Original Paper

Selected soil chemical properties in the campus of Slovak University of Agriculture in Nitra

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Urbanized areas are distinguished by great heterogeneity of soil morphological, physical, chemical and biological properties. Hence, the aim of this study was to characterize selected chemical properties of urban soil in the park and garden of Slovak University of Agriculture (SUA) in Nitra with regard to different soil management. Soil properties of studied Fluvisols were investigated in three soil pits dug 100–400 meters from the left bank of the river Nitra. Obtained results showed, that carbonates content in studied profiles was in range from 0.25 to 0.8% and correspond with increased pH values. Soil in SUA campus had high buffering capacity related to carbonates content, high to very high cation exchange capacity and high degree of base saturation. Concentrations of organic carbon (22.2–24.7 g kg^{-1}) in topsoil of studied Fluvisols were higher than reported average content in Fluvisols in Slovakia. It suggests that in SUA campus, the correct practices for organic matter maintaining and even increasing were followed.

Keywords: urban soil, pH, sorption, carbonates, soil organic matter

1. Introduction

Soil is one of the principal natural resources, which always accompanies humans. It provides to mankind, whether directly or indirectly, foodstuff, livelihood and other basic needs, thus, on the soil is directly dependent the whole civilization. On the other hand, humans can cause substantial transformation, even complete devastation of soil by many activities – improper cultivation, construction of settlements, industrial objects, roads, waste landfill etc. (Šarapatka, 2014).

Soil degradation in its various forms is a fundamental and persistent problem which has increased mainly in the past decade. As major causes of soil degradation in urban adjacent areas of Europe were determined land take and soil sealing (EC, 2012). Soil cover in urban and industrial areas is one of the main ecosystem components, which undergoes irreversible changes. Soils in such areas are dominated or strongly affected by human-made material and exhibit a high spatial heterogeneity (Charzyńsky et al., 2013).

Urban soils occur in urban, industrial, transportation, mining and military areas. Since as urban are considered soils in the official borders of the town (Sobocká, 2007), the soil in the campus of Slovak University of Agriculture is regarded as soil in urbanized area of town Nitra. Generally, also this soil can have different properties depending on the properties of primary soil, the way of its use, or on the soil management practices (Sobocká, 2007; Šarapatka, 2014).

Pickett et al. (2011) reported that nowadays, 52% of the planet population lives in cities, up to 30% from 50 years ago, and urban areas are gaining 67 million people per year.

Since urbanized areas are steadily increasing, the objective of this study was to characterize selected chemical properties of urban soil in the park and garden of Slovak University of Agriculture in Nitra with regard to different soil management.

2. Material and methods

2.1 Locality description

The town Nitra is situated on south-western part of Slovakia (48º 18'N; 18º 05'E). Majority of the Slovak University of Agriculture (SUA) campus is located next to the left bank of the river Nitra. The soil forming substrate in the campus area is Quaternary loamy-clayey alluvial sediments of the river Nitra and originally developed soil type was Fluvisol. According to WRB (2006), Polláková and Šimanský (2015) classified the soil in the park of SUA campus as Calcaric Fluvisol, and cultivated soil in university gardens as Hortic Calcaric Fluvisol. Ground water level ranges from 1.20 to 2.50 m. The climate in

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area is warm and dry, long term average temperature is 10.2 °C and precipitation 539 mm per year (Špánik et al., 2002).

2.2 Soil sampling and analytical methods

Chemical properties of studied soils were characterized in three soil probes dug in the spring 2012:

- Soil probe 1 was located 400 meters from the left bank of the river Nitra under the kept lawn in park of SUA Nitra. The park and lawn in SUA campus was established in 1966. The dominant herbage in the park's lawn is *Lolium perenne* L.
- Soil probe 2 was located 100 meters from the left bank of the river Nitra under the herbicidal fallow in experimental lawn garden of SUA Nitra. The herbicidal fallow lasted for eight years and before was used for experimental growing the clover (*Trifolium resupinatum* L., *Trifolium alexandrinum* L.) and alfalfa (*Medicago falcata* L., *Medicago lupulina* L.) on soil cultivated to the depth of 0.3 m. During herbicidal fallow the soil was not cultivated.
- Soil probe 3 was located 380 meters from the left bank of the river Nitra on temporarily bare soil with corn (*Zea mays* L.) forecrop, in the main garden of SUA Nitra. The area of main garden was annually intensively cultivated to the depth of 0.3 m (Figures 1, 2).

Polláková and Šimanský (2015) analysed and described for each abovementioned soil profile the physical and morphological properties.

Soil samples for determination the chemical characteristics were taken from all horizons of studied soil profiles. In laboratory, samples were air dried and sieved through the sieve with mesh size of 2 mm, and for

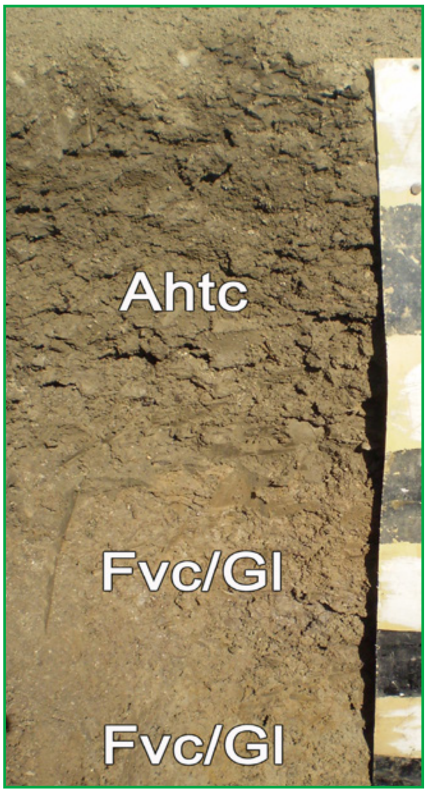

Figure 2 Soil profile 3 in main garden of SUA Nitra

organic carbon determination through the mesh size of 0.25 mm.

Total soil organic carbon content (C_{ox}) was analyzed by Tyurin method (Orlov et al., 1981); soil reaction – potentiometrically in distilled H_2O and 1 mol dm^{-3} KCl (1 : 2.5); content of exchangeable bases and hydrolytic acidity by Kappen's method, carbonates

Figure 1 Main garden of SUA Nitra

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content – volumetrically (Hrivňáková et al., 2011); humus fractionation – by Kononova-Belchikova method (1961) – isolated humus substances (HS) and humic acids (HA); spectral analyses of HS and HA – by 6400 Spectrophotometer (Jen Way).

Soil samples were analysed in triplicate and in this study the average value of each soil parameter was calculated from three repeated analyses.

3. Results and discussion

Sustainable use of soil resource requires extensive knowledge about its genesis, morphology, and properties. Consequently, soil data are basis for improved land use management and soil conservation (Junge and Skowronek, 2007).

Values of basic chemical properties are shown in Table 1. Soil pH/H_2O ranged from neutral to slightly alkaline and soil pH/KCl from slightly acidic to slightly alkaline. Carbonates content in studied profiles was in range from 0.25 to 0.8% and correspond with increased pH values. Since in the studied urban soil were not found any artifacts or building materials we suppose that carbonates in the soil occurred naturally. Assumption was confirmed by findings of Čurlík and Šefčík (2006) who reported that carbonates naturally occur in alluvial sediments of river Nitra, since around 80% of the territory which crosses river Nitra contains 5.72% carbonates in A horizon. On the other side, Szombathová et al. (2009) found in park Sihoť (fluvial plane of the river Nitra in town Nitra) soil containing mixture of fluvial and building material, which enriched natural carbonates concentration to 14.3% in soil classified as Calcaric Urbi-Anthropic Regosols (ISSS-ISRICFao, 1994), or according to new classification as Calcaric Anthrosol (WRB, 2006).

Values of hydrolytic acidity (H) differed only slightly. In all studied profiles they were in range of mild to

Table 1 Soil pH, carbonates and characteristics of sorption complex

Locality	Horizon	Depth in m	pH/H_2O	pH/KCl	CO_3^{2-}	H	S	CEC	BS
					%	mmol kg^{-1}			%
1 kept lawn	*Ac*	0.02–0.25	7.81	7.07	0.40	6.1	450.9	457.0	98.7
	Fvc	0.25–0.55	8.01	7.23	0.80	5.7	488.5	494.2	98.8
	Fvc/Gl	>0.55	8.22	7.31	0.40	5.3	381.5	386.8	98.6
2 herbicidal fallow	*Ahtc*	0.0–0.3	6.94	6.43	0.33	8.4	326.0	334.4	97.5
	Fvc	0.3–0.4	6.89	6.32	0.25	8.1	299.0	307.1	97.4
	Fvc/Gl	>0.4	7.06	6.53	0.40	6.3	360.0	366.4	98.3
3 main garden	*Ahtc*	0.0–0.3	7.41	6.99	0.43	6.1	419.3	425.5	98.6
	Fvc/Gl	0.3–0.6	7.46	6.82	0.30	6.4	365.0	371.4	98.3
	Fvc/Gl	>0.6	7.51	6.88	0.40	4.4	237.0	241.4	98.2

H – hydrolytic acidity; S – sum of bases (Na^+, K^+, Ca_2^+, Mg_2^+); CEC – cation exchange capacity, BS – base saturation, CO_3^{2-} – carbonates

Table 2 Organic carbon and humus quantity and quality

Locality	Horizon	C_{ox}	C_{HS}	C_{HA}	C_{FA}	C_{HA}/C_{FA}	C_{HS}	C_{HA}	C_{FA}	$Q^{4/6}_{HS}$	$Q^{4/6}_{HA}$
		g kg^{-1}					% of C_{ox}				
1 kept lawn	Ac	22.2	6.3	2.4	3.8	0.64	28.2	11.0	17.2	–	–
	Fvc	12.6	3.8	1.7	2.1	0.82	30.4	13.7	16.7	–	–
	Fvc/Gl	10.3	2.9	1.6	1.4	1.16	28.7	15.4	13.3	–	–
2 herbicidal fallow	*Ahtc*	24.7	7.6	3.4	4.2	0.81	30.8	13.8	17.0	5.30	4.50
	Fvc	19.4	6.1	2.9	3.2	0.91	31.4	14.9	16.5	4.40	4.00
	Fvc/Gl	9.6	3.5	2.1	1.4	1.50	36.5	21.9	14.6	5.16	4.61
3 main garden	*Ahtc*	23.6	6.5	2.8	3.7	0.76	27.5	11.9	15.7	3.79	3.30
	Fvc/Gl	13.5	4.4	1.7	2.7	0.63	32.6	12.6	20.0	5.22	4.64
	Fvc/Gl	6.8	2.0	1.1	0.9	1.22	29.4	16.2	13.2	5.74	6.13

C_{ox} – total soil organic carbon, C_{HS} – carbon of humus substances, C_{HA} – carbon of humic acids, C_{FA} – carbon of fulvic acids C_{HA}/C_{FA} – humic acids to fulvic acids ratio, $Q^{4/6}_{HS}$ – absorbance ratio $A_{4/6}$ of humus substances, $Q^{4/6}_{HA}$ – absorbance ratio $A_{4/6}$ of humic acids

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moderate and decreased with depth (Table 1). Cation exchange capacity (CEC) was in range high to very high (241–494 mmol kg^{-1}). It related to the type of sediments of predominantly silty-clayey-loamy textural composition and to carbonates content. Moreover, in A horizons, the CEC values were also affected by the soil organic matter concentration. When compare cation exchange capacity in all soil horizons, it is evident, that Fvc/Gl horizon in main garden had the lowest CEC values (241 compared to 307–494 mmol kg^{-1}). Probable reason was textural composition of substrate with a high proportion of sand (47.2%) in mentioned horizon compared to the other horizons of investigated profiles (8.8–23.3% of sand). Complete textural composition of studied profiles was published by Polláková and Šimanský (2015). In all profiles, high values of sum of bases (S) were reflected as full saturation of sorption complex with base cations (BS), ranging between 97–99%. Soil in SUA campus was characterized by high buffering capacity related to carbonates content, high to very high CEC and high degree of base saturation.

Soil organic matter is a main attribute of soil quality since it has far-reaching effects on soil physical, chemical and biological properties. Main indicator of the amount of organic matter is the organic carbon content (C_{ox}). The C_{ox} content gradually decreased along soil profiles in all studied sites of SUA campus. In A horizons, the stock of total soil organic carbon was high (22.2–24.7 g kg^{-1}) and in subsoils decreased to 6.8–19.4 g kg^{-1} (Table 2). Such concentration of C_{ox} was slightly higher than average values reported for Eutric Fluvisols in Slovakia by Sotáková (1982). She stated that the average C_{ox} content varies in topsoil from 13 to 20 g kg^{-1}, in depth of 0.5–0.6 m from 6 to 12 g kg^{-1}. Moreover, newer data reached in the frame of Soil Monitoring showed even lower average C_{ox} content (17 g kg^{-1}) in A horizons of Eutric Fluvisols (Kobza et al., 2010). High C_{ox} concentration in topsoil of all studied sites in SUA campus suggests that staff responsible for university gardens follows the correct practices for maintaining or even increasing organic matter content in the soil.

The quality of humus was determined as ratio of humic acids to fulvic acids carbon ($C_{HA} : C_{FA}$). Generally, more favourable humus has higher amount of humic acids than fulvic acids. Obtained results showed increased humus quality in deeper parts of profiles than in topsoils, what is the evidence of more humified and stabile humus forms occur in depth (Table 2). Similar results of increased humus quality with depth in Fluvisol was described in a number of works (Szombathová et al., 2007; 2008b; 2009; Polláková et al., 2013).

Compared to slightly anthropically influenced soil under the kept lawn in park of SUA Nitra, more favourable humus quality was ascertained in A horizon under herbicidal fallow in the garden (intensively cultivated eight years ago) and in cultivated soil of main garden (Table 2). It is known that due to cultivation the topsoil layer is stirred, homogenized and aerated. Enhanced aeration promotes the oxidation of less condensed fractions of humic substances (i.e. fulvic acids) in the soil, therefore humus acquires higher proportion of humic acids what increases its overall quality. Similar results of higher humus quality in arable compared to undisturbed soil have been published by Szombathová et al. (2001; 2008a), Szombathová (2010), Gonet et al. (2009). Determined $C_{HA} : C_{FA}$ ratios in studied A horizons are in accordance with results of Sotáková (1982) who reported the average $C_{HA} : C_{FA}$ ratio for Eutric Fluvisols <1.0. Moreover, she noted that more intensive soil cultivation and base cations content can improve humus composition in favour of humic acids. The same trend was observed also in our study.

4. Conclusions

Soil pH/H_2O ranged from neutral to slightly alkaline and soil pH/KCl from slightly acidic to slightly alkaline and correspond with carbonates content.

Since in the studied urban soil were not found any artifacts or building materials we suppose that carbonates in the soil occurred naturally. Soil was characterized by high buffering capacity related to carbonates content, high to very high cation exchange capacity and high degree of base saturation.

High organic carbon concentration in topsoils (22.2–24.7 g kg^{-1}) suggests that staff responsible for university gardens follows the correct practices for maintaining or even increasing organic matter content in the soil.

Humus quality was higher in cultivated soil ($C_{HA} : C_{FA}$ = 0.81 and 0.76) compared to slightly anthropically influenced soil in the park ($C_{HA} : C_{FA}$ = 0.64).

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