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Changes in soil physical properties under the effect of irrigation

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Abstract. The mechanical composition of soils in the middle reaches of the Zarafshan River (Jambay, Samarkand, Payarik, Ishtikhon, Kattakurgan and Narpay districts) and the processes of formation of soil layers under the influence of irrigation water of general physical properties were scientifically analyzed. In this case, the inflow of the Zarafshan River played an important role in the formation of light agroirrigation strata. An increase in nutrients and humus with an increase in the amount of physical sludge over a long period of time (35–40 years) is positively assessed for thickening of the soil layer, but leads to an increase in bulk mass of 0.15–0.3 g / cm³ and soil compaction.

1. Introduction

In many dry and semi-arid locations of the world, urban wastewater is being used for agricultural irrigation as a substitute for freshwater resources as a result of water scarcity [1]. Wastewater, generally untreated, is used to irrigate 10% of the world's crops, covering approximately 20 million hectares of land [2]. As water scarcity worsens and wastewater creation rises, this is anticipated to expand significantly over the next few decades. Currently, more than 80% of sewage created in developing nations is discharged into the environment untreated, and almost 50% of the population relies on polluted water sources for various purposes, including irrigation [2].

When natural precipitation is insufficient to ensure grain and forage production, supplemental irrigation is required [3]. Water application is typically made possible by using contemporary power sources from deep well pumps and storage of vast quantities of water in reservoirs, ponds, streams, and rivers, depending on the size of the farm and the type of irrigation system [4]. Small farmers who employ drip irrigation for their food plots frequently use city water directly.

The presence of high nutrient concentrations (N and P), high total dissolved solids, and other elements such as heavy metals, which are added to the soil through time, have a significant impact on agricultural soil [5–7]. Despite this, there are conflicting findings about the effects of wastewater on soil qualities. Because of the deposition of organic matter from wastewater, some studies find reduced porosity, increased bulk density, and pores becoming smaller. Another aspect is that at low salt concentrations, damage to physical qualities shows quickly [8, 9]. Swelling and dispersion of clay and organic debris are unavoidable after irrigation with low-quality water [10]. The rise in alkalinity and Mg concentration in arid vertisol soil was produced in part by the irrigation water's composition, and in part by the reduction and dissolution of Fe oxides, as well as Fe₂₊ fixation on clay mineral exchange sites [11, 12]. The effect of salt on soil hydraulic properties should not be overlooked because it might lead to major



blunders in irrigation management [13, 14]. Low ESP and salinity levels have a big impact on clay dispersion and hydraulic conductivity [15-17].

Rational and efficient use of lands in Uzbekistan plays an important role in saving the natural resources. In recent years, in the field of agricultural development in the Republic, one of the most pressing issues today is the study of the mechanical composition and general physical properties of soils under the influence of irrigation. For this purpose, studies were conducted on changes in the mechanical composition and general physical properties of soils under the influence of irrigation of soils of the middle reaches of the Zarafshan River (light gray, meadow-gray, meadow-alluvial, typical gray).

2. Methods

Analysis of soils was conducted in the field and laboratory conditions "Methods of field experiments" and "Methods of agrochemical, agrophysical and microbiological research in irrigated cotton areas" [18].

3. Results and Discussions

3.1 Changes in the mechanical composition of the soil under the influence of irrigation

Extensive work has been done to change the mechanical composition of the soil under the influence of irrigation. In particular, Orlov was one of the first to substantiate the emergence of a new type of irrigated soil under the influence of irrigation and its impact on the mechanical composition of the soil and its structural condition [19]. The main reason for such a drastic change in the mechanical composition of soils is the Zarafshan River, i.e., gray-meadow soils, which have undergone many changes within irrigated soils.

They are mainly distributed along the long wide field in the second terrace region of the Zarafshan River. It runs along the perimeter of the reservoir, the villages of Mirankal, Imam Aksak, and Kildon. These soils were medium sandy 40-50 years ago, the middle layers were slightly heavier from about 200 cm.

The first point of our study is the change of properties of soils in the middle part of the Zarafshan River from Jambay district to the town of Payshanbe in Kattakurgan district under the influence of irrigation. The mechanical composition of soils, although a slowly changing indicator, varies greatly depending on the quality of irrigation water and, most importantly, the process of soil formation.

The main reason for such a sharp change in the mechanical composition of soils is the Zarafshan River. That is, gray-grass soils that have undergone many changes within irrigated soils. They are mainly distributed along the long wide field in the second terrace region of the Zarafshan River. It runs along the perimeter of the reservoir, the villages of Mirankal, Imam Aksak, and Kildon. These soils were medium sandy 40-50 years ago, the middle layers were slightly heavier from about 200 cm. The amount of physical mud in the driving layer was 43-45% and in the light sandy layer 28%. Also, when analyzing the agrophysical properties of the soil, in the 0-20 cm layer of section 231, aggregates with a size of $> 0.25-0.01$ mm accounted for 46.9-60.2%. At the same time, the highest aggregate content (60.2%) was found in the soil layer of 140-150 cm with a size of $> 0.25-0.01$ mm. According to the above layers, the amount of physical mud < 0.01 was 39.8-53.1%. Its amount was found to be the highest in the 20 cm layer.

In our study, changes in the mechanical composition of the soil under the influence of irrigation were observed. The research scientifically analyzed the processes of formation of soil layers under the influence of irrigation water of the mechanical composition of soils distributed in the middle reaches of the Zarafshan River (Jambay, Samarkand, Payarik, Ishtikhan, Kattakurgan and Narpay districts).

The importance of the mechanical composition as the main factors increases under hydromorphic conditions, since zero production depends on a fully regular regime. In our research, the mechanical composition of soils is different. The predominance of this or that fraction in determining the mechanical composition is as follows: sandy (1.0-0.05 mm), coarse sandy (0.05-0.01 mm), sandy (0.01-0.001 mm) and loamy (less than or equal to 0.001 mm).

Table 1. Changes in the mechanical composition of the soils of the middle reaches of the Zarafshan River in 2020 year (% unit)

No	Layer. cm	Fractional amount [%] and particle size [mm]							physic al mud. ≤0.01	physical sand> 0.25-0.01 mm	Names of soils according to mechanical composition
		>0.25	0.25- 0.1	0.1- 0.05	0.05- 0.01	0.01- 0.005	0.005- 0.001	<0.00 1			
Meadow-alluvial soils of Jambay massif of Jambay district, %											
1	0-23	5.4	5.7	13.4	23.1	12.7	25.1	14.6	52.4	47.6	heavy sand
	23-38	5.5	6.3	14.4	22.2	12.2	25.1	14.3	51.6	48.4	heavy sand
	38-87	8.9	21.1	21.7	19.3	10.6	9.1	9.3	29	71	Light sand
	87-130	9.2	21.3	21.5	19.0	10.5	9.1	9.4	29	71	Light sand
Gray-meadow soils of Sh. Rashidov square of Samarkand district											
2	0-20	5.1	3.3	19.1	28.1	11.2	19.3	13.9	44.4	55.6	Medium sand
	20-35	4.5	3.4	19	28.2	11.6	19.2	14.1	44.9	55.1	Medium sand
	35-70	5.6	7.2	29.4	39.2	5.1	7.2	6.3	18.6	81.4	Sandy
Grass-meadow soils of Otakul Umarov massif of Payarik district.											
3	0-20	4.6	4.9	19.5	27.2	11.1	19.5	13.2	43.8	56.2	Medium sand
	20-32	4.5	3.8	19.4	28.0	11.7	19.5	13.1	44.3	55.7	Medium sand
	32-91	4.3	3.6	20.4	27.3	11.3	18.9	14.2	44.4	55.6	Medium sand
	91-140	4.6	3.6	20.3	27.1	11	19.2	14.2	44.4	55.6	Medium sand
Meadow-alluvial soils of M.Juraev massif of Ishtikhon district											
4	0-20	3.5	3.4	12.5	28.5	13.3	24.5	14.3	52.1	47.9	heavy sand
	20-33	3.6	3.5	12.3	27.3	13.3	24.5	15.5	53.3	46.7	heavy sand
	33-75	4.8	2	22.7	29	11.4	19.6	10.5	41.5	58.5	Medium sand
	75-115	5.3	1.6	23.1	29.1	11.4	18.4	11.1	40.9	59.1	Medium sand
Typical gray soils of Maska massif of Kattakurgan district											
5	0-23	4.8	4.4	21.8	27.2	12.2	19.5	10.1	41.8	58.2	Medium sand
	23-37	4.5	4.3	21.1	27.6	12.3	19.6	10.6	42.5	57.5	Medium sand
	37-71	4.2	5.3	20.8	25.4	12.1	18.9	13.3	44.3	55.7	Medium sand
	71-83	6.3	7.4	18.3	24.5	13.4	19.6	10.5	43.5	56.5	Medium sand
	83-109	3.2	4.4	15	20.3	16.7	26.6	13.8	57.1	42.9	heavy sand
Meadow-alluvial soils of Thursday town of Kattakurgan district											
6	0-22	2.3	3.4	12.5	24.8	16.7	18.2	22.1	57	43	heavy sand
	22-32	2.8	5.3	9.5	24.2	15.5	19.6	23.1	58.2	41.8	heavy sand
	32-63	3.5	4.7	8.6	26.5	16.9	17.9	21.9	56.7	43.3	heavy sand
	63-95	6.4	8.8	13.8	26.5	9.2	15.2	20.1	44.5	55.5	Medium sand
	95-110	11.2	12.6	13.4	27.2	9.4	11.1	15.1	35.6	64.4	Medium sand
	110-130	17.2	14.6	13.0	27.8	7.2	9.7	10.5	27.4	72.6	Light sand
	130-150	5.2	21.1	24.1	31.8	4.4	6.8	6.6	17.8	82.2	Sandy
Zarafshan massif of Narpay district is light gray											
7	0-24	4.9	8.1	15.2	27.8	15.5	17.9	10.6	44	56	Medium sand
	24-32	4.8	8.0	15.2	27.1	15.3	19.0	10.6	44.9	55.1	Medium sand
	32-55	5.0	8.4	15.4	27.3	15.5	18.6	9.8	43.9	56.1	Medium sand
	55-71	4.9	8.8	14	27.3	15.5	18.7	10.8	45	55	Medium sand
	71-110	5.9	8.6	16.1	27.5	14.9	15.9	11.1	41.9	58.1	Medium sand

In all the data obtained during the study, the main place is occupied by large dust particles in the upper layers, and large and medium sand particles in the lower layers, and depending on its amount, there are sharp changes in the mechanical composition of soils.

For example, in the arable layer of typical gray soils of the Maska quarter of Kattakurgan district, the amount of particles with a size of 0.05-0.01 mm is 27.2-27.6% (Table 1).

The sand particles are almost the same in all regions, which in turn is explained by the flow of the Zarafshan River.

It should also be noted that in almost all regions of our country the level of groundwater is around 130-220 cm, and with a weak level of mineralization, the soil from this layer becomes lighter.

In addition, one of the factors contributing to soil change is the Kattakurgan Reservoir, which was formed in a natural foothill depression with a volume of less than 1.0 billion m³ of water, and it moves freely to the north.

Table 2. Changes in the mechanical composition of irrigated soils under the influence of irrigation

№	Depth of layer, cm	Fractional amount [%] and particle size [mm]							physical mud <0.01	physical sand> 0.25-0.01 mm
		> 0.25	0.25-0.1	0.1-0.05	0.05-0.01	0.01-0.005	0.005-0.001	< 0.001		
Gray-meadow soils										
231*	0-20	4.9	1.2	22	27	12.6	20.8	11.5	44.9	55.1
	40-50	5	1.7	22.3	26.5	12.6	19.4	12.5	44.5	55.5
	100-110	5.3	1.8	23.0	28.1	11.8	19.4	10.6	40.8	58.2
	140-150	5.5	1.7	23.8	29.2	11.0	17.5	11.3	39.8	60.2
	210-220	2	0.6	12.3	32.0	14.5	23.0	15.6	53.1	46.9
5**	0-23	4.8	4.4	21.8	27.2	12.2	19.5	10.1	41.8	58.2
	23-37	4.5	4.3	21.1	27.6	12.3	19.6	10.6	42.5	57.5
	37-71	4.2	5.3	20.8	25.4	12.1	18.9	13.3	44.3	55.7
	71-83	6.3	7.4	18.3	24.5	13.4	19.6	10.5	43.5	56.5
	83-109	3.2	4.4	15	20.3	16.7	26.6	13.8	57.1	42.9
Meadow-alluvial soils										
160-85***	0-28	2.2	3.3	9.0	26.4	16.6	19	23.7	59.2	40.8
	28-40	1.8	3.2	8	27	15.5	18.5	26	60	40
	40-60	3.5	4.4	9	28.5	16.3	16.5	21.8	54.6	45.4
	60-82	6.7	9.7	14.6	26.8	8.7	14.3	19.2	42.2	57.8
	82-96	9.2	13	14.8	29	9.3	11.1	13.6	34	66
	96-126	26.2	13	12.6	21.4	7.7	9.2	9.9	25.9	73.2
	126-150	3.1	22.1	25.9	32	4.8	5.7	6.4	16.9	83.1
6****	0-22	2.3	3.4	12.5	24.8	16.7	18.2	22.1	57	43
	22-32	2.8	5.3	9.5	24.2	15.5	19.6	23.1	58.2	41.8
	32-63	3.5	4.7	8.6	26.5	16.9	17.9	21.9	56.7	43.3
	63-95	6.4	8.8	13.8	26.5	9.2	15.2	20.1	44.5	55.5
	95-110	11.2	12.6	13.4	27.2	9.4	11.1	15.1	35.6	64.4
	110-130	17.2	14.6	13.0	27.8	7.2	9.7	10.5	27.4	72.6
	130-150	5.2	21.1	24.1	31.8	4.4	6.8	6.6	17.8	82.2

If the perimeter of the reservoir consists of sands with heavy mechanical content, the useful coefficient decreases sharply. In clayey rocks, its value is 0.01 m/day, which means that moisture can be absorbed by 1 cm during the day and night. This means that over the past 50-60 years, under the influence of the Kattakurgan reservoir, groundwater and soil layers with moisture in soils with light mechanical composition have provided a distance of 7000-8000 m from the shore. In soils with heavy mechanical composition, this figure reached a distance of 2,000 meters.

According to the State Unitary Enterprise "Soil Bonitrovka" of the Institute "Uzdaverloyikha" in the district 6200.7 hectares, ie 27.3% of the land with heavy mechanical composition and 15475.9 hectares 68.1% of the land with medium and light mechanical composition has a direct impact on productivity and reclamation. It is known that the heavier the mechanical composition of the soil, the higher the water capacity, the weaker the water permeability, and the more complex the process of processing it. Therefore, when using the soil in production, it is necessary to take into account all its properties. Changes in the mechanical composition of the soil under the influence of irrigation have been analyzed for many years.

In this case, the relevant data on the mechanical composition of irrigated gray-meadow and meadow-alluvial soils were obtained by comparison and analysis with the data of section 5, section 231 and section 6, section 160-85.

In particular, according to the mechanical composition of irrigated loamy soils, the amount of physical sludge (<0.01 mm) in the 0-140 cm layer of soil in section 231 decreased by 44.9-39.8%, in section 5 its content increased by 41.8-43.5% in the 0-83 cm layer of soil, or decreased by 3.1-2% in the amount of physical mud (<0.01 mm) in the 0-40 cm layer in 5 sections compared to the 231 section. in the remaining layers it increased by 3.5-4.0% according to the results of the analysis.

We can also see that the amount of physical sand ($> 0.25-0.01$ mm) increased to 55.1-60.2% in section 231 and decreased to 58.2-42.9% in section 5. Or the amount of physical sand in Section 5 increased by 7.70-5.5% compared to Section 231 (Table 1, Table 2).

Also, according to the mechanical composition of irrigated meadow-alluvial soils, the amount of physical sludge (<0.01 mm) in the section 160-85 is the same as in the 0-150 cm layer of physical sludge (<0.01 mm).) decreased by 59.2-16.9%, and in Section 6 by 57.0-17.8%, but in Section 6 compared to 160-85, in the 0-40 cm layer of soil the amount of mud (<0.01 mm) decreased by 2.2–1.8%. However, in 40-150 cm layers of soil it increased to 2.1-0.9%.

The amount of physical sand ($> 0.25-0.01$ mm) increased by 40.8-83.1% in section 160-85 and by 43.0-82.2% in section 6.

we can also see that the amount of physical sand increased by 2.2-1.8% in the 0-40 cm layer of soil, and its share decreased by 2.1-0.6% in the 40-150 cm layer of soil. (Table 1, Table 2)

This can be explained as follows, i.e., as a result of leaching of aggregates <0.01 mm in size from the upper layers to the lower layers under the influence of irrigation, an increase of $> 0.25-0.01$ mm aggregates was observed in the upper layers of the soil relative to the lower layers. This of course differs according to the mechanical composition of the soil. It may also have been influenced by wind to reduce aggregates <0.01 mm in size in the upper layers of the soil.

Thus, the inflow of the Zarafshan River played an important role in the formation of light agroirrigation strata. In this case, with an increase in the amount of physical sludge, we can positively assess the increase in nutrients and humus and the thickening of the soil layer, but it leads to an increase in bulk mass and soil compaction.

Also, in the upper layers, the main place is occupied by large dust particles, and in the lower layers by large and medium sand particles, and depending on its amount, there are sharp changes in the mechanical composition of soils. For example, in the upper sections of the soil in section 5, the aggregates with a size of 0.05-0.01 mm are 27.2-27.6% (relative to the weight of the soil), this figure is 24.8-24.2% in section 6.

Such a conclusion can be made on the basis of data obtained by field and laboratory methods and their analysis. Firstly, the study area has a different mechanical composition of soils and their placement in different layers is influenced by the irrigated waters of the Zarafshan River.

3.2 Changes in the general physical properties of soil under the influence of irrigation

Changes will take place in the physicochemical and agrochemical properties of typical and dark gray soils of mountainous and foothill regions of the country under the influence of erosion and irrigation processes [20, 21].

Under the conditions of irrigated agriculture, knowledge of the general physical properties of soils plays an important role in enhancing their production properties..

Also, the mechanical mass is inextricably linked with the specific mass, and in the study of the mechanical composition it is important to study the specific mass, i.e. the weight of the solid phase of the soil. Relative mass is usually less variable unit.

If we look at the specific mass of the soil of the above-mentioned massifs in our research, the specific gravity in the 0-70 cm layers of gray-meadow soil of the Sh. Rashidov massif of Samarkand district was 2.70 g / cm^3 (Table 3).

The volumetric mass of soils, on the other hand, is a variable quantity that depends on several properties of the soil. First of all, tillage, irrigation, structural disturbances lead to an increase in the volume mass. The volume mass of soils of M.Juraev massif of Ishtikhon district, depending on the condition of soils, is around 1.35-1.37 g / cm³ in the upper driving layers, and 1.38 g / cm³ in the lower driving layers. The high volume mass under the drive layer may be due to improper application of irrigation water and agrotechnology (Table 3). In turn, the volume mass affects the porosity of the soil to one degree or another. That is, studies have shown that soil porosity fluctuates (46-50%). Since this figure depends on the volume mass, the porosity also changes as the volume mass increases. In the lower layers, the amount of this indicator naturally decreases (Table 3).

Table 3. General physical properties of the soils of the middle reaches of the Zarafshan River, (2020 year)

№	Name of districts	Shear depth, cm	Specific mass, g / sm ³	Size weight, g / sm ³	General porosity, %
1	Jomboy district Jomboy massif meadow alluvial	0-23	2.71	1.40	48
		23-38	2.72	1.42	48
		38-87	2.70	1.34	50
		87-130	2.70	1.34	50
2	Massif of Sh. Rashidov of Samarkand district gray meadow	0-20	2.70	1.30	52
		20-35	2.70	1.35	50
		35-70	2.70	1.27	53
3	Otakul Umarov massif of Payariq district typical gray	0-20	2.70	1.35	50
		20-32	2.72	1.45	47
		32-91	2.72	1.46	46
		91-140	2.72	1.43	47
4	Ishtikhon district M.Juraev massif meadow alluvial	0-20	2.71	1.35	50
		20-33	2.71	1.37	50
		33-75	2.70	1.38	49
		75-115	2.70	1.34	50
5	Masta massif of Kattakurgan district typical gray	0-23	2.70	1.34	50
		23-37	2.70	1.35	50
		37-71	2.70	1.35	50
		71-83	2.70	1.30	52
		83-109	2.70	1.25	54
6	Kattakurgan district Thursday town Pakhtakor massif meadow gray	0-22	2.70	1.38	49
		22-30	2.70	1.35	50
		30-60	2.71	1.42	48
		60-97	2.73	1.45	47
		97-110	2.73	1.48	46
		110-130	2.70	1.35	50
7	Zarafshan massif of Narpay district light gray	130-150	2.70	1.29	52
		0-24	2.70	1.38	49
		24-32	2.71	1.42	48
		32-55	2.72	1.45	47
		55-74	2.72	1.47	46
		74-110	2.70	1.39	49

In general, negative factors can always affect the quality of the soil, that is, its general physical properties, both simultaneously and together. To study the gradual change in the scope of these factors, research is needed.

Over the years, changes in the general physical properties of soil under the influence of irrigation have been studied.

In this case, the specific mass in the 0-150 cm layer of irrigated meadow-alluvial soils is 2.67-2.73 g/cm³ in section 160-85 and 2.67-2.73 g / cm³ in section 6; the highest value is in the 40-60 cm layer in the 160-85 section, which corresponds to the 60-90 cm layer in the 6th section or an increase of 0.03 g/cm³ compared to the 160-85 section in the 6th section. The volume mass is 1.23-1.48 g/cm³ in section 160-85 and 1.38-1.48 g/cm³ in section 6 respectively.

Table 4. General physical properties of the soils of the middle reaches of the Zarafshan River

No	Sequence number of the section	Depth of the Section cm	Specific mass g / sm ³	Size mass g / sm ³	General porosity %
1	160-85	0-10	2.67	1.23	54
		10-28	2.69	1.32	51
		28-40	2.69	1.39	48
		40-60	2.73	1.48	46
		60-82	2.70	1.40	48
		82-96	2.69	1.37	49
		96-126	2.69	1.35	50
		126-150	2.69	1.36	49
2	6	0-22	2.70	1.38	49
		22-30	2.70	1.35	50
		30-60	2.71	1.42	48
		60-97	2.73	1.45	47
		97-110	2.73	1.48	46
		110-130	2.70	1.35	50
		130-150	2.70	1.29	52

The highest value is 40-60 cm in section 160-85 and 60-110 cm in section 6 or 0.15 g/cm³ compared to section 160-85 in section 6 and the total porosity of the soil in section 6 decreased by 46–52% or by 6% compared to section 160–85 in section 6.

The main reason for this is the increase in the mechanical composition of the soil under the influence of irrigation, ie the amount of physical sludge (Table 4).

In summary, irrigation affects changes in the general physical properties of soils to varying degrees.

4. Conclusions

Based on the data obtained and their analysis, the following conclusions can be drawn: Firstly, studied area is the influence of the irrigated waters of the Zarafshan River on the fact that the soils have different mechanical composition and are located in different layers.

Secondly, as a result of long-term development of agricultural culture, scientific management of agro-technical works in these areas, fertile soils were formed.

Also, an increase in nutrients and humus with an increase in the amount of physical sludge over a long period of time (35-40 years) is positive if we consider the thickening of the soil layer, but it leads to an increase in bulk mass of 0.15–0.3 g/cm³ and soil compaction.

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