Diversity and classification problems of sandy soils in subboreal zone (Central Europe, Poland)

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Abstract
The aim of this study was to present some examples of sandy soils and to discuss their position in soil systematics. 8 profiles represent: 4 soils widely distributed in postglacial landscapes of Poland (Central Europe), typical for different geomorphological conditions and vegetation habitats (according to regional soil classification: Arenosol, Podzolic soil, Rusty soil and Mucky soil) and 4 soils having unusual features (Gleyic Podzol and Rusty soil developed in a $CaCO_3$-rich substratum and two profiles of red-colored Ochre soils). According to WRB (IUSS Working Group WRB, 2007), almost all of these soils can be named Arenosols. Considering their individual morphological features (stage of development, sequence of horizons) and different ecological value, most of the studied soils should be classified into other Reference Soil Groups or even distinguished in individual units.

Key Words
Soil classification, Soil geography, Soil morphology, Arenosols, Podzols, Sand.

Introduction

Soils developed from loose quartz sands generally represent the least fertile mineral soils in the World. According to WRB soil classification (IUSS Working Group WRB 2007), one genetic variant - Podzols - is distinguished as individual unit from that textural group of soils. Most of the other sandy soils can only be classified as Arenosols, irrespective to their development rate, soil horizons sequence or ecological properties. Such arrangement does not reflect the real diversity of sandy soils, especially in comparison to the number of divisions covering soils of heavier texture. In some regions of the Earth, for example in postglacial landscapes of Central Europe (European sand belt; Zeeberg 1998), subboreal zone, soils built from glacial, glaciofluvial, glaciolacustrine, fluvial, lacustrine and aeolian sands occupy big areas and represent diverse, mature morphological and ecological variants associated with different plant communities.

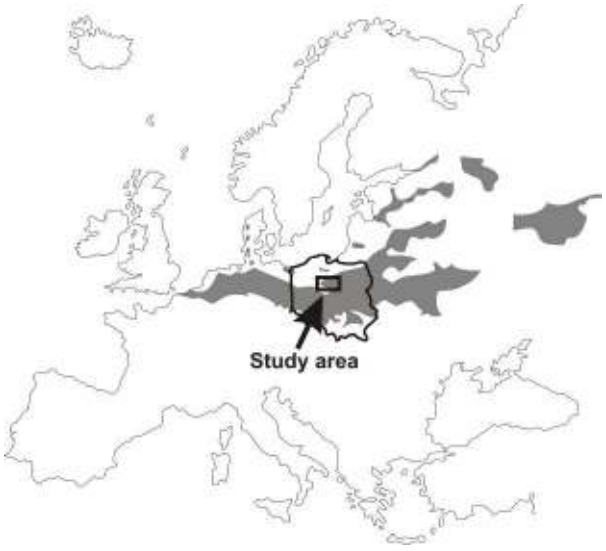

Figure 1. Location of the study area in the European sand belt (Zeeberg 1998)

The aim of this work is to emphasize sandy soils diversity and necessity of their more detailed classification, important for both scientific and practical aspects.

Methods

The study area is located in Northern Poland, Central Europe (Figure 1). The climate in the region is of a temperate, humid type (average annual temperature 7-8 ^{o}C, precipitation 450-650 mm) and deciduous and coniferous forests are the potential natural vegetation. Eight representative profiles of morphologically and ecologically different sandy soils were chosen for studies in two groups: typical soils, widely distributed in the area (profiles 1-4), and examples of more rare soils with specific, unusual features (profiles 5-8). During field works site conditions were determined in respect to geomorphological situation, vegetation and moisture regime, as well as soil morphology. In samples taken from all genetic horizons, basic properties were determined using standard methods: texture, organic carbon and nitrogen contents, pH, $CaCO_3$ content, total Fe, oxalate extractable Fe and Al contents. The typological position of soils was established using criteria of WRB (IUSS Working Group WRB 2007) and regional classification systems: Systematics of Polish Soils (SPS 1989) and Classification of Polish Forest Soils (CPFS 2000).

Results

All studied soils developed from poor, loose sands building geomorphological forms of various origin: aeolian, glaciofluvial, fluvial and lacustrine (Table 1).

Table 1. Site characteristics and classification of soils according to WRB (IUSS Working Group WRB 2007) and regional, Polish classification systems (SPS 1989, CPFS 2000)

No	Geomorphology	Vegetation	Soil classification	
			WRB	Regional names
1	aeolian cover	dry grassland (*Corynephorus canescens*)	Haplic Arenosol	Arenosol
2	dune	humid coniferous forest (*Pinus sylvestris*)	Albic Arenosol	Podzolic soil
3	glaciofluvial outwash plain	humid mixed forest (*Pinus sylvestris/Quercus robur*)	Brunic Arenosol (Orthodystric)	Rusty soil
4	glaciofluvial marginal valley terrace	wet deciduous forest (*Alnus glutinosa/Fraxinus excelsior*)	Haplic Gleysol (Humic, Arenic) or Umbric Gleysol (Arenic)	Mucky soil
5	glaciofluvial outwash plain	humid deciduous forest (*Quercus robur/Carpinus betulus*)	Brunic Arenosol (Endoeutric)	Rusty soil
6	lake terrace with $CaCO_3$ gytia interlayer	wet mixed forest (*Pinus sylvestris/Quercus robur*)	Gleyic Podzol	Gleyic Podzol
7	fluvial terrace	wet mixed forest (*Picea abies, Alnus glutinosa*)	Rubic Arenosol	Ochre soil
8	glaciofluvial terrace	humid mixed forest (*Pinus sylvestris/Quercus robur*)	Rubic Arenosol	Ochre soil

They represent anthropogenic initial grassland (profile 1) or, more natural for the area, coniferous, mixed and deciduous, humid and wet forests (profiles 2-8). According to WRB 2007, six of these profiles belong to the Arenosols, one to the Gleysols and one to the Podzols. Using regional names (SPS 1989, CPFS 2000) only the first profile represents an Arenosol - a weakly developed sandy soil without any genetic horizon, apart from an initial AC horizon (Figure 2, Table 2). The rest of the WRB Arenosols are mature, well developed soils. They have clearly visible sequences of genetic horizons with distinct, individual features, being the effect of different soil-forming processes: high organic matter accumulation in the A horizon, (Mucky soil, Rusty soils, Ochre soil), visible iron and aluminum translocation from the E to the Bhs (Podzolic soil and Gleyic Podzol), gleyic properties in the Cr (Mucky soil, Gleyic Podzol and Ochre soil), residual concentrations of iron in the Bwo (Rusty soils) or allochthonous concentrations of iron in the Bwo (Ochre soils).

Apart from the weakly developed Arenosol, all soils show a distinct organic carbon content in the A horizon (1 to 4 %). C/N ratio values vary from 11 to 27. The reaction of the genetic horizons is mostly acid (pH KCl 2.6 to 6.5), even when the soils are formed in materials primarily containing high amounts of calcium carbonate (Gleyic Podzol, Rusty soil).

Although the weakly developed soil (Haplic Arenosol), the strongly podzolized, gleyed soil (Gleyic Podzol)

and the humus rich, gleyed soil (Haplic Gleysol (Humic, Arenic) or Umbric Gleysol (Arenic)) can be classified into particular Reference Soil Groups reflecting their individual features, the position of the Podzolic soil, the Rusty soils and the Ochre soils among Arenosols is controversial. The Podzolic soil, although it does not meet the quantitative criteria of WRB Podzols, shows clear evidences of podzolization (Charzynski 2000). The Rusty soils and the Ochre soils represent individual, mature soil variants, morphologically closer to Cambisols than to Arenosols, but lacking a cambic horizon due to their sandy texture.

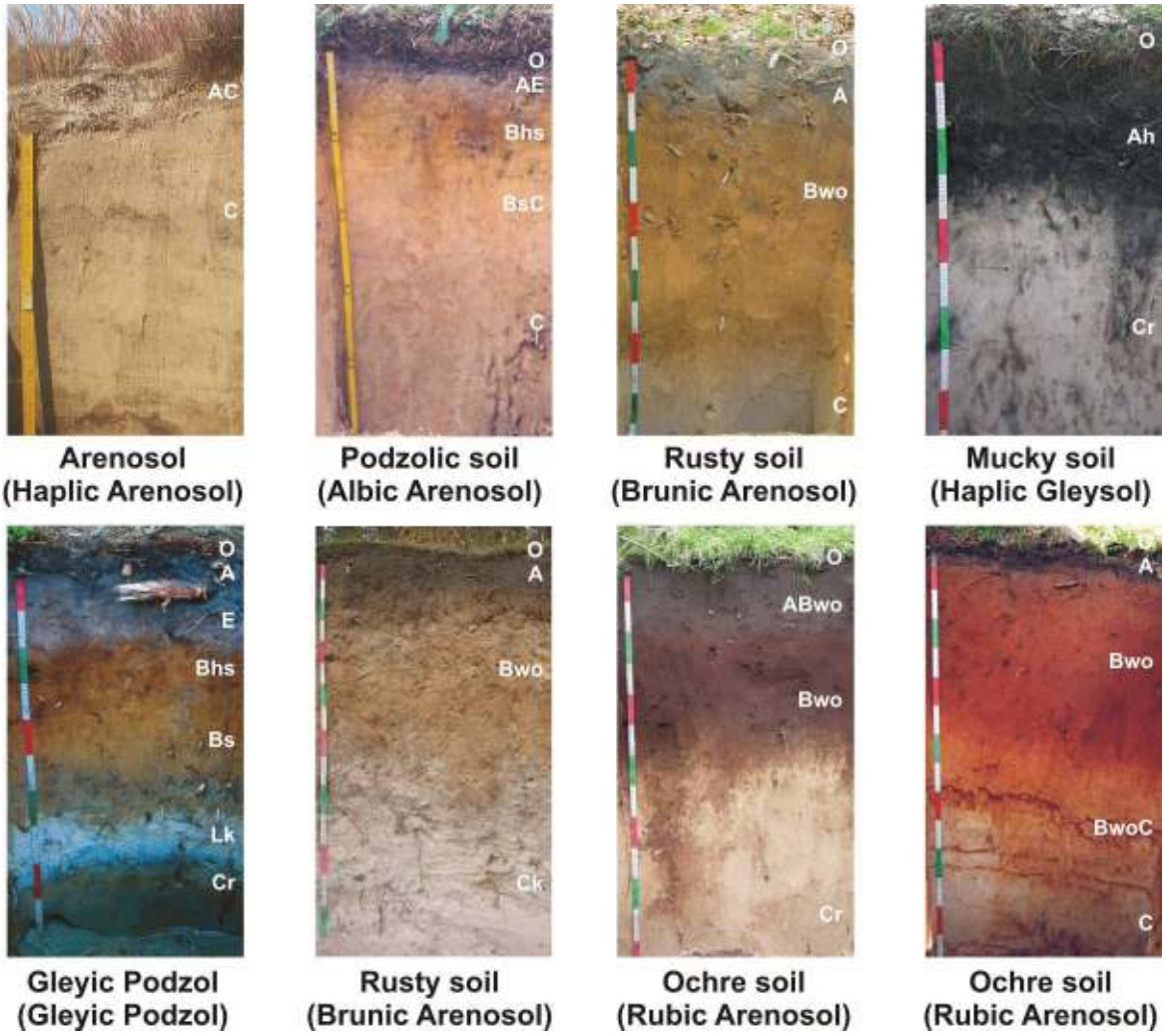

Figure 2. Morphology of sandy soils under study

Table 2. Main properties of soils

No	Soil regional names	Morphology	Texture sand/silt /clay [%]	pH KCl A-C	OC in A [%]	C/N in A	Fe_t	Fe_o	Al_o
							[%]		
1	Arenosol	AC-C	97/3/0	4.3-4.4	0.24	12	AC 0.18 C 0.12	0.03 0.02	0.03 0.03
2	Podzolic soil	AE-Bhs-BsC-C	96/4/0	3.4-4.7	1.10	24	E 0.30 Bhs 0.40 C 0.40	0.05 0.15 0.05	0.04 0.17 0.12
3	Rusty soil	A-Bwo-C	100/0/0	3.6-4.5	2.22	22	A 0.46 Bwo 0.46 C 0.23	0.18 0.07 0.03	0.17 0.10 0.03
4	Mucky soil	Ah-Cr	97/2/1	4.5-4.8	2.51	17	Ah 0.25 Cr 0.14	0.12 0.01	0.30 0.06
5	Rusty soil	A-Bwo-Ck	97/3/0	3.4-9.0 18 % $CaCO_3$	3.20	27	A 0.49 Bwo 0.58 Ck 0.36	0.13 0.08 0.02	n.d.
6	Gleyic Podzol	A-E-Bhs-Bs-Lk-Cr	97/2/1	2.6-8.6 18% $CaCO_3$	1.33	22	E 0.12 Bhs 0.70 Cr 0.26	0.01 0.11 0.02	0.01 0.19 0.01
7	Ochre soil	ABwo-Bwo-Cr	85/14/1	5.8-7.0	4.21	11	A 2.07 Bwo 4.28 Cr 0.37	0.35 1.10 0.01	0.08 0.10 0.02
8	Ochre soil	A-Bwo-BwoC-C	90/6/4	4.5-5.8	1.57	19	A 0.81 Bwo 1.92 C 0.24	0.55 1.17 0.04	0.07 0.07 0.01

Among the presented profiles, the most atypical for sandy soils of the region are: the strongly acid Gleyic Podzol and the Rusty soil, both developed from sediments containing carbonates and the Ochre soils having an unusual red colour (2.5R-5YR by Munsell) as well as high concentrations of iron (up to 4.5 %).

Conclusions

It is worth to notice that, although sandy soils generally have disadvantageous properties for agriculture, as forest sites they constitute productive habitats. Even within the narrow texture group, these soils are morphologically, chemically and ecologically diverse. In regions, where different variants of sandy soils occupy big areas, there is a need to distinguish more detailed classification units, as it is proposed in WRB (2007) for Arenosols. Including all sandy soils in one Reference Soil Group only on the basis of texture, irrespective of their development rate, horizons sequence and ecological value, does not reflect their real diversity. The advanced developmental stage of some sandy soils suggests that they should be classified on the same level of classification as other typologically mature soils.

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