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## Morphological and agrochemical characteristics of irrigated meadow-grey soils in Mughan plain (Saatli district)

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### Abstract

The research is devoted to the study of the morphological and agrochemical characteristics of irrigated meadow-grey soils distributed in the Saatli district of the Mughan plain. During field studies, soil profiles were excavated, morphological descriptions were conducted across genetic horizons, and agrochemical analyses were performed under laboratory conditions. Soil samples were analyzed for particle size distribution (granulometric composition), sum of exchangeable bases, soil reaction (pH), and primary nutrients. The investigations revealed that the meadow-grey soils in the Saatli district are characterized by heavy clay and clayey textures, being both carbonated and low in humus content. Due to the influence of groundwater, signs of gleying are observed in these soils. The obtained results are of scientific and practical importance in terms for evaluating the fertility properties of irrigated meadow-grey soils and their sustainable management.

**Key words:** agrochemical indicators, fertility, irrigated soils, meadow-grey soils, morphology, Mughan plain

### Introduction

The sustainable development of agricultural production is inseparably connected with the conservation of soil resources and the maintenance of their fertility properties. In arid and semi-arid regions, long-term agricultural use, particularly under irrigated farming systems, leads to significant transformations in soil morphology and

agrochemical characteristics. Numerous studies conducted in Azerbaijan have demonstrated that irrigation practices considerably influence soil structure, salinity regime, carbonate accumulation, and humus content, often accelerating degradation processes in intensively cultivated areas (Babaev et al., 2015).

The Mughan plain is one of the most important agricultural regions of the country, where

irrigated farming constitutes the dominant land-use system. The soils of the Kura-Aras lowland, including those of the Saatli district, have been widely investigated in terms of their morphogenetic features and classification (Babayev et al., 2011; Babayev et al., 2017; Nuriyeva, 2019). These classifications have been further refined to align national soil categories with international standards (Babayev et al., 2017). These soils are formed under specific hydrothermal conditions, influenced by shallow groundwater levels, arid climate, and prolonged irrigation practices.

Among the various soil types distributed in the Mughan plain, meadow-grey soils occupy a significant position in agricultural production. Formed mainly on alluvial and alluvial-deluvial deposits, they are typically characterized by heavy clay and clayey textures, carbonate-rich parent materials, and relatively low humus reserves (Mammadov, 2007; Gashimova, 2021). The interaction between groundwater conditions and irrigation regimes frequently results in the development of gleying features and modifications in exchangeable base composition, directly affecting soil fertility indicators.

Although previous research has addressed soil classification, morphogenesis, and agrochemical properties in the Kura-Aras lowland, a comprehensive and updated evaluation of irrigated meadow-grey soils within the Saatli district remains limited (Mustafayev, 2020). In particular, the combined analysis of morphological characteristics across genetic horizons together with primary agrochemical indicators requires further systematization under current land-use conditions.

In this context, the present study focuses on the investigation of the morphological structure and primary agrochemical characteristics of irrigated meadow-grey soils distributed in the Saatli district of the Mughan plain.

## **Object and methods of research**

The research was conducted in the Saatli district of the Mil-Mughan economic region within the Mughan plain of Azerbaijan. The study area is characterized by an arid semi-desert climate and

represents a zone of intensive irrigated agriculture. Irrigated meadow-grey soils widely distributed in this region were selected as the object of investigation.

Two representative soil profiles were excavated in agricultural fields located within the Azadkend and Fatolikend municipalities. The profiles were selected to reflect typical conditions of irrigated meadow-grey soils formed under intensive agricultural use. The geographical coordinates of each profile were determined using GPS measurements, and their elevation above sea level was recorded.

Morphological descriptions were carried out directly in the field across genetic horizons in accordance with accepted soil science methodology (Babayev et al., 2011). Soil color was identified using the Munsell color chart. Horizon thickness, boundary characteristics, texture, structure, carbonate accumulations, gleying features, and visible salt traces were recorded during field observations.

Soil samples were collected from each genetic horizon, air-dried under laboratory conditions, crushed, and sieved through a 1 mm sieve prior to analysis. The granulometric composition was determined by the pipette method. Humus content was analyzed using the Tyurin method. Total nitrogen was determined according to the Kjeldahl method. Available phosphorus was measured by the Machigin method, and exchangeable potassium was determined by flame photometry. The carbon to nitrogen (C:N) ratio was calculated by dividing the organic carbon content, derived from humus values using the Bemmelen factor of 1.724, by the total nitrogen content. The sum of exchangeable bases was calculated following extraction with ammonium acetate solution. Soil reaction (pH) was measured potentiometrically in a soil-water suspension at a ratio of 1:2.5.

The analytical data were organized according to genetic horizons for subsequent presentation within the study.

## **Analysis and discussion**

The investigated area is located in the central

part of the Mughan plain within the Mil-Mughan economic region and represents a segment of the Kura-Aras lowland. The territory is characterized by flat relief conditions, arid semi-desert climate, high evaporation rates, and shallow groundwater levels. Long-term irrigation and intensive agricultural activity have significantly influenced soil-forming processes in irrigated meadow-grey soils of the studied sites.

The examined soil profiles (SR-4 – Fetelikend and SR-5 – Azadkend) were formed on alluvial-deluvial deposits. Field morphological observations indicate weak humification in surface horizons and the gradual intensification of carbonate accumulations, rust mottles, and gleying features toward deeper layers. Field morphological observations indicate weak humification in surface horizons, with colors identified as light brownish gray (10YR 6/2) and pale brown (10YR 6/3) according to the Munsell chart. These characteristics reflect the combined influence of groundwater conditions and irrigation regime.

The granulometric analysis demonstrates that both investigated profiles are characterized by heavy texture conditions. In SR-4, physical clay content ( $<0.01$  mm fraction) exceeds 60% and increases with depth, reaching more than 75% in lower horizons (Table 1). Such distribution indicates heavy clay texture and limited permeability (Table 2).

In SR-5, physical clay content varies between approximately 45–54%, corresponding to clayey and heavy loamy texture classes. Compared to SR-4, this profile exhibits relatively more balanced particle-size distribution, which may provide comparatively improved water-air regime conditions.

Humus content in both profiles shows a clear decreasing trend with depth, as presented in Table 3 and Table 4. Surface layers contain relatively higher organic matter reserves, while deeper horizons demonstrate noticeable reduction. The vertical differentiation of humus is accompanied by a similar decline in total nitrogen content, indicating the concentration of organic residues in upper layers and progressive mineralization under arid climatic conditions.

C:N ratios suggest relatively active decomposition processes and limited accumulation of stable organic matter compounds (Table 3 and Table 4). These features are typical for irrigated meadow-grey soils formed under semi-desert environments.

The results of available nitrogen, phosphorus, potassium and electrical conductivity are presented in next tables.

The distribution of available nutrients within the investigated profiles reflects the interaction between organic matter dynamics, irrigation regime, and parent material composition. As presented in Table 5 and Table 6, a pronounced vertical differentiation of available nitrogen is observed in both SR-4 and SR-5. In SR-4, nitrogen content decreases progressively from  $24.20 \text{ mg.kg}^{-1}$  in the surface horizon to  $6.03 \text{ mg.kg}^{-1}$  in the 98–130 cm layer. A comparable tendency is recorded in SR-5, where nitrogen declines from  $15.62 \text{ mg.kg}^{-1}$  to  $7.79 \text{ mg.kg}^{-1}$  along the profile.

This downward trend corresponds closely with the reduction of humus reserves, and indicates that nitrogen availability in these soils is largely controlled by organic matter content. The relatively sharp decrease in deeper horizons suggests limited biological activity and reduced accumulation of organic residues under semi-desert climatic conditions.

Available phosphorus demonstrates moderate vertical variability. In SR-4, higher phosphorus concentrations in upper horizons may be associated with fertilization practices under irrigated agriculture, while deeper layers show comparatively lower values. In SR-5, phosphorus distribution appears more stable, which may reflect differences in texture and water regime between the two profiles.

Exchangeable potassium values fluctuate within a relatively narrow range in both profiles, indicating sufficient potassium reserves. However, slight redistribution along the profile suggests ion migration processes influenced by irrigation and soil solution dynamics. Electrical conductivity values remain generally low, confirming non-saline to slightly saline conditions. Nevertheless, the gradual increase of EC in deeper layers of

**Table 1.** Granulometric composition of irrigated meadow-grey soils. SR-4 (Fetelikend)

| Depth (cm) | Physical clay (<0.01 mm, %) | Physical sand (>0.01 mm, %) | Texture class |
|------------|-----------------------------|-----------------------------|---------------|
| 0–25       | 61.35                       | 38.65                       | Heavy clay    |
| 25–50      | 64.20                       | 35.80                       | Heavy clay    |
| 50–70      | 64.50                       | 34.70                       | Heavy clay    |
| 70–98      | 76.79                       | 23.21                       | Heavy clay    |
| 98–130     | 76.30                       | 23.70                       | Heavy clay    |

**Table 2.** Granulometric composition of irrigated meadow-grey soils. SR-4 (Azadkend)

| Depth (cm) | Physical clay (<0.01 mm, %) | Physical sand (>0.01 mm, %) | Texture class |
|------------|-----------------------------|-----------------------------|---------------|
| 0–20       | 53.60                       | 46.40                       | Clayey        |
| 20–30      | 49.20                       | 50.80                       | Clayey        |
| 30–75      | 45.90                       | 54.20                       | Heavy loam    |
| 75–90      | 45.60                       | 54.40                       | Heavy loam    |
| 90–130     | 48.00                       | 52.00                       | Clayey        |

**Table 3.** Humus, total nitrogen and C:N ratio (SR-4)

| Depth (cm) | Humus (%) | Total N (%) | C:N |
|------------|-----------|-------------|-----|
| 0–25       | 1.82      | 0.15        | 7.1 |
| 25–50      | 1.45      | 0.12        | 6.8 |
| 50–70      | 1.12      | 0.10        | 6.3 |
| 70–98      | 0.78      | 0.08        | 5.5 |
| 98–130     | 0.56      | 0.06        | 4.6 |

**Table 4.** Humus, total nitrogen and C:N ratio (SR-5)

| Depth (cm) | Humus (%) | Total N (%) | C:N |
|------------|-----------|-------------|-----|
| 0–20       | 1.85      | 0.15        | 7.1 |
| 20–30      | 1.62      | 0.13        | 6.9 |
| 30–75      | 1.24      | 0.11        | 6.2 |
| 75–90      | 0.93      | 0.09        | 5.7 |
| 90–130     | 0.45      | 0.06        | 4.6 |

**Table 5.** Available N, P, K and EC in irrigated meadow-grey soils (SR-4)

| Depth (cm) | N (mg.kg <sup>-1</sup> ) | P (mg.kg <sup>-1</sup> ) | K (mg.kg <sup>-1</sup> ) | EC (dS.m <sup>-1</sup> ) |
|------------|--------------------------|--------------------------|--------------------------|--------------------------|
| 0–25       | 24.20                    | 43.69                    | 170.43                   | 0.36                     |
| 25–50      | 23.21                    | 38.07                    | 139.10                   | 0.70                     |
| 50–70      | 21.77                    | 34.16                    | 123.87                   | 0.93                     |
| 70–98      | 14.33                    | 37.61                    | 119.77                   | 1.00                     |
| 98–130     | 6.03                     | 27.77                    | 126.52                   | 1.50                     |

**Table 6.** Available N, P, K and EC in irrigated meadow-grey soils (SR-5)

| Depth (cm) | N (mg.kg <sup>-1</sup> ) | P (mg.kg <sup>-1</sup> ) | K (mg.kg <sup>-1</sup> ) | EC (dS.m <sup>-1</sup> ) |
|------------|--------------------------|--------------------------|--------------------------|--------------------------|
| 0–20       | 15.62                    | 26.78                    | 167.30                   | 0.47                     |
| 20–30      | 15.19                    | 26.16                    | 155.01                   | 0.46                     |
| 30–75      | 14.56                    | 24.47                    | 141.08                   | 0.43                     |
| 75–90      | 12.82                    | 23.14                    | 144.50                   | 0.43                     |
| 90–130     | 7.79                     | 23.10                    | 127.49                   | 0.44                     |

SR-4 indicates a tendency toward salt accumulation under prolonged irrigation, particularly in heavy-textured horizons, where permeability is limited.

**Conclusion**

1. The investigation of two representative irrigated meadow-grey soil profiles in the Saatli district revealed distinct morphological and agrochemical features, formed under arid climatic conditions, carbonate parent materials, and prolonged irrigation influence. The studied profiles are characterized by heavy clay and clayey granulometric composition developed on alluvial-deluvial sediments.
2. Morphological observations indicate weak humification in surface horizons and progressive intensification of carbonate accumulations, rust mottles, and gleying features toward deeper layers. These characteristics reflect the influence of shallow groundwater and long-term irrigation on profile differentiation.
3. The distribution of humus and total nitrogen demonstrates a clear decreasing trend with depth, indicating concentration of organic matter in upper horizons and active mineralization processes under semi-desert conditions. Available nitrogen

follows a similar pattern, while phosphorus and potassium exhibit moderate variability along the profile.

4. Exchangeable bases are dominated by calcium and magnesium ions, and soil reaction varies from weakly alkaline to alkaline. Electrical conductivity values confirm generally non-saline conditions, although a tendency toward salt accumulation in deeper horizons of SR-4 was observed. The obtained results characterize the current fertility status of the investigated profiles and reflect the combined influence of texture, irrigation regime, and hydrogeological conditions. The results demonstrate that the fertility status of irrigated meadow-grey soils in the Saatli district is shaped by the interaction of their morphological structure, agrochemical indicators, and existing hydrogeological conditions.

**Conflict of interest**

The authors declare that there is no conflict of interest regarding the publication of this paper. This research, titled “Morphological and agrochemical characteristics of irrigated meadow-grey soils in Mughan plain (Saatli district)”, was conducted without any commercial or financial relationships that could be construed as a potential conflict of

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