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5-7 December 2016

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Programme

Monday (5 December 2016)		
Start	**End**	
07:30	08:00	Bus ride to UFS
08:00	08:30	Welcome remarks (Danie Vermeulen) & Housekeeping (Cornie)
08:30	09:00	Guy Smith Award / International Soil Day
09:00	09:30	An international system of soil horizon nomenclature (Monger C; Anjos LHC; Zhang G; Goryachkin SV; Harms B; Schad P; Fox C; Yeon-kyu S)
09:30	10:00	How informative are soil names in WRB? The role of a strong versus a flat hierarchy (Schad P)
10:00	10:30	Tea
10:30	10:55	Major steps in classifying soils – from genetic to numerical (Michéli E; Láng V; Owens PR; McBratney A; Hempel J)
10:55	11:20	Evaluation of automated mapping of Reference Soil Groups of WRB2015 at the global level (Mantel S; Caspari T; Kempen B; Schad P; Eberhardt E)
11:20	11:45	Automated derivation of soil names according to WRB 2015 – lessons learnt and further development (Eberhardt E; Schad P; Mantel S; Caspari T)
11:45	12:10	WRB 2014 Spanish translation: experience and challenges in the process (Chávez S; Manríquez FJ; Cruz CO)
12:10	12:35	National and international soil classification systems: a complementary approach for overcoming the current needs and challenges. The case of the Belgium soil map. (Legrain X; Dondeyne S; Colinet G)
12:35	13:30	Lunch
13:30	13:55	Fundamental changes to Soil Taxonomy (Galbraith J; Stolt M; Needelman B; Beaudette D; Monger C; O'Geen A; Rabenhorst M; Ransom M; Shaw J; Drohan P; Lindbo D)
13:55	14:20	Keeping science in Soil Taxonomy (Lindbo D; Monger C; Scheffe K; Levin M; Stolt M)
14:20	14:45	Soil Taxonomy proposals for acid sulfate soils and subaqueous soils (Wessel B; Levin M; Fanning D; Rabenhorst M)
14:45	15:15	Tea
15:15	15:40	Transfer function in soil classification (Khitrov NB)
15:40	16:05	The value of soil morphological data in pedotranfer functions (Van Tol JJ; Le Roux PAL)
16:05	16:30	A brief history of the D-horizon; archaic or commendable? (Harms B)
16:30	19:15	Cocktail
20:30		Bus ride to Bain's Lodge

Tuesday (6 December 2016)		
Start	**End**	
07:30	08:00	Bus ride to UFS
08:00	08:25	Systems approach for universal soil classification (Nikiforova A; Fleis M; Borisov M)
08:25	08:50	The use of soil functional groups as a classification approach for landscape level mapping and evaluation. (Botha JO; Mitchell FJ)
08:50	09:15	Whole regolith pedology classification: examples from Brazil (Jérôme J; De Azevedo AC; Santos RA; Dondeyne S)
09:15	09:40	Soil classification and ecosystem services: the necessity for including soil degradation in WRB (Krasilnikov PV; Nachtergaele FO)
09:40	10:05	Application of VIS-NIR reflectance spectroscopy as a tool of soil classification (Csorba A; Szegi TA; Dobos E; Michéli E)
10:05	10:45	Tea
10:45	11:10	How garden soils become Hortic Anthrosols? (Charzyński P; Hulisz P; Kim K-H; Bechet B; Szolnoki Z; Farsang A)
11:10	11:35	Towards simpler and coherent classification of anthropogenic soils: comparison of phosphorus tests for diagnostic soil horizons and properties (Kabala C; Galka B; Labaz B)
11:35	12:00	Pedogenic processes in mine tailings - a myth or reality (Van Deventer PW; Koch J)
12:00	12:25	Oxidation illuviation and accumulation of uranium in anthropogenic soils - motivation for the inclusion of radioactivity as a family criteria in the South-African taxonomic classification system (Koch J; Van Deventer PW)
12:25	13:25	Lunch
13:25	16:55	Business Meetings
16:55	20:25	Gala dinner
21:15		Bus ride to Bain's Lodge

Wednesday (7 December 2016)		
Start	**End**	
07:30	08:00	Bus ride to UFS
08:00	08:25	Classification of soils of the Eastern slope of Mount Kenya region (Mutuma E; Lang V; Csorba A; Nagy J; Michéli E)
08:25	08:50	Spodosols in Brazil: characteristics and pedogenesis environments (De Menezes AR; Fontana A; Anjos LHC)
08:50	09:15	Soil development in non-volcanic andic soils (Bäumler R)
09:15	09:40	Proposal of colluvial soils definition and their introduction into international soil classification WRB. (Zádorová T; Penížek V)
09:40	10:20	Tea
10:20	10:45	A morpho-functional classification of organic and organic-mineral soil horizons for surveying soil biological functioning (Zanella A; Ponge J-F)
10:45	11:10	Quantitative pedology to evaluate a soil profile collection from Brazilian semiarid region (Pinheiro HSK; Anjos LHC; Xavier PA; Silva Chagas C; Carvalho Junior; W)
11:10	11:35	Lateral Transport in Stagnosol Landscapes and Horizontal Horizon Sequences. (Herrmann L; Jahn R; Stahr K)
11:35	12:00	Soil classification issues relating to pedons with clay illuviation from Poland. (Świtoniak M; Charzyński P; Kabała C)
12:00	13:00	Closure / Bus ride to airport

Posters
A hierarchical soil-landscape classification and associated maps (Nikiforova A; Fleis M; Borisov M)
Andosols and problems of their classification in Central European conditions (Kobza J)
Anthropogenic Soils in Soil Taxonomy (Galbraith JM)
Classification problems of intensively cultivated sandy soils in the World Reference Base for Soil Resources (Fodor H; Csenki S; Szegi T; Láng V; Michéli E)
Educational role of IT resources in Soil Classification Teaching (Charzyński P; Świtoniak M)
Predictive value of soil classification in southeast Nigeria (Ukaegbu EP; Ezeaku PI; Jidere CM)
Proposal to Use the International Soil Judging Contests (Brazil 2018) to test compare and vet our international classification systems and field nomenclature (Levin MJ; Galbraith JM; Monger C)
Stockpiled soils on South African coal mines within the South African Anthrosol concept (Paterson DG)
Study on the Classification of Soil Containing Artifacts (Wu kening; Gao xiaochen)
Testing WRB 2014 on subalpine soils influenced by touristic induced erosion (Drewnik M; Musielok L; Stolarczyk M; Predki R)
WRB and soils of Bosnia and Herzegovina (Tunguz V; Nesic L; Vasin J)
WRB classification of Technosols developed from ashes derived after bituminous coal and lignite combustion: examples from Poland (Uzarowicz Ł; Zagórski Z)

Contents

Soil development in non-volcanic andic soils

Bäumler R

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Numerous soils have been described at sites of various bioclimatic zones and parent materials having andic and partly spodic properties, but have been developed in non-volcanic and commonly non-allophanic materials, and lacking visible Podzol eluvial and illuvial horizons. They are either assigned to Andisols/Andosols, Podzols/Spodosols or andic Inceptisols in WRB and Soil Taxonomy. The aim of this presentation is to give an overview about the properties and processes of soil formation described so far to stimulate the discussion about their position in the world of soils.

Analytical results indicate advanced soil development with high amounts of oxidic Fe and Al compounds, commonly thixotropic features of subsoil B horizons, and a dominance of Al-hydroxy-interlayered 2:1 clay minerals. Sand fractions consist of micro-aggregates of clay and fine silt particles highly resistant to dispersion. Column experiments indicate podzolization dynamics with mobilization and translocation of DOC, Fe and Al inducing the high SOM contents in subsoil horizons. Radiocarbon ages of SOM are high in subsoil B horizons (up to 16 ka BP; KI-4987), which are subject to recent biogenic processes. 13C NMR spectroscopy of the SOM, 14C ages, and column experiments indicate re-stabilization of DOM against biodecay despite recent rooting, successive biodegradation, and rejuvenation processes in a leaching environment. These soils appear to have andic and spodic characteristics, but commonly fail sole diagnostic features of Andosols/Andisols and Podzols/Spodosols, i.e. no visible E horizon or the amount of Al_o+½Fe_o.

Almost all sites therefore appear to merge soil forming conditions favorable to andosolization and/or podzolization, i.e. moderate or cooler temperatures and high humidity, high input of organic material, good drainage, and weathering conditions or weatherability of the parent materials providing a fast release of metal cations, forming metal-organic compounds and most probably also acting as binding cations to form pseudosand-like micro-aggregates that may also cause thixotropy. Commonly these soils appear not to dry out at all despite the fact that some of the studied sites have monsoon climate with a dry season (Bäumler, 2015).

Soil development aspects might be frequent freeze-thaw cycles during the cold periods (J. Galbraith, 2003, pers. comm.), and a major role of iron shown by EDX element mapping of the micro-aggregate surfaces having high contents of evenly distributed Fe (Bäumler et al., 2004). It indicates a stronger influence of Fe compounds, as previously thought, which might be named "ferro-andic" properties. Another aspect might be the addition of airborne, fine-grained sediments independent of the driving forces and the source either volcanic or non-volcanic, and providing the basis for the specific soil physical and chemical properties.

A re-definition of the current classification is suggested. These soils need to be further investigated as hitherto existing results may indicate that they are different from Andosols and Podzols in a narrow sense.

Keywords: andic properties; Andosol; ferro-andic; non-volcanic

References:

Bäumler R., Caspari Th., Totsche K.U., Tshering Dorji, Chencho Norbu & I. Baillie (2005): Andic properties in soils developed from non-volcanic materials in Central Bhutan. Journal of Plant Nutrition and Soil Science, 168, 703-713.

Bäumler R. (2015): Soils. In: G. Miehe, C.A. Pendry & R. Chaudhary (eds.), Nepal: an introduction to the natural history, ecology and human environment in the Himalayas – A companion to the Flora of Nepal. The Royal Botanical Garden Edinburgh, ISBN 978-1-910877-02-9, Pages 125-134.

The use of soil functional groups as a classification approach for landscape level mapping and evaluation

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Soil classification systems as the basis for evaluating land for various land uses have received greater attention as pressure on natural resources from a growing global population has increased. In addition, competing land uses such as mining, housing and conservation, have led to rapid changes in legislation and policy in an attempt to preserve and protect agricultural land for food production. Soil scientists and land use planners are currently facing an enormous challenge to accurately determine and spatially depict land production potential at landscape level so as to recommend both appropriate land use (farming system) and sustainable land use management practices. Traditionally, soil classification surveys to soil form and family level achieve empirical point data which is extrapolated to a soil map, the scale of mapping being determined by the initial objective. To determine whether a land portion should be retained for food production or released for non-agricultural land use, information is generally required at landscape (whole farm) rather than field (precision farming) level. In addition, a farm level plan must result in the achievement of practical management units for whole farm operations. For this reason, a detailed soil classification map may be impractical to implement as a land use decision tool, since it could contain too many mapping units per unit area. The interpretation and grouping of soil physical properties into functional units or ecotopes, with similar production potential and management requirements, can be of greater value to land use planners than individual soil forms. To achieve an ecotope map, soils of similar physical properties, rather than soil form, are assigned to one functional group or ecotope. This could result in soils of the same classification form eg. Glenrosa or Cartref falling into two functional groups of widely varying production potential, based on the inherent differences in soil profile properties. Thus, the variation in properties of soils within a functional group would be significantly less than that between functional groups, in terms of production potential and management practices. Detailed soil classification information remains the base data layer; it must be robust, accurate and reproducible within each functional unit and typical of the area and localized terrain so as to be truly representative of the landscape. This is especially so in more geologically and topographically complex landscapes, which would require careful placement and a greater number of survey points. The ecotope approach, as described in the KwaZulu-Natal Bioresource Programme, has defined soil functional groups, based on soil profile production characteristics, and is widely used to inform land use decisions and agricultural development applications at landscape level.

Keywords: soil classification, landscape, soil functional groups, high value land

References:

Camp, K.G.T. 1999. *Guide to the use of the Bioresource Programme*. Cedara Report No N/A/99/1. KZN Department of Agriculture. Pietermaritzburg, South Africa.

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Smith, B. 2006. *The Farming Handbook*. Pages 34-52. University of KwaZulu-Natal Press, Pietermaritzburg, South Africa.

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Educational role of IT resources in soil classification teaching

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Globalization and global environmental issues, as well as unification of scientific researches and teaching on EU level necessitate harmonization and correlation of technical languages, such as the one used in soil science. Despite the passage of years and the development of unified European system of soil description it is still not used in a satisfactory manner among teaching staff at EU universities. National bias in soil teaching still dominates and seriously complicates exchange of information and teaching process. Existing national or cross-border projects are limited either territorially or as a result of the use of national methods of description and classification. International projects overcome these limitations but usually refer to one or a few selected environmental aspects. Another drawback of these projects from didactical point of view is a typical scientific approach, which results in a low availability of raw data and complicated manner of their presentation. Therefore, they are nearly useless for teaching purposes.

The Freely Accessible Central European Soil (FACES) project will create a student fieldwork manual, course curriculum and soil database of Central Europe, covering the Poland, Czech Republic, Slovakia, Hungary, Slovenia, Lithuania, Latvia and Estonia with possibility to extend the coverage of created database to other countries. The product will be extensive and offered in unified format. Moreover it will be user-friendly. International system of the characteristics of soils adopted by the FAO will be used for the presentation of the data. Interpretation of the origin and systematic position of soils will be based on the international classification of soils World Reference Base for Soil Resources (IUSS Working Group WRB 2015). Development of extensive database applying the new version is thus essential from didactic point of view. Project will allow to prepare state of the art teaching resources, to be up-to-date didactical tools for many years.

On the basis of obtained field and laboratory soil data will be prepared online database and chapters for soil atlases in which soils will be presented in context of V. V. Dokuchaev words from 1898 "Soil is the mirror of landscapes" (Świtoniak & Charzyński 2014). There are also planned two summer schools. These meetings will take place in 2017 (Lithuania) and 2018 (North Poland). The main objectives of these activities will be testing and evaluation of pilot educational module.

Elaborated data base (and other outcomes) will be freely accessible as a web site throughout European Union and whole world as well. The obtained product, due to its modern form should be powerful tool in teaching at universities. It will also improve cooperation between European institutions dealing with soil science, environmental issues, geoinformation systems etc. The use of developed product will be resulting in raising of theoretical and practical qualifications and skills of students and soil science professionals.

Open-access materials elaborated during the project (field manual for students, database, visualization of soilscapes – spherical panoramas, soil atlases, Lingua Franca for European soils curriculum) will be available to download as pdf's from project website.

Keywords: WRB; teaching; soil classification education; soil database

References:

IUSS Working Group WRB. 2015. World Reference Base for Soil Resources 2014, update 2015. International soil classification system for naming soils and creating legends for soil maps. World Soil Resources Reports No. 106. FAO, Rome.

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WRB 2014 Spanish translation: experience and challenges in the process

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In this paper we present our experience as soil scientists in Mexico when translating the World Reference Base for soil resources 2014 Update 2015 draft to Spanish working together as a team, and the challenges and problematic we faced during the process. It took almost ten months, three soil scientists and uncountable work hours to achieve the draft that was sent to the WRB board, who polished it in order to obtain the document we have available today.

The translation work was not an easy task, given that it involves the challenge of reproducing the message in the original language to the target language, in the most reliable and accurate way possible, so that it is understandable and useful to all Spanish speaking soil scientists in their field work. It is not only translating concepts and ideas, but trying to homologate terms in a language that is spoken in more than 20 countries in the world. It was necessary to have not only the acquaintanceship of both languages, but knowledge in the subject, complemented by the team member's experience, and the competence to write in our mother tongue. We believe that achieving conceptual equivalence between two languages presents some complications when the subject paper is not in the scientist's first language.

It is important to mention that we did not start working from ground zero, there was a previous document in Spanish from the WRB 2006 edition by Dra. Mabel Susana Pazos, and we used it as a basis for continuing the translation work.

As expected, we incurred into several common errors during the process when translating a scientific text, which were identified and corrected in most cases. Some of these common mistakes were the use of English words into Spanish, use and abuse of gerunds, using very long phrases and syntax order. Fortunately, there was a great revision work and support from the WRB board in order to correct these details, and also the final review and edition by Dr. Roque Ortiz from Spain, resulting in the final document.

One of the major challenges was the strict use of soil names and qualifiers in the original language, and the specified sequence of qualifiers, according to the rules. We were not used to using the terms in the original language, and translating the text respecting these restrictions turned out to be a very interesting task.

In the end, it was an enriching experience, and we learned a lot from the newest version of the WRB on the progress. We appreciate the constant assistance from the WRB board President Peter Schad, who was available for questions and advice at all times, as well as our fellow soil specialists in Mexico, for their constant support.

Keywords: translation; Spanish; English

How garden soils become Hortic Anthrosols?

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The hortic horizon results from transformation of any natural A horizon upon gardening practices. Changes in soil properties are caused by deep cultivation, intensive fertilization and/or long-continued application of animal and eventually human waste and other organic residues (IUSS Working Group WRB 2015).

This paper is aimed to evaluate how long horticultural practices should take place to transform humus horizon into hortic horizon (as defined in WRB classification) and thus primary soil into Hortic Anthrosol.

In total 134 samples were collected from garden soils in 4 countries: South Korea, Poland, France and Hungary (Tab. 1). All analyses necessary to identify the hortic horizon according to WRB criteria were performed.

Table 1. Characteristics of the studied garden soils

Country	Number of samples	Duration of horticultural practices	Percentage of A horizons fulfilling all *hortic* criteria
Korea	70	3-30 years	30%
Poland	33	35-80 years	15%
France	24	16-85 years	21%
Hungary	7	circa 50 years	29%

The obtained data demonstrated that different criteria were not fulfilled in particular countries. In Korean and French samples most problematic was the colour and in some cases OC content while in Polish and Hungarian ones it was phosphorus content. These soil parameters didn't show the correlation with the duration of cultivation.

As a result, only 25% of all researched soils could be classified as Hortic Anthrosols (Tab. 1). It can suggest that the duration of horticultural practices is probably not a crucial factor in the development of hortic horizon. The inherited features of original soils may be of key importance.

Keywords: WRB; soil classification; garden soils, Hortic Anthrosols, phosphorus

References:

IUSS Working Group WRB. 2015. World Reference Base for Soil Resources 2014, update 2015. International soil classification system for naming soils and creating legends for soil maps. World Soil Resources Reports No. 106. FAO, Rome.

Educational role of IT resources in soil classification teaching

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Application of VIS-NIR reflectance spectroscopy as a tool of soil classification

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In this study the application of visible and near-infrared (vis-NIR) reflectance spectroscopy in soil characterization and classification is demonstrated. The objectives of this work were to evaluate the applicability of the vis-NIR spectral measurements 1.) for profile characterization 2.) to determine and visualize the similarity between the studied soils 3.) for definition of classification units (diagnostic elements and reference soil groups of the World Reference Base for Soil Resources (WRB).

For the spectral measurements samples were collected from thirteen soil profiles in fixed depth intervals. For reference laboratory (organic carbon, $CaCO_3$ and clay content) measurements samples from genetic horizons were collected.

To estimate the reference soil parameters in the fixed depth intervals mass preserving spline function was fitted on the reference dataset. To reduce the high dimensionality of the spectral dataset Principal Component Analysis was performed. The PC scores were used as variables describing the spectral diversity of the soils. To test the "profile description ability" of the spectral dataset Fuzzy C-means clustering was performed on the matrix of the PC factors scores. The resulting fuzzy membership values and the "spline estimated" reference values were plotted against the depth. The distribution of cluster membership values show similarity with the distribution of laboratory reference data, and the main horizons can be identified.

To determine the taxonomic relationships of the profiles Euclidean distance values were calculated using the PC factor scores as profile descriptor variables. PCA was performed on the similarity matrix to visualize the taxonomic relationships. The resulting patterns were compared to the WRB classification determined for the profiles.

The results show that the distribution of the Fuzzy C-means membership values of the Clusters A and B along the profile is in good correlation with the distribution of organic carbon and $CaCO_3$ content, respectively. The Cluster C was related to the clay increase. The Euclidean distance measurements and the PCA performed on the similarity matrix show clear separation of the selected soil classes.

Keywords:
vis-NIR spectroscopy, taxonomic distance, World Reference Base, diagnostics

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Hartemink, A.E., Minasny, B. (2014) Towards digital soil morphometrics. Geoderma. 230-231. 305-317.

IUSS Working Group WRB (2015) World Reference Base for Soil Resources 2014, update 2015. World Soil Resources Reports No. 106. FAO, Rome

Spodosols in Brazil: characteristics and pedogenesis environments

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Spodosols soil order is defined in the Brazilian Soil Classification System (SiBCS) by the presence of a spodic horizon, which is characterized by illuvial organic matter accumulation, combined or not with aluminum, with or without iron, and forming complex with the organic matter (Santos et al., 2013). The Spodosols occur in specific environmental conditions in Brazil such as: low lands in the Amazon basin, in the coastal tablelands, and along the sandbank coastal fringe ("restinga"), and are associated, respectively, to vegetation locally known as "*campinarana*", "*muçununga*" and "*restinga*", the same name as the environment. These vegetations are characterized by sparse occurrence of trees with lianas, bushes and grasses, with variable density of the plant groups according to the environments. The Spodosols are also registered in *Pantanal* region and in some high altitude mountain ranges of Brazil. The objective of this study was to assess the variations in attributes used to define Spodosols, and to relate their pedogenesis in different Brazilian conditions. From data in the literature, morphological, physical and chemical characteristics of profiles classified as Spodosols (SiBCS), and general identification of their environment, were organized in a spread sheet. The spodic horizons analytical data presented in this work are: granulometry, pH, organic carbon, sum of bases and base saturation. Other results, such as iron and aluminum, were available for a few profiles. The spodic horizons had predominance of sand fraction in all regions of Brazil, and the sand content was the most expressive in the *restinga*, which showed a median value of 110 g kg^{-1} for coarse sand and 787g kg^{-1} for fine sand. The coarse sand fraction was dominant for spodic horizons from the Amazon basin, the high altitude mountain ranges and *Pantanal*; and the fine sand in coastal tablelands and *restinga* environments. This reflects variations in the parent materials (rocks or sediments) in these areas. The spodic horizons from high altitude showed slightly higher clay content, average and median of 108 and 105 g kg^{-1}, and the coastal tableland soils had more silt (average of 140 g kg^{-1}). For all the environments, except for *Pantanal*, values of average and median for pH were 4.5 and 4.0, for sum of bases 0.2 and 0.7 g kg^{-1}, and the base saturation 2.0 and 14%. There was wide amplitude of organic carbon content, but the average values were: 13.9 g kg^{-1} for Amazon basin soils, 26.8 g kg^{-1} in the high altitude regions, and 16.9 g kg^{-1} in the *restinga*; and the median values were of 12.0, 11.0 and 11.7 g kg^{-1}, respectively. The coastal tableland Spodosols showed higher organic carbon average and median, 21.1 g $kg^{-1}$and 17.9 g kg^{-1} correspondingly. The spodic horizons from *Pantanal* showed values of pH, sum of bases, base saturation, and organic carbon very distinct from all the other environments studied. Their average and median values were respectively: for pH, 7.1 and 6.9; sum of bases, 2.5 and 1.9 $cmol_c$ kg^{-1};base saturation, 60 and 68%; organic carbon, 2.5 and 1.9 g kg^{-1}. In general, the spodic horizons formed in the Brazilian tropical and subtropical conditions studied have dominance of sand (values from 343 to 988 g kg^{-1}, with an average of 855 g kg^{-1}), pH in the region of 4.5 and 4.7, mainly with low or very low base saturation, and they present a dystric character. It is possible to relate the variations of granulometry to contribution of parent material, and the soils classified as Spodosols in the *Pantanal* region show characteristics very distinct from the central concept of the class in the taxonomic systems.

Keywords: pedoenvironments; diagnostic attributes; soil taxonomy

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Testing WRB 2014 on subalpine soils influenced by touristic induced erosion

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Soil classification is a tool which enables a systematic approach to soil genesis, morphology and its properties. In this scope different soil classifications give different possibilities. WRB as a continuously improving international classification system at the present time offers the widest range of opportunities as well as applications. An interesting, however so far rarely discussed, problem is the influence that geomorphic processes have on the change of soil systematic position.

The main objective of the research was testing the latest edition of WRB on soils which has been eroded in varying degrees due to the influence of hiking tourism within the subalpine zone of the Bieszczady Mountains (Eastern Carpathians, SE Poland). Soils undergoing the renaturalization processes after exclusion from touristic usage were also considered in this study. In the field 15 research plots were investigated. On each research plot three soil profiles were located: (1) soil on a tourist trial, (2) renaturalized soil, (3) undisturbed – natural soil (as reference profile). Soils were described according to 'Guidelines for soil description' (FAO, 2006); basic soil features were determined using common laboratory methods. Soils were classified according to WRB 2014 (update 2015).

The results indicate that WRB 2014 enables to show the differentiation of soil cover caused by tourist induced erosion: (1) RSGs is changed due to the stage of soil erosion, (2) reference soil pedons are usually classified as Umbrisols or Cambisols – soils types characteristic for the investigated zone, (3) regenerated (and less eroded) soils usually show depletion of the diagnostic properties in uppermost horizons, (4) soils under erosion are classified as Regosols (in case of the absence of diagnostic horizons) or Leptosols (if the eroded soil profile is very shallow). The improved definition of lithic discontinuity in WRB 2014 (criterium #6) allowed to include the whole conception of cover beds in soil classification system. In the analyzed profiles it also helped to detect cases where the uppermost part of the solifluction layer was eroded (soil truncation).

There is a problem with classifying soils under erosion (occurences of truncated soil profiles). WRB can be improved by providing 'nudi-' as a universal subqualifier to be used with any subsurface diagnostic horizon/material starting with the mineral soil surface (similarily to nudilithic, nudiargic, nudinatric). The proposed solution extends the definition of ‚nudi-' (in case of eroded soils) by adding a possibility to use it if a corresponding horizon exists in the surrounding pedon. In some of the analyzed soils, cambic horizon diagnosing was impossible just because of lithic distontinuities' occurrence in the profile. Cover-beds (and lithic discontinuities recognized due to the their existence) in the investigated area are of Pleistocene origin (solifluction layers), while the soil cover development and cambic horizon formation is of Holocene origin. Thus, differentiation of the coarse fragments content as well as differences in sand fractions shouldn't exclude a possibility to diagnose cambic horizon within the non-recent cover-bed.

Keywords: soil classification, WRB 2014, soil erosion, subalpine zone, Eastern Carpathians

Automated derivation of soil names according to WRB 2015 - lessons learnt and further development

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An automated way to derive soil names according to the second edition of the World Reference Base for Soil Resources (WRB) 2006, update 2007, was developed some years ago. Designing computer algorithms and applying them to soil profile data revealed inconsistencies, incomplete definitions and identified rather complex definitions. This experience resulted in many proposals that finally found their way into the third edition of WRB and its 2015 update. Current algorithm design and programming activities for deriving WRB 2015 soil names from German soil data show that the current WRB edition is often simpler, clearer and - almost completely - self-consistent. The automated derivation yields highly reliable results if input data quality is of medium level or better.

The approach is now being adapted to soil description data obtained with the FAO Guidelines for Soil Description, so that the profiles of the World Soil Information System (WOSIS) of ISRIC can be re-classified according to WRB 2014, update 2015. This does not only harmonize soil names in a sound, properties-based way, but also immensely increases the value of this global dataset. This can ultimately be used to improve world-wide predictions on distribution of WRB RSGs and on various soil properties through the ISRIC SoilGrids system.

Keywords: World Reference Base for Soil Resources; Data evaluation; Data quality assurance; WRB derivation tool

Classification problems of intensively cultivated sandy soils in the World Reference Base for Soil Resources

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Beside natural soil forming factors human activities can profoundly modify soil genesis and soil properties by the application of organic and mineral materials, wastes, and cultivation and irrigation. These soils with significant influences and results of human activities are classified Anthrosol according to the WRB.

The aim of our investigation was to determine the effects of long lasting (60 years), intensive horticultural cultivation on soils of Horticulture Experimental Farm of Szent István University, Gödöllő, Hungary. The area is covered with coarse sandy soil.

Ten soil profiles were described by the FAO Guidelines for soil description and each horizon was sampled for lab investigations according to international standards.

In the last half century soil managing activities, fertilizer and manure applications, and cultivation caused a transformation of physical, chemical and biological soil properties. The depth of the organic material rich surface layers became deeper and high phosphorus contents were measured.

Despite of the anthropogenic characteristics of the investigated sandy profiles, the soils failed to be classified as Anthrosol in the WRB due to the criteria of biological activity which is required for the hortic horizon. No other anthropogenic horizions could be established, therefore none of the soils were classified as Anthrosols. Eight of the ten soil profiles keyed out as Arenosol, one as Calcisol and one as Technosol). In the Arenosol Reference Soil Group there is no opportunity to express the visible, measureable anthropogenic influences on the qualifiers level, therefore the final classification of the studied soils is not providing information about the significant changes due to the intensive land use.

Based on our study anthropogenic qualifier(s) should be introduced to the Arensols to acknowledge the results of the long lasting intensive agricultural use in those cases when criteria of Anthrosol is not fulfilled.

Keywords: Anthrosol; Arenosol; Classification; Intensive cultivation

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Fundamental changes to Soil Taxonomy

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It has been 40 years since the 7th Approximation of Soil Taxonomy was released for field testing. In that time, there have been 12 updates to the Keys to Soil Taxonomy and a second edition published. Previously, many of our soil classification systems went through complete revision about every 30 years. A task force was organized by SSSA in 2014 to take a look at Soil Taxonomy and to suggest fundamental changes. The task force objective: to facilitate an open and transparent process to develop a suite of fundamental changes to Soil Taxonomy leading to a more user-friendly product that can and will be used by more than just trained soil scientists. The proposed changes should have minimal negative effects on existing National Cooperative Soil Survey (NCSS) mapping products. The fundamental changes in Soil Taxonomy should complement the concepts used in other soil taxonomic systems (specifically the WRB and the Universal Soil Classification System), but fundamental changes should improve Soil Taxonomy without losing the decades of knowledge embedded in the current system. Broad input will be required from both the United States and international community. If accepted, these changes may lead to the publication of a 3rd edition of Soil Taxonomy. Specific projects include: reducing complexity of low activity (Kandic) diagnostic horizon recognition; creating an Official Series Description (OSD) database and harmonize meanings across the hierarchy of Soil Taxonomy; changing definitions and criteria of soil organic materials and epipedons; creating a new soil order for wet mineral soils and removing the soil moisture and temperature regimes from the suborder level; and simplifying the definition of the mollic definition. A few examples of the progress will be discussed, along with data using the Shannon Diversity Index to demonstrate the impact of removing climatic regimes from suborder to family level. It is hoped that the international community will weigh in on some of the proposals and contribute toward harmonization between major systems.

Key Words: Shannon Diversity Index, climatic regime, mollic, kandic

Anthropogenic soils in Soil Taxonomy

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Anthropogenic soils have been subtly addressed in many soil classification systems because of their supposed small extent and their location in developed, non-agricultural areas. In 2014, a section was added for human-altered and human-transported (HAHT) soils to the 12th Ed. of the Keys to Soil Taxonomy for field-testing. The new material is novel because it allows soil class allocation to be based partly on landform location, artifacts, densic contacts, and manufactured layers. Included are lists of anthropogenic landforms and microfeatures. Additions also included definitions for human-altered material, human-transported material and field evidence for their identification. Removals include scattered taxa at various levels, and requirement for high P content in epipedons due to lack of consistent evidence. Another major shift from previous changes to Soil Taxonomy is the addition of one of seven subgroups to identify HAHT soils. Rather than adding empty taxa in multiple soil orders, new subgroups can easily be added to any existing great group. There is no central concept to HAHT soils; but there are several major types. The variability in HAHT soils made it impractical to add a single soil order or even four new orders. Each of the existing 12 soil orders would have had to be replicated under each new order, forcing a very large increase in the size and complexity of Soil Taxonomy. Even though HAHT soils are so variable that single polypedons are seldom in large extent, the total amount of HAHT soils worldwide is cumulatively large and make them important soils for soil science and soil survey in the future.

Key words: human-altered, human-transported, artifacts, anthropogenic landforms

A brief history of the D-horizon; archaic or commendable?

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The ‘D layer’ was once part of soil science nomenclature to describe layers below the solum (AB profile) or the C horizon that are unlike the material above and unlike the material from which the solum formed. In the 1962 revision of the USDA Soil Survey Manual, these contrasting layers were incorporated into the C horizon(s). At about the same time in Australia, a variation on the D-layer concept was developed to describe deeper layers that are unlike the solum in general character and not C horizons. This usage is typically applied to buried soils for which no reliable horizon designation can be given.

This paper explores the history of the D horizon, provides examples of its use and asks whether there is merit for its retention in soil science terminology.

Keywords: solum, D Horizon, C Horizon, lithologic discontinuity, buried horizon.

Lateral transport in Stagnosol landscapes and horizontal horizon sequences

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Normally we describe soils by vertical horizon sequences. However, since decades in some South-West German Stagnosol and Planosol landscapes soils are observed that show in their vertical horizon sequence only element losses and others that show only gains. The mentioned soils regularly occur in specific topographic positions that indicate their lateral connection by subsurface flow. While the soils in plateau position with element losses can be easily classified using the WRB, this is not conclusive for the soils that are enriched in slope position. A conceptional conclusion might be that we do not only need to consider vertical horizon sequences but horizontal ones, too, and as a consequence define soilscapes.

We present examples from six different Stagnosol/Planosol landscapes in Central Europe. The emphasis is on those ones that show lateral distribution of redox sensitive elements.

We observe in all cases a regular Catena. In the plateau position we normally find soils that represent a kind of zonal soil and well defined in the WRB like Cambisols, Luvisols or Podsols. In the upper flat slopes we find soils that are characterised by absolute loss of redox sensitive elements like Stagnosols or Planosols. in these soils E-horizons are observed that do not have a corresponding enriched horizon in the vertical sequence. Farther downslope soils with absolute element enrichment occur that cannot be explained by a vertical redistribution in the local profile, because they do not have horizons with recent depletion. Furthermore we map soils that are locally called “Ockererde” with diffuse enrichment of ferrihydrite and goethite. For these soils no proper name exists in any soil classification. We, therefore, would like to propose to call them Ochresol because of their indicative horizon with smeary iron enrichment.

These soils are characterised by a strong temporal change in water saturation, which may reach complete saturation, but only for a short period of time. However, the redox-potential does not drop down into the iron reducing range, consequently allowing for iron and manganese accumulation.

At the landscape scale we observe typical element distributions, with bleached E-horizons that have lost iron and manganese in Stagnosols and Planosols upslope. These redox sensitive elements are then laterally transported and accumulate in the A and B horizons of the Ochresol downslope. Furthermore we have regularly observe O or H horizons on top of the bleached soils, while in the Ochresol the organic matter is mainly found in the A-horizon with a strong relation to the iron enrichment.

The quantitative estimate of element losses from the bleached part of these Catenas is much higher than for other bleached soils like Podsols in the same area. The iron and manganese enrichment in the Ochresols is also higher than in adjacent Gleysols in the same landscape. However, it is still in discussion if the iron, which is mobilized in the upper part of the described catenas is quantitatively redistributed to the Ochresols. Field estimations and first calculations let us hypothesize, that the landscape as a whole shows a loss of iron and manganese.

As a consequence of the above observations we propose two additional symbols for horizon designation. The first should characterize the loss of elements without corresponding enrichment in the same vertical profile. This horizon can be named E%.

The horizon that is characterised by a gain of material without depletion in the same profile may be called B#. Soils with the diagnostic B#-Horizon should be called Ochresol.

Whole regolith pedology classification: examples from Brazil

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A clear interest for classifying regolith material was expressed during the "Whole–Regolith Pedology" symposium organized by the "Soil Science Society of America" in 1992. Buol (1994) subsequently proposed a Saprolite-Regolith Taxonomy (SRT) but this classification system has hardly been adopted by the soil science community. In principal subsolum layers (C and R layers) within 2 m from the soil surface ought to be considered as they are part of the object of classification of both World Reference Base (WRB) and Soil Taxonomy (ST). As these classification systems focus on diagnostic features in the surface horizon (A, H) and/or pedogenic subsurface horizons (E, B), they lack concepts and definitions to include subsolum layers when naming soils. In WRB, the only way to explicitly refer to subsoil material is when shallow continuous rock (WRB) occurs (defining Leptosols and Leptic qualifier) or in ST as a lithic contact or the Lithic subgroup. However, many researches have stressed the importance of considering features of C and R layers in soil classification for their ecological function as roots can extend deep below the solum and for their hydrological function as infiltration of water and contaminants is controlled by geogenic features such as cracks or sedimentary beds. To address these shortcomings, a new classification system has been proposed (Juilleret et al, 2016). Based on the weathering stage and properties of the C and R layers, four Subsolum Reference Group (SRG) are distinguished: Regolite, Saprolite, Saprock and Bedrock. Intergrades of these SRG's can be categorized with principal qualifiers, while morphologic and lithologic characteristics can be categorized with supplementary qualifiers. To foster the discussion on the need for a classification system which encompasses the whole regolith, we compare the classification of four soil profiles from Brazil according to the SRT and SRG classifications. The cases illustrate that SRT emphasizes geo-mechanic properties and is restricted to the classification of soft materials with a special focus on the mineralogy and lithology. The SRG allows to also cover hard materials and to convey informations on morphological features such as texture, rooting capacity and the nature of rock fragments. We also argue that there is a need for creating a subsolum working group within the soil classification commission, to further test, develop and assess the need for integrating subsolum features into the current soil classification systems.

Keywords: soil classification, regolith classification, WRB, Soil Taxonomy, Brazil

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Towards simpler and coherent classification of anthropogenic soils: comparison of phosphorus tests for diagnostic soil horizons and properties

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Although the international classification of soils merges various original concepts of soil diagnostic horizons and properties, it should point towards unification of the tests of a particular soil feature, crucial for soil allocation among complementary classification units. High phosphorus content is evident for soils highly impacted by agricultural practices, including organic fertilization. However, each of diagnostic horizons and properties (WRB 2014/2015) requires different test for its identification: 1% citric acid, Olsen, and Mehlich 1 tests, for anthric properties (partly also for plaggic horizon), hortic, and pretic horizon, respectively. The use of different tests prolongs the time and enhances costs of classification if the soil allocation is not obvious (e.g. hortic or anthric). First of all it arises the question whether the requirements correspond with an expected advantage of soil transformation reflected by definitions of diagnostic horizons and properties.
Traditionally, the identification of anthropogenic soils based on phosphorus test routinely used by agricultural laboratories. Citric acid was among the first introduced tests, as an agent simulating the organic acids excreted by plant roots. Its application was limited by interferences from citrate at direct colorimetric P determination. The dilute mineral acid extraction known as Mehlich-1 is an easy and popular test, however, it is much less efficient in alkaline and calcareous soils. By contrast, the Olsen test (based on $NaHCO_3$) is dedicated mainly to calcareous soils. Presently, the Mehlich-3 test is preferred by many agricultural laboratories and national surveys as a buffered solution for P extraction in variety of soils (both acid and alkaline) and for multi-element extraction at all.
The aim of the paper was to compare the results of various P tests in variety of soils (1) to derive the recalculation equations, (2) to check the “strength” of P requirements in the diagnostic horizons and properties of WRB classification, and (3) to provide arguments to choice one P test as indicative for intense human (agricultural) impacts.
A set of 100 soil samples was extracted using four reagents (the citric acid, lactate, sodium bicarbonate, and mixture of Mehlich-3, respectively) and dedicated procedures; however, P concentration in extracts was measured by ICP technique. The extracting efficiency of P tests can be ordered by decreasing P amount: 1% citrate acid (11.9-1840 ppm; mean 314 ppm), Mehlich-3 (10-999 ppm; mean 239 ppm), lactate/Egner-Riehm (4.4-1221 ppm; mean 158 ppm), and bicarbonate/Olsen (11.5-209 ppm; mean 49 ppm). Good linear correlation was found between bicarbonate (Olsen) and citric acid extraction (y=0.097x+18.5, R2=0.81) and similarly good non-linear equation was found for citric acid and Mehlich-3 (y=-0.0002x2+0.92x-8.95; R2=0.95), whereas the relation between Olsen and Mehlich-3 procedures was influenced by other soil properties (y=5.06x-8.32; R2=0.70). The P requirement for anthric properties according to WRB 2014/2015 (>654 ppm P in citric acid) was fulfilled in 8 samples, which means it is significantly stronger than for hortic horizon (43.6 ppm P by Olsen), fulfilled in 45 soil samples. Mehlich-3 test has several theoretical and technical advantages, including lack of interferences and relatively high P level in diluted extracts; however, the P threshold based on this test requires a choice (or compromise) between 220 ppm (respective for hortic/Olsen) and 500 ppm (respective for anthric/citric acid).

Keywords: phosphorus; soil test; anthric; hortic; pretic

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Transfer function in soil classification

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A transition from a certain classification system to another one cannot be unambiguous because of different tools applied to solve the problem; these are diagnostic horizons, properties and materials with their own criteria and quantitative limits; in some cases soil forming agents are involved. Therefore, correlation procedure is mostly performed by experts, who search adequate taxonomic groups in the systems with the purpose of correlating one group in one system with one taxonomic group in the other system.

An alternative approach is proposed. It is named “development of soil classification transfer function (SCTF)”. SCTF presumes special rules for choosing additional diagnostic criteria for a more adequate transition from one classification system to another system when naming soils, in other words, for more adequate correlation of soil names in two classification systems. SCTF comprises three steps. First, the soil profile is separate identified in terms of each classification system. The next step is the development of a soil database in the region investigated, and both soil names are sorted irrespective of each other. Three alternatives may be the result of the second step: (1) several names in the first system correspond to one name in the second system; (2) names are one to one; (3) one name in the first system corresponds to two or more names in the second system. A congruence conformity graph may be helpful. The third step comprises choice of additional criteria for the transition from the first classification system to the second one basing on the comparison of diagnostic criteria of taxonomic groups in the second system adequate to one soil name in the first system. Thus, SCTFs are formed for each taxonomic group in the first system and may be schematically presented as the following sequence: soil name in the first system + additional diagnostic criterion $\rightarrow$ soil name in the second system. Basically, SCTF1$\rightarrow$2 does not coincide with the inverse SCTF2$\rightarrow$1.

Examples of SCTF implementation for steppe soils of the East European Plain are discussed for the transition from the Russian Soil Classification system (2004, 2008) and WRB-2014 (*IUSS Working Group WRB, 2014*).

Keywords: diagnostic criteria, Russian Soil Classification system, WRB-2014.

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Andosols and problems of their classification in Central European conditions

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Andosols occurring and developed in Central European conditions are evaluated in this contribution. These soils are represented by very dark brown to black color (Munsell color value and chroma 10YR 2/1 – 2/2 when moist), humous (more than 10 % ofsoil organic carbon - SOC), and acid to very acid (pH/KCl mostly between 4.0 – 5.0) (Kobza, 2008). Soil color is strongly influenced by parent material (Richardson and Daniels, 1993). The andosols developed in Central European conditions are situated on volcanic rocks, mainly pyroclastic deposits with vitric components and existence of allophanes. More typical andosols have been identified under forest, slightly developed andosols occur also on agricultural land (mostly on greenland near forest) with often existing of andic cambic B horizon (as a part of cambic B horizon) could be classified as Andic Cambisols. There it is possible to distinguish the soils with more or less developed andic properties mostly from Andic (Vitric) Cambisols to Andosols sequence mostly in the forest landscape.

Andic properties may be identified using the sodium fluoride field test of Fieldes and Perrott (1966). A pH in NaF of 9.5 and more indicates allophane. According to several previous and latest international and national classification systems andic properties include mostly: an Al_{ox} + ½ Fe_{ox} value of 2.0 percent or more; and a bulk density of 0.90 $g.cm^{-3}$ or less; and a phosphate retention of 85 percent or more (WRB 2015); and less than 25 percent (by mass) organic carbon; and increasing amount of allophanes with depth; and thixotropy (field test for soil material change under pressure or by rubbing, from a plastic solid into a liquefied stage and back into the solid condition).

However, above described properties are not always sufficient for identification of typical Andosols. According to our additional experimental results as well as Δ pH ≤ 0.5 (difference between pH/H_2O and pH/KCl), content of Fed > 2 % (iron in dithionite extract), resp. Feox/Fed < 0.6, Alox + ½ Feox > 3 % (oxalate extractable aluminium and iron), content of organic phosphorus 1500 - 2000 $mg.kg^{-1}$, content of Nt > 0.8 %, C_{HA} : C_{FA} < 1 and C : N ratio between 12 – 15 (moder humus form), Q^4_6 3.5 – 4, bulk density less than 0.9 $g.cm^{-3}$ are characteristic for these soils. Concerning the indicators of ^{13}C NMR spectrum is also very important a percentual distribution of aliphatic (Calif) and aromatic carbon (Car). It was determined that the aliphatic carbon is predominant (Calif/Car is running mostly in the range 1.3 – 1.8) in evaluated soils. In addition, existence of melanic A horizon was not determined according to our obtained results but fulvic A horizon has been identified in described soils where melanic index is higher than 1.7 (WRB 2015). These additional indicators could help better to classify typical Andosols in heterogenous soil cover.

Keywords: Andosols, soil classification, andic properties, thixotropy

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Oxidation, illuviation and accumulation of uranium in anthropogenic soils - motivation for the inclusion of radioactivity as a family criteria in the South-African taxonomic classification system.

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The South-African (SA) economy is largely based on the exploitation of natural resources, more specifically mining underpins a significant section thereof. As a part of the mining process large volumes of waste material is deposited in tailings storage facilities (TSF's). These TSF's are composed primarily of rock forming minerals, crushed and in some cases chemically treated. These minerals, once exposed to atmospheric conditions initiate the process of chemically equilibrium to environmental conditions through the basic processes known as chemical weathering or pedogeneses depending on the chosen field of study.

As an example the ore of the Witwatersrand gold fields being a sulphide based ore reserve is also associated with relatively high concentrations of uranium (U). The chemical reactivity of U being a metal is mostly determined by the oxidative state (Eh), the pH as well as the presence of complexing anions. The oxidation process of sulphides produces ideal chemical conditions for the mobilization of U which can then be transported via pore based flow vertically and/or horizontally to other locations.

Recent studies as well as results from re-mining and floor cleaning of TSF's have shown that U is transported and deposited in the original soil horizons below the TSF's where oxides of iron and manganese strongly adsorb U complexes.

The total surface area of SA covered by gold mines, with variable contents of U, equates to approx. 32 000 hectares, not including surrounding areas contaminated by dust blown and water transported potential radioactive material. If other mining operations with higher contents of radioactive materials like Karoo coal deposits, phosphates from carbonatites (high affinity for radioactive materials in both depositional and igneous ores), Rear Earth deposits, pegmatite deposits and hydrothermal sulphide based ores of the Greenstone belts and metamorphic provinces are considered, the picture changes to one of significance.

Anthropogenic soils in the SA context are defined as any soil in which the physical and/or chemical composition of the original soil and soil horizons has been impacted by human activities. Radioactive contamination through mining, urbanization or agriculture (potassium and other fertilizers) changes the chemical compositions of soils and affects the potential land use of those soils.

Keywords: Industria, radioactivity, uranium, anthropogenic soils

Soil classification and ecosystem services: the necessity for including soil degradation in WRB

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Basic 'genetic' soil classifications, unlike applied classifications based on single soil properties, group soils for multiple purposes. This allows the use of taxonomic soil maps for predicting soil productivity, the determination of their best use and management, and in general for accessing their quality and health. Recent reports showed that soils not only contribute to the natural capital and to ecosystem services, but that their contribution can be evaluated and expressed economically (Dominati et al., 2010). The contribution of different soil reference groups to ecosystem services related to soils was shown to be different: the Status of the World's Soil Resources Report (FAO, 2015) provides a review of specific ecosystem services related to each soil group. This relation may be evident and broad, such as higher production service in potentially fertile soils (e.g. Chernozems, Phaeozems, Kastanozems) or specific, such as the contribution of Histosols to greenhouse sequestration. The Report provides a rather general picture, because most soil reference groups includes diverse soils at the highest level of generalization. Each soil reference group may have various modifiers that are commonly related to certain properties and consequently with certain soil functions and processes. Consequently more work needs to be done to relate individual soils with a set of soil-dependent ecosystem functions. However, even now a traditional soil map can serve as a good base for mapping ecosystem services of soils.

The utility of soil classification and mapping for evaluating ecosystem services related to soils is strongly reduced by the lack of information on soil degradation in most soils classifications of the world. In this sense WRB (IUSS Working Group WRB, 2014) has a significant advantage compared to other classification systems. WRB has two special reference groups related to soils transformed by humans through of agricultural (Anthrosols) and non-agricultural (Technosols) activities. Also, WRB has a number of qualifiers that characterize soil transformation in urban environments, contaminated soils, and soils with accumulation of colluvial material on the surface. However, WRB does not reflect partly truncated soils and hence cannot show eroded soils on soil maps. Neither is there a qualifier related to anthropogenic compaction of soil surficial horizons. There is also no way to indicate that soil is affected with severe loss of organic carbon or nutrient depletion. A qualifier indicating Anthropogenic acidification is also lacking in the classification. In the topsoil horizons rich in organic matter the reaction is evident because of the presence of mollic vs. umbric horizon, but for other soils the pH of the surface horizon remains unknown in most cases.

Taking into account the abovementioned considerations, we propose to include a number of new qualifiers in the WRB system that would relate to the ecosystem function of soils or indicators of soil degradation.

Keywords: soil erosion, soil contamination, modifiers, soil functions

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National and international soil classification systems: a complementary approach for overcoming the current needs and challenges. The case of the Belgium soil map.

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A systematic soil survey of Belgium was conducted from 1948 to 1991. Field surveys were done at the detailed scale of 1:5000, while the maps were published at a 1:20,000 scale. The purpose was to have a soil information base adequate for boosting agricultural production after the Second World War. With the wider environmental concern now these maps are also used as input layer for modelling environmental processes or for estimating some key environmental properties as e.g. infiltration capacity, erodibility…

To enable soil surveyors to identify soils in the field, an original soil classification was developed based on readily observable physical and morphogenetic characteristics. The legend of the soil map of Belgium is based primarily on soil texture, drainage status and profile development. Soil mapping units are defined in an open and non-hierarchical structure by combining these three categorical variables, and to which modifiers can be added such as parent material, stoniness or depth to a substratum.

The digitalisation of the soil map of Belgium and the structuring in a logical way of the information delivered by its legend has been seen as a bargain for practical applications. However, the choices made by the map maker in term of level of information embedded in the soil mapping units lead the user to have a spatial and locally contextualised interpretation of the map, in order to decipher the implicit information. But the current needs and how the information is exploited largely changed since the edition of the maps:

(i) There is a focus on soil features and properties, as input layer for modelling. Therefore, the database linked to the soil mapping units is favoured at the expense of the information conveyed by the map through its spatial dimension.

(ii) The investigation zone exceeds the plot for encompassing a vaster area.

(iii) The potential users are not always soil scientists and they don't still understand well the concepts needed for a suitable reading and interpretation of the soil maps.

In 1998, the IUSS endorsed the World Reference Base (WRB) for Soil Resources as its officially recommended terminology to name and classify soils. In Belgium, the conversion of the national soil map legend into WRB is being implemented. The objective of this presentation is to investigate how WRB, with its own concepts, formality and vocabulary, could be helpful for refining and enriching the soil map of Belgium, in a complementary way with the national system, taking into account the current challenges mentioned above.

Keywords: Belgium; national soil classification systems; WRB; soil map

Proposal to use the international soil judging contests (Brazil 2018) to test, compare, and vet our international classification systems and field nomenclature

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The International Soil Judging Contests (Australia 2010; Korea, 2014; Hungary 2015) were effective venues to test, compare, and vet our international classification systems and field nomenclature. The Contests have provided a platform for worldwide sharing of field tacit knowledge and blending of field nomenclature and horizon designation standards. In each competition we progressively refined a mode to disseminate information on soil classification and field nomenclature as well as reinvigorate an interest in the science of soil classification amongst our emerging field experts worldwide. Participation and coordination of the Australia 2010; Korea, 2014; Hungary 2015 contests has illuminated the effectiveness and flaws of the competition in an international setting. With these previous experiences, we will be better prepared to support of the next contest at the World Soil Congress in Brazil in 2018. In preparation for these contests (and the doing of them) we have found strengths and weaknesses in both WRB and US Soil Classification systems as well as a platform for comparison that could lead eventually to a Universal system. Interpretations are also a critical part of the Soil Judging contests as well as the intensive student education experience that will test and disseminate our classification systems. As the bridge between field description, soil classification, and practical analysis of both field and lab data, soil interpretations gives the students a framework and platform for using soil information in their future work.

Keywords: soil judging; soil classification; field nomenclature; education

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Keeping science in Soil Taxonomy

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In addition to the traditional agricultural, soils are increasingly recognized for their importance in scientific and environmental issues, which have the potential to be a positive situation for continuing the soil survey program. The soil survey program in the United States can be divided into three generations. *Generation 1* (1890s to 1930s) produced general maps of soil series based on parent material, drainage, soil texture, and color. These 1st-generation maps were made using plane tables and were displayed as color polygons on topographic maps with the purpose of developing a scientific understanding of how soils differ across the landscape. *Generation 2* (mid-1940s to 1990s) produced county-by-county maps of soil series, slopes, and erosional phases based on diagnostic horizons and landforms. These maps were made using stereoscopes and displayed on aerial photographs with the purpose of helping farmers increase agricultural production and assisting land owners with understanding limitations of soils for land use. *Generation 3* (2000s +) is the current stage of soil survey and is characterized by computers and digital imagery. Like previous generations, the purpose is to document and increase our understanding of soils, but instead of plane tables and stereoscopes, digital elevation models, GIS, and raster-based mapping are the main tools for assisting the soil mapper with differentiating soil types. *"Soil Survey 2016"* is an effort currently underway to complete the mapping of the USA, including Alaska. Coupled with this effort is an increased interest in mapping subaqueous soils.

Keywords: soil classification; land use; environmental issues; food production

Evaluation of automated mapping of Reference Soil Groups of WRB2015 at the global level

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Automated mapping of World Reference Base (WRB) Reference Soil Groups (RSGs) at a global level has great advantages. When new data become available, maps can be updated in a short time span with relatively little effort. ISRIC SoilGrids is an automated system that provides global predictions for standard numeric soil properties at seven standard depths down to 200 cm, currently at spatial resolutions of 1km and 250m. In addition, the system provides predictions of depth to bedrock and distribution of soil classes based on WRB and USDA Soil Taxonomy (ST). In SoilGrids250m(1), soil classes (WRB, version 2006) consist of the RSG and the first prefix qualifier, whereas in SoilGrids1km(2), the soil class was assessed at RSG level.

In SoilGrids, correlation tables are used to translate soil names of older versions of FAO/WRB and national classification systems into names according to WRB 2006. Soil properties and classes are predicted independently from each other. This means that the combinations of soil properties for the same cells or soil property-soil class combinations do not necessarily yield logical combinations when the map layers are studied jointly. The model prediction procedure is robust and probably has a low source of error in the prediction of RSGs. It seems that the quality of the original soil classification in the data and the use of correlation tables are the largest sources of error in mapping the RSG distribution patterns.

Predicted patterns of dominant RSGs were evaluated in selected areas and sources of error were identified. Suggestions are made for improvement of WRB2015 RSG distribution predictions in SoilGrids.

Keywords: Automated global mapping; World Reference Base for Soil Resources; Data evaluation; Data quality assurance

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Major steps in classifying soils - from genetic to numerical

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Early soil classification systems were developed based on the genetic foundation of Dokuchaev. Most currently applied systems were elaborated before the recent boom in observation and measurement technologies, data storage and processing developments. The soil science community is challenged to apply the accumulated new knowledge on soil formation, soil differences and related functions in a modernized and simplified and to the extent possible global classification system. The paper will review the big revolutionary steps in soil classification and related tools and methods. The approaches and results from the genetic to diagnostic and numerical will be discussed, as well as the objective tools of laboratory, field and proxy or remote measurements. The modern pedometric approaches of the present, data-rich environment will be also part of the review. The current efforts of creating centroids of the major units of different classification systems (Soil Taxonomy, WRB, and national systems) and the calculation of the taxonomic relationships between them will follow the review. The centroids are based on 22 key soil parameters for 11 set depth intervals. The taxonomic distances were determined by the Mahalanobis distance method.

The initial results suggest that the pedometric approaches can support the objective evaluation of similiraties and differences of soils and the development of an envisioned Universal Soil Classification System.

Keywords: genetic classification, diagnostics, centroids, taxonomic distance, universal soil classification

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An international system of soil horizon nomenclature

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As a consequence of progressively greater communication across national boundaries, there is a need to harmonizing the way we classify and describe soils. A task group established within the Universal Soil Classification System Working Group of the IUSS has the charge of comparing international soil horizon nomenclature and recommending standards. From this comparison, much commonality is apparent. Nomenclature for eluvial, illuvial and organic horizons is almost universal. Pedogenic carbonates, gypsum, silica, soluble salts, slickensides, concretions, buried genetic horizons, gleying, strongly weathered horizons, strong cementation, ploughing, and weak development are also widely recognized, although symbols for these properties often differ. Other properties are less cosmopolitan, such as anthropic disturbance, human-induced soil formations, cryoturbation, phosphorus accumulation, sulfides, unweathered material, low bulk density, lamellic features, and dry permafrost because of different environments among countries – e.g. cryogenic features are important for Canada and Russia and sulfides are important in Australia. In the majority of systems, a very limited number of uppercase letters are used for master horizons, which are combined with one or more lower case letters used for indexes. Still, these symbols are often inadequate to reflect the up-to-date knowledge of soil features of the world. So, there is much potential for advancing soil horizon nomenclature for the Universal Soil Classification. The compilation and blending of existing systems will not only enhance international communication, but will also provide a greater understanding of soils across the globe.

Keywords: pedology; soil survey; soil morphology; soil classification; global soil science

Classification of soils of the Eastern slope of Mount Kenya region

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Soil sampling on the agricultural land covering 1200 km^2 in the Eastern part of Mount Kenya region was carried out to assess the status of Soil organic carbon (SOC) as a soil fertility indicator. The geology of the area consists of volcanic rocks and recent superficial deposits. The volcanic rocks are related to the Pliocene time; mainly: lahars, phonolites, tuffs, basalt and ashes. A total of 28 open profiles and 49 augered profiles with 269 samples were collected. The samples were analysed for total carbon, organic carbon, particle size distribution, percent bases, cation exchange capacity (CEC) and pH among other parameters. The initial goal was to evaluate the variability of SOC in different Reference Soil Groups (RGS) which resulted to the observations discussed below. Soil classification was done based on the World reference base (WRB) for soil resources 2014. Both morphological features and laboratory data were used during classification. Based on the earlier surveys, geological and environmental setting, Nitisols were expected to be the dominant soils of the sampled area. However, this was not the case. The major differences to earlier survey data (KENSOTER database) are the high CEC_{clay} (range 27.6 $cmol_c$/kg - 70 $cmol_c$/kg) of the soils, high silt content (range 32.6% - 52.4%) and silt/clay ratio (range of 0.6-1.4) keeping these soils out of the Nitisols RSG. The soils were mainly clay (33.3%) or Silt Clay (63.7%). There was good comparison of the morphological features with the earlier survey but failed the silt/clay ratio criteria for Nitisols. This observation calls attention to set classification criteria for Nitisols and other soils of warm, humid regions with variable rate of weathering to avoid difficulties in interpretation. On the contrary most of the diagnostic elements (like the presence umbric, vitric, andic horizons) and the qualifiers (Humic, Dystric, Clayic, Skeletic, Leptic, etc) represent useful information for land use and management in the area. Has an effort to address the interpretation problem(highlighted earlier), this paper will further discuss the legacy classification information, field classification, the classification in the 2006 and 2014 versions of the WRB and the calculated taxonomic relationships (based on distance calculations) of the studied soils. This is expected to divulge the chaotic circumstances that these different classification systems cause and thereafter give suggestions for improvement.

Key words: Mount Kenya region, taxonomic relationships, diagnostics, reference soil groups

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A hierarchical soil-landscape classification and associated maps

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A hierarchical soil-landscape classification is being developed alongside with creation of a multiscale series of associated soil-landscape maps. Soil-landscape maps integrate information on essential properties of physical landscape elements - rocks, air, water, organisms, and soils (Fig.1). The maps are created in GIS by an analysis of about 250 thematic and topographic maps, which are, for example, landscape, soil, geological, geomorphological, agroclimatic, and maps of vegetation and of the ground waters, of different scales and from world maps down to maps of farm enterprises.

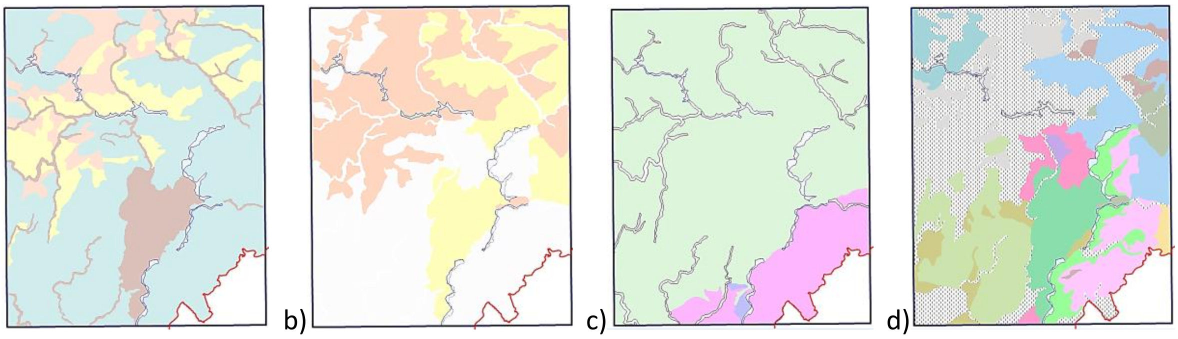

Fig.1. Examples of the maps of properties of landscape elements at the same scale range: a) Soil texture, b) Soil stoniness, c) Salinity of rocks, d) Subjacent rocks

The multiscale series of maps is regarded as a system of maps of all scale ranges adjusted in relation to thematic and geographical content. The maps for four scale ranges (1:60,000,000 - 1:80,000,000; 1:15,000,000 - 1:25,000,000; 1:4,000 000 - 1:10,000 000; 1:500,000 - 1:1,500,000) were created for different in size but linked areas of the European part of Russia (Fig.2).

Mapping units are labeled by identification codes serving as connecting links between the maps and the classification.

Soil-landscape maps contain all the necessary information for soil and landscape sustainable management and assessment at all levels, from global to local.

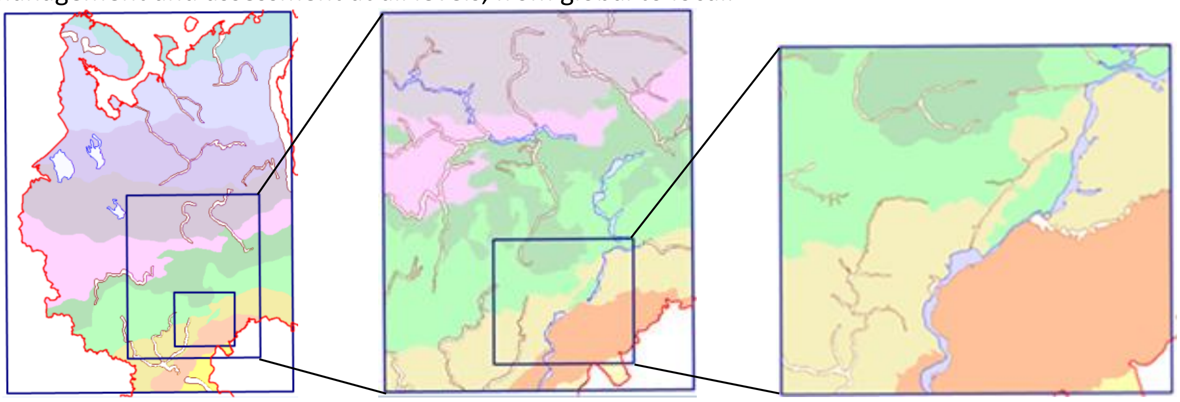

Fig.2 The multiscale series of maps of zonal types of vegetation at different scale ranges

Keywords: systems approach; soil-landscape mapping; multiscale series of maps; maps of properties; identification codes; sustainable management

Systems approach for universal soil classification

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The systems approach is proposed for development of a universal hierarchical soil classification. Soil is considered as a self-sufficient system and as an element of a system of a higher level - a physical landscape. Landscape sphere represents the initial classification level. At levels I, II and III, change or constancy and type of vertical structure of landscapes as well as presence or absence of soils in landscapes are used as characteristics of division. These features characterize the 'landscape-systems" in general (Fig.1). At lower levels, properties of basic landscape elements, which are rocks, air, water, and organisms, responsible for properties of soils, are relevant. For example, these are megarelief, zonal type of vegetation, the density of rocks. Landscapes and soils are divided into classes and subclasses until all properties of landscape elements are homogeneous.

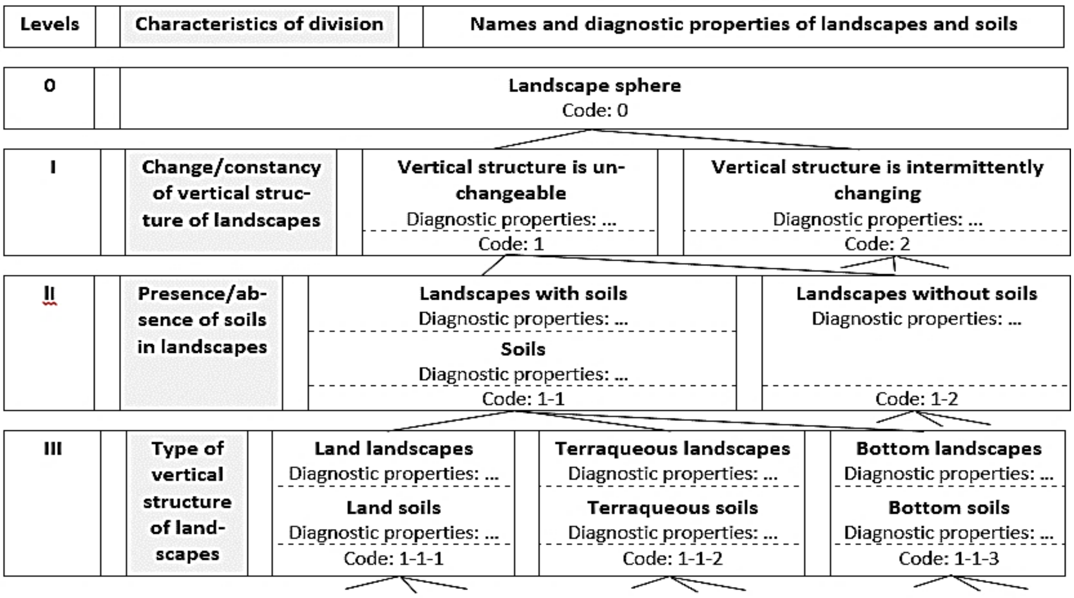

Fig.1. The scheme of soil-landscape classification

For each class of soils and landscapes, the diagnostic properties are defined. The diagnostic properties of the land landscapes are the following: "The scheme of vertical structure: Air + Water – Soils - Rocks+ (Ground waters). In case of an abnormal amount of rain, short-term waterlogging of soils is possible". The diagnostic properties of land soils are "The upper horizon is humus, muck or peaty; depth of a peaty horizon permits plant roots to achieve mineral rocks". Therefore, the classification can function as a distinguishing system. The classification may have a time coordinate, which could permit to consider the age and development history of soils and landscapes. Thus, the classification structure becomes three-dimensional. With the development of the classification the problem of soil and landscape nomenclature could be solved as well. The classification is being developed as interactive and is being tested in the process of a multiscale GIS mapping. The pilot area is the European part of Russia. Mapping units are labeled by identification codes serving as connecting links between the maps and the classification. We propose a new type of soil classification and name it "soil-landscape" classification.

Keywords: soil-landscape classification; interactive classification; characteristics of division; diagnostic properties; distinguishing system; landscape-systems; elements of physical landscape

Stockpiled soils on South African coal mines within the South African Anthrosol concept

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In the latest version of the South African soil classification system (Soil Classification Working Group, in prep.), soils are split into natural soils and man-made soils, or Anthrosols. Within the Anthrosol grouping (Van Deventer, 2016), soils impacted by coal mining activities constitute a significant portion of these, of which stockpiled soils occupy a large area. Such soils are classified as "Transported Anthrosols", falling within the Witbank form. Typically, after a period varying from a few months to more than a decade, these materials are once again transported as part of the rehabilitation process.

A project has recently been completed for the Coaltech Research Organisation to investigate some of the changes that coal mine soils undergo in the stockpiling phase, and while there are many immediate detrimental effects, such as increased bulk density, loss of organic matter, acidification and physical mixing of horizons, in time the natural soil-forming processes start to act on these soil materials. If the stockpiled soil has not been excessively compacted, a vegetation layer often builds up, accompanied by darkening of the A horizon and an increase in organic carbon content.

At one of the mine sites, the external (unmined) soils sampled had an average organic carbon value in the topsoil of 1.38%, which compared to 2.94% for some 21-year-old stockpiles and 4.88% for some 15-year-old rehabilitated areas. The difference, however, is that the unmined soils have an effective soil depth of around 0.8-1.2 m, while the stockpiles have effective depths of less than 0.6 m. For the rehabilitated areas, despite often having 0.75 m or more soil material, the effective depth is often only around 0.3 m, due mainly to compaction.

Regarding the classification of these transported soils, distinction has to be made between those cases where the replaced soil material, although disturbed, is broadly the same as the original soil profile (usually yellow-brown to red, apedal, sandy loam) as opposed to different materials (such as underlying plinthite or gravelly saprolite) which end up in an unnatural position in the profile due to poor soil stockpiling practices. This can possibly be addressed at family level within the classification system. More data, especially regarding the age of the stockpiles, will also be invaluable.

Keywords: Anthrosols; stockpiling; organic carbon; rehabilitation.

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Quantitative pedology to evaluate a soil profile collection from Brazilian semiarid region

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This work applies pedometric tools to analyze information from soil properties that are relevant to morphological characterization and soil classification. The harmonization of soil key-properties, such as granulometry, pH, CEC, among others; enables the comparison between soil profiles, the transference of information to other pedologist, and the modeling of spatial distribution horizons. In this sense, the global consortium for soil mapping - GlobalSoilMap.net (Hartermink et al., 2010; Arrouays et al., 2014) suggests a harmonization of data at depths at predefined intervals, to compound the global database and to generate maps for different soil properties. The harmonized data is useful to many purposes including the correspondence between soil taxonomic systems. An example is presented by Pinheiro et al. (2016), comparing Ferralsols in Brazil. The objective of this study is to point similarities among soils from a collection of 1267 soil profiles (legacy data), sampled in states located in the Brazilian semi-arid region. The study area has mainly plain relief, and is characterized by a dry winter and a short rainy season in the summer, with average annual rainfall of 400 mm, and average temperature of 26˚C. The area presents unique vegetation, known as hyperxerophilic “Caatinga”, represented by sparse shrubs and cactus, with high xerophytes’ degree, due the seven to eight dry months of the year. The most important cause of soil variability in this area is the parental material, comprising of limestone and gneiss-granite rocks, and sediments derived from them. The representative soil classes (WRB, 2014) are Vertisols, Cambisols and Planosols, but Regossols and Acrisols also occurs. The motivation for the research, besides the singular conditions of the area, is the lack of standardization and methods to analyze large soil profile collections. Addressing this issue, the study is based on the application of algorithms for quantitative pedology, known as AQP package (Beaudette et al., 2013), which is implemented in the R software. The application of the ‘slice-wise’ algorithm from AQP package allows defining values for soil properties in each one centimeter layer of the soil profile. After that it is possible to regroup the data in different layer thickness, thus allowing analyzes of the similarity between profiles, using a dissimilarity matrix for each depth slice.

Keywords: pedometrics; algorithms for quantitative pedology- AQP; soil depth functions; soil properties

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How informative are soil names in WRB? The role of a strong versus a flat hierarchy

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If a soil classification system is good, the soil name should inform us about soil properties, soil genesis and soil functions. Hearing the name, a picture of the soil should appear in our mind.

We are used to have the field and laboratory data of a soil first, and then detect the soil name. In this presentation, examples are given for the opposite way: We have a soil name and will see, what it tells us. In a first step, the soil with all its properties will be designed from its name. This gives very good results. In a second step, the formation of the soil will be detected. This is more difficult and unambiguous only for certain Reference Soil Groups. The third step works well again: The important soil functions can be derived from the name. Especially the qualifiers carry the information about soil functions.

Why is this working so well? One precondition are precise definitions. The other is the architecture of the WRB. Adding all applying qualifiers makes sure that all important characteristics are part of the name. Stronger hierarchical systems restrict the information at every hierarchical level, which makes it impossible to derive comprehensive information from the soil name.

Keywords: World Reference Base for Soil Resources; Soil names; Soil information

Soil classification issues relating to pedons with clay illuviation from Poland

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Clay translocation (illuviation) is one of the most widespread soil-forming processes in pedoenvironment of Poland. Soils with Bt-argic horizon cover about 50% of whole country (excluding the soils with both argic and mollic horizons). The variability of these soils is very high, both in the context of their genesis and as regards their properties. The heterogeneity of pedons with argic horizon causes that they are classified in a number of different RSG-s according to WRB (IUSS 2015). The aim of this study is to present classification problems relating to clay-illuvial soils of Poland. Clay-illuvial soils most often were correlated with Luvisols (e.g. Piotrowska and Długosz 2012; Paluszek 2013) or, with Albeluvisols (Glina et al. 2013; Szymański et al. 2014) by Polish authors. Currently, only the non-gleyed clay-illuvial soils can be simply correlated with Luvisols. Many of the clay-illuvial soils with with an abrupt textural difference and periodic water stagnation over/in argic horizon are now correlated with Planosols (Kabała (Ed.) 2015, Musztyfaga and Kabala 2015). Furthermore, soils with argic Bt horizon and strong stagnic properties in the upper section of soil profile, but without abrupt textural difference may presently be correlated with Stagnosols (Kabała and Musztyfaga 2015). Only very few glossic clay-illuvial soils with thick interfingering of albic material into Bt horizon belongs to Retisols (Świtoniak et al. 2014). This RSG has replaced former Albeluvisols, but strong stagnic properties and abrupt textural difference are in these soils excluded that makes this RSG rather a marginal. Finally, some clay-illuvial soils characterized by very low base saturation have to be described as Alisols (Świtoniak 2008; Kabała and Musztyfaga 2015). Separate type of wet clay-illuvial soils is characterized by strong reductic conditions and gleyic properties starting near the surface, thus is a close counterpart of Luvic Gleysols.

Keywords: WRB, clay-illuviation, argic horizon, Luvisols, Stagnosols, Planosols, Retisols, Alisols

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WRB and soils of Bosnia and Herzegovina

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The World Reference Base for Soil Resources (WRB) is the internationally-accepted soil classification system, endorsed by the International Union of Soil Science (IUSS), and hence by the International Council of Scientific Unions (ICSU).

The aim of this study is to determine the characteristics of soil investigations of certain types of soil, using the example of Eastern Herzegovina (Bosnia and Herzegovina), harmonization of the national classification system of soil, with WRB classification.

Field research was carried out in 2010 to 2015. A total of 44 profiles of soil were open on the surface, which covers about 30,000 hectares. The external and internal morphology is described for all pedological profiles, soil samples in a disturbed state were taken for all genetic horizons. Soil samples in undisturbed condition were taken from individual genetic horizons, in three repetitions, by cylinders of Kopecký and average soil samples were taken too. Laboratory testing of physical and chemical properties of the soil were carried out according to ISO methods in laboratory Faculty of Agriculture in East Sarajevo, Bosnia and Herzegovina.

Setting aside systematic soil units of the studied area was done according to the principles of valid soil classification of soils in Yugoslavia (Škorić et al., 1985). From the order of automorphic soils, the following types of soil were singled out: 25 profiles represented limestone-dolomite soils (Calcomelanosol). According to the classification of the soil of Yugoslavia (Škorić et al., 1985), they belong to the order of automorphic soil, to the humus-accumulative class, subtype organo-mineral black soil, variety: lytic, with A-C profile structure, with mollis horizon. Resulović et al. (2008) denote horizons of limestone-dolomite black soils as Ah-mC, and there is no transitional AC horizon. According to WRB classification, limestone-dolomite black soil is Molic Leptosol (FAO, 2006; 2014).

Work on pedological study and mapping of Bosnia and Herzegovina are in the seventies and eighties of the last century. WRB classification will provide comparability, but also the international applicability of the results.

Keywords: *Soils of Eastern Herzegovina, WRB classification, Soil classification of Yugoslavia*

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Predictive value of soil classification in southeast Nigeria

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The study compared predictive abilities of taxonomic units at different categories of USDA soil taxonomy to determine the possibility of mapping Greatgroups in Southeast Nigeria. 36 profiles located at the false-bedded sandstone/upper coal measure, cross river plain and coastal plains sand landforms in southeast Nigeria were used for the study. Soil parameters tested for were Exch. bases (Ca, Mg, K, Na), pH, CEC, BS, OC, TN, av.P, Sand, Silt, and Clay. Parameters varied differently and highly across units, only reducing to moderate at the subsoil for Greatgroup and series. The best predicted parameters at topsoil were Mg, K, CEC, OC, TN, Silt, with average values of 0.42 to 0.88, while at the subsoil they were Ca, K, CEC, BS, OC, av.P, Sand, Silt, with average values of 0.95 to 0.84. There was no significant difference between categories and environments in terms of Predictive Value. Results were better expressed in terms of parameters well predicted. Percentages of parameters predicted at the Greatgroup for Cross river plain were ≤30.8%, while for the other landforms they were ≥69%. It is recommended that mapping soils in these other landforms, survey efforts should aim at mapping Greatgroups. Using taxonomic units higher than series as mapping units in the location depends on the environment.

Keywords: Soil Taxonomy, Predictive Value, Soils of Southeast Nigeria

WRB classification of Technosols developed from ashes derived after bituminous coal and lignite combustion: examples from Poland

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The classification of soils developed from ashes from thermal power stations (TPSs) was done previously by Zikeli et al. (2005). However, Zikeli et al. (2005) classified the soils according to an old version of WRB (ISSS/ISRIC/FAO, 1998). Therefore, the classification of soils developed from ashes according to the current criteria used in international soil classification systems is needed.

Study areas were located in Poland on abandoned fly ash and bottom ash disposal sites (settling ponds and dry landfills) of the selected TPSs combusting bituminous coal and lignite. Chronosequences of soil profiles (from a few years old up to several dozen of years old soils) developed on these disposal sites were studied. The soils studied were technogenic soils showing a low degree of advancement of soil-forming processes. Soils occurring on settling ponds had a distinct layering of soil substrate. Well-developed humus horizons were formed in the upper part of the oldest (several decades) soil profiles. The soils developed on settling ponds were characterized by variation of texture within the soil profiles (e.g. alternating layers of sand and loam). The soils studied had a low bulk density (of approx. 0.5 to 1.4 $g \cdot cm^{-3}$) and high total porosity (48–80%). The pH value measured in 1M KCl ranged from 5.2 to 10.3 (soils developed from bituminous coal ash) and from 7.8 to 12.6 (soils from lignite ash). Carbonate content was variable in soil profiles and amounted up to 5.9% (landfills at hard coal fired power plants) and up to 89.7% (landfill at lignite fired power plants). Soils developed from lignite ash often had a hard layer resembling petrocalcic horizon. Base cations (especially Ca and Mg) predominated in the sorption complex of the soils studied, which resulted in a high percentage of base saturation (generally more than 90%). The soils examined had variable phosphate retention in the range 10.1–81.1% (bituminous coal ash), and from 10.7 to 95.6% (lignite ash). Due to large amounts of artefacts (i.e. ashes from TPSs), the soils investigated were classified as Spolic Technosols. The following supplementary qualifiers can be assigned to the soils (IUSS Working Group WRB, 2015): Alcalic or Eutric; Arenic or Loamic (depending on the texture of a specific layers); Calcic or Petrocalcic (depending on whether layers with secondary carbonates are soft or hard); Fluvic (the soils developed on settling ponds only); Hyperartefactic (≥ 50% artefacts within 100 cm of the soil surface); Immissic (im) (at the soil surface a layer ≥ 10 cm thick, recently sedimented ash that meets the criteria of artefacts); Laxic (occurrence of a mineral soil layer ≥ 20 cm thick, that has a bulk density of ≤ 0.9 kg dm^{-3}); Mollic (A horizon in the oldest soils); Relocatic (in situ remodelled by human activity to a depth of ≥ 100 cm); Skeletic (≥ 40% (by volume) coarse fragments averaged over a depth of 100 cm); Tephric or Vitric.

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Keywords: Technosols; fly ash; bottom ash; WRB

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Pedogenic processes in mine tailings - a myth or reality

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Although mine tailings dams are man-made deposits it is expected that soil forming (pedogenic) processes are active e.g. transformation and translocation of elements, minerals and particles. These two main entities of soil forming processes are controlled by environmental factors, also called soil forming factors i.e. parent material, climate, topography, and biota. In the case of manmade deposits, the anthropogenic factor could also be added. These factors operate and interact over time. Due to the time-zero phase of about all factors, the soil forming processes are also in an embryonic stage and often with poorly recognisable properties and diagnostic horizons, but the chemical and physical characteristics are clear and pronounced as time goes by. Irrespective of the time since deposition or rehabilitation, well defined pedochemical transformation processes e.g. pH and changes in cation exchange capacity took place in about all the tailings types. Other pedogenic processes such as leaching, eluviation-illuviation and oxidation and normal weathering are also present. Field observations also reveal other processes such as salinization, crystal-pedoturbation, erosion and crusting and also horizon differentiation. Horizon differentiation will become more pronounced if pedogenic processes become more active and dominant. Analytical results show that accumulation of some elements in a "new" B-horizon is possible. It must be emphasised that the time factor on these man made deposits is turned back to zero comparing to natural soils which have thousands and millions of years of time. Although the concept of pedogenesis sounds very academic, it has a very important place in rehabilitation and mine closure. During mine closure procedures one has to demonstrate that the rehabilitated tailings is sustainable and one criteria for sustainability is equilibrium or at least a predictive dynamic system. As soon as pedogenic processes are present and prominent and certain elements are in equilibrium (like in natural soils), one can assume that the specific medium becomes stable and in equilibrium with itself and its environment. One of the main differences between natural soils and mine tailings is the dominance of primary minerals in the tailings and the lack of plate structured clays. The nano-morphology of the individual particle in mine tailings is dominated by sharp edges and therefore the natural packing of particles is not the same and consequently the aeration and hydraulic conductivity also differs. The lack of soil structure in mine tailings is also a major concern when one would like to compare it with natural soils. It is foreseen that the presence of proper pedogenic processes in a rehabilitated tailings material will be a performance criteria for sustainability of that material. The main focus and objective of rehabilitation is to bring these factors into operation as soon as possible to achieve proper soil-like characteristics and to stabilise the surface properly. Due to many differences in various tailings (gold, platinum, kimberlite, carbonatite, manganese, iron etc), the level of pedogenic processes differs tremendously. It is possible to see horizon differentiation and illuviation in kimberlite within a period of two to three years and in gold tailings only after about ten years.

This abstract and presentation focuses on different pedogenic processes on a few types of mine tailings materials.

Keywords: transformation and transportation, time factor of zero, pedochemical processes, equilibrium, nano-morphology

The value of soil morphological data in pedotranfer functions

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PedoTransfer Functions (PTF's) are defined by Bouma (1989) as '*translating data that we have into what we need'.* PTF's make use of easily observable/measurable soil properties to estimate properties which are difficult or time consuming to measure. PTF's are widely used in soil hydrological studies; for example, the estimation of water retention charateristics from texture and hydraulic conductivity from texture and organic carbon contents. PTF's are however often only applicable and reliable for the areas/soils where they were developed (Wagner et al., 2001), with limited extrapolation value to other environments i.e. different climates, geologies and soils. PTF's seldom include soil morphological properties even though these are often the most observable easily identifiable properties of soils.

In this paper we explored the value of including soil morphological descriptions in two PTF's namely for estimating Water Conducting Macroporosity (WCM) and estimating the Plasticity Index (PI). For the first part of this study WCM was measured in 120 South African soil horizons. *Best model* multiple regression statistics were then used to predict the WCM from measured data such as bulk density, particle size distributions, extractable cations and OC. A double cross method (Green & Carol, 1978) was used for function validation. The resultant function had a R^2 of 0.61 and RMSE of 1.92. When morphological descriptions such as the structure size, type and grade, amount of roots and diagnostic horizons were included in the regression statistics the R^2 increased to 0.72 while the RMSE decreased to 1.63. In the second part, horizons from the Land Type database of South Africa were used. A total of 533 horizons with measured PI values, measured properties influencing PI and adequate soil morphological descriptions were identified. Two-thirds of the data were randomly selected for model development and the remainder for model validation. Again, *best model* multiple regression statistics were used to predict PI from measured data such as particle size distributions, CEC, extractable cations, pH, Fe and Mn. The resultant function had an R^2 of 0.59 and RMSE of 5.85. Before the morphological descriptions was included in the multiple regression analysis, classes within individual explanatory variable were first coded (with whole numbers) by exploring the slope of a linear relation between PI and the variable in question. For example with structure grade: apedal = 1; weak = 2; moderate = 3 and strong = 4. The coded morphological descriptions included; field estimated texture classes; structure type, grade, and size; soil colour; the frequency of occurrence of roots, cutans and slickensides and the transition to the underlying horizon. The inclusion of these morphological descriptions improved the R^2 to 0.68 and increased model stability, evident by reduction in the deviation from the 1:1 line and RMSE (5.12). The inclusion of morphological properties can improve the accuracy and stability of PTF's.

Keywords: Multiple regression; Plasticity index; Water Conducting Macroporosity;

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Genesis and classification of loess-influenced soils – an example from Sudeten Foreland - Mt. Ślęża massife, Poland

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We proposed with this study a new insight into the origin of soils in the Sudeten Foreland. Our research for the first time proved that ressiduum materials from weathering of local crystalline rocks (i.a. granites, basalts, serpentinites, rhyolites) no longer play an independent role of parent material for soils in that region, while in the many locations has been replaced or enhanced with aeolian silt, which became a new substrate for soil development and an agent that control past and present-day soil forming processes (Yaalon and Ganor 1973; Karathanasis and Macneal, 1994; Schaetzl and Luehmann, 2013).

We sampled eight pedons in the area of Mt. Ślęża massife at the slopes with western exposition, both in the granite and serpentinite complex. Each of soils had formed in the superficial thin (30-45 cm) loess layer (deposited during Vistulian phase) over coarser subsoil (granite regolith, serpentinite regolith or glacial till). Soils were described in the filed according to Guideline for soil description (2006) and classified using WRB system (IUSS working group WRB, 2014). Main attention was paid on soil morphology, in detailed boundary between aeolian silt and residual materials were notice as well as degree of their mixing, development of the transition zone between those two substrates, arrangement of coarse fragments. Usually uppermost horizons have silt loam texture, while underlain strata sandy loam, loam or sandy clay loam. In our opinion presence of silt-riched mantles influenced pedogenesis, in particular clay translocation. Degree of clay migration can be stimulated or limited by: (i) the loess thickness or (ii) way of mixing aeolian silt with residuum materials. Our research documents that in the further perspective it can generates formation of an *argic* horizon and/or *lithic discontinuity* (non pedogenetic change in clay content) and more frequent classifying loess-affected soils as Luvisols e.g. Hyperskeletic Luvisols (Siltic,Magnesic) on serpentinites saprolites or Stagnic Luvisol (Siltic)/Abruptic Luvisol (Siltic) on granite regoliths; instead of Cambisols, Alisols or Leptosols.

Keywords: soil classification, aeolian silt deposition, Luvisols, Alisols

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Soil Taxonomy proposals for acid sulfate soils and subaqueous soils

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The 8th International Acid Sulfate Soils Conference, College Park, MD, July 17-22, 2016, presented several examples and discussion for classification of "acid sulfate soils" as well as related issues for classification of "subaqueous soils". When acid sulfate soils are disturbed or exposed they react with oxygen and produce sulfuric acid. In addition, metals may be released from sediments and become bioavailable in the environment, oxygen may be removed from the water column, and gases such as hydrogen sulfide, sulfur dioxide and methane may be released. Acid sulfate soils in inland and coastal aquatic ecosystems may be disturbed and acidified in situations of dewatering, dredging, or land excavation. Changes to land use, hydrological regimes, excessive extraction of ground and surface water, drought and a changing environment, or a combination of these factors can also produce conditions of acidification with potentially extreme repercussions for land use and aquatic resources. Presence of pyrite, jarosite, other iron minerals, sulfidic materials, organic matter, natural or anthropogenic auxiliary calcium-carbonated materials (i.e. oyster shells), and physical characteristics of oxidation and reduction may be used for classification to represent native conditions and can provide interpretation potential for extreme acidification with disturbance. Soil Taxonomy in the US has approximated baseline classification recommendations for physical and chemical properties as well as thresholds for incubation of sulfidic materials for acidification. Based on discussions and examples from field tours the conference has several proposals to modify classification thresholds centered on interpretative value as well as use and management.

Keywords: acid sulfate soils; coastal systems; dredging; acidification; classification

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Study on the classification of soil containing artifacts

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After the industrial revolution, the human effects on soil evolution are becoming profound with the accelerated process of urbanization and industrialization. The classification of soil containing artifacts in WRB (World reference base for soil resources) and ST (Soil Taxonomy) has been systematic, but there is little research on the classification of soil containing artifacts in Chinese soil taxonomy. The research on the classification of soil containing artifacts will help to clarify the diagnostic basis and the type of soil in Chinese soil taxonomy.

Ten typical soil profiles are selected in Henan Province as the research object, compared with 3 natural profiles in the physical, chemical properties and profile form. WRB and ST are used to classify the soil. After adaptability evaluation of ST and WRB for soil containing artifacts, proposal scheme is put forward about Chinese soil taxonomy applying on the soil containing artifacts. And classify the types of soil containing artifacts using the proposed projects in Henan Province. The results are as follows:

(1) The soil layers containing artifacts are messy; the intrusion of artifacts change the physical and chemical properties of soil: the soil bulk density value is reduced by the presence of the ash layer in the profiles affected by the ancient human being, and other typical soil profiles duing to road construction, garbage accumulation or soil reclamation make the soil bulk density become larger; the content of coarse bone substance in the soil containing artifacts is significantly increased; the pH and EC of the soil containing concrete, calcareous building materials, coal gangue and flyash are slightly increased; the content of organic carbon in reclaimed soil is low, but it is high in soil with living garbage; the total phosphorus content of the soil containing the relics of the ancient human activity was slightly higher.

(2) WRB, ST and CST are used to classify the soil containing artifacts. It is found that WRB is not suitable for all the test soil, and the property of soil containing artifacts is only reflected in Entisols in ST.

(3) Soil containing artifacts is defined, and artificial disturbance level is added. Adding a subgroup with the "technology" as the prefix in a group which meet the artificial disturbance level, and the subgroup will be retrieved firstly. Categories of artifacts have been added to the standard of soil family division, with the other four used together.

A systematic study of the soil containing artifacts and the proposal scheme is proposed for the classification of soil containing artifacts for the first time filling the gaps in the research of soil containing artifacts to a certain degree in China. Further studying and classifying scientifically of the soil containing artifacts are of great significance to improve the understanding of this kind of soil and serve for the landscape planning and urban construction..

Keywords: Chinese soil taxonomy, Artifacts, World reference base for soil resources, Soil taxonomy

Proposal of colluvial soils definition and their introduction into international soil classification WRB

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Colluvial soils have received attention in different areas of environmental and geoarchaeological research over last two decades (Dotterweich, 2008). However, their pedological functioning and status as a specific soil unit have been seldom discussed. The concept and general understanding of the term “colluvial soil” often vary, and its definition is vague and needs unification. We present colluvial soils as a soil unit with specific profile development and characteristics formed via a specific process. Because of uniqueness of the colluvial soils formation and theirs characteristic, we feel need to propose clear definition and implementation in soil classification. The term “colluvial soils” is broadly used by different scientific communities. This leads to wide range of meanings for term and sometimes can be a subject of misunderstanding forcing the scientists to avoid the term and replace it a by a more specific one (Kleber, 2006).

We suggest understanding colluvial soils as recent soils developed through periodic rejuvenation of the soil profile due to accumulation of eroded topsoil. The proposed definition of colluvial soil accentuates: i) the accumulation of eroded soil material as the primary process in colluvial soil development, ii) specific terrain position and iii) the presence of humus as a typical feature of colluvial soils. The dominant process leading to soil profile development is soil accumulation, not an in-situ pedogenetic process.

Colluvial soils are described as a soil taxonomic unit in many national soil classifications at a high level. Nevertheless, discrepancy in their concept is also reflected by the diverse definitions in different soil classification systems. Two major international soil classifications, World Reference Base and Soil Taxonomy, consider colluvial soils only at a lower taxonomic level.

There are several pros and cons for its possible introduction as a new Reference Soil Group (RSG). Reasons for extending the RSG list by using “Colluvisols” RSG are as follows: 1) soil unit distinguishable from other RSGs by terrain position and specific soil profile stratigraphy, 2) soil unit developed by a specific process, 3) soil unit recognized at a high level in numerous national soil classifications, 4) soil unit with presumably significant spatial extent, at least at the regional and local scale, 5) soil unit with worldwide occurrence, 6) soil unit with significant environmental value. The main possible restraints for the introduction of “Colluvisols” as RSG are connected to the possibility of its mapping at small scale (Zádorová et al. 2015).

Taking into consideration previously discussed aspects and specificities of colluvial soils, we propose colluvial soils definition and possible consideration of implementation of “Colluvisols” at Reference Soil Group level in World reference Base for Soil resources.

Keywords: colluvial soils; colluviums; soil accumulation; soil classification; soil redistribution

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A morpho-functional classification of organic and organic-mineral soil horizons for surveying soil biological functioning

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Since 2003 a group of soil biologists worked on the standardization of vocabulary and field references for improving the survey of organic and organic-mineral soil horizons. A first publication of the group delineated the main diagnostic characters to consider in field investigations for understanding the biological functioning of terrestrial and submerged soils (Zanella et al. 2011). A proposal for integrating the WRB manual was also formulated (Jabiol et al. 2014). Comparisons between natural and anthropogenic features of organic and/or organic-mineral horizons (Topoliantz et al. 2000), correlated to the animal origin of them (Pelosi et al. 2013), allowed to enlarge the classification to anthropogenic topsoils. Some other pioneer biological activities were also taken into account and a complete morpho-functional classification of organic and organic-mineral horizons can be presented for evaluation to an assembly of soil scientists.

The biological functioning of the soil is circumscribed by focusing on morphology, structure and biological origin of the materials composing organic and organic-mineral horizons. A field key of classification of animal droppings has been prepared as well as many photographs of soil horizon references in different climatic and environmental situations.

The series of horizons generated in correspondence with given groups of biological determinants are called “humus systems”. There are terrestrial, submerged and intergraded humus systems. Among them, with the naked eye or with the help of a pocket-magnifying lens (x 10) it is possible to distinguish typical, atypical, natural or anthropogenic humus systems. Following the natural trend recognized in each type of soil, the application of natural or artificial humus horizons to poorly zoogenic natural or anthropogenic soils is suggested for improving their biological functioning

Keywords: humus system; soils structure; soil biology; soil functioning

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