to NPK fertilizers, the increase in soil bulk density ranged from 0.03 to 0.04 g/cm3.

In addition, changes in chloride ion content in the soil were also determined experimentally. Before the experiment began, the chloride ion content in the soil was around 3.340-3.350%. By the end of the experimental period, the chloride ion content had increased. The accumulation of chlorine from spring to autumn ranged from 2.710% to 2.102%. During the experimental period, the highest accumulation of chloride ions (3.420-3.720%) was observed in variants treated with mineral fertilizers. When innovative fertilizers such as Khaudag bentonite and Agrobentofos were applied in combination with mineral fertilizers, the accumulation of chloride ions was lower compared to variants treated with mineral fertilizers alone, amounting to 2.320-2.511%. From spring to autumn, the accumulation of dry residue was equivalent to that of chloride ions.

# CONCLUSION

In this research study, the results of laboratory work on determining the amount of cations and anions in the experimental field soils, as well as the humus content and bulk density of the soil, are presented in a table. Water extracts were prepared from the soils, and both qualitative and quantitative analyses were conducted. Modern instruments used in physicochemical analysis, including photometers, spectrophotometers, and atomic absorption spectrophotometers, were extensively utilized.

It has been determined that the average chloride ion content, which is the primary indicator of salinity level, is 3.340% in the saline soils of the "Tik-uzik" massif in the Muynak district. The effects of local, mineral, and innovative fertilizers, as well as Khaudag bentonite and Agrobentofos, on soil properties were studied at different rates of 600, 900, and 1200 kg/ha. It has been experimentally proven that the soil bulk density increased by 0.06 g/cm3, and the accumulation of chloride ions was lower compared to the variants treated with mineral fertilizers, ranging from 2.320% to 2.511%. It has been experimentally proven that the volume of soils increased by 0.06 g/cm3, and the accumulation of chloride ions was lower than in the variants treated with mineral fertilizers, reaching 2.320-2.511%.

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