Ecological and meliorative condition of soils in the Karakalpakstan, Kegeyli District

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Abstract. Soil samples were collected from newly irrigated meadow-alluvial soils in the Kegeyli district of northern Karakalpakstan to investigate their physical and mechanical properties, with particular focus on macro- and microaggregate composition. Comparative analysis of samples taken from two depth intervals (0-30 cm and 30-60 cm) revealed distinct soil characteristics. Porosity measurements showed values of 49.4% in the upper layer (0-30 cm) compared to 47.2% in the deeper layer (30-60 cm). Aggregate size distribution analysis demonstrated significant differences between depth layers. In the 0-30 cm samples, particles <0.25 mm and aggregates larger than 28.6 mm were classified as macroaggregates, while the 30-60 cm samples contained smaller quantities of both <0.25 mm particles and aggregates up to 10.0 mm, indicating variations in structural composition with depth. Further examination of soil layers at 0-25 cm and 25-33 cm depths revealed textural differences. The upper layer (0-25 cm) contained 24.9% physical clay and 36.0% physical sand, while the lower layer (25-33 cm) showed slightly reduced values of 23.0% physical clay and 32.0% physical sand. These findings provide valuable insights into the vertical heterogeneity of soil properties in newly irrigated meadow-alluvial soils of the study region.

1 Introduction

Currently, saline lands worldwide make up approximately 25% of the Earth's land surface. Over the next 25 years, due to the high presence of water-soluble salts in the soils of irrigated lands across more than 75 countries in arid and semi-arid regions, along with the intensification of desertification, salinization, and erosion processes, more than 2,000 hectares of land are being subjected to various types of degradation processes every day [1].

For this reason, scientific research is being conducted globally to preserve soil fertility, improve the efficiency of land use, enhance the ecological and meliorative conditions of irrigated lands, increase agricultural soil productivity, assess soil degradation and its impact on agriculture, and develop preventive measures to mitigate negative consequences .

The most effective and simplest method for calculating the salt reserves in soil layers (0-100 cm, 100-200 cm, 0-200 cm) is to determine the average comparative salt content in

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genetic soil horizons for a specific layer (e.g., 0-100 cm) and multiply it by the calculated layer thickness and its bulk density, expressing the result in tons per hectare (t/ha). This method allows for an objective assessment of soil salinity levels and the meliorative-ecological conditions of irrigated soils, guiding appropriate improvement measures.

Various soil types are found in the Republic of Karakalpakstan, with irrigated soils in the region experiencing the most severe meliorative conditions. All 15 districts of the Republic of Karakalpakstan contain irrigated soils with varying degrees of salinity.

Types of Irrigated Soils in Karakalpakstan:

1. Irrigated Meadow-Takir Soils:
   - The plow layer is 25-30 cm thick.
   - Based on mechanical composition, the soil varies from heavy, medium, to light loamy.
   - Humus content ranges from 0.9-1.0%, while nitrogen content is 0.04-0.05%, decreasing to 0.5-0.7% in deeper layers.
   - Carbonate content is 7.0-8.0%, and gypsum ranges from 0.1-0.8%, reaching 1.5-4.6% in highly saline horizons.
   - These soils are generally moderately to highly saline.
2. Irrigated Takir-Meadow Soils:
   - The plow layer is 27-30 cm thick.
   - Mechanically, these soils are predominantly heavy and medium loamy, with some areas having light loamy and sandy compositions.
   - Humus content in light loamy soils ranges from 0.4-0.6%, while in heavy loamy soils, it increases to 0.7-1.0%.
   - Nitrogen content varies between 0.03-0.07%.
   - Carbonate content (CO_2) fluctuates between 6.6-8.1%.
   - These soils exhibit weak to moderate salinity.
3. Irrigated Meadow-Alluvial Soils:
   - Their mechanical composition ranges from heavy loamy to sandy.
   - These soils are highly compacted with a coarse cloddy structure.
   - Humus content varies from 0.5-0.8% to 1.1-1.5%.
   - Nitrogen content ranges from 0.01-0.09%.
   - Carbonate content fluctuates between 6.3-8.3%.
   - Gypsum content is 0.1-0.5%.
   - These soils show weak, moderate, and high levels of salinity.

Using the references mentioned above, the ecological and meliorative conditions of the soils in the northern region of Karakalpakstan, specifically in the Kegeyli district, have been studied.

2 Materials and Methods.

The soils of the northern region of Karakalpakstan, specifically in the Kegeyli district, were selected as the study object. The main goal was to examine the ecological and meliorative conditions of the soils in this area, as well as their salinity levels. One of the primary laboratory methods for analyzing soil composition and salinity levels is the water extract analysis.

Water extract analysis is commonly used to compare the amount and composition of water-soluble substances in different soils and to determine soil salinity levels. In Uzbekistan, for carbonate-rich soils, the preparation process for analysis involves dispersing the soil with a sodium pyrophosphate solution. The essence of this preparation method is to break down soil aggregates composed of tightly bound mechanical elements.

In many soils, calcium plays the role of a binding agent. Therefore, chemical reagents that can displace calcium from the soil absorption complex are used for soil treatment. Hydrochloric acid is often used as a reagent. However, in gray soils where the carbonate content reaches 20-30%, hydrochloric acid is avoided to prevent carbonate breakdown. Instead, a 4% sodium pyrophosphate solution is used as a dispersant for soil preparation in mechanical analysis.

Soil samples taken from the northern region of Karakalpakstan, specifically in the Kegeyli district, were analyzed for their physical, mechanical, macro, and microaggregate composition using the Kachinsky method [2-5].

3 Results and Discussion

Regardless of depth, the observed soil composition revealed that toxic salts—chloride-sulfate salts—were significantly present in heavy soils, with chloride levels being 8.6 times higher and sulfate levels 8 times higher compared to lighter soils. It was determined that compared to light soils, lower clayey soils exhibited a higher degree of salinity (100-140 cm depth).

Soil moisture content was measured at 21.6% in light soils (at a depth of 100 cm) and 21.73% in heavy soils (at a depth of 100 cm) [6].

Soil samples from the northern region of Karakalpakstan, specifically in the Kegeyli district, were analyzed for their physical, mechanical, macro-, and microaggregate composition. The results are presented in the following tables (Tables 1, 2, 3, 4).

Table 1. General Physical Properties of Soils from the Kegeyli District

Profile Number, Soil, and Area Name	**Layer Depth, cm**	**Bulk Density, g/cm³**	**Relative Density, g/cm³**	**Total Porosity, %**
Profile 1. Newly Irrigated Meadow-Alluvial Soil.	0-30	1,34	2,62	49,4
	30-60	1,36	2,64	47,2

When comparing the samples taken from newly irrigated meadow-alluvial soil in the Kegeyli district (as presented in Table 1), soil porosity was found to be 49.4% at a depth of 0-30 cm and 47.2% at a depth of 30-60 cm. It was observed that the porosity percentage of the 0-30 cm layer was higher than that of the 30-60 cm layer.

Table 2. Macro- and Microaggregate Composition of Soils from the Kegeyli District

Profile №	Layer Depth, cm	Particle Content %, Measured in mm								
		>10	10-7	7-5	5-3	3-2	2-1	1-0,05	0,5-0,25	<0,25 Less than
1	0-30	7,84	7,02	19,0	3,6	3,36	19,2	6,2	5,18	28,6
2	30-60	23,2	11,08	12,53	9,5	7,12	16,52	4,8	5,25	10,0

According to the data presented in Table 2, soil samples were taken from the Kegeyli district at depths of 0-30 cm and 30-60 cm, and their macro- and microaggregate composition was analyzed. In soil samples taken from the 0-30 cm layer, the proportion of particles smaller than 0.25 mm was 28.6%, while soil particles larger than 28.6 mm were classified as macroaggregates. In contrast, soil samples taken from the 30-60 cm layer contained 10.0% of particles smaller than 0.25 mm, indicating a finer texture and a predominance of microaggregate composition.

Table 3. Mechanical Composition

Profile No. and Sampling Location Name	Layer Depth, cm	Particle Content %, Measured in mm									Classification
		>0,25	0,25-0,1	0,1-0,05	0,05-0,01	0,01-0,005	0,05-0,001	<0,001	Physical Clay	Physical Sand	
Profile 1. Newly Irrigated Meadow-Alluvial Soil	0-25	33,1	2,9	11,3	27,8	11,7	9,3	3,9	24,9	36,0	Light Loam
	25-33	30,5	2,5	30,1	14,4	7,7	7,0	7,8	23,0	32,0	Light Loam

According to Table 3, soil samples were taken from newly irrigated meadow-alluvial soil layers at depths of 0-25 cm and 25-33 cm. The analysis revealed that:

In the 0-25 cm layer, physical clay content was 24.9%, while physical sand was 36.0%.

In the 25-33 cm layer, physical clay content decreased to 23.0%, and physical sand content was 32.0%.

It was observed that the physical clay and sand contents were higher in the 0-25 cm layer compared to the 25-33 cm layer.

Based on the study results, the soil classification of the samples taken from the 0-25 cm and 25-33 cm depths in Kegeyli district indicates that they belong to the light loam soil category.

Table 4. Agrochemical Analysis of Soil Samples

Layer Depth, cm	Humus, %	Total, %			N-NH_3 кг/га	Mobile, mg/kg		CO_2 Carbonates, %	SO_4 Gypsum, %	pH N
		N	P	K		P_2O_5	K_2O			
Newly Irrigated Meadow-Alluvial Soil.										
0-30	0,95	0,131	0,214	2,21	95,5	1,36	263,1	8,49	0,112	7,4
30-60	1,11	0,094	0,118	1,84	75	1,44	374,4	7,51	0,134	7,3

When conducting the agrochemical analysis of soil samples, samples were taken from soil layers at depths of 0-30 cm and 30-60 cm. The analysis revealed that the humus content in the 0-30 cm soil sample was 0.95%, whereas in the 30-60 cm soil sample, it was 1.11%.

It was determined that the humus content in the 30-60 cm soil sample (1.11%) was higher compared to the 0-30 cm sample.

During the research, the composition of N, P, K elements in the soil was analyzed. The results showed that in the 0-30 cm soil sample:N – 0.131%, P – 0.214%, K – 2.21%.

Whereas in the 30-60 cm soil sample: N – 0.094%, P – 0.118%, K – 1.84%.

Additionally, the N-NH_3 content was: 95.5 kg/ha in the 0-30 cm soil layer, 75 kg/ha in the 30-60 cm soil layer.

These results indicate that the N, P, and K contents in the 0-30 cm soil sample were higher compared to the 30-60 cm sample.

When analyzing the mobility of P_2O_5 and K_2O compounds: In the 0-30 cm soil sample: P_2O_5 – 1.36 mg/kg, K_2O – 263.1 mg/kg, In the 30-60 cm soil sample: P_2O_5 – 1.44 mg/kg, K_2O – 374.4 mg/kg.

CO_2 and SO_4 analysis results:

In the 0-30 cm soil sample: CO_2 – 8.49%, SO_4 – 0.112%, In the 30-60 cm soil sample: CO_2 – 7.51%, SO_4 – 0.134%.

These findings indicate that the SO_4 content was higher in the 30-60 cm soil layer.

The gypsum content was also analyzed, revealing that the gypsum percentage in the 30-60 cm soil sample was higher than in the 0-30 cm sample.

When measuring the pH levels: In the 0-30 cm soil layer, pH – 7.4, In the 30-60 cm soil layer, pH – 7.3.

This shows that the pH level in the 0-30 cm soil sample was slightly higher.

Table 5. The Amount of Water-Soluble Salts in the Soil Composition

Section No. and Sampling Location Name	Layer Depth, cm	Dry Residue	Total HCO_3	Cl	SO_4	Ca	Mg
Newly Irrigated Meadow-Alluvial Soil	0-30	2,037	0,122	0,213	1,08	0,210	0,073
			2,0	6,0	22,5	10,5	6,0
	30-60	4,518	0,067	0,160	0,804	0,210	0,027
			1,1	4,5	16,75	10,5	2,25

When studying the amount of water-soluble salts in the soil composition in Table 5, soil samples were taken from newly irrigated meadow-alluvial soil at depths of 0-30 cm and 30-60 cm. The results showed that in the 0-30 cm soil sample, the total amount of HCO_3 was 0.122, Cl was 0.213, SO_4 was 1.08, Ca was 0.210, and Mg was 0.073. In the 30-60 cm soil sample, the total amount of HCO_3 was 0.067, Cl was 0.160, SO_4 was 0.804, Ca was 0.210, and Mg was 0.027. Throughout our research, it was observed that the amount of water-soluble salts in the 0-30 cm soil sample, particularly HCO_3 (0.122), Cl (0.213), SO_4 (1.08), and Mg (0.073), was higher compared to the 30-60 cm soil sample.

4 Conclusion

Soil samples were taken from the northern region of Karakalpakstan, specifically from the Kegeyli district, to study the general physical properties of the soils. When comparing newly irrigated meadow-alluvial soil samples taken from depths of 0-30 cm and 30-60 cm in the Kegeyli district, the soil porosity was found to be 49.4% at 0-30 cm and 47.2% at 30-60 cm.

In soil samples taken from the 0-30 cm depth, the proportion of particles smaller than 0.25 mm was 28.6%, while macroaggregates larger than 10.0 mm were dominant in the 30-60 cm samples, indicating differences in the macro and microaggregate composition of the soil.

For newly irrigated meadow-alluvial soil layers, physical clay content was 24.9% and physical sand was 36.0% in the 0-25 cm samples, whereas in the 25-33 cm samples, physical clay was recorded at 23.0% and physical sand at 32.0%.

According to the agrochemical analysis of the soil samples, the humus content was 0.95% in the 0-30 cm soil samples, whereas it was 1.11% in the 30-60 cm samples. The nitrogen (N), phosphorus (P), and potassium (K) levels were determined as follows: at 0-30 cm depth, N was 0.131%, P was 0.214%, and K was 2.21%; at 30-60 cm depth, N was 0.094%, P was 0.118%, and K was 1.84%.

The soil composition analysis revealed that P_2O_5 content in the 0-30 cm layer was 1.36, and K_2O was 263.1, while in the 30-60 cm layer, P_2O_5 was 1.44, and K_2O was 374.4, indicating higher soil mobility characteristics in the deeper layer.

Based on the results of the analysis, it was determined that the ecological and meliorative condition of the Kegeyli district soils at the 0-30 cm depth was better compared to the 30-60 cm depth samples.

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