Impact of salinity levels on the physical properties of irrigated meadow alluvial soils in Bukhara region

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Abstract. This article provides data on the impact of salinity levels on the physical properties of irrigated meadow alluvial soils with varying salinity levels in the Bukhara region. It thoroughly examines the degree of influence of soil salinity on soil mechanical composition, overall physical properties, bulk density, specific gravity, and porosity

1 Introduction

Soil mechanical composition is a fundamental indicator of soil characteristics. Many soil properties are contingent upon its mechanical composition. Among the most crucial are water, nutrients, air, salt, and temperature regimes [1-24]. These properties and regimes differ significantly between soils with heavy and light granulometric compositions. Agricultural practices employed in crop cultivation also vary significantly between soils with heavy and light granulometric compositions [11,12,5,6,7]. The design and implementation of irrigation and fertilization systems are based on the soil's mechanical structure. The amount of nutrients present in the soil, field moisture capacity, water permeability, absorption capacity, density, air exchange, and mineralogical composition are all influenced by the soil's mechanical structure. Therefore, understanding the soil's mechanical composition is paramount. The leaching of saline meadow alluvial soils takes into account their mechanical composition because it significantly affects water permeability and water retention capacity. Additionally, the amount of salts present changes depending on the soil's mechanical composition [1,2,4,8,9].

Irrigation also impacts the mechanical composition of the alluvial soils of the Bukhara Oasis meadow. Over many years of irrigation, an agro-irrigation layer has formed, altering the mechanical composition of the soil. Irrigated deposits often exacerbate the soil's mechanical composition [3,10]

2 Materials and Methods

The study was carried out in an expeditionary manner, in which irrigated grassland alluvial soils with varying degrees of salinity were isolated and studied for genetic horizons using

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cross-sections. Soil samples were taken according to genetic horizons and analyzed by chemical analysis in laboratories, according to which:

1. mechanical composition of the soil - by the pipette method according to Kachinsky;
2. volumetric mass of the soil-cylinder method;
3. specific mass of the soil-pycnometer method;
4. soil porosity - by calculation;
5. soil moisture - by drying at a temperature of 105 oC;
6. dry residue - determined by evaporation of the aqueous extract in a water bath.

3 Results and Discussion

Generally, the mechanical composition of irrigated meadow alluvial soils in the Bukhara region was predominantly sandy, with moderate and heavy sandy fractions predominating. For example, the mechanical composition of unsalted alluvial soils (section 41) varied along the soil profile, with moderate sand in the 0-31 and 31-63 cm layers, heavy sand at 63-94 cm, moderate sand at 94-113 cm, and loamy sand at 113-148 cm (Table 1). These mechanically composed soils were predominantly composed of particles with diameters of 0.05-0.01 mm. The proportion of these particles in the soil's mechanical composition ranged from 20.25% to 42.33%. This fraction predominated in soils with moderate and heavy sandy mechanical compositions. In loamy sand mechanically composed soils, the fraction of particles with diameters of 0.05-0.01 mm constituted only 20.25%. Additionally, fractions with diameters of 0.005-0.001 mm were relatively high, ranging from 17.31% to 28.20% across soil profile horizons. The highest proportion (28.20%) of the highest grade was observed in soils of the 113-148 cm horizon, which had a loamy sand mechanical composition. In layers of moderate and heavy sandy mechanical composition soils, the fraction of particles with diameters of 0.005-0.001 mm constituted 17.31-22.09% (Table 3.2.1). In the granulometric composition of these soils, particles with diameters >0.25 and 0.25-0.1 mm were predominant (0.85-0.87% and 0.38-4.15%, respectively). The physical clay content in loamy and heavy sandy mechanical composition soils ranged from 43.55% to 51.37%. In loamy sand mechanically composed soils, this fraction constituted 61.31%.

The mechanical and granulometric composition of weakly and moderately saline irrigated meadow alluvial soils did not show significant differences between layers. For example, in the case of weakly saline irrigated meadow alluvial soils, the mechanical composition of the soil profile at 0-29 cm depth was determined to be predominantly composed of coarse sand, while at other depths (29-49; 49-81; 81-109; 109-140 cm), the soil profile was identified as predominantly consisting of fine sand. However, at the depth of 49-81 cm, the mechanical composition of the soil indicated moderate sandiness. In the granulometric composition of weakly saline irrigated meadow alluvial soils, fractions with a diameter of 0.05-0.01 mm had the highest proportion, ranging from 36.05 to 41.20% (Table 1). Additionally, the fraction of 0.005-0.001 mm also had a relatively high proportion, ranging from 17.77 to 23.04%. In this soil, the fine (<0.01 mm) fraction was predominant throughout the soil profile, ranging from 44.39 to 51.64% across horizons. Furthermore, fractions with diameters >0.25-0.1 mm had the smallest proportion in the soil, ranging from 0.39 to 0.84% and 1.65 to 2.78% respectively.

If the mechanical composition of the soil profile of weakly saline irrigated meadow alluvial soils is dominated by fine sand, the moderately saline irrigated meadow alluvial soils showed a greater predominance of medium sand. The mechanical composition of the soil in the remaining horizons of the soil profile (0-26; 26-47; 47-80; 80-105; 105-137 cm) was characterized by a predominance of medium sand (Table 1). In the granulometric composition of the soil, the fraction with a diameter of 0.05-0.01 mm was the most prevalent, observed across all horizons of the soil profile. The proportion of this fraction varied from 32.55 to 37.24% across layers. Additionally, fractions with diameters of 0.1-0.05 mm and 0.005-0.001 mm also had relatively high proportions. The smallest fractions (<0.25 and 0.25-0.1 mm) had proportions ranging from 0.30 to 0.95% and 3.25 to 5.33% respectively. Throughout the soil profile, the fine fraction predominated, ranging from 3.85 to 47.79%. In moderately saline irrigated meadow alluvial soils, the mechanical composition of the soil showed a slight increase in fines, primarily consisting of medium sand. However, at the depth of 79-108 cm, the mechanical composition of the soil indicated medium sand predominance. Unique differences were observed in the remaining horizons, where fractions of 0.25-0.1 mm and 0.1-0.05 mm increased noticeably. This contributed to the densification of the soil's mechanical composition. Additionally, fractions forming a fine texture (<0.01-0.05; 0.005-0.001; <0.001 mm) were predominant in soils with higher proportions of fractions >0.25 mm. Conversely, fractions of 0.01-0.005 and <0.001 mm were relatively smaller compared to other fractions. Consequently, the fine texture proportion decreased to 24.19-32.42% across the soil profile (Table 1), which is an important finding.

Table 1. Mechanical composition of irrigated grassland alluvial soil with varying degrees of salinity

Section	Depth (cm)	Fractions, %							Physical loam, %	Type
		>0,25	0,25-0,1	0,1-0,05	0,05-0,01	0,01-0,005	0,005-0,001	<0,001		
Unsalted										
41	0-31	0,87	3,32	17,84	32,98	11,67	18,43	14,89	44,99	Medium loam
	31-63	0,51	4,15	16,01	34,62	12,33	17,31	15,07	44,71	Medium loam
	63-94	0,44	0,65	5,21	42,33	11,30	22,09	17,98	51,37	Heavy loam
	94-113	0,32	0,38	18,13	37,62	9,15	18,29	16,11	43,55	Medium loam
	113-148	0,05	0,55	17,84	20,25	14,72	28,20	18,39	61,31	Light mud (clay loam)
Lightly saline										
11	0-29	0,69	2,05	10,97	40,21	9,22	23,04	13,82	46,08	Heavy loam
	29-49	0,42	1,65	14,01	38,52	10,90	20,88	13,62	45,40	Heavy loam
	49-81	0,39	1,93	12,09	41,20	10,20	20,41	13,79	44,39	Medium loam
	81-109	0,45	2,36	10,54	39,89	13,09	17,77	15,90	46,76	Heavy loam
	109-140	0,84	2,78	8,69	36,05	13,95	20,66	17,03	51,64	Heavy loam
Moderately saline										
7	0-26	0,95	4,62	15,49	35,02	12,30	17,57	14,05	43,92	Medium loam
	26-47	0,67	4,41	17,21	36,75	11,06	16,79	13,11	40,96	Medium loam
	47-80	0,36	3,25	15,69	32,91	11,95	19,12	16,72	47,79	Heavy loam
	80-105	0,44	3,98	22,49	37,24	8,60	12,91	14,34	35,85	Medium loam
	105-137	0,30	5,33	24,01	32,55	9,83	14,37	13,61	37,81	Medium loam
Strongly saline										
40	0-25	2,28	15,24	24,06	29,75	7,17	11,47	10,03	28,67	Light loam
	25-49	2,84	16,78	24,65	30,64	6,52	10,04	8,53	25,09	Light loam
	49-79	3,45	20,09	22,35	28,01	7,83	10,44	7,83	26,10	Light loam
	79-108	6,01	22,54	18,09	20,94	8,11	14,59	9,72	32,42	Medium loam
	108-138	6,54	28,94	21,86	18,47	5,56	8,95	9,68	24,19	Light loam

So, the alluvial soils of the Bukhara region are mainly loamy in texture, making them suitable for agricultural cultivation. These soils have the advantage of retaining moisture and salts well, which is beneficial for crop growth. Additionally, their high water permeability facilitates irrigation practices, making them convenient for agricultural operations. The soil composition includes various fractions, with particles ranging from 0.05-0.01, 0.1-0.05, and 0.005-0.001 mm in diameter. In comparison to clay, the silt fraction is often higher, indicating favourable conditions for water retention and drainage.

The general physical properties of the soil are determined by parameters such as bulk density, particle density, and porosity. The bulk density of the soil depends on its mechanical and mineralogical composition, structure, and organic matter content. Irrigation and cultivation practices influence the soil's bulk density directly or indirectly. The presence of soluble salts in the soil can also affect its bulk density, either directly or indirectly. The difference in bulk density between cultivated and uncultivated soils is primarily noticeable in the upper humus layer.

In this case, the volume mass of the soil has increased as the soil has been cultivated. For example, the volume mass of uncultivated alluvial soils was 1.37 g/cm3 at a depth of 0-31 cm and 1.40 g/cm3 at a depth of 31-63 cm, while these indicators in similarly cultivated alluvial soils were found to be 1.39 and 1.43 g/cm3, respectively, in the 63-94 cm, 94-113 cm, and 113-148 cm horizons. Medium-plowed alluvial soils showed volume mass values of 1.39, 1.45, 1.47, 1.49, and 1.49 g/cm3 in the 0-26 cm, 26-47 cm, 47-80 cm, 80-105 cm, and 105-137 cm horizons, respectively (Figure 3.2.1). Thus, cultivation primarily affects the soil volume mass in the topsoil layer. The main reason for this is that plowing influences the soil volume mass through the soil humus layer. An essential factor is the increase in salt content, which affects the suppression of microbiological activity in the soil and the processes of humus formation. Consequently, the humus content in the soil decreases, leading to a deterioration in its structure. This, in turn, contributes to soil compaction. Moreover, in cultivated soils, there is insufficient organic matter, resulting in reduced biomass accumulation. This negatively affects the soil's humus regime. Additionally, in uncultivated soils, the high content of sodium and magnesium cations disrupts the soil structure and causes fragmentation. As a result, soil compaction occurs, contributing to an increase in soil volume mass. When soil cultivation decreases and meliorative conditions improve, microbiological processes are activated, and the negative impact of sodium and magnesium cations is reduced. Such changes have a positive effect on soil volume mass.

Thus, soil cultivation leads to an increase in soil volume mass. This condition primarily occurs in the upper and lower horizons of the plow and plow sole layers.

The soil bulk density is also of significant importance. Soil bulk density depends on its mineralogical composition. Variously cultivated alluvial soils have a higher bulk density compared to uncultivated soils. With the increase in cultivation intensity, the bulk density has also increased. Medium and heavy-plowed alluvial soils have the highest bulk density.

Differences in bulk density between uncultivated and cultivated soils were observed in all soil horizons.

Table 2. General physical properties of the Bukhara region soils

Horizon and depth, cm	Bulk density, g/cm^3	Particle density, g/cm^3	Porosity, %
Unsalted			
0-31	1,37	2,61	47,5
31-63	1,40	2,62	46,5
63-94	1,43	2,62	45,4
94-113	1,46	2,63	44,4
113-148	1,47	2,65	44,5

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Lightly saline			
0-29	1,39	2,62	46,9
29-49	1,43	2,63	45,6
49-81	1,45	2,63	44,8
81-109	1,48	2,65	44,1
109-140	1,48	2,66	44,3
Moderately saline			
0-26	1,39	2,63	47,1
26-47	1,45	2,65	45,2
47-80	1,47	2,66	44,7
80-105	1,49	2,67	44,2
105-137	1,49	2,68	44,4
Strongly saline			
0-25	1,40	2,63	46,7
25-49	1,45	2,67	45,7
49-79	1,46	2,67	45,3
79-108	1,48	2,68	44,8
108-138	1,48	2,69	44,8

Soil-specific gravity increased from top to bottom along the soil profile at both non-salinity and all salinity levels.

For example, if the specific mass in the 0-31 cm layer was 2.61 g/cm3 in non-saline soil, this indicator is 31-63; 63-94; 2.62 in layers 94-113 and 113-148 cm, respectively; 2.62; was 2.63 and 2.65 g/cm3 (Table 2). Moderately saline grassland alluvial soils 0-26; 26-47; 47-80; 80-105; The specific mass of soil in layers 105-137 cm is 2.63, respectively; 2.65; 2.66; 2.67; 2.68 g/cm3, 0-25 of strongly saline meadow alluvial soils; 25-49; 49-79; 79-108; 2.63 at horizons of 108-138 cm; 2.67; 2.67; 2.68; It was found to be 2.69 g/cm3 (Table 2). Therefore, the specific mass of saline soils was higher than that of non-saline soils throughout the soil profile. The specific mass increases towards the lower layers. Soil porosity is also important. Uncompacted structural soils have high porosity, and air exchange in such soils is much better. This has a positive effect on soil fertility and crop growth. Porosity in non-saline soils was slightly higher than that of saline soils. Grassland alluvial soils with different salinity levels did not differ significantly in terms of porosity.

In general, soil porosity fluctuated around 44.2-47.5% for all soils (Table 2). In all soil cases, porosity decreased from top to bottom along the soil profile. In the lower horizons, the porosity had the smallest value. For example, the porosity in the 0-31 cm horizon of non-saline meadow alluvial soils was 47.5%, while this indicator was 46.5 in the 31-63 cm, 64-94 cm, 94-113 cm, and 113-148 cm horizons, respectively; 45.4; 44.4; 44.5%, 0-26 of moderately saline meadow alluvial soils; 26-47; 47-80; 47.1 in the 80-105 and 105-137 horizons, respectively; 45.2; 44.7; 44.2; It was found to be 44.4% (Table 2).

Therefore, the porosity of non-saline and saline soils is not significantly different. In all cases, the porosity decreases towards the lower horizons.

Thus, soil salinity has a certain effect on the general physical properties of soil. In this case, the volume and specific mass of the soil increases. This condition was more evident in the upper humic layers.

4 Conclusion

The general physical properties of meadow alluvial soils change to a certain extent depending on soil salinity. In the upper layers of non-saline soil, the volume mass is 1.37-

1.40 g/cm3, in weakly saline soil it is 1.39-1.43 g/cm3, in moderately and strongly saline meadow alluvial soil it is 1.39-1.45 and 1, respectively. It was 40-1.45 g/cm3. The volume mass increase in saline meadow alluvial soil is related to the decrease in humus content and increase in sodium and magnesium cation content in these soils. There is no significant difference in the specific mass of non-saline and different salinity soils. Soil porosity fluctuates around 44.2-47.5% for all soils.

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