SOIL COVER OF THE PROTECTED AREAS OF PRAGUE AS AN INDICATOR OF ENVIRONMENTAL CHANGES

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ABSTRACT
The structure of soil cover in Prague and its changes are defined on the basis of the study of soils in protected areas and localities with different types of anthropogenic load. Conditions of pedogenesis are determined on the basis of pH, cation exchange capacity, exchangeable cations, soil organic matter, particle-size distribution, mineralogy of clay component, macromorphological and micromorphological analyses. The degree of pedodiversity is higher in the protected areas than in areas with anthropogenic activity. Disturbance of stability of soil development in agricultural, urban and rural areas of Prague is a common phenomenon. The state of the soil organic matter was used as an indicator of environmental changes.

KEYWORDS: protected areas, pedodiversity, elementary soil processes, structure of soil cover, parent materials, mineralogy, micromorphology

1. INTRODUCTION

The protected areas of Prague exibit a wide variety of soils that have never been studied in detail. The research of soil cover is an urgent task because these studies can provide much needed information about the role of the intensity of anthropogenic factor, urbanization, past environmental development and, as such, they contribute to the municipal natural management policy.

2. PROJECT OBJECTIVES

The detailed soil study concentrated on the analysis of development soil cover in the protected areas of Prague. The project was aimed at the determination of the principles of the structure of soil cover in the area of the capital of Prague that reflect past and present environmental changes.

3. METHODS

The project was solved in the following steps:

1. Selection of soil profiles on the basis of soil survey.
2. Selection of significant localities in the individual protected areas and areas with human activity for understanding the effect of anthropogenic factor on soil development.
3. Establishment of a database of soil profiles in the protected areas of Prague including their GPS positions.
4. Determination of the elementary soil processes in relation to pedodiversity.

The coordinates are given in the WGS 84 system. Morphological description of soils follows the guidelines by Catt (1990) and Jahn et al. (2006). The colours were identified using Munsell Soil Color Charts (1994). Soil horizons and types were classified according to the IUSS Working Group WRB (2006) and the Czech taxonomic soil classification system (Němeček et. al., 2001). Samples for analyses were collected from individual soil horizons. Micromorphological properties were studied on thin soil sections from oriented samples. Thin sections were prepared and described according to Smolíková (1967, 1972) and Stoops (2003). Mineral composition was determined for soil particles < 0.001 mm, separated by sedimentation in distilled water, and mounted on oriented slides using the method of Jackson (1979). The specimens were studied first air-dried, and then saturated in ethyleneglycol at 80 °C for four hours in a drier furnace and finally heated at 550 °C for four hours in a muffle furnace. X-ray diffraction spectra were obtained on a diffractometer Philips PW 3710 under the following working

Table 1 Positions of soils profiles and land use distribution in the area of the capital of Prague.

Profile	Land use	Altitude	Coordinate N	Coordinate E
Bohdalecká	Urban area	248 m	50^{0}03.586′	14^{0}28.172′
Evropská	Urban area	267 m	50^{0}05.935′	14^{0}22.166′
Internacionální	Urban area	290 m	50^{0}06.915′	14^{0}31.456′
Kbelská 1A	Rural area	271 m	50^{0}06.898′	14^{0}31.499′
Kbelská 1B	Rural area	258 m	50^{0}08.919′	14^{0}23.109′
Kněžívka	Agricultural area	348 m	50^{0}07.425′	14^{0}17.425′
Kosoř 1	Radotínské údolí Nature Reserve	336 m	49^{0}59.594′	14^{0}18.923′
Kosoř 2	Radotínské údolí Nature Reserve	343 m	49^{0}59.763′	14^{0}18.787′
Lochkov	Lochkovský profil National Nature Monument	247 m	49^{0}59.835′	14^{0}20.678′
MO	Urban area	255 m	50^{0}05.703′	14^{0}23.849′
Nebušice	Agricultural area	258 m	50^{0}06.212′	14^{0}18.094′
Opukový lom	Opukový lom u Přední Kopaniny Nature Monument	342 m	50^{0}06.922′	14^{0}17.419′
Purkrabský háj	Šárka - Lysolaje Nature park	276 m	50^{0}06.120′	14^{0}18.251′
Radotínsko-Chuchelský háj 1	Radotínsko-Chuchelský háj Nature park	258 m	50^{0}01.014′	14^{0}23.180′
Radotínsko-Chuchelský háj 2A	Radotínsko-Chuchelský háj Nature park	231 m	50^{0}01.526′	14^{0}23.296′
Radotínsko-Chuchelský háj 2B	Radotínsko-Chuchelský háj Nature park	237 m	50^{0}01.507′	14^{0}23.288′
Radotínsko-Chuchelský háj 3	Radotínsko-Chuchelský háj Nature park	249 m	50^{0}01.533′	14^{0}23.317′
Roztocká	Roztocký háj - Tiché údolí Nature Reserve	195 m	50^{0}08.664′	14^{0}23.748′
Roztocký háj	Roztocký háj - Tiché údolí Nature Reserve	231 m	50^{0}09.083′	14^{0}23.540′
Roztocká 1293	Rural area	129 m	50^{0}08.762′	14^{0}23.807′
Ruzyně 1A	Experimental field	339 m	50^{0}05.082′	14^{0}18.008′
Ruzyně 1B	Experimental field	345 m	50^{0}05.110′	14^{0}17.823′
Suchdol	Experimental field	280 m	50^{0}07.664′	14^{0}22.446′
U Spáleného mlýna 1A	Roztocký háj - Tiché údolí Nature Reserve	208 m	50^{0}08.919′	14^{0}23.109′
U Spáleného mlýna 1B	Roztocký háj - Tiché údolí Nature Reserve	229 m	50^{0}08.892′	14^{0}23.128′
U Spáleného mlýna 1C	Roztocký háj - Tiché údolí Nature Reserve	264 m	50^{0}08.857′	14^{0}23.204′
Thákurova J4	Urban area	213 m	50^{0}06.235′	14^{0}23.409′

condition: CuKα radiation, 40 kV, 55 mA, goniometric shift $1^0 \cdot min^{-1}$, 2Θ. Semiquantitative values were calculated from individual mineral basal peaks. Soil analyses were carried out including pH values, $CaCO_3$ content, particle size analysis, cation exchange capacity, exchangeable cations (H^+, K^+, Na^+, Ca^{2+}, Mg^{2+}), organic carbon and nitrogen measurement (Hraško, 1962 and van Reeuwijk, 2002). Hot-water extractable carbon determination follows the method of Ghani et al. (2003).

4. RESULTS

The list of soil profiles with the land use, altitude and geographic coordinates is presented in Table 1.

The type of pedogenesis and individual stage of soil development were characterized on the basis of macromorphological and micromorphological analyses.

Cambisols develop on a different type of parent materials, such as basalts (Radotínsko - Chuchelský háj 1) and spongilitic marlstones (Nebušice and Purkrabský háj). Calcaric Leptosols on spongilitic marlstones (Opukový lom) are typical for sites with steeper slopes.

Haplic Leptosols are situated on extremely sloping relief, predominantly on schists, wackes and acidic rocks of Proterozoic age.

Rendzic Leptosols on limestones were recognized at slope positions (Lochkov and Kosoř 2). The presence of the other soil type on limestones, such as Terra Fusca (Kosoř 1), is limited to platform positions on a karstic type relief.

Table 2 Chemical properties of selected soil profiles.
CEC – cation exchange capacity, H^+ - exchangeable H, K^+ - exchangeable K, Na^+ - exchangeable Na, Ca^{2+} -exchangeable Ca, Mg^{2+} exchangeable Mg.

Profile	Depth	pH_{H2O}	pH_{KCl}	$CaCO_3$	CEC	H^+	K^+	Na^+	Ca^{2+}	Mg^{2+}
	cm			%	mmol+/100 g	mmol+/100 g	mmol+/100 g	mmol+/100 g	mmol+/100 g	mmol+/100 g
Roztocká	0-6	5.32	4.98	<0.1	33.97	0.50	0.91	0.40	18.52	2.71
	6-20	4.51	3.75	<0.1	16.53	<0.50	0.33	0.45	6.47	1.82
	20-70	5.04	4.08	<0.1	25.90	2.00	0.44	0.47	13.31	4.63
	70-110	5.52	4.67	<0.1	19.77	2.00	0.43	0.55	12.67	4.43
	110-173	7.66	7.27	4.0	15.55	<0.50	0.41	0.58	15.79	3.72
Ruzyně 1A	0-32	7.67	7.32	0.3	23.97	<0.50	0.56	0.44	23.68	1.22
	32-56	7.62	7.17	0.1	24.42	<0.50	0.45	0.45	24.45	1.28
	56-72	7.72	7.32	8.5	19.25	<0.50	0.36	0.41	23.71	1.78
	72-125	7.83	7.27	2.6	26.90	<0.50	0.37	0.50	29.07	3.79

Table 3 Soil organic matter of selected soil profiles.
Chw – hot-water extractable carbon.

Profile	Depth cm	Cox %	Nt %	C/N %	Chw v % Cox	Chw mg/kg
Roztocká	0-6	4.63	0.44	10.43	5.26	2718
	6-20	1.19	0.13	9.15	3.95	478
	20-70	0.46	0.07	6.67	2.63	147
	70-110	0.20	0.05	3.92	4.87	73
	110-173	0.22	<0.05	4.40	3.84	73
Ruzyně 1A	0-32	1.27	0.13	9.24	2.68	341
	32-56	0.97	0.10	9.51	2.34	227
	56-72	0.42	0.04	9.54	3.17	133
	72-125	0.31	0.04	8.15	6.71	208

Table 4 Particle-size distribution of selected soil profiles.

Profile	Depth cm	<0.001 mm %	0.001-0.01 mm %	<0.01 mm %	0.01-0,05 mm %	0.05-0,25 mm %	0.25-2.00 mm %
Roztocká	0-6	14.8	23.5	38.3	49.2	8.8	3.7
	6-20	20.9	21.3	42.2	44.1	8.5	5.2
	20-70	38.7	16.4	55.1	38.8	4.7	1.4
	70-110	26.5	14.8	41.3	45.9	9.3	3.5
	110-173	20.5	16.1	36.6	49.0	13.1	1.4
Ruzyně 1A	0-32	21.0	25.2	46.2	42.3	8.8	2.6
	32-56	27.3	21.7	49.0	43.7	6.2	1.1
	56-72	23.6	20.5	44.1	41.3	12.7	1.8
	72-125	21.5	30.3	51.8	33.1	12.5	2.6

Pedogenesis on loess proceeded under a variety of different conditions, producing Chernozem, Luvisol and Albeluvisol.

Experimental fields (Ruzyně 1A, Ruzyně 1B and Suchdol), agricultural areas (Kněžívka and Nebušice), urban areas (Bohdalecká, Evropská, Internacionální, MO, Thákurova J4), rural areas (Kbelská 1A, Kbelská 1B, Roztocká 1293) were chosen for the investigation of pedogenesis with anthropogenic impact. Territories with natural conditions are represented by the Lochkovský profil National Nature Monument, Opukový lom u Přední Kopaniny Nature Monument, Radotínsko - Chuchelský háj Nature Park, Šárka - Lysolaje Nature Park, Radotínské údolí Nature Reserve and Roztocký háj – Tiché údolí Nature Reserve.

Table 5 Mineralogy of fraction <0.001 mm of selected soil profiles.

Profile	Depth cm	Calcite %	Chlorite %	Illite %	Kaolinite %	Feldspar %	Lepidocrocite %	Plagioclase %	Smectite %	Quartz %
Roztocká	0-6	0	1	8	6	5	7	7	1	64
	6-20	0	3	7	8	5	0	5	0	73
	20-70	0	2	9	9	8	0	4	7	60
	70-110	0	0	9	9	5	0	7	4	66
	110-173	0	3	15	13	5	0	4	6	55
Ruzyně 1A	0-32	3	1	6	4	5	0	5	2	75
	32-56	0	2	4	6	5	0	6	0	76
	56-72	15	4	4	5	3	0	3	2	62
	72-125	4	2	3	7	5	0	4	4	70

The results of analyses of selected soil profiles (Ruzyně 1A, Roztocká) are shown in Tables 2, 3, 4 and 5. Soils at these chosen localities developed on loesses. The soil cover was classified as Haplic Chernozem at Ruzyně 1A and as Albic Luvisol at Roztocká.

The values of pH, cation exchange capacity, exchangeable cations and $CaCO_3$ of soil cover in Prague correspond to the character of the parent material. Soils of the protected landscape areas show a higher degree of diversity and variability in pH values than soils of agricultural landscape, and are predominantly weakly acidic to neutral. In the case of soils on spongilitic marlstones, upper part of profiles showed weakly acidic values in agricultural landscape, and very acidic values in protected areas.

Cox and Nt contents are the highest in the A horizons of the all soils. Qualitative parameters of soil organic matter (C/N and hot-water extractable carbon) indicate differences between the same soil type with different land-uses and various soil types. The results of particle-size distribution showed different distributions of individual particle sizes. Fraction 0.01–0.05 mm dominates the soils on loesses. Elevated contents of particles <0.001 mm in the Bt and Btd horizons indicate the process of clay illuviation in soil types like Albeluvisols and Luvisols.

The studied soils developed on different parent materials. Mineral composition of the studied soils is controlled by the parent material and the type of pedogenesis. Illite and quartz are the dominant components of soils in the area of the capital of Prague. Other minerals include kaolinite, chlorite and minor feldspar, plagioclase, smectite and accessory amphibole, goethite and lepidocrocite.

5. CONCLUSIONS

The principles of the structure of soil cover in the area of the capital of Prague are controlled by the variability of parent materials, topographic relief and anthropogenic influence in the area.

A wider variability of soil types was documented in protected areas.

The significant parent material in the human-affected areas is loess.

The quartz/illite ratio varies among the individual soil types.

The character of pedogenetic processes was affected by anthropogenic factor to a variable degree. The highest impact was observed in the uppermost 30 cm layer of soil. Human activity has an emphatic significance to the specification of complex elementary soil processes.

Soils in protected landscape areas show a higher variability in pH values than soils of agricultural landscape. The results suggest a degradation of chemical properties by anthropogenic influence. A weaker anthropogenic impact on soil development was encountered in cases of soil profiles buried beneath a landfill layer.

A elementary soil process of humification is present in all soils. The rate of this process in the set of elementary soil processes is the highest for the Chernozems soil type.

Determination of hot-water extractable carbon and micromorphological analysis are suitable for the qualitative statement of humification.

A network of 27 soil profiles is suitable as a long-term standard for the monitoring of soil cover changes.

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PŮDNÍ POKRYV V CHRÁNĚNÝCH ÚZEMÍCH PRAHY JAKO UKAZATEL ENVIRONMENTÁLNÍCH ZMĚN

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ABSTRAKT:
Struktura půdního pokryvu v Praze a její změny byly stanoveny na základě studia půd v chráněných územích a prostorech s různým typem antropogenního zatížení. Podmínky pedogeneze byly definovány z hlediska výsledků stanovení pH, kationtové výměnné kapacity, výměnných kationtů, půdní organické hmoty, zrnitostního rozboru, mineralogie jílové frakce, makromorfologické a mikromorfologické analýzy. Stupeň pedodiverzity je vyšší v chráněných územích než v antropogenně ovlivněné krajině. Narušení stability pedogeneze v územích se zemědělským zatížením, intravilánu a extravilánu je běžným jevem. Indikátorem environmentálních změn je stav půdní organické hmoty.