Soil-meliorative conditions of the basin of the Zarafshan River

[1] Namazov Khushvaqt Karakhanovich, [2] Amonov Odilbek Sultonovich

[1]Assistant Professor, Candidate of Biological Sciences, Department of Soil Science and Agrochemistry, Tashkent State Agrarian University
namozov1965@mail.ru
[2]Scientific Researcher, Tashkent State Agrarian University
100140, University str., 2, Kibray district, Tashkent region, Uzbekistan
alp.lentinus@yandex.ru

Abstract: *The article presents long-term studies of the processes of soil formation, ameliorative properties of irrigated soils in the basin of the river Zarafshan, which is a geostructural intermountain basin filled with alluvium. The soil-ameliorative state of soil soils is characterized by taking into account natural conditions and anthropogenic factors, the causes, regularities in the formation and geographical distribution of saline soils are revealed. The regional features of salt accumulation, intensity and direction of the processes of salinization and desalination of soils are established. A clear dependence of salt accumulation is shown in connection with the dynamics of changes in the depth and mineralization of groundwater.*

Keywords: *Irrigated soils, groundwater, salinity, salt accumulation, ameliorative condition, melioration.*

1. INTRODUCTION:

Among the zones of irrigated farming, the cotton-growing zone occupies a special place, and in the arid regions of Uzbekistan, the increase in the yield of agricultural crops along with natural factors is determined by the technical level of the existing engineering and irrigation systems, the efficiency of irrigated land use and their ameliorative condition.

Despite the relatively low percentage of land used in irrigated agriculture, the Zarafshan river has a large share in the cotton growing of the republic. Currently, about 10-12% of all Uzbek cotton products are produced here. Land spaces and favorable climatic conditions with adequate provision of irrigation water make it possible to significantly increase the share of this territory in cotton growing. Over the past 25-30 years, only about 40,000 hectares have been developed here in the currently irrigated zone and adjacent parts. Within the irrigated zone there are still about 80,000 hectares of virgin and fallow lands suitable for irrigation [27].

Basin of the Zarafshan river (Bukhara and Navoi regions) are located in the Turan facies [5, 6], or provinces [17], occupying the central part of Central Asia. In the north, they border on the Republic of Kazakhstan in the south on the Republic of Turkmenistan, in the west on the Republic of Karakalpakstan, in the east - on the Republic of Kazakhstan with Samarkand and Kashkadarya regions of Uzbekistan.

At present, before irrigated agriculture, there are big tasks to raise the yield of agricultural crops and increase its productivity. Excessive salinization of soils is the main barrier which, on large areas, does not allow you to step from yields of raw cotton at 12-15 / ha to normal values of 28-30 c/ha, from a low payback of agricultural labor to a higher one. Therefore, the methods and ways of amelioration of saline soils, the methods of hanging their productivity in connection with the absence of ready-made standard recipes for the radical improvement of the ameliorative state of soils until today, require an optimal solution for each specific condition, consisting of changes in their water-salt regime and groundwater balance and should rely on a complex of scientific research, on the results of field observations and experiments, as well as generalization of the experience of practice.

The optimal (desired) water-salt regime of saline soils is achieved by careful consideration of the natural features of the territory: the degree of its natural drainage, the salinity of soils in the aeration zone, the mineralization and pressures of groundwater, the mechanical composition and lithological structure of soils of the saturation zone, etc., according to which the type of drainage (horizontal, vertical and combined) is determined and projected. The type of washes (capital or light), type of irrigation regime (all irrigation should be done flushing or rarefied flushing). If these provisions are observed, optimum - rational water-salt regime is created, ensuring maximum salinization of saline soils and desalination of groundwater with minimum labor costs and scarce irrigation water.

2. MATERIALS AND METHODS:

The object of the research were irrigated soils of the basin of the Zarafshan river within the territory of the Samarkand, Navoi and Bukhara regions, located in various lithological-geomorphological, hydrogeological, soil-climatic and irrigation-economic conditions, and differing significantly in the structure of the relief, the genesis of the soil-forming rocks, the mechanical and mineralogical composition, the water- physicochemical, chemical, agrochemical and ameliorative properties, degrees of intensity and general orientation of salinization and desalinization processes, and also the level of soil productivity, etc.

Taking into account the natural and anthropogenic - economic conditions, the supporting (and key) farms are selected, located in the ten administrative districts according to the natural conditions and soil-ameliorative properties of which are characteristic of the vast desert and semi-desert zones of the Republic of Uzbekistan, and also for the districts with developed irrigation of medium and low flow of the Zarafshan river.

The basis of the research methodology is comparative geographic, soil-hydrogeological, soil-geochemical and laboratory-analytical methods, methods of "Key sites" and expert-analytical assessments of the modern ameliorative state of irrigated soils. A systematic structural approach has been introduced to study the genesis of saline soils and a method of careful morphological analysis of the earth's surface has been used. It is a completely original method of plastics of the terrain, which makes it possible not only to characterize the territory by meso and micro relief forms, but also to reasonably subdivide the territory according to its genesis, manifestation and geographical distribution of saline soils under conditions of lithological-filtration variability of the water-bearing medium, and also allow quite confidently and accurately carry out soil-reclamation and hydrogeological-ameliorative zoning of the entire territory of Zarafshan Valley.

The described territory is included in Zarafshan district according to the soil and climatic zoning of Uzbekistan for agricultural purposes. The district is confined to the basin of the Zarafshan River, bounded from the north and south by low mountain ranges and open to the west into the desert. The territory of the district in administrative terms is located in Bukhara, Samarkand and partially Navoi regions. In connection with a significant difference in altitudes, the average annual temperature varies between 11.6-15.1°, the sum of effective temperatures in the gray-soil part is 2040-2330°, in the desert - 2530-2840°. About half of the winters (42-54%) in light gray soils and 52-54% in the desert zone are among the vegetative zones. The period with temperatures above + 10°C in the desert and gray-soil zone is 200-225 days.

In the western part of the plain, the district enters the central subzone of the desert zone, the eastern part is represented by the gray-soil belt and, to a lesser extent, by the belt of brown soils. Irrigated agriculture on irrigated typical and light gray soils and meadow soils of the gray-soil belt in the upper segment of the valley (within the Samarkand region) and in irrigated meadow soils of the desert zone are systematically washed in the district, in the lower part of the basin (cotton, alfalfa, rice, wheat, sorghum gardening and other crops). Wide agriculture is also widely developed, concentrated on foothill loess plains mainly with typical gray-soil in the eastern part of the district.

The Zarafshan Valley is divided into four geomorphological regions that differ significantly in the structure of the relief and the nature of the quaternary sediments: 1) Samarkand Basin, 2) Bukhara Sub aerial Delta; 3) Karakul Sub aerial Delta; and 4) Navoi-Konimekh Oasis.

Navoi - Konimeh oasis occupy the south - the western edge of Zarafshan depression, bounded from the south by the spurs of Zarafshan, and from the north by the Turkestan ridges, in this part bearing the name Zerabulak and Nurata mountains. However, the mountain ridges themselves are not adjacent to the oasis. It is bounded from the north by a proluvial - deluvial foothill accretion formed by streams flowing down from the Karatau mountains, from the south by the Tertiary Plateau of Avtobachi and proluvial - deluvial - flat - wavy slope, flooded with water flows from the Azkamar mountains (Zerabulak mountain system), gradually merging with the tertiary Kyzyltepa plateau.

The Bukhara delta (oasis) is limited from the Navoi-Konimekh Hazarin gorge embedded in the tertiary deposits of the Avtobachi and Kiziltepa plateaus. It is the first sub aerial delta of Zarafshan, considered [14] as a transitional formation between a wide alluvial plain and delta. The length of this oasis is about 80 km, the maximum width is about 50 km. Its boundaries are: in the east Khazarin gorge, in the south-west Jangar throat, in the north Kizilkum and AvtoBachi plateau, in the south and south-west - Kuyumazar, Kiziltepa and Daukhan plateaus.

The Karakul Delta (oasis) is located in a smaller and younger in age [14] actually sub aerial delta of Zarafshan, developed behind the Jangar Throat, embedded in the body of the Karakul plateau. The oasis is bounded from the north to the east by the Karakul plateau with the Djangar throat, from the north by the sands of the Kizilkum and the Karakul plateau, from the southwest by Sundukli sands, adjacent to the tertiary ridge separating the Zarafshan valley from the valley of the middle reaches the Amu Darya. The oasis is only open but southeast to the Dengizkul depression (in the past the lake), to the level of which, apparently, the Karakul Delta was formed. This depression now represents a huge saline basin, which is the main oasis for receiving drainage waters.

The Samarkand basin (oasis) begins at the exit of Zarafshan from the narrow Penjikent valley. Its width in the east is 40 km, in the west - 10-15 km. Within its boundaries there are three terraces, not counting the narrow (0.5-1 km) pebble and sandy floodplain. Below Samarkand, Zarafshan divides into two channels - Akdarya and Karadarya, between

which the island of Miankol is located. Near the village Khatirchi in the narrowed part of the valley of the river again merge into one stream.

This article presents the results of the research conducted within the framework of State program (project - 11.1.15) for assessing the soil-ameliorative state of irrigated lands in the basin of the river. Zarafshan within the territory of three large cotton-growing areas - Samarkand, Navoi and Bukhara, playing an important role in the economy of the Republic.

3. RESULTS AND DISCUSSIONS:

The tremendous role of groundwater in the secondary salinization of soils in the irrigated zone of Central Asia has been established by various investigators [3, 23, 4, 14, 13, 15, 16, 10, 11, 18, 8, 9, 24, 19, 20, 12, 21, 22, 25, 7, 1, 2, 27] and the essence of the established provisions is reduced to the fact that the groundwater raised by irrigation is carried by a salt source of salts, which under local hot and dry climate conditions are mixed with capillary currents into the root layers of soils, leading them to secondary salinity.

Studies have shown that, the groundwater of the middle and lower reaches of the Zarafshan river., depending on the conditions of the relief, lithological-geomorphological structure, degree and artificial drainage of territories and the technical state of the irrigation and drainage systems, as well as the type of cultivated crops lie at different depths, and their mineralization varies widely from fresh to highly mineralized (Table 1).

Table 1

Depth of occurrence, mineralization and chemical composition of groundwater

No. Of Section	Depth, cm	Dense residue	HCO_3	CI	SO_4	Ca	Mg	Na	Salinity	
			g/l						Type	Level
Samarkand region										
24.	130	1,830	0,476	0,042	0,816	0,160	0,091	0,241	C	Weak
25.	145	0,970	0,409	0,028	0,432	0,100	0,085	0,103	C	Fresh
26.	170	2,130	0,159	0,021	0,272	0,270	0,049	0,279	C	Weak
22.	120	1,460	0,317	0,042	0,792	0,110	0,098	0,214	C	Weak
35.	115	3,450	0,177	0,378	1,656	0,320	0,220	0,320	X-c	Medium
39.	135	4,270	0,329	0,406	2,184	0,270	0,354	0,453	X-c	Medium
34.	165	3,940	0,604	0,266	2,040	0,490	0,384	0,087	C	Weak
36.	130	3,280	0,399	0,301	1,624	0,316	0,273	0,243	X-c	Medium
12.	120	1,260	0,128	0,084	0,648	0,130	0,079	0,114	C	Weak
14.	160	3,440	0,328	0,200	1,824	0,130	0,140	0,748	C	Medium
20.	190	0,880	0,213	0,259	0,456	0,060	0,098	0,080	C	Fresh
Navoi region										
41.	200	1,350	0,396	0,070	0,672	0,100	0,134	0,147	C	Weak
42.	135	1,080	0,311	0,035	0,528	0,080	0,073	0,162	C	Weak
44.	80	1,480	0,348	0,042	0,792	0,050	0,122	0,249	C	Weak
45.	60	4,400	0,555	0,252	2,400	0,130	0,281	0,840	C	Medium
47.	120	5,640	0,793	0,664	2,532	0,226	0,317	1,082	C	Medium
Bukhara region										
1.	140	10,200	0,579	1,155	4,965	0,480	0,823	1,236	X-c	Strong
2.	180	3,400	0,335	0,630	1,250	0,230	0,226	0,441	X-c	Medium
5.	190	4,860	0,116	0,490	2,447	0,530	0,250	0,465	X-c	Medium
8.	160	8,790	0,164	0,176	4,143	0,500	0,543	1,206	X-c	Medium
10.	210	4,590	0,164	0,560	2,189	0,570	0,201	0,438	X-c	Medium
12.	150	6,470	0,427	1,015	2,773	0,580	0,287	0,937	X-c	Medium
16.	170	9,340	0,262	0,987	4,719	0,470	0,628	1,269	X-c	Medium
20.	165	3,700	0,531	0,490	1,559	0,270	0,213	0,551	X-c	Medium
21.	200	1,600	0,274	0,203	0,666	0,170	0,085	0,197	X-c	Weak
23.	170	6,070	0,421	0,861	2,653	0,450	0,355	0,836	X-c	Medium
25.	210	4,500	0,390	0,763	1,777	0,150	0,360	0,639	X-c	Medium
43.	200	6,050	0,286	0,819	2,810	0,550	0,329	0,730	X-c	Medium
45.	170	10,80	0,219	1,568	4,978	0,490	0,720	1,557	X-c	Strong
42.	160	5,620	0,329	0,476	3,044	0,460	0,317	0,761	X-c	Medium

Note: C – sulfate, XC – chloride - sulfate.

The supply of groundwater is due to precipitation falling on the plains, as well as due to underground flow from the mountains and filtration of water from the sais that cut through the foothills. In the peripheral part of the cones, carrying out underground water (on the irrigated part) is largely fed from canals and from irrigated areas. Underground waters due to high mineralization are not used in irrigated agriculture. The level of groundwater in the studied areas of the basin of the river. Zarafshan as a whole lie close to the surface of the earth and make up in the vegetation period within the limits of 1.25-1.75 m.

The degree of groundwater mineralization in Navoi and Bukhara regions varies greatly. In the Navoi-Kanimekh oasis, it varies mainly from 2 to 10 g/l, in Bukhara from 1.6 to 10.8 and Karakul from 3 to 15 g/l, the highest mineralization is characteristic of Kagan and Karakul districts of Bukhara region, where fallow and empty peripheral areas increases to 20-50 g/l and more.

The intensively irrigated massifs are dominated by sulfate and chloride-sulfate types of mineralization, and on the periphery, where groundwater is in conditions of slow flow, the mineralization is variegated. A weak outflow of groundwater, a close occurrence of them and an intensive expenditure on evaporation increase the salt accumulation in soils, especially in the lower reaches of the Zarafshan river and promotes the development of numerous variants of saline soils.

Overestimated irrigation rates (12-14 thousand m^3/ha) used so far in many farms of the regions in conditions of weak natural and artificial drainage of the territory contributed to a fairly rapid closure of infiltration irrigation waters with groundwater and a sharp rise in the level of the latter and, accordingly, to intensive salt accumulation and, consequently to the general unfavorable ameliorative condition of irrigated lands. The level of groundwater nevertheless, as a result of artificial drainage of the territory is partially kept below the critical depth (<2.5 m). At the same time, in the main part of the irrigated territory, under the influence of irrigation during the growing season, a second level of irrigation-groundwater is formed, which has a fairly high mineralization and creates salinization process in the soils.

The considered medium and low currents of Zarafshan concern the desert zone (Bukhara and Navoi regions) and the gray-soil belt (Samarkand region) with a hot arid climate , where the historical process of territorial development naturally leads to intensive accumulation of salts in soils, ground and groundwater. This is facilitated, respectively, by a large variety of natural and irrigation-economic conditions of the irrigated zone of the regions, which causes a considerable diversity both in the qualitative and quantitative composition of the salt accumulations, and in the intensity and general direction of the soil salinization process.

The general conditions for the formation of groundwaters in a large part of the studied territory, almost their stagnant character, nutrition due to infiltration from the irrigation (hydrographic) network and from irrigated fields and the loss, mainly, by the evaporation and transpiration by plants determines here the direction of the salt balance.

So analyzes of numerous data establish that the variegation of salinity in the studied irrigated soils is observed both along the profile of soils and in space, manifested by alternating non-saline (washed) and slightly saline soils with medium, strong and sometimes very strongly saline. Among the studied soils, it is possible to single out all possible variants both in terms of the level and type of salinity, and the position of the salt horizon (Table 2). The depth of the salt horizon (salt maximum) of its thickness and the degree of salinity of the soil is a great variety, determined mainly by climatic and soil-ameliorative, as well as by irrigation and economic conditions of the territories.

Among the irrigated meadow desert and gray-soils, apart from the usual widely distributed salinated soils, saline and non-saline soils are distinguished. The number of salts along the profile of salinated soils is different, often with several second-order maxima in the layers of heavy mechanical composition. The absence of water-soluble salts in some salinated soils up to a depth of 1.0-1.5 m is explained by their washing out by washing irrigation and atmospheric precipitation, and salinized below this depth by capillary removal (rise) from groundwater.

The data presented in the table 2 is shown that the content of water-soluble salts in irrigated meadow soils varies very widely with the content of readily soluble salts over a dense residue of 0.1-0.2% to strongly saline with a salt content of 2-3%, saline soils are not uncommon level of salt marshes (> 3.0%). According to the content of readily soluble salts in the arable horizon, the soils described refer mainly to medium and highly saline soils, in a significant area of the gray-soil belt, soils with a low degree of salinity are found. However, salinated soils of the desert zone with a salt content of 3 to 7-8% are often observed, with a chlorine content of 1.2-1.4 and sulfates 1.0-1.3%. With a salt content of 8.750%, the amount of chlorine is 2.786% (section # 27).

According to the character of salinization, the studied meadow soils are mainly chloride-sulfate, sulfate, and often sulfate-chloride. Chloride-sulphate type of salinity, typical for weakly and moderately saline soils. It remains the same even with a strong and very strong salinity (Table 2). A great variety is represented by the described soils and by the qualitative composition of the salts. At low degrees of soil salinity. The main place belongs to sulfates of calcium, magnesium and sodium to a lesser extent sodium chloride and calcium bicarbonate. With an increase in salinity, the sulfate and chloride-sulfate types of salinity transfer to sulfate-chloride salts, respectively, sodium chloride predominates in the composition of the salts.

Table 2.
Content of dense residue, chlorine and sulphates in irrigated meadow soils

No. Of section	Depth, cm	Dence residue	CI	SO_4	Type of salinity	No. Of section	Depth, cm	Dence residue	CI	SO_4	Type of salinity
		% %						% %			
	0-30	0,210	0,042	0,090	X-C		0-30	2,560	0,584	0,802	X-C
	30-50	0,205	0,028	0,092	X-C		30-47	1,125	0,105	0,524	X-C
9.	50-85	0,180	0,024	0,088	X-C	**7.**	47-100	1,250	0,047	0,732	X-C
	85-120	0,280	0,024	0,142	X-C		100-142	0,435	0,056	0,167	X-C
	120-160	0,270	0,028	0,136	X-C		142-200	0,580	0,052	0,292	X-C
	0-26	0,385	0,031	0,204	C		0-34	2,680	0,717	0,728	C-X
	26-37	0,315	0,024	0,164	C		34-50	0,545	0,035	0,255	C
19.	37-85	0,265	0,014	0,154	C	**11.**	50-86	0,260	0,024	0,105	X-C
	85-155	0,160	0,010	0,086	C		86-155	0,560	0,036	0,267	X-C
	155-200	0,220	0,014	0,115	C		155-200	0,375	0,021	0,177	C
	0-25	0,620	0,091	0,290	X-C		0-30	3,110	0,458	1,384	X-C
	25-52	0,585	0,059	0,276	X-C		30-43	2,050	0,178	1,048	X-C
26.	52-95	0,255	0,017	0,115	X-C	**45.**	43-68	1,125	0,063	0,627	C
	95-135	0,525	0,017	0,300	C		68-120	0,590	0,042	0,321	C
							120-180	0,645	0,049	0,345	C
	0-23	0,725	0,021	0,400	C		0-36	4,055	1,197	0,958	C-X
	23-45	0,740	0,021	0,420	C		36-53	0,715	0,087	0,315	X-C
21.	45-71	0,630	0,017	0,350	C	**24.**	53-92	0,430	0,045	0,181	X-C
	71-105	0,350	0,038	0,148	C		92-130	0,390	0,031	0,175	X-C
	105-155	0,270	0,024	0,136	C		130-170	0,345	0,035	0,146	X-C
	0-30	1,390	0,259	0,502	X-C		0-32	4,929	1,400	1,347	C-X
	30-56	1,620	0,294	0,605	X-C		32-52	0,800	0,091	0,372	X-C
5.	56-80	0,495	0,070	0,171	X-C	**8.**	52-96	0,815	0,035	0,455	C
	80-145	0,460	0,063	0,171	X-C		96-145	0,770	0,042	0,432	C
							145-200	0,555	0,035	0,304	C
	0-30	1,810	0,392	0,576	X-C		0-32	0,645	0,105	0,261	X-C
	30-54	0,910	0,101	0,356	X-C		32-65	8,750	2,786	2,415	C-X
1.	54-96	0,535	0,0380,0	0,253	X-C	**27.**	65-95	0,670	0,185	0,179	C-X
	96-148	0,390	38	0,154	X-C		95-155	0,235	0,056	0,057	C-X
	148-200	0,340	0,032	0,142	X-C		155-200	0,270	0,073	0,047	C-X

4. CONCLUSION:

1. Complex lithological-geomorphological and hydrogeological, climatic, soil-ameliorative conditions imposed a significant imprint on the soil in the investigated territory, as a result, original gray-soils and desert soils characteristic of the basin of the Zarafshan river were formed. In its limits there are different ages of alluvial terraces, foothill plains, cones of outposts, modern and ancient deltas, aboriginal plateaus and uplands, wide depressions of plains sharply differing in terms and types of salt accumulation and the nature of secondary salinization in connection with irrigation.

2. The complexity of the geological and lithological-geomorphological structure of the territory caused an extraordinary variety of its hydrogeological conditions. Groundwater in different areas of development and occupation have different sources of nutrition, depth of occurrence, mineralization, soil salinity chemistry, etc. The hydrogeological conditions here contribute to the fact that the groundwater formed, as well as a large number of surface irrigation waters, do not have sufficient outflow and are consumed mainly on evaporation and transpiration, which creates the prerequisites for the development of the salinity process, especially intensively on poorly drained lands.

3. Unsatisfactory ameliorative condition of irrigated soils of the pre-existing part of the territory of the Zarafshan river. is explained in many respects by significant shortcomings in the operation of irrigation, especially the collector-drainage network. The technical imperfection of the irrigation and drainage system, unregulated and uncontrolled water use causes a huge overspending of fresh water. The salt balance of non-drainage and not sufficiently drained lands varies from year to year in the unfavorable direction of salt accumulation, which is associated with the evaporation of mineralized groundwater close to the surface.

4. Irrigated soils of the basin of the Zarafshan river are salinized to varying degrees with the pre-emergence of medium and severe salinization in Bukhara region and weak-, medium-, and sometimes severe salinization in Navoi and Samarkand regions. The ameliorative well-being of irrigated lands in the irrigated part of the investigated territory is not stable, i.e. on these lands groundwater remains medium (3-10 g/l) and strongly (> 10 g/l) mineralized.

5. The quantity of readily soluble salts of the described territory accumulated in soils is still relatively small, but it will gradually increase if urgent irrigation measures are not taken. However, the obtained materials allow estimating the soil-ameliorative conditions of the irrigated zone of the basin of the river. Zarafshan is relatively favorable for the successful and effective management of irrigated agriculture, although in each farm (area) there are significant areas of medium-, highly saline soils.

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