

Study of the modern reclamation and ecological state of soils in Azerbaijan

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ABSTRACT

For many years in the Republic of Azerbaijan, numerous reclamation and ecological measures aimed at attracting agricultural lands of natural cenoses to use in agrocenoses were carried out. The soils of the studied territory are quite unique in terms of their soil-forming structure and ecological conditions, and they differ from other regions of the country in terms of irrigation water content. The article reflects some important results of soil and water studies conducted over the last years. Determining the qualitative composition of groundwater and irrigation water in different seasons of the year using modern methods is relevant from an environmental and reclamation point of view. Based on remote sensing and geographic information system (GIS) technologies, our research is based on the analysis of natural and anthropogenic landscape changes and changes in natural conditions as a result of agricultural development in the 20 km buffer zone along the banks of Kura and Araz rivers. As a result of the conducted research, it was determined that the rapid growth of the population has caused the reduction of the area of agro-landscapes, the salinization of the soil, the drying of the water in the water basins, the expansion of the construction areas. This has disrupted the natural balance.

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1. INTRODUCTION

In dry years, the reduction of surface water resources, as a result of the lack of regulation of the water flow of inland rivers, flood waters flow into the sea without being fully used, which makes it difficult to provide irrigation water to agricultural fields. The role of efficient use of available land and water resources in increasing agricultural production is very important. The protection of soil fertility and its effective use are of great importance for the development of the agricultural sector. Preserving and increasing the fertility of the land creates great opportunities for future generations, in addition to ensuring the living conditions and health of the population. For effective use of land, it is necessary to properly regulate its water, food, air, and thermal regimes, depending on the phenological and biological characteristics of the development of agricultural plants, and create an optimal agricultural background. If the soil is not used properly, its beneficial properties gradually disappear and become unsuitable for growing crops. Any improper exploitation of the land leads not only to a decrease in yield and quality indicators but also to a disruption of the ecological balance, and long-term loss of fertility leads to disadvantages [1]–[6].

In the new economic conditions, priority should be given to techniques and technologies that allow saving land resources, and minimizing land cultivation, which is of great importance for the use of intensive technologies, the use of combined methods, and environmental balancing of the agricultural landscape. The organization of an ecological-landscape farming system that includes natural laws, the requirements of the modern era, and ensuring sustainable development, is very important from the point of view of existence. The total soil fund of the Republic of Azerbaijan is $8641.5 \cdot 10^3$ ha, and about half of them are used in agriculture. The total area of the Kura-Araz plain is 2242 thousand hectares, of which $1439 \cdot 10^3$ ha are irrigated soils. According to statistics, the area of irrigated land in the world is approximately $220-230 \cdot 10^6$, and on the territory of the republic $1429 \cdot 10^6$ ha [7], [8].

As a result of prolonged irrigation and agrotechnical measures, soil parameters change dramatically. The Kura-Araz lowland is located between the mountain ranges of the Greater Caucasus in the north and the Lesser Caucasus in the southwest, in the south, the Talish Mountains and the Lankaran lowland, and in the east, its shores are washed by the Caspian Sea. Its length is about 250 km, and its width is about 150 km [9], [10]. The relief has been studied quite fully to date and is represented by a slightly undulating plain formed by IV sedimentary deposits and alluvial deposits of the Kura and Araz rivers. In the Upper strata of soils, soils, the fact that the formation of the lowland proceeded under the decisive influence of transgressively regressive fluctuations in the sea level is of particular importance. The terrain is flat and rises from 10 m to 200 m above sea level. The Caspian deposits are overlain by the alluvial deposits of the Kura and Araz, reaching a thickness of 10 to 20 m, which gradually decreases from west to east. These lands are areas of ancient, irrigated agriculture. In the western part, deluvial and deluvial-proluvial deposits are most widespread. Within the steppe, meadow, and gray-brown salinization.

The rational intensification of agricultural production, capable of ensuring soil fertility and obtaining stable and sustainable crop yields, is a global problem of our time. The soil, being a component of a very finely balanced natural ecosystem, is in dynamic equilibrium with all other components of the biosphere. When used in a variety of economic activities, the soil often loses its natural fertility or even completely collapses. In areas of intensive agriculture and areas of high concentration of industrial production, the anthropogenic load on soils has become not only commensurate with the intensity of the soil-forming process but also significantly exceeds it [11]–[13]. The creation of farms, served as a general violation of all agrotechnical practices, non-compliance with irrigation standards, and widespread chemicalization of soils, which in turn gave impetus to the spread of irrigation erosion, raising the level of groundwater, exposing lands to secondary salinization and, in places, waterlogging. In this connection, there is no doubt that both from an environmental and economic point of view, it is more expedient to prevent adverse changes in soils than to carry out expensive work to restore them. The main goal of the study is to study the current soil-ecological state of the soil cover of the Kura-Araz lowland, the territory of which is characterized by a high degree of development and widespread development of irrigated agriculture [6], [14].

Based on the data obtained, it is planned to develop recommendations on agricultural practices and science-based farming, to preserve soil fertility and obtain high, sustainable, and environmentally friendly agricultural products. The novelty of the conducted research is the first time in the last years that a systematic analysis of long-term irrigated soils from soil-ecological positions, considering environmental factors and reclamation state, fixing the exact location of soil profiles, which in turn will form the basis of digital maps of environmental assessment of soils using geographic information system (GIS) technologies [15], [16]. The study of the resources of the biosphere in connection with the daily change of its representatives of both the flora and fauna, the disappearance of some, and the appearance of other living beings, from the simplest to the highest, as well as a straightforward increase in the population. Contributing to the aggravation of the food problem and the increasing burden on the environment has become particularly relevant today. The study of agro-physical properties is one of the important issues in increasing soil fertility and productivity [2], [17]–[20]. The study of the degree of silt and the chemical composition of water in cultivated cenoses irrigation systems of the Kura-Araz plain of Azerbaijan is also a very topical issue. Irrigation systems use rivers, canals, water distribution, ditches, and collector water. Dry subtropical semi-desert CM – 0.08-0.24; ID – 3-4; $10\text{ }^\circ\text{C}-4800\text{ }^\circ\text{C}$, $t_{\text{air}} > 10\text{ }^\circ\text{C}-300$ days, $t_{\text{soil}} > 5\text{ }^\circ\text{C}-350$ days. Capacity 2-3 cm and density of soddy horizon is very weak. Depth of penetration of root mass 20-30 cm [21], [22]. The color of the humus horizon is grey and greyish in the upper layers. The capacity of the humus horizon is 20-25 cm in the soil profile. The granulometric structure is average and heavily loamy. Structure of horizon Al' granular, Al'' granular crumbly.

2. RESEARCH METHOD

For research, samples were taken from the waters of the Head Mugan Canal, the Sabir Canal, the Upper Karabakh Canal, and the waters of the Lower Mugan Canal. With prolonged irrigation with muddy waters, certain thickenings are found in the soil cover due to irrigation (Figure 1). An increase in water

mineralization and a decrease in the level of silting directly affect the course of soil-forming processes after some time when irrigating cultivated cenoses. The silty part of the soil is saturated with fine-grained carbonate crystals [23], [24]. There is a drainage network on the experimental site, consisting of three options, the distance between which is 200, 400, and 600 m. Long-term observations were carried out to study the elements of the water-salt balance. In the first years, water samples were taken on the 20th and 30th of each month, and in subsequent years, only on the 15th of the month. A comparison of the mineral content of drain water shows that the mineral content of the water they carry is closely related to the salinity of the soil in the environment where it is located. Samples were taken from distributors and ditches in different seasons of the year (winter, spring, summer, and autumn) and laboratory analyses were carried out according to general rules [4], [5], [25].

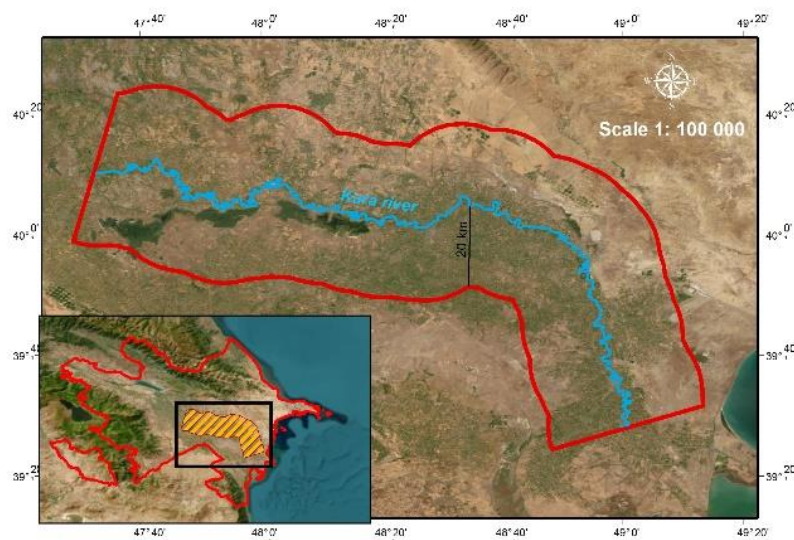


Figure 1. The study region of the country

3. RESULTS AND DISCUSSION

Depth of penetration of root mass 20-30 cm. The color of the humus horizon is grey and greyish in the upper layers. The capacity of the humus horizon is 20-25 cm in soil profile. The granulometric structure is average and heavily loamy. Structure of horizon Al' granular, Al'' granular crumbly. The depth of the carbonate horizon is 20-30 cm, and the carbonates form white soft spots. The depth of gypsum appearance is 80-100 cm, and the depth of subterranean waters is 2.5-5 m, soil appraisal-66. Natural dominant species in studied area: *Aceraceae* Juss., *Apiaceae* Lindl., *Asteraceae* Dumort., *Brassicaceae* Burnett., *Caryophyllaceae* Juss., *Chenopodiaceae* Vent., *Anacardiaceae* Lindl., *Dipsacaceae* Juss., *Convolvulaceae* Juss., *Euphorbiaceae* Juss., *Fabaceae* Lindl., *Gentianaceae* Juss., *Cyperaceae* Juss., *Papaveraceae* Juss., *Poaceae* Barnhart., *Papaveraceae* Juss., *Polygonaceae* Juss., *Pyrolaceae* Dumort., *Rhamnaceae* Juss., *Rosaceae* Juss., *Salicaceae* Mirb., *Saxifragaceae* Juss., *Scrophulariaceae* Juss., *Solanaceae* Juss., *Orchidaceae* Lindl., *Malvaceae* Juss., *Melanthaceae* Batsch., *Liliaceae* Juss., *Tamaricaceae* Lindl., *Ranunculaceae* L., *Violaceae* Batsch. The drains are numbered from 1 to 50. Since the level of soil salinity in the service area of drain D-5 is relatively low, medium in drains D-45 and high in drains D-9, their initial mineralization by dry residue is 19.46, respectively; 24.07 and 80, and 70 each of chlorine 1.89, 2.62, and 11.09 g/l. During 5 years of observations, the drainage water's salinity continued to decrease from year to year, although at a slower pace.

As a result of the use of leaching and irrigation of agricultural crops cultivated on leached areas, the process of desalinization took place in the soil layer, part of the washed salts was concentrated in the lower layers, and the other part was discharged with drainage water. A sharp difference in the amount of water discharged by drains depends on the initial reclamation state of the soil in the zone of influence of each drain, drainage parameters, and the composition of the measures taken. Balance observations show that the amount of salt carried out by drainage water is several times higher than the amount of salt supplied with irrigation water. At present, one of the main tasks facing ameliorators is the correct use of land, the study of ways to increase their fertility, and the productivity of agricultural plants. The Kura-Araz plain occupies about 33% of the area of Shirvan. Mineralization of drainage waters in the region ranges from 16.1 g/l to 24.54 g/l. The impact of irrigation on soil composition and important parameters is related to the qualitative composition of

irrigation water. Changes in the degree of silting studied waters are mainly observed in the spring and autumn seasons (Table 1). In staging water samples, the silt index in channels and ditches is slightly lower than in rivers and large canals. The granulometric composition of sediments varies in different seasons of the year and depending on the water sampling places. The highest indicators of physical clay were in July and October. The pH of the sludge particles ranges from 8.5 to 7.4 and has alkaline properties. Figure 2 shows changes in the content of granulometric indicators (%) in silt particles contained in irrigation water in the spring to the autumn period (Figures 2(a)-(b)). Figure 3 shows the monthly rainfall for the 2020-2023 year, monthly rainfall (mm) from January to December is shown in Figure 3(a), and the provision curve (%) for the number of days (30 days) with dry weather in the territory is shown in Figure 3(b).

It was established that gray-brown irrigated soils degraded to a certain extent as a result of long-term anthropogenic impact on the study area, so their physical and chemical properties changed significantly. As a result of the misuse of land for 25 years in the topsoil (0-35 cm), the amount of humus decreased by 25-30%. On the whole, the amount of total nitrogen in the 0-100 cm layer in soils is 0.10–0.15%; porosity is 45-50%. Research materials show that 34.93% of the territory is not degraded, 10.41% is slightly degraded, 26.2% is moderately degraded and 23.26% is severely degraded. The correlation between soil humus and salinity was calculated, which is $r=0.86$ (Figures 3 and 4). The composition and quantity of mineral components of drainage water used for irrigation of the region were determined. From these indicators, it is clear that the water used for irrigation is beneficial to crops and provides them with essential nutrients (Table 2).

As a result of the analysis, changes in the amount of sludge and granulometric composition indicators in different seasons of the year were determined. Several particle sizes have been identified in water used for irrigation. The study of these parameters and the use of irrigation water are of great importance for the development of agriculture. In the summer months, the amount of silt in river waters is large, and in terms of its granulometric composition, it is considered heavy granular. The amount of physical clay in autumn is high compared to other indicators, and it is considered medium clay (Figure 2). Indicators of particle size distribution were determined in water samples taken from different sections of the Kura and Araz rivers, which are the main sources of irrigation water (Figures 4(a)-(b)).

The change in the amount of humus depending on the content of absorbed bases, was determined during a full-flow soil analysis. The amount of absorbed base components in relation to the amount of humus accumulates in the soil (Figure 5). Based on the conducted research, the following results were obtained [24]. The intensive development of agriculture in the Kura-Araz plain has caused changes in natural conditions. The strong development of cotton crops has led to soil salinization. Ignoring the level of groundwater during irrigation was observed with the intensification of salinization. The dynamics of vegetation development show that the area of cultivated fields has expanded significantly and the territory has been intensively exploited. It is closely related to the relief and climatic conditions of the study area. The plain relief has led to the development of both agriculture and winter pastures. Intensive exploitation of the territory has caused microclimate and water levels in water basins to decrease. The water level in the Kura and Araz rivers has decreased. Even the riverbeds have dried up and turned into settlements. Figure 6 shows the change in the amount of carbon at a depth of 0-30 cm in different sections of the profile is shown as a percentage (Figure 6(a)). The amount of total nitrogen was calculated from the total humus and showed its change with depth (Figure 6(b)).

Increased pressure on semi-desert zones through unsystematic grazing has a negative impact on the physical and chemical parameters of soils. With excessive grazing, pasture soils degrade and negative physical effects occur in the soil cover. It has been established that the natural drainage of the Kura-Araz plain the rate is quite low. Compiled regional total according to the water balance, flows enter and leave the lowland area flows and this difference is 351 m^3 per year/ha. As a result, there was an increase in groundwater levels on irrigated lands, an increase in physical evaporation, and soil salinization.

Table 1. Seasonal change in the composition of silt (%) in canal waters

Season	Source of water samples	Humus (%)	Water-soluble humus (%)	Hygroscopic moisture	pH	Nitrogen (%)
Spring season	Main Mugan	2.33	0.046	3.26	7.4	0.16
	Lower Mugan	1.61	0.062	3.63	7.5	0.12
	Sabir	0.56	0.017	2.17	8.0	0.07
	Upper Karabagh	1.20	0.063	2.67	7.6	0.10
Autumn season	Main Mugan	1.19	0.058	3.62	7.8	0.10
	Lower Mugan	0.81	0.066	2.86	7.6	0.09
	Sabir	0.92	0.068	3.61	7.4	0.07
	Upper Karabagh	0.84	0.062	2.12	7.9	0.08

Table 2. Mineral components of some drainage waters

Components	D-5	D-9	D-45
Cl ⁻	0.094	0.133	0.144
SO ₄ ²⁻	0.53	0.57	0.57
Na ⁺	0.21	0.23	0.24
Ca ²⁺	0.040	0.005	0.004
Mg ²⁺	0.007	0.002	0.002
Total	0.881	0.94	0.96
Ca(HCO ₃) ₂	0.056	0.024	0.041
CaSO ₄	0.050	0.022	0.030
MgSO ₄	0.26	0.25	0.23
Na ₂ SO ₄	0.42	0.45	0.46
NaCl	0.13	0.17	0.92
Total	0.916	0.926	0.921

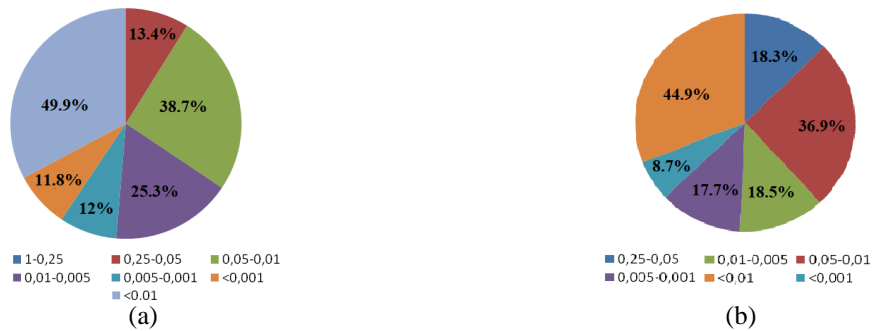


Figure 2. Granulometric composition of silt fractions of water used for irrigation in (a) spring and (b) autumn

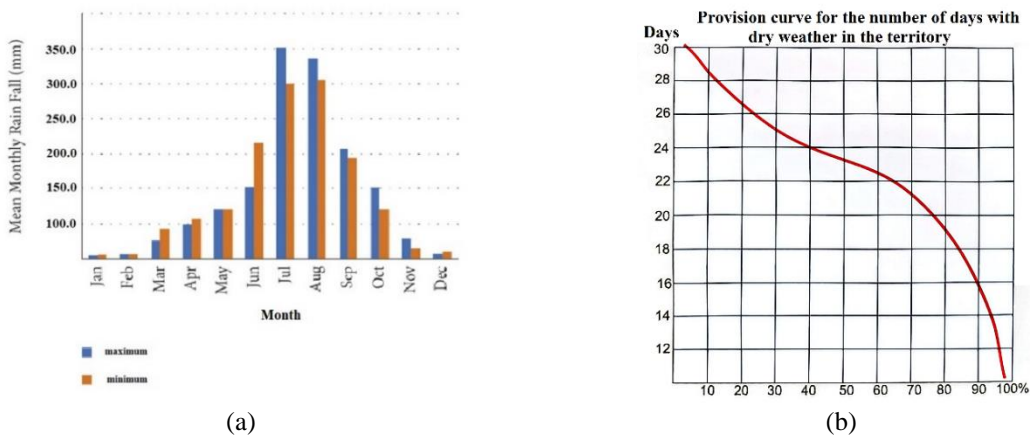


Figure 3. Monthly rainfall in the 2020-2023 year from (a) January to December and (b) Provision curve (%) for the number of days (30 days) with dry weather in the territory



Figure 4. Granulometric composition of silt fractions of waters in (a) Kura and (b) Araz river

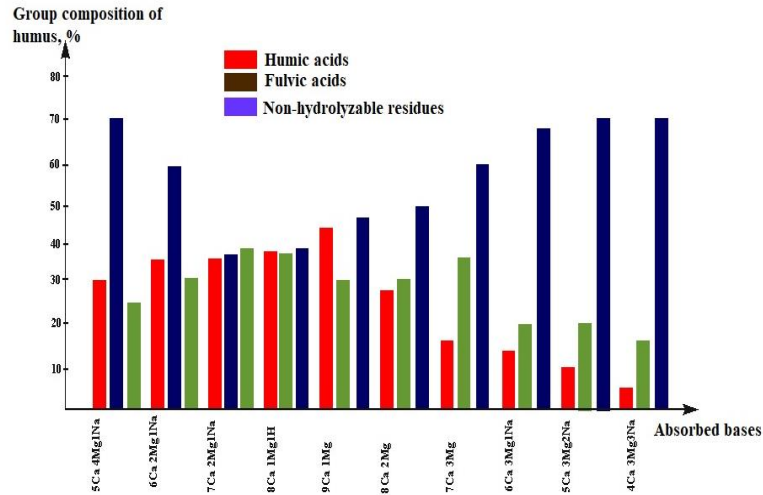


Figure 5. Dependence of the group composition of humus on absorbed bases

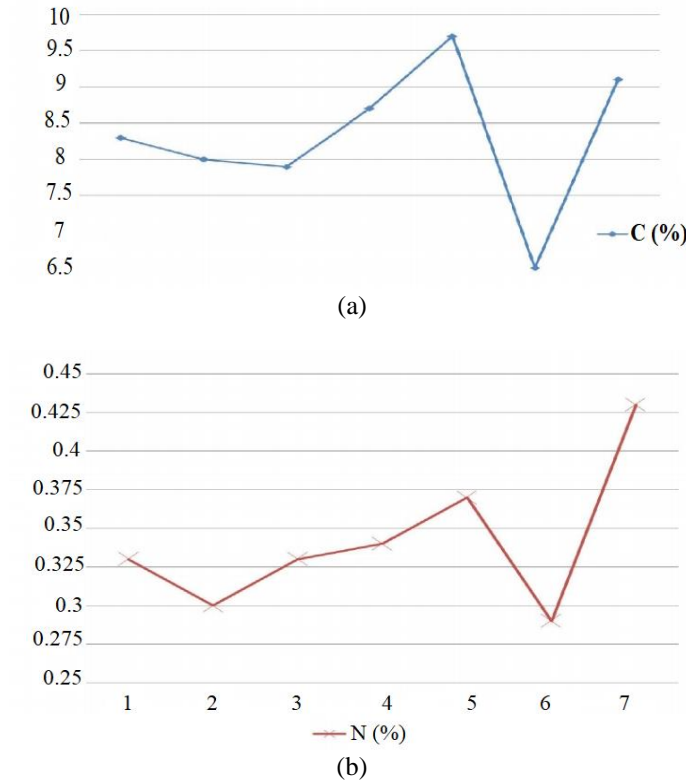


Figure 6. There are changes in the soil horizon 0-30 cm (a) organic carbon and (b) nitrogen content (%)

4. CONCLUSION

It has been established that the reclamation and ecological state of the irrigated lands of the Kura-Araz plain is unsatisfactory. $661.5 \cdot 10^3$ ha of soil were subjected to salinization to one degree or another, and $470 \cdot 10^3$ ha of land was subjected to salinization. The groundwater level was located at a depth of 5-10 meters from the surface of the earth, and in recent years it has been determined to a depth of 0-3 meters. After the operation of the collector-drainage network built on the Kura-Araz plain, the degree of groundwater mineralization has decreased by 3-4 times. By activating collector-drainage waters with a mineralization of 17.8 g-l in a magnetic field, it is possible to accelerate the removal of toxic salts, using them to flush well-

permeable soils. Thus, water for irrigation and soil washing is saved 1.8 times. As a result of research, it was established that the possibility of using water with a high degree of mineralization depends not only on the chemical composition of the water used and the degree of mineralization but also on the water-physical properties of the soil, mainly water absorption capacity, the degree of drainage of the territory, the depth and minerality of groundwater, climatic factors (precipitation, temperature), mode and method of irrigation; influenced by agrotechnical measures, biological characteristics of plants and salt tolerance. The problem of using water with a high degree of mineralization cannot be solved unambiguously. This problem must be studied in each specific natural and economic condition.




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