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Resource-Efficient Technologies for Improvement of Land Reclamation and Ecological Condition

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Abstract: *This article focuses on the establishment of effective measures to identify and prevent adverse processes of the ameliorative-ecological state of irrigated lands of Bukhara Oasis. Recommendations have been made on improving ameliorative-ecological state of soil, maintaining, increasing productivity and their effective use, introduction of resource-saving technologies preventing secondary salinization.*

Keywords: *Soil salinity cartographic maps, biological productivity, water-salt balance, soil salinization, hydro carbonate-sulfate, agriculture, irrigation water.*

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Introduction. Today, the main problems of the world land resource are the reduction of soil fertility, soil erosion, pollution loss of biological productivity, salinization and swamping of arable lands. It is estimated that humanity has so far lost 2 billion hectares of arable land, including 5-6 million hectares of agricultural land each year due to erosion alone, and 1.5 million hectares of agricultural land due to salinization and swamping [1]. Therefore, it is important to develop scientifically based measures to increase the efficiency of irrigated lands, improve the reclamation and ecological condition of soil cover, protect them from degradation processes, prevent them and increase their productivity [3, 4].

Scientific work is carried out in several priority areas in the world on the determination of the current state of soils and their changes under the influence of anthropogenic factors, dehumidification, loss of water-resistant granular structure, condensation, optimization of water-salt balance, prevention of secondary salinization, erosion and other negative processes, improvement of ameliorative-ecological condition. In this regard, special attention is paid to the assessment of water-physical, technological, agrochemical properties and reclamation of soils, the development of agro-ameliorative, agro-technical measures following the soil-climatic conditions of the regions, maintenance, restoration and increase of soil fertility.

Extensive ameliorative measures and research work on the development of science- based agriculture are being carried out and certain results are achieved by improving the ameliorative-ecological condition of irrigated lands in the Republic, increasing productivity and using them effectively, introducing resource-saving technologies in the fight against secondary salinization processes.

The Action Strategy of the Republic of Uzbekistan for 2017-2021 states that "... further improvement of the reclamation of irrigated lands, development of reclamation and irrigation networks, introduction of intensive methods of agricultural production, first of all, modern water and resource-saving agro-technologies" tasks have been identified [2]. Consequently, the effective use of irrigated land in the further development of agriculture in the Republic, improvement of its ameliorative condition, stabilization of water-salt balance of soils, level and mineralization of groundwater, determination of indicators reflecting the ecological condition of soils and implementation of agro-ameliorative measures on this basis with stratification is of great importance.

Materials and Methods. The aim of the study is to identify the processes occurring in the reclamation and ecological condition of irrigated soils of the Bukhara oasis in the conditions of water scarcity and to develop recommendations for their improvement.

The objectives of the study are to determine the extent to which the depth and salinity of groundwater in irrigated lands have an impact on soil reclamation; analysis of collector-drainage water flow and its mineralization level; to determine changes in salinization processes in irrigated Oasis soils under the factors of natural and anthropogenic factors; determination of the water-salt balance of irrigated lands; to determine the degree of irrigated lands pollution with toxic agricultural substances and, on this basis, assess the ecological condition of the area's soil; making "soil salinity cartographic maps" on a scale of 1:10 000 of selected basic areas of the Bukhara Oasis, on this basis to develop scientifically based recommendations on improving the reclamation and ecological condition of irrigated lands.

The object of the study was to select ancient irrigated meadow-alluvial soils in the Bukhara oasis. Improving the ecological and reclamation condition of the soil, increasing its fertility, optimal management of the water-salt regime requires correct analysis of key indicators that represent the processes currently taking place. In this regard, the research work carried out in the Bukhara region is noteworthy. The total area of the Bukhara region is 4183.1 thousand hectares, which is divided into 11 agricultural districts. Irrigated lands are 954.3 thousand hectares, of which irrigated lands are 226.6 thousand hectares, of which 192.8 thousand hectares or 85.1% are salines to varying degrees. [5, 6, 7]

Several scientific types of research carried out by our soil scientists and land reclamation scientists are aimed at determining the reclamation status of irrigated lands of the republic, prevention and mitigation of existing negative conditions inefficient use, the existing collector-drainage networks are not in working condition. [8, 9, 10]

Soil salinization leads to a sharp decline in crop yields, and a lot of labour is required to care for and grow crops. In low-salinity soils, cotton yields decreased by 20-30%, in moderately saline soils by 40-60%, and in highly saline soils by 70-80%. Therefore, to reduce the damage of salts to plants, it is necessary to develop specific methods of agro-ameliorative and agro-technical measures in the care of crops in saline soils. Improving land reclamation is one of the most pressing issues in agriculture. After all, the income of farmers and peasants depends in many respects on the fertility of the soil, the productivity of crops, and, consequently, on the reclamation of lands. Therefore, the scale of measures aimed at improving the reclamation of lands in our country, reducing the level of groundwater, reducing the level of soil salinity is expanding every year. [11].

Bukhara region is located on the northern border of subtropical and temperate climates. The average temperature in July in most districts of the region is $+28^0$ C, and in Kagan and Karavulbozor districts - up to $+30^0$ C. The absolute maximum temperature is $+44\text{-}46^0$ C, the average temperature in January increases from -8^0 C in the north to 0^0 C in the south, the minimum temperature reaches -18^0 C. The coldest periods in the oasis are 205-220 days, and the windless periods are 90-100 days. The positive air temperature during the growing season varies from 4700 to 4800^0 C, and the effective temperature is $2600\text{-}2700^0$ C. The average annual amount of atmospheric precipitation is 98-144 millimeters, the bulk of precipitation falls in the winter and spring months.

Geologically, the territory of the Bukhara region has a saddle structure and is filled with continental deposits up to 400 meters thick. They lie everywhere on the marine clays of the widespread Paleocene period. The depth of groundwater is 1.5-3.0 meters. The direction of flow is north-west, with a slope of 0.001–0.004. The chemical composition of groundwater is a hydrocarbon and hydro carbonate-sulfate in the upper part of the oasis, sulfate in the central part, sulfate-chloride and chloride-sulfate in the margins and deserts. High air temperatures and many hot days lead to high consumption of groundwater near the surface for evapotranspiration. This, in turn, leads to a sharp increase in the amount of salt in the aeration zone. As a result, salinity is restored in irrigated areas.

In the irrigated areas of the Bukhara and Karakul deltas, mainly old-irrigated meadow-alluvial, meadow-desert and meadow-bald soils of the desert zone are distributed. The mechanical composition of irrigated soils varies from light, medium and heavy sandstone to sandy and loamy, and the lower layers consist mainly of medium and light mechanical composition. To detect changes in ecological and reclamation processes, stationary observations were conducted in the territory of specially selected parts, the soil cover of which consists mainly of old irrigated meadow-alluvial soils. According to the analysis of analytical data of soil samples, the amount of physical clay (<0.01 mm) particles in the upper (0–100 cm) layer of soils ranged from 21.3 to 43.6%. In some parts of Karakul district, there are sandy and light sandy soils with mechanical composition, which alternate with layers of sand and clay. [17].

Development in agriculture, irrigation and land reclamation, the introduction of the latest achievements in crop production and agriculture, as well as the widespread use of fertilizers and pesticides, as well as the use of chemicals against pests and diseases require a rich and high yield of crops. In the meantime, the used chemical fertilizers and pesticides accumulate in the soil and form a dense layer under the plough, which impairs water, air permeability, metabolism, growth of microorganisms, and ultimately leads to deterioration of the ecological condition of soils. It is known that each soil-climatic zone is in constant contact with natural and anthropogenic processes. Being in constant dynamics under the influence of a combination of different factors, they may retain or lose their properties and natural products as a result of the development of the desertification process or the accumulation of toxic substances within permissible limits. However, in addition to the positive effects, the use of agrochemicals can lead to dangerous consequences, mainly against the background of environmental pollution and especially large-scale agricultural production. Accumulation of chemical residues in the environment leads to pollution of the atmosphere, soil, biosphere and groundwater. This situation is one of the main reasons for the sharp deterioration of irrigated land areas where cotton is grown. These soils are experiencing a heavy load due to the use of large amounts of minerals and various pesticides: insecticides, herbicides, defoliants and others are among them. As a result, not only the soil but also the whole environment is polluted and the amount of toxins is increasing year by year [19, 20].

Results and Discussion. Irrigated lands of "Uzbekistan" part of Karakul district of Bukhara region and "Khalkabad" part of Romitan district were selected as the main study area. In each of the common areas, observation sites were identified, taking into account soil properties and salinity levels, fertility. In the field, morphological features of the base sections were recorded, soil samples

were taken from genetic layers, as well as chemical samples were taken from soil samples from 0–30 cm and 0–100 cm layers in selected areas. To fully assess the reclamation and ecological condition of the soil, samples were taken from irrigation water and collector water and analyzed. Commonly accepted methods in soil science were used to study the composition and properties of the above soils.

According to the results of agrochemical analysis, the irrigated soils of the oasis are explained by the small amount of humus, which can be observed in its distribution in the soil profile. The content of humus in the topsoil is 0.8-1.4%, nitrogen 0.06-0.12%, total phosphorus 0.11-0.18%. The amount of mobile phosphorus absorbed is 8–13 milligrams per 1 kg of dry soil, and the amount of exchangeable potassium is 120–150 mg/kg. In the studied soil, gypsum ($CaSO_4\ 2H_2O$) is found in some places at a depth of 70-80 cm above the soil surface, and their content is low (0.1-0.8%). The amount of CO_2 carbonates in the soils fluctuates between 4.5% and 8.5%, and no regularity was observed in their distribution in the soil profile. The share of $CaCO_3$ in carbonates is 85-90% of the total $MgSO_3$ is 10-15%.

To assess the reclamation and ecological status of irrigated soils in 2016 and 2021, the level of pollution of Karaun stream, domestic irrigation canal, inter-farm and inter-farm collector-drainage water flowing through the territory of Karakul district and pesticides and other elements of irrigation and collector water changes were monitored. The analysis of the chemical composition data of irrigation water is reflected in the figures given below. The total amount of salts in the dry residue was 0.940–8.360 mg/l, the anions were determined in descending order of salinity: sulfate ion – 219.74–274.88 mg/l, bicarbonates (HCO_3) –158.6 –244.0 mg/l, chloride ion – 95.57–138.68 mg/l. The content of sodium ions in cations is relatively high – 181.0-106.0 mg/l. The highest mineralization in the section of the reservoirs under consideration was determined in the inter-farm collector, and the highest mineralization of the flow was observed in 2016 at 41.536 g/l and in 2021 at 13.188 g/l.

According to the analytical analysis of some collector-drainage waters of the Bukhara oasis, in 2016-2021 there are fewer pesticides than alpha hexachlorocyclohexane ($\boldsymbol{\alpha}$-GXSG) and gamma hexachlorocyclohexane ($\boldsymbol{\gamma}$-GXSG). In 2016, the minimum amount of alpha hexachlorocyclohexane ($\boldsymbol{\alpha}$-GXSG) in the water of the Main Karakul collector was 0,002 mg/l, and the maximum amount in the Chorbakr collector was 0.090 mg/l. The laboratory analyses also revealed the presence of pesticides in the Central Bukhara and Parsankul collectors during the study period – 0.045 and 0,068 mg/l, respectively. According to repeated laboratory analyses in recent years, the presence of $\boldsymbol{\alpha}$-GXSG pesticides in inter-farm collector water was relatively high – 0.014 mg/l, in the Main Karakul collector - DDE and DDT – 0.001 mg/l and 0.003 mg/l, respectively. Traces of these pesticides are also found in small amounts in the waters of inter-farm and on-farm collectors.

When analyzing the ecological condition of the studied soils, the amount of some pesticides used in agriculture in soil samples taken from the selected areas was determined. Analysis of the data shows that today the irrigated grassland-alluvial soils of the Bukhara oasis are often below the allowable amount of pesticides such as $\boldsymbol{\alpha}$-GXSG, $\boldsymbol{\gamma}$-GXSG, DDE and DDT (0,1 mg/kg) and, in general, their soil, irrigation and the negative impact on the environmental situation in the drainage system is relatively small. In soils obtained from section 1004 alone, gamma hexachlorocyclohexane ($\boldsymbol{\gamma}$-GXSG) from pesticides was found to be several times higher than the allowable amount. The comparison of the analytical results of the conducted laboratory and the number of pesticides detected by its analysis are shown in Picture 1.

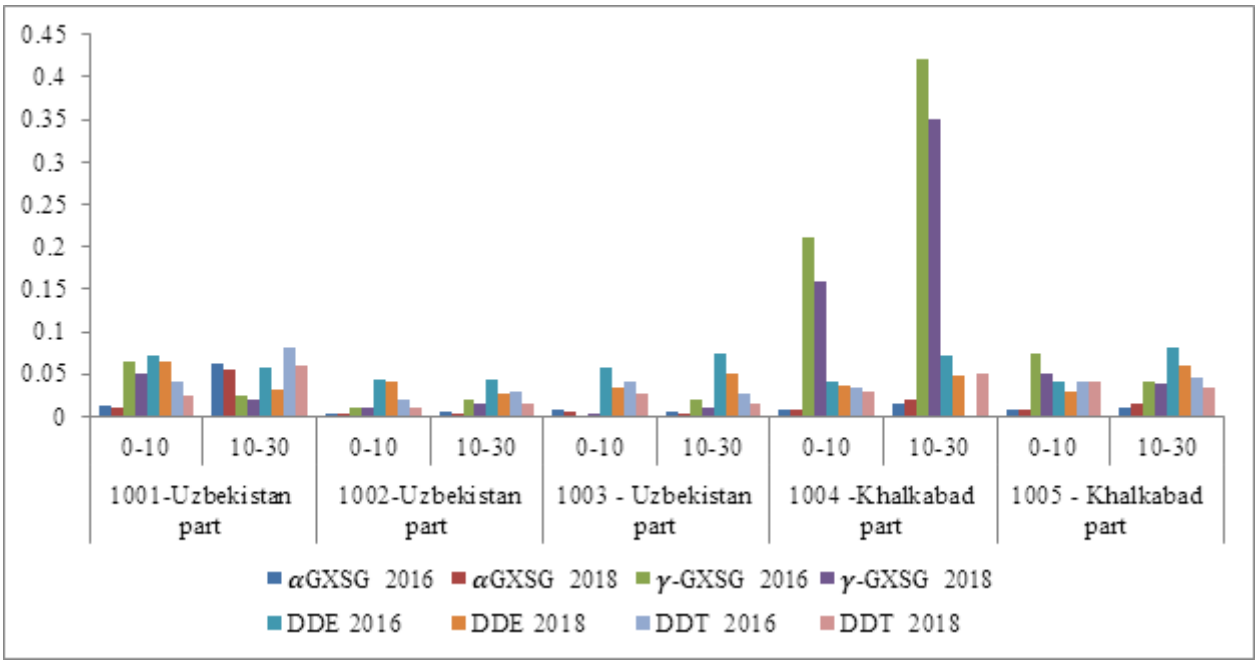

Figure 1. Changes in the number of pesticides in ancient irrigated meadow-alluvial soils

One of the main factors characterizing the ecological and reclamation status of irrigated areas is the amount and composition of salts in the zone of the active layer where the plant roots are scattered. In all optimal conditions of agro technology, the loss of yield in low-salinity soils is about 20-30%; 40–50% in moderately saline soils; in highly saline soils it is 60-80%. Under the influence of natural and economic conditions, the quantitative indicators of salts in soils, the process of salinization and the removal of salts from the soil layers are observed over a wide range.

These processes are reflected in the results of our research in the Karakul district. Studies of soil sections selected for observations show that the salinity levels of ancient irrigated meadow-alluvial soils vary at different intervals. The content of salts in the soil layer of 0–100 cm ranges from 0.090–0.925% (section 1001, 1021) 1.090–2.740% (section 1059, 1021) on the dry residue, the amount of toxic chloride ions that are dangerous to plants is 0.01–0.35% oscillates in the range (Table 1).

Observations show that more than 70% of the irrigated lands of the Karakul oasis consist of ancient irrigated meadow-alluvial, meadow-alluvial-bald, sandy desert soils. It was found that 40-45% of these soils are saline and compacted to varying degrees, and the amount of humus and basic nutrients in them also varies. The above-mentioned situation was also observed in the irrigated soils of the Bukhara oasis. Based on field research and laboratory analysis, quantitative indicators of salts, salinity levels and salinity types showed that they vary in different areas of Karakul and Romitan districts. The results of the analysis were carefully studied and the total amount of water-soluble salts in the soil profile and their total reserves were determined. Quantitative indicators of salt reserves assessed the reclamation status of the soil and developed a cartogram of soil salinity of the parts.

Table 1. Amount of water-soluble salts and ion content in ancient irrigated meadow-alluvial soils, %

Cut №	Horizon sm	Dry residue	HCO_3^-	Cl^-	SO_4^{-2}	Ca^{+2}	Mg^{+2}	Na^+	Component gather disi	Salinity	
										type	Degree
1001	0-30	0,125	0,038	0,024	0,025	0,015	0,006	0,010	0,118	s-x	Weak
	30-60	0,128	0,037	0,017	0,025	0,015	0,006	0,008	0,108	x-s	Weak
	60-100	0,115	0,038	0,014	0,025	0,015	0,006	0,007	0,105	x-s	Weak
1021	0-30	2,740	0,024	0,353	1,380	0,090	0,125	0,558	2,530	x-s	Very strong
	30-44	1,105	0,024	0,123	0,565	0,070	0,080	0,127	0,989	x-s	Strong
	44-68	1,300	0,030	0,178	0,615	0,040	0,073	0,237	1,173	x-s	Strong
	68-100	0,940	0,021	0,150	0,425	0,040	0,056	0,157	0,849	x-s	Average
	100-130	0,925	0,027	0,109	0,445	0,020	0,046	0,184	0,831	x-s	Average
1011	0-30	0,306	0,021	0,031	0,138	0,020	0,018	0,037	0,265	x-s	Average
	30-60	0,225	0,015	0,070	0,053	0,015	0.009	0,042	0,204	s-x	Weak
	60-100	0,205	0,015	0,070	0,035	0,015	0,006	0,039	0,180	s-x	Weak
1059	0-30	0,110	0,018	0,016	0,038	0,015	0,006	0,007	0,100	x-s	Weak
	30-40	0,190	0,018	0,014	0,087	0,020	0,009	0,017	0165	x-s	Weak
	40-60	1,090	0,018	0,110	0,545	0,080	0.074	0,107	0,934	x-s	Strong
	60-115	0,126	0,018	0,014	0,049	0,020	0,006	0,005	0,112	x-s	Weak

Conclusion. Currently, the technical condition and operation of the existing collector-drainage networks in irrigated areas, the level of water supply in the area, the quality of irrigation water and the volume and technology of soil salinization are insufficient for targeted management of reclamation and environmental processes in irrigated areas. Irrigated agriculture in the oasis is characterized by:

- high salt accumulation in the root layer of plants (0–1 m) during the growing season;
- sharp negative variability of groundwater depth and mineralization level in irrigated lands;
- Insufficient number of existing collector-drainage networks per hectare and low efficiency in optimizing the water-salt balance of soils;
- Existence of imbalances in the rules, norms and technology of the use of pesticides and biogenic substances.

Saline leaching is one of the main measures to improve the reclamation and ecological condition of irrigated soils and in the conditions of Bukhara, such saline leaching accelerates the natural desalination of autumn-winter atmospheric precipitation. As a result of winter prophylactic irrigation can be achieved a satisfactory reduction in the amount of salt in the drive and underdrive layers. Winter prophylactic irrigation gives good results when the norm is 1500–3000 m^3/ha. Taking into account the mechanical composition of the soil, the degree of salinity and water permeability, saline leaching measures 2.0-2.5 thousand m^3/ha of weakly saline ancient irrigated meadow-alluvial soils, 3.5-5.0 thousand m^3/ha of moderately saline soils. ha and highly saline, mechanically heavy soils with the leaching of water at the rate of 5.0–6.5 thousand m^3/ha and its

implementation in several stages, in this regard, the use of a structured salinity cartogram of the parts gives positive results.

Along with agro-ameliorative measures, the introduction of crop rotation is also important in improving the reclamation of lands. In the soil-climatic conditions of the Bukhara oasis, alfalfa reduces the groundwater table by an average of 30-60 cm during the growing season. To improve the reclamation and ecological condition of lands in the conditions of water scarcity, it is recommended to widely use methods of land use in the Bukhara oasis by using resource-efficient agro-technologies and introducing a system of crop rotation: cotton: alfalfa: grain (4:3:3).

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