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THE EFFECT OF IRRIGATED AGRICULTURE ON RETURN FLOW AND GROUNDWATER MINERALIZATION IN MEDIUM ZARAFSHAN OASES

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ABSTRACT: This article provides information about the Central Zarafshan oasis, as well as factors influencing the formation of return waters. Using the data of the Zarafshan Irrigation Systems Basin Department and its reclamation expedition, the amount of water received for irrigation purposes and the formed return flow in the region for the period 2002-2020 was estimated in the irrigated lands of the Central Zarafshan oasis. According to the results of the study, more than 50% of the amount of water taken to irrigated areas is consumed in the form of return flow. Data on the distribution and mineralization of groundwater in the Central Zarafshan oasis are given. This article also shows an increase in groundwater levels and mineralization to the west of the Central Zarafshan oasis and in the newly developed lands.
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The Central Zarafshan region begins in the east with the Ravothoja dam and continues to the tectonic part on the west side of Navoi near the village of Khazora. To the east of Central Zarafshan are the Samarkand oasis, the Kattakurgan oasis after the meridian of Kattakurgan, and the Karmana oasis around Navoi. Administratively, the Samarkand and Kattakurgan oases are located in the Samarkand region. Due to the natural-geographical conditions and arid climate of the Central Zarafshan oasis, the cultivation of agricultural crops cannot be carried out without irrigation. In Uzbekistan today, the problems of assessing the reclamation of irrigated lands and monitoring their condition are very important. In order to prevent these problems, thousands of kilometers of collector drainage networks have been built. Currently, the water generated from the fields of crops in these trenches is millions of m^3. [7,10].

For this purpose, on the basis of data from the Zarafshan Basin Department of Irrigation Systems and its Reclamation Expedition, changes in the amount of available water in the Central Zarafshan oasis, the amount of return flow in irrigated areas in 2002-2020 were analyzed (Figure 1).

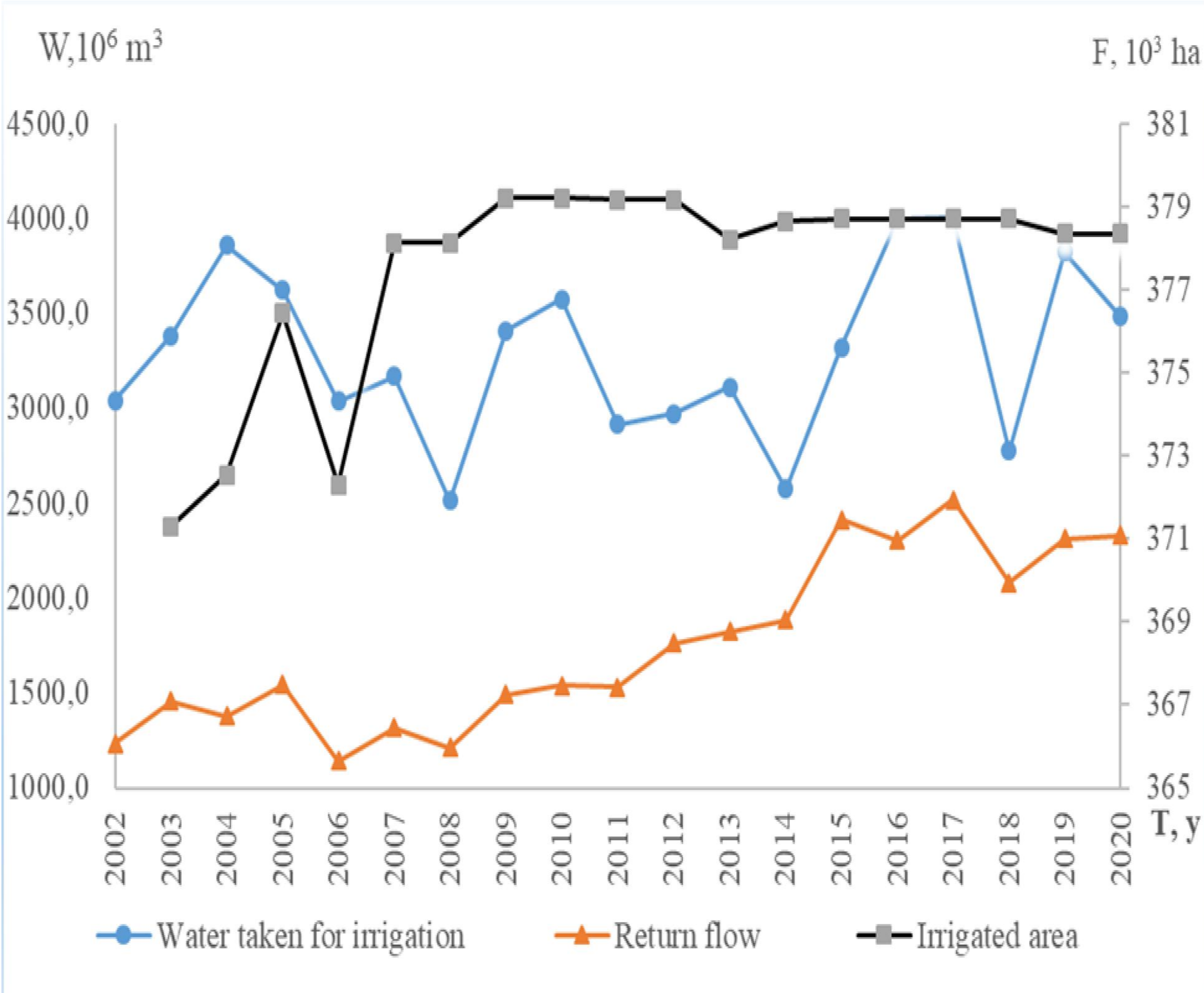

Figure 1. Annual variation of irrigated areas, water taken for irrigation and return flows in the Central Zarafshan oasis.

The results of the analysis show that at present, despite the high value of water taken from the Zarafshan River for the purpose of irrigating irrigated lands in the region, we can see that it is not used efficiently. During the study period, more than 50% of the water received from the area for irrigation was discharged into the Zarafshan River in the form of backflow. Compared to other regions of the country, this figure is 37-45% in the Fergana Valley, 30% in Mirzachul and more than 30% in the Kashkadarya oasis [10].

The fact that much of the relief of irrigated areas in the Central Zarafshan oasis consists of wavy plains and in the distribution of the annual flow of the Zarafshan River in the regions, more than 70% of the total water is taken to the Samarkand region [4, 9] ensures that the amount of return water is more than 53%.

As can be seen from the chart above, the irrigated area was at least 371,3 thousand hectares in 2003 and 372,6 hectares in 2006. In the remaining years, there was almost no change in the change in irrigated area.

The lowest amount of water received in the region in 2008 was 2516,7 million m^3, in 2014 – 2576,6 million m^3, in 2018 – 2775,8 million m^3. The main reason for this is that the less observed years of water intake in the region are also less watery years in the Zarafshan river. The lowest values of return water were in 2006 and 2008, respectively, their volume was 1142.5 million m^3, 1212,7 million m^3. The consumption of the return flow formed in the territory of the Central Zarafshan oasis in the last five years has been studied and analyzed. The results obtained are presented in Table 1.

Table 1. Consumption of return flow formed in the Central Zarafshan oases

Years	F, for 10^3	An area provided with ditches, for 10^3	Water taken to the area, for mln, m^3	Return water flow, for mln, m^3	Removed			Amount of return water extracted from 1 ha m^3 / ha
					River	Used for irrigation	Used for irrigation	
2016	378,7	127,2	3997,6	2304,3	1218, 1	867,5	218,5	6070,3
2017	378,7	127,2	4006,9	2520,2	1301,5	949,8	268,8	6639,2
2018	378,7	127,2	2775,8	2080,9	1029, 8	784,9	266,1	5481,7
2019	378,3	127,2	3826,1	2311,6	1245, 9	894,1	171,5	5875,6
2020	378,3	143,5	3483,2	2329,8	1302,8	866,7	174,8	6142,1
Average			**3617,9**	**2309,4**	**1219, 6**	**872,6**	**219,9**	**6041,8**

The analysis of the table data shows that over the past five years, an average of 9,2% of the return water in the study area was irrigated, 52,8% was discharged directly into the Zarafshan River, and the rest (37,7%) was discharged out of the region.

In the next stage of the work, the mineralization of groundwater of the study area was studied on the basis of the collected data. The depth of groundwater in the Samarkand oasis of the Central Zarafshan oasis is on average 4-8 meters, depending on local conditions. In some higher areas and on the third terrace of the Zarafshan river it is 7-10 meters, in the areas adjacent to the foothills it is 10-25 meters. In the western part of the Central Zarafshan oasis, in Narpay and Pakhtachi districts of Kattakurgan oasis, the groundwater level is slightly closer to the surface. The depth of groundwater in this area is on average 3-7 meters. On river banks, their depth is closer to the surface.

Changes in water levels and accumulation of salts in the soils and groundwater of irrigated agriculture are natural. Irrigation of lands radically changes their water and salt regime. Moistening of the active layer of the soil in most cases leads to the addition of soil water to the groundwater. Since the addition of these waters cannot move the natural flow of groundwater, their level rises. As a result, the water-soluble salts in the movement layers dissolve, causing secondary salinization of the soils.

For this purpose, based on the data of the Zarafshan Basin Department of Irrigation Systems and its reclamation expedition, data from the table of distribution of irrigated lands in Samarkand region according to the salinity of groundwater were analyzed (Table 2).

Table 2. Distribution of irrigated areas in Samarkand region according to the salinity of groundwater.

Name of districts	Years	Irrigated lands, thousand/ha	Division of groundwater depending on salinity in thousands / ha and in percent					
			0-1 gr/l	%	1,-3 gr/l	%	3-5 gr/l	%
Bulungur	2002	29,97	29,97	100				
	2020	29,10	29,10	100				
Jomboy	2002	30,85	30,85	100				
	2020	31,59	31,59	100				
Ishtixon	2002	31,18	31,18	100				
	2020	31,49	30,97	98	0,53	1,7		
Kattaqurgan	2002	34,51	34,21	99	0,3	0,9		
	2020	34,47	32,14	93	2,33	6,8		
Narpay	2002	27,48	24,38	89	3,1	11,3		
	2020	27,44	23,06	84	4,38	16,0		
Nurobod	2002	7,77	7,77	100				
	2020	7,40	7,36	99	0,04	0,5		
Okdaryo	2002	27,29	27,29	100				
	2020	28,92	28,85	99,8	0,07	0,2		
Payariq	2002	40,79	40,79	100		0,0		
	2020	40,82	39,46	97	1,36	3,3		
Pastdargom	2002	52,57	52,57	100				
	2020	53,86	53,18	99	0,68	1,3		
Paxtachi	2002	23,92	21,12	88	2,8	11,7		
	2020	23,71	18,45	78	5,03	21,2	0,23	1
Samarkand	2002	17,1	17,1	100				
	2020	15,40	15,40	100				
Taylok	2002	16,31	16,31	100				
	2020	16,28	16,28	100				
Urgut	2002	29,25	29,25	100				
	2020	30,41	30,40	100				
Kushrabot	2002	1,74	1,74	100				
	2020	5,75	5,75	100				
Total by region	**2002**	**370,73**	**364,5**	**98,3**	**6,2**	**1,6**		
	2020	**376,64**	**361,9**	**96,08**	**14,42**	**3,82**	**0,23**	**0,06**

Note: The table is based on the data of the Zarafshan Irrigation Systems Basin Department and its reclamation expedition.

The table shows that the salinity of groundwater is high, both by years and regions, in Pakhtachi, Narpay and Kattakurgan districts. We know that the area where these districts are located is located in the western part of the Central Zarafshan oasis, in the Kattakurgan oasis. The absolute height of the relief of the Kattakurgan oasis is 430-440 m in the east and 335 m in the west. The distance between them is 106 km. This means that the average slope of the river is 1 meter for every 1,000 meters. In the Samarkand oasis, the average slope is 3 meters per 1,000 meters. Due to the low slope, the speed of surface and groundwater movement downstream along the valley is reduced. This, in turn, creates conditions for groundwater to rise to the surface, salinization and swamping of soils. In general, the level of mineralization of groundwater in the region increases from the upper to the lower part of the Middle Zarafshan oasis [2]. The development of new lands for irrigated agriculture has intensified salt migration. As a result of the development of the foothills of the northern slopes of the Zirabulak and Ziyovutdin mountains, the eastern part of the Ulus desert, the salinization of irrigated soils on the left bank of the Zarafshan River has increased, groundwater mineralization has rised Table 3.

Table 3. Groundwater mineralization of the Central Zarafshan oasis (2019)

№	Depth of well, m	Unit of measurement	*pH*	*HCO^-_3*	*Cl^-*	*SO^-_4*	*Ca^+*	*Mg^+*	*Na+K*	Mineralization	Hardness
1	*16,0*	*mg/l*		*252*	*24,9*	*310*	*40,1*	*85,11*	*59,7*		
		mg-ekv/l	*7,10*	*4,13*	*0,70*	*6,45*	*2,00*	*6,99*	*2,49*	*785*	*9,0*
2	*6,0*	*mg/l*	*7,30*	*533*	*39,9*	*337*	*16,0*	*30,42*	*330,6*	*1299*	
		mg-ekv/l		*8,78*	*1,13*	*7,01*	*0,79*	*2,50*	*13,8*		*3,3*
3	*7,0*	*mg/l*	*6,93*	*226*	*61,1*	*1399*	*340,7*	*237,1*	*4,4*	*2253*	
		mg-ekv/l		*3,70*	*1,72*	*29,1*	*17*	*19,5*	*0,19*		*34,5*
4	*5,0*	*mg/l*	*7,17*	*227*	*48,0*	*967*	*120,2*	*182,4*	*102,9*	*1653*	
		mg-ekv/l		*3,72*	*1,35*	*20,1*	*5,99*	*15,00*	*4,29*		*21,0*
5	*9,0*	*mg/l*	*7,19*	*314*	*91,1*	*610*	*96,2*	*126,46*	*127,2*	*1370*	
		mg-ekv/l		*5,15*	*2,57*	*12,7*	*4,80*	*10,4*	*5,29*		*15,2*
6	*6,0*	*mg/l*	*7,14*	*189*	*244,6*	*1798*	*501*	*194,56*	*163,9*	*3117*	
		mg-ekv/l		*3,09*	*6,90*	*37,4*	*25,0*	*16,0*	*6,83*		*41,0*
7	*11,0*	*mg/l*	*7,20*	*180*	*185,9*	*1546*	*290,6*	*212,79*	*212,7*	*2658*	
		mg-ekv/l		*2,95*	*5,24*	*32,2*	*14,5*	*17,5*	*8,86*		*32,0*
8	*24,0*	*mg/l*	*7,14*	*171*	*127,3*	*1614*	*475,9*	*173,31*	*53,1*	*2629*	
		mg-ekv/l		*2,80*	*3,59*	*33,6*	*23,7*	*14,2*	*2,21*		*38,0*

Note: The table was analyzed in Uzhydromet laboratory.

According to the table, №1-2 wells were selected from Pasdargom district, №2-4 wells from Nurabad district, №5-6 wells from Narpay district, № 7-8 wells from irrigated areas of Pakhtachi district. Water hardness is high in ordinary well (groundwater) water, which is sharply increased from the top to the bottom of the river basin. Water hardness depends on the amount of Ca^{+}, Mg^{+} and Fe ions dissolved in water. According to O.A. Alyokin (1952), the average hardness in water was given as 3-6 mg-eq/l. In Oz Dst 950: (2000) for drinking water, the norm for total hardness is 7 mg-eq/l. According to F.E. Rubinova, Yu.N.Ivanov (2005), with increasing water mineralization, water hardness also increases. According to the results of the analysis, only the hardness of №2 well water was 3 mg-eq/l, and in all other samples it was found to be above the norm. Some areas have large indicators of water hardness, which is due to increased salt migration in newly developed lands.

The established norm amount of chlorine ion is defined as 300-350 mg/l. In general, chlorine ions also increase from the top to the bottom of the Middle Zarafshan oasis, depending on the salinity of the water. In the upper part of the Central Zarafshan oasis, chlorine ion in ordinary well waters does not reach 100 mg/l, while in the lower part its amount increases. For example, in Pastdargom district it reaches 39,9 mg/l, in Nurabad district 61 mg/l, in Narpay district 244,6 mg/l. The main source of chloride ion in water is the mineral halite (NaCl), which has fast solubility and mobility properties in water. Chlorides do not reach established norm in all well waters. This is due to the rapid dissolution of chloride salts in water, which move with surface and groundwater and accumulate in the sediments, causing soil salinization. The sodium ion is also responsible for the lack of chlorine ions in the water, as it quickly combines with chlorine to form NaCl. The solubility of CaCl and MgCl salts in water is also higher than that of NaCl, due to which the salts are washed from the soils and subsurface deposits and move to the lowlands [1]. For this reason, chlorine ions move from the upper part of the river to the lower part, increasing the salinity of the soils.

Established norm 450 mg/l was prescribed for sulfate ions. They also have great mobility, but less than chloride ions [8]. The main sources of sulfate ions are sedimentary rocks containing gypsum and anhydrides. In the foothills of Zirabulak, Ziyovutdin and Karatag in the Central Zarafshan region, gypsum ($CaSO_4 \cdot 2H_2O$) and gypsum-rich deposits are widespread. They dissolve rapidly in water and migrate with water. The abundance of sulfate ions in the groundwater of Nurabad, Narpay, Pakhtachi districts is associated with these deposits.

The main sources of hydrocarbonate and carbonate ions are carbonate rocks, ie limestones, dolomites, marls and others. The amount of carbonates (CO_3) in natural waters is inhibited by Ca ions, which quickly combine with CO_3 to form insoluble $CaCO_3$ [1].

As the mineralization of water changes, the amount of Ca^{+}, Mg^{+} and $Na^{+}+K^{+}$ cations also changes. Calcium is abundant in these cations and it is common in low-mineralized waters. The main sources of calcium are limestones, dolomites, limestone deposits and gypsum. It ranks first among cations in terms of sodium ion distribution because sodium salts have a rapid melting property and its migration property is large. Sources of sodium are igneous rocks as well as rock salt and mirabilites. These salts are common in deposits. The amount of potassium salts in water is low, so it is taken together with sodium in its calculation. Magnesium ion is less common than calcium. Its sources are igneous rocks, dolomites, marls and other rocks. Magnesium ion is found in all groundwater, but it does not rise as much as calcium, sodium ions. Typically, low-mineralized waters have the most calcium, while highly mineralized waters have the highest sodium content. The fixed norm is 180 mg/l for calcium, 40 mg/l for magnesium, and 120 mg/l together for sodium and potassium. The amount of calcium in the groundwater (ordinary well) of Pastdargom district does not reach the norm, ie 180 mg / l. In the newly developed lands of Nurabad, Narpay, Pakhtachi districts, its content will increase from 1.3 to 2.5 times the norm.

The amount of magnesium ion is lower than established norm in № 2 well water in Pastargom district and higher than established norm in other well water. The abundance of magnesium salts is due to their rapid solubility relative to calcium salts [1].

All sodium salts are rapidly soluble, so there is a high probability that sodium salts will migrate. The origin and proliferation of sodium ions are related to NaCl, $NaHCO_3$. It is known that in dry hot conditions the evaporation of moisture from the soil increases and the salts in it remain in the soil and increase its salinity. The bulk of these salts are sodium salts. In low-mineralized groundwater, the amount of sodium salt is not large, but as the water mineralization increases, the amount of sodium ion increases In the waters of the well №2, the amount of sodium and potassium ions has the greatest indicator, it is found that they are 2,5 times more than established norm.

CONCLUSION. In conclusion, the limited availability of water resources in arid climates, as well as in the Middle Zarafshan oasis, requires the use of water-saving technologies in the region, the widespread introduction of modern techniques and technologies in agricultural irrigation systems and irrigation networks. The analysis of the results of the research shows that there are opportunities for more efficient use of water resources in the region. This can be achieved through more efficient use of water for irrigation, introduction of new irrigation technologies, improvement of irrigation methods, more efficient use of water.

The mineralization of groundwater has increased in the western part of the Central Zarafshan oasis compared to the eastern part. The main reasons for this are due to the impact of irrigated agriculture. In the development of saline grounds in the area, it is necessary to reduce the impact of surface water on groundwater as a result of drip irrigation, using new irrigation technologies, rather than the method of furrow or flood irrigation.

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