SOIL ORGANIC MATTER CHARACTERISTICS IN NATURE RESERVE ŽITAVSKÝ WETLAND - NATURA 2000 SITE

VLASTNOSTI PÔDNEJ ORGANICKEJ HMOTY PRÍRODNEJ REZERVÁCIE ŽITAVSKÝ LUH – OBLASŤ NATURA 2000VLASTNOSTI PÔDNEJ ORGANICKEJ HMOTY PRÍRODNEJ REZERVÁCIE ŽITAVSKÝ LUH – OBLASŤ NATURA 2000

Nora SZOMBATHOVÁ1*, Milan MACÁK2, Eva CANDRÁKOVÁ3

1*Department of Pedology and Geology, Slovak University of Agriculture, Tr. A.Hlinku 2, 949 76 Nitra, Slovakia, +421 37 641 4389, *E-mail: nora.szombathova@uniag.sk

2Department of Sustainable Agriculture and Herbology, Slovak University of Agriculture, Tr. A.Hlinku 2, 949 76 Nitra, Slovakia,

3Department of Plant Production, Slovak University of Agriculture, Tr. A.Hlinku 2, 949 76 Nitra, Slovakia

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ABSTRACT

The aim of this study was to characterize soil organic matter in the Nature Reserve Žitavský wetland. The area is located on a fluvial plain of Žitava River. Soil pits were trenched on Mollic Fluvisol, Eutric Fluvisol and Histi-Umbric Gleysol. Since the average C_T pool in topsoil of Histi-Umbric Gleysols in Slovakia is around 15.8 $g.kg^{-1}$, we assume, that high content of organic carbon in A horizon (72.54 $g.kg^{-1}$) occur due to sedimentation of organic particles from water. Based on results of organic carbon content and its stability, but mainly on sharp increase of humus quality (HA : FA increased from 0.82 to 1.72) we concluded, that in depth of 0.6 m started A horizon of buried Mollic Fluvisol. The highest pool of hot water extractable carbon (C_{hws}) and labile carbon (C_L) in Histi-Umbric Gleysol indicate the great amount of organic matter available to microbial oxidation in this soil.

Key words: NATURA 2000, humus, organic carbon, wetland, soil

ROZŠÍRENÝ ABSTRAKT

Cieľom tejto práce bola charakteristika vlastností pôdnej organickej hmoty Prírodnej rezervácie Žitavský luh a pôdy z umelo zaplavovanej vodnej nádrže Žitavského luhu.

Skúmaná lokalita sa nachádza v blízkosti obce Maňa, okres Nové Zámky (18°19´ v.d., 48°09´ s.š.). Klimaticky patrí do teplej suchej oblasti s miernou zimou a dlhým slnečným svitom. Územie sa rozprestiera v povodí rieky Žitava, ktorá ho rozdeľuje na časť prislúchajúcu k Hronskej sprašovej pahorkatine a k Žitavskej sprašovej pahorkatine.

V južnej časti Žitavského luhu boli vykopané 3 sondy na rôznych pôdnych typoch: prvá na čiernici modálnej, druhá na fluvizemi kultizemnej a tretia na gleji močiarovom – táto po vypustení a vysušení vodnej nádrže v lete. V odobratých pôdnych vzorkách boli analyzované: obsah uhličitanov; obsah organického uhlíka (C_T) - oxidimetricky; frakčné zloženie humusu; spektrofotometrické merania humusových látok a humínových kyselín; obsah ľahko oxidovateľného uhlíka (C_L) a horúcou vodou rozpustného uhlíka (C_{hws}); celkový obsah dusíka (N_T). Každá analýza bola vykonaná v troch opakovaniach a v príspevku sú uvedené priemerné hodnoty.

Zistili sme, že celkový obsah organického uhlíka (C_T) v A horizonte bol najvyšší v gleji (72.54 $g.kg^{-1}$), nižší v čiernici (19.10 $g.kg^{-1}$) a najnižší vo fluvizemi (17.05 $g.kg^{-1}$) (Tabuľka 1).

Keďže priemerný obsah C_T v gleji na území Slovenska je 15,8 $g.kg^{-1}$ predpokladáme, že veľmi vysoký obsah C_T v A horizonte skúmaného gleja (72,54 $g.kg^{-1}$) bol spôsobený sedimentáciou organických čiastočiek z vody počas obdobia zaplavenia pôdy vodou.

Na základe výsledkov obsahu organického uhlíka a jeho stability (percento C_{NL} vzrástlo z 90,8% na 94,6%), no najmä z výsledkov veľkého zvýšenia kvality humusu (HK : FK vzrástlo z 0,82 na 1,72, a QHS sa znížil z 4,38 na 2,95) predpokladáme, že v hĺbke 0,6 m sa začína humusový horizont pochovanej čiernice (Tabuľka 1,2).

Najvyšší obsah v horúcej vode rozpustného uhlíka (C_{hws}) a labilných foriem organického uhlíka (C_L) v gleji indikuje, že takmer 11% organickej hmoty v A horizonte tejto pôdy je ľahko prístupným zdrojom živín a energie pre mikróby (Tabuľka 1).

Zvýšené pomery uhlíka humínových kyselín k fulvokyselinám (HK:FK) a znížené pomery absorbancií (Q) potvrdili zvýšený stupeň humifikácie organickej hmoty v hlbších častiach profilov v porovnaní s humusovými horizontmi. Rovnako i percento stabilných foriem organickej hmoty pôdy (C_{NL}) s hĺbkou vzrastalo.

Výsledky nášho výskumu potvrdili negatívny vplyv ľudských aktivít v lokalite Žitavský luh na stav pôd, ich pokryv a vegetačnú štruktúru.

Kľúčové slová: NATURA 2000, humus, organický uhlík, mokraď, pôda

INTRODUCTION

Wetlands are important ecological entities, often among the most productive of all natural systems and critical to the biogeochemical transformations of nutrients, the sequestering of heavy and other toxic metals and organic compounds, as well as affecting groundwater recharge and shoreline stabilization [8].

Nature Reserve (NR) 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 NR, 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 and 174 bird species live in the NR Žitavský wetland [18].

Žitavský wetland is proposed to be recorded in the National list of Protected bird areas NATURA 2000, which goal is the preservation of selected types of natural areas and sites of threatened plants and animals species important for European Union [14].

Soils represent the basic support system for upland and wetland ecosystems because of their role in providing nutrients, water, oxygen, heat and mechanical support to vegetation. Soil properties considerably influence plant growth and species composition. On the other side, plant cover strongly affects soil forming process and soil chemical, physical and biological characteristics.

The objective of this study was to characterize the soil organic matter in NR Žitavský wetland and in the soil from the artificial water reservoir Žitavský wetland.

MATERIALS AND METHODS

Žitavský wetland is located close to Maňa village in Nové Zámky district (E 18°19´, N 48°09´). The locality has continental climate with an average annual temperature 10.2°C and annual precipitation 539 mm [22]. The area is located on a fluvial plain of the Žitava River, which divides the area on a part, belonging to Žitava loess highlands and to Hron loess highlands [16].

Three soil pits were trenched in the south part of Žitavský wetland:

- on Mollic Fluvisol [7] at a 5 m distance from the agricultural land and 50 m from the artificial dike of water reservoir.

- on Eutric Fluvisol [7], at a 70 m distance from the water reservoir. This land was excluded from agricultural use in year 2004.

- inside of the water reservoir on Histi-Umbric Gleysol [7] in August, after draining of the artificially flooded water reservoir.

Fallowed analyses of organic carbon, humus and carbonates content were done for each soil profile:

total soil organic carbon (C_T) - by Tyurin method [15]; fractional composition of humus - by Tyurin method in Ponomareva-Plotnikova modification [15]; spectral analyses of humus – 6400 Spectrophotometer (Jen Way); hot water soluble carbon – by Körchens-Schulz [10]; susceptibility of organic carbon to oxidation by 1/3 mol. dm^{-3} $KMnO_4$ [12]; carbonates content by volumetric method [3]; total nitrogen content (N_T) – by Kjeldahl [4].

Each analyse was done in three analytical replications and in paper are written average values.

RESULTS AND DISCUSSION

Generally, soil organic matter plays a key role in crop production under the natural conditions, and it is a main attribute of soil quality since it has far-reaching effects on soil physical, chemical and biological properties. The main indicator of the amount of organic matter is the organic carbon content (C_T).

As it is evident from results of our research, the sharp decrease of C_T content along the profile was found in Mollic Fluvisol and Histi-Umbric Gleysol (Table 1). Moreover, Mollic Fluvisol had formed deeper A horizon compared to other studied profiles what is the evidence of long time performed, not interrupted soil forming process, during which was accumulated high amount of organic carbon.

Sotáková [20] stated that for Mollic Fluvisols is characteristic great and deep accumulation of humus substances with lower degree of condensation, mainly in conditions of higher moisture and $CaCO_3$ content. She reported that Mollic Fluvisols in climatic conditions of Slovakia have C_T content in topsoil 19-29 $g.kg^{-1}$, in depth 0.5-0.6 m around 10 $g.kg^{-1}$ and in subsoil 5 $g.kg^{-1}$. In accordance, Kobza et al. [9] reported newer data reached through Soil Monitoring of Slovak Republic (C_T - 23.4 $g.kg^{-1}$).

The highest organic carbon pool was found in A horizon of Histi-Umbric Gleysol (72.5 $g.kg^{-1}$). Since the average C_T content in topsoil of Histi-Umbric Gleysols in Slovakia is around 15.8 $g.kg^{-1}$ [9], we can assume, that high content of organic carbon in A horizon occur due to sedimentation of organic particles from water. On the base of Žitavský wetland history and topography we can suppose that after regulation of Žitava water course, the building of dike and then artificial flooding of Žitavský wetland, the original Mollic Fluvisol was covered by

Table 1: Carbonates, soil carbon content and its characteristics
Tabuľka 1: Uhličitany, obsah organického uhlíka a jeho charakteristiky

Horizon (1)	Depth (2)	$CaCO_3$	C:N (3)	C_T (4)	C_{hwl} (5)	C_L (6)	C_{hws} (5)	C_L (6)	C_{NL} (7)
	[m]	[$g.kg^{-1}$]		[$g.kg^{-1}$]			[% of C_T]		
Mollic Fluvisols(8)									
Am	0.0-0.35	1.0	9.8	19.10	0.53	1.85	2.8	9.6	90.4
A/CGo	0.35-0.62	1.0	7.8	6.37	0.10	0.53	1.6	8.3	91.7
CGo	>0.62	18	7.1	4.11	0.04	0.24	0.9	3.5	96.5
Eutric Fluvisols(9)									
Ap	0.0–0.20	0.0	10.9	17.05	0.49	1.63	2.9	9.6	90.4
C	0.2–0.45	0.0	11.4	12.31	0.32	1.00	2.6	8.1	91.9
C/Go	> 0.45	0.0	8.9	7.26	0.10	0.41	1.2	5.4	94.6
Histi-Umbric Gleysols(10)									
Ao	0.0–0.1	1.0	12.5	72.54	0.84	7.82	1.2	10.8	89.2
Gor	0.1–0.6	0.0	11.4	9.56	0.14	0.90	1.5	9.2	90.8
Gr	0.6–1.2	0.0	13.5	10.15	0.08	0.52	0.8	5.4	94.6

(3) C:N – ratio C:N, (4) C_T – total soil organic carbon, (5) C_{hws} – hot water soluble organic carbon, (6) C_L - organic carbon oxidible by 1/3 M $KMnO_4$, (7) C_{NL} - organic carbon susceptible to oxidation
(1) horizont, (2) hĺbka, (3) C:N – pomer C:N, (4) C_T – celkový obsah organického uhlíka, (5) C_{hws} horúcou vodou rozpustný uhlík, (6) C_L - labilná frakcia organického uhlíka oxidovateľného pomocou 1/3 M $KMnO_4$, (7) C_{NL} - nelabilná frakcia organického uhlíka odolného voči oxidácii pomocou 1/3 M $KMnO_4$, (8) černica modálna, (9) fluvizem kultizemná, (10) glej močiarový

layer of new sediments. According to dynamics of C_T content in profile (the second maximum of C_T content started in depth of 0.6 m) we presume, that the new sedimentation started with deposition of mainly mineral, heavier particles and after were deposited lighter, organic particles and detritus, therefore in the upper part of soil was found very high C_T content.

Compared to other profiles, C_T content was the lowest and in A horizon of Eutric Fluvisol and it gradually decreased along the profile (Table 1). Hanes et al. [5] stated that the gradual decrease of C_T content in Eutric Fluvisols is common, as this soil type has soil forming process interrupted with new sediments deposited during flooding, which cower original A horizon, and after new soil forming process starts. According to Sotáková [20], the average content of C_T in Slovak Eutric Fluvisols varies in topsoil from 13-20 $g.kg^{-1}$, in depth of 0.5-0.6 m from 6 to 12 $g.kg^{-1}$ and in subsoil 5 $g.kg^{-1}$. Newer data reached by Soil Monitoring showed the average C_T content in Eutric Fluvisols is 16 $g.kg^{-1}$, but this amount slowly decreases [9].

Labile organic matter pools (C_{hws} and C_L) can be considered as fine indicators of soil quality that influence soil function in specific ways and that are much more sensitive to changes in soil management practice [6].

Compared to other studied soils, the highest pool of hot water soluble carbon (C_{hws}) and labile carbon (C_L) was determined in Histi-Umbric Gleysol. This suggests, that Histi-Umbric Gleysol contains great amount of organic matter available to microbial oxidation as an easily utilisable source of their energy. Also the concentration of C_L per unit of C_T was the highest just in Histi-Umbric Gleysol (Table 1). Mungai et al. [13] stated that soil with greater amounts of high quality carbon or high C_L will release higher amounts of CO_2 since soil microbial populations can more utilize such C substrates – i.e. soil has favourable biological activity. Labile carbon - C_L mostly comprise of soil carbohydrates and some unidentified aromatic compounds, fulvic acids and microbial biomass carbon [2]. C_{hws} occurs in soil by leaching from organic matter, and releases from microbial activity and root exudation [19].

Important parameter C:N ratio had decreasing tendency with increased depth of soil profiles in Mollic Fluvisol and Eutric Fluvisol. In contrary, this tendency was opposite in Histi-Umbric Gleysol (Table 1). Baytes [1] stated, that progressive humification could be expected as decreasing values of C:N ratio and found with depth

Table 2: Fractional composition of humus
Tabuľka 2: Frakčné zloženie humusu

Hori-zon (1)	1 HA (2)	2 HA (3)	3 HA (4)	Σ HA (5)	1a FA (6)	1 FA (7)	2 FA (8)	3 FA (9)	Σ FA (10)	HA:FA (11)	$Q_{4/6}$ HS (12)	$Q_{4/6}$ HA (13)
	Humic acids [% of C_T] (14)				Fulvic acids [% of C_T] (15)							
Mollic Fluvisols (16)												
Am	4.1	13.6	9.5	27.2	5.9	2.7	12.7	4.2	25.5	1.07	3.39	2.98
A/CGo	5.2	25.1	12.6	42.9	7.1	0.0	9.9	3.5	20.4	2.11	3.06	2.77
CGo	9.7	18.7	8.7	37.2	7.5	0.0	9.5	6.1	23.1	1.31	3.95	2.25
Eutric Fluvisols (17)												
Ap	5.0	11.4	7.6	24.1	7.3	9.3	16.0	7.5	39.9	0.60	4.66	5.57
C	4.3	14.2	18.0	36.6	7.4	3.8	17.2	15.9	44.3	0.82	4.19	3.33
C/Go	5.0	11.7	8.7	25.3	7.2	0.0	18.2	7.2	32.4	0.78	3.74	2.09
Histi-Umbric Gleysols (18)												
Ao	6.0	10.4	10.4	26.8	1.7	8.8	1.5	16.5	28.4	0.94	4.09	4.37
Gor	4.3	12.6	23.2	40.1	9.2	3.5	20.2	15.9	48.7	0.82	4.38	3.41
Gr	3.7	23.2	12.6	39.5	4.8	0.0	13.5	4.6	23.0	1.72	2.95	2.79

(2) 1 HA – free humic acids, (3) 2 HA – HA bind with Ca^{2+} , (4) 3 HA – HA bind with mineral soil part, (5) Σ HA of humus, (6) 1a FA – fulvic acids extracted with 0.05 $mol.dm^{-3}$ H_2SO_4, (7) 1 FA – free fulvic acids, (8) 2 FA – FA bind with Ca^{2+}, (9) 3 FA – FA bind with mineral soil part, (10) Σ FA of humus, (11) HA:FA – humic acids to fulvic acids ratio, (12) $Q_{4/6}$ HS - absorbance ratio $A_{4/6}$ of humus substances, (13) $Q_{4/6}$ HA - absorbance ratio $A_{4/6}$ of humic acids

(1) horizont, (2) 1 HA - voľné humínové kyseliny, (3) 2 HA - humínové kyseliny viazané s Ca^{2+}, (4) 3 HA - humínové kyseliny viazané na minerálny podiel, (5) Σ HA humusu, (6) 1a FA - fulvokyseliny extrahované 0,05 $mol.dm^{-3}$ H_2SO_4, (7) 1 FA - voľné fulvokyseliny, (8) 2 FA - fulvokyseliny viazané s Ca^{2+}, (9) 3 FA - fulvokyseliny viazané na minerálny podiel, (10) Σ FA humusu, (11) HA:FA – pomer humínových kyselín a fulvokyselín, (12) $Q_{4/6}$ HS – pomer absorbancií $A_{4/6}$ humusových látok, (13) $Q_{4/6}$ HA - pomer absorbancií $A_{4/6}$ humínových kyselín, (14) – humínové kyseliny [% z C_T], (15) – fulvokyseliny [% z C_T], (16) čiernica modálna, (17) fluvizem kultizemná, (18) glej močiarový

in mineral horizons and suggests an increasing degree of soil organic matter decomposition. As it is evident from our results, increased humic to fulvic acids ratio (HA : FA) and decreased absorbance ratio (Q) confirmed progressive humification in deeper parts of studied profiles (Table 2).

Results of humus fractional composition are presented in Table 2. Predominant fraction of humic acids (HA) and fulvic acids (FA) was that bound with Ca^{2+}, what points on abundant presence of Ca^{2+} in soil. Moreover, according to Sotáková [20], HA bound with Ca^{2+} is considered the best humus fraction.

The quality of humus was determined as HA : FA ratio (more favourable humus has higher amount of HA than FA) and absorbance ratio - Q (low Q may be an indicative of more humified and highly condensed i.e. aromatic substances and more ancient origin) [21].

Compared to topsoils, increased humus quality was found in deeper parts of profiles, what is the evidence of more humified and stabile humus forms occur in depth. Increased values of HA : FA ratio down to the depth had similar tendency like percentage of stabile forms of soil organic matter expressed as C_{NL} (Table 1). The most favourable humus quality in topsoil was ascertained in Mollic Fluvisol, then in Histi-Umbric Gleysol and low quality in Eutric Fluvisol.

Determined values of HA : FA ratios are in accordance with results of Sotáková [20] who reported the average HA : FA ratio for Mollic Fluvisols 1.2-2.6, for Eutric Fluvisols and for Histi-Umbric Gleysols < 1.0.

Surprisingly sharp increase of humus quality was found in Gr horizon of Histi-Umbric Gleysol in depth 0.6 m (Table 2). This is in contradiction with typical average values reported by Pospíšil [17], who stated that for Histi-Umbric Gleysol is characteristic gradual decrease of humus quality down to the depth (HA : FA decrease from 0.9 to 0.4). Therefore, based on results of organic carbon pool and its stability (C_{NL} proportion), but mainly on sharp increase of humus quality we concluded, that in depth of 0.6 m started A horizon of buried Mollic Fluvisol. The flooding and a consequent burying of favourable Mollic Fluvisol under the layer of new sediments as a result of human activity is in accordance with Kouzmina et al. [11] who concluded that human-induced changes in the water regime have a negative effect on the state of soils, their fertility and finally on the soil cover structure and vegetation.

CONCLUSIONS

- On the area of Žitavský wetland were found three soil types (Mollic Fluvisol, Eutric Fluvisol and Histi-Umbric Gleysol), which differed in soil organic matter quantity and quality.
- On the base of Žitavský wetland history and topography we suppose that the original Mollic Fluvisol was covered by layer of new sediments, since in depth of 0.6 m was found sharp increase of humus quality, stability and content.
- Results of our study confirmed the effect of human activities in Žitavský wetland on state of soils, their cover structure and vegetation.

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