

Eco-reclamative and agrochemical indicators of irrigated gray-meadow soils of Uzbekistan

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Abstract. The agricultural land in the Republic of Uzbekistan is strategically classified into three key categories: irrigated lands, arable lands, and natural pastures. Currently, the Republic faces a diverse range of salinization levels on its irrigated lands. This article endeavors to establish a scientific foundation for the systematic distribution of irrigated soils across the provinces of Uzbekistan, taking into account the varying ecological conditions prevalent in the region. The primary focus of this article is on the analysis of soil samples derived from the Tashkent and Syrdarya provinces. A comprehensive examination is conducted, encompassing ecological, reclamation, agrochemical, and physical properties of these soils. By shedding light on these key attributes, the article aims to provide valuable insights into the overall condition of agricultural lands in Uzbekistan. Crucially, the article delves into the state of mineralization of groundwater and surface runoff, both essential components in irrigated agriculture. This analysis is pivotal in understanding the impact of these water sources on the plants cultivated in the region. Given the vital role of irrigated agriculture in Uzbekistan's food production, addressing the challenges posed by salinization and ensuring sustainable land management practices are imperative for safeguarding the agricultural sector's productivity and ecological balance. Through this scientific exploration, the article contributes to the broader understanding of the intricate interplay between soil properties, water quality, and successful agricultural practices in the Republic of Uzbekistan.

1 Introduction

Agricultural lands belong to fertile lands and are the main means of ensuring national wealth, agricultural production and food security of the country.

The total area of agricultural lands of the Republic of Uzbekistan is 20 236 300 hectares, of which arable land is 3 988 500 hectares, perennial tree groves are 383 100 hectares, gray lands are 76 000 hectares, hay fields and pastures are 11 028 300 hectares, other lands amount to 4 760 400 hectares [1].

The area of irrigated lands in Uzbekistan is 9.6%, and the impact of anthropogenic pressure on irrigated lands is growing. This, in turn, increases the intensity of soil processes, leading to the development of adverse conditions, in particular salinization, erosion, contamination with agrochemicals and other processes, this effect can be assessed as positive and negative in irrigated soils due to diversity [2].

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The Central Mirzachul desert consists of irrigated gray-meadow, meadow-gray, light gray and meadow soils developed on loess deposits. In this regard, heavy, medium, light sandy soils of different mechanical composition are found. Irrigated grassland soils form the basis of irrigated agriculture in the province and are fully used in practice [3].

The first soil samples were taken from Gulistan district of Syrdarya province, where irrigated gray-grass soils are widespread, which have their own characteristics. Its natural conditions played a key role in this. The Syrdarya plains themselves had a very slow natural flow of groundwater, as a result of which irrigation caused them to rise to the surface and increase vertical water exchange. This, in turn, allowed automorphic soils to become semi-hydromorphic, then hydromorphic soils, and secondary salinization to occur [4-7].

The gray-meadow soils of the provinces are the basis of irrigated agriculture, which are practically fully utilized. These soils are connected to the two geomorphological provinces of the mountains and river cones spread in the Central Mirzachul plains. Soil-forming rocks consist of deluvial-proluvial loess. According to the mechanical composition, the soils are medium and light sand, sometimes there are layers of different granulometric composition. The upper layer is loose-soft, the cross-section (profile) is weakly thickened towards the lower parts, there are fine grains of salts and crystals of gypsum. In the flat plains of the foothills, large sand dunes are laid [8-10].

Gray-meadow soils have 2-3 m of groundwater, which to a certain extent affects the processes of soil formation formed in deep conditions. These soils are (intermediate) soils transitioning from gray soils to grassland soils. The transition of gray soils to gray-meadow soils is associated with the rise of groundwater and strong wetting of the lower part of the soil profile. The location of mineralized ground water near the earth's surface accelerates the salinization processes, which eventually leads to soil salinization. According to the degree of salinity, the soils are strongly saline, with spots, moderately and weakly saline. Chlorides take the main place in the composition of salts that are easily soluble in water, in some cases they are found in a certain ratio with sulfates [11]. The type of salinity of gray-meadow soils is chloride-sulfate and sulfate-chloride.

2 Materials and methods

The Botanical Garden of the National University of Uzbekistan, located in the Almazar district of Tashkent, and the experimental plots in the Experimental station of the Gulistan district in the Syrdarya province serve as crucial sites for the collection of soil and water samples. This initiative aims to conduct a detailed analysis of the environmental conditions and quality of these key components in distinct geographical locations within Uzbekistan.

The sampling process involved the extraction of soil and water samples from these designated sites. The Botanical Garden in Tashkent and the Experimental station in the Syrdarya province were chosen to represent urban and rural contexts, respectively, providing a comprehensive overview of diverse environmental settings.

Following the sample collection, a meticulous analytical process unfolded over a span of 10 days, involving different laboratory conditions. The laboratory settings were tailored to meet the specific requirements of each type of analysis, ensuring accuracy and reliability in the results obtained. Various parameters, including but not limited to ecological, reclamation, agrochemical, and physical properties, were scrutinized during this period.

This comprehensive study serves as a valuable resource for understanding the soil and water characteristics in these distinct regions, contributing to a broader knowledge base for environmental management and agricultural practices in Uzbekistan. The findings derived from this analytical endeavor will likely inform strategies for sustainable land use, water resource management, and environmental conservation in both urban and rural settings.

Soil sampling, storage, laboratory, lysimetric experiments State Standard (SS): 17.4.3.01-83, Sampling and storage of soil samples Chemical and physical properties of soils Pansu method [12-15], State standards of soil fertility and reclamation (SS: 17.5.1.01.-83; SS: 17.5.3.04-83), a statistical analysis of the results obtained from the Statgraphics Centurion XVII program.

3 Results

The proximity of different levels of mineralized groundwater to the surface accelerates salinization processes, resulting in salinization of soil soils. Chlorides play a key role in the composition of water-soluble salts; in some cases, they occur in certain proportions with sulfates. The salinity types of gray-meadow soils are chloride-sulfate and sulfate-chloride (Table 1).

The amount of salts in the 0-30 cm layer of all the cross-sections studied varied, including the amount of chlorinated salts in cross-section 1.09, cross-section 0.99 and cross-section 0.89 ml eq. These are moderately saline soils. The amount of sulfate salts was 16.87 ml in the 1st section, 16.25 ml in the 2nd section and 15.21 ml in the 3rd section. was found to be strongly saline. The dry residue content was 1.410% in section 1, 1.334% in section 2, and 1.240 % in section 3, which is due to weak salinity.

Table 1. Salinity condition of irrigated gray-meadow soils, on a layer of 0-30 cm.

Alkalinity		Cl		SO ₄		Dry residue, %	pH
Total HCO ₃ , %	Total HCO ₃ , ml.eq	%	ml.eq	%	ml.eq		
0.027	0.44	0.039	1.09	0.810	16.87	1.410	7.74
0.028	0.46	0.035	0.99	0.780	16.25	1.334	7.80
0.028	0.46	0.032	0.89	0.730	15.21	1.240	7.85

The amount of calcium, magnesium and sodium in irrigated gray-meadow soils was also found to vary. According to the results, the amount of sodium in section 1 was 2.38 ml.eq. In section 2 was 2.07 ml.eq and 1.62 ml.eq was in 3 sections. The amount of sodium in these soils is low (Table 2).

Table 2. Ability of irrigated gray-meadow soils to provide absorbing cations.

Ca		Mg		Anion	Cation	Na	
%	ml.eq	%	ml.eq	%	ml.eq	%	ml.eq
0.234	11.68	0.053	4.35	18.40	16.02	0.055	2.38
0.23	11.48	0.050	4.15	17.69	15.62	0.048	2.07
0.222	11.08	0.047	3.85	16.55	14.93	0.037	1.62

The amount of magnesium and calcium was almost the same in the three sections studied and did not differ significantly from each other, including calcium 11.68 in section 1, 11.48 in section 2, and 11.08 ml.eq in section 3. The amount of these soils is high in terms of supply. The amount of magnesium in sections 1 and 2 is 4.35 and 4.15 ml.eq, respectively. In the amount of 3.85 ml.eq is moderately provided. The amount of nutrients and humus in the studied soils were also found to vary, including mobile phosphorus 200 mg/kg in section 1.685 mg/kg in section 2 and 78.0 mg/kg in section 3, and phosphorus in the first section.

The amount is almost 3 times higher than in subsequent cuts, these soils are considered to be very high in phosphorus supply (Table 3).

Table 3. Status of nutrient and humus supply of irrigated gray-meadow soils.

Soil layers	Active, mg/kg		N-NO ₃ , mg/kg	Total, %		N, %	Humus, %	Carbon C, %
	P ₂ O ₅	K ₂ O		P ₂ O ₅	K ₂ O			
0-30	200.0	524.9	19.6	0.250	0.81	0.125	1.844	1.241
0-30	68.5	279.3	18.0	0.221	0.81	0.094	1.733	1.005
0-30	78.0	322.7	18.2	0.132	0.87	0.097	1.755	1.018

The supply of active potassium is not the same as that of phosphorus, the amount of active potassium in section 1 is 524.9 mg/kg, which is considered to be very strong, in sections 2 and 3 it is 279.3 mg/kg, 322.7 mg/kg, respectively. The supply of 2 cross-sectional soils is high, 3 cross-sectional soils are very high supply. The amount of humus also did not differ much in all sections, according to which the amount of humus in section 1 was 1.844%, in section 2, 1.733% and in section 3, 1.755%, these soils are considered to be weak and moderately supplied with humus.

In terms of mechanical composition, these soils have almost the same mechanical composition, the amount of physical sludge was 28.6% in section 1, 31.8% in section 2 and 30.2% in section 3 (Table 4).

Table 4. Mechanical composition of irrigated gray-meadow soils.

Soil layers, cm	Fraction, %							Physical clay, %
	>0.25	0.25-0.1	0.1-0.05	0.05-0.01	0.01-0.005	0.005-0.001	<0.001	
0-30	2.4	1.5	15.0	52.5	12.7	11.3	4.6	28.6
0-30	1.2	6.1	10.8	50.1	12.7	11.9	7.2	31.8
0-30	1.2	1.4	16.3	50.9	11.9	11.9	6.4	30.2

These soils are soils with light sandy and moderately sandy mechanical composition. The applied agrotechnical measures and the scientific cultivation of plants for many years may affect the partial change of some particles in the mechanical composition.

Table 5. Salinity condition of typical irrigated gray soils, 0-30 cm per layer.

Alkalinity		Cl		SO ₄		Dry residue, %	pH
Total HCO ₃ , %	Total HCO ₃ , ml.eq	%	ml.eq	%	ml.eq		
0.034	0.56	0.007	0.20	0.033	0.69	0.092	8.13
0.032	0.52	0.007	0.20	0.030	0.62	0.086	8.15
0.032	0.52	0.007	0.20	0.030	0.62	0.088	8.17

The following major geomorphological provinces are located in Tashkent: high mountains, medium mountains and low mountains, foothills and foothills, as well as lower and upper river terraces. The diverse surface structure has led to significant climate change affecting

plant species and genetic types of soils. The hydrogeological conditions of the province are derived from geomorphological-lithological and relief conditions. Groundwater is mainly formed as a result of ground transit water flowing in mountain and foothill plains. In addition, they are formed from the filtration water of Chirchik, Ahangaran, Karasuv and other irrigation networks, partly from atmospheric precipitation.

According to the results of chemical analysis of soils from the second study area, Tashkent, the salinity of the soils is as follows (Table 5).

According to the results, the typical gray soils irrigated are not saline, as they are considered unsalted by the chloride ion, with the amount of chlorinated salts in all sections being 0.20 ml.eq. is lower than Similarly, the amount of sulphate salts is not saline according to the classification of soil salinity, including 0,69 ml.eq in section 1 and 0.62 ml.eq in sections 2 and 3 amount. According to the results, the amount of dry residue was less than 0.3%, 0,092% in the 1st section, 0,086% in the 2nd section and 0,088% in the 3rd section. The pH of the soil is alkaline, which is probably due to the total carbonates in the soil. Studies have also found that the amounts of cations and anions in typical gray soils that are irrigated also vary (Table 6).

Table 6. The ability of irrigated typical gray soils to provide absorbing cations.

Ca		Mg		Anion	Cation	Na	
%	ml.eq	%	ml.eq	%	ml.eq	%	ml.eq
0.01	0.50	0.004	0.30	1.44	0.80	0.65	0.015
0.01	0.50	0.003	0.25	1.34	0.75	0.60	0.014
0.01	0.50	0.002	0.20	1.34	0.70	0.65	0.015

The amount of calcium in these soils is very low, and in all sections, it is 0.50 ml.eq. This is a very poor soil. Similarly, the amount of magnesium is very low, 0.30 ml.eq in section 1 and 0.25 ml.eq in section 2. and 0.20 ml.eq in 3 sections. was found to be the amount of sodium is similarly 0.60-0.65 ml.eq. oscillations were detected between. It can be seen that it corresponds to a lower supply level than the sum of cations and anions.

The amount of humus in the soil was found to be higher than that of cations and anions, including 2.88% in section 1, 3.06% in section 2, and 3.70% in section 3 (Table 7). The amount of carbon increased in proportion to the amount of humus. In terms of humus supply, these soils are considered moderate and strong.

The amount of mobile phosphorus and potassium is also somewhat higher, the amount of mobile phosphorus is 54 mg/kg in section 1, 52 mg/kg in section 2 and 43 mg/kg in section 3, these soils are considered to be very high in phosphorus. Potassium content is 308.2 mg/kg in section 1, 394.9 mg/kg in section 2 and 337.1 mg/kg in section 3, which are among the high-supply soils.

Table 7. Status of nutrient and humus supply of typical gray soils irrigated.

Soil layers	Active, mg/kg		N-NO ₃ , mg/kg	Total, %		N, %	Humus, %	Carbon C, %
	P ₂ O ₅	K ₂ O		P ₂ O ₅	K ₂ O			
0-30	54.0	308.2	21.4	0.214	0.81	1.850	2.889	1.676
0-30	52.0	394.9	20.4	0.235	0.77	1.900	3.06	1.775
0-30	43.0	337.1	12.6	0.242	0.66	2.006	3.702	2.147

The supply of mobile nitrogen differs from the supply of other nutrients, including mobile nitrogen at 21.4 mg/kg in section 1, 20.4 mg/kg in section 2 and 12.6 mg/kg in section 3, according to this supply classification, soils obtained from sections 1 and 2 are moderately well-supplied, while soils from sections 3 are considered poorly provided. The particle size in the mechanical composition of the typical irrigated gray soils studied also varies (Table 8).

Table 8. Mechanical composition of irrigated typical gray soils.

Soil layers, cm	Fraction, %							Physical clay, %
	>0.25	0.25-0.1	0.1-0.05	0.05-0.01	0.01-0.005	0.005-0.001	<0.001	
0-30	1.3	1.5	6.6	47.7	15.1	12.2	15.6	42.9
0-30	1.3	1.5	7.4	46.9	15.1	12.8	15.0	42.9
0-30	1.6	2.0	6.6	47.7	14.3	13.0	14.8	42.1

According to the results, 0.25 mm particles were 1.3% in sections 1 and 2, 1.6% in sections 3, 0.25-0.1 mm fractions were 1.5% in sections 1 and 2, and 2% in sections 3 and 2. 0.1-0.05 mm fractions between 6.6-7.4% in the corresponding sections, 0.05-0.01 mm fractions 46.9-47.7%, 0.01-0.005 mm fractions 14.3-15.1%, and 0.005-0.001 mm particles were found to be between 12.2-13.0, 0.8 mm fractions and 14.8-15.6% smaller particles. These soils are medium sandy soils in terms of mechanical composition. In typical gray soils, as in light gray soils, ephemeral plants grow. However, more ephemeral plant species grow here due to more rainfall, more moisture in the layer, and a later onset of the summer drought.

Due to the rapid growth of the country's population, the transfer of agricultural land to other categories and the sharpening of the impact of global climate change, the area of irrigated land per capita has decreased by 24% (from 0.23 to 0.16 hectares) over the past 15 years has also been significantly reduced [1].

4 Discussion

Over the years, inefficient use of agricultural land has led to declining soil fertility and crop yields, deteriorating crop quality, and ultimately environmental pollution. Improving the quality of crops grown through the use of irrigation water based on crop demand, as well as raising the level of groundwater and preventing soil salinization are of great importance.

We know that as a result of non-compliance with the rules of chemical fertilizers and water use, the amount of mobile phosphorus in irrigated arable lands decreased by 93%, potassium by 68.3%, and humus by 79.3% [1].

At present, one of the most urgent tasks is to complete the inventory of low-yielding cotton, wheat and other crops, to formulate a program of measures to increase productivity and efficiency, as well as to develop proposals for the placement of high-yield crops in these areas.

In water-scarce areas, low-water, drought-resistant crops are grown and zoned [6]. The seasonal irrigation rate for crops grown on saline soils is 20-25% higher than the irrigation rate for crops grown on non-saline soils. This is due to the fact that during the growing season, as a result of high air temperatures and the proximity of mineralized groundwater to the surface, rapid evaporation is observed, resulting in soil salinization, i.e. the accumulation of salts in the topsoil [7].

Irrigation water depends on the nature of the source, the concentration and turbidity of the water in the source or the presence and management of sediments. It has been scientifically and practically determined that groundwater has almost no water turbidity, but they have a high degree of mineralization. River water has a very low level of mineralization, but they contain sticky substances that are rich in minerals. The amount of water taken from the reservoir may vary depending on the location of the reservoir relative to the river.

Any irrigation water has requirements for the number of turbid particles in it, the amount of dissolved salts and the temperature. Depending on the nature of the water source, the turbidity, salt content and temperature may vary.

The size in water is 0.10 - 0.15 mm. When the muddy particles fall into the irrigation network, it sinks and shrinks its core. Although the muddy particles of 0.005 - 0.10 mm are not rich in nutrients, the mechanical composition falling into the irrigation area through irrigation networks improves the physical properties of heavy soils, water permeability. Although turbid particles smaller than 0.005 mm in size are rich in nutrients for the plant, their frequent entry into the irrigation field worsens the physical properties of the soil, water permeability and air circulation [8].

It is advisable that the temperature of the irrigation water is equal to the soil temperature ($t > 14^{\circ}\text{C}$), if the water is cold, the water in open basins should be heated in sunlight and then given for irrigation. The optimum temperature of water for irrigation is 20°C . If the plant is watered when the water temperature is low, the growing season will be longer. This leads to a decrease in crop quality and low yields.

The quality of irrigation water is required to meet the following:

- ensure good development of agricultural crops and the intended yield;
- prevent deterioration of soil water-physical properties;
- Irrigation systems do not reduce performance [9].

River water has the highest turbidity, groundwater has the lowest turbidity, and irrigation water turbidity is required to be up to 1.5 kg/m^3 . Excessive turbidity in irrigation water leads to turbid flooding of canals and structures. While some of the mud particles have a positive effect on irrigated soils, they have a negative effect on the amount of water required to irrigate crops from the canal. Although the size of turbid particles in the range $d = 0.1 \dots 0.005 \text{ mm}$ is less productive, it serves to improve the physical properties of soils with heavy mechanical composition. Concentration increases the water permeability of soils with heavy mechanical composition. Turbid particles around $d < 0.005 \text{ mm}$ improve soil reclamation and are a good nutrient.

It was observed that the mineralization of water in river waters is mainly 1 g/l . In practice, highly mineralized waters can be found in ponds and lakes. The mineralization of water depends mainly on the composition of the chemical elements present in the water. Irrigation may be allowed if the water contains up to $2\text{-}3 \text{ g/l}$ of salt. Mineralization in water is up to $5\text{-}8 \text{ g/l}$ salt can be used for salt-tolerant plants, $15\text{-}20 \text{ g/l}$ toxic salts, cannot be used in irrigation [10].

On May 15, 2019 in the experimental fields of Experimental mahalla of Gulistan district of Syrdarya province and in the Botanical Garden of the National University of Uzbekistan in Almazar district of Tashkent studied the quality of water used for irrigation of essential oil plants and obtained analytical results and their impact on plants.

Samples of water were determined in the laboratory of the State Unitary Enterprise "Uzbekhydrogeology" of the State Committee for Geology and Mineral Resources of the Republic of Uzbekistan (Table 9).

Based on the data in Table 9 above, it can be concluded that the chemical composition of the waters of the two different provinces is also different. Although similarity was observed in both experiments on the clarity of irrigation water, the biological and chemical absorption of oxygen in Gulistan district is 3 times higher, i.e. 0.45 mg/l and 11.43 , the total amount of

substances is 9 times higher, NO_2 is 250 times higher, The fact that the amount of dry residue is 5 times higher indicates the low quality of irrigation water.

Table 9. Results of water analysis of provinces.

Types of analysis	Water composition of Tajribakorlar mahalla of Gulistan district of Syrdarya province	Water composition of the Botanical Garden of the National University of Uzbekistan, Almazar district, Tashkent
Clarity of water	Colorless	Colorless
Biological assimilation of oxygen (for 5 days) $\text{mg O}_2/\text{l}$	0.45	0.12
Chemical assimilation of oxygen mg/l	11.43	3.81
The total amount of substances mg/l	27	3
NO_2^- amount mg/l	2.5	< 0.01
NO_3^- amount mg/l	94	59
NH_4^+ amount mg/l	< 0.1	< 0.1
PO_4 amount mg/l	0.192	0.053
HCO_2 amount mg/l	470	390
Cl^- amount mg/l	443	26
The amount of dry residue. mg/l	3102	616

It should be noted that the chemical composition of the water differed sharply. The results of water analysis obtained from our research site in the experimental mahalla of Gulistan district of Syrdarya province showed that the alkalinity of the water there is high.

5 Conclusions

According to the results of the analysis of soil samples taken from the Botanical Garden of the National University of Uzbekistan in Almazar district of Tashkent and Gulistan district of Syrdarya province, we found and studied that the soils are different in chemical, mechanical and physical structure.

Due to the results of the analysis of soil and water samples in the experimental area of the Botanical Garden of the National University of Uzbekistan, Almazar district, Tashkent, when we studied the level of salinity, no salinity was observed. According to the results of the analysis of soil and water samples in the experimental area of the experimental mahalla of Gulistan district of Syrdarya province, we determined the average salinity level.

Any soil contains a certain amount of water-soluble salts. They affect plants differently depending on the salt content and salinity level. When their amount is in excess, it has a detrimental effect on the growth, development and yield of crops. Their toxic and osmotic effects on plants distinguish salts.

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