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Selected chemical properties of soil in the Nature Reserve Žitavský wetland

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Abstract

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We described and compared selected chemical properties of soils near Nature Reserve Žitavský wetland (Mollic Fluvisols and Eutric Fluvisols) and soil from artificial water reservoir Žitavský wetland (Histi-Umbric Gleysols). On the base of results of sorption properties, soil reaction and carbonates content and also character the surrounding relief and position of Žitavský wetland we can conclude, that alluvial soil forming substrate of Mollic Fluvisols was partially layered by carbonate loess eroded from near gentle slope. As in Mollic Fluvisols and Eutric Fluvisols profile the total organic carbon (C_T) content decreased gradually (from 19.10 g kg^{-1} to 4.11 g kg^{-1}; and from 17.05 g kg^{-1} to 7.26 g kg^{-1} respectively), the dynamics of C_T content in Histi-Umbric Gleysols profile was different. In Ao horizon of Histi-Umbric Gleysols was found very high C_T content (72.54 g kg^{-1}), which gradually decreased till depth of 0.6 m (Gr horizon), where was reached second maximum of C_T content. Probably in this depth begins humus horizon of buried original Mollic Fluvisols. This assumption was confirmed by humus quality, which sharply increased just in Gr horizon (humic to fulvic acids ratio increased from 0.86 to 2.15, and colour quotient of humus substances declined from 6.26 to 4.05). Other chemical properties of Histi-Umbric Gleysols were also changed in Gr horizon.

Key words

wetland, soil, pH, sorption, organic carbon

Introduction

Wetlands belong to the most endangered Earth's ecosystems. They represent significant habitats for many rare and endangered plants, microbial and animal species. They are also high important for appropriate water regime of the land. Despite the fact that the values, functions, and importance of wetlands are more and more acknowledged, they are subjected to a continual devastation (Eistelová, 1996).

Sustainability of biotopes and ecosystems, management of infrastructure (water management works) and sustainability of traditional extensive systems are important topics discussed in the EC Resolution No. 1257/1999 for Rural Development (Macák, 2006).

The Nature Reserve Žitavský wetland was declared in year 1980 on the area of the former Gendiarske wet meadows. The original area of Žitavský wetland was 140 ha, but after the drastic canalisation of the Žitava River (1980–1981), the acreage has decreased to 74.68 ha. In south part of Nature Reserve, the regulated river was provided with a dike with lock controlling the height of artificial flooding (flooding begins on March 15 and finishes 15 of June. Nowadays, 262 taxons of higher flora (36 endangered) and 174 bird species (51 nesting in the area) live in the NR Žitavský wetland (ANONYMUS, 2007).

The aim of the work was to characterise and compare selected chemical properties between soils in neighbourhood of the Nature Reserve Žitavský wetland and soils from the artificial water reservoir Žitavský wetland.

Material and methods

The Nature Reserve Žitavský wetland is situated in southwest part of the Slovak Republic (altitude 18°19´, longitude 48°09´), district Nové Zámky on a fluvial plain of the Žitava River. The Žitava River, dividing the study area, represents the border between the Žitava and Hron loess highlands. The relief of the area has been modelled by wind and fluvial action (PESTÚN et al., 1967).

Soil pits were taken in the south part of the Žitavský wetland:

- Soil pit 1: Mollic Fluvisols (ISSS-ISRIC FAO, 1994) at a 5 m distance from the agricultural soil and 50 m from the artificial water reservoir.
- Soil pit 2: Eutric Fluvisols (ISSS-ISRIC FAO, 1994), at a 70 m distance from the water reservoir. Since 2004, this land has been excluded from agricultural use.
- Soil pit 3: inside the water reservoir, Histi-Umbric Gleysols (ISSS-ISRIC FAO, 1994) was taken in August, after draining of the artificially flooded water reservoir.

For each soil pit, we characterised morphological and physical properties of the sampled soil (SZOMBATHOVÁ et al., 2005).

We also analysed the following chemical properties: soil reaction – potentiometrically, in H_2O and in KCl; exchangeable base ions and hydrolytical acidity – by the Kappen's method (HANES et al., 1995); carbonates content – by the volumetric method (ČURLÍK et al., 2003); phosphorus (P) and potassium (K) – by method Melich III (MELICH, 1984), total nitrogen content – N_T – by Kjeldahl (FECENKO, 1991); total soil organic carbon (C_T) – by the Tyurin method (ORLOV and GRISHINA, 1981); humus content was calculated C_T * 1.724; humus fractions – according to KONONOVA and BELCHIKOVA (1961); spectral analyses of humus substances (HS) and humic acids (HA) – 6400 Spectrophotometer (Jen Way). Each analyse was repeated three times, and the average values were recorded.

Results and discussion

Soil reaction values gradually increased downwards to the C horizons in each of the studied profiles (Table 1). The highest values of pH were found for the Mollic Fluvisols. The whole profile of this soil contained carbonates, keeping pH neutral or slightly alkaline in the CGo horizon. On the other hand, KUKLA (2002) investigated pH values and carbonate content of Calcaric Mollic Fluvisols in the Nature Reserve Šúr. He found increasing contents of carbonates and pH values from the lower layers (Equiv. $CaCO_3$ = 0.1%, pH_{H2O} = 6.46) to the upper layers (Equiv. $CaCO_3$ = 4.75%, pH_{H2O} = 7.06), but he detected the maximum value of soil reaction at a depth of 10–20 cm (Equiv. $CaCO_3$ = 1.3%, pH_{H2O} = 7.35). He concluded that this phenomenon could be connected with presence of aragonite shells accumulated from dead little organisms in the topsoil.

The low content of carbonates (precipitated on surface in the form of meadow chalk) determined in the Ao horizon of Histi-Umbric Gleysols allow us to suppose, that the soil reaction should be higher than 5.29. On the other hand, this horizon was found having a very strong hydrolytic acidity (H = 18.0 mmol kg^{-1}). This strong acidity may be caused by acidic products from the decomposing organic matter. It is known that in moist conditions, the products of organic matter transformation are mostly acidic, because low-molecular organic substances and fulvic acids contain high amounts of dissociating H^+ ions increasing the soil acidity (HANES et al., 1997, 2002). Very high hydrolytic acidity and corresponding low pH values were found also in the Akp and C horizons of Eutric Fluvisols (Table 1).

The sorption complex was fully saturated with base cations (BS) in each soil profile, and the degree of BS increased with increasing depth (Table 1). High base saturation corresponded to the dominance of base cations in the adsorption complex and also to the fact that soils did not loose cations by leaching.

The observed soil colour, high contents of silt (SZOMBATHOVÁ et al., 2005), sorption properties, soil reaction, carbonates contents, character of the surrounding relief and position of the Žitavský wetland allow us to conclude that the alluvial soil forming substrate for Mollic Fluvisols was partially layered with carbonate loess eroded from a near gentle slope.

The content of macronutrients in the profile is illustrated in Table 1. According to the scale Melich II (LOŽEK et al., 1995), both terrestrial profiles were found having very low contents of accessible phosphorus, and high contents of potassium corresponding to grassland. Potassium and nitrogen contents gradually decreased across each profile. Surprisingly, middle phosphorus content was determined in the Ao and also in Gr horizons of Histi-Umbric Gleysols. In terrestrial profiles, phosphorus contents decreased with depth.

Lower C/N ratio of soil organic matter throughout the entire profile of Mollic Fluvisols suggests that the mineralization of soil organic matter was higher in this profile (Table 1).

Very high total organic carbon (C_T) content was found in the A-horizon of Histi-Umbric Gleysols (72.54 g kg^{-1}). C_T content in the A-horizon of Mollic Fluvisols was high (19.10 g kg^{-1}) and in the A-horizon of Eutric Fluvisols middle (17.05 g kg^{-1}). Organic carbon content in Mollic and Eutric Fluvisols profiles gradually decreased with depth, but a sharper drop was observed in the Mollic Fluvisols profile (Table 2).

The sharp decrease in C_T content in Mollic Fluvisols refers about a long, progressive, continual soil

Table 1. Soil sorption, pH values, contents of carbonates and macronutrients (total nitrogen, phosphorus and potassium) in Mollic Fluvisol, Eutric Fluvisol and Histi-Umbric Gleysol

Soil subtype	horizon	pH H_2O	pH KCl	H	S	BS	$CaCO_3$	P	K	N_T	C_T/N_T
				(mmol kg^{-1})		(%)			(mg kg^{-1})		
Mollic Fluvisol	Amč	7.83	7.07	6.1	287	97.9	0.12	12.2	537	1,868	9.84
	A/CGo	7.94	7.20	4.4	254	98.3	0.10	14.3	353	825	7.75
	CGo	8.35	7.57	3.1	469	99.3	1.75	13.5	350	577	7.13
Eutric Fluvisol	Akp	6.15	4.68	27.8	285	91.1	0.00	18.0	218	1,570	10.86
	C	7.02	5.72	12.4	322	97.5	0.00	9.3	196	1,080	11.40
	C/Go	7.39	6.15	5.8	283	97.9	0.00	10.8	178	819	8.86
Histi-Umbric Gleysol	Ao	5.99	5.29	18.0	314	94.6	0.10	46.0	353	5,813	12.48
	Gor	6.84	5.55	13.6	313	95.8	0.00	27.5	221	841	11.37
	Gr	7.74	6.49	6.5	340	98.1	0.00	47.5	200	754	13.46

Amč – subhorizon with cutants of Fe^{3+} and Mn^{4+} (see Morphogenetic classification system of Slovakia – 2000), H – hydrolytic acidity, S – sum of bases (Na^+, K^+, Ca^{2+}, Mg^{2+}), BS – base saturation, P – phosphorus content, K – potassium content, N_T – total nitrogen content, C_T/N_T – ratio C_T/N_T

Table 2. Quality and quantity of humus for Mollic Fluvisol, Eutric Fluvisol and Histi-Umbric Gleysol

Soil subtype	horizon	depth	C_T	humus	C_{HS}	C_{HA}	C_{FA}	HA/FA	$Q_{4/6}$ HS	$Q_{4/6}$HA
		(m)	(g kg^{-1})			(% of C_T)				
Mollic Fluvisol	Amč	0.0–0.35	19.10	32.9	26.2	13.0	13.2	0.98	4.28	3.46
	A/CGo	0.35–0.62	6.37	11.0	24.0	15.2	8.7	1.75	4.05	3.18
	CGo	>0.62	4.11	7.1	22.9	14.6	8.0	1.82	3.80	2.97
Eutric Fluvisol	Akp	0.0–0.20	17.05	29.4	37.7	11.9	25.5	0.47	6.31	4.69
	C	0.2–0.45	12.31	21.2	33.1	10.8	21.8	0.50	5.74	4.40
	C/Go	>0.45	7.26	12.5	28.4	10.5	17.2	0.65	4.92	3.97
Umbric Gleysol	Ao	0.0–0.1	72.54	125.1	24.4	12.4	12.2	1.01	6.34	5.65
	Gor	0.1–0.6	9.56	16.5	32.8	15.4	17.9	0.86	6.26	4.74
	Gr	0.6–1.2	10.15	17.5	28.7	19.3	9.0	2.15	4.05	3.68

Amč – see Table 1, C_T – total soil organic carbon, humus content was calculated C_T * 1.724, C_{HS} – carbon of humus substances, C_{HA} – carbon of humic acids, C_{FA} – carbon of fulvic acids, HA/FA – humic acids to fulvic acids ratio, $Q_{4/6}$ HS – colour quotient of humus substances, $Q_{4/6}$ HA – colour quotient of humic acids forming process, during which there was formed the thick A-horizon with high content of humus. In contrary, the total organic carbon content in Eutric Fluvisols decreased gradually. It is known that the soil forming process in Eutric Fluvisols used to be interrupted with floods. During the flooding, the original A-horizon was covered with new sediments, and then a new soil forming process started.

Sotáková (1982) stated that for Eutric Fluvisols development is characteristic organic matter accumulation, both biological and mechanical. Mechanical accumulation means not only by flooding water, but also deluvial accumulation of soil matter eroded from the humus horizon of soil on the slope.

The dynamics of total organic carbon content in Histi-Umbric Gleysols was different compared to the previous profiles. It gradually decreased from the A-horizon (72.54 g kg^{-1}) to Gr horizon where the second maximum of C_T content was found (Table 2). It is supposed, that the second maximum in Histi-Umbric Gleysols corresponds to the humus horizon of the buried soil. We suppose that after the regulation of the Žitava water course, building the dike and artificial flooding of the Žitavský wetland, the original Mollic Fluvisols or Eutric Fluvisols (according to humus quality reported by Barančíková (2002) more probable are Mollic Fluvisols) were covered by a layer of new sediments.

Also the quality of humus in Histi-Umbric Gleysols gradually decreased along the profile down to the Gr horizon, where there was found a dramatic increase in quality (Table 2). The ratio of humic acids to fulvic acids (HA/FA) increased from 0.86 to 2.15, colour quotient $Q_{4/6}$ of humus substances (HS) was diminished from 6.26 to 4.05, and $Q_{4/6}$ of HA from 4.74 to 3.68. The higher degree of humification (percentage C_{HA} of C_T) in the Gr horizon also indicated that larger proportion of soil carbon had been transformed to humic acids. Higher quality and quantity of humus in the Gr horizon confirmed presence of buried Mollic Fluvisols.

The quality of humus in Eutric Fluvisols was very low (HA/FA ratio in A-horizon was only 0.47, in C-horizon 0.50 and in C/Go horizon 0.65). Unfavourable humus quality in Eutric Fluvisols was confirmed through high absorbance ratios $Q_{4/6}$ of HS and HA, which slowly decreased in profile (Table 2). Low humus quality was probably caused by permanently high soil moisture content, which slows down the process of organic matter decomposition and promotes formation of fulvic acids and other organic acids with low-molecular weight. Sotáková (1982) stated that low quality of humus in Eutric Fluvisols is caused by their young age.

The humus quality in Mollic Fluvisols was much higher compared to Eutric Fluvisols and distinctly raised with depth (Table 2). We assume that carbonate loess and mainly Ca^{2+} presence in A/C and C Go horizons caused the sharp increase in humus quality. In contrary, Barančíková (2003) found a higher HA/FA ratio in the topsoil compared to the subsoil.

Analysis of soil chemical properties reported in this study allow us to outline the possible history of recent soil-forming process over the investigated area.

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References

Barančíková, G. 2003. Changes in content and quality of soil organic matter in the territory touched by Danube hydropower structure. *Humic substances in the environment*, 3/4: 3–10.

Barančíková, G. 2002. Monitoring obsahu a kvality pôdnej organickej hmoty [Monitoring of content and quality of soil organic matter]. In Kobza, J. (ed.). *Monitoring pôd Slovenskej republiky* [Soil monitoring of Slovak Republic]. Bratislava: VÚPOP, p. 71–90.

Čurlík, J. et al. 2003. *Pôdna reakcia a jej úprava* [Soil reaction and its adjustment]. Bratislava: Suma print. 250 p.

Eistelová, M. 1996. *Obnova jezerních ekosystémů – holistický přístup* [Restoration of lake ecosystems – a holistic appoach]. Oxford: Wetlands International IWRB. 190 p.

Fecenko, J. 1991. *Agrochémia a výživa rastlín* (*praktikum*) [Laboratory exercise manual for plant nutrition and agrochemistry]. Nitra: Slovenská poľnohospodárska univerzita. 121 p.

Hanes, J., Čurlík, J., Linkeš, V., Mucha, V., Sisák, P., Zaujec, A. 1997. *Pedológia* [Pedology]. Nitra: Slovenská poľnohospodárska univerzita. 119 p.

Hanes, J., Chlpík, J., Mucha, V., Sisák, P., Zaujec, A. 1995. *Pedológia* (*praktikum*) [Pedology (Laboratory manual)]. Nitra: Slovenská poľnohospodárska univerzita. 153 p.

Hanes, J., Poláček, Š. 2002. *Koloidná chémia pôdy* [Soil colloidal chemistry]. Bratislava: VÚPOP. 108 p.

Isss-Isric-Fao, 1994. *World Reference Base for Soil Resources. Draft.* Wageningen, Rome. 161 pp.

Kononova, M., Belchikova, N.P. 1961. Uskorennyje metody opredelenija sostava gumusa [Short methods for determining humus structure]. *Počvovedenije*, 125–129.

Kukla, J. 2002. Geobiocenoses of the Jelšový les (alder forest) locality in the National Nature Reserve Šúr. *Ekológia* (*Bratislava*), 3: 307–323.

Ložek, O., Fecenko, J., Borecký, V. 1995. *Základy výživy a hnojenia rastlín*. [Basics of plant nutrition and fertilising]. Nitra: NOI – Ústav vedecko-technických informácií pre pôdohospodárstvo v Nitre. 132 p.

Macák, M. 2006. *Agroenvironmentálne indikátory hodnotenia udržateľnosti poľnohospodárstva* [Agro-environmental indicators for evaluation of agricultural sustainability]. Nitra: Slovenská poľnohospodárska univerzita. 122 p.

Melich, A. 1984. Melich 3 soil test extractant – a modification of Melich 2 extractant. *Soil Sci. Plant Anal*., 15: 1409–1416.

Orlov, V., Grishina, I. 1981. *Praktikum po chimiji gumusa* [Guide of humus chemistry]. Moskva: Izdateľstvo Moskovskogo universiteta. 124 p.

Pestún, V., Šiška, A., Szákáll, F. 1967. *Záverečná správa KPP pre JRD Maňa* [Final report of a soil survey performed for the Maňa agricultural cooperative]. Bratislava: Laboratóriá pôdoznalectva.

Anonymus. 2007. *Prírodná rezervácia Žitavský luh* [Nature Reserve Žitavský wetland]. www.seps.sk/zp/eic/newluh2.htm

SotákovÁ, S. 1982. *Organická hmota a úrodnosť pôdy* [Organic matter and fertility of soil]. Bratislava: Príroda. 234 p.

Szombathová, N., Chlpík, J., Nádašský, J., Noskovič, J. 2005. Morfologická charakteristika a fyzikálne vlastnosti pôdnych typov prírodnej rezervácie Žitavský luh [Soil morphology and physical properties of the Nature Reserve Žitavský wetland]. *Acta fytotechn. zootechn*., 2: 41–48.

Vybrané chemické vlastnosti pôd Prírodnej rezervácie Žitavský luh

Súhrn

Zisťovali a porovnávali sme vybrané chemické vlastnosti pôd v blízkosti Prírodnej rezervácie Žitavský luh – černice modálnej a fluvizeme kultizemnej a pôdy z umelo zaplavovanej mokrade Žitavský luh – gleja močiarového. Na základe výsledkov analýz sorpčného komplexu, pôdnej reakcie a obsahu uhličitanov v pôde, ako i charakteru okolitého reliéfu a polohy prírodnej rezervácie Žitavský luh usudzujeme, že aluviálny pôdotvorný substrát černice bol čiastočne prekrývaný sprašovým materiálom oderodovaným z blízkeho mierneho svahu. Kým v profile černice a fluvizeme sa celkový obsah organického uhlíka (C_T) s hĺbkou rovnomerne znižoval (od 19,10 g kg^{-1} do 4,11 g kg^{-1}; a od 17,05 g kg^{-1} do 7,26 g kg^{-1}), dynamika obsahu C_T v profile gleja bola nerovnomerná. V Ao horizonte gleja sme zistili veľmi vysoký obsah C_T (72,54 g kg^{-1}), ktorý s hĺbkou postupne klesal až do 0,6 m (zodpovedá Gr horizontu) – kde nadobudol druhé maximum. Pravdepodobne sa v tejto hĺbke začína humusový horizont pochovanej černice. Tento predpoklad bol potvrdený aj kvalitou humusu, ktorá sa výrazne zvýšila práve v Gr horizonte (zastúpenie humínových kyselín k fulvokyselinám vzrástlo z 0,86 na 2,15, a hodnoty farebného koeficienta humusových látok poklesli z 6,26 na 4,05). Aj ostatné chemické parametre gleja močiarového sa v Gr horizonte výrazne menili.

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