

General Characteristics of Irrigated Grey Soils (Case Study: Yangiyo'l District, Tashkent Region)

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Abstract This study investigates the agrochemical properties, content of water-soluble salts, and mechanical composition of irrigated grey, meadow-grey, meadow, and marshy soils in the Yangiyo'l district of the Tashkent region. The findings highlight the evolutionary development stages of these soils and provide insights into the changing properties of soils under irrigation.

Keywords Irrigated grey, Meadow-grey, Meadow, and marshy soils, Fertility, Mechanical composition, Salinization

1. Introduction

Currently, the intensive development of agriculture has led to increased land degradation, primarily due to soil erosion, depletion of nutrient reserves, increased salinity, and drought, all contributing to land deterioration. Notably, anthropogenic factors have led to the degradation of 34% (1,660 million ha) of agricultural lands [1].

In Uzbekistan, soils are formed within vertical and horizontal zones, with grey soils developing predominantly in the central regions. These soils possess unique characteristics due to their soil-climatic and regional conditions. Grey soils are found in all regions except Karakalpakstan, Bukhara, Syrdarya, and Khorezm. In Tashkent region, they account for 12.6% of the country's typical grey soils [2].

Groundwater plays a key role in soil formation, leading to distinct soil types. Meadow soils form at depths of 1.0–2.0 m, while meadow-grey soils form at depths of 2.0–3.0 m. During the growing season, irrigation raises groundwater levels, fluctuating 1.0–1.5 m depending on the terrain. The genetic soil types in Yangiyo'l district include irrigated typical grey, meadow-grey, meadow, and marshy-meadow soils. These soils vary in erosion, salinity, nutrient content, and mechanical composition due to topographic diversity.

Therefore, it is essential to study the organic matter, chemical, and physicochemical properties of hydromorphic soils to scientifically maintain and improve fertility. This includes identifying the content of organic matter, physical-chemical properties, humus levels, and predicting evolutionary changes [3].

Grey soil types within irrigated classifications include dark grey, typical grey, light grey, meadow-grey, and oasis variants [4].

The cation exchange capacity in typical grey soils ranges from 9–11 meq/100 g in Zangiota and 9–14 meq/100 g in Yangiyo'l. The exchange complex is saturated with alkaline earth metals, with calcium and magnesium making up 90–94%, and potassium and sodium comprising 6–10%. The total area of the studied land is 35,972 ha, of which 22,831.6 ha are irrigated agricultural lands [5].

These lands are irrigated primarily through the Jon and Bo'z water canals branching from the Chirchik River. In upland areas, irrigation is supported by pumps. Collector-drainage systems maintain groundwater levels below critical thresholds [6].

2. Research Methods

Field studies were conducted in the irrigated soils of Yangiyo'l district, Tashkent region. Soil profiles and sampling were performed according to Dospekhov (1985) [7]. Chemical analysis followed guidelines from the 1977 "Methods of Agrochemical Analysis of Soils and Plants of Central Asia" and Arinushkina's manual. Analytical techniques included genetic-geographical, profile-geochemical, and chemical-analytical methods [8,9]. Humus distribution was studied per Toshqoziev's guidelines [10]. The research adhered to national soil survey protocols, with statistical analysis done in Microsoft Excel.

Yangiyo'l district, established on September 29, 1926, borders Kazakhstan (Turkistan region) and several Tashkent districts. Covering 0.42 thousand km², it is predominantly flat with some uplands. The district contains five terraces of

the Chirchik River and is characterized by grey and meadow soils. Its continental climate supports vegetation such as reeds, wormwood, tamarisk, bindweed, couch grass, and others. Wildlife includes jackals, foxes, hares, badgers, and various birds [11].

In the Xalqobod massif, soil profiles still exhibit residual signs of original grey coloration and weak carbonate accumulation. Nutrient levels (humus, total K, N, mobile

P₂O₅, K₂O, and N-NO₃) are highest in the upper 0–41 cm layers. Total P, however, is higher in the deeper 103–151 cm layer. Similar trends were observed in Ulug'bek, Zarafshon, Yangi Hayot, and Yuksalish massifs.

Various salts in the soils of the study area negatively affect the growth and development of plants. The amount of water-soluble salts in the soils of the study area was investigated (Table 2).

Table 1. Agrochemical Properties of Irrigated Soils in Yangiyo'l District, Tashkent Region (2024)

Profile Number	Sampling Depth, cm	Humus	Overall, %			Available, mg/kg		N-NO ₃ , mg/kg	C:N
		%	P	K	N	P ₂ O ₅	K ₂ O		
Gray soil of the Xalqabod massif									
7-Sample	0-26	1,123	0,108	0,89	0,083	6,5	183,4	68,6	8,6
	26-41	0,598	0,102	0,81	0,049	4,0	142,1	62,4	9,0
	41-71	0,487	0,126	0,81	0,038	4,0	97,4	39,8	9,8
	71-103	0,479	0,118	0,76	0,035	2,0	97,3	39,9	7,1
	103-151	0,381	0,111	0,68	0,033	2,0	83,9	47,7	7,0
	NCR _{0,5}	0,003	0,004	0,31	0,32	0,43	0,41	0,31	0,004
	R%	0,58	0,61	3,78	8,16	0,38	0,68	4,41	0,33
Gray pasture soil in the Ulug'bek massif									
25- Sample	0-21	1,034	0,134	1,0	0,072	11,0	452,8	115,9	8,3
	21-36	1,013	0,115	0,9	0,072	5,0	168,5	108,2	8,2
	36-69	0,76	0,13	1,1	0,052	8,0	158,9	85,8	8,5
	69-90	0,865	0,165	1,1	0,06	12,0	197,5	71,6	8,4
	90-145	0,928	0,221	1,0	0,064	17,0	264,9	46,9	8,4
	NCR _{0,5}	0,003	0,004	0,33	0,32	0,44	0,42	0,31	0,004
	R%	0,58	0,61	3,78	8,16	0,38	0,68	4,41	0,33
Pasture gray soil in the Zarafshon massif									
50- Sample	0-22	1,123	0,236	0,69	0,075	27,0	258,8	52,5	10,5
	22-48	0,998	0,142	0,69	0,068	21,0	156,7	45,8	8,6
	48-73	0,756	0,141	0,71	0,072	14,0	135,2	37,6	6,0
	73-109	0,428	0,139	0,68	0,054	9,5	112,5	42,3	4,9
	109-151	0,341	0,137	0,68	0,035	7,0	103,9	36,8	5,9
	NCR _{0,5}	0,003	0,004	0,42	0,31	0,41	0,33	0,32	0,004
	R%	0,57	0,52	3,76	8,07	0,39	0,67	4,52	0,34
Pasture soils in the Yangi Hayot massif									
73- Sample	0-22	1,645	0,158	0,68	0,098	28,0	252,6	79,8	10,3
	22-48	1,486	0,135	0,54	0,076	19,5	235,2	54,6	10,3
	48-75	0,983	0,126	0,42	0,045	16,0	173,5	43,7	13,1
	75-106	0,645	0,107	0,34	0,028	14,0	116,9	36,4	12,6
	106-142	0,253	0,078	0,28	0,014	8,0	97,8	21,6	12,0
	NCR _{0,5}	0,003	0,004	0,42	0,32	0,43	0,32	0,31	0,004
	R%	0,57	0,52	3,76	8,07	0,39	0,67	4,52	0,34
Marsh soils in the Yuksalish massif									
87- Sample	0-20	2,722	0,17	0,84	0,155	13,0	130,0	42,0	10,2
	20-35	1,498	0,146	0,9	0,095	14,0	120,4	43,8	9,1
	NCR _{0,5}	0,003	0,004	0,34	0,32	0,43	0,41	0,32	0,003
	R%	0,54	0,68	3,78	7,18	0,31	0,69	7,09	0,37

Table 2. Water-Soluble Salt Content of Irrigated Soils in Yangiyo'l District, Tashkent Region

Profile Number	Sampling Depth, cm	HCO ₃ ⁻	Cl ⁻	SO ₄ ²⁻	Ca ²⁺	Mg ²⁺	Na ⁺	Dry residue	Salinity level
Xalqabod massif (gray soil)									
7- Sample	0-26	0,036	0,008	0,045	0,017	0,007	0,011	0,128	Non-salinized
	24-41	0,038	0,007	0,023	0,011	0,005	0,013	0,114	Non-salinized
	41-71	0,034	0,006	0,034	0,012	0,003	0,012	0,121	Non-salinized
	71-103	0,028	0,007	0,128	0,038	0,011	0,014	0,234	Non-salinized
	103-151	0,027	0,007	0,144	0,041	0,012	0,013	0,245	Non-salinized
	NCR_{0,5}	0,026	0,0032	0,128	0,028	0,032	0,028	0,026	
	R%	7,28	6,42	6,43	6,53	5,21	4,43	8,26	
Ulug'bek massif (gray semi-desert soil)									
25- Sample	0-21	0,041	0,007	0,034	0,013	0,005	0,012	0,121	Non-salinized
	21-36	0,038	0,007	0,034	0,012	0,005	0,012	0,116	Non-salinized
	36-69	0,037	0,007	0,032	0,012	0,004	0,013	0,110	Non-salinized
	69-90	0,035	0,007	0,042	0,014	0,005	0,013	0,128	Non-salinized
	90-145	0,035	0,007	0,058	0,016	0,008	0,013	0,145	Non-salinized
	NCR_{0,5}	0,028	0,0034	0,028	0,026	0,0032	0,028	0,0281	
	R%	7,605	4,57	7,27	9,12	6,52	5,17	7,605	
Zarafshon massif (steppe-gray soil)									
50- Sample	0-22	0,035	0,007	0,031	0,009	0,006	0,011	0,108	Non-salinized
	22-48	0,034	0,008	0,021	0,009	0,004	0,012	0,102	Non-salinized
	48-73	0,034	0,007	0,023	0,011	0,004	0,013	0,121	Non-salinized
	73-109	0,036	0,007	0,021	0,010	0,003	0,012	0,118	Non-salinized
	109-151	0,036	0,006	0,025	0,011	0,004	0,013	0,114	Non-salinized
	NCR_{0,5}	0,028	0,0028	0,005	0,003	0,0032	0,0032	0,0028	
	R%	8,038	4,357	2,182	3,869	7,33	6,352	8,038	
Yangi Hayot massif (steppe soil)									
73- Sample	0-25	0,034	0,008	0,039	0,013	0,007	0,012	0,128	Non-salinized
	25-52	0,035	0,007	0,028	0,011	0,005	0,013	0,118	Non-salinized
	52-79	0,034	0,006	0,020	0,009	0,005	0,013	0,105	Non-salinized
	79-102	0,035	0,007	0,019	0,009	0,003	0,013	0,101	Non-salinized
	NCR_{0,5}	0,028	0,0028	0,093	0,0025	0,0034	0,033	0,281	
	R%	7,91	5,73	4,84	4,36	6,28	5,64	7,96	
Yuksalish massif (marsh soil)									
87- Sample	0-20	0,035	0,007	0,045	0,014	0,006	0,012	0,126	Non-salinized
	20-35	0,037	0,007	0,032	0,011	0,005	0,012	0,118	Non-salinized
	NCR_{0,5}	0,035	0,0025	0,032	0,025	0,002	0,035	0,119	
	R%	8,84	5,71	8,02	6,77	6,66	9,86	5,714	

According to the analysis results, the soils of the study area are non-saline, with the continuous leaching of soils across the massifs being one of the main reasons for this.

All processes occurring in the soil are related to their mechanical composition. Accurate determination of soil mechanical composition is important for conducting preliminary field soil investigations and mapping. This is because information on mechanical composition serves as a scientific basis for classifying soil types, determining irrigation or salt leaching norms throughout the year, organizing and locating drainage and collector systems, and

establishing fertilizer application rates, as well as for developing all necessary agrotechnical and ameliorative measures.

The mechanical composition of the soil significantly influences its physical, physico-chemical, agrochemical, and biological activity properties. The mechanical composition is determined according to soil moisture content and the nutrient availability for plants. It has been found that as the diameter of effective mechanical elements in the fractions decreases, the amount of humus, infiltration capacity, moisture retention, and soil swelling increase several times.

Research indicates that the soils of the studied area, according to their mechanical composition, include light, medium, and heavy loam types.

Analysis of soil research data indicates that in section 7 of the Xalqabod massif, the gray soils are characterized by a predominance of fine sand (0.1–0.05 mm) fractions ranging from 8.2 to 12.8%, and coarse silt (0.05–0.01 mm) fractions

between 48.2 and 58.7%, while the clay fraction (<0.001 mm) is comparatively lower, ranging from 13.8 to 8.8%.

In section 25 of the Ulug'bek massif, the gray-pasture soils are dominated by coarse silt fractions (0.05–0.01 mm) at 56.8–50.9%, and fine sand fractions (0.1–0.05 mm) at 7.5–7.4%, with the clay fraction (<0.001 mm) relatively low at 12.7–18.3%.

Table 3. Mechanical Composition and Physical Clay Content of the Soil (in %)

Profile Number	Sampling Depth, cm	Fractions, %							Physical clay, %
		>0,25	Physical clay, %	0,1-0,05	0,05-0,01	0,01-0,005	0,005-0,001	<0,001	
Xalqabod massif (gray soil)									
7- Sample	0-26	0,3	0,8	8,2	48,2	12,8	15,9	13,8	42,5
	24-41	0,3	0,5	5,3	56,5	10,9	13,8	12,7	37,4
	41-71	0,3	0,5	14,5	47,5	9,8	14,5	12,9	37,2
	71-103	0,3	0,8	12,8	56,9	8,7	10,7	9,8	29,2
	103-151	0,3	0,8	11,9	58,7	8,9	10,6	8,8	28,3
	NCR _{0,5}	0,28	0,16	0,32	0,28	0,32	0,32	0,34	
	R%	6,35	4,52	3,17	4,51	3,84	3,53	3,11	
Ulug'bek massif (gray-steppe soil)									
25- Sample	0-21	0,2	0,2	7,5	56,8	3,6	19,1	12,7	35,4
	21-36	0,1	0,2	5,1	58,8	4,8	17,5	13,5	35,8
	36-69	0,2	2,5	5,1	57,2	5,6	16,7	12,7	35,0
	69-90	0,2	0,3	7,4	54,9	4,8	18,3	14,3	37,4
	90-145	0,1	0,3	7,4	50,9	7,2	18,3	15,9	41,3
	NCR _{0,5}	0,24	0,26	0,28	0,36	0,28	0,26	0,34	
	R%	3,25	6,45	4,63	3,54	5,59	1,45	2,18	
Zarafshon massif (steppe-gray soil)									
50- Sample	0-22	3,8	4,9	5,8	52,7	4,1	14,8	13,9	32,8
	22-48	3,1	3,8	7,9	51,8	3,3	14,9	15,2	33,4
	48-73	2,1	2,5	7,9	54,4	3,9	15,8	13,4	33,1
	73-109	0,4	0,7	5,6	54,1	6,7	16,9	15,6	39,2
	109-151	0,4	0,4	7,2	51,9	6,5	16,7	16,9	40,1
	NCR _{0,5}	0,26	0,34	0,32	0,36	0,38	0,28	0,26	
	R%	3,41	5,77	4,71	3,56	6,64	4,76	3,49	
Yangi Hayot massif (steppe soil)									
73- Sample	0-22	1,5	5,8	20,8	33,1	14,9	12,8	11,1	38,8
	22-48	1,3	5,9	24,9	32,0	10,9	12,6	12,4	35,9
	48-75	1,9	12,1	28,6	25,4	8,9	12,3	10,8	32,0
	75-106	0,7	10,1	36,1	24,5	7,6	11,2	9,8	28,6
	106-142	Loose sand							
	NCR _{0,5}	0,31	0,36	0,32	0,37	0,25	0,36	0,32	
	R%	3,68	4,11	2,21	4,35	2,62	7,68	4,11	
Yuksalish massif (marsh soil)									
87- Sample	0-20	12,6	10,9	14,6	31,0	9,5	11,5	9,9	31,0
	20-35	24,2	13,4	9,2	27,8	8,0	9,5	8,0	25,4
	NCR _{0,5}	0,35	0,34	0,35	0,32	0,25	0,39	0,44	
	R%	2,69	2,45	3,23	3,02	2,82	2,88	4,52	

In section 50 of the Zarafshon massif, pasture-gray soils show dominance of coarse silt fractions (0.05–0.01 mm) at 52.7–51.9%, and fine sand fractions (0.1–0.05 mm) at 4.1–6.5%, with the clay fraction (<0.001 mm) relatively low at 13.9–16.9%.

In section 73 of the Yangi Hayot massif, pasture soils are dominated by coarse silt fractions (0.05–0.01 mm) at 33.1–24.5% and fine sand fractions (0.1–0.05 mm) at 14.9–7.6%, while the clay fraction (<0.001 mm) is relatively low at 11.1–9.8%.

In section 87 of the Yuksalish massif, marsh soils show dominance of coarse silt fractions (0.05–0.01 mm) at 31.0–27.8% and fine sand fractions (0.1–0.05 mm) at 9.5–8.0%, with the clay fraction (<0.001 mm) relatively low at 9.9–8.0%.

The transition from automorphic to hydromorphic conditions is accompanied by differences between gray soils and gray-pasture and pasture-gray soils in the predominance of large, medium, and fine silt particles, and between gray soils and pasture and marsh soils in the predominance of large, medium, and fine sand particles.

3. Conclusions

Irrigation of gray soils formed on the Chirchik river terraces has led to gradual morphological and agrochemical changes that depend on the relief. The amounts of humus and nutrients increase towards semi-hydromorphic and hydromorphic soils compared to automorphic soils (1.123–2.722%). Long-term irrigation has resulted in a gradual decrease in humus content in the lower soil layers of the studied soils. The soil types have shifted from pasture to marsh-pasture soils, reflecting changes in the water-air regime. Partial formation of agro-irrigation layers has been observed in some areas.

The irrigated lands of the studied areas in Yangiyo'l district are non-saline and consist of various mechanical compositions. To maintain soil fertility and productivity and increase crop yields continuously, comprehensive implementation of hydraulic, agrotechnical, and reclamation measures is required.

To prevent groundwater rise and associated secondary salinization processes, it is crucial to regulate irrigation water use, technically re-equip and properly maintain irrigation canal and drainage systems, and to determine irrigation schedules, frequency, and norms accurately. This should consider soil and climatic conditions, crop types, growth periods, water

requirements, groundwater depth, and other factors, ensuring strict adherence to irrigation regimes.

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