Soil Changes and Improvement Measures under Irrigation in the Middle Flow of Zarafshan River

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Abstract: ***The article considers the measures with the groundwater formation in the middle flow of Zarafshan river, its chemical composition and saline compounds introduction into irrigation areas by irrigation water, and the Kattakurgan reservoir impact on the toxic salts accumulation for plants in the soil.***

Keywords: soil, aquifer, groundwater, anion, cation, ditches, collector, hydrogeological conditions, salt balance, mineralization degree, mechanical composition, water physical properties.

1. Introduction

Samarkand region is located in the upper part of Zarafshan valley in the central part of our Republic. The main areas are cotton, grain and horticulture. More than 370,000 land hectares in the region are irrigated, and its climate is radically different in geological, geomorphological and hydrogeological conditions terms. There is a information wealth on the soils properties and characteristics that have changed positively and negatively under the rivers and canals influence in different parts of the world, the great scholars of the IX-XIII centuries, such as al-Kharazmi, Ahmad Fergani, Beruni, Nasir Khisrav, Mahmud Kashkari, Zamakhshari, Muhammad Najib Bakron, who contributed not only to mathematics, geology, geography, astronomy, language development, but also soil science and hydrology.

By the 1950, irrigated agriculture in the country was developing at an unprecedented rate, thousands gray and protected lands hectares were developed. At the same time, large industrial centers were built, and the irrigated agriculture area was expanded. As a result, the need for water has increased. However, non-compliance with irrigation regulations and norms in many crop areas has led to rising groundwater levels, soil salinization, swamping and erosion due to a attention lack to collector drainage networks. Due to developing methods imperfection and applying measures against them, irrigated fertile lands have become low-yielding saline soils. The above negative processes have occurred as a human inadequate result consideration of nature and non-compliance laws with scientifically based recommendations, irrigation, saline washing, fertilization, agrotechnics and so on, and this negative process continues in some areas today.

Samarkand region also plays an important role in the development of agriculture in the Republic of Uzbekistan. In 1907-1912, a special program was developed for the saline soils reclamation in different levels in Mirzachul and Zarafshan valleys, the ditches construction at different depths and distances, the saline soils origin spread and the need to study the work to combat it, and on the basis of these decisions a lot of scientific research has been and is being done.

Scientists have been studying the hydrogeological conditions and relief in the middle part of the Zarafshan river since the 1920s. For example, in 1924, the first expedition was organized under A.M. Kulchitskiy leadership [1], which included N.V. Guseva and Yu.A. Otakulova [2] conducted scientific research and concluded that the Zarafshan lowland consists of alluvial plains, and water-soluble salts are insignificant or do not accumulate at all because of groundwater good hydrogeological and geomorphological conditions. However, as the distance from the river slowed down the groundwater flow, hydrocarbon layers formation in the soil and groundwater, it was concluded that in this case, the soils were caused by carbonate-magnesium salinity [3, 4, 5, 6, 7, 8].

In this situation, the Samarkand lowlands have long been an oasis of irrigated agriculture, and at the same time river water and its tributaries were used in agriculture, so the salinity was less. But groundwater began to approach the surface

2. Materials and Methods

Soils analysis in the field and laboratory conditions was carried out on the basis of methodological manuals of UzCRI scientists such as “Agrochemical, agrophysical and microbiological research methods in irrigated cotton soils regions”, “Soil chemical analysis guide” of E.V. Ashurka, TAITI scientists’ manuals such as “Guidelines for chemical and agrophysical soil analysis in land monitoring” and “Methods of conducting field experiments” (2007) of Sh.Nurmatov and others. Statistical analysis of obtained results was performed on the basis of B.A. Dospekhov's “Field experiment technique” manuals and Microsoft Excel programs.

3. Results and Discussion

This process explanation can be seen in irrigation water consumption in some districts of the region and salts amount brought with them (Table 1). For example, in Kattakurgan district, on average, 365-370 mln/m^3 water is used for irrigation per year, it contains 0,39% of total salts; from which chlorine ion is 0,02-0,03% and 10-11 salt thousand tons enters the soil annually, and the output is 5-8 thousand tons. This means that 2-5 salt tons remain in the soil every year. The main reason for this process is the groundwater slow flow, which averages 107-109 mln/m^3. The irrigation water amount is 3-4 times more. This means that salts amount in the soil increases with the moisture accumulation increase in the soil layers, as well as the salinization process in the soil.

Table 1: Water and salt balance of Samarkand oasis lands

№	Districts name	years	The arrival part			salt arrival m.t	Consumption part			salts outflow m. t.		Variation in salt content	
			Obtained for irrigationмлн. m3	irrigation water minerality		chlorine	Underground water flow mln. m3	irrigation water minerality degree		Dense residue	chlorine	Dense residue	chlorine
				Dense residue	chlorine			Dense residue	chlorine				
1	Jambay	2017	198,15	0,40	0,02	3,96	173,56	0,50	0,03	86,78	5,20	-7,52	-1,24
		2018	222,88	0,39	0,02	4,45	205,03	0,52	0,03	106,6	6,15	-19,69	-1,70
2	Ishtikhon	2017	227,01	0,39	0,03	6,81	103,03	0,57	0,04	58,72	4,12	29,81	2,69
		2018	284,58	0,39	0,02	5,69	115,15	0,52	0,03	60,11	3,46	50,87	2,23
3	Kattakurgan	2017	365,26	0,38	0,03	10,95	107,45	0,62	0,05	66,62	5,37	72,18	5,58
		2018	370,03	0,39	0,03	11,10	109,44	0,66	0,08	72,23	8,75	72,08	2,35
4	Narpay	2017	305,73	0,45	0,03	9,17	77,14	1,24	0,13	95,65	10,03	41,93	-0,86
		2018	318,19	0,44	0,03	9,54	92,04	1,21	0,13	111,4	11,96	28,63	-2,44

In addition, the ravines role and ravines flowing from the Zarafshan and Turkestan mountain ranges in the groundwater formation is significant, as well as the irrigation water flow in the canals and their absorption into the soil. In almost all Samarkand region irrigated areas, groundwater is approaching the surface, and this process is observed in strong groundwater accumulation, especially in the irrigated areas of Kattakurgan district. In the eastern part of the Kattakurgan reservoir (mainly irrigated areas), the reservoir plays a major role in the groundwater accumulation, ranking third in the country in volume and capacity terms, and 3-4 times stronger than other reservoirs in side effects terms. The reservoir was built and put into operation in 1941-1952 in order to increase the agriculture, water supply efficiency and irrigated lands improvement in the Zarafshan oasis. At that time it was replenished with Karadarya water, in addition to which water was brought from the left bank of the Zarafshan river through special irrigation devices. Due to this source construction, the water supply 390 thousand land hectares has been improved and 65 thousand land hectares have been redeveloped.

The current capacity of the Kattakurgan reservoir is 818,23 mln/m^3, which 2.90 m^3/sec is used annually for irrigation, but currently 4,20 m^3/sec of water is being extracted from this capacity. The increase in water consumption is having a negative impact on the water and salt order of the soils scattered around it.

In addition, the soil-forming parent rocks around the reservoir are loess and loess like deposits, so they are prone to salinization. Due to lands large-scale agricultural use in this area, non-compliance with irrigation regulations and norms, the groundwater level has risen under the the reservoir influence, gray soils have become gray-meadow, meadow, meadow-swamp soils, varying salinity degrees, even landslides occur near the reservoir.

Today, the increase in the capacity and the reservoir level has affected thousands of land hectares over the years, as well as changes in the environment and soil cover. In particular, as a the direct impact result of the Kattakurgan reservoir on the agrochemical, agrophysical and surrounding soils reclamation status, as well as water and salt regimes, excess moisture in the soil cover increases and its fertility decreases. Therefore, one of the most pressing issues today is the in-depth soil changes study in the region under the reservoir influence, its properties analysis and the negative changes prevention in soil cover.

In Samarkand region land fund, agricultural lands make up 1505,3 thousand hectares or 7,38% of the total land fund. As mentioned above, 309,5 thousand hectares lands are used for intensive farming, and irrigated and arable lands are 182,9 thousand hectares. Irrigation and fertilization works carried out on these lands for agriculture development have resulted in a number positive changes in the soil layers, as well as negative processes. One of the main ones is the groundwater formation, their approach to the soil surface, a decrease in soil fertility due to soils salinization, erosion and compaction. Because under the single reservoir influence, the groundwater level rises to Karasuv. For example, around the reservoir, groundwater fluctuates around 1-1,5 m, which in itself indicates that the groundwater flow in the area is almost non-existent (Table 2).

Table 2: Zarafshan middle flow groundwater irrigated lands level change dynamics

№	Districts name	years	Depending on the inclusion depth (ha)			Average	
			0-1 m	1-1,5 m	1,5-2 m	0-1 m	1-1,5 m

1	Jambay	2017	0,370	0,680	2,790	0,367	0,668
2	Ishtikhon		0,34	0,630	2,950	0,357	0,600
3	Kattakurgan		0,438	1,347	3,960	0,431	1,311
4	Narpay		0,168	0,627	2,257	0,155	0,604
5	Jambay	2018	0,320	0,740	2,650	0,272	0,628
6	Ishtikhon		0,160	0,380	2,890	0,126	0,423
7	Kattakurgan		0,470	1,470	3,590	0,458	1,408
8	Narpay		0,137	0,404	2,389	0,127	0,409

The table shows that in 2017 only in Kattakurgan district, the groundwater level with a 0-1 meters level was 0,438 hectares, while in 2018 this figure was 0,470 hectares. However, the groundwater level at 1-1,5 meters depth fell from 1,374 hectares to 0,380 hectares. This means that an average about 1,000 (thousand) hectares of groundwater has been eroded by up to 0,5 meters per year (Table 1). Such indicators are very low in Jambay, Ishtikhon and Narpay districts. Such groundwater can be considered as the only reservoir that caused the rise in water level in Kattakurgan district. If we pay attention, the areas up to 0-1 meters, mainly from 50 meters around the western part of the reservoir to 2 km west of the reservoir, the groundwater level does not exceed the above figure. This in turn affects their mineralization level as well. If we analyze the groundwater chemistry in this area, first of all, the water mineralization level in the reservoir ditches and reservoirs located in the area, the composition and groundwater balance formed in the soil layers are as follows. Magnesium carbonate salts accumulate in relatively high layers because they are relatively well soluble in water. Our research also shows that groundwater salinity in most areas, except around the Kattakurgan Reservoir, is not very high, and it is mainly hydrocarbonate type salinity. The lightly soluble salts content in the gray soils groundwater distributed around the third stage of the Zarafshan River is about 0,678-0,836 g/l and is almost not saline. In the western part of the region, mainly in areas with light glacial soils, groundwater is weakly mineralized, forming a sulfate salinity of 1,22-3,95 g/l (dry residue). Groundwater in our study areas ranged from 0,4 m to 3-3,5 m. Such close groundwater proximity is mainly due to the water absorption from the Kattakurgan reservoir, as mentioned above, and their addition to the groundwater flow, and the groundwater regime is violated under the reservoir water influence. It can also be seen from the table data given. For example, the mineralization level of the Zarafshan River fluctuates in the range of 0,87-1,25 g/l throughout the year, averaging 1,2 g/l, but this amount of water is 3,8 g/l of salts flowing into the soil through ditches. This figure reaches 4,7 g/l in groundwater. This situation is the same for both chlorine ions and sulfate ions throughout the oasis, i.e. almost three times the level of mineralization of water entering the oasis is released through the collector-ditch. Thus, it is known that the role of soil-forming rocks, internal erosion and especially irrigation water in the accumulation of salts in the soil is very large. Therefore, in the assessment of the reclamation of soils, even in non-saline lands, the activity of collector-drainage networks is directly involved in the management of these processes.

The salts ingress through irrigation water is one of the soil salinization causes. Salinization occurs not only through mineralized water (1-3 g/l), but also from normal (0.5-1 g/ l) irrigation water. Irrigation water also carries large amounts of naturally dissolved salts in its direction. The chemical composition of brackish water is mainly chloride-sulfate, in some places sulfate (Table 3). The water of the collector-drainage networks is weakly saline. The annual salt accumulation in the basin averages 109 tons per hectare. 33-35% of water-soluble salts are released from the area through collector-drainage networks. Their amount averages 35-37 t ha. It is 71-73 t/ha per year and is mainly excreted by soil washing. In general, the object of study is the accumulation of salt in the soils of oasis geosystems.

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Table 3: Mineral composition of Zarafshan river basin waters (average)

Waters	Vibration range			Average performance			salinity type
	Dry residue	Cl	SO_4	Dry residue	Cl	SO_4	
Irrigation	0,870-1,252	0,122-0,181	0,412-0,630	1,201	$\frac{0,146}{4,12}$	$\frac{0,506}{10,53}$	X-C
Drainage	1,830-5,810	0,238-0,476	0,683-3,044	3,820	$\frac{0,357}{10,07}$	$\frac{1,864}{38,79}$	X-C
Collector	1,910-5,768	0,301-0,392	1,020-3,537	3,840	$\frac{0,346}{9,76}$	$\frac{2,278}{47,41}$	X-C
Dirt	1,470-10,800	0,203-1,568	0,452-4,978	4,724	$\frac{0,607}{17,12}$	$\frac{2,174}{45,24}$	X-C

To check the water hydrochemical composition entering the reservoir from different directions and water collected in the reservoir, it significantly fluctuate when water samples were taken from the main canal (station1) 300 meters above platinum from the main channel from Zarafshan to the reservoir, from the western part (station 4) to the southeast well (station 5), the amount of lightly soluble salts and nutrients in them varied.

The waters of the Kattakurgan reservoir are mainly calcium bicarbonate, with a mineralized level of 340-350 mg/l. The impact on the soils around this reservoir is due to the fact that the riverbed and the groundwater absorb them from different directions, and as a result of strong evaporation, relatively strongly mineralized water accumulates on the soil surface, their content reaches 360 mg/l, especially in July, only in the spring months their level of mineralization decreases slightly under the influence of high flow and atmospheric precipitation. It should also be noted that the reservoir mineralization level is high and rapid, due to the relatively submerged moisture strong mineralization in the soils around the reservoir.

For example, in March-April, the mineralization level in most parts of the reservoir is close to each other, that is, at the reservoir surface and bottom, this figure is partially increased from July to November. This means that in mineralization terms, the reservoir composition increases sharply (1,4-2,2 mg/l) in mineralization terms, especially during strong moisture evaporation periods in the reservoir, and they affect the soil cover around the reservoir. This process can also be observed from the fact that the reservoir changes the cations and anions amount throughout the year.

4. Conclusion

In conclusion, the main reason for the changing the Zarafshan oasis hydrogeological conditions is: the Zarafshan river and its chemical and mineralogical composition activity, the second: , due to the irrigation water impact on existing reservoirs in the region, the groundwater movement is significantly closer to the surface, causing the harmful salts accumulation for plants in the soil layers.

Therefore, in order to improve the soils ecological and reclamation condition in the middle flow of the Zarafshan River, it is necessary to reduce the groundwater level. At the same time it is necessary to clean and improve the surrounding drainage collector system performance. In the second place it is recommended to wash the saline soil areas with saline. It is recommended to carry out phytomeliorative measures to restore and increase soil fertility.

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