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Biodiagnostic and Nomenclature Anthropogenic Soils of Azerbaijan

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Abstract Morphogenetic Diagnostics, Nomenclature and Classification of Azerbaijan Soils has been prepared on the basis of the newest ideas concerning the available printing and fund materials of the field, chamber, laboratorial researches in the Institute of Soil Science and Agrochemistry of ANAS. Protection and preservation of the available soils require the soil diagnostics formation which is up to the contemporary requirements. The materials concerning the soil diagnostics, nomenclature and classification constantly expand and improve. The local soil condition and individual characters are assumed as a basis by using of the ideas and principles of WRB, FAO-UNESCO schools, Russian soil science in the given Azerbaijan soil classification preparation. The soils morphogenetic structure is assumed as a main principle in Azerbaijan soil classification. The soil is classified naturally and its morphogenetic diagnostics is given. For the first time great soil taxons (soil class, section, type) and low taxons (soil subtype, sort, type, diversity, line) which are up to the international and national requirements separated and a large diagnostics has been given. Formation of the soils contemporary diagnostics and classification concerning the International standards will be basis for the preparation of the Red Book of Soils.

Keywords Biodiagnostics of Soils, Nomenclature And Classification of Soils, Soil Taxons, Protection and Preservation of the Available Soils, Anthropogenic Soils, Red Book of Soils

1. Introduction

Soil classification is necessary for scientific and applied investigations related to the assessment of land resources, the compilation of soil maps, and the adequate regulation of soil fertility. The first soil classification system for Azerbaijan was proposed by S.A. Zakharov [26] and was then considerably improved by A.N. Dimo, V.P. Smirnov-Loginov, V.R. Volobuyev, I.A. Aliyev, M.E.Salayev, and other scientists.

The systematized list of soils of Azerbaijan was an important contribution to the classification. It was compiled at the final stage of the land inventory of the republic and the compilation of the soil map of Azerbaijan on a scale of 1 : 200 000 [20].

The list of soils was discussed at the Dokuchaev Soil Science Institute of the USSR Academy of Sciences in 1966 and tested during the Transcaucasian Symposium on the Problems of Nomenclature and Classification of Transcaucasian Soils. The final version of the systematized list of soils of Azerbaijan was published in 1969 in Izvestiya AN AzSSR [1].

After that, more detailed soil system and soil nomenclatures were elaborated on the basis of a comprehensive analysis of the results of large-scale soil surveys in Azerbaijan. The new list included 1600 soil names. The names of soils of dry subtropical steppes and hydromorphic and irrigated soils of Azerbaijan were improved and added to [18].

Special studies of the energy of pedogenesis and the ecology, composition of organic matter, agrophysical characteristics, and mineralogical composition of Azerbaijan soils were conducted. In a generalized form, the results of these studies were taken into account during the preparation of the new soil classification system of the Soviet Union [8].

An improved variant of the classification of Azerbaijani soils was also developed [17]. This classification system was based on the properties and regimes of soils with due account for the soil-forming factors. It differed from the previous classification by a new ecologic-genetic concept and a more detailed system of soil taxa [1].

The classification system has been successfully used for soil investigations and mapping in Azerbaijan up to now.

At present, the development of international cooperation in different sciences, including soil science, poses the problem of the creation of a new soil classification system that should be based not only on the regional and national classification concepts but also linked with the internationally accepted soil classification systems.

We have made an attempt to elaborate a classification of

this kind.

The proposed Azerbaijani soil classification system is based on the concepts of the types of soil formation adopted in the Russian school of soil classification.

The World Reference Base for Soil Resources (WRB) [25] and the Russian Soil Classification System (Shishov and et al., 2004) are the main documents used at present for soil mapping purposec, creation of the soil information base, and soil assessment. The World Reference Base for Soil Resources [25] was developed on the basis of the legend to the FAO-UNESKO Soil Map of the World [9], and it is not a proper soil classification. It is aimed at the correlation of national soil classification systems.

The new classification of Russion soils [19] based on the soil classification system elaborated V.M. Frindland [10, 11]. In essence, it is a substantive-genetic oil classification system, i.e., it is based on the morphology and properties of soil profiles as reflecting the character of soil-forming processes. The highest levels of the classification (soil orders and soil types) are distinguished with respect to a characteristic set of interdependent genetic horizons and diagnostic soil properties formed by the particular processes [23].

Classification units are specified with respect to diagnostic soil horizons determined on the basis of their qualitative morphological and chemical characteristics. Quantitative characteristics are also used when necessary.

National and World soil classification systems are being continuously improved and refined, as well as the soil nomenclature; many countries use the soil names suggested in the most popular soil classification systems along with national, regional, and local soil names.

2. Results and Discussion

2.1. The Class Naturally Evolved Soils

Azerbaijan is characterized by a great diversity of natural and anthropogenically transformed landscapes. The vertical natural soil zonality is complicated by the agrogenic factor of soil formation. It includes forest cutting, grazing pressure, intensive land use with water and chemical amelioration, and technogenic disturbances of the soil cover.

These conditions require a new approach to soil classification [5, 6]. It is based on the concept of soil appreciation as a natural object that is constantly transformed under the impact of natural factors of pedogenesis and anthropogenic activity.

Following the modern classification of Russian soils [19], the new classification of Azerbaijan soils is based on the genetic principle with due account for soil evolution. It is developed as an open hierarchical system based on the profile-genetic concept, which makes it possible to consider both natural and anthropogenically transformed soils within the unified system of soil classification.

The new classification naturally absorbs and develops the positive features of previous soil classification systems; traditional national soil names are preserved in it.

Prior to elaboration of the new Azerbaijan soil classification system, a complete systematized list of soils was compiled on the basis of the explication to the soil map of Azerbaijan on a scale 1 : 100 000 [22], which characterizes in detail the spatial distribution of different genetic soil groups [2].

The new soil classification system includes a number of additional divisions in comparison with the previous classification [17]. In particular, the classes of anthropogenically transformed soils and technogenically disturbed soils (polluted with oil and disturbed upon mining) are included into it.

The correlation of the soil units distinguished in the new national soil classification with the soil units of international soil classification systems is important for the more efficient use of the new classification in the republic and abroad.

The taxonomic soil units are determined in terms of the characteristic morphogenetic features of the soil profile. The highest levels of the classification are soil classes and soil orders.

Soil classis is the taxonomic unit of the highest level. It is specified by the ratio between the natural and anthropogenic soil-forming processes in the soil development.

Three soil classes are distinguished: (A) naturally evolved, (B) anthropogenically transformed , and (C) technogenically disturbed soils (table 1).

Table 1. Azerbaijan Soil Classification System Anthropogenically transformed soils

No.	Type	Subtype	Profile	WRB analogues
1	2	3	4	5
		Class B: Anthropogenically transformed soils		
		Order of texture-differentiated soils		Iragric Gleyic Acrisols
1	Irrigated zheltozemic gley		AUIv-AYcIIg-A/BTg-BTfe-CL	
2	Irrigated alluvial meadow forest	1.New irrigative 2.Irrigative	AUa^{I}-AUa^{II}-Bgh-Cg AUaIvi-AUa^{II}zi-Bgh-Cg	Iragric Fluvisols Iragric Mollic Gleyic Fluvisols
		Order of humus-accumulative soils		
3	Irrigated meadow brown	Cultivated brown Cultivated chernozems	AUa^{I}-AYa^{II}zca-A/Bzvg-Bg-Cg AUa^{I}z-AYa^{II}zca-BMcavc AUa^{I}z-AYaIIvz-BTcavc-Ccas	Irragri Gleyic Kastonozems Antric Kastonozems Antric Chernozems
4	Irrigated grey-brown (chestnut)	1.New irrigative grey-brown (chestnut) 2. Irrigative grey-brown (chestnut) 3. Irrigative compact grey-brown (chestnut) 4.Cultiveted grey-brown (chestnut)	AUa^{I}-AYa^{II}-BCA-Ccs AUa^{I}z-AYa^{II}z-BCA-Ccsca AUa^{I}v-AYave-BCAvc-Ccacss AUa^{I}v-AYa^{II}z-BCAz-Cca	Irragri Coleocic Kastonozems Irragri Kcastonozems Irragric Vertic Kastonozems Antric Kastonozems
5	Irrigated meadow sierozems	1.Irrigative meadow grey 2.Irrigative compact meadow grey	AUa^{I}caz-AYa^{II}caz-BCAsg-Ccacs AUa^{I}ca-AYa^{II}cazve-BCAsve-Ccacs	Irrigri Gleyic Calsisols Irrigri Vertic Calsisols
6	Irrigated meadow	1. Irrigative taminated meadow 2. Irrigative gleyey meadow 3. Irrigative morly meadow	AUa^{I}-AYa^{II}zI-BCAIg-(Cg)-Cca AUa^{I}-AYa^{II}z-BCAgox-B/Ccagox-Cg AUa^{I}z-AYa^{II}zcs-BMLcacs-CMLca	Irrigri Fluvic Gleysols Irrigri Gleysols Irrigri Gypsic Gleysols
		Order of carbonate-accumulative soils		
7	Irrigated sierozems	1.New irrigative gray 2. Irrigative gray 3. Irrigative compact gray	AUa^{I}-AYa^{II}ca-BCgca-Cscs AUa^{I}z-AYa^{II}ca-BCAs(n)-Ccascs AUa^{I}z-AYa^{II}zca-BCAve-Ccacs	Irragri Haplic Calsisols Irragri Gypsic Calsisols Irragri Vertic Calsisols
8	Irrigated gray brown	1. New irrigative gray brown 2. Irrigative gray brown	AYa^{I}z-AYa^{II}-BCAs-Ccascs AYa^{I}z-AYa^{II}z-BCAs-Ccascs	Irragri Calsic Gypsisols Irragri Luvic Gypsisols
		Order of irrigation-accumulative soils		
9	Irrigation accumulative dry-steppe	Irrigative accumulative glayey meadow	AYa^{I}iz-AYa^{II}iz-Aa^{III}iz-Bica-Ahhd-Chhd	Irragri accumulic Anthric cumilic Kastonozems
10	Irrigation accumulative semidesert		AYa^{I}izca-AYa^{II}izca-Bicars-Ahhds-Bhhs-C/D AYa^{I}i-AYa^{II}izg-Big-Ahhzv-Bhh-C/D	Irragri accumulic Anthric Colsols Irragri accumulic Anthric Gleysols
11	Irrigation accumulative meadow	Compact irrigative accumulative meadow	AYa^{I}zi-AYa^{II}zi-BTvc-Ahh-Bhh-CD	Irragri accumulic Vertisols
		Class C: *Technogenically disturbed soils*		
		Order of technogenically disturbed soils		
12	Oil polluted	1.Mazut 2.Bitumen 3.Polluted by oily-mazut waters	Am-Ab(A)-(B)h-(C)	Oil polluting Mazut Bituminization Polluted by Tower Rocks
		Order of soils disturbed upon mining		
13	Soil-ground	1.Cutting soil-ground 2.Filling soil-ground		Cutting Soil Ground Filling Soil Ground

Note: Explanation of the indices of the soil horizons.
O - litter composed of deformed and semidecomposed plant and animal remains, sometimes with an admixture of fine earth: the thickness is 3-10 mm.
AT - Raw -humus horizon; dark brown or brown compact mixture of raw organic material with mineral soil.
AY - Light humus with a weak thin platy structure; the humus content is low (2-3%); fulvic acids predominate in the soil humus; the horizon is saturated with bases.

AU - Dark humus horizon: dark gray or dark brown, with crumb- granular structure: the humus content is about 4-7%: humate and fulvate-humate types of humus predominate; the horizon is saturated with bases and has a neutral or slightly alkaline reaction.
EL - Eluvial light - colored horizon; whitish-pate, with loose crumb structure; impoverished in clay and sesquioxides; the humus content is 1.5-2.5% with a predominance of fulvic acids.
BT - Clay-illuvial (textural) horizon; brown, with angular blocky structure; compact; clayey and iron-clayey films are seen on ped faces; the texture is heavy due to the accumulation of clay.
BM - Metamorphic horizon, brown or gray-brown, with coarse angular blocky or prismatic structure; the structure is poorly manifested in the very compact horizons; vertic features may be present; the horizon is enriched in clay and sesquioxides.
BCA - Carbonate-accumulative horizon; pale brown, with coarse angular blocky or coarse crumb structure; carbonate concentration of different morphologies (veins, nodules, soft powder, etc.) are abundant.
fe- Iron-manganic concentrations of illuval origin (typical of the BT horizon).
se- solonetzic or solonchakous pedofeatures.
v - Living parts of plants forming a dense sod mat on the soil surface.
s - Soluble salts (in the subtypes of saline soils).
g - Dove-colored and rusty spots (gley features).
ca - Accumulation of Ca and Mg carbonates, which is typical of the subtypes of chernozemic, gray-brown and sierozemic soils.
h - Buried dark brown humus horizons (the content of humate or fulvate-humate humus may be higher than in the top humus horizon).
cs - Presence of gypsum crystals.
n - Hard nodules of any composition that can be easily separated from the soil mass.
a - Anthropogenically transformed horizons.
p - Pebbles (from fine to coarse) and rock fragment in amounts of 10-15% of the horizon volume.
z - Abundant features of zoogenic activity
I - Stratified soil profile with layers of different mineralogical and textural compositions.
i - Agroirrigation sediments with poorly pronounced stratification and with gley features.
ve - Vertic properties (slickensides; high compaction in the dry state and high viscosity and stickiness in the wet state).
d - Artifacts (pieces of broken pottery brick fragments, tc)
ox - Abundant rusty spots.
L- Rock.

Soil orders include soils with similar soil-forming processes and morphology of their profile, i.e., the sequence of genetic horizon related to the environmental and anthropogenic factors of soil formation.

The class of naturally evolved soils includes all the natural soil types with similar leading soil-forming processes. The orders distinguished in this class correspond to the notions of the types of soil formation, soil associations (as suggested by Volobuev and Kovda) [13, 24], soil families (as suggested by Glazovskaya) [12], or large soil groups (as suggested by Sokolov) [21]. For creation of classification of soils we also had been used biological parameters [7, 15, 16]

The following soil orders are distinguished in the class of naturally evolved soils.

The order of soddy organic-accumulative soils includes well-drained soils with pronounced accumulation of organic matter and the formation of soddy horizons in which living or dead plant roots are abundant. The order of soddy organic-accumulative soils includes the types of mountainous meadow soils subdivided into primitive, soddy-peat, and soddy subtypes.

The order of texture-differentiated soils encompasses soils with a pronounced redistribution of mineral particles in the soil profile. Soils of this order are formed in the semihumid subtropical zone of Azerbaijan.

The order of humus-accumulative soils is relatively large; it includes the soils with active decomposition of organic matter and the formation of deep humus horizons.

The order of low-humus carbonate-accumulative soils includes the soils with a low humus content, an enrichment of the soil profile with carbonates, and accumulation of soluble salts and gypsum. *The order of metamorphic soils* includes the soils with a relatively weak differentiation of the soil profile and the formation of metamorphic horizon in the middle part of the soil profile.

The order of alluvial soils is distinguished on the floodplains in the arid and semihumid subtropical zones of Azerbaijan.

The order of halomorphic soils includes solonchaks that form complexes and combinations with dry-steppe and desert-steppe zonal soils of Azerbaijan.

2.2. The class of Anthropogenically Transformed Soils

The class B of anthropogenically transformed soils. The genetic specificity of irrigated semidesert and desert soils of Central Asia was shown by pedologits of the Dokuchaev school (Dimo, Orlov, and Rozanov). Their ideas on the genesis of irrigated soils were further developed by N.G. Minashina [14], M.P. Aranbaev [3] and others.

Soils of the dry-steppe subtropical zone in the Transcaucasian region have been irrigated for thousands of years. In Azerbaijan, they were first distinguished as a separate taxonomic unit by M.P. Babayev [4]. The area of anthropogenically transformed soils in Azerbaijan is about 2.6 million ha. Irrigation-induced changes in the air and water regimes and biological activity and the formation of a layer of agroirrigation horizons are the features that specify the separation of irrigated soils on agroirrigation deposits into the class of anthropogenically transformed soils.

Irrigation results in changes in the water, temperature, and air regimes of irrigated soils as compared with their rainfed analogues. We recognize the following stages of development of irrigated soils: (a) soils with unstable soil-forming processes in recently irrigated plots (their morphology and properties generally correspond to those of natural zonal soils), (b) soils with a stabilized regime of pedogenesis after a long-term irrigation period (their morphology and properties are strongly changed and differ considerably from natural soils and newly irrigated soils), (c)

soils in the areas of ancient agriculture (long-term irrigation with turbid river and flood water has resulted in the formation of new genetic horizons on agroirrigation deposits of 1.5-2.0 m in thickness; these are very homogeneous and highly fertile soils).

Thus, anthropogenically transformed (irrigated) soils are subdivided into the groups of newly irrigated and old-irrigated soils, and a specific group of soils on agroirrigation deposits is formed upon long-term irrigation with turbid water.

Irrigated soils are classified with respect to the duration of the irrigation, the degree of soil cultivation, and the zonal soil features. It should be noted that intensive soil management on irrigated fields attenuates the initial zonal soil differences. However, natural factors exert a certain effect on the human-controlled soil formation.

The morphogenetic classification of anthropogenically transformed soils of Azerbaijan is elaborated on the basis of data on the soil properties at different stages of the development of irrigated soils.

The class anthropogenically transformed soils is subdivided into several orders with respect to the main tendencies of the pedogenesis.

The order of texture-differentiated soils includes irrigated zheltozemic gley soils of the humid and semihumid subtropical zone of Azerbaijan; these soils are used for growing tea, vegetable, cucurbits, and cereals.

The order of alluvial soils includes irrigated alluvial meadow-forest and meadow soils.

Irrigated alluvial meadow-forest soils are widespread in tugai lowland forests that have been partly cut to free the area for crop growing. These soils are used for growing cereals, fodder crops, vegetables, and cucurbits. They are characterized by a deep dark gray cultural horizon.

The order of humus-accumulative soils includes several types of soils that have been irrigated since ancient times with artesian and water. These are irrigated meadow-cinnamonic, cinnamonic, chestnut, sierozems, and meadow-sierozems soils. The subtypes of well-cultivated (cultural) soils and irrigated soils are distinguished.

The order of carbonate-accumulative soils includes gray-brown and sierozemic soils irrigated for a long period with clear river and artesian kahriz waters. The thickness of the upper cultural (agric) horizon (Aa) in these soils reaches 40-50 cm.

The order of irrigation-accumulative soils includes soils irrigated since ancient times turbid river water. These soils are developed from thick agroirrigation deposits enriched in nutrients and soluble salts. The layer of agroirrigation deposits has an indistinct stratification, because the original stratification of the irrigation deposits was disturbed in the course of the soil cultivation; it may contain gley features. Under this layer, the profiles of buried natural or cultivated soils are found. The surface soils have completely lost the features of zonal soils and have a specific profile. Soils with a thickness of the agroirrigation deposits of 40-80 cm characterize the first stage of the human-controlled pedogenesis. Long-term irrigation results in the formation of deep uniformly colored fertile soil [4].

The types of dry-steppe irrigation-accumulative, semidesert irrigation-accumulative, gleyed irrigation-accum ulative and vertic irrigation-accumulative soils are distinguished in this order.

The class of technogenically transformed soils occupies considerable areas in Azerbaijan, especially on the Apsheron Peninsula. The class is subdivided into the orders of oil-polluted soils and soils disturbed upon mining of mineral resources.

The order of oil-polluted soils includes soils with well-pronounced features of morphological transformation of the soil profile under the impact of aggressive chemical substances (oil, gas condensate, and deep rocks). Soils of oil fields are also polluted by industrial and municipal wastes and are disturbed by trenches and pits.

The order of soils disturbed upon mining includes artificially created man-made soils, truncated soils, and landfills. At present, these specific bodies are insufficiently studied.

3. Conclusion

1) Soil taxa of the highest levels - soil classes and orders - are specified in the new classification system of Azerbaijan soils for the first time. The following taxonomic units are distinguished in this system: soil classes, orders, types, and subtypes. Three soil classes - naturally evolved, anthropogenically transformed, and technogenically disturbed soils - are recognized.
2) The class of naturally evolved soils includes all the natural soils specified with respect to the leading soil-forming processes or the types of pedogenesis; the orders of soddy organic-accumulative, texture-differentiated, humus-accumulative, low-hum us carbonate-accumulative, alluvial, and holomorphic soils are distinguished in this class.
3) The class of anthropogenically transformed soils includes the soils with considerably changed natural pedogenesis under the impact of irrigation. These soils have specific water, air, and biological regimes. In the course of long-term irrigation with turbid water, a thick layer of agroirrigation deposits is formed; the surface soil is developed from this specific and fertile substrate. The orders of texture-differentiated, alluvial, humus-accumulative, carbonate- accumulative, and irrigation-accumulative soils are distinguished in this class.
4) In this paper, the first attempt to correlate the major soil units in the national soil classification system of Azerbaijan with the soil units in the internationally recognized WRB system is made.

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