THE DIVERGENCE OF THE SYSTEM OF ASSOCIATION HORIZON NOTATION OF SOILS WIDESPREAD IN THE REPUBLIC OF MOLDOVA

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Abstract

The World Reference Base (WRB) is the international standard for the soil classification system approved by the International Union of Soil Sciences. As far as possible, diagnostic criteria are matched with those of existing systems so that correlation with national and previous international systems is as simple as possible. The WRB is not intended to replace national soil classification systems, but to be a tool for better correlation between national systems. The aim of this work is to identify and highlight the divergence of the system of notation of the association horizons of soils with similar properties or attributes spread over the territory of the Republic of Moldova. Some of which, characterized by a combination of attributes reflecting common, widespread results of soil formation processes, are thus, identified and found in the fourth edition of the WRB which was launched in 2022. Ambiguities in the notation of association horizons for soils of the Republic of Moldova, need to be correlated in a more concise way and closer to the WRB being officially recognized also by the public authorities of the country. As diagnostic materials will serve the factors that significantly influence soil formation processes based on their distinctive characteristics. This paper provides an overview of the nationally diagnosed association horizons compared to those in the world, which could be useful for students of agriculture, forestry and engineering. In this case, the proper identification and linking of diagnostic association horizons to the new World Reference Base will facilitate the national soil classification system in naming and describing soils, as well as the creation of legends for specific land use soil maps. It is hoped, that this publication will contribute to the awareness and understanding of the role of the universal soil science system for the general public and the scientific community.

Key words: Association Horizon, divergence, soil diagnostics, Republic of Moldova, World Reference Base

The first edition of the US Soil Taxonomy was published in 1975 (Soil Survey Staff, 1975) and the second in 1999 (Soil Survey Staff, 1999). The Soil Taxonomy was preceded by seven approximations, the seventh published in 1960 (Soil Survey Staff, 1960). Later, a supplement to the seventh approximation was issued (Soil Survey Staff, 1962). All these publications use the concept of diagnostic horizons, which are defined by a set of diagnostic criteria.

The first edition of the WRB (FAO, 1998) was presented at the 16th World Congress of Soil Science in 1998 in Montpellier. The second edition (IUSS Working Group WRB, 2006) was published in 2006 at the 18th World Congress of Soil Science in Philadelphia. An update was published in 2007 (IUSS Working Group WRB, 2007). The third edition (IUSS Working Group WRB, 2015) was first published in 2014 at the 20th World Soil Science Congress in Jeju and updated in 2015.

On 1 August 2022, at the World Congress of Soil Science in Glasgow, the fourth edition (IUSS Working Group WRB, 2022) was published, 24 years after the first edition, in which two new elements completed the system: I) firstly, the newly developed Field Guide which provides the necessary definitions of field characteristics and allows an accurate survey and recording of all field characteristics required for the WRB criteria; II) secondly, the horizon and layer designations allow a complete description of the soil.

By the time the American WRB program was described, long before 1899 a program in Russia was specifically mentioned. At least 124 years ago V.V. Dokuchaev and his colleagues, carried out the soil survey to improve the basis of assessment and equalization of taxes (Yarilov A.A., 1927). The first scientific version of the soil classification system developed by V.V. Dokuchaev was published in 1886. In 1962, Muir assessed the situation with regard to soil classification as follows: 'soil classification is still at an elementary stage of development'. Much time has passed since then, but it cannot be said that the

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situation has fundamentally changed. Despite the fact that during this time a lot of empirical data has been accumulated and modern computer technology has appeared and been used, the transition to a qualitatively new stage in the development of soil classification has not taken place. The problems of soil classification remain the same; they are still unsolved and relevant for discussion. The main problem is the creation of a universal (i.e. basic, unified, global, generally accepted) soil classification system. This was confirmed in 2010 at the 19th World Congress of Soil Science, where, by decision of the Council of the International Union for Soil Science, a Working Group on Universal Soil Classification was officially established (Nikiforova A.A., 2019).

Because of its ultimate effect on soil science as a whole, and eventually on all studies and soil classification, the elaboration and publication of editions using the concept of diagnostic horizons has been initiated at international level, a model that the Republic of Moldova should also follow.

MATERIAL AND METHOD

In the Republic of Moldova, under the leadership of Nicolae Dimo, various large-scale soil researches have been carried out over several decades to produce soil maps at different scales (Dimo N.A., 1958). The official Soviet soil classification was mainly used for soil mapping (Egorov *et al.*, 1977). According to V.V. Dokuchaev, the essential characteristic and diagnostic of a soil is its morphological structure on a vertical profile consisting of two main horizons and subsoil (Dokuchaev, 1948).

The classification of soils of the Republic of Moldova, was developed, discussed and adopted by the National Society of Soil Science of Moldova (Ursu A., 1997; 1999) and confirmed as an official document by the Decision of the Government of the Republic of Moldova (MO, 2004), is based on a special principle.

The system of soil classification and soil classification for improving the quality of soil research was developed at the request of the Ministry of Agriculture and Food Industry and is a more refined version of the analogue system, approved as a normative document for the General Land Cadastre by the Decision of the Government of the Republic of Moldova No. 24 of 11.01.1995 (Cerbari V., 2001).

RESULTS AND DISCUSSIONS

The former land valuation base of the 1960s lacked ecological certainty because the zonal farming systems themselves lacked a certain ecological approach. Land valuation was without agro-ecological alternatives, as were farming systems, usually unambiguous. Many land assessment materials of all levels (soil, agroclimate, rehabilitation, erosion and other thematic maps of all scales, survey data and experiments) were very limited in practice because of the extensive agrarian policy and the low technological level of agriculture. Where land evaluation requirements have increased, particularly in the rehabilitation of degraded land, there has been poor integration of evaluation decisions due to the division of specialists of different profiles (Ursu, 1994). Different aspects of the evaluation of „privatized" land have manifested themselves in particular in the replacement of land grouping by soil grouping, which has inhibited the possibility of developing a land and soil classification on the territory of the Republic of Moldova (Ursu, 1994). The higher the level of agricultural intensification and the provision of highly efficient, science-intensive agricultural technologies, the greater the requirements for the completeness and accuracy of the agricultural land value base (Ursu, 1996).

The soil classification of the Republic of Moldova was adopted by the National Soil Science Society of Moldova, which is based on a special principle (Ursu, 1997; Ursu, 1999).

At present, only one global soil classification system has been accepted by all - the World Reference Base of Soil Resources (WRB), but it is not under development for our country. There are 3 main directions in soil nomenclature, each of them based on its own system of soil diagnosis and classification:

a) Russian naturalist;

b) American (USA);

c) global (FAO/UNESCO and WRB legend).

The improved systematic list of soils in the Republic of Moldova was prepared on the basis of the Russian naturalist system of classification, with the evidence of new concepts related to soil classification and diagnosis developed in the years of A. In the Republic of Moldova, the application of the international FAO/UNESCO system for the first time was recommended by V.V. Cerbari in 2001, with symbols of the pedogenetic horizon, largely influenced by that of Russian genetic pedology.

Thus, the first edition of the WRB (FAO, 1998) was originally conceived as a framework for international interaction and communication, as an official recommended system for soil nomenclature and classification. A working group of the International Union of Soil Sciences (IUSS) collaborated with soil scientists from around the world to develop and test the WRB proposal,

which led to the publication in 1998 by FAO of the Global Reference Base for Soil Resources. It was developed by the IUSS at the 1998 World Congress of Soil Science in Montpellier, France, as a harmonised soil classification system for the 16th session. The latest version (ISRIC) of the WRB was presented at the 20th World Soil Science Congress in Jeju in 2014.

The World Soil Resources Reference Base (WRB) is an international standard for soil classification systems, endorsed by the International Union for Soil Science. It has replaced the FAO/UNESCO World Soil Map legend as the international standard. The WRB borrows heavily from modern soil classification concepts, such as soil taxonomy, the 1998 FAO soil map legend, the Soil Reference and the Russian concept. The diagnostic criteria largely correspond to those of existing systems, allowing the simplest possible attribution to previous national and international systems.

If we refer to the taxonomy and description of soil units according to the data of the recently published World Soil Resources Reference Base 2022 (IUSS, 2022), for comparison some descriptions have been reproduced in *table 1* and *2* that could be associated with the soil subtype of the Republic of Moldova.

Table 1

Specification of the symbol of Soil Resource Reference groups with list of main and additional qualifiers (IUSS, 2022, pp. 111) - as an example for Chernoziom

Key to the Reference Soil Groups	Principal qualifiers	Supplementary qualifiers
Other soils having: 1. a horizon *chernic* (***ch***)*; and 2. starting < 50 cm below the lower limit of the *mollic horizon* and, if present, above a *petrocalcic horizon*, a layer with protocalcic properties, > 5 cm thick, or a *calcic horizon*; and 3. a base saturation (with 1 M NH_4OAc - ammonium acetate, pH 7)* by > 50 % from the surface of the mineral soil to the layer with *protocalcic properties* or to the *calcic horizon* in its entirety. **CHERNOZIOM**	Petroduric/ Duric Petrocalcic Leptic Hortic Gleyic Vertic Greyzemic Luvic Calcic Cambic Skeletic Vermic Tonguic Haplic	Arenic/ Clayic/ Loamic/ Siltic Andic Aric Densic Fluvic Fractic Humic Novic Oxyaquic Pachic Pyric Raptic Salic Sodic Solimovic Sombric Stagnic Technic/ Kalaic Tephric Transportic Turbic Vitric

Note: *A *chernic horizon* (from Russian čeornyj - чёрный, black) is a relatively thick, well-structured, very dark surface horizon with high base saturation, high biota activity, and moderate to high organic matter content (pp. 40). Any *chernic horizon* also meets the criteria of a *mollic* horizon. Thus, the *mollic horizon* may extend below the *chernic horizon*. If base saturation data are not available, pH values can be used according to Annex 2 (Chapter 9.13, p. 218).

In order to express the individuality of the vertical profile, the main diagnostic characteristics of soils in the Republic of Moldova were identified. Each diagnostic sign that can be attributed to both A and B horizons is identified by a symbol. The initial soil name is based on its diagnostic characters. They condition not only the soil name, but also the taxonomic level and the general characteristic. Soil peculiarities and specificity are expressed and established only by emphasizing the interdependencies between A and B, A and C genetic horizons (Ursu, 2009).

Table 2

Symbols used for notation of association horizons (IUSS, 2022, pp. 224-226)

Symbol	Criteria	Combination with
a	Organic material in an advanced state of decomposition; after gently rubbing, ≤ one sixth of the volume (related to the fine earth plus all dead plant remnants) consists of recognizable dead plant tissues [*a* like **a**dvanced].	H, O
b	Buried horizon; first, the horizon has formed, and then, it was buried by mineral material [*b* like **b**uried].	H, O, A, E, B
c	Concretions or nodules (only used if following another suffix (k, q, v, y) that indicates the accumulated substance) [*c* like **c**oncretion].	
d	Drained [*d* like **d**rained].	H
e	Organic material in an intermediate state of decomposition; after gently rubbing, ≤ two thirds and > one sixth of the volume (related to the fine earth plus all dead plant remnants) consist of recognizable dead plant tissues [*e* like interm**e**diate].	H, O C
f	Permafrost [*f* like **f**rost].	H, O, A, E, B, C
g	Accumulation of Fe and/or Mn oxides (related to the fine earth plus accumulations of Fe and/or Mn oxides of any size and any cementation class) predominantly inside soil aggregates, if present, and loss of these oxides on aggregate surfaces (A, B, and C horizons), or loss of Fe and/or Mn by lateral subsurface flow (pale colours in ≥ 50% of the exposed area; E horizons); transport in reduced form [*g* like sta**g**nic].	A, B, C
h	Significant amount of organic matter; in A horizons at least partly modified in situ; in B horizons predominantly by illuviation; in C horizons forming part of the parent material [*h* like **h**umus].	A, B, C
i	Organic material in an initial state of decomposition; after gently rubbing, > two thirds of the volume (related to the fine earth plus all dead plant remnants) consist of recognizable dead plant tissues [*i* like **i**nitial].	H, O
k	Accumulation of secondary carbonates (related to the fine earth plus accumulations of secondary carbonates of any size and any cementation class), evident by one or both of the following: • visible even in moist state, • has a calcium carbonate equivalent of ≥ 5% higher (absolute, related to the fine earth plus accumulations of secondary carbonates of any size and any cementation class) than that of an underlying layer and no lithic discontinuity between the two layers [*k* like German **K**arbonat].	H, O, A, E, B, C
l	Accumulation of Fe and/or Mn in reduced form by upwardmoving capillary water with subsequent oxidation (related to the fine earth plus accumulations of Fe and/or Mn oxides of any size and any cementation class): accumulation predominantly at soil aggregate surfaces, if present, and reduction of these oxides inside the aggregates [*l* like capi**l**lary].	H, A, B, C
m	Pedogenic cementation in ≥ 50% of the volume (related to the whole soil); cementation class: at least moderately cemented (only used if following another suffix (k, l, q, s, v, y, z) that indicates the cementing agent) [*m* like ce**m**ented].	
n	Exchangeable sodium percentage ≥ 6% [*n* like **n**atrium].	E, B, C
o	Residual accumulation of large amounts of pedogenic oxides in strongly weathered horizons [*o* like **o**xide].	B
p	Modification by cultivation (e.g. ploughing); mineral layers are designated A, even if they belonged to another layer before cultivation [*p* like **p**lough].	H, O, A
r	Strong reduction [*r* like **r**eduction].	A, E, B, C
s	Accumulation of Fe oxides, Mn oxides and/or Al (related to the fine earth plus accumulations of Fe oxides, Mn oxides and/or Al of any size and any cementation class) by vertical illuviation processes from above [*s* like **s**esquioxide].	B, C
t	Accumulation of clay minerals by illuviation processes [*t* like German **T**on, clay].	B, C
v	Plinthite (related to the fine earth plus accumulations of Fe and/or Mn oxides of any size and any cementation class) [the suffix *v* has no connotation].	B, C
w	Formation of soil structure and/or oxides and/or clay minerals (layer silicates, allophanes and/or imogolites) [*w* like **w**eathered].	B
y	Accumulation of secondary gypsum (related to the fine earth plus accumulations of secondary gypsum of any size and any cementation class) [*y* like gypsum or Spanish **y**eso].	A, E, B, C
z	Presence of readily soluble salts [*z* like Dutch **z**out].	H, O, A, E, B, C

According to the great pedologists, such as academician A. Ursu (1999) and prof. V. Cerbari (2001) the main characters of horizons, conditioned by various genetic processes that can be used for diagnosis and nomenclature of

common soils in the Republic of Moldova are presented in table 3.

Table 3

Symbols used for notation of soil association horizons for the Republic of Moldova

(Cerbari, 2001; Ursu, 1999)

According to A. Ursu (1999)		**According to V. Cerbari (2001)**	
elluvial (*e*)	luvic, podzolite, powdered with amorphous silica dioxide, with low humus and clay mineral content	*(e)*	weak eluviation
albic (*a*)	podzolic, light grey, rich in amorphous SiO_2	-	-
illuvial (i)	brown or reddish-brown, with accumulation of clay, sescvicoxides (R_2O_3), bulbous or columnar structure	-	-
mollic (*m*)	(chernoziomic) dark grey, humified (humatic), structured (grainy), loose	(*m*)	cemented horizon, this symbol is applied in combination with another symbol designating the genesis of cementing
ocric (*o*)	greyish, with brown or yellowish (fulvous) shades, grainy structure, or small nuciform	(*o*)	weakly evolved horizon
cambic (*c*)	brown, with reddish shades, yellowish, argillaceous, differing in colour and composition from the parent rock	(*c*)	accumulation in the form of concretions, used in combination with other capital letters, showing the genesis of concretions
leachate (*l*)	without carbonates and soluble salts	(*l*)	accumulation of fresh organic material, undecomposed or very little decomposed (lithier)
carbonate (*ca*)	contains carbonates (effervescence with HCl)	(*k*)	presence or accumulation of calcium carbonates
vertic (*v*)	clayey, dark grey, sometimes with greenish nuances, with sliding faces, bulbous, or prismatic structure	(*v*)	„in-situ" argilization followed by the vertical process
solodized (*so*)	light grey, powdered with SiO_2, amorphous, weak pronounced structure	-	-
natric (alkalized) (*n*)	solonized, dark grey, columnar or bulbous structure	(*n*)	high saturation in exchangeable Na^+
salinised (*s*)	with soluble salts	(*s*)	sescvioxide accumulation
hydric (*h*)	moist, with access of moisture, aquifer (waterlogged)	(*h*)	the accumulation of humic organic substances (humus) in the mineral horizons. Horizons with humus content > 1.0% are marked with h
gleyc (*g*)	with different forms of oxidation-reduction (rusty spots, marbleization)	(*g*)	gleisation, expressed by reduction-oxidation colour spots. Gleated are considered to be horizons with a gleated section area up to 75%.
turbos (*t*)	marshy, with peat layers	(*t*)	accumulation of oriented clay by illuviation
scheletic (*sc*)	contains hard rock fragments (limestone, sandstone) > 5 %	-	-
-	-	(*f*)	an accumulation of freshly fermented, incompletely decomposed organic material in which plant debris with a characteristic structure can be recognized with the naked eye or with a magnifying glass
-	-	(*ț*)	horizon of uncultivated soil
-	-	(*p*)	the arable layers
-	-	(*z*)	accumulation of soluble salts
-	-	(*r*)	reduction horizon in which the reduction colours appear in more than 50% of the glazed area
-	-	(*y*)	gypsum accumulation
-	-	(*d*)	degraded horizon
-	-	(*b*)	buried horizon
-	-	(*w*)	„in situ" (on-site) argilization or cambic process

CONCLUSIONS

The soil association horizon scoring system discussed in the paper is dynamic and may change as new knowledge in soil science is gained. These changes concern the revision and harmonization of the divergence of the widespread soil association horizon notation system in correlation with the World Reference Base (WRB), launched in 2022. We hope that this publication will help to increase awareness and understanding of the role of the Universal Soil Science System among the general public and the scientific community in the Republic of Moldova.

We find that the notation of association horizons according to the classification rendered after Cerbari (2001) is a little closer to the World Reference Base classification, but to which adjustments are still needed.

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