Salinization of soils and groundwaters of the Fergana valley

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Abstract: *In the analytical review, the processes of occurrence, development and some problems of modern salinization of irrigated soils of the Fergana Valley are considered, which is a kind of region of Uzbekistan. The relationship between secondary salinization and factors of soil formation is also examined: lithologic-geomorphological structure, climate, relief and depth of groundwater, economic activity in its most intensive form, under irrigation. The results of studies aimed at studying, salinization of soils, patterns of their manifestation in different parts of the valley are presented. It is established that with the advance from the upper part of the cones of removal to its periphery, the parameters of groundwater and the content of readily soluble salts in soils vary; the type of salinity varies from sulfate to chloride-sulfate. The complex measures for restoration and increasing of fertility and regulation of salt processes are offered.*

Key Words: *Irrigated soils, soil formation, relief, climate, salinity, salt content and reserves, groundwater, geochemical processes, collector-drainage network, melioration.*

1. INTRODUCTION:

In the irrigated agriculture of Uzbekistan, cotton production occupies a special place. Despite serious achievements in the development of irrigation and reclamation, the risk of secondary salinization of irrigated land is not reduced. Soils because of accumulation in a large number of toxic salts continue to lose fertility, and measures to combat salinization is insufficient. Saline soils on the territory of Uzbekistan occupy a huge space, making up a significant part of the land fund in such important agricultural areas as, for example, cotton-growing areas. Salinization manifested in irrigated lands is due to various causes, but regardless of its genesis, salinity always adversely affects the growth and development of the plant and the properties of the most soils. It destroys soil structure, worsens water-physical, physicochemical and biological properties, influences microbiological activity and other properties, and thereby causes soil degradation and plant death.

Low crop yields in irrigated lands are due to their strong salinity. It has been established that cotton yields are reduced by 20-30% in comparison with non-saline soils, by 40-60% in medium saline soils, by 80% and more on saline soils, and cotton completely dies in the fields of continuous strong salinization (solonchaks). Large damage to irrigated lands is caused by spotty salinity, which often amounts to 30-40% on irrigated land, and sometimes up to 50% of the surface falls on solonchak spots with fallen cotton.

In recent years, the soil-meliorative and ecological state of irrigated soils has deteriorated sharply in many cotton-growing areas, particularly in Central Fergana, the level of mineralized groundwater has risen above the "critical" depth, the processes of salt accumulation, desertification have increased, the content of organic substances (humus) and nutrients, fertility and productivity of irrigated land has decreased. The radical disturbance of the natural environment caused by irrigation determined the change in hydrogeological, hydrological, geochemical and soil processes and created prerequisites for an enhanced manifestation of secondary salinization.

Analysis of research materials and production experience in land improvement showed that the reason for the growing salinity of irrigated soils is still an inadequate network of collector-drainage structures. The failure of a significant part of the wells of vertical and horizontal drainage, unregulated and uncontrolled water use over a long period has virtually led to a general rise in the level of groundwater with varying degrees of mineralization in irrigated soils.

A successful solution of the problem now depends on the urgent inventory of the reclaimed land for the establishment of priority reconstruction sites and the development of appropriate technologies, agro-meliorative measures. The problem of salinization of irrigated areas should be addressed in a comprehensive manner, the struggle against soil salinization should be conducted all year round, as apart from the rhythmic work of drainage, it is necessary to establish correct vegetative watering, which largely determines the level of groundwater and the general condition of irrigated lands.

2. MATERIALS AND METHODS:

The object of the study was irrigated to a varying degree saline typical and light serozem soils of the upper

part of the cones of removal and hydromorphic-meadow-serozem, meadow, meadow-alluvial and meadow-saz soils of the Ferghana Valley, administratively part of the Ferghana, Andijan and Namangan regions of Uzbekistan.

The Ferghana Valley is located within the desert zone and the serozem belt. From its western outskirts to the east and from the central axis of the valley, almost all types and varieties of soils encountered in the desert and semi-desert zones of Central Asia are developed into the ridge of the mountain frame. In the western desert part of the territory, mainly irrigated meadow-alluvial and meadow-saz soils are allocated, desert-sandy and takyr-like soils are subordinate to the distribution [1].

On the territory belonging to the desert zone, two soil-meliorative regions are distinguished. The first region is western (mainly the Kokand group of administrative districts), with meadow-oasis and bog-meadow-oasis soils, mainly with slightly and medium saline, light-loamy in the main mechanical composition. Groundwater here lies at a depth of 1-2.5 m and has a weak and medium degree of mineralization. The second area, the territory of Central Fergana itself, which in the past served as a wastewater receiver and was occupied by impassable tugai, marshes and lakes, as well as sandy area, now meadow-arzic and gypsum-bearing medium- and heavily saline irrigated and newly-developed soils, difficultly reclaimed. Groundwater is medium- and strongly mineralized, lying at a depth of 1.5-3.0 m [2].

Central Fergana, represented by the periphery of the cones of removal, intercone depressions, the lacustrine proluvial plain and sandy areas, is characterized by a complex meliorative state of the lands, which is due to natural and historical factors - geomorphological structure, lithological structure, hydrogeological and soil processes, and the geomorphological features of the valley, that it is characterized by a peculiar facial-landscape lithochemical zoning, which distinguishes it from foothill and alluvial plains. Lithogeochemical zones reflect the regionally specific features of the valley [3].

The study of soils and groundwaters in the Fergana Valley was carried out by laying soil samples located in linear alignments, intercepting areas from the south to the north and from west to east in a vertical and horizontal direction and covering all the main geomorphological elements of the territory and directed from the foothills, to the plain - the zone of their wedging.

The total area of the study covered by the soil survey is 22,904.7 hectares, of which Sokh-Pap vertical direction is 5941.5 ha, Vadil-Nanay-8292.2 ha. and Khanabad-Besharik horizontal direction 8671.0 hectares, the length of the alignments is 80.2 and 245.0 km. respectively. In the 86 basic soil samples and about 30 groundwater samples were analyzed for HCO3, Cl, SO4, Ca, Mg, Na and hard residues in them, the reserves of readily soluble salts in the layers of 0-30, 0- 50, 0-100, 0-200 cm.

3. RESULTS:

The Fergana Valley is an almost closed intermountain tectonic depression surrounded by three wings of mountain hills, from which all its natural features, including geochemistry of the soil cover, flow out. It is characterized by a peculiar facial-landscape lithogeochemical zoning, which distinguishes it from foothill and alluvial plains. The whole history of the development of the valley is represented by a single process of the introduction and deposition of solid flow, migration and accumulation of geochemical compounds.

The ground waters of the Fergana Valley lie at different depths, in the zone of typical serozems it is noted at a depth of 10-20 m, in light serozem soils - 4-6 m, and in the hydromorphic soils of Central Fergana, groundwater is found at a depth of 0.5-2.0 m., (Table 1).

Analysis of the data in Table 1 shows that groundwaters in meadow soils of Central Fergana occur at a depth of 106-170 cm, and their salinity fluctuates between 2.395-3.605 g/l in a hard residue, with a chlorine content of 0.056-0.224 g/l. Groundwaters are characterized here mainly by sulfate type of salinity. In the qualitative composition of the salts, CaSO4 predominates, MgSO4 occupies the second place, the content of toxic salts in them varies within the limits of 30-44% of the total amount of readily soluble salts.

The content of water-soluble salts in the irrigated soils of the Fergana Valley varies widely, ranging from non-saline soils to highly saline soils and solonchaks, depending on lithologic, geological, hydrogeological and soil-climatic conditions (Table 2). As the movement from the upper and middle part of the cones of removal to its periphery, there is a natural increase in the number of salts and their reserves in the thickness of soil. The nature of the effect of groundwater on soil formation (salinity) is determined by mineralization, which depends on general climatic conditions, the nature of the water bearing rocks and the mobility of the ground flow [4].

Table.1 Depth, mineralization and chemical composition of groundwaters of hydromorphic soils of the Ferghana Valley

№ sample	Depth, cm	Hard residue	HCO_3	Cl	SO_4	Ca	Mg	Na	Salinization	
		g/l							Type*	degree
7	150	2,395	0,317	0,224	1,107	0,460	0,036	0,199	ch-s	low

8	170	3,605	0,665	0,196	1,785	0,540	0,306	0,033	s	medium
13	150	2,820	0,262	0,203	1,522	0,470	0,210	0,022	s	low
19	170	2,830	0,592	0,070	1,399	0,450	0,198	0,047	s	low
20	130	2,490	0,409	0,203	1,183	0,420	0,194	0,003	ch-s	low
21	170	2,870	0,268	0,056	1,769	0,500	0,210	0,013	s	low
22	154	2,995	0,354	0,063	1,761	0,630	0,138	0,033	s	low
23	106	3,160	0,317	0,070	1,921	0,500	0,264	0,011	s	medium

* ch-s – chloride-sulfate, s - sulfate

Typical serozems, developed in the upper and middle parts of the cones of removal, where groundwaters lie quite deep (10-20 m) are liberated from appreciable amounts of readily soluble salts, and only in contact with light serozem soils are represented by deep-solonchaks and deeply saline differences [5]. These soils up to a depth of 100-120 cm are practically not saline, the sum of salts does not exceed 0.225-0.255%, below this depth salts are found in the amount of 0.300-0.450%. Type of salinity is sulfate (Table 2).

Below the belt of typical serozems, light serozem soils are developed, where groundwaters occur 4-6 and more meters, are salinized to varying degrees and are represented by deep solonchaks, solonchakous varieties with a salt content of 0.300-0.330 to 0.460-0.650%, with very little content chlorine. Type of salinity is sulfate.

Meadow-serozem (transitional) soil is characterized by a more elevated soil moistening compared to the previously described serozems, groundwater lies here at a depth of 3-5 meters. These soils are characterized by a predominance of salinity both weak and medium up to a strong degree with a uniform distribution of salinity to a depth of 1.5-2.0 m. In this example (12 sample), the salt content is 0.645-0.920%. Type of salinity is sulfate.

The whole territory of Central Fergana is in hydromorphic conditions. This group of meadow soils, meadow-alluvial and meadow-saz soils, where the groundwater level is raised above the critical level (0.5-2 m from the surface) and develops under conditions of increased ground moisture, are characterized by medium, strong and very strong salinity up to the degree of solonchaks and a fairly even distribution of salts of only 1.5-2.0 meters layer.

The content of readily soluble salts by a dense residue in the upper arable horizons of the group of meadow soils ranges from 1,270-1,350 to 2,905-3,205%, i.e. the maximum number of salts is concentrated in the upper root zone (0-50 cm). The soils described differ not only in the depth of the salt horizon, but also in the salt profile, they often encounter two or three salt horizons, characteristic only for these soils. Salinity chemistry in meadow soils is sulfate, and meadow-alluvial and meadow-saz-solonchak soils-chloride-sulfate (Table 2).

Table.2
The content of readily soluble salts in soils of Ferghana Valley

№ sample	Depth, cm	Hard residue	HCO_3	Cl	SO_4	Ca	Mg	Na	Salinization	
		% %							Type*	Degree
Typical serozem										
30	0-31	0,135	0,036	0,007	0,054	0,015	0,006	0,016	s	non saline
	31-49	0,255	0,039	0,007	0,140	0,020	0,012	0,039	s	non saline
	49-87	0,225	0,036	0,007	0,121	0,020	0,012	0,030	s	non saline
	87-150	0,300	0,033	0,007	0,175	0,020	0,015	0,048	s	low
Light serozem										
10	0-31	0,245	0,033	0,014	0,113	0,015	0,015	0,030	s	non saline
	31-50	0,315	0,033	0,011	0,154	0,010	0,006	0,072	s	low
	50-92	0,355	0,037	0,011	0,175	0,010	-	0,073	s	low
	92-124	0,330	0,037	0,007	0,164	0,010	0,003	0,080	s	low
	124-150	0,460	0,037	0,011	0,257	0,010	0,006	0,118	s	low
Meadow-serozem										
12	0-33	0,720	0,024	0,010	0,463	0,180	0,006	0,019	s	low
	33-46	0,645	0,024	0,007	0,421	0,1710	0,006	0,008	s	low
	46-75	0,650	0,024	0,007	0,421	0,160	0,009	0,014	s	low
	75-105	0,900	0,021	0,007	0,586	0,203	0,015	0,028	s	low
	105-155	0,920	0,018	0,007	0,607	0,240	0,006	0,014	s	low
Meadow										
42	0-30	1,270	0,027	0,017	0,749	0,280	0,012	0,035	s	medium
	30-60	1,350	0,024	0,021	0,802	0,320	0,003	0,033	s	medium
	60-110	1,360	0,021	0,021	0,808	0,290	0,030	0,018	s	medium

	110-170	1,425	0,027	0,021	0,843	0,300	0,024	0,037	s	medium
Meadow-alluvial-solonchak										
21	0-27	2,905	0,021	0,374	1,275	0,205	0,177	0,029	ch-s	solonchak
	27-48	2,460	0,018	0,290	1,080	0,195	0,101	0,296	ch-s	solonchak
	48-78	1,875	0,021	0,196	0,874	0,185	0,076	0,171	ch-s	high
	78-117	1,120	0,018	0,098	0,547	0,130	0,052	0,084	ch-s	high
	117-157	0,870	0,021	0,063	0,439	0,140	0,033	0,064	s	low
Meadow-saz-solonchak										
15	0-38	3,205	0,024	0,273	1,691	-	-	-	ch-s	solonchak
	38-54	2,090	0,018	0,133	1,111	-	-	-	ch-s	solonchak
	54-76	1,885	0,021	0,192	0,905	-	-	-	ch-s	high
	76-100	1,690	0,021	0,175	0,812	-	-	-	ch-s	high
	100-150	2,705	0,018	0,175	1,492	-	-	-	ch-s	solonchak

* ch-s – chloride-sulfate, s - sulfate

The features of the lithologic-geomorphological structure and hydrogeological conditions determined the redistribution of salt reserves along the territory of the Ferghana Valley and determined the allocation of areas with different salinization, determined by both relict and modern salt accumulation processes. The very weak drainage of the main part of the territory, and its mountain frame contributed to the formation here of permanent geochemical flows that carry and store readily soluble salts in closed drainless depressions in zones of prolonged accumulation of salts. The arid climate, which determines the current bioclimatic features of the territory, contributes to the preservation of salt reserves in eluvial-accumulative landscapes (Central Fergana), especially in hydromorphic conditions.

The total reserves of readily soluble salts in the studied soils of the valley vary very widely and in the two-meter layer of soil there are from 72-103 to 417-710 tons / ha of salts. As can be seen from the data in Table. 3, with the advance from the south to the north, from the upper and middle parts of the cones of removal to the periphery, the reserves of readily soluble salts naturally increase and in the 0-2 m layer in the zone of propagation of meadow soils it reaches 700-750 t / ha, of which in the upper root layer (0-1 m) 330-360 t / ha (Table 3).

Table-3

Reserves of readily soluble salts in irrigated soils of Fergana Valley

Soil	**№ sample**	**Layer, cm**			
		0-30	**0-50**	**0-100**	**0-200**
Typical serozem	30	5,59	12,63	20,50	72,10
Light serozem	10	10,14	18,84	43,06	103,95
Meadow-serozem	12	29,81	47,95	101,43	228,25
Meadow	42	52,58	89,84	183,54	384,97
Meadow-alluvial-solonchak	21	118,42	184,71	291,16	417,09
Meadow-saz-solonchak	15	134,61	205,62	332,16	710,86

In the geographical distribution of soils and in their profile, the results of past and current displacements and spatial migration of geochemically active compounds, both depending on their solubility and the sources of their intake, are now clearly visible. The main reasons for the widespread development of salinity in the territory are arid climate, relief structure and hydrogeological conditions, as well as the history of the development of the Ferghana Valley and its mountain range.

The development of poorly drained and naturally highly saline plains, as well as high foothill plains, caused flooding of the underlying land, all of which led to the disruption of natural geochemical flows, the alteration of salt balance in geochemical landscapes, to the activation of salinization processes and the involvement of relic reserves of salts. In addition, the low technical level of land reclamation systems led to large irrational losses of irrigation water, which also contributed to the increase in the level of mineralized water in irrigated areas.

The dominance of the cotton monoculture, the increase in the areas of rice growing during a long period, high irrigation rates - all this also contributed to the secondary hydromorphism and secondary salinization, against the background of leaching nutrients from the soil, their depletion, loss of fertility, i.e. general degradation of irrigated soils.

4.CONCLUSION:

To improve the meliorative and ecological situation in the region, it is necessary to carry out a set of measures that includes: reconstruction of land reclamation systems to increase the water use efficiency and drainage efficiency, exclude or minimize the discharge of collector-drainage water into rivers, reduce irrigation standards, improve irrigation quality water, lowering the level of groundwater, eliminating the causes of soil salinization.

Complex melioration should be aimed at preserving and improving the natural fertility of soils and ecological conditions on irrigated areas and geochemically conjugated landscapes in order to improve the human environment.

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