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PROBLEMS ENCOUNTERED WHEN CLASSIFYING PODZOL SOILS OF POLAND USING INTERNATIONAL CLASSIFICATION WRB 1998 AND 2006

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Classification World Reference Base for Soil Resources (WRB) from the moment of publication draws attention of many Scientists throughout the World. There is however a lot of controversy connected with Diagnostics Criteria and definitions of soil units. In many countries also researches was carried to test WRB according to local conditions. In Poland, the most controversial in 1998 edition of WRB was definition of *spodic* horizon and Podzols soil unit. Podzols and Podzolic soils, as defined in Systematics of Polish Soils, cover around 37000 sq km (12% of country territory). Classification of Polish Podzols using WRB causes many problems.

In this paper there are presented results for 7 soil profiles situated in Brodnica Lakeland and Toruń Basin (Central Poland) and on Baltic bay bars (North Poland). Those soils which keyed out as Arenosols in previous version of WRB became Podzols in 2006 edition.

Keywords: Podzols, Arenosols, spodic diagnostic horizon, WRB classification, WRB improvement

Introduction. Since the WRB classification [11] was published in 1998, numerous papers have been published in order to test and evaluate the system's usefulness for individual countries or geographical regions [14, 2, 10, 19, 22, 17, 8]. In Poland most controversial in 1998 edition of WRB was definition and criteria of *spodic* horizon and, what's follow, Podzols Reference Soil Group (RSG). Verification of systematic position of podzols from the area of North Poland proved that soils with evident features of podzolization process but developed on poor glacial deposits of last glaciation have in most cases not enough aluminium and iron to meet criteria of *spodic* horizon in WRB 1998 edition [2, 6, 4]. Without modifications of *spodic* horizon definition from 1998 edition of WRB Podzols would nearly disappear from not only soil map of Poland but also North Germany, Lithuania and other countries, which territory is at least partly covered by material from last glaciation. The aims of present paper are:

- ✓ to show morphologically well developed podzols according to Systematics of Polish Soils with illuvial horizon, which didn't fulfils the criteria of *spodic* horizon according to WRB (1998);
- ✓ to evaluate definitions of *spodic* horizon and Podzol reference soil group after the changes made in new edition of WRB (2006) on the base of soil data from North Poland.

Object and Methods. Podzols and podzolic soils cover about 12% of territory of Poland [1]. This are soils which are generally develop from poor parent materials (quartzitic dune sands with very low nutrient status, loamy sands, outwash sands and ice-marginal valley sands) with the participation of boreal forest vegetation (coniferous trees with dominant specie of *Pinus sylvestris*). Poland is located between 49º00' and 54º50' E, cover area of approximately 312000 km^2. Mean temperature of January is varying meridionally from –1º in area of Zalew Szczeciński (in North-West Poland) to –5,5º in Suwalszczyzna (in North-East Poland). In July temperature is increasing towards south from 17º on utmost north of Poland to 19º in Middle Poland, Silesia Plain, Sandomierska Basin and South-East Poland. Mean annual temperature range from 6ºC to 8.5ºC. Growing season lasts from 195 days in East Poland to 220 days in Western part of the country.

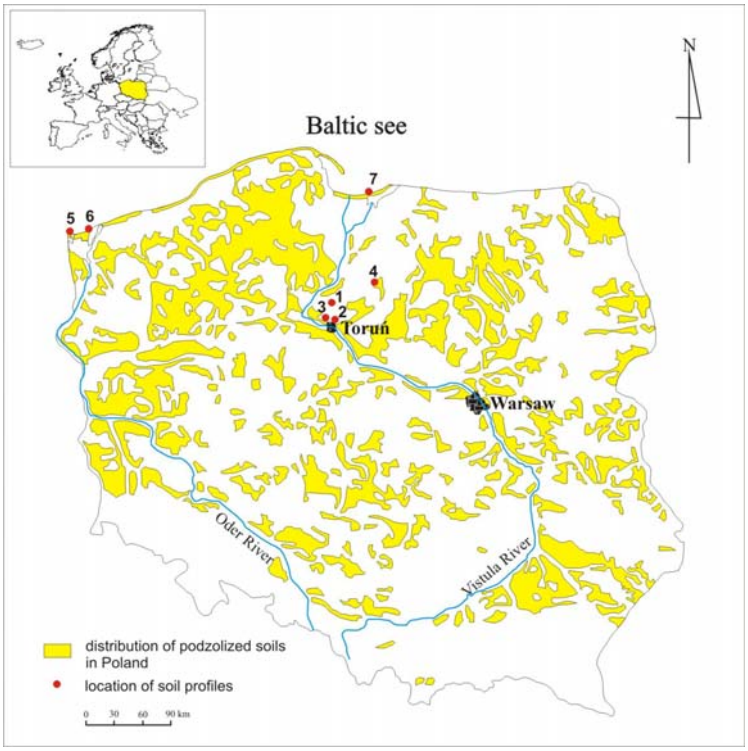

Fig. 1. Distribution of podzolic soils in Poland and localization of study sites

Central Poland receives 480-500 mm of precipitation, while Tatra Mountains receive 1700 mm [15]. Poland lies in humid climatic zone, where precipitation excess evapotranspiration. Such climatic conditions favour process of podzolization [9, 16].

Soils was investigated in four areas, two of them located on Baltic coastline and another two inland (Fig.1). Profile 1 is situated on outwash plain in Brodnica Lakeland, parent material is windblown fluvioglacial sand. Profiles 2, 3 and 4 are situated in Toruń Basin. Profiles 2 and 4 was dug on dune on the terrace, parent material is dune sand. Profile 3 is situated on terrace plain; parent material is ice marginal stream terrace sand. Profiles 5, 6 and 7 were situated on Baltic bay bars and have been formed on dunes whose origin has been referred to the Post-Lithorina Transgression period.

Soil profiles were examined in 2001, except profiles No. 9, 10, 11, which was examined few years earlier. Manually dug pits were examined to a depth of approximately 180 cm, photographed and described according to the FAO Guidelines for Soil Description [7] but tailored to Polish conditions, particularly with respect to texture. The samples were taken from particular soil horizons connected with podzolization process.

The following methods were used to characterize all samples:

- ✓ pH potentiometrically in a 1 : 1 soil/water suspension [21];
- ✓ colour of the moist and crushed samples according to Munsell [18];
- ✓ organic carbon (OC) content according to Walkley-Black procedure;
- ✓ iron (Fe_{ox}) and aluminium (Al_{ox}) by the acid (pH 3) oxalate extraction;

Only those chemical parameters was measured, which are necessary to establish soil systematic position according to WRB, as well as Polish system. All analysis was made in the laboratory of Soil Science Department of Nicolaus Copernicus University in Toruń, Poland.

The soils were classified according to two editions of WRB [11, 12] and Systematics of Polish Soils [20]. Symbols of soil horizons are given after Guidelines for Soil Description [7].

Results and their discussion. All investigated soils are covered with temperate coniferous forests, with dominant species of Scots Pine (*Pinus sylvestris*).

The sequence of genetic horizons in morphology of all investigated soils is:

O – organic horizon with thickness from 4 cm to 19 cm, type of humus is mor;

A – humus horizon is well developed in all of profiles, apart of profile No. 1, which have transitional AE horizon;

E – eluvial horizon with thickness from 8 to 22 cm;

B – illuvial horizon, with different degree of cementation. Most cemented horizons were fund in soils on Baltic bay bars (profiles 5, 6 and 7). Those horizon have different thickness, sometimes they have dichotomic morphology (in coastal soils) – thin upper layer Bhs and much more thick lower layer, with little content of OC (Bs);

not altered parent material occurs on depth 100 to 110 cm.

Fig. 2. Site No. 2 Wrzosy

Fig. 3. Site No. 6 Przytor Bay Bar

Despite well developed and clearly visible morphological features of podzolization process (e.g. profiles No. 2 and No. 6, see Figure 2. and Figure 3.), all analyzed profiles according to WRB 1998 couldn't be classified as Podzols because of insufficient content of oxalate extractable aluminium and iron (varying from 0.148% to 0.433%), as well as insufficient OC content in case of profiles No. 2 and 3 (0.5 and 0.51%). Other diagnostic criteria of *spodic* horizon (thickness, colour and pH) were fulfilled. Thickness of illuvial horizon in all profiles exceeds 2.5 cm. Colour (moist and crushed) of all illuvial horizons is compliant with WRB criterion - hue of 7.5 YR or redder, value is 5 or less and chroma is 4 or less. According to WRB pH (1:1, in water) must be 5.9 or less. In our samples pH varies from 4.1 to 4.9, thus all of it fulfils discussed criterion.

1. Soil characteristics of the eleven sites (only eluvial and illuvial horizons)

Soil Profile	**Horizon**	**Depth,** cm	**Colour (moist and crushed),** Munsell	**OC,** %	**pH** H_2O (1:1)	**Al_o +$^1/_2Fe_o$,** %
Site No. 1 Otłoczyn	AE Bsh	0-15 15-25	7.5YR 6/2 7.5YR 4/3	0.95 0.65	4.6 4.7	0.054 0.433
Site No. 2 Wrzosy	E Bshl	25-47 47-95	7.5YR 6/2 5YR 3/2	0.07 0.5	3.9 4.6	0.011 0.148
Site No. 3 Olek	Ees Bsh	12-20 20-30	7.5YR 3/1 7.5YR 3/2	0.61 0.51	4.2 4.4	0.059 0.208
Site No. 3 Łąkorz	E Bsh	0-7 7-10	7.5YR 4/1 5YR 3/2	1.39 1.29	3.8 4.1	0.076 0.161
Site No. 5 Karsibor Bay Bar	E Bh	12-33 33-35	5YR 4/1 2.5YR 2.5/2	0.43 1.59	4.7 4.5	0.015 0.380
Site No. 6 Przytor Bay Bar	E Bh	3-23.5 23.5-26	5YR 5/2 2.5YR 3/2	0.44 0.89	4.4 4.6	0.025 0.285
Site No. 7 Vistula Bay Bar	E Bh	4-16 16-18	5YR 4.5/2 2.5YR 3/2	0.52 1.22	4.3 4.3	0.030 0.325

Because of its chemical parameters all researched soils have to be classified as Arenosols.

Changes introduced in *spodic* definition of 2006 edition of WRB (lowering criterion of OC from 0.6 to 0.5% and introducing morphological criterion – presence of albic horizon and appro-

priate colour – which made criterion of Al_{ox} +1/2 Fe_{ox} content only facultative, lead to different systematic position of presented soils according to new edition of WRB. All could be now classified as Podzols: profiles 1, 3 and 4 as Albic Podzols, profile 2 as Gleyic Podzol while profiles 5, 6, 7 as Albic Ortsteinic Podzols.

2. Classification of studied soils according to WRB 1998 and WRB 2006

Soil Profile	WRB 1998	WRB 2006
Site No. 1 Otłoczyn	Albic Arenosol	Albic Podzols
Site No. 2 Wrzosy	Albi-Gleyic Arenosol	Gleyic Podzol
Site No. 3 Olek	Albic Arenosol	Albic Podzols
Site No. 3 Lakarz	Albic Arenosol	Albic Podzols
Site No. 5 Karsibor Bay Bar	Albic Arenosol	Albic Ortsteinic Podzols
Site No. 6 Przytor Bay Bar	Albic Arenosol	Albic Ortsteinic Podzols
Site No. *7* Vistula Bay Bar	Albic Arenosol	Albic Ortsteinic Podzols

Conclusions.

WRB undergoes a permanent process of evaluation and improvement. A rough correlation of Podzolized soil in WRB 1998 and in Systematics of Polish Soils 1989 [20] is as follow: most of Podzols and Podzolic Soils according to Systematics of Polish Soils are Dystri-Albic Arenosols, only some of them could be classified as Podzols. Podzols and Podzolic Soils with gleyic properties according to Systematics of Polish Soils could be classified according to WRB 1998 as Podzols and Arenosols and some of them as Gleysols and Umbrisols. Changes introduced in diagnostic criteria of this RSG in 2006 edition of WRB lead to different correlation. Previously published comparative study showed greater versatility of new version of WRB system [5]. Present definition of WRB *spodic* horizon is much better than previous one. It reflects in optimal way soil conditions of last glaciations areas. Changes in definition caused, that soils with evident features of podzolization process but developed on poor glacial deposits of last glaciation, which unfortunately have to be classified as Arenosols according to 1998 edition WRB 'became' Podzols in 2006 edition.

This case of Polish podzolized soils shows that quantitative approach to soil classification could be dangerous. In classification, which has the ambition to be world-wide, like WRB, diagnostics quantitative criteria have to be tested on soils from different geographical locations to assure that they well mirror soil processes. Quantitative approach de-emphasized the role of soil processes but albeit hidden in the shadow, they are still underpinning soil classification systems.

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ПРОБЛЕМИ, ЯКІ ВИНИКАЮТЬ ПРИ КЛАСИФІКАЦІЇ ПІДЗОЛИСТИХ ҐРУНТІВ ПОЛЬЩІ З ВИКОРИСТАННЯМ МІЖНАРОДНОЇ КЛАСИФІКАЦІЇ WRB 1998 І 2006

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Світова реферативна база грунтових ресурсів з моменту свого опублікування викликає інтерес багатьох вчених світу. Існує, однак, багато протиріч, пов'язаних із діагностичними критеріями і визначеннями грунтових одиниць. Дослідження з тестування WRB в місцевих умовах проведені в багатьох країнах. В Польщі найбільше протиріч у виданні WRB 1998 року викликало визначення горизонту *spodic* і грунтової одиниці Podzols. Підзоли і підзолисті ґрунти є одними із найрозповсюдженіших ґрунтів Польщі. Класифікація польських підзолів із використанням WRB створила багато проблем. Більшість із підзолів не класифікувалась Podzols згідно WRB через дуже низький вміст карбону і феруму/алюмінію. В статті представлені результати дослідження 7 профілів ґрунтів. Ґрунти, які відносились до ареносолей в попередній версії WRB, стали Podzols у виданні 2006 року.

Ключові слова: підзоли, ареносолі, діагностичний горизонт spodic, класифікація WRB, удосконалення WRB