Short communication

REASSESSMENT OF THE ANTHROPOGENIC SOILS CLASSIFICATION OF SLOVAKIA IN THE LIGHT OF THE NEWEST KNOWLEDGE

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Abstract

Problem of adequate and correct description and classification of anthropogenic soils occurs very often and can result in very different approaches in many countries. Two groups of anthropogenic soils (cultivated and technogenic) are the subject of our reassessment in terms of soil classification principles, distinguishing criteria, and ordination into the soil reference groups. The issue of re-evaluation of the current system of anthropogenic soils of the Morphogenetic Soil Classification (MSCS 2014) is observed in coincidence with anthropogenic Soil Reference Groups in the World Reference Base for Soil Resources (WRB 2015). Both observed groups are differentiated by cultivated horizon(s) (in the MSCS "in-situ" developed soil material) affected by permanent cultivation and by anthropogenic horizon(s) (in the MSCS "ex-situ" developed soil material) made from technical human activities. In the new prepared version of anthropogenic soil classification in Slovakia there is a need to highlight newly defined diagnostic horizons and properties including anthropogenic substrata, to facilitate better development and refinement of classification criteria. Cultivated horizon is well-known described horizon in many scientific references, and no substantial changes are required. The real problem lies in technogenic soil types and their transient subtypes. Several improvements in technogenic soil diagnostics, including a new artefact percentage proposal have been proposed, as well human transported and altered material (HTAM). Some correlations with similar systems of anthropogenic soil were made and discussed.

Keywords: anthropogenic soil classification, diagnostics, cultivated soils, technogenic soils, WRB 2015, MSCS 2014

1. INTRODUCTION

During the 20 years, there were recognized many classification systems of anthropogenic soils with different diagnostics and criterial scheme. Anthropogenic soils can be considered as the youngest and polycyclic soil group (Burghardt 2001, Burghardt *et al.* 2015). The multiple direct or indirect impact of human on soil outlined a new problem: how to classify new acquired soil properties of these soils? Despite the fact that many of the acquired soil properties as a result of anthropogenic impacts fundamentally changing the character of the original natural soil (Certini & Scalenghe 2011), the typological and classification consequences have so far been addressed carefully and slowly (Bedrna 1995, Sobocká *et al.* 2000). Several original scheme of anthropogenic soils classification systems were presented in Germany (Blume 1989, Blume & Giani 2005, Burghardt 1994, 2001, Lehmann & Stahr 2007, DBG 1998, Schleuss, Wu, Blume 1998; Burghardt *et al.* 2015, Makowsky & Schneider 2017, Meuser & Blume 2001), in Russia (Shishov *et al.* 2001, Tonkonogov & Lebedeva 1999, Stroganova, *et al.* 1998, Tonkonogov & Lebedeva 1999, Prokofyeva *et al*., 2014, Prokofyeva, Martynenko, Ivannikov 2011; Prokofyeva & Martynenko, 2017), in Poland (Charzyński *et al.* 2013, 2011, Greinert 2015, Charzynski & Hulisz 2017, Kabala *et al.* 2019), and other countries: France (Blaize 1998), USA (Soil Survey Staff 1999, Bullock & Gregory 2009, Hartman, Ammons, Hartgrove 2004, Galbraith 2018), Hungary (Puskás & Farsang 2009). In Slovakia

can be found some soil anthropogenic classification systems in Sobocká *et al.* (2000), Sobocká (2001, 2008c, 2011), Hraško *et al.* (1991), SPS, VÚPOP (2000), and Societas pedologica slovaca (2014).

Sobocká (2003) proposed to distinguish two terminological terms that have appeared in the pedological references for soils considered as affected by anthropogenic factors: anthropogenic soil and urban soil. There is a distinguishing the term "urban soils" as general terminology for soils occurring in urban, industrial, transport, mining and military areas. Recently, Charzyński *et al.* (2013) has explained the term SUITMA soils (Soil of Urban, Industrial, Traffic, Mining and Military Areas) as an abbreviation for the SUITMA Working Group in IUSS and for the general naming of these soils (Morel & Heinrich 2008, Dickinson *et al.* 2011). Within this IUSS Working Group a common publication was issued (Levin *et al.* 2017) and focusing on classification in Charzyński *et al.* (2017) as a background for new studies on urban and anthropogenic soils.

The term "anthropogenic soils" is a "*terminus technicus*" which could be used for soils classified according to anthropogenic diagnostic criteria and features (like anthropogenic parent materials, amount of artefacts, *etc.*). It means that this classification concept could be designed only for soils classified as anthropogenic soils. This means that soils have such diagnostic horizons and properties that clearly place it in the group of anthropogenic soils.

Currently, human affected soils can be distinguished into the following categories: i) soils altered by man; ii) soils transformed by man; iii) man-made soils (Burghardt 1994, Rossiter 2006, Lehmann & Stahr 2007, Hartman 2004). These categories can be identified at different taxonomic levels in various systems. Several anthropogenic soil classification systems use the scheme of natural soils, if they are in the initial stage of development e.g. Regosols, Rendzinas, in the German classification (DBG 1998) or Entisols, or Inceptisols in USDA Soil Taxonomy (Soil Survey Staff, 2019). An example of a Russian school is separation of these soils from the classification of natural soils and their naming as "technogenic surface formations" (Tonkonogov & Lebedeva 1999). Later these "soils" were incorporated into the Russian classification system (Prokofjeva *et al.* 2014). Very interesting systems for studying is a system of the French and Polish classification systems (Blaize 1998, Charzyński *et al.* 2013, 2015). Several works are dealing with urban soil characteristics, i.e. Greinert (2015), Hulisz, Charzyński, Greinert (2018), Puskás & Farsang (2009). Stroganova *et al.* (1998) works with the concept of Urbanozems as urban soil type. Rossiter (2007) had a very progressive role in creating a new soil group Technosols Group in WRB 2006 (IUSS Working Group WRB 2006).

In most cases, anthropogenic soils are differentiated by classification scheme dividing anthropogenic soils in two groups of soils, one of which represents cultivated soils and the other technogenic soils following concept of the WRB 2015 (IUSS Working Group WRB 2015). This concept was developed also in other classification systems and several correlations were made in Charzyński *et al.* (2013), Sobocká (2008a, 2008b, 2017), and others. Very useful means for soil profiles manifestation was Technogenic Soil Atlas published by Charzyński, Markiewicz & Świtoniak (2013).

Two groups of anthropogenic soils are involved in the Morphogenetic Soil Classification System of Slovakia – MSCS 2014 (Societas pedologica slovaca 2014) which follows roughly previous Slovak classification MSCS from 1991 (Hraško *et al.* 1991) and 2000 (SPS, VÚPOP 2000):

1) group of cultivated soils with two types: Kultizem and Hortizem mostly soil "*in situ*" deeply transformed by agricultural activities;
2) group of technogenic soils with two soil types: Anthrozem and Technozem mostly soils developed from human-transported and altered substrates (HTAM), i.e. *"ex-situ"* soils containing artefacts.

The latest World Reference Base for Soil Resources (IUSS Working Group WRB 2015) defines anthropogenic soils as soils with strong human influence distinguishing them on Anthrosols (soils with long and intensive agricultural use) and Technosols (soils containing significant amount of artefacts). Unlike the group of cultivated soils, the group of technogenic soils is not satisfactorily resolved respecting the existing knowledge database. There were found many different interpretations that followed relatively different classification concepts of anthropogenic horizons development.

The aim of this study is to present an innovative diagnostic aspects of anthropogenic soils especially technogenic soils as a new proposal to be used for update of the Morphogenetic Soil Classification Systems of Slovakia. For better understanding and comparison, this system allows to get closer to the World Reference Base (WRB 2015) criterial system. By a detailed study of the criterion classification features, it is possible to identify differences and derive the degree of anthropogenic influences and genesis in the soil profile.

MATERIAL AND METHODS

Nachtergaele (2005) reformulated the question "what is soil?" into the more practical question "what should a soil scientist study?" This means that the soil expert can name all the bodies on the Earth's surface that create an intersection between the atmosphere, the hydrosphere, the lithosphere, the biosphere, and the anthroposphere. WRB 2015 (IUSS Working Group WRB 2015) defines soil as "any material within 2 m of the Earth's surface that is in contact with the atmosphere excluding living organisms, areas with continuous ice not covered by other material, and water bodies deeper 2 m". The classification object of the MSCS (Societas pedologica slovaca 2014) is defined as stand-alone natural body forming in uppermost part of the Earth's crust, being in interaction zone of the lithosphere, atmosphere, hydrosphere and biosphere, with which it is in permanent material and energy exchange and can be significantly affected by anthroposphere elements (noosphere)".

The MSCS 2014 there are included two groups of anthropogenic soils that represent two entirely diverse soils: cultivated soils (Kultizem and Hortizem soil types) and technogenic soils (Anthrozem and Technozem soil types).

Cultivated soils have significant cultivated ameliorated (*kultivačný melioračný*) Akj-horizon or cultivated hortic (*kultivačný hortický*) Ako-horizon having features transformed by intensive and permanent cultivation and fertilization of originally natural soil. It is a topsoil humus horizon transformed by cultivation, fertilization or other cultivation interventions of a human with different characteristics having:

a) thickness ≥ 35 cm;
b) organic C content ≥ 0.3% (by weight);
c) possible occurrence of subsoil horizons and / or artefacts; and
d) at least one of the following characteristics:
   - cultivation characteristics (ploughing signs, homogenization of the layer, distinct to sharp transition, colour differentiated, compaction at its lower boundary), and /or
   - admixture of agrochemicals, limestone, manure and other organic-mineral fertilizing components.

Kultizems have profound transformation of the soil profile by deep tillage, trenching, cultivation, fertilizers application and other agricultural practices. All these human activities improve soil properties and increase production conditions. These soils can be identified only in agricultural land with long-term cultivation as deeply transformed soils, garden soils, or soils of special crops such as vineyards, orchards. They have got many features similar to Anthrosols in WRB 2015, but not all characteristics are refined by the same way. Similarly, in other soil classification systems this horizon is approximately described (IUSS Working Group WRB 2015, Kabala *et al.* 2019, Němeček *et al.* 2011, *etc.*).

Horizon varieties:

Kultizem (KT) has cultivated amelioration (*kultivačný melioračný*) Akm horizon having at least one of the properties d) at a depth of ≥ 35 cm:

- without other diagnostic horizons or its signs … Modal (*modálna*) (KTm)
- with signs or even with the rest of the substrate C horizon on unconsolidated silicate to carbonate sediments except to fluvial sediments … Regozemic (*regozemn*á) (KTr)
- with signs or even with the rest of the substrate C horizon on Holocene fluvial sediments … Fluvic (*fluvizemná)* (KTf)
- with signs or even with the rest of the mollic Am horizon … Chernozemic (černozemná) (KTb)

- with signs or even with the rest of the mollic Amč horizon … Phaeozemic (čiernicová) (KTč)
- with signs or even with the rest of the luvic Bt horizon … Luvic (*hnedozemná*) (KTh)
- with signs or even with the rest of the eluvial luvic El horizon above the luvic Bt horizon … Retic (*luvizemná*) (KTl)
- with signs or even with the rest of the cambic Bv horizon … Cambic (*kambizemná*) (KTk)
- with signs or even with the rest of the mottled Bg horizon … Stagnic (*pseudoglejová)* (KTg)
- with signs or even with the rest of the gleyic G horizon … Gleyic (*glejová)* (KT_G)
- with signs or even with the rest of the Salic S horizon … Salic (*slanisková*) (KTs)
- with signs or even with the rest of the Natric Bn-horizon … Sodic (*slancová*) (KTc)

Hortizem (HZ) has cultivated hortic (*kultivačný hortický*) Ako horizon having at least one of the properties (d) at a depth of ≥ 35 cm with content of SOC ≥ 1% by weight. This horizon has a colour criterion for mollic Am horizons, biological activity (coprolites, zooedaphone, *etc.*) >20% (by vol.), content of P_2O_5 in 1% citric acid >250 $mg.kg^{-1}$ and usually slightly alkaline reaction. Subtypes are characterized similarly like at Kultizems as Modal (*modálna*) (HZm), Fluvic (*fluvizemná*) (HZf), Chernozemic (černozemná) (HZb), Phaeozemic (čiernicová) (HZč), Luvic (*hnedozemná*) (HZh) Retic (*luvizemná*) (HZl), Cambic (*kambizemná*) (HZk), Stagnic (*pseudoglejová*) (HZg), Gleyic (*glejová*) (HZ_G). A comparison of Kultizems with analogues of the WRB 2006 was published in Sobocká (2008a).

Technogenic soils are perceived like man-made soils developing from human-transported and altered material (HTAM) having Anthropogenic diagnostic (*antropogénny*) Ad-horizon. This "ex-situ" material is divided in three subgroups: with natural, natural-technogenic and technogenic provenance (Sobocká *et al.* 2000), however mostly feature of artefacts presence is dominating. Their occurrence does not correspond with climatic, geologic, geomorphologic, nor pedological conditions of the site, but depends upon artificial transport and deposits of very heterogeneous substrata, having various organic matters (Cox) content and very young age (Burghardt 2001). In discussion we will focus on simplification of technogenic material following criterion WRB 2015 (IUSS Working Group WRB 2015).

Anthropogenic (*antropogénny*) Ad-horizon having:

1) Thickness of ≥ 1 cm,
2) Organic carbon content > 0.3 %,
3) Possible presence of artefacts (brick, pottery fragments, glass, plastic materials, iron, slag, coal, *etc.*).

Anthrozem (AN) has diagnostic anthropogenic initial or recultivated top horizon or subsoil anthropogenic horizon formed from the human-transported and altered material with cumulative thickness > 60 cm. HTAM are of natural and technogenic provenance containing < 40 % artefacts. Horizon subtypes are:

- with anthropogenic initial horizon) … Initial (iniciálna) (ANä);
- with mottled Bg horizon or its signs … Stagnic (pseudoglejová) (ANg)
- with gleyic reduction Gr or redox Gro horizon up to 100 cm from the surface … Gleyic (glejová) (AN_G)
- with anthropogenic recultivated horizon … Recultivated (rekultivačná) … (ANô).

Anthropogenic Initial Adi-horizon (< 10 cm) representing primitive stage of soil forming process from anthropogenic substrata. Anthropogenic recultivated Adr-horizon having evidence of recultivated measures supporting vegetation growth and can be similar to Anthroposols Reconstitués (Blaize *et al.* 1998) in which the solum must be at least 50 cm thick.

Technozem (TZ) has diagnostic anthropogenic initial or recultivated top horizon or subsoil anthropogenic horizon formed from the human-transported and altered material with cumulative thickness ≥ 60 cm. HTAM are of technogenic provenance containing > 40 % artefacts. Subtypes are characterized similarly like at Anthrozems: Initial (*iniciálna*) (TZä); Stagnic (*pseudoglejová*) (TZg); Gleyic (*glejová*) (TZ_G), and Recultivated (*rekultivačná*) (TZô).

Technozem is developed from the human transported material which origin is from the other ecological locality that adjacent area. Material can consist of various material and also by artefacts which can

be seen as the second diagnostic feature. Most of such soils are appeared in urban areas due to building activities (machinery, recultivation processes, *etc.*). In the soil survey anthropogenic transported layer is very simply recognizable in soil profile compared to natural horizons.

There is distinguished also diagnostic subsoil anthropogenic horizon (Hd) with identical characteristics such as topsoil horizon (HTAM divided in three subgroups: with natural, natural-technogenic and technogenic provenance) in the MSCS. In following discussion, we would like to explain why this subsoil horizon is not considered as diagnostic one and therefore, we make proposal for excluding this horizon from the diagnostics. In the MSCS 2014 this horizon is applied in both soil classification types (Anthrozem and Technozem).

As diagnostic features we consider:

Artefacts (h) (MSCS 2014) – solid or liquid substances in the soil that are created or modified by man as a result of industrial, construction, mining and other activities such as construction materials, glass, ceramics, rubber, plastics, metals, fly ash, petroleum products, sludge, textiles, *etc.*

Anthropogenically transported material (ATM) – human-transported and transformed material that has been displaced by human activities (using mechanized means or manually) from other source areas and forms surface horizons (in EN language HTAM). ATM does not include cases of material movements during water wind erosion, floods, natural colluvial material or natural disasters. However, it includes also cases of destruction of war zones.

The classification of anthropogenic substrata depends on kind or type of the substrata (Tab. 1). Essentially, top horizon of this material "copies" the physic-chemical and biological characteristics. In the results and discussion, we would like to simplify classification of the HTAM, i.e. to be in line with WRB 2015.

Table 1

Anthropogenic (transported) substrata = HTAM (a) (MSCS 2014)

Substrata of natural provenance, <10 % artefacts (ap):	
sand	(ap1)
loam	(ap2)
clay	(ap3)
gravel	(ap4)
loamy gravel-sand	(ap5)
stony to boulder material	(ap6)
mixed loamy-gravel-sand and stony material	(ap7)
peat and humolite material	(ap8)
Substrata of natural-technogenic provenance 10 – 40 % artefacts (az):	
tailings waste from the mining industry	(az1)
tailing waste from metallurgic industry	(az2)
mixed technologic-recultivation material	(az3)
Substrata technogenic substrata > 40 % artefacts (at):	
construction waste material (with components brick, concrete, plastic material, mortar, cement, metals, glass, pitch, *etc.*)	(at1)
ashes (product of hard coal and lignite processing, combustible waste)	(at2)
slag and cinder (iron and non-ferrous metal processing waste)	(at3)
dumping waste (with household and municipal waste components)	(at4)
sludge mud (sludge waste)	(at5)
industrial waste (waste products of the chemical, metallurgical, plastic, woodworking, dyeing, gas industries)	(at6)
biotechnological waste (composted organic waste)	(at7)

A comparison of Kultizems (MSCS 2000) with WRB 2006 analogue Anthrosols was published in Sobocká (2008a), similarly a correlation of Anthrozems and Technozems (MSCS 2000) with Technosols (WRB 2006) in Sobocká (2008b). Anthropogenic soil classification system correlation including diagnostic horizons, varieties and forms in the MSCS 2014 with WRB 2015 were published in Sobocká (2017), and in Saksa & Fulajtár (2017).

RESULTS AND DISCUSSION

Soil classification is a process (procedure) of grouping soil objects into more or less homogeneous groups, in which defined criteria are respected (Cline 1967). Definition of every taxon is mostly an intellectual act and delimitation of soil units (preferably anthropogenic) is a difficult task which cannot be solve satisfactorily. There is a need to note that taxonomy of soil types is complicated by numerous transition stages and deviations from standards (Charzyński *et al.* 2013). In the anthropogenic soil classification there are three issues which are under re-assessment in this paper:

- subsoil anthropogenic diagnostic horizon;
- artefact content for Technozems;
- new classification of the human-transported and altered material.

Also other parts of the system were reviewed and assessed.

Object of the soil classification

The latest definitions of soils in the world emphasize not only their natural nature, but also the human impact on soil as a socio-economic factor. The progressive approach has also been adopted by the latest edition of the World Reference Base (2015). It states that it has many advantages, in particular it allows to solve environmental problems in a systematic and holistic approach and prevents sterile discussions about the universality of soil definitions. Both definitions of the soil classification object include elements of anthropogenic activities and properties, although in WRB 2015 the object of classification is understood beyond the pedological classification.

Anthropogenic soil groups

In the Tab. 2 there is shown comparison of both anthropogenic soil groups (MSCS 2014 and WRB 2015.

Table 2

Anthropogenic soil groups

Definition: MSCS 2014	Definition: WRB 2015
Cultivation Soil Group: with a significant cultivation soil-forming process (*soils in-situ*)	Reference Soil Group (RSGs): soils with strong human influence
Kultizems and Hortizems: soils with a dominant cultivated ameliorated or cultivated hortic horizon transformed by intensive tillage and fertilization of originally natural soil	Anthrosols: soils with long and intensive agriculture use: principal qualifiers are: Hortic/ Hydrargic*/Irrargic*/Plaggic* /Pretic*/Terric*
Technogenic Soil Group: with soil-forming processes significantly influenced by technogenic activities of human (*soil ex si-tu*)	Reference Soil Group (RSGs): soils with strong human influence
Anthrozems and Technozems: soils with top anthropogenic horizon or subsoil anthropogenic horizon formed from anthropogenically transported materials of natural, natural-technogenic or technogenic provenance	Technosols: soils containing significant amount of artefacts (≥ 20%)
* Qualifiers do not occur in the Slovak Republic	

Similar groups of anthropogenic soils scheme can be found in other classification systems like in Kabata *et al.* (2019), Lehmann, Stahr (2007), Rossiter (2004), and Němeček *et al.* (2011). Charzynski *et al.* (2013) compared Polish technogenic soils to the WRB system. Stroganova *et al.* (1998) and Prokofyeva, Gerasimova, Bezuglova (2014) classified urban soils formerly described in another nomenclature: urbanozems, urbiquasizems, and culturozems: now are correlated with the taxa in all the trunks of the system. The accepted proposal was used for the next updated version of the new Russian soil classification system Prokofyeva *et al.* (2014).

Diagnostics of the soil types

According to the Table 2 Kultizems in the MSCS 2014 are classified as Anthrosols in the WRB (IUSS Working Group 2015) with principal qualifiers (only Hortic can be applied in Slovakia). It can be added the additional appropriate qualifiers (Fluvic, Chernic, Luvic, Calcic…). Hortizem is classified in the WRB (2015) as Hortic Anthrosols. The main qualifier Hortic means: having a Hortic horizon, which is a human-affected mineral top horizon as result of deep cultivation, intensive fertilization and/or long-term application of human-animal waste and other organic residues (e.g. manure, kitchen waste, compost) (Saksa & Fulajtár 2017).

Anthrozems (MSCS 2014) are soils with a diagnostic anthropogenic surface initial or recultivated horizon forming from mostly displaced natural or natural-technogenic materials with < 40 % artefacts. In the WRB (2015), such soils are characterized as a separate RSG – Regosol however with artefact content ≤ 20%, and without any technic material criterion limitation.

Technozems (MSCS 2014) are soils with similar characteristics as Anthrozems however the content of artefacts is > 40 %. In the WRB (2015), such soils are characterized as Technosols – soils containing a significant amount of artefacts (having > 20%) up to 100 cm from the surface or a continuous technical material or cemented reinforced layer, or a continuous permeable or impermeable building geomembrane up to 100 cm from the surface. To these subtypes can be added principal and supplementary qualifiers (Stagnic, Gleyic, Calcaric, *etc.*), and also qualifiers like Transportic with relocated material without artefacts presence or Technic qualifier with content >10% of artefacts (Saksa & Fulajtár 2017).

Artefact content for Anthrozems and Technozems

Artefacts as diagnostic material are solid or liquid substances that are (IUSS Working Group WRB 2015):

- created or substantially modified by humans as a part of an industrial or artisanal manufacturing process, or brought to the surface by human activity from a depth where they were not;
- having substantially the same properties as when first manufactured, modified or excavated.

Examples are: bricks, pottery, glass, crushed or dressed stone, industrial waste, garbage, processed oil products, mine spoil and crude oil. This definition is the same as in the MSCS 2014.

Principal issue is newly definition and distinguishing of Anthrozems and Technozems in the MSCS. In the previous classification it was based on the classification of anthropogenic substrates according to natural materials with a share of less than 10% of artefacts, natural-technogenic materials with a share of 10-40% of artefacts and technogenic materials with a share of more than 40% of artefacts. Greinert (2015) published the radioactive artefact can be less than 10 %.

This resolution makes difficult to identify individual materials, as well as the percentage of artefacts that are vague. Therefore, we decided to use the WRB system, which clearly sets the percentage of artefacts ≥ 20%, which defines Technosols and, in our case, Technozem. For the MSCS 2014 it is recommended to add another criterion: HTAM, in WRB (2015) it is a *Technic material*: having ≥ 10% (by vol., weighted average) artefacts in the upper 100 cm from the soil surface or to continuous rock or a cemented or indurated layer whichever is shallower, or having a layer ≥ 10 thick, and starting ≤ 90 cm from the surface, with ≥ 50% (by vol., weighted average) artefacts.

Correlation of both systems and new proposal of artefacts as classification criterion is shown on the Tab. 3.

Table 3
Correlation of anthropogenic soil classification types according to MSCS (2014) and WRB (2015) and proposals for change

Soil type and criterion proposals		**Soil subtype proposal**		
MSCS 2014	**WRB 2015**	**MSCS 2014**	**Translation**	**WRB 2015**
Kultizem No change	**Anthrosol No change**	modálna	Modal/Typical	Anthrosol
		regozemná	Similar to Regosol	Anthrosol (Arenic/ Clayic/ Loamic/ Siltic)
		fluvizemná	Fluvic	Anthrosol (Fluvic)
		černozemná	Chernic	Anthrosol
		čiernicová	Similar to Phaeozem	Anthrosol
		hnedozemná	Luvic	Anthrosol (Luvic)
		luvizemná	Retic	Anthrosol (Luvic)
		kambizemná	Cambic	Anthrosol (Dystric)
		pseudoglejová	Stagnic	Anthrosol (Stagnic)
		glejová	Gleyic	Anthrosol (Gleyic)
		slanisková	Salic	Anthrosol (Salic)
		slancová	Sodic	Anthrosol (Sodic)
		nasýtená*	Saturated	–
		nenasýtená*	Non-saturated	–
		karbonátová*	Calcaric	Anthrosol (Calcaric)
Hortizem No change	**Anthrosol No change**	modálna	Modal/Typical	Hortic Anthrosol
		fluvizemná	Fluvic	Hortic Anthrosol (Fluvic)
		černozemná	Chernic	Hortic Anthrosol
		čiernicová	Like Phaeozem	Hortic Anthrosol
		hnedozemná	Luvic	Hortic Anthrosol (Luvic)
		luvizemná	Retic	Hortic Anthrosol (Luvic)
		kambizemná	Cambic	Hortic Anthrosol (Dystric)
		pseudoglejová	Stagnic	Hortic Anthrosol (Stagnic)
		glejová	Gleyic	Hortic Anthrosol (Gleyic)
		nasýtená*	saturated	–
		nenasýtená*	Non-saturated	–
		karbonátová*	Calcaric	Hortic Anthrosol (Calcaric)
Anthrozem ≤ 20% artefacts and HTAM substrate	**Regosol** ≤ 20% artefacts	iniciálna	Initial	Regosol
		pseudoglejová	Stagnic	Stagnic Regosol
		glejová	Gleyic	Gleyic Regosol
		rekultivačná	Recultivated	Regosol (Humic, Relocatic)
		dystrická*	Dystric	Dystric Regosol
		nasýtená*	Saturated	Eutric Regosol
		nenasýtená*	Non-saturated	Dystric Regosol
		karbonátová*	Calcaric	Calcaric Regosol

Technozem ≥ 20% artefacts and HTAM substrate	**Technosol** ≥ 20% artefacts	iniciálna	Initial	Technosol
		pseudoglejová	Stagnic	Technosol (Stagnic)
		glejová	Gleyic	Technosol (Gleyic)
		rekultivačná	Recultivated	Technosol (, Relocatic, Humic)
		dystrická*	Dystric	–
		nasýtená*	Saturated	–
		nenasýtená*	Non-saturated	–
		karbonátová*	Calcaric	Technosol (Calcaric)
Note: * mandatory (one) variety				

Subsoil anthropogenic diagnostic horizon

The MSCS 2014 contains also subsoil diagnostic horizon Hd for identification of Anthrozems or Technozems. This diagnostic horizon has the same characteristics as the surface anthropogenic diagnostic horizon, except that HTAM has > 40% artefacts. It should be noted that the subsoil horizon of Technozem is not mentioned in any foreign literature. The only exception is the subsoil diagnostic horizon identifying paddy soils, which represents features the impact of rice paddy flooding during the growing season (Gong 1983).

For Anthrozems and Technozems in general, this horizon is debatable, as it does not involve the diagnosis of the subsoil horizon or the process through which it was formed. It is simply a technical material with a certain percentage of artefacts. According to this amount, it can be identified as Anthrozem or Technozem. That is why we propose to exclude this horizon from the database of diagnostic horizons in the MSCS 2014. If a primary cambic horizon began to form in the subsoil horizon, (e.g. from ashes) the soil type would be called Cambic.

New classification of the human-transported and altered material

Respecting above mentioned suggestions on classification of Anthrozems and Technozems we have proposed a new classification of anthropogenic material as technic (substrate) material (Tab. 4).

Table 4

New proposal for the Human-transported and altered material (HTAM) classification

Substrata of natural-technogenic provenance ≥ 20% artefacts (ap):	
sand	(ap1)
loam	(ap2)
clay	(ap3)
gravel	(ap4)
loamy gravel-sand	(ap5)
stony to boulder material	(ap6)
mixed loamy-gravel-sand and stony material	(ap7)
peat and humolite material	(ap8)
Substrata of natural-technogenic provenance ≥ 20% artefacts (at):	
tailings waste from the mining industry	(at1)
tailing waste from metallurgic industry	(at2)
mixed technologic-recultivation material	(at3)
construction waste material (with components brick, concrete, plastic material, mortar, cement, metals, glass, pitch, *etc.*)	(at4)
ashes (product of hard coal and lignite processing, combustible waste)	(at5)

slag and cinder (iron and non-ferrous metal processing waste)	(at6)
dumping waste (with household and municipal waste components)	(at7)
sludge mud (sludge waste)	(at8)
industrial waste (waste products of the chemical, metallurgical, plastic, woodworking, dyeing, gas industries)	(at9)
biotechnological waste (composted organic waste)	(at10)

This means that we have introduced a new classification scheme for anthropogenic substrates, which is simplified and allows for a more flexible estimation of the percentage of artefacts in HTAM. This approach can be considered in line with some other anthropogenic soil classification (Charzyński *et al.* 2013, Kabala *et al.* 2019, IUSS Working Group WRB 2007, 2015, Němeček *et al.* 2011).

Issues on parent material introduced into Technosol system described Bragina & Gerasimova (2017). These soil and soil-like bodies are usually young formations with poorly formed and/or thin genetic horizons. Nevertheless, criteria used for developed soil horizons are applied for such formation with weak manifestation of pedogenesis, and non-convention features of substrata. When features of pedogenesis permit to refer to soil, and how we can be separate soils, pre-soils or non-soils? Boundaries are unclear but primitive stage of horizon development can be seen in other soil types (Arenosols, Pelosols, *etc.*). Therefore, this anthropogenic substrata system deserves further research.

CONCLUSIONS

Transformation of soils, progress in soil science and changing socio-economic conditions are major driving forces for the changes in soil classification, if the classification is to be understood as a modern reflection of current knowledge about soils and their functions. Predominantly anthropogenic soils and their classification is an issue learning in more-less successful however, the lack of knowledge in this area, especially the soil survey, description and evaluation are the subject of various speculations or inaccurate inclusion in the classification system. This was a reason to simplify the system for surveyors in order to obtain reliable data on these soils. Of course, research in this area does not end there, and we expect new findings, studies or databases to help better understand these soils.

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