Taxonomic attribution of the haplic gleysols of the Azerbaijan Republic in world reference base for soil resources

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ABSTRACT

The aim of the research was to obtain new information about the genesis, status, diagnostic features, and properties of the meadow-boggy soils of the Azerbaijan Republic and to perform the taxonomic attribution of those soils in accordance with the international soil classification system in compliance with the world reference base (WRB) for soil resources. Field experiments, physical, and chemical analyses of soil samples were carried out by standard methods. The morphological properties of the meadow-boggy soils in the Greater Caucasus and Lankaran regions of Azerbaijan have been characterized. Carbonate sediments are almost always invisible in the upper layers (13.27-17.14% (No 426); 10.46-27.39% (No 5); 0.87-1.33% (No 55)). According to the humus content, they are not highly humic (1.44-1.85% (No 426); 0.90-1.58% (No 5); 3.10-3.29% (No 55) in the upper layers). The magnitude of the reaction of the soil solution varies from 8.0 to 8.5. For the first time, an attempt is made to determine the name of meadow-boggy soils in accordance with the international soil classification in compliance with the WRB 2015. The above soils are assigned to the gleysols reference soil group (RSG) with various principal and supplementary qualifiers.

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1. INTRODUCTION

Soil classification is a scientific system that groups soils according to their basic properties and allows one to determine the differences between soil types depending on their composition, structure, color, density, acidity, and other factors. Soil classification plays an important role in agronomy, ecology, geography, and other sciences related to soil science. Soil classification is of great importance in various fields of scientific and practical activities. It allows you to systematize information about soils and establish connections between them, which facilitates agricultural research, land use planning, development of agrotechnical measures, and selection of optimal crops for specific areas. Soil classification is also the basis for the development of soil protection and restoration schemes, as it allows us to determine the characteristics and vulnerability of different soil types [1]–[5].

Soil can be classified in many ways by the Unified Soil Classification System (USC), the American Association of State Highways and Transport Office System (AASHTO), and the Indian Standard Soil Classification System (ISSCS). USC system. This classification was developed by Casagrande. Initially, it was developed for airfields and later modified for the embankments. 4 major groups are there namely: coarse-grained, fine-grained, organic, peat. If the particles passing through 75 microns are >50% then coarse-grained. If the particles passing through 75 microns are <50% then fine-grained soil. Azerbaijani soils have always been at the forefront of the former Union in terms of study and research. The Azerbaijan soil classification was prepared by a genetic profile principle. The basic unit of soil classification was soil type. Later, national staff in the field of soil science were grown [4], [6]–[8].

The World Reference Base (WRB) for soil resources system is an internationally recognized soil classification system that provides a framework for organizing and classifying soils on a global scale. It was developed by the International Union of Soil Sciences (IUSS) and the International Soil Reference and Information Center (ISRIC). The WRB system aims to facilitate communication and understanding between soil scientists, researchers, and practitioners working in different countries and regions. It provides a common language and terminology for describing and categorizing soils based on their properties, formation processes, and geographic distribution [9]–[11]. Since 2002 it has been correlative to the Azerbaijan soil classification to the WRB system. Azerbaijan is a country with a museum set of soils, which is associated with its geographical position in the territory, which is in two climatic zones subboreal and subtropical [12]–[15].

In Azerbaijan, meadow-boggy soils are confined to wide deltaic depressions, low river terraces, and the periphery of coastal depressions, spread over a relatively insignificant territory in geomorphological terms. They develop in conditions of excessive moisture. Groundwater in the areas of development of meadow soils lies close to the surface (0.5-0.7 m), and in the drier months it descends from 0.1-1.5 m, and in the spring months, during the period of the flood, it curves out. In this regard, the names of the Azerbaijan-classified soils had to be redefined according to the WRB this also affected meadow-boggy soils. Meadow-boggy soils were classified under the reference group gleysols [16]–[18]. The meadow-boggy soils are mostly found in the Lankaran region and locally found in other areas (Figure 1). The object of the present study is the meadow-boggy soils of the Sheki and Astara districts of Azerbaijan at an altitude of 500-850 m above sea level.

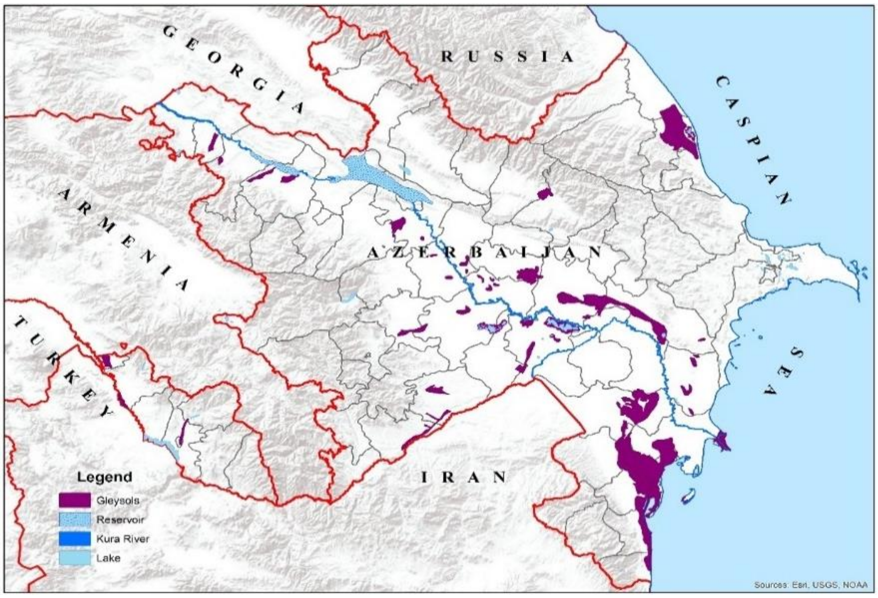

Figure 1. The area of the gleysols

2. RESEARCH METHOD

Azerbaijan is characterized by a diverse range of landforms. The country is home to the Greater Caucasus Mountains in the north, which provide a natural barrier between Azerbaijan and Russia. These mountains have peaks reaching over 4,000 meters and are a popular destination for hiking and mountaineering. In the central part of the country, there are vast plateaus and fertile valleys, including the

Kura-Araz Lowland. Azerbaijan is rich in natural resources, which play a significant role in its economy. The country has extensive oil and gas reserves, making it one of the world's leading energy producers. It also has significant mineral resources, including limestone, gypsum, and iron ore. Additionally, Azerbaijan has abundant water resources, with numerous rivers and lakes within its borders. This natural wealth has shaped the country's development and provides opportunities for industries such as energy, mining, and agriculture.

The description of the food and agriculture organization (FAO) method includes the determination of various soil horizons, such as soil profile, base, and top of the horizon, as well as their chemical, physical, and biological characteristics. This method also includes a systematic classification of soil horizons based on their common properties and differences. The description of the method is an important basis for more detailed classification and identification of soil types. The use of this method in soil taxonomy offers several advantages. First, this method provides an international standard, making it easier to compare and exchange soil resource information between different countries and regions of the world. Secondly, the method allows for a systematic description and classification of soil types, which facilitates the study and understanding of their distribution, properties, and functions. In addition, the use of this method ensures uniform terminology and categories, which helps improve the efficiency and accuracy of soil science research [19], [20]. Based on the results of the analysis of soil characteristics, the belonging of the soil to a certain class is determined. At the end of the process, the results obtained are documented. All information about the samples collected, analyses performed, and soil classification is recorded for further analysis and use. Collection and analysis of soil samples is one of the main stages of applying the FAO method in soil taxonomy. To collect samples, it is necessary to identify areas of scientific or practical interest. The results of determining the main soil characteristics are used to classify soil and make rational decisions in the field of agriculture and forestry. Soil classification using the FAO method is carried out on the basis of data obtained in the previous stages [21]–[23].

The results of the analysis of texture, structure, acidity, and nutrient content allow us to determine whether the soil belongs to a certain class. The FAO method uses an international classification system that is based on certain criteria and classification units. By classifying soil using the FAO method, experts can more accurately determine its properties and use the results to make decisions in agriculture, forestry, and conservation. Documentation of the results is the last step in applying this method in soil taxonomy. No significant differences were found in the indices of the agrophysical properties of the subsurface horizons of soils and underlying sediments. The morphological differences of haplic gleysols of a rice field from a natural cenoses area were revealed, which subsequently determined the properties of the soil cover of the Kura River delta. The basic principles of the FAO method for soils include the determination of soil fertility, and the assessment of the physical, chemical, and biological properties of the soil. Determining soil fertility allows you to assess its potential to support vegetation and produce food crops. Assessment of soil physical properties include the determination of soil texture, structure, and moisture, as well as its air and water regimes [24]–[26].

3. RESULTS AND DISCUSSION

In Azerbaijan, the meadow-boggy soils are distributed over a relatively small territory and, in geomorphological terms, are confined to wide deltaic depressions, low river terraces, and the periphery of coastal depressions. They are found in small tracts in dry and desert steppes. They develop in conditions of excessive moisture under meadow-like vegetation. Currently, the meadow-boggy soils have not been utilized and a significant part is located under pastures and fallows. A small part of the soil is used for vegetables, melons, rice, and winter grains cultures. Profile No was coded as 426 and was located in Sheki district, village Ashagi Goynik, and coordinated as $41^{0}16^{I}48.06^{II}$N, $46^{0}59^{I}01.30^{II}$E. The vegetation comprises reeds. Currently, the field is mowed.

As a result of the alternation of oxidation-reduction processes, rust, and bluish-grey predominate in the color gamut of the profile. Such colors are particularly different in the 58-87 and 148-167 cm layers (Table 1). These soils are saturated with groundwater for a long enough period. Under the creation of reducing conditions, the gleyic properties appeared. Carbonate accumulation is almost always invisible in the upper layers. Morphologically, carbonates are not visible in the wet soil condition but can be seen in the dry soil condition as the mycelium or mottles form. The amount of physical clay is 7.44-23.10%, and silty particles -38.16-50.84%. These soils have a very high content of the 0.25-0.05 mm fraction -24.94-39.70% along the entire profile (Table 2). In addition, these soils are classified as non-saline soils. The dry residue is not more than 0.3% (Table 3). The results of this assessment help to understand the extent of plant root development, soil permeability to water and air, and potential problems associated with erosion and salinity. The FAO method for soils provides an effective tool for assessing the physical properties of soil and their further use in various sectors of human activity.

Table 1. Analysis results over three years

The depth of sampling (cm)	Humus (%)	Nitrogen (%)	C:N	pH soil: water 1:5 extract	Hygroscopic water in soil (%)	$CaCO_3$ content (%)	Cation-exchange capacity (cmolc/kg) Ca^{2+}	Mg^{2+}	Na^+
Profile No. 426, Sheki district, village Ashagi Goynik									
0-24	1.85	0.15	7.1	8.3	4	13.27	7	4	0.5
24-36	1.44	0.13	6.4	8.2	3.7	16.29	15.62	7.75	0.7
36-58	1.2	0.11	6.3	8	4.6	13.72	13.25	8.25	0.6
58-87	1.12	0.1	6.4	8.1	5.1	15.39	13	8.75	0.8
87-148	0.78	0.08	5.6	8.3	4.9	17.14	14.75	8.37	0.9
148-167	0.54	0.07	4	8.1	4.6	14.57	13.12	8	0.6
167-below	0.46	0.06	4	8.4	4.9	16.72	14.75	7.12	0.7
Profile No. 5, Astara district, village Maskhan									
0-37	1.58	0.13	6.38	8.2	3.89	16.31	26.83	16.41	Undefined
37-61	0.9	0.09	5.25	8	3.15	12.15	14.98	10.4	-
61-89	0.59	0.07	4.43	8.1	3.43	10.46	18.07	10.6	-
89-102	0.46	0.06	4.03	8.3	1.44	27.39	8.94	12.62	-
102-137	0.41	0.06	3.59	8.5	10.81	1.42	39.19	35.54	-
Profile No. 55, Astara district, village Artupa									
0-28	3.29	0.24	7.2	8	Undefined	1.33	32.56	7.92	Undefined
28-61	3.1	0.23	7.08	8.1	-	1.33	25.55	10.64	-
61-84	2.46	0.19	6.8	8.1	-	0.87	21.42	12.89	-
84-105	2.38	0.18	6.94	8.2	-	0.87	15.64	21.02	-

Table 2. Composition of haplic gleysols (%)

The depth of sampling (cm)	Particle size in (mm), quantity (%) Physical sand 1–0.25	0.25–0.05	Physical clay 0.05–0.01	0.01–0.05	0.005–0.001	<0.001	Amount of granulometric texture <0.01
Profile No. 426, Sheki district, village Ashagi Goynik							
0-24	1.6	33.6	24.96	20.22	12.18	7.44	39.84
24-36	1.4	39.7	20.74	17.46	11.08	9.62	38.16
36-58	1.38	32.52	20.66	11.34	15.62	18.48	45.44
58-87	0.74	25.3	23.12	11.8	17.64	21.4	50.84
87-148	1.14	26.68	23.62	11.16	17.28	20.12	48.56
148-167	0.86	31.68	21.8	18.12	16.2	11.34	45.66
167-190	0.8	24.94	25.44	8.2	17.52	23.1	48.82
Profile No. 5, Astara district, village Maskhan							
0-37	2.84	33.96	25.2	13.6	14	5.6	38
37-61	0.36	42.84	22.8	14	14.4	10	34
61-89	0.36	16.84	24.8	16	32	14	58
89-102	1.04	13.36	23.6	16	32	20.4	62
102-137	0.41	22.39	22	16.4	18.4	12.4	55.2
Profile No. 55, Astara district, village Artupa							
0-28	0.75	37.25	16	12	18.8	15.2	46
28-61	0.74	53.26	14.8	10.8	9.6	10.8	31.2
61-84	0.7	41.7	15.6	20	12.4	9.6	42
84-105	12.96	46.24	14.4	12.4	11.2	2.8	26.4

Table 3. Water extract of different soil sections (%)

The depth of sampling (cm)	Dense residue	Dry residue	HCO_3^-	Cl^-	$SO4^{2-}$	Ca^{2+}	Mg^{2+}	Na+K
Profile No. 426, Sheki district, village Ashagi Goynik								
0-24	0.185	0.182	0.043	0.009	0.08	0.03	0.006	0.014
24-36	0.29	0.286	0.046	0.04	0.12	0.048	0.015	0.017
36-58	0.32	0.314	0.031	0.035	0.16	0.065	0.015	0.008
58-87	0.28	0.276	0.034	0.049	0.115	0.05	0.015	0.013
87-148	0.24	0.297	0.046	0.018	0.108	0.045	0.014	0.006
148-167	0.185	0.182	0.04	0.013	0.081	0.028	0.012	0.008
167-190	0.203	0.199	0.037	0.022	0.088	0.035	0.011	0.01
Profile No. 5, Astara district, village Maskhan								
0-37	0.16	0.181	0.054	0.033	0.041	0.028	0.003	0.022
37-61	0.11	0.134	0.046	0.024	0.025	0.026	0.002	0.011
61-89	0.14	0.161	0.044	0.017	0.058	0.024	0.01	0.008
89-102	0.18	0.235	0.04	0.03	0.099	0.043	0.009	0.014
Profile No. 55, Astara district, village Artupa								
0-28	0.02	0.18	0.029	0.085	0.016	0.019	0.007	0.039
28-61	0.179	0.24	0.02	0.085	0.016	0.019	0.01	0.029
61-84	0.17	0.12	0.01	0.071	0.033	0.021	0.008	0.027
84-105	0.133	0.16	0.012	0.053	0.025	0.017	0.02	0.02

Profile No was coded as 5 and was located–in Astara district, village Maskhan, and coordinated as $38^{0}55^{I}34^{II}$N, $48^{0}85^{I}93^{II}$E. The area is covered with a meadow. Groundwater stabilized at 130 cm depth (Table 4). Laboratory analysis methods play a crucial role in soil analyses within the framework of WRB. These methods allow for a comprehensive examination of various soil properties, ranging from physical to chemical characteristics. By utilizing laboratory analysis techniques, researchers can accurately determine the mineral composition, nutrient content, and pH level of soil samples. Additionally, these methods enable the assessment of soil fertility, potential contaminants, and the presence of organic matter. Through laboratory analysis, scientists can gather valuable data to aid in understanding soil quality, which ultimately assists in making informed decisions about land use, agriculture, and environmental management. The reliability and precision of laboratory analysis methods contribute significantly to the validity and effectiveness of soil analyses in the overall context of WRB. Interpreting soil analysis results plays a crucial role in the WRB. By analyzing the data obtained from soil samples, researchers can gain valuable insights into the composition and characteristics of the soil. This information is essential for various purposes, including agricultural planning, land management, and environmental monitoring. Interpreting the results allows for the identification of nutrient deficiencies or excesses, pH levels, organic matter content, and soil fertility. These findings help guide decision-making processes related to crop selection, fertilization strategies, and soil remediation techniques. Through proper interpretation of soil analysis results, professionals can optimize soil management practices and ensure sustainable land use.

Table 4. Morphological structure of the soil profile of section 426

Horizon	Depth	Description
A1	0-24	Hue 10YR 3/3 (dark brown, in wet condition), silty loamy, cloudy, soft, many reed roots, large pores, strong visible effervescence, low moist, clear smooth boundary to;
A2	24-36	Hue 10YR 3/3 (dark brown, in dry condition), silty loamy, structureless, soft, few roots, large pores, low moist, strong visible effervescence, clear smooth boundary to;
A/B	36-58	Hue 10YR 3/3 (dark brown, in dry condition), silty loamy, cloudy, soft, roots, many rusty mottles (Hue 7.5 R 4/8), signs gleying prosses, low moist, strong visible effervescence, clear wavy smooth too;
B1	58-87	Hue 10YR 3/3 (dark brown, in dry condition), granular and cloudy, firm, few roots, bluish-grey with many rusty mottles (Hue 5 B 5/1, Hue 7.5 R 4/8), carbonate mottles, carbonate mycelium, ways of plant roots, low moist, strong visible effervescence, clear smooth boundary to;
B2	87-148	Hue 10YR 3/4 (dark brown, in dry condition), silty clay loamy, structureless, firm, few roots, many rusty mottles (Hue 7.5 R 4/8), few carbonate mottles and mycelium, low moist.
B/C	148-169	Hue 10YR 4/1 (brownish grey, in dry condition), silty clay loamy, structureless, bluish-grey with many rusty mottles (Hue 5 B 5/1, Hue 7.5 R 4/8), few roots, large pores, prominent carbonate, strong visible effervescence, gradual smooth boundary to;
CL	169-below	Hue 10YR 4/2 (dark greyish brown, in dry condition), silty clay loamy, signs gleying prosses, yellowish mottles, pores, few carbonate mottles, clay-loam, alluvial, silty lake sediments, strong visible effervescence, low moist.

Currently, the meadow-boggy soils have not been utilized and a significant part is located under pastures and fallows. A small part of the soil is used for vegetables, melons, rice, and winter grains cultures. Profile No was coded as 426 and was located in Sheki district, village Ashagi Goynik, and coordinated as $41^{0}16^{I}48.06^{II}$N, $46^{0}59^{I}01.30^{II}$E. The land position is plain and flat slope. The vegetation comprises reed. Currently, the field is mowed (Table 4). As our understanding of soil properties and processes evolves, it is essential to update the classification system to reflect these advancements. By incorporating new scientific knowledge, we can improve our understanding of soil diversity and enhance our ability to make informed decisions regarding land use and management. Additionally, incorporating new scientific knowledge allows for better communication and collaboration among researchers, policymakers, and land managers, ultimately leading to more effective soil conservation and sustainable land use practices. However, this process is not without challenges, such as variations in soil properties across regions and language barriers. Overcoming these challenges will require the integration of digital soil mapping techniques, the development of standardized classification frameworks, and the continuous updates and revisions of classification systems.

4. CONCLUSION

In Azerbaijan, these soils are distributed over a small area and have very important practical significance. Taking into account their morphological features and analytical data, diagnostic horizons are identified. Associated processes were diagnosed by the presence of gleyization, the degree of humus content, cation exchange capacity, particle size distribution, and carbonate content. These two systems are commonly used in Azerbaijan for soil classification and mapping. On this basis, meadow-bog soils can be classified as gleysols according to the WRB system. In summary, the variation in soil properties across regions underscores the significance of WRB system classification. It enables a deeper understanding of soils, fosters effective communication among soil scientists and land managers, and plays a vital role in guiding sustainable land use practices and soil resource management. The importance of WRB system classification lies in overcoming language and terminology barriers. Furthermore, continuous updates and revisions of classification systems are necessary to reflect evolving scientific understanding and address emerging soil classification challenges.

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