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STUDIES OF DIFFERENT SOIL SALINITY INDICES OBTAINED USING SATELLITE IMAGES OF KUR-ARAZ LOWLAND LANDSCAPES

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Abstract

The article presents important results of research conducted in June-September 2023-2024 on saline soils of flat landscapes of the Kura-Araz lowland. The dominant vegetation cover of the natural cenoses of the territory was studied. The development phases of various plant groups percentage of dominant and accompanied species of canopy cover calculated on transects. Based on soil samples taken from genetic layers, morphological diagnostic parameters of the soil cover were determined, the amount of mineral salts and their dependence on electrical conductivity were established. The results obtained using innovative methods are considered to be very relevant for the development of agriculture in the Republic of Azerbaijan and can be used as a source of literature.

Keywords: anthropogenic factors, saline soils, salt content, remote sensing, agrocenoses

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Introduction:

Currently, a distinction is made between primary or natural salinization and secondary or accelerated salinization due to human activity. When groundwater is close to the surface, a constant upward flow of water is formed, which, when evaporated, deposits salts in the soil. Capillary salinization of the soil occurs more intensively, the greater the evaporation, the higher the salinity of the water and the longer the evaporation process [1]. People have greatly altered almost all elements of the ecosystem as a result of their activities. After the industrial revolution, they are intensified the process of developing natural fields in order to develop agriculture, and this caused a change in the forms of ecosystems and wild nature was rapidly transformed into agricultural fields. Anthropogenic influence has also manifested itself in the process of soil formation [2]. The planning of rivers into basins, giant drainage systems have caused changes in the properties, color and thickness of soils. Controlling floods and lowering groundwater levels stabilizes the soil oxidation reduction regime, affects biological activity and development of plant root systems, which gives impetus to morphological and diagnostic changes in the soil profile [3]. Profile change and transformation also depend on land use, because land use contributes to the change of genetic horizons formed over many years, or the formation of new horizons. Rational use of soils, along with the use of preventive measures against degradation, also allows us to understand long-term changes in the study area. The study of anthropogenic impact on soil, as the main component of the environment, allows for the rational use, protection and restoration of soils [4-5].

Changes in chemical and morphological indicators of irrigated soils of the Kur-Araz lowland, under the influence of anthropogenic action were studied by M.P. Babaev and he differentiated the main anthropogenic influences. Since 1945, in connection with the development of these territories and their involvement in agriculture, research work was started and large irrigation canals were built. And this contributed to the acceleration of the re-salinization of the territory. The numerous irrigation canals and ditches that were built increased the level of groundwater. Since the groundwater in these territories has a high mineralization, evaporation contributes to the accumulation of salts in the soil surface [6-7].

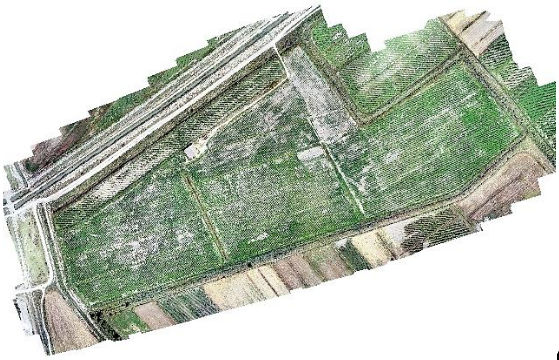
Methods:

The area under study is a long-standing irrigated part of Azerbaijan and has soils that are widely used in agriculture. For this reason, soil studies in Azerbaijan were conducted for the first time in this area [8]. To study the anthropogenic transformation process, was chosen the Ujar Experimental Station, which is located in the Kur-Araz lowland (Fig. 1). The main type of soil in these areas is irrigated meadow-gray [9]. To study the formation of diagnostic and morphological changes in soils under the influence of anthropogenic action, soil sections were made in irrigated and virgin soils in the study area and their comparative analyses were made (Fig 2). Soil samples taken from genetic layers were air-dried and sieved. Granulometric composition analysis was determined by the Pipette method. However, since these soils have high carbonate content, they were treated with $Na_2P_2O_7$ before analysis. Microaggregate composition was determined using the Kachinsky method, humus and total nitrogen according to I.V. Tyurin, total phosphorus (P_{total}) according to A.M. Meshcheryakov, assimilable phosphorus according to B.N. Machigin, water-soluble salts according to K.K. Hedroits, pH (in water) with a pH meter, absorbed Ca and Mg according to I.V. Ivanov, absorbed Na according to K.K. Hedroits. Field studies were conducted in June 2023 and 2024 in the Kur-Araz Lowland [10-12].

Results ad discussion:

Long-term anthropogenic actions have caused morphogenetic and diagnostic transformations of soils and quite pronounced changes have formed in the genetic layers of the soil profile. Anthropogenic transformation has contributed to the formation of a new type of soils [13]. Irrigated soil profiles have a gradual transition between new colors and genetic layers. The soil color (Musell Color CHART) varies within 10YR4/3-10YR3/2. In natural soils, these limits are 10YR6/2-10YR5/3. Irrigated meadow-gray soils of the study area were formed on the alluvial materials of the Kur River. These soils are irrigated by the canals of the Kur River which has high mineral and nutritional properties. The mineralization of irrigated waters is 570-890 mg/l, and the amount of water-soluble humus, during irrigation, is 32-44 mg/l. As a result of the use of these waters for irrigation of crops, the morphological and diagnostic indicators of soils have changed significantly.


A

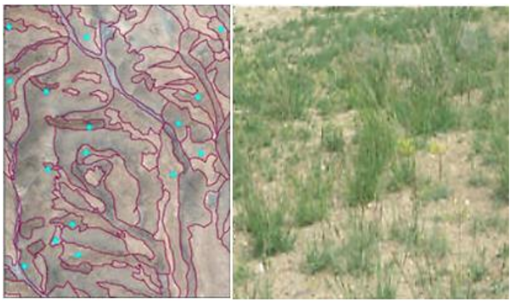

B


C

Source: by author in 2024 year

Fig. 1. Research area A - Saline soils; B - Orthophoto agrocenoces in saline areas; C - Orthophoto of selected agrocenoses in Kur-Araz lowland


A

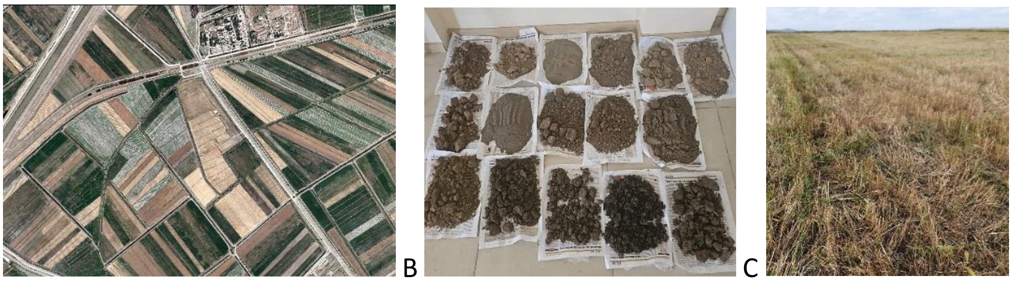

B


C


D

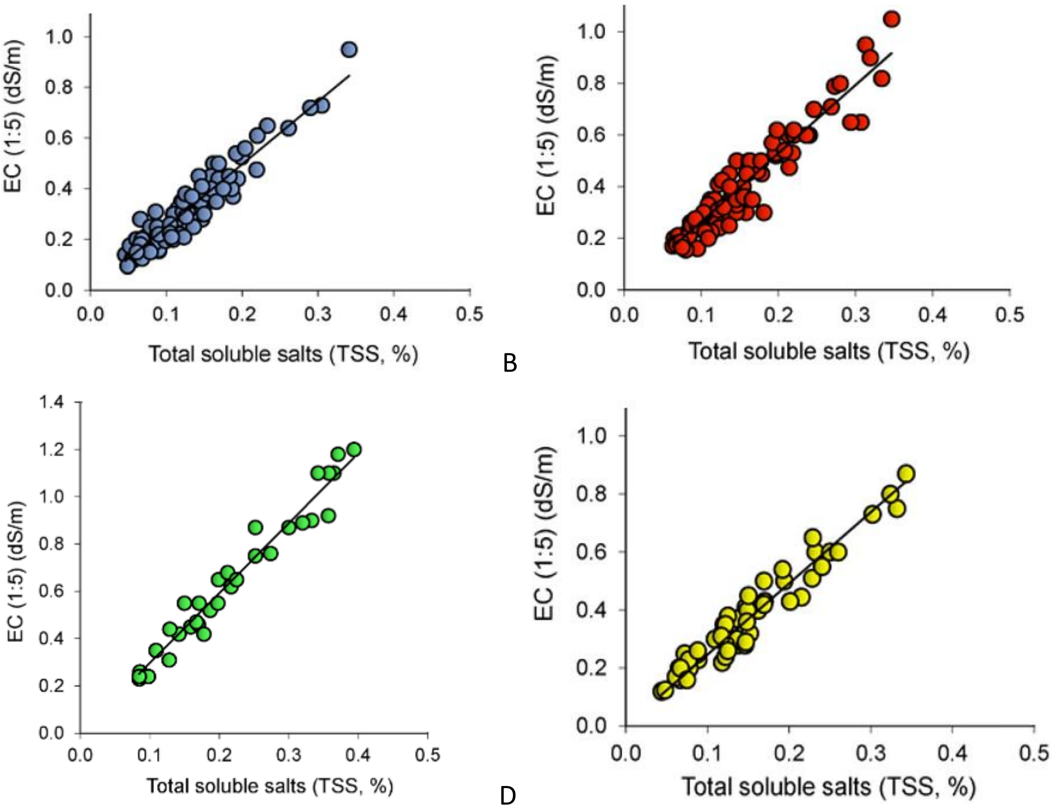
Note: A – *Astragalus verus* Olivier (23.4%) (As ve)* Accompanied species: *Scariola orientalis* Boiss. (2.5%); *Alyssum lilifolium* Steph. (2%); *Heteranthelium piliferum* Hochst. (1.8%); *Astragalus macropelmatus* Bunge. (1.3%); *Acantophyllum spinosum* C.A. Mey (0.8%). B – *Bromus tomentellus* Boiss (8.9%) (Br to)* Accompanied species: *Phlomis olivieri* Benth. (2.5%); *Stipa hohenackeriana* Rupr. (2%); *Achillea* *wilhelmisii* C. Koch. L. (1.8%); *Centaurea aucheri* Wagenitz. (1.2%); *Gypsophila struthium* (1%). C – *Scariola orientalis* Boiss. (9.25%) (Sc or)* Accompanied species: *Noaea mucronata* Forsk. (2.5%); *Polygonum aridum* Boiss. (1.5%); *Stachus inflata* Benth. (1.2%); *Tragopogon longirostis* Bischoff. (1%); *Chardinia orientalis* L. (0.5%). D – *Astragalus verus* Olivier (8.6%)* *Bromus tomentellus* Boiss. (5.4%) (As ve-Br to)* Accompanied species: *Euphorbia azerbadjhanica* Bordz. (2%); *Phlomis persica* Boiss. (1.5%); *Turginia latifolia* Hoffm. (1.5%); *Astragalus effussus* Bunge. (1.3%); *Cichorium intybus* L. (0.5%). Dominant life forms in Kur-Araz lowland A - (As ve)* *Shrub*; B - (Br to)* *Tall grass*; C - (Sc or)* *Semi shrub*; D - (As ve-Br to)* *Shrub-Tall grass*. Percentage of dominant and accompanied species of canopy cover calculated on transects

Fig. 2. The location in Google Earth images and the corresponding field photos in natural cenoses

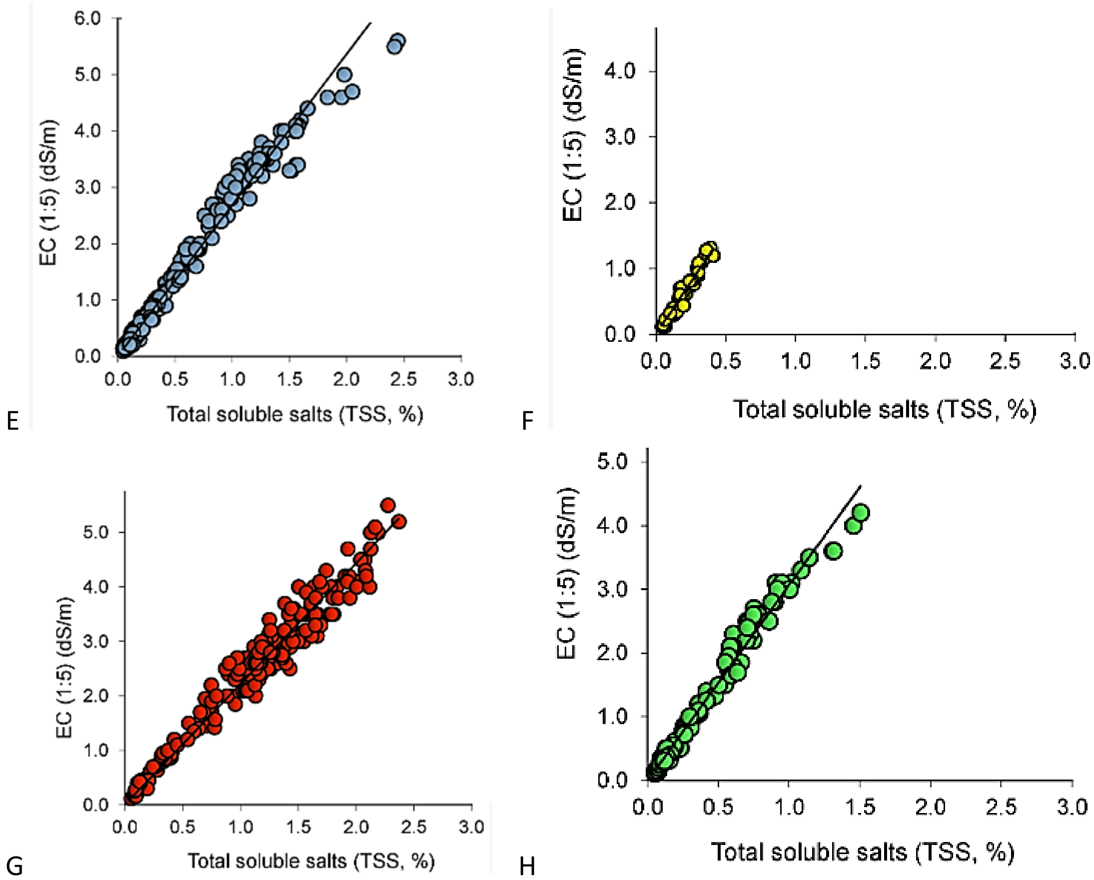


A B C

Fig. 3. Salinization soils of cultivated cenoses in Kur-Araz lowland. A - orthophoto; B - soil samples from different horizon layers; C - selected agrocenoses

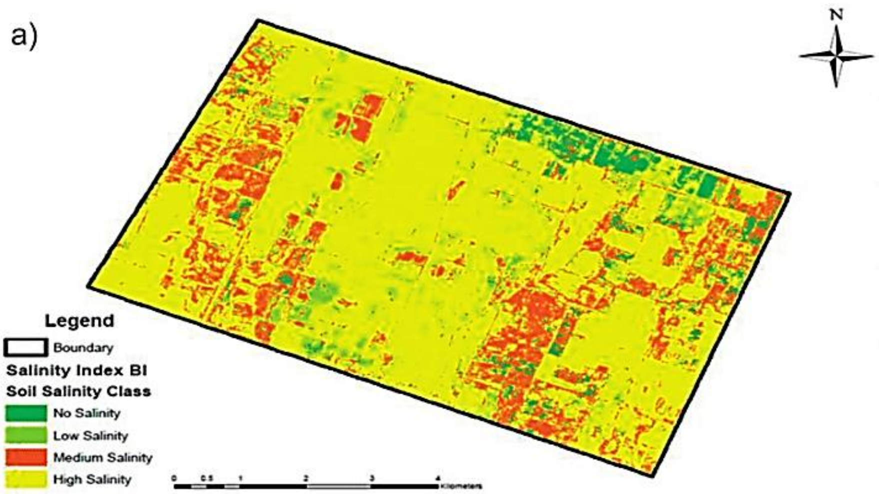


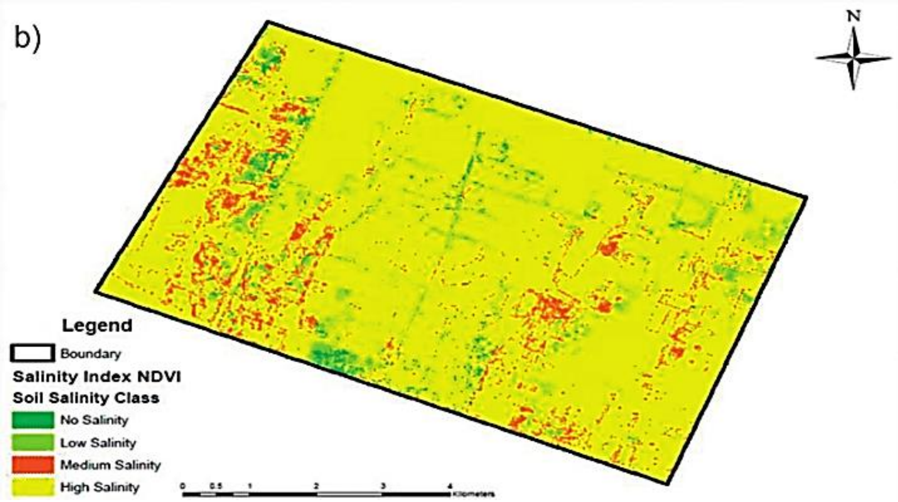
A B C D



EC 1:5, dS m^{-1} and total soluble salt content: TSS, % or g salt/100 g soil for 1:5 soil-to-water extract as affected by alkaline pH > 8.5 salinity type: (A) Sulfate-Soda (SO_4-HCO_3); (B) Soda-Sulfate (HCO_3-SO_4) ; (C) Soda-Chloride (HCO_3-Cl); (D) Chloride-Soda (Cl-HCO_3); (E) Chloride-Sulfate (Cl-SO_4); (F) Chloride (Cl); (G) Sulfate (SO_4); (H) Sulfate-Chloride (SO_4-Cl)

Fig. 4. Relationship between the electrical conductivity





Source: based on data from field survey, in May-June 2024

Fig. 5. Salinity map of the soils in the study area by the minimum distance classification method in the top indices using Landsat 8 satellite imagery in 2024 of Ujar region in Kur-Araz lowland (a) Soil Salinity Index BI and (b) NDVI (Landscapes mapping using Landsat 8 OLI data)

Conclusion:

Long-term irrigation, the use of mineral and organic fertilizers, affecting the soil-forming processes, contributed to the formation of the irrigation horizon in meadow-gray soils. The thickness of the irrigation layer, depending on the date of irrigation and the quality of irrigation waters > 50 cm. In the classification of soils of Azerbaijan, meadow-gray soils, because of anthropogenic action, are an indicator of the evolution of types of irrigated meadow-gray soils. In natural soils, gley and humus layers are clearly visible. The thickness of the humus layer is 23-30 cm. and in irrigated soils, the arable layer is clearly visible. The thickness of the humus layer is >50 cm. In natural soils, the granulometric composition is mainly clay and irrigated soils are distinguished by a variety of granulometric composition. The reason is the particles brought by irrigation water. Based on the WRB soil classification system (2014), meadow-gray soils are correlative to *Calcisols* and *Gleysols*. Taking into account the rules of soil classification in the international classification system, the transformation of the studied soil types is even better observed. Because of the conducted research, it was established that arid soils of the Kur-Araz lowland have low biological activity.

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