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Relationships between soil pH and base saturation – conclusions for Polish and international soil classifications

Abstract: Taking into account the fact that (a) measurement of the cation exchange capacity and base saturation is practically unavailable in the field, that formally makes impossible the reliable field classification of many soils, (b) base saturation is measured or calculated by various methods those results significantly differ, (c) base saturation and soil pH are highly positively correlated, it is suggested to replace the base saturation with pH_w (measured in distilled/deionized water suspension) in the classification criteria for diagnostic horizons and soil units/subunits, both in the Polish Soil Classification and FAO-WRB. Based on statistical analysis of 4500 soil samples, the following pH_w values are recommended instead of 50% base saturation: pH_w <5.5 for umbric and pH_w ≥5.5 for the mollic horizon, and for Chernozems, Kastanozems, Phaeozems (directly) and Umbrisols (indirectly). Furthermore, the pH_w <4.7 may feature the Dystric qualifier in mineral soils and respective Reference Soil Groups of WRB; while the pH_w ≥4.7 may feature the Eutric qualifier. The distinction between subtypes of the brown soils in the Polish Soil Classification may base on the pH_w 4.7 or 5.0, but using different requirements of pH distribution in the depth control section. The replacement of the base saturation with pH refers to the formal soil classification only, and does not exclude the use of base saturation for professional soil characteristics.

Keywords: base saturation, pH, soil classification, WRB, Polish Soil Classification

INTRODUCTION

The saturation of soil cation exchange capacity (CEC) with exchangeable base cations, simplified to as “base saturation” (BS), has been considered a complex physicochemical parameter that approximates the relationships between exchangeable “basic” and “acidic” cations in relation to other soil properties and external factors, such as weathering stage, parent material origin, texture, organic matter content, climate, vegetation, fertilization, contamination etc. (Blosser and Jenny 1971, Gałka et al. 2014, Gruba and Mulder 2015, Bojko and Kabała 2016, Musielok and Drewnik 2016, Józefowska et al. 2017). As a direct measure, base saturation may indicate the behaviour and availability of crucial elements (Bloom et al. 2005, Bielińska and Mocek 2010). Therefore, BS became a general indicator of soil trophic status, presumed to be better than other single characteristics, including the pH value (Bieganowski et al. 2013, Kobierski et al. 2015, Łabaz et al. 2016), and thus – became widely used in soil characterisation and classification as one of crucial diagnostic criteria (Kacprzak and Derkowski 2007, Mendyk et al. 2015, Świtoniak 2015, Kowalska et al. 2017, Krupski et al. 2017, Charzyński et al. 2018, Waroszewski et al. 2018).

However, CEC and BS cannot be measured in the field, due to special equipment necessary for analysis. Therefore, the reliable and final naming, classification and cartography of many soils is in fact impossible until the analytical data from the laboratory were delivered, that may take weeks. Such a prolonged lack of final decision is particularly inconvenient at soil mapping, where the contours of soil unit should be approximated during the field investigation (Brevik et al. 2016). The above mentioned problem is not marginal. Such a crucial diagnostic horizons as mollic and umbric, common qualifiers Eutric and Dystric, and reference groups Phaeozems, Alisols, Luvisols etc. include BS in their diagnostic criteria (IUSS Working Group WRB 2015). It means, many basic distinctions cannot be completed without advanced laboratory analysis. The formal requirements for diagnostic horizons/qualifiers do not allow a field approximation of BS of mineral soils based on their field-measured pH, even if this approximation is commonly applied by many soil scientists. One can therefore conclude, that the classification of many soil units in the field is a fiction at present, if laboratory data are unavailable.

The other disadvantage of BS is variable methodology of its measurement. There is no universal extracting agent similarly effective in both the acid,

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neutral and alkaline soils; mineral and organic; rich or poor in carbonates, gypsum, and easily soluble salts (Ross et al. 2008). The methods developed over the century of investigation were suited to local climate and soil conditions, and to the particular needs (Sumner and Miller 1996). As the agriculture-oriented attempts prevailed in the studies on soil sorption and cation exchange phenomena, the standard methods refer to potential equilibrium state, at the target pH of 7.0 or 8.2, depending on local soil conditions (Schollenberger and Simon 1945, Maksimow and Góralski 1959). However, such attempt, theoretically and practically justified for the local optimization of the fertilization, is not acceptable in soil classification, where the universal criteria must be applied for all soils to avoid different classification of the same soil, depending on the method used for the analysis (Sumner and Miller 1996). Thus, most of the national soil classifications have accepted only one method of CEC and BS analysis, but not the same (Nemeček et al. 2001, Reintam and Köster 2006, Secu et al. 2008, Shi et al. 2010). As a result, a common, but hidden problem is a limited correlativity of national soil maps and databases merged within international programmes (Jones et al. 2005, Reintam and Köster 2006, Keesstra et al. 2016).

The international soil classification WRB (IUSS Working Group WRB 2015) requires two different methods of BS calculation:

(1) as a ratio of base cations (BC) to CEC_7, where both BC and CEC_7 are measured in the extract obtained after soil percolation with NH_4OAc at pH 7 in the glass pipes; applied to distinguish between mollic and umbric horizons, and to identify Chernozems, Kastanozems, Phaeozems, and, indirectly, Umbrisols; designated here BS_7, and

(2) as a ratio of BC (measured in NH_4OAc at pH 7) to so called effective cation exchange capacity ($ECEC_{AL}$), i.e. the sum of BC and exchangeable aluminium (extracted with 1M KCl, unbuffered) – diagnostic for Eutric/Dystric qualifiers, and for Acrisols, Alisols, Lixisols, and, indirectly, also for Luvisols; designated here BS_{AL}.

This approach has been criticized as too complicated – requiring two measures for the same soil feature, even in one soil profile (e.g. in Gleysols, where different BS is applied to recognise the mollic/umbric horizons, if present, and the Eutric/Dystric qualifier).

The problem with BS in soil classification has also arisen in Poland since the classification based on diagnostic horizons has introduced 0.2M $BaCl_2$ to measure the "total exchangeable acidity" (PSC 2011). Unfortunately, the comparability of this extraction with the methods accepted in WRB classification has not been proven. Moreover, $BaCl_2$ solution has never been widely used in Poland and the utility of archival data to classify soils using the new criteria is unknown. The most typically in Poland, BS_{TA} was calculated as the ratio of BC (extracted with 1 M NH_4Cl pH 7.8–8.2) to the sum of BC and total ("hydrolytic") acidity (TA) extracted with 0.5 M $Ca(OAc)_2$ or 1 M NaOAc (Maksimow and Góralski 1959, Lityński et al. 1976, Weber et al. 2007, Jaworska et al. 2008, Kalembasa et al. 2011, Szewczyk et al. 2015). This concept of $ECEC_{TA}$ and BS_{TA} was derived intentionally for arable soils (regularly limed and fertilized), and is known to underestimate the base saturation in acid forest soils (Kabała et al. 2013) by overestimating the total acidity (due to the raising the equilibrium to the level that does not and cannot occur in most forest soils). To get a more realistic view into the present BS in the acid soils, such as most of the forest soils under temperate humid climate, many authors suggested (Lityński et al. 1976 Leitgeb et al. 2013) to calculate BS_{EA} as the ratio of BC in NH_4OAc at pH 7 extract to $ECEC_{EA}$ being a sum of BC and exchangeable acidity (EA) in 1 M KCl, or using exchangeable Al instead of EA. The popularity of the latter method comes from an assumption that BS_{EA} below 50% automatically indicates the domination of exchangeable aluminium, that is known of its toxicity to plant roots (Pokojska 1986, Porębska et al. 2008).

To avoid the above mentioned inconsistency related to different methods of BS calculation, that are deeply rooted in the local pedological traditions and cannot be modified/unified within a short time period, and to allow the reliable soil classification in the field, it is postulated to replace the BS with pH value as diagnostic criterion. The aim of this work is to testify the correlation between soil pH and BS calculated using two methods commonly used in Poland, and to derive the threshold pH values – respective to 50% level of base saturation.

MATERIALS AND METHODS

A database of 4500 mineral soil samples was compiled, representative for a wide collection of arable and forest soils (Luvisols, Cambisols, Planosols, Stagnosols, Gleysols, Retisols, Alisols, Phaeozems, Chernozems, Arenosols, Podzols, Leptosols, and Fluvisols) from SW Poland and, to a lesser extent, other regions of Poland (Kabała et al. 2016a). The collection included samples from all mineral genetic horizons, thus the presented relationships may differ from other reports, that based mainly on topsoil layers (Clark and Hill 1964, Blosser and Jenny 1971, Jaremko and Kalembasa 2014). Large variability of soil texture is involved, with predominance of sand, loamy sand, sandy loam, loam, and silt loam classes. Similarly, samples were featured by broad range of organic carbon content and soil pH (Table). All laboratory analyses were conducted in the fine earths (<2 mm), after sample drying, crushing, and sieving. Soil pH was measured potentiometrically, in the distilled water (pH_w) and in 1M KCl (pH_{KCl}) suspensions at soil:solution ratio 1:2.5 v/v. Soil organic carbon (SOC) was determined by dry combustion with spectrometric detection of released CO_2 (CS-Matt 5500), after carbonate removal if present; or by wet oxidimetric method with an external heating, the so called Tyurin method. Exchangeable base cations (BC) were extracted with 1M NH_4OAc at pH 7 (soil:solution 1:40) and the concentration of Ca, Mg, K, and Na cations was determined using ICP technique (Kabała and Karczewska 2017). An exchangeable acidity (EA) was extracted with unbuffered 1 M KCl (soil:solution 1:10) and titrated potentiometrically up to pH 7.8. Exchangeable aluminium was measured in the same extract by potentiometrical titration, indirectly, after aluminium precipitation using NaF. Total ("hydrolytic") acidity (TA) was extracted with 0.5M $Ca(OAc)_2$ (soil:solution 1:10) and titrated potentiometrically up to pH 7.8 (Kabała and Karczewska 2017). Base saturation was calculated in three ways:

(1) using the exchangeable aluminium to calculate the aluminium-effective cation exchange capacity: BS_{AL} [%] = BC *100 / $ECEC_{AL}$, where $ECEC_{AL}$ = BC + exchangeable aluminium;

(2) using the exchangeable acidity (EA) to calculate the effective cation exchange capacity: BS_{EA} [%] = BC *100 / $ECEC_{EA}$, where $ECEC_{EA}$ = BC + EA;

(3) using the total ("hydrolytic") acidity (TA) to calculate the "total" cation exchange capacity: BS_{TA} [%] = BC *100 / CEC_{TA}, where CEC_{TA} = BC + TA.

The database has been completed over the years using the results of variably focused projects using different analytical protocols for particular samples. Thus, the number of samples used for particular correlation may greatly differ. It is displayed in Table, separately for each soil characteristics.

As the values of pH measured in distilled water and 1M KCl are highly correlated in Polish soils (Kabała et al. 2016a), the modelling of the relationship between pH and BS was made in this study for the pH_w only, and pH_w was selected due to two technical circumstances: (a) field tests of soil pH are conducted in water suspension as a standard, both using the rapid potentiometric measurements and indication dyes, including the Hellige test (Steinhardt and Mengel 1981), and (b) distilled/deionised water is elsewhere available, including most petrol stations, that allows its easy gaining in case of exhaustion during field work.

Basic statistical parameters, correlation coefficients, and regression equations were calculated using the Statistica 12 package, whereas the fitting of mathematical models – using the CurveExpert Pro 2.5 (Hyams Development).

RESULTS

Mean total ("hydrolytic") acidity was nearly two-fold higher than mean exchangeable acidity (Table); however, the difference between acidities decreased with increasing acidity values (Figure 1). Despite relatively high determination coefficient (r^2=0.70), huge variability of respective acidity values should be noted. For example, at the total acidity of 20 cmol(+) kg^{-1}, soils had the exchangeable acidity in a

TABLE. Summary statistical characteristic of the soils used for calculations and correlations

Value	pH_w	pH_{KCl}	SOC	Sum of base cations B	Al_{ex}	Echangeable acidity	Total acidity	Base saturation		
						EA	TA	BS_{AL}	BS_{EA}	BS_{TA}
			%	cmol(+) kg^{-1}				%		
N	4580	4580	4210	3480	3600	4130	3070	2900	3480	2150
Mean	4.9	4.2	2.7	3.7	2.5	3.6	6.5	51.4	43.0	31.5
Minimum	2.9	2.1	0.03	0.05	0.0	0.0	0.0	1.6	1.6	1.1
Maximum	8.3	7.7	17.8	85.0	22.1	28.4	70.0	100	100	100
SD	0.9	0.9	2.8	6.8	3.3	3.9	7.0	31.8	29.8	27.2

Explanation: Al_{ex} – exchangeable aluminium, N – number of cases under investigation, SOC – soil organic carbon, SD – standard deviation.

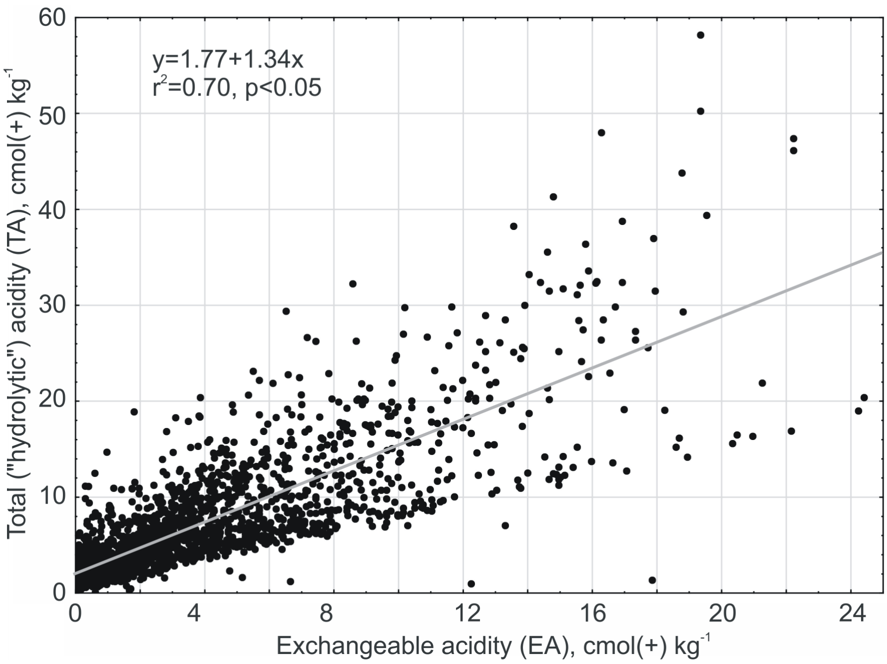

FIGURE 1. Relationships between exchangeable (EA) and total (TA) acidity in soils under investigation (N=3070).

broad range of 4–25 cmol(+) kg^{-1}. This is probably a result of high content of pH-dependent charge as typical for some humus- and iron oxide-rich soils, that may produce unexpectedly high potential acidity, if buffered salt was used to acidity extraction (Bloom et al. 2005). Despite the opinions on insignificant contribution of exchangeable hydrogen to exchangeable acidity as compared to exchangeable aluminium in mineral soils (Sumner et al. 1996, Leitgeb et al. 2013), the exchangeable aluminium created only ca. 70% of exchangeable acidity, on average (Table). This difference confirms the importance of pH-dependent charge of soil organic matter (Bloom et al. 2005). If the mean values of exchangeable aluminium and acidity differ, also the difference may be expected in the pH value respective to 50% base saturation calculated using these two parameters.

Both EA and TA were highly positively correlated with pH_w; however, the relationships were non-linear, with many outliers (Figure 2), in particular at pH_w values below 5. One of differences between EA and TA was the pH level, at which acidity dropped to zero. Only the single samples have EA>1 cmol(+) kg^{-1} at $pH_w \leq 6$ and EA practically dropped to zero at $pH_w > 6.5$. Whereas in case of TA, many samples have TA>1 cmol(+) kg^{-1} even at $pH_w > 7$, and TA decreased to zero level in apparently alkaline samples, i.e. at $pH_w > 8$ (Figure 2). The latter statements have direct link to the relationships between pH_w and BS calculated using EA or TA, as part of $ECEC_{EA}$ or CEC_{TA}, respectively (Figure 3). Some TA was found even in slightly alkaline soils containing carbonates, that was the case of soils developed from calcareous materials in the Pieniny Mts (Kowalska et al. 2017).

Relationship between pH and base saturation was non-linear irrespectively of the way of BS calculation (Figure 3). Even if some authors suggested a linear or near-linear trends in particular sections of pH-BS relationship (Clark and Hill 1964, Blosser and Jenny 1971), a direct fitting of the whole data set to non-linear model seems more reliable solution. Among numerous tested equations, the Richards Sigmoidal Model (for pH_w and BS_{AL} relationship) and the Morgan-Mercer-Flodin Sigmoidal Model (MMF), for all tested relationships, got the best fit to original data, confirmed by the highest values of determination coefficient, i.e.:

– for the relationship between BS_{AL} (Richards Model)
  $BS_{AL}=100/(1+e^{19.8-3.5*x})^{0.2}$, $r^2=0.50$,
– for the relationship between BS_{EA} and pH_W (MMF Model)
  $BS_{EA}=(20.5*2336067241+102*x^{13})/(2336067241+x^{13})$, $r^2=0.71$,
– for the relationship between BS_{TA} and pH_w (MMF Model)
  $BS_{TA}=(3.2*602147+104*x^{8})/(602147+x^{8})$, $r^2=0.66$.

where x is a pH_w value.

The pH_w values related to 50% base saturation were approximated based on above mentioned equations to the values of pH_w 4.7, 5.0, and 5.4 for BS_{AL}, BS_{EA}, and BS_{TA}, respectively (Figure 3). However, large variability must be stressed ("cloud" of results), even if the determination coefficients got satisfactory levels. In particular, the broad "foot" was evident in all graphs (Figure 3), including large number of soils featured by very low BS in a pH_w range of 4–5.

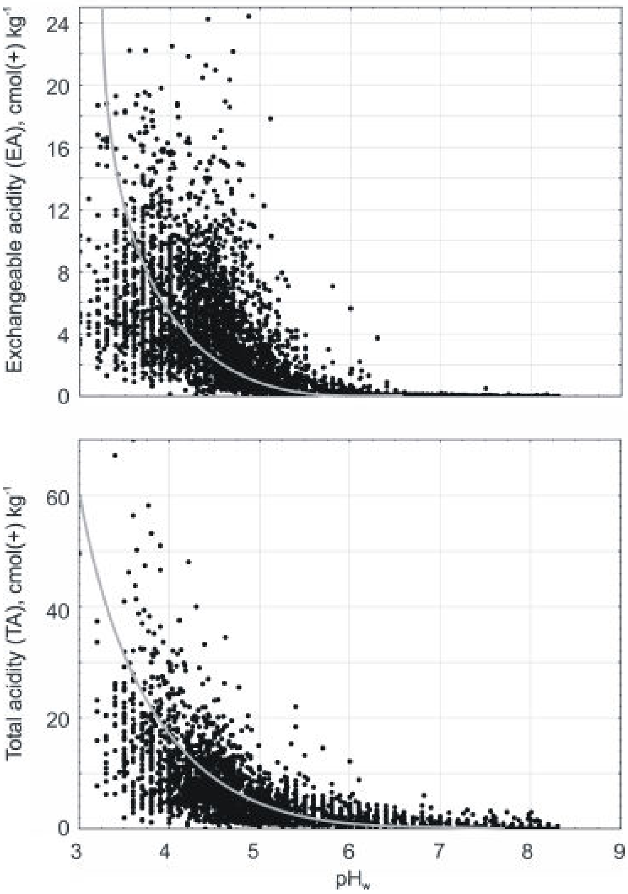

FIGURE 2. Relationships between pH_w and exchangeable (EA) or total (TA) acidity in soils under investigation (N=4130 and N=3070, respectively)

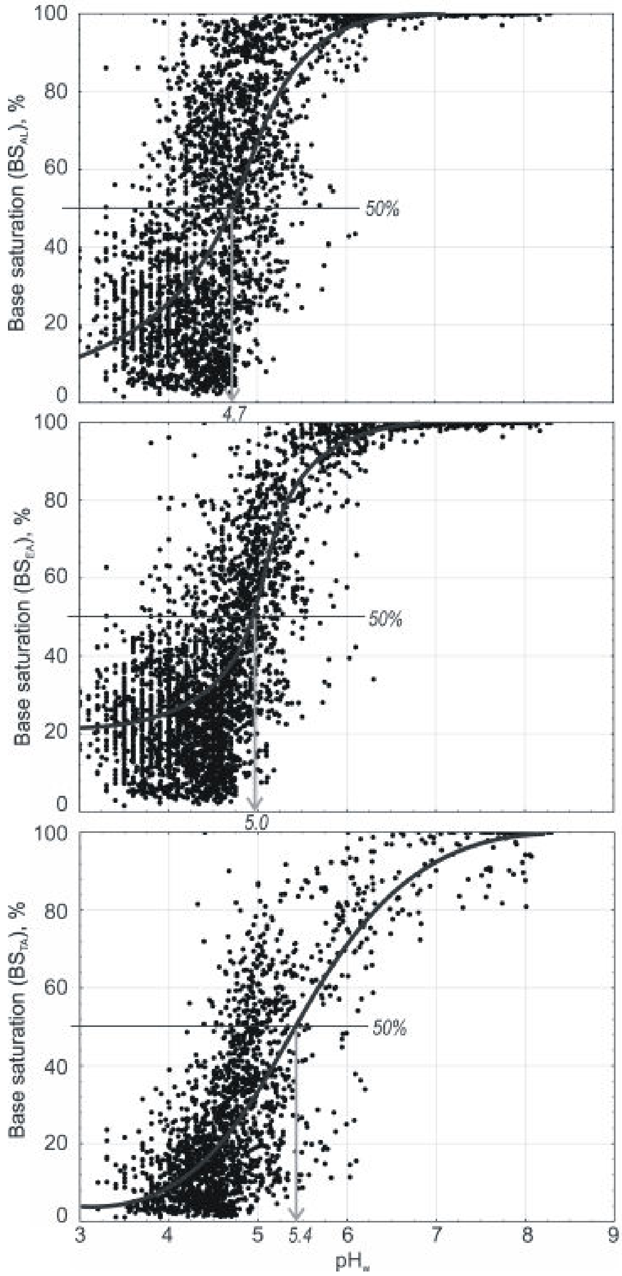

FIGURE 3. Relationships between pH_w and base saturation calculated using the exchangeable aluminium (BS_{AL}) exchangeable acidity (BS_{EA}) or total/hydrolytic acidity (BS_{TA}) in a full range of soil pH (N=2900, N=3480, and N=2150, respectively)

DISCUSSION

The CEC_{TA}, relatively simple and inexpensive in analytical terms, calculated as a sum of BC and TA, became popular in Poland after confirmation of its general comparability with more laborious and expensive CEC_7, measured by soil leaching with NH_4OAc pH 7 in glass columns (Lityński et al. 1976). Therefore, by analogy, the BS_{TA} is believed comparable with BS_7 (Gruba and Mulder 2015). If we accept this assumption, the pH_w value 5.4 at which BS_{TA} reached 50%, may be considered appropriate to distinguish between mollic and umbric horizons, as related to the requirements of WRB (IUSS Working Group WRB 2015), Soil Taxonomy (Soil Survey Staff 2014), and also Polish Soil Classification (PSC 2011). The threshold value must be disjunctive as a quantitative requirement, thus the rounded value of $pH_w \leq 5.5$ is recommended for mollic, whereas $pH_w < 5.5$ for umbric horizon. In the same way, the $pH_w \leq 5.5$ is recommended where the $BS_7 \geq 50\%$ is required, i.e. in Phaeozems, Chernozems and Kastanozems (IUSS Working Group WRB 2015).

Similarly, the pH_w value of 4.7, at which BS_{AL} reached 50% level, may be considered appropriate for distinguishing between Eutric and Dystric qualifiers, i.e. $pH_w < 4.7$ for Dystric and $pH_w \leq 4.7$ for Eutric qualifiers, prevailing in a 20–100 cm soil layer, respectively to original requirements (IUSS Working Group WRB 2015). Suggested threshold refers to mineral soils only. The organic materials (e.g. peat, litter) are unsatisfactory represented in a database under analysis. However, the pH_w values related to 50% BS, calculated for limited number of organic samples, are in the range 5.3–5.5, that confirm the rightness of pH_w value 5.5 already used to distinguish between Dystric and Eutric qualifiers in the organic materials (IUSS Working Group WRB 2015).

Bridging the quantitative criteria of WRB system (IUSS Working Group WRB 2015) and the Polish Soil Classification (PSC 2011), and also the Classification of Forest Soils of Poland (Klasyfikacja gleb leśnych Polski 2000), the pH_w <5.5 is suggested to feature the umbric, while pH_w ≤5.5 – the mollic horizon, instead of 50% base saturation. Furthermore, the pH_w value ≤5.5 may be used as supplementary criterion for black earths, in Poland correlated with Phaeozems or Chernozems (Kabała et al. 2016b). The above suggested pH_w threshold was tested using the recently published and easily available sources containing complete soil data, including the Soil Sequences Atlas II (Świtoniak and Charzyński 2018), the papers of Świtoniak (2015), Łabaz and Kabala (2016), and Łabaz et al. (2018). The recognition of horizon or RSG based on pH_w differed from the original classification based on base saturation in 2 of 47 soil cases/profiles only.

The implementation of criteria for dystric/eutric characteristic in Polish soil classifications is more complex. First, dystric/eutric qualifiers do not have direct equivalents in PSC (2011). The eutrophic/dystrophic characteristic of soil is applied at type or subtype level specifically for brown soils and vertisols only (Cambisols and Vertisols, respectively, according to Kabała et al. 2016b). Moreover, not two, but three subtypes of brown soils are traditionally distinguished in Poland, i.e. proper – leached – acid (Classification of Forest Soils 2000) or eutrophic – leached – dystrophic (PSC 2011). Furthermore, in Polish classifications, the particular BS (e.g. <50% for dystrophic/acid brown soils) is required in the entire depth control section (between 30 and 80 cm, or 20 and 100 cm), whereas in WRB, the qualifier Dystric refers to BS <50% prevailing in a depth control section (between 20 and 100 cm). And the last, BS has never been calculated in Poland as BS_{AL} (as WRB requires for Dytric/Eutric qualifiers) even in acid forest soils, but using the "hydrolytic" or exchangeable acidity (Gałka et al. 2013, 2014; Bojko and Kabala 2016). Taking into account the above mentioned circumstances, all three thresholds (pH_w values 4.7, 5.0 and 5.5) were tested using the examples of brown soils (Cambisols) published in the Atlas of Forest Soils (Brożek and Zwydak 2003). The distinction made at pH_w 5.5 (derived from a large database of various soils, not only brown soils/Cambisols) led to significant underestimation of proper/eutrophic brown soils, thus identified as leached or acid/dystrophic brown soils, even in the forest habitats characterised as "hypertrophic". Conversely, the threshold at pH_w 4.7, applied to entire depth control section 20–100 cm, led to a conversion of some acid brown soils into leached brown soils subtype. However, if the classification applied the pH_w <4.7/≥4.7 to the prevailing part of the depth control section (following the rules of WRB classification), the differences between "old" and "new" soil names/classifications were minimal (in 2 of 34 profiles). Also the allocation of soil profiles into dystrophic and eutrophic (proper and leached) groups of brown soils was nearly identical with the allocation into Dystric and Eutric qualifiers of WRB. A reconsidering of the brown soils presented in the Atlas (Brożek and Zwydak 2003) using the pH_w <5.0/≥5.0 as a threshold value (applied to the entire control section 20–100 cm for the acid and proper brown soils, respectively) led to single changes in Polish names of soils and single incompatibilities with the names derived from WRB. It was, therefore, concluded, that both the pH_w 5.0 and 4.7 may be alternatively used as threshold value to differentiate the subtypes of brown soilsbrown soils in the Polish Soil Classification; however, different pH distribution requirements must be applied within the depth control section:

(1) pH_w 4.7 as a threshold:
- proper brown soils – pH ≤4.7 throughout the entire control section (20–100 cm),
- leached brown soils – pH /4.7 in the prevailing part of the control section,
- acid brown soils – pH <4.7 in the prevailing part of the control section; or

(2) pH_w 5.0 as a threshold:
- proper brown soils – pH ≤5.0 throughout the entire control section (20–100 cm),
- leached brown soils – pH <5 in any part (sublayer) of the control section,
- acid brown soils – pH <5.0 throughout the entire control section.

It seems that the suggested conversion of BS into pH as the diagnostic criteria for key horizons and soil units may significantly decrease the costs of the soil classification and cartography. In many countries, including Poland, the simplification of criteria may enlarge the acceptance for modern soil classification.

Also, this must be clearly stated, that above mentioned recommendations refer to the formal soil classification only, and do not exclude the further use of base saturation for soil characteristic and diagnosis, e.g. for evaluation of the trophic soil varieties, following the methodology of SIG – Soil Trophic Index (Brożek et al. 2015). The same refers to exchangeable acidity (including exchangeable aluminium) and total ("hydrolytic") acidity as popular and valuable soil characteristics, used for professional analysis of soil cation exchange phenomena, calculation of fertilization or liming needs, soil degradation, etc. (Gałka et al. 2013). Cation exchange capacity still must be analysed if low activity clays are present in soil and very CEC is expected, to identify the Ferralsols, Lixisols, and Acrisols.

CONCLUSIONS

Taking into account the fact that (a) measurement of the cation exchange capacity and base saturation is practically unavailable in the field, that formally makes impossible the reliable field classification of many soil units, (b) base saturation is measured or calculated using various methods those results significantly differ, (c) base saturation and soil pH are highly positively correlated, it is suggested to replace the base saturation with pH_w (measured in distilled/deionized water suspension) in the classification criteria for diagnostic horizons and soil units/subunits.

Based on statistical analysis of some 4500 soil samples, the following pH_w values are recommended instead of 50% base saturation (both in the Polish and WRB soil classifications): pH_w <5.5 for umbric, and pH_w ≤5.5 for mollic horizon and for Phaeozems, Chernozems, Kastanozems (directly), and Umbrisols (indirectly). Furthermore, the pH_w <4.7 may replace 50% base saturation for the Dystric qualifier in mineral soils and as criterion for Alisols, while pH_w ≤4.7 may feature the Eutric qualifier (and Luvisols, indirectly). Both the pH_w 4.7 and 5.0 may be applied to distinguish between eutrophic – leached – dystrophic (or proper – leached - acid) brown soils in Polish soil classification, but using different requirements for pH distribution throughout the depth control section.

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Współzależności między pH gleby a wysyceniem kationami zasadowymi – wnioski dla polskiej i międzynarodowej klasyfikacji gleb

Streszczenie: Uwzględniając następujące fakty: (a) pomiar pojemności wymiany kationów oraz wysycenia kompleksu sorpcyjnego kationami zasadowymi jest praktycznie niemożliwy w terenie, co formalnie czyni niemożliwą klasyfikację wielu typów gleb w trakcie prac terenowych, (b) wysycenie kationami zasadowymi jest wyznaczane kilkoma metodami, których wyniki różnią się istotnie, a także (c) wysycenie kationami zasadowymi i pH gleby są istotnie dodatnio skorelowane, sugeruje się, aby wartość pH_w (mierzona w zawiesinie wody destylowanej/dejonizowanej) zastąpiła wysycenie kationami zasadowymi jako kryterium klasyfikacyjne w definicjach poziomów diagnostycznych i jednostek/podjednostek glebowych w Systematyce Gleb Polski oraz w klasyfikacji WRB. Bazując na analizie statystycznej ponad 4500 próbek glebowych, rekomenduje się zastąpienie kryterium 50% wysycenia kationami zasadowymi: wartością pH_w <5.5 dla poziomu umbric i pH_w ≥5.5 dla poziomu mollic, oraz dla Chernozems, Kastanozems, Phaeozems (bezpośrednio) i Umbrisols (pośrednio). Podobnie, pH_w <4.7 proponuje się dla kwalifikatora Dystric w glebach mineralnych i odpowiednich grup referencyjnych WRB, oraz odpowiednio pH_w ≥4.7 dla kwalifikatora Eutric. Rozróżnianie podtypów gleb brunatnych w Systematyce Gleb Polski może bazować na pH_w 4.7 lub 5.0, ale z zastosowaniem innych kryteriów co do zróżnicowania pH w sekcji kontrolnej. Propozycja zastąpienia wysycenia kationami zasadowymi przez wskaźnik pH odnosi się wyłącznie do systematyki gleb i nie umniejsza znaczenia wskaźnika wysycenia kationami zasadowymi w profesjonalnej charakterystyce gleb.

Słowa kluczowe: wysycenie kationami zasadowymi, pH, klasyfikacja gleb, WRB, Systematyka gleb Polski