

# Physical, chemical, and biochemical characteristics of soils in watersheds of the Bohemian Forest lakes: II. Čertovo and Černé Lakes

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## Abstract

Basic physical, chemical, and biochemical properties of mountain forest soils were determined in the watersheds of Čertovo (CT) and Černé (CN) Lakes in the period of 1997–2001. The CT watershed was predominantly covered with ~0.5 m deep spodo-dystric cambisol (58%) and podzol (21%), and shallow (~0.2 m) undeveloped organic rich soil (17%). The dominant contribution of spodo-dystric cambisol and podzol was evident also in the CN watershed. Stones >2mm in diameter, fine soil, and moisture contributed on average ( $\pm$  standard deviation)  $50\pm 17\%$ ,  $27\pm 12\%$ , and  $23\pm 9\%$ , respectively, to the total soil pools in the watersheds. Fine soil was sandy (48–81%), with a low (1–4%) content of clay, and its watershed weighted mean (WWM) pools were 225 and 143 kg.m<sup>-2</sup> in the CT and CN watersheds, respectively. Concentration of organic C was the dominant parameter, affecting concentrations of N, S, exchangeable base cations and protons. Relationship between C and P was less straightforward due to inorganic P forms associated predominantly with the Fe oxides in horizons rich in illuvial metals. The WWM element pools in the CT and CN watersheds were respectively: C, 1350 and 1120 mol.m<sup>-2</sup>; N, 59 and 50 mol.m<sup>-2</sup>; P, 5.4 and 3.4 mol.m<sup>-2</sup>; and S, 2.8 and 2.6 mol.m<sup>-2</sup>. Soil pH was generally low, with the lowest pH<sub>c(a)2</sub> values (2.5–3.3) in A horizons and highest (3.6–4.5) in the C horizons. The WWM cation exchange capacity of the CT and CN soils was 104 and 123 meq.kg<sup>-1</sup>, respectively, and was dominated by exchangeable Al<sup>3+</sup> (62% and 55%). The WWM base saturation of the CT and CN soils was 9% and 15%, respectively. It was primarily based on exchangeable Ca<sup>2+</sup> (~50%) and the contribution of Mg<sup>2+</sup> and K<sup>+</sup> was roughly equal (~20%). The WWM C:N ratio was 23 and 22 for the whole CT and CN soil profiles, respectively, and varied between 23 and 28 in the forest floor (O horizons). Concentrations of C, N, and P in soil microbial biomass represented 0.3–1.4%, 2–4%, and 1–15% (average 9%) of the total C, N, and P contents, respectively, suggesting high microbial activity of soil. While the carbon mineralization rates were comparable in the CT and CN watersheds (with highest values in the O horizons, 19–60 mmol.kg<sup>-1</sup>.d<sup>-1</sup>), nitrogen mineralization and nitrifying potential were 50–70% higher in the CN watershed. The average N mineralization potential in two uppermost soil horizons (O plus A) of the CT and CN soils (2.1 and 2.8 mmol.m<sup>-2</sup>.d<sup>-1</sup>, respectively) was one order of magnitude higher than atmospheric deposition of N onto the forest floor and their respective nitrification potentials (2.8 and 4.2 mmol.m<sup>-2</sup>.d<sup>-1</sup>) were higher than NH<sub>4</sub><sup>+</sup> supplied by both atmospheric deposition and soil nitrogen mineralization.

**Key words:** Carbon, nitrogen, phosphorus, sulfur, pH, cation exchange capacity, nitrification, mineralization

## INTRODUCTION

Studies on stream water composition showed significant differences in the element concentrations and fluxes between the watersheds of the Bohemian Forest lakes (VESELY et al. 1998a,b; KOPACEK & HEJZLAR 1998; KOPACEK et al. 2001a,b,c). Plešné Lake receives the highest terrestrial export of phosphorus, dissolved organic carbon, silica,  $\text{Ca}^{2+}$ , and  $\text{Na}^+$ , while the Čertovo Lake has the highest input of  $\text{H}^+$  and  $\text{SO}_4^{2-}$  ions, Černé Lake has the highest input of  $\text{NO}_3^-$ , ionic Al forms, and  $\text{Mg}^{2+}$ . Some of these differences, like 3-fold higher Ca:Mg molar ratio or higher  $\text{Na}^+$  and P concentrations in the Plešné Lake tributaries, can be in part explained by a different bedrock composition of the watersheds (VESELY 1994, KOPACEK et al. 1998). However, understanding the parameters like terrestrial organic carbon export and watershed ability to assimilate atmospherically deposited nitrogen or to adsorb sulfate and phosphate requires knowledge on soil pools, chemistry, and biochemistry.

In addition, extensive data on soil pH, cation exchange capacity, base saturation, C, N, and S contents, and soil sorption characteristics are necessary for the simulation of future development of soil chemistry under changing rates of acid deposition (e.g., COSBY et al. 1985). Such relevant and detail data on the Bohemian Forest soils are still unavailable.

The major aim of this paper is to present and evaluate basic physical, chemical, and biochemical properties of soils in the watersheds of Čertovo and Černé Lakes and compare them with the similar data from Plešné Lake watershed (KOPACEK et al. 2002 – this issue) with respect to differences in the bedrock composition.

## MATERIALS AND METHODS

### Study site description

Čertovo (CT) and Černé (CN) Lakes are situated at  $49^\circ 10'$  to  $11' \text{ N}$  and  $13^\circ 11'$  to  $12' \text{ E}$ , at altitudes of 1030 and 1008 m a.s.l., respectively, in the massive of the Jezerní Hora Mt. (1343 m a.s.l.). The CT watershed covers an area of 87.5 ha (including lake area of 10.3 ha), and is east oriented. The CN watershed covers an area of 129 ha (including lake area of 18.4 ha), and is north oriented (ŠVAMBERA 1939). Both watersheds are steep with the maximum local relief of 313 m (CT) and 335 m (CN). Their bedrock is predominantly made up of mica-schist (muscovite gneiss) with quartzite intrusions in the CT watershed (VESELY 1994).

Vegetation in the CT watershed is dominated by 90–150 years old Norway spruce forest (with sparse fir and beech), which nearly completely covers the whole watershed. The forest was used for charcoal and potash production for local iron smelters and glassworks, respectively, in the 17<sup>th</sup> century, and for fuel and timber in the 18<sup>th</sup> and 19<sup>th</sup> centuries (VESELY et al. 1993). Between 1754 and 1859, the area was used as a pasture for approximately 100 cow herds, until grazing was prohibited; marshy soils were drained and the watershed replanted with spruce forest (VESELY 1994).

The forest in the CN watershed is of a secondary origin, mostly from 1820, and is dominated with Norway spruce and sparse beech (VESELY 1994). Some changes in the original forest composition (decrease in numbers of beech) occurred probably as early as in the 13<sup>th</sup> century (VESELY 1998). In the 17<sup>th</sup> and 18<sup>th</sup> centuries, the CN forest was used for similar man activities (charcoal and potash production) as the CT forest. The area of both watersheds has been protected as a nature park since 1911 and, moreover, an access and most kinds of land-use have been restricted in this area due to frontier protection between 1948 and 1989.

## Sampling and analyses

### Soil profiles

Soils were sampled between 1028 and 1320 m a.s.l. at sites representative for particular parts of the CT and CN watersheds (Fig. 1) in September 1997, May 2000, and May 2001. The list of samples is given in Table 1. Soil samples were taken from 0.25 m<sup>2</sup> pits (50×50 cm), excavated down to the bedrock. Sampling was performed as described in Part I (KOPÁČEK et al. 2002 – this issue).

Number of samples, which were taken from the pit, depended on the soil profile characteristics. For the purpose of this study, we use the following classification of horizons: (i) In podzols, samples were taken from the organic litter layer consisting predominantly of decaying spruce needles, branches, and bark (O horizon), the uppermost mineral horizon with accumulated humified organic matter (A horizon); eluvial grey horizon with a low content of organic matter (E horizon); horizon rich in illuvial organic matter Fe oxides (B horizon). The Bs and Bh horizons were not regularly separated (only in the profile CT11). (ii) In spodo-dystric cambisol, samples were taken from O horizon. A horizon (if well distinguishable from the following Ae horizon), Ae horizon (organic rich mineral horizon), and all existing distinguishable

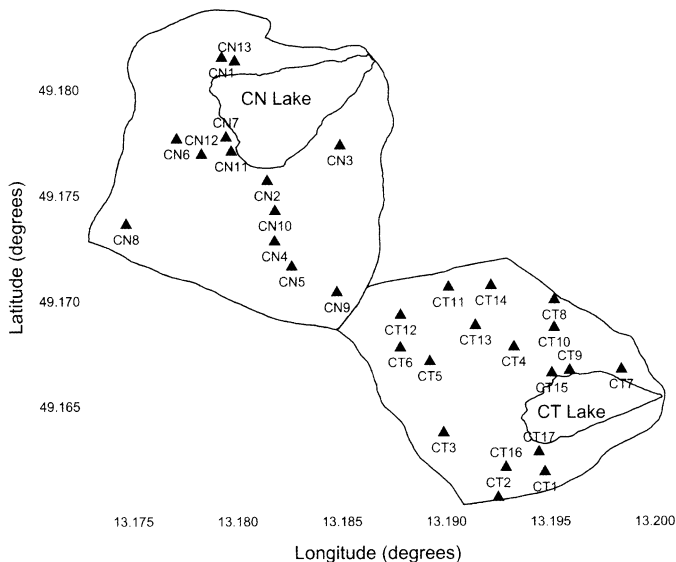


Fig. 1. Map of the Čertovo and Černé Lake watersheds with the location of sampling pits.

**Table 1.** List of samples and horizons taken in the Černý (CN) and Čertovo (CT) watersheds and their major physical soil characteristics. Samples were taken in May 2000, except for CN8 (May 2001) and CT9 to CT11 (September 1997). Not determined, n.

Profile	Sampling					Soil characteristics <sup>3</sup>						
	Floor <sup>1</sup>	Horizons	Coordinates <sup>2</sup>			Depth m	Total pool	Stones		H <sub>2</sub> O	Soil	LOI
			N	E	Alt. (m)			Large <sup>1</sup>	Small			
CN1	s	O, A.E, B, C	49.1815	13.1793	1028	0.61	994	586	71	151	186	15
CN2	s	O, A, Ae, Bsv	49.1757	13.1815	1040	0.70	772	288	137	176	171	19
CN3	s	O, A, Ae, E, B, C	49.1773	13.1850	1050	0.31	326	104	47	90	85	28
CN4	m	A, Ae, C	49.1728	13.1818	1250	0.75	597	268	79	120	130	23
CN5	s	O, A, E, B, C	49.1716	13.1826	1310	0.47	740	180	117	171	272	9
CN6	s	O, A, E, B, C	49.1777	13.1771	1110	0.41	398	46	67	187	98	34
CN7	s/b	O, A, Ae, C	49.1777	13.1795	1040	0.63	574	178	82	147	167	20
CN8	s	O, A, E, B, C	49.1736	13.1747	1320	0.54	736	296	212	115	113	19
CT1	s	O, A, E, B, C	49.1619	13.1947	1040	0.69	791	495	45	132	119	24
CT2	s	O, A, Ae, Bsv, C	49.1607	13.1925	1140	0.57	654	180	126	93	256	9
CT3	s	O, A, E, B	49.1637	13.1899	1200	0.38	616	336	43	116	120	25
CT4	s	O, A, E, B	49.1678	13.1933	1110	0.76	961	678	36	125	122	21
CT5	s	O, A, Ae1, 2, 3	49.1671	13.1892	1240	0.70	844	206	163	235	240	18
CT6	s	O, A, Ae, B	49.1678	13.1878	1315	0.78	770	398	66	153	153	20
CT7	s	O, A, E, B, C	49.1667	13.1984	1040	1.10	1539	138	225	346	830	8
CT8	s/b	O, A, Ae1, Ae2	49.1700	13.1952	1180	1.30	1708	50	204	600	853	9
CT9	s	A, E, B, C	49.1667	13.1959	1040	0.50	n	n	n	n	n	n
CT10	s/b	A, Ae1, Ae2, C	49.1687	13.1952	1120	0.62	n	n	n	n	n	n
CT11	s	A, E, B, B, C	49.1706	13.1901	1280	0.58	n	n	n	n	n	n

<sup>1</sup> Floor refers to the type of forest floor: spruce (s), mixed spruce and beech (s/b), meadow (m).

<sup>2</sup> Longitude and latitude are given in the WGS-84 coordinates. Alt. (altitude) is given in m a.s.l.

<sup>3</sup> Soil characteristics refer to: Large stones (>50 mm), Small stones (2–50 mm), H<sub>2</sub>O (loss on drying at 105°C), Soil (dry weight soil fraction <2mm), LOI (vertically homogenized loss on ignition at 550°C).

mineral horizons (Bsv, C). In some soil profiles, the Ae horizons exhibited slightly decreasing content of organic matter with depth. In that case, more samples were taken (e.g., Ae1, Ae2, and Ae3 in the profile CT5). (iii) In the undeveloped soil on steep slopes and thin soils with no distinguishable diagnostic mineral horizons (lithosol and/or ranker), samples were taken from O horizon and, if present, from A horizon.

All samples taken from the soil profiles CT1 to CT11 and CN1 to CN8 (Table 1) were analyzed individually for physical, chemical, and selected biochemical analyses. In May 2001, mixed samples were prepared from the identical soil horizons from the profiles CT12 to CT17 and/or from CN8 to CN13 for biochemical and selected chemical characteristics.

#### Grid sampling of soils

The soil depth and type in the CT watershed was in detail estimated from May to August 2000 by pushing a steel soil corer down to the bedrock (3-fold within ~10 m<sup>2</sup>) at each node in the 75 by 75 m grid. Soil samples from each corer were separated according to the horizons and combined to obtain a watershed-integrated sample of the individual horizons. Samples were

stored in the dark at 5°C until analyzed. In the total, the soil was sampled from 450 cores at 150 sites regularly distributed within the whole CT watershed.

### Physical, chemical, and biochemical analyses

For the detail description of soil sample manipulations prior analyses (storage, sieving, and drying) and for analytical techniques see Part I (KOPÁČEK et al. 2002 – this issue). Briefly:

(i) Soil texture was determined for nine mineral horizons from soil profiles CT9 to CT11 by wet sieving and a sedimentary analysis. The content of sand, silt, and clay was calculated as percentage by weight of particles  $>60\ \mu\text{m}$ , from 2 to  $60\ \mu\text{m}$ , and  $<2\ \mu\text{m}$  in diameter, respectively.

(ii) Chemical soil properties were determined as follows: Dry weight (DW), loss on ignition (LOI), total (organic) carbon (C), total nitrogen (N), total phosphorus (P), total sulfur (S), total content of metals (Ca, Mg, Na, K, Al, Fe, Mn, Ti, and Si), pH in water ( $\text{pH}_{\text{H}_2\text{O}}$ ) and 0.01M  $\text{CaCl}_2$  solution ( $\text{pH}_{\text{CaCl}_2}$ ), exchangeable base cations ( $\text{BC}_{\text{Ex}} = \text{sum of Ca}^{2+}_{\text{Ex}}, \text{Mg}^{2+}_{\text{Ex}}, \text{Na}^{+}_{\text{Ex}}, \text{and K}^{+}_{\text{Ex}}$ ) and exchangeable acidity ( $\text{Al}^{3+}_{\text{Ex}}$  and  $\text{H}^{+}_{\text{Ex}}$ ). Cation exchange capacity (CEC) was the sum of the 1M  $\text{NH}_4\text{Cl}$  extractable  $\text{BC}_{\text{Ex}}$  and the 1M KCl extractable  $\text{Al}^{3+}_{\text{Ex}}$  and  $\text{H}^{+}_{\text{Ex}}$ , and all concentrations were expressed on an equivalent basis ( $\text{meq}\cdot\text{kg}^{-1}$ ; 1 equivalent is 1 mole of charge). Total cation exchange capacity ( $\text{CEC}_T$ ) was determined by the sample titration with 0.1M  $\text{Ba}(\text{OH})_2$ . Other chemical analyses were: oxalate-extractable Fe ( $\text{Fe}_{\text{Ox}}$ ), Al ( $\text{Al}_{\text{Ox}}$ ) phosphorus ( $\text{P}_{\text{Ox}}$ ), and soluble reactive phosphorus ( $\text{SRP}_{\text{Ox}}$ ); citrate-dithionite extractable Fe ( $\text{Fe}_{\text{CD}}$ ) and Al ( $\text{Al}_{\text{CD}}$ ); and water extractable sulfate ( $\text{SO}_4\text{-S}$ ). Water extractable  $\text{SO}_4\text{-S}$  was measured in the mixed samples. In 2000, the average samples of A, Ae, E, B, and C horizons were prepared by (i) mixing of constant amounts of moist subsamples from the identical horizons in the profiles CT1 to CT8 and CN1 to CN7 for the CT and CN watershed, respectively (list of horizons is in Appendix 1), and (ii) sample integration during the grid sampling (CT watershed). In 2001, the average samples were prepared by mixing of constant amounts of moist subsamples from the following soil profiles: (i) CN8 to CN13 (O and A horizons), CN9 and CN11 (Ae horizon), and CN8, CN12, and CN13 (B horizon) in the CN watershed, and (ii) CT12 to CT17 (O and A horizons), CT12, CT13, and CT17 (Ae horizon), and CT14 and CT15 (E, B, and C horizons) in the CT watershed.

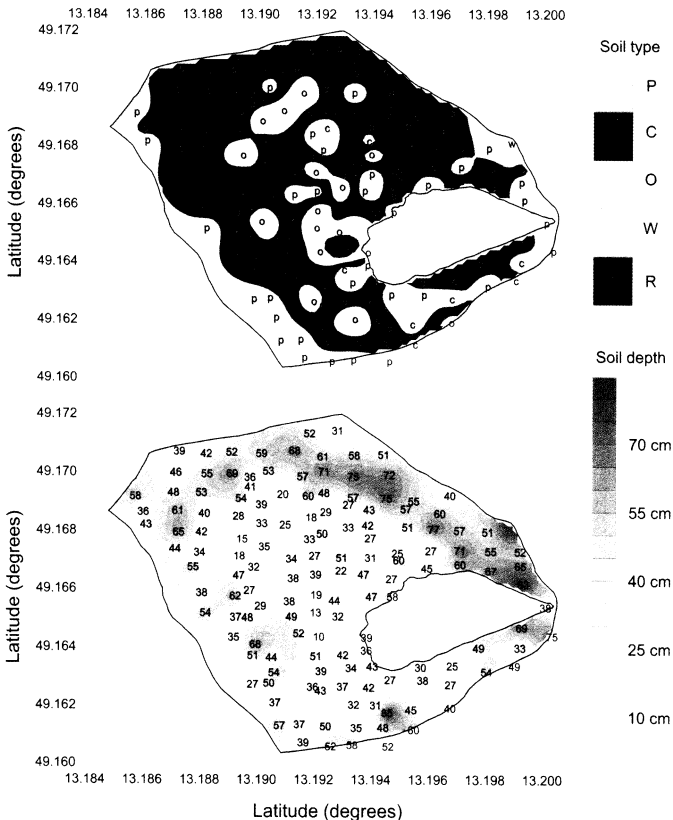
(iii) Biochemical analyses were performed with the original-moist  $<5\text{-mm}$  soil fraction and included concentrations of C, N, and P in soil microbial biomass ( $C_{\text{MB}}$ ,  $N_{\text{MB}}$ , and  $P_{\text{MB}}$ , respectively), carbon mineralization rate ( $C_{\text{Min}}$ ), nitrogen mineralization rate ( $N_{\text{Min}}$ ), and potential nitrification ( $N_{\text{Nitr}}$ ). Concentrations of  $C_{\text{MB}}$ ,  $N_{\text{MB}}$ ,  $P_{\text{MB}}$ , and  $C_{\text{Min}}$  were determined in individual samples from May 2000, as well as in the mixed samples from May 2001, while  $N_{\text{Min}}$  and  $N_{\text{Nitr}}$  were determined only in the mixed samples. The mixed samples were prepared as described for  $\text{SO}_4\text{-S}$ .

All chemical and biochemical results further reported in this paper were recalculated per the DW  $<2\ \text{mm}$  soil samples. All abbreviations of soil constituents and analytical methods are summarized in Table 2.

Representative samples of bedrock were taken in May 1997 (Czech Geological Survey in Prague) in the CN watershed (2 samples of mica schist) and CT watershed (one sample of mica schist and quartzite). The samples were crushed and the size fractions between 0.125 and 0.2 mm were used for analyses of total contents of P, S, Ca, Mg, Na, K, Si, Al, Fe, Mn, and Ti with the same method as in the soil.

The physical, chemical, and biochemical characteristics of soils in the Plešné Lake (PL) watershed, used for comparison in this study, come from KOPÁČEK et al. (2002 – this issue).

### Longitude (degrees)



**Fig. 2.** Soil map of the Čertovo Lake watershed with the areas of dominant occurrence of soil types (upper panel) and soil depths (lower panel). The abbreviations in upper panel refer to podzol (p), spodo-dystric cambisol (c), undeveloped organic rich soil (o), wetland (w), and rocks (r) and are situated in the 75 by 75 m grid. Numbers in lower panel represent the maximum soil depth in each node of grid.

## Regionalization of soil properties

The vertical heterogeneity of soil properties within a soil profile was 'homogenized' to provide one set of soil parameters for each pit as described by KOPÁČEK et al. (2002 – this issue).

In the CT watershed, the watershed weighted mean (WWM) soil parameters were obtained by their weighting according to their spatial coverage in the watershed as described by KOPÁČEK et al. (2002 – this issue), assuming 3 dominant types of soil cover (podzols, spodo-dystric cambisol, and undeveloped organic soils with only O and A horizons covering the rocks).

In the CN watershed, the watershed weighted soil parameters were calculated from the following equation:

$$C_{WWM} = M_{GM} / A_{GM} \quad (1)$$

where  $C_{WWM}$  (mol.kg<sup>-1</sup>) is WWM concentration of the individual soil component and  $M_{GM}$  and  $A_{GM}$  are the geometrical means of soil component pools and amounts of the DW <2 mm soil, respectively, calculated for the CN1 to CN8 profiles.

In both watersheds, the variability in composition of individual soil horizons was evaluated by coefficients of variation of the mean. In this calculations and further in the text, the Bsv and C horizons of spodo-dystric cambisol were evaluated together as C horizons.

**Table 2.** List of abbreviations and analytical methods used in this study.

Soil constituent	Analytical method
DW	Dry weight at 105°C
LOI	Loss on ignition at 550°C
C	Total (organic) carbon
N, P, S	Total nitrogen, phosphorus, and sulfur
Ca, Mg, Na, K, Al, Fe, Mn, Ti, and Si	Total content of metals after mineralization with H <sub>2</sub> SO <sub>4</sub> , HNO <sub>3</sub> , and HF
pH <sub>H2O</sub>	pH in water; 1:5; 2.5-hour extraction
pH <sub>CaCl2</sub>	pH in 0.01M CaCl <sub>2</sub> ; 1:5; 2.5-hour extraction
BC <sub>Ex</sub>	1M NH <sub>4</sub> Cl extractable base cations (sum of Ca <sup>2+</sup> <sub>Ex</sub> , Mg <sup>2+</sup> <sub>Ex</sub> , Na <sup>+</sup> <sub>Ex</sub> , and K <sup>+</sup> <sub>Ex</sub> ).
Ca <sup>2+</sup> <sub>Ex</sub> , Mg <sup>2+</sup> <sub>Ex</sub> , Na <sup>+</sup> <sub>Ex</sub> , and K <sup>+</sup> <sub>Ex</sub>	1M NH <sub>4</sub> Cl extractable Ca <sup>2+</sup> , Mg <sup>2+</sup> , Na <sup>+</sup> , and K <sup>+</sup>
Al <sup>3+</sup> <sub>Ex</sub> and H <sup>+</sup> <sub>Ex</sub>	1M KCl extractable Al <sup>3+</sup> and H <sup>+</sup>
CEC	Cation exchange capacity: the sum of BC <sub>Ex</sub> , Al <sup>3+</sup> <sub>Ex</sub> , and H <sup>+</sup> <sub>Ex</sub> .
CEC <sub>3</sub>	Total cation exchange capacity (SANDHOFF 1954)
Fe <sub>Ox</sub> , Al <sub>Ox</sub>	Oxalate-extractable Fe and Al
P <sub>Ox</sub> , SRP <sub>Ox</sub>	Oxalate-extractable phosphorus and soluble reactive phosphorus
Fe <sub>CD</sub> , Al <sub>CD</sub>	Citrate-dithionite extractable Fe and Al
SO <sub>4</sub> -S	Water extractable sulfate (AIFEWELL 1998)
C <sub>MB</sub> , N <sub>MB</sub> , P <sub>MB</sub>	Concentrations of C, N, and P in soil microbial biomass (JENKINSON & POWLSON 1976)
C <sub>Min</sub>	Carbon mineralization rate (ŠANTRUČKOVÁ et al. 1993).
N <sub>Min</sub> , N <sub>Stn</sub>	Nitrogen mineralization rate and potential nitrification (ŠANTRUČKOVÁ et al. 2002)
CT, CN, and PL	Čertovo Lake, Černé Lake, and Plešné Lake
WWM	Watershed weighted mean
meq.kg <sup>-1</sup>	mmol(+).kg <sup>-1</sup> ; 1 equivalent is 1 mole of charge

## Physical soil characteristics

Results on soil depth and type distribution within the CT watershed are given in Table 3 and Fig. 2. The grid sampling showed that soil cover was dominated (58%) by the spodo-dystric cambisol, which was  $0.49 \pm 0.20$  m deep (average  $\pm$  standard deviation). Podzol ( $0.49 \pm 0.24$  m deep) covered 21% of the watershed and undeveloped organic rich soil (O and A horizons on the rocks) was  $0.23 \pm 0.13$  m deep and covered 17% of the watershed. Wetlands and bare rocks represented  $\sim 3\%$  and 1% of the watershed area, respectively. Similarly to the PL watershed, the real soil distribution in the CT watershed was more heterogeneous than can be deduced from Fig. 2. Sometimes there were all types of soil and different depths even in the same node of grid. In that case, the deepest core was used for the construction of Fig. 2. Consequently, the type and depth distribution given in Fig. 2 represent areas of their most probable (but not exclusive) occurrence. That is why some podzol profiles were found even in the areas with the dominant occurrence of spodo-dystric cambisol. Similarly, the total number of sites with undeveloped thin soil was higher than shown in Fig. 2 and this type of soil cover could be found in the whole watershed.

The total soil depths in the CT watershed, determined by coring in the individual nodes of the grid, varied from 0.01 to 1.15 m ( $0.45 \pm 0.22$  m) (Fig. 2). The WWM depth of individual horizons measured in the grid sampling was: O, 0.09 m; A, 0.06 m; Ae, 0.13 m; E, 0.02 m; B, 0.03 m; and C, 0.06 m. These values represent a hypothetical uniform distribution of all soil types over the whole watershed (i.e., depth of horizon not found in the individual cores was set to zero for the purpose of the calculation) and differ from the average horizon depths in the dug pits (Table 3).

Of the eleven soil profiles sampled in the CT watershed (Table 1), six were well developed podzols with the eluvial gray E horizons, and dark to rusty brown B horizons, and five were spodo-dystric cambisol in different stage of development of Ae, Bsv, and C horizons (Table 1). Especially, the Ae horizons in spodo-dystric cambisol exhibited a great variation in the content of organic matter and presence of light grains of resistant minerals, showing different stage of transition between A and E horizons (see later). Nevertheless, all the Ae horizons were well distinguishable from the C horizons, which had significantly lower content of organic matter (all samples) and exhibited signs of illuvial concentration of Fe in some of profiles. The depth of dug profiles (0.38–1.3 m, 0.65 m on average) was higher than the average depth found during the grid sampling.

The dominant contribution of spodo-dystric cambisol and podzol can be expected also in the CN watershed (based on the soil profile sampling) but their proportions were not assessed in detail by the grid sampling. Four of the eight soil profiles sampled in the CN watershed were well-developed podzols and four were spodo-dystric cambisols in different stage of development (Table 1). The depth of these profiles varied from 0.31 to 0.75 m with the average of 0.55 m.

Total amount of material in the soil profiles varied between 326 and 1708  $\text{kg}\cdot\text{m}^{-2}$  in both watersheds and was higher in CT ( $985 \pm 410$   $\text{kg}\cdot\text{m}^{-2}$ ) than in CN ( $642 \pm 215$   $\text{kg}\cdot\text{m}^{-2}$ ) watershed.

Of the total soil amount, 46–678 and 36–225  $\text{kg}\cdot\text{m}^{-2}$  were stones  $>50$  mm and 2–50 mm in diameter, respectively, and 90–600  $\text{kg}\cdot\text{m}^{-2}$  was moisture. Pools of the  $<2$ -mm DW soil fraction varied between 85 and 853  $\text{kg}\cdot\text{m}^{-2}$  with the WWM values of 225 and 143  $\text{kg}\cdot\text{m}^{-2}$  for the CT and CN watersheds, respectively. Proportions of stones, fine soil, and moisture in the dug material were similar in both watersheds, being  $50 \pm 17\%$ ,  $27 \pm 12\%$ , and  $23 \pm 9\%$ , respectively and the average homogenized LOI concentrations varied between 8% and 34% (Table 1).



**Table 3.** The percent distribution of major soil types (undeveloped organic rich soil, ORG; podzol, POD; spodo-dystric cambisol, CAM; wetland, WET; and rocks) in the Čertovo Lake watershed (Part a) and the averages and quartiles of total soil depth and depth of individual horizons (Part b). The results are based on the grid sampling in the 75 by 75 m grid. Number of observations, No.

Part (a)	Unit	Soil type					
		All types	ORG	CAM	POD	WET	ROCK
No		450	75	259	96	15	5
Watershed cover	%	100	17	58	21	3	1

Part (b)	Unit	Total	Horizons					
			O	A	Ae	E	Bs	C
No		430	427	352	257	103	97	136
Average	cm	45	9	11	22	10	13	18
Standard Dev.	cm	22	8	8	13	6	6	8
Minimum	cm	1	1	1	2	1	2	2
25%	cm	27	5	5	14	5	10	11
Median	cm	40	7	10	20	10	12	16
75%	cm	60	10	15	30	12	17	25
Maximum	cm	115	46	60	98	30	30	40

**Table 4.** Soil texture (relative distribution) in mineral horizons from podzol (CT9 and CT11) and spodo-dystric cambisol (CT10) profiles in the Čertovo Lake watershed.

Profile	Horizon	Sand (>60 $\mu\text{m}$ ), %	Silt (2–60 $\mu\text{m}$ ), %	Clay (<2 $\mu\text{m}$ ), %
CT9	E	71.3	25.9	2.8
CT9	B	52.3	43.9	3.8
CT9	C	57.2	39.1	3.7
CT10	Ae1	47.9	48.7	3.4
CT10	C	81.0	16.8	2.2
CT11	E	73.5	23.7	2.8
CT11	B <sub>h</sub>	64.5	33.6	1.9
CT11	B	70.6	27.7	1.7
CT11	C	66.4	32.1	1.4

The particle size distribution was determined in three soil profiles distributed along the elevation gradient in the subwatershed of the major tributary of Čertovo Lake (Fig. 1) and the results are given in Table 4. Fine soil was dominated by sand (48–81%) and silt (17–49%), while the clay fraction varied between 1.4 and 3.8% (~3% on average).

The soil characteristics of the CT and CN watersheds differed from the PL watershed predominantly in ~2-fold higher soil depth and pools of fine soil in the pits but the proportions of stones, moisture, fine soil, and particle size distribution were comparable despite the different bedrock.

## Chemical soil characteristics

A detailed list of chemical properties of the soil is given in Appendix 1. The WWM soil parameters and average compositions of individual horizons are summarized in Tables 5 (CN) and 6 (CT).

Similarly as in the PL watershed, concentration of organic C was the dominant parameter, affecting most of soil properties in the CT and CN watersheds. The C concentrations positively correlated with N, S, exchangeable base cations, and  $H^+_{1x}$  ( $P < 0.001$  for all relationships) and negatively with pH (Fig. 3). Highest C and N concentrations were found in the O horizons (37–45 and 1.4–1.8 mol.kg<sup>-1</sup>, respectively) and lowest in the C horizons (1–4 mol.kg<sup>-1</sup> of C and 0.02–0.17 mol.kg<sup>-1</sup> of N). In spodo-dystric cambisol, the C and N concentrations decreased with depth (Tables 5 and 6). Despite the lower WWM concentration of C in the CT watershed, the WWM pool of C was higher in the CT than CN watershed due to bigger pool of soil (1350 vs. 1120 mol.m<sup>-2</sup>; i.e., 162 vs. 134 t.ha<sup>-1</sup>, respectively). The respective WWM pools of N were 59 and 50 mol.m<sup>-2</sup> (i.e., 8.2 and 7 t.ha<sup>-1</sup>). Both the C and N pools were significantly larger in the CN and CT than in PL watershed.

The C:N ratios in the CT and CN forest floor (O horizons) varied from 23 to 28 and were slightly lower than in the PL watershed (averages 26±2 vs. 29±2). The C:N ratios were comparable in the A horizons of CT and CN soils (24±6) and similarly to the PL soils they decreased with the decreasing concentrations of organic carbon (Fig. 3h). The WWM C:N ratios of the whole soil profiles were slightly lower in the CT (23) and CN (22) watersheds than in the PL watershed (24) suggesting a higher risk of the elevated NO<sub>3</sub> leaching (e.g. GUNDERSEN et al. 1998). In concordance, the ability of CT and CN watersheds to assimilate atmospherically deposited N was lower than in the PL watershed (KOPÁČEK et al. 2001a,b,c). Among the watersheds of Bohemian Forest lakes, the highest stage of nitrogen saturation was observed in the CN watershed with the lowest C:N ratios and all-year-round highest NO<sub>3</sub> concentrations in the streams, which exceeded ~60 μmol.l<sup>-1</sup> even in the growing season (KOPÁČEK et al. 2001b).

The highest S concentrations were found in the O horizons (50–81 mmol.kg<sup>-1</sup>) and lowest (one order of magnitude lower) in the C horizons with the S concentrations comparable to the bedrock composition (Table 5). Despite the highest S concentrations in the O horizons, the highest S pools (>50% of total S pool) were associated with the A and Ae horizons. The WWM pools of S were 2.8 and 2.6 mol.m<sup>-2</sup> (i.e., 0.90 and 0.83 t.ha<sup>-1</sup>), respectively, in the CT and CN watersheds. The tight correlation between C and S (Fig. 3b) implicated the dominance of organically bound S in the total S pool in the soils, which is a common feature of forest soils even in areas exposed to the elevated atmospheric deposition of sulfate (e.g., JOHNSON & LINDBERG 1992).

Concentrations of water extractable SO<sub>4</sub>-S were two orders of magnitude lower than total S, being highest in the A horizons (0.7–0.8 mmol.kg<sup>-1</sup>), lowest in E horizons (0.2–0.4 mmol.kg<sup>-1</sup>), and elevated again in the B horizons (0.5–0.6 mmol.kg<sup>-1</sup>). The percent contribution of SO<sub>4</sub>-S to the total S pool increased with depth. It was lowest (<2%) in the A horizons (despite the highest SO<sub>4</sub>-S concentrations) and increased up to 9% in the B and 12% in the C horizons, which was significantly more than in the PL soils (maximum up to 4%). This pattern was probably associated with sulfate immobilization in soil by adsorption onto hydrous oxides and sesquioxides in the horizons with the illuvial Fe and Al (see later).

In May 2000, the SO<sub>4</sub>-S concentrations determined in both mixed samples and integrated soils from the grid sampling were mostly well comparable (Table 6), suggesting reasonable precision of sample preparation and analytical technique. However, the SO<sub>4</sub>-S results were significantly lower in May 2001, especially in the upper mineral horizons, with the respective

concentrations of 0.24, 0.24, and 0.60 mmol.kg<sup>-1</sup> in the A, Ae, and B horizons of CT soils and 0.43, 0.47, and 0.45 mmol.kg<sup>-1</sup> in the A, Ae, and B horizons of CN soils. These changes in SO<sub>4</sub>-S concentrations represented 40 and 15 mmol.m<sup>-2</sup>.yr<sup>-1</sup> decrease in the soil SO<sub>4</sub>-S pools in the CT and CN watersheds, respectively. Similar results were obtained by mass budget of sulfate fluxes within these watersheds in the 2000 hydrological year, which showed that the CT and CN soils were net sources of 40 and 45 mmol.m<sup>-2</sup>.yr<sup>-1</sup> of sulfate (KOPACEK et al. 2001a,b). Similar rapid decline in sulfate concentrations in the uppermost soil horizons was also observed in whole-watershed experiment with the exclusion of S deposition (GIESLER et al. 1998).

Based on the present amount of water extractable SO<sub>4</sub>-S in the CT and CN soils (~100 mmol.m<sup>-2</sup>), we estimate that a similar level of leaching would only continue for the next ~3 years. However, the SO<sub>4</sub>-S leaching rate may gradually decrease and S removal may last longer. Moreover, the soil SO<sub>4</sub>-S pool is also supplied by mineralization of organic S (NOVAK et al. 1996; TORSSANDER & MÖRTH 1998), as well as from sources of inorganic S (e.g., Al-SO<sub>4</sub> complexes; NORDSTROM 1982), which could substantially prolong the process of sulfate wash out from the CT and CN soils to more than three decades (KOPACEK et al. 2001d).

Concentrations of total P decreased along the depth profile with the averages of 34±3 and 16±4 mmol.kg<sup>-1</sup> in the O and C horizons, respectively (Table 6). In podzol, the lowest P concentrations (8–17 mmol.kg<sup>-1</sup>) were in the E horizons. The WWM pools of P were 5.4 and 3.4 mol.m<sup>-2</sup> (i.e., 1.7 and 1.1 t.ha<sup>-1</sup>), respectively, in the CT and CN watersheds, with the dominant storage in B and Ae horizons in podzol and spodo-dystric cambisol, respectively. These P pools were ~2-3-fold higher than the soil P pool of PL watershed.

Relationship between C and P (Fig. 3c) was weaker than that between C and N (or S) due to the high contribution of inorganic P forms (SRP<sub>ox</sub>) to the total P pool (SRP<sub>ox</sub>:P ratio) especially in the B horizons, rich in illuvial Fe and Al. Their concentrations were quantified as the oxalate and citrate-dithionite extractable Al and Fe (Table 5 and 6) and showed the following patterns.

The Al<sub>ox</sub> and Al<sub>cd</sub> concentrations were well comparable (Al<sub>cd</sub> = 1.06×Al<sub>ox</sub>; r = 0.98) for all the samples taken in the CT and CN watersheds (Appendix 1). Concentrations of Al<sub>ox</sub> were lowest in the O and E horizons (averages between 40 and 50 mmol.kg<sup>-1</sup>) and were 2 to 10-fold higher in the other horizons (Tables 5 and 6). These values were well comparable to the PL watershed. Of the total Al concentrations the Al<sub>ox</sub> and Al<sub>cd</sub> represented 10–34% and 4–20% in the O and A horizons, respectively, were lowest (1–6%) in the E horizons, and slightly elevated (up to 11%) in the B horizons.

The Fe<sub>cd</sub> concentrations were consistently 40% higher than Fe<sub>ox</sub> (Fe<sub>cd</sub> = 1.40×Fe<sub>ox</sub>; r = 0.95) due to the redox conditions during citrate-dithionite extraction, and this difference was nearly twofold higher than in the PL soils. Similarly to Al<sub>ox</sub>, the Fe<sub>cd</sub> concentrations were lowest in the O horizons (1–105 mmol.kg<sup>-1</sup>) and highest (up to 862 mmol.kg<sup>-1</sup>) in the B and C horizons (Appendix 1). Concentrations of Fe<sub>cd</sub> in the CT and CN soils were comparable only in the A and Ae horizons, but the lower horizons had 2 to 3-fold higher Fe<sub>cd</sub> in the CN than CT soils (Table 5 and 6). But even the CT soils had 4-fold higher WWM Fe<sub>cd</sub> concentrations than the PL soils (350 vs. 83 mmol.kg<sup>-1</sup>). The citrate-dithionite extraction liberated on average 56% of total Fe in the samples in the CT and CN soils regardless the soil horizon (Fe<sub>cd</sub> = 0.56×Fe; r = 0.91).

In agreement with the distribution of Al<sub>ox</sub> and Fe<sub>cd</sub> in the soil horizons, the SRP<sub>ox</sub>:P ratios were lowest in the E, O and A horizons and highest (up to 0.8) in the B and C horizons (Fig. 3d). Similarly, the SRP<sub>ox</sub>:P<sub>ox</sub> ratios increased with concentrations of Al and Fe oxides and were highest (up to 1) in the B and C horizons. Consequently, the P concentrations depended on concentrations of both Al and Fe oxides and organic C. But the individual relationships

**Table 5.** Average chemical properties of soil profiles in the Černé Lake watershed. Abbreviations refer to: WWM, watershed weighted mean; AVG, arithmetical mean; SD, standard deviation; No, number of observations; and n, not determined. Columns represent: WWM concentrations for the Černé Lake watershed (CN), and average composition of individual soil horizons ( $C_p$ ,  $C_v$ ,  $C_w$ ,  $C_s$ ,  $C_b$ , and  $C_c$ ), and bedrock ( $C_{BED}$ ).

Unit	CN WWM	$C_p$ AVG±SD	$C_v$ AVG±SD	$C_w$ AVG±SD	$C_s$ AVG±SD	$C_b$ AVG±SD	$C_c$ AVG±SD	$C_{BED}$	
No	8	8	8	3	5	8	6	2	
Depth	cm	53	4±1	12±7	21±21	9±8	19±16	11±5	n
Soil	kg.m <sup>-2</sup>	143	4±2	23±17	53±34	27±21	35±60	45±42	n
LOI	%	19.5	88±4	57±22	17±5	12±3	15±6	7±3	n
C	mol.kg <sup>-1</sup>	7.8	41±3	26±11	7.0±2.4	5.3±1.6	5.1±1.6	2.4±1.4	n
N	mmol.kg <sup>-1</sup>	351	1561±102	1037±262	409±107	234±67	230±71	95±62	n
P	mmol.kg <sup>-1</sup>	23.9	34±3	30±6	28±10	15±2	25±8	23±19	10.9
S	mmol.kg <sup>-1</sup>	18.1	65±7	50±12	18±5	11±3	13±5	8±4	6.3
Ca	mmol.kg <sup>-1</sup>	24.1	47±9	31±6	32±13	28±28	28±23	29±22	65
Mg	mmol.kg <sup>-1</sup>	173.4	30±10	64±42	188±97	69±13	192±72	287±93	530
K	mmol.kg <sup>-1</sup>	617	71±28	327±211	650±98	657±185	628±99	744±90	833
Na	mmol.kg <sup>-1</sup>	244	39±18	158±130	322±140	303±166	273±144	301±155	493
Si	mol.kg <sup>-1</sup>	9.1	1.4±0.5	5.2±2.5	9.6±0.6	10.9±0.8	9.6±1.2	10.4±0.5	10.5
Al	mol.kg <sup>-1</sup>	2.7	0.3±0.1	1.4±0.8	2.7±0.3	2.8±0.6	2.9±0.3	3.2±0.2	3.6
Fe	mmol.kg <sup>-1</sup>	678	106±45	256±160	728±172	344±50	949±181	930±91	864
Mn	mmol.kg <sup>-1</sup>	4.7	2.0±0.6	1.8±1.0	4.4±1.5	2.8±0.1	5.0±1.4	7.2±1.7	8.3
Ti	mmol.kg <sup>-1</sup>	95	15±5	52±33	97±12	104±20	112±20	107±11	107
Ca <sup>2+</sup> <sub>Ex</sub>	meq.kg <sup>-1</sup>	7.3	85±17	35±32	3.5±0.9	4.4±2.5	3.1±0.8	2.5±0.8	n
Mg <sup>2+</sup> <sub>Ex</sub>	meq.kg <sup>-1</sup>	3.2	20±2	11±6	2.8±1.0	1.7±0.8	1.8±0.6	1.2±0.4	n
Na <sup>+</sup> <sub>Ex</sub>	meq.kg <sup>-1</sup>	1.2	2.6±1.1	3.2±2.9	0.9±0.3	1.2±0.8	1.1±0.6	1.0±0.7	n
K <sup>+</sup> <sub>Ex</sub>	meq.kg <sup>-1</sup>	2.7	16±3	7.7±2.2	2.4±0.6	1.9±0.5	1.6±0.3	1.1±0.3	n
Al <sup>3+</sup> <sub>Ex</sub>	meq.kg <sup>-1</sup>	67.5	38±21	93±22	78±15	38±14	75±23	58±14	n
H <sup>+</sup> <sub>Ex</sub>	meq.kg <sup>-1</sup>	41.5	88±11	100±25	43±20	36±11	49±33	16±9	n
SRP <sub>Ex</sub>	mmol.kg <sup>-1</sup>	6.8	4.5±0.8	4.2±2.2	8.0±2.6	2.3±0.6	8.9±2.5	10.4±8.9	n
P <sub>Ex</sub>	mmol.kg <sup>-1</sup>	11.1	7.7±1.5	10.7±6.7	16±8	5.6±1.3	14±7	14±17	n
Al <sub>Ex</sub>	mmol.kg <sup>-1</sup>	125	47±18	92±26	139±52	42±21	171±49	169±52	n
Fe <sub>CD</sub>	mmol.kg <sup>-1</sup>	356	50±36	131±89	385±153	223±76	614±187	455±109	n
pH <sub>CaCl2</sub>		3.25	2.9±0.1	2.8±0.2	3.4±0.1	3.1±0.1	3.4±0.3	3.9±0.1	n
pH <sub>H2O</sub>		3.85	3.6±0.2	3.4±0.2	4.0±0.2	3.7±0.1	4.0±0.3	4.3±0.2	n
SO <sub>4</sub> <sup>2-</sup> <sub>S<sup>1</sup></sub>	mmol.kg <sup>-1</sup>	n	n	0.82	0.48	0.39	0.61	0.69	n
C <sub>MB</sub>	mmol.kg <sup>-1</sup>	n	n	175±39	48±20	37±15	25±14	16±13	n
N <sub>MB</sub>	mmol.kg <sup>-1</sup>	n	n	28±8	8.4±4.9	6.4±3.2	3.9±2.2	2.1±1.4	n
P <sub>MB</sub>	mmol.kg <sup>-1</sup>	n	n	2.4±1.2	0.5±0.2	0.6±0.5	0.5±0.3	0.2±0.2	n
C <sub>Min</sub>	mmol.kg <sup>-1</sup> .d <sup>-1</sup>	n	35±14	9.1±2.7	2.4±0.9	0.9±0.6	1.4±0.5	0.5±0.5	n
N <sub>Min</sub> <sup>2</sup>	mmol.kg <sup>-1</sup> .d <sup>-1</sup>	n	0.44	0.05	0.01	0.01	n	n	n
N <sub>Min</sub> <sup>2</sup>	mmol.kg <sup>-1</sup> .d <sup>-1</sup>	n	0.24	0.14	0.05	0.03	n	n	n

<sup>1</sup>)Data on the mixed samples from 2000.

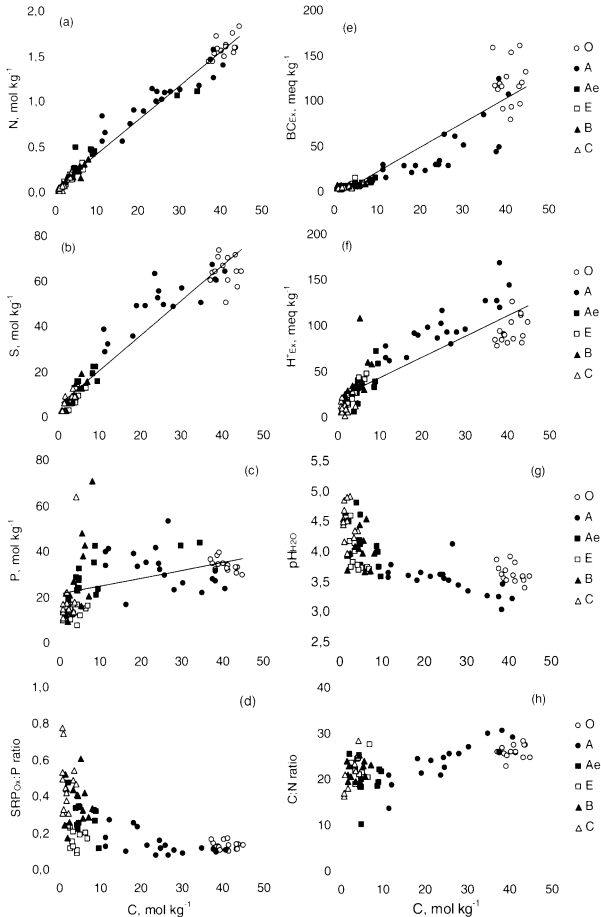
<sup>2</sup>)Data on the mixed samples from 2001.

**Table 6.** Average chemical properties of soil profiles in the Čertovo Lake watershed. Abbreviations refer to: WWM, watershed weighted mean; AVG, arithmetical mean; SD, standard deviation; MS, mica schist; Q, quartzite; No, number of observations; and n, not determined. Columns represent: WWM concentrations for the Čertovo Lake watershed (CT), and average composition of individual soil horizons ( $C_{0A}$ ,  $C_{1A}$ ,  $C_{2A}$ ,  $C_{3A}$ ,  $C_{4A}$ ,  $C_{5A}$ , and  $C_{6A}$ ), and bedrock ( $C_{BRD}$ ).

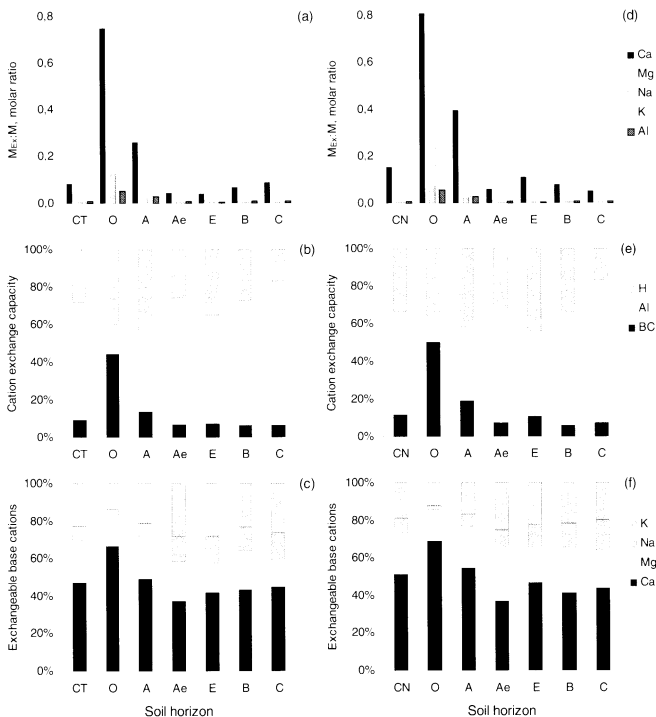
Unit		CT	$C_{0A}$	$C_{1A}$	$C_{2A}$	$C_{3A}$	$C_{4A}$	$C_{5A}$	$C_{6A}$	$C_{BRD}$	Q
WWM		AVG±SD	AVG±SD	AVG±SD	AVG±SD	AVG±SD	AVG±SD	AVG±SD	AVG±SD	MS	
No		11	8	11	9	6	9	6	1	1	
Depth	cm	65	5±1	10±7	24±33	17±9	20±15	22±20	n	n	
Soil	kg.m <sup>-2</sup>	225	4±2	24±12	159±265	81±63	80±67	184±297	n	n	
LOI	%	15.2	88±4	57±19	26±24	8±2	10±6	5±2	n	n	
C	mol.kg <sup>-1</sup>	6.0	41±2	26±9	12±12	3.3±0.7	3.6±2.5	1.4±0.6	n	n	
N	mmol.kg <sup>-1</sup>	261	1603±124	1028±311	450±382	143±40	151±101	54±23	n	n	
P	mmol.kg <sup>-1</sup>	24.0	34±3	34±10	31±9	13±3	28±21	16±4	12.7	5.6	
S	mmol.kg <sup>-1</sup>	12.5	65±8	50±12	13±5	6±2	5±4	3.2±0.1	12.6	6.3	
Ca	mmol.kg <sup>-1</sup>	28.0	50±13	30±10	33±19	32±19	22±17	18±12	52	11	
Mg	mmol.kg <sup>-1</sup>	146.2	28±11	56±44	146±106	67±26	108±88	172±122	454	104	
K	mmol.kg <sup>-1</sup>	442	61±21	242±118	386±163	542±103	474±126	477±127	537	191	
Na	mmol.kg <sup>-1</sup>	201	31±14	139±92	252±135	266±126	236±109	228±96	553	22	
Si	mol.kg <sup>-1</sup>	10.2	1.5±0.4	5.6±1.8	10.3±0.9	11.8±0.9	11.6±1.4	11.9±0.8	12.0	15.4	
Al	mol.kg <sup>-1</sup>	2.4	0.3±0.1	1.5±0.8	2.7±0.5	2.7±0.5	2.6±0.5	2.6±0.6	2.49	0.53	
Fe	mmol.kg <sup>-1</sup>	617	102±38	241±141	596±331	206±88	595±306	637±169	869	207	
Mn	mmol.kg <sup>-1</sup>	4.6	3.2±1.6	3.6±3.7	4.0±2.1	5.5±6.4	4.4±1.4	5.1±2.0	7.1	3.1	
Ti	mmol.kg <sup>-1</sup>	80	13±3	51±25	82±7	102±26	98±24	75±21	83	9	
Ca <sup>2+</sup> <sub>Ex</sub>	meq.kg <sup>-1</sup>	4.6	75±21	20±14	3.0±2.4	2.3±0.7	2.9±1.3	2.1±0.4	n	n	
Mg <sup>2+</sup> <sub>Ex</sub>	meq.kg <sup>-1</sup>	1.9	19±8	7.9±3.6	1.8±1.0	1.0±0.4	1.5±1.0	0.7±0.2	n	n	
Na <sup>+</sup> <sub>Ex</sub>	meq.kg <sup>-1</sup>	1.0	4.5±4.1	2.9±4.3	0.7±0.3	0.8±0.4	1.0±0.6	0.7±0.2	n	n	
K <sup>+</sup> <sub>Ex</sub>	meq.kg <sup>-1</sup>	2.2	16±8	6.8±2.5	2.1±1.0	1.4±0.4	1.6±0.6	1.4±0.3	n	n	
Al <sup>3+</sup> <sub>Ex</sub>	meq.kg <sup>-1</sup>	64.7	45±28	115±49	70±21	44±21	74±33	44±14	n	n	
H <sup>+</sup> <sub>Ex</sub>	meq.kg <sup>-1</sup>	29.4	99±15	100±31	27±16	21±5	28±14	10±6	n	n	
SRP <sub>Ex</sub>	mmol.kg <sup>-1</sup>	8.0	4.6±0.9	4.9±3.1	8.6±2.7	2.2±1.0	10.5±7.4	8.2±3.8	n	n	
P <sub>0A</sub>	mmol.kg <sup>-1</sup>	13.2	8.1±2.0	11.2±6.9	15±4	5.2±2.2	16±10	9.5±3.5	n	n	
Al <sub>0A</sub>	mmol.kg <sup>-1</sup>	145	53±35	126±75	401±411	50±17	136±101	194±76	n	n	
Fe <sub>CD</sub>	mmol.kg <sup>-1</sup>	350	17±14	114±83	364±232	75±54	337±270	278±106	n	n	
pH <sub>CaCl2</sub>		3.47	3.0±0.2	2.9±0.3	3.8±0.5	3.4±0.2	3.6±0.3	4.1±0.3	n	n	
pH <sub>H2O</sub>		4.02	3.6±0.1	3.6±0.2	4.3±0.5	4.1±0.3	4.2±0.3	4.7±0.3	n	n	
SO <sub>4</sub> <sup>2-</sup>	mmol.kg <sup>-1</sup>	n	n	0.68 (0.66)	0.48 (0.50)	0.24 (0.24)	0.50 (0.53)	0.38 (0.61)	n	n	
C <sub>MB</sub>	mmol.kg <sup>-1</sup>	n	n	102±16	25±21	13±4	12±8	4.1±1.3	n	n	
N <sub>MB</sub>	mmol.kg <sup>-1</sup>	n	n	29±7	6.4±5.4	4.3±1.7	1.8±1.4	0.6±0.4	n	n	
P <sub>MB</sub>	mmol.kg <sup>-1</sup>	n	n	2.8±0.9	0.6±0.6	0.2±0.1	0.1±0.1	0.05±0.04	n	n	
C <sub>Min</sub>	mmol.kg <sup>-1</sup> .d <sup>-1</sup>	n	33±13	8.5±2.3	1.7±1.1	1.1±0.3	1.2±1.0	0.5±0.1	n	n	
N <sub>Min</sub> <sup>2-</sup>	mmol.kg <sup>-1</sup> .d <sup>-1</sup>	n	0.36 (0.27)	0.03 (0.03)	0.00 (0.00)	0.01 (0.02)	0.02 (0.00)	(0.00)	n	n	
N <sub>Min</sub> <sup>2-</sup>	mmol.kg <sup>-1</sup> .d <sup>-1</sup>	n	0.15 (0.13)	0.09 (0.07)	0.04 (0.02)	0.02 (0.01)	0.01 (0.00)	(0.01)	n	n	

<sup>1</sup>Data on the mixed samples from 2000; in brackets – integrated samples from the grid sampling.

<sup>2</sup>Data on the mixed samples from 2001; in brackets – integrated samples from the grid sampling.



**Fig. 3.** Relationship between carbon concentration and selected soil characteristics in the soil horizons of Čertovo and Černé Lake watersheds. Solid lines represent linear regressions between the variables: (a),  $y = 0.037x + 0.047$ ,  $r = 0.99$ ; (b),  $y = 1.5x + 4.9$ ,  $r = 0.96$ ; (c),  $y = 0.34x + 21$ ,  $r = 0.44$ ; (e),  $y = 2.7x - 6.0$ ,  $r = 0.92$ ; (f),  $y = 2.2x + 22$ ,  $r = 0.87$ .



**Fig. 4.** Exchangeable cations in the soil horizons of the Čertovo (left column) and Černé (right column) Lake watersheds: (a) and (d) molar ratio of exchangeable metals to their total content in soil ( $M_{Ex}:M$ ); (b) and (e) relative contribution of exchangeable  $H^+$ ,  $Al^{3+}$ , and base cations to the cation exchange capacity; and (c) and (f) relative contribution of exchangeable  $K^+$ ,  $Na^+$ ,  $Mg^{2+}$ , and  $Ca^{2+}$  to the pool of exchangeable base cations. The columns CT and CN represent watershed weighted mean values in the Čertovo and Černé Lake watersheds, respectively.

differed from that observed in the PL watershed in two following aspects. (i) The relationship between P and the sum of  $Al_{Ox} + Fe_{CD}$  was highly significant ( $P < 0.001$ ) not only in the E, B, and C horizons (as observed in the PL watershed) but also in the A horizon. (ii) While there was an expectedly positive correlation between P and C concentrations in the O and A horizons of PL soils ( $P < 0.01$ ), it was surprisingly negative in both O ( $P < 0.01$ ) and A ( $P < 0.01$ ) horizons in the CT and CN watersheds. In the E, B, and C horizons, the P vs. C relationship was already positive ( $P < 0.001$ ), similarly to the PL soils.

Another difference in the P chemistry of soils covering mica schist (CT and CN) and granite (PL) is evident from the higher WWM concentrations of P in the CT and/or CN than in PL soils (24 vs. 20 mmol.kg<sup>-1</sup>) despite (i) the lower P content in the mica schist compared to granite (11–13 vs. 37 mmol.kg<sup>-1</sup>) and (ii) significantly lower ability of mica schist to liberate P under acidic conditions (KOPÁČEK et al. 1998). The above data show that the P concentrations in the CT and CN soils were higher than in their bedrock, suggesting net P accumulation in these soils. In contrast, P concentrations in the PL soils were lower than in their bedrock, implying the net terrestrial P export. These patterns are in good agreement with the observed terrestrial losses of P via the lake tributaries, which were 1.03, 0.15, and 0.15 mmol.m<sup>-2</sup>.yr<sup>-1</sup> in the PL, CT, and CN watersheds, respectively, in the 2000 hydrological year (KOPÁČEK et al. 2001a,b,c). Hence, the higher P accumulation in the CT and CN mineral soils was probably associated with significantly higher concentrations of Fe oxides than in the PL soils. However, the available data do not explain the differences in the P chemistry in the forest floor. Particularly they do not explain why the C to P relationship was positive in the PL soils and negative in the CT and CN soils. This pattern may be associated with the litter composition and its decomposition rate. Differences in potential C and N mineralization rates in the O horizons, that were observed among the watersheds (see below), support this hypothesis.

Total concentrations of mineral constituents in the C horizons of CN watershed were roughly comparable with the bedrock composition for Na, K, Si, Al, Fe, Mn, and Ti, while the Ca, and Mg concentrations in soil were lower (Table 5). In contrast, the average concentrations of all mineral soil constituents of the C horizons were lower (except for Si, which was higher) in the CT watershed than in the CN watershed (compare data in Tables 5 and 6). Also, the variability in the mineral composition of the C horizons was higher in the CT than CN watershed. There were only minor differences (except for higher S and lower K content) in the mica schist composition in the CT and CN watersheds (Tables 5 and 6). A probable explanation of the observed differences in soil composition is that they originate in the higher contribution of siliceous rocks (quartzite) to the bedrock composition of CT watershed, while the CN watersheds is predominantly underlined by mica-schist (VESELY 1994).

The Ca concentrations followed a different pattern than the other base cations along the depth gradient of soil profiles. While concentrations of Mg, Na, and K generally increased from organic to mineral horizons, the Ca concentrations were highest in the O horizons (35–71 mmol.kg<sup>-1</sup>) and lowest in the C horizons (18±12 and 29±22 mmol.kg<sup>-1</sup> in the CT and CN watersheds, respectively). This difference resulted predominantly from high concentrations of Ca<sup>2+</sup><sub>Ex</sub> in organic rich horizons. The molar ratio of exchangeable metals to their total content in soil (M<sub>Ex</sub>:M) was by far highest for Ca in all horizons, reaching maximum of ~0.8 in the O horizons and decreasing with concentrations of organic matter to values <0.1 in the mineral horizons (Fig. 4a,d). The M<sub>Ex</sub>:M ratio of other base cations and aluminum were substantially lower than Ca<sub>Ex</sub>:Ca in all horizons and were (with the exception of the O horizons) <0.03. Despite ~6-fold higher Ca content and ~5-fold lower Mg content in the PL bedrock (granite) than in mica schist in the CN watershed, soil concentrations of Ca<sup>2+</sup><sub>Ex</sub> and Mg<sup>2+</sup><sub>Ex</sub> differed only slightly. Concentrations of Ca<sup>2+</sup><sub>Ex</sub> were only 10–20% higher and Mg<sup>2+</sup><sub>Ex</sub> concentrations ~20% lower in the O horizons of the PL than in CT and CN soils and were well comparable in the deeper horizons.

Cation exchange capacity expectedly decreased along the soil profile with decreasing C content (Tables 5 and 6) due to the tight relationships between C and concentrations of exchangeable base cations (Fig. 3e) and protons (Fig. 3f). However, while the CEC of the O and A horizons (206–282 and 154–415 meq.kg<sup>-1</sup>, respectively) was dominated by protons and base cations, Al<sup>3+</sup><sub>Ex</sub> represented the principal proportion (60–75%) of CEC in the Ae, B, and



C horizons (Fig. 4b,e). Total cation exchange capacity was determined in 11 samples representing all mineral horizons in the CN watershed and 5 integrated samples from the grid sampling in the CT watershed (Appendix 1). The  $CEC_T$  concentrations were up to 4-fold higher than CEC, but there was a linear relationship between them ( $CEC = 42 + 0.23 \times CEC_T$ ;  $r = 0.98$ ). This relationship was comparable with that observed for the PL soils. The  $CEC_T$  could be considered as the uppermost limit of soil exchangeable capacity, not accessible under natural conditions due to high pH and unrealistically high degree of organic acids dissociation during the determination. Consequently, the very high  $CEC_T$  to CEC ratios highlighted the dominant role of organic matter in the soil sorption characteristics of the samples studied.

The CEC values represented a more realistic estimate of the real soil exchangeable capacity at ambient conditions because of the not-buffered pH of extraction solutions. There were only negligible differences between CEC concentrations in the individual soil horizons of the CT, CN, and PL watersheds, as well as in their base saturation, with the two following exceptions: (i) The highest average base saturation was in the O horizons of CN soils (50% vs. 44% and 43% in the CT and PL watersheds, respectively), and (ii) the CT soils had a lower average base saturation of the A horizon (14%) than the two other watersheds (19%). The WWM values of CEC were slightly lower in CT than in CN soils (104 vs. 123  $meq.kg^{-1}$ ), as well as the WWM base saturation (9% vs. 15%) and  $H^+_{Ex}$  (28% vs. 34%). In contrast, the CEC of CT soils was more saturated with  $Al^{3+}_{Ex}$  (62% vs. 55%). The WWM base saturation of CT and CN soils was primarily (~50%) based on  $Ca^{2+}_{Ex}$  and the contribution of  $Mg^{2+}_{Ex}$  and  $K^+_{Ex}$  was roughly equal (~20%) (Fig. 4c,d). In the individual soil horizons, the relative  $Ca^{2+}_{Ex}$  contribution to total  $BC_{Ex}$  pool decreased, while that of  $Na^+_{Ex}$  increased from the O (~2%) to C (~15%) horizons. However, these changes in the relative  $BC_{Ex}$  composition along the CT and CN soil profiles were substantially less pronounced than in the PL watershed (Fig. 4 in KOPÁČEK et al. 2002 – this issue).

The  $pH_{CaCl_2}$  values exhibited a similar pattern along the depth profiles of all soils, being 2.7–3.3 in O horizons, lower in A horizons (2.5–3.3), and increasing with depth to their maxima in C horizons (3.6–4.5). The  $pH_{H_2O}$  profiles were comparable to  $pH_{CaCl_2}$  but were ~0.6 unit higher (Tables 5 and 6). The WWM  $pH_{CaCl_2}$  values, as well as  $pH_{CaCl_2}$  in the mineral soil profiles were ~0.2 unit higher in CT than in CN soils probably due to lower C and  $H^+_{Ex}$  concentrations (Tables 5 and 6).

### Biochemical soil characteristics

A complete set of biochemical analyses was not performed on all soils samples (Appendix 1). Hence, the biochemical parameters were not regionalized in the same way as the chemical data. Instead, arithmetical means and standard deviations were calculated for concentrations of  $C_{MB}$ ,  $N_{MB}$ ,  $P_{MB}$ , and  $C_{Min}$  in the individual horizons. The  $N_{Min}$  and  $N_{Nir}$  rates were determined only in the mixed samples (Tables 5 and 6). However, even incomplete, these data provided useful information on differences in biochemical parameters between the watersheds studied.

Concentrations of C, N, and P in soil microbial biomass decreased with soil depth along with concentration of organic matter. Highest concentrations were found in the A horizons (O horizons were not analyzed), with the ranges of 79–222  $mmol.kg^{-1}$   $C_{MB}$ , 15–39  $mmol.kg^{-1}$   $N_{MB}$ , and 0.2–4  $mmol.kg^{-1}$   $P_{MB}$ . These concentrations represented 0.3–1.4%, 2–4%, and 1–15% (average 9%) of total C, N, and P concentrations, respectively. Concentrations of  $C_{MB}$  were significantly higher in the CN than CT watershed, while  $N_{MB}$  and  $P_{MB}$  concentrations were comparable (Tables 5 and 6). Consequently, ratios of  $C_{MB}:N_{MB}$  and  $C_{MB}:P_{MB}$  were lower in the CT than CN soils (e.g., 4 vs. 6 and 38 vs. 69, respectively, in the A horizons). The  $C_{Min}$  rates were highest in the O horizons (19–60  $mmol.kg^{-1}.d^{-1}$ , with comparable averages and variation coefficients in both watersheds), ~4-fold lower in A horizons and negligible in lower mineral horizons (Tables 5 and 6).

Lower C:P and C:N ratios in microbial biomass of the CT soils indicates that soil microbes accumulated the storage compounds inside the cells. It could be caused by nutrient or oxygen limitation. In such conditions microbes accumulate storage compounds and respiration exceeds biomass production. The hypothesis is supported by the comparable  $C_{\text{Min}}$  rate (i.e. respiration rate) in the CN and CT watersheds but lower accumulation of C in microbial biomass in the CT watershed.

The decrease of  $N_{\text{Min}}$  and  $N_{\text{Nitr}}$  rates with soil depth exhibited a similar pattern as  $C_{\text{Min}}$  rate in both, CT and CN soils. But the  $N_{\text{Min}}$  and  $N_{\text{Nitr}}$  rates were 50–70% higher in the O and A horizons of CN than CT soils (Tables 5 and 6).

In the PL soils, the amount of nutrients in microbial biomass, their ratios, and  $C_{\text{Min}}$  rates were comparable with the CN soil but microbial N transformation differed as follows: (i) The  $N_{\text{Min}}$  rates in the O horizons were highest in the CN watershed, while the PL soils showed the highest N mineralization rates in the A horizons with the following averages for the CN, CT, and PL soils, respectively: 0.44, 0.36, and  $0.23 \pm 0.10 \text{ mmol.kg}^{-1}.\text{d}^{-1}$  in the O horizons and 0.05, 0.03, and  $0.12 \pm 0.08 \text{ mmol.kg}^{-1}.\text{d}^{-1}$  in the A horizons. (ii) The nitrifying potential of the CN and CT soils was significantly higher than in the PL soils with the respective averages of 0.24, 0.15, and  $0.05 \pm 0.04 \text{ mmol.kg}^{-1}.\text{d}^{-1}$  in the O horizons and 0.14, 0.09, and  $0.08 \pm 0.03 \text{ mmol.kg}^{-1}.\text{d}^{-1}$  in the A horizons.

The differences in nitrogen mineralization rates and nitrifying potential of the CN, CT, and PL soils were consistent with the nitrate export and abilities of the watersheds to retain inorganic nitrogen from atmospheric deposition. The terrestrial export of nitrate was the highest in CN ( $151 \text{ mmol.m}^{-2}.\text{yr}^{-1}$ ), intermediate in the CT ( $120 \text{ mmol.m}^{-2}.\text{yr}^{-1}$ ) and the lowest in the PL ( $85 \text{ mmol.m}^{-2}.\text{yr}^{-1}$ ) watershed in the 2000 hydrological year (KOPÁČEK & al. 2001a,b,c). The percent retention of atmospherically deposited inorganic N was -28%, ~0%, and 16% in the CN, CT, and PL watersheds, respectively. The negative value of N retention in the CN watershed suggested that soil organic N pools became an important net source of nitrate. The input/output N fluxes were roughly balanced in the CT watershed, where the nitrate export roughly equaled atmospheric deposition of nitrate and ammonium on the forest floor ( $70$  and  $51 \text{ mmol.m}^{-2}.\text{yr}^{-1}$ ) in the 2000 hydrological year. The PL watershed was the only site exhibiting a net N retention in the soils.

Comparison of the major terrestrial fluxes of inorganic nitrogen with the soil microbial activity in the three watersheds is given in Table 7. The data show two following important patterns in the soil N chemistry. (i) The N mineralization rates were about one order of magnitude higher than atmospheric deposition of inorganic nitrogen. This fact, together with a high content of N in microbial biomass ( $100$ – $1200 \text{ mmol.m}^{-2}$  in A and Ae horizons) highlighted the importance of soil microbial activity in the possible explanation of the elevated terrestrial  $\text{NO}_3^-$  export. (ii) The nitrifying potential of the O and A soil horizons was higher than atmospheric deposition of  $\text{NH}_4^+$  in all watersheds and, in the case of CN watershed, even significantly higher than  $\text{NH}_4^+$  supplied by both atmospheric deposition and soil nitrogen mineralization. In concordance, only a low  $\text{NH}_4^+$  export from the watersheds was observed. Similar results have been reported also by ANDERSON et al. 2000, who demonstrated the highest rates of nitrification in the CN soils among watersheds of the Bohemian Forest lakes. The above biochemical data showed that forest ecosystem ability to retain N or to export  $\text{NO}_3^-$  corresponded not only to the C:N ratios but also to the soil potential nitrification.

In the acid soils, heterotrophic nitrification is referred to as being of the dominant importance (GUNDERSEN & RASMUSSEN 1990) because the growth of nitrifying chemoautotrophic organisms is usually restricted at  $\text{pH} < 6$  and only some acid-resistant strains may occur to  $\text{pH} 4.5$  (KENNEDY 1992). We hypothesize that the high nitrifying potential and high nitrate export from the watershed studied could be associated with heterotrophic nitrification. Consequently, a

**Table 7.** Comparison of major fluxes of inorganic nitrogen with soil microbial activity in three watersheds of the Bohemian Forest lakes. N deposition represents daily average atmospheric deposition onto the forest floor (i.e., throughfall in the forest and precipitation in the open area) and N export represents daily average N output from the watersheds via streams in the 2000 hydrological year. These data were recalculated from the annual averages given by KOPÁČEK et al. (2001a,b,c). Nitrogen mineralization ( $N_{min}$ ) and potential nitrification ( $N_{pot}$ ) in the soils were calculated from the average data on their rates in the O and A horizons and the respective watershed weighted mean pools of fine soil (Tables 5 and 6; KOPÁČEK et al. 2002 – this issue). All units are expressed in  $mmol.m^{-2}.d^{-1}$ .

	Watershed		
	Černé	Čertovo	Plešné
NO <sub>3</sub> <sup>-</sup> deposition	0.192	0.192	0.173
NH <sub>4</sub> <sup>+</sup> deposition	0.140	0.140	0.118
NO <sub>3</sub> <sup>-</sup> export from watershed	0.414	0.328	0.233
NH <sub>4</sub> <sup>+</sup> export from watershed	0.010	0.007	0.010
$N_{min}$ in O and A horizons	2.849	2.112	2.325
$N_{pot}$ in O and A horizons	4.203	2.840	1.025

contribution of heterotrophs such as fungi to oxidation of organic N to nitrate (STROO et al. 1986) should be considered in the acid Bohemian Forest soils to explain the observed differences in the potential nitrification rates and the ability of watersheds to retain N.

### Variability in the measured soil characteristics

The O horizons had the most uniform chemical and biochemical composition among the horizons sampled, with low coefficients of variation (between 4% and 91%; median of 31%). However, even in other horizons, concentrations of constituents varied in surprisingly narrow ranges with coefficients of variation only exceptionally exceeding 100% (see Tables 5 and 6 for standard deviations). Even the biochemical parameters analyzed in different years usually showed well comparable values (Table 6) and the results on  $C_{MIB}$ ,  $N_{MIB}$ ,  $P_{MIB}$ , and  $C_{Min}$  in the mixed samples, prepared in 2000 and 2001, were within the ranges given in Tables 5 and 6 for the individual samples. The highest variability in the chemistry and biochemistry was observed in Ae and B horizons of the CT soils with coefficients of variation ranging from 9% to 108% (median values of 56% and 67%, respectively).

Relatively high differences in the soil amount between the profiles resulted in a higher variability in the pools of soil chemical constituents, which was 1.5 to 4 times higher (especially in the C horizons of CT soils) than the concentration variability. This means that the sampled sites differed primarily in the pools of soil constituents and less in the soil composition, which was relatively uniform in the same horizons within the CT and CN watersheds.

### CONCLUSIONS

The soils of CT watershed are composed of ~0.5 m deep spodo-dystric cambisol (58%) and/or podzol (21%), ~0.2 m deep undeveloped organic rich soil (17%), wetlands (3%), and bare rocks (1%). Spodo-dystric cambisol and podzol dominate also the area of CN watershed.

The CT and CN soils are acid with the lowest  $pH_{CaCl_2}$  in A horizons (2.5–3.3) and highest (3.6–4.5) in C horizons. The respective WWM cation exchange capacities of the CT and CN soils (104 and 123 meq.kg<sup>-1</sup>) are dominated by exchangeable Al<sup>3+</sup> (62% and 55%), with low (9% and 15%) contribution of base cations. The C:N ratio varies between 23 and 28 in the forest floor (O horizons) and is 23 and 22 in the whole CT and CN soil profiles, respectively.

Physical soil characteristics in the CT and CN watershed differ from the PL watershed predominantly in ~2-fold higher soil depth and pools of fine soil but the proportions of stones, moisture, fine soil, and particle size distribution are comparable.

Chemical composition of the CT and CN soils differs from the PL soils relatively little, considering relatively large differences in the bedrock chemistry. For example, the ~6-fold higher Ca content and ~5-fold lower Mg content in the PL granite than in mica schist in the CN bedrock has only a limited impact on the soil concentrations of  $\text{Ca}^{2+}_{\text{Ex}}$  and  $\text{Mg}^{2+}_{\text{Ex}}$ . However, the CT and CN soils have a significantly higher concentration of Fe oxides, which increases their sulfate and P sorption capacity. Hence, the CT and CN soils have a higher  $\text{SO}_4\text{-S:S}$  ratio in mineral horizons and higher P concentrations in all horizons, despite a lower P content in bedrock. The higher net P accumulation in the soils, the lower P concentration in bedrock, and the low potential P liberation from bedrock result in lower terrestrial P losses from the CT and CN watersheds than from the PL watershed.

Biochemical characteristics of the CT and CN soils show important differences from the PL soils in N dynamics. While the  $C_{\text{MB}}$ ,  $N_{\text{MB}}$ , and  $P_{\text{MB}}$  concentrations, as well as  $C_{\text{Min}}$  rates are well comparable in the three watersheds, nitrogen microbial activity of the CT and CN soils is higher than in the PL watershed. In the forest floor of the CN, CT, and PL soils, the  $N_{\text{Min}}$  rates are 0.44, 0.36, and 0.23  $\text{mmol.kg}^{-1}.\text{d}^{-1}$ , respectively, and the nitrifying potentials are 0.24, 0.15, and 0.05  $\text{mmol.kg}^{-1}.\text{d}^{-1}$ , respectively. These results are consistent with the highest terrestrial losses of nitrate in the CN watershed and, in contrast, the highest ability of the PL watershed to retain N.

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**Appendix 1.** Chemical and biochemical properties of soil samples taken in profiles within the Černé (CN) and Čertovo (CT) watersheds in the 1997–2000 period. For abbreviations of soil horizons and soil constituents see chapter "Sampling and analyses" and Table 2. Location of soil profiles is given in Table and Fig. 1. Mixed sample from the grid sampling in CT watershed is CT-GS. All data are expressed per dry weight <2mm soil fraction. Not determined, n.

Profile	Horizon	Basic soil properties					Total concentrations												
		Depth m	Pool kg.m <sup>-1</sup>	LOI %	pH <sub>CaCl2</sub>	pH <sub>H2O</sub>	C	N	P	S	Cu	Mg	K	Na	Si	Al	Fe	Mn	Ti
		mmol.kg <sup>-1</sup>																	
CN1	O	0.05	3	95.0	2.92	3.38	43.9	1.59	33.2	57.3	50.1	18.7	34	17	0.7	0.1	38	1.7	7
CN1	A	0.10	9	82.1	2.49	3.02	38.5	1.26	26.9	60.7	40.5	26.8	130	56	2.2	0.6	117	1.5	26
CN1	E	0.20	44	12.2	3.01	3.71	5.1	0.24	12.0	9.5	16.3	77.9	823	326	10.2	3.3	404	4.4	127
CN1	B	0.21	72	12.5	3.51	4.05	4.4	0.18	23.3	9.7	16.5	181.4	649	252	9.5	3.2	1171	6.1	132
CN1	C	0.05	58	4.4	3.86	4.54	0.9	0.05	10.2	3.2	23.5	306.0	772	297	10.8	3.2	902	8.0	124
CN2	O	0.03	3	84.5	2.96	3.54	38.9	1.53	38.4	60.2	45.8	37.2	95	66	1.9	0.5	136	2.1	17
CN2	A	0.11	25	44.2	2.98	3.64	19.3	0.91	33.6	49.0	31.7	134.8	370	222	6.9	1.4	461	2.8	60
CN2	Ac	0.07	37	13.3	3.55	4.12	5.1	0.50	24.1	15.9	38.2	321.3	604	309	10.0	2.7	878	6.3	87
CN2	B <sub>sw</sub>	0.49	106	13.2	3.92	4.44	4.8	0.25	27.9	15.9	39.9	315.2	647	328	9.8	2.9	878	6.9	90
CN3	O	0.04	4	82.1	2.97	3.71	37.8	1.46	34.8	63.5	47.7	37.1	100	59	2.2	0.5	163	1.8	20
CN3	A	0.09	21	54.7	2.84	3.54	24.8	1.10	32.1	55.4	26.0	49.1	257	165	5.7	1.2	297	1.2	44
CN3	Ac	0.05	13	22.6	3.25	3.75	9.2	0.42	21.2	22.6	29.5	130.6	534	290	9.0	2.4	875	2.9	97
CN3	E	0.01	3	15.2	3.06	3.73	6.7	0.33	15.1	12.7	30.8	65.6	522	295	10.9	2.3	370	2.6	85
CN3	B	0.10	20	14.7	3.40	3.97	5.4	0.24	16.4	12.9	31.3	235.3	606	299	9.5	2.8	1129	5.1	102
CN3	C	0.04	24	10.3	3.67	4.22	3.4	0.15	13.9	9.6	32.9	266.3	679	326	10.1	3.0	958	5.5	101
CN4	A	0.10	35	35.1	2.93	3.57	11.5	0.84	39.9	38.7	18.4	89.5	604	160	7.6	2.2	455	3.0	72
CN4	Ac	0.50	71	20.5	3.40	3.99	9.0	0.47	42.6	22.5	14.7	104.4	736	176	9.4	2.7	603	3.8	90
CN4	C	0.15	24	10.7	3.90	4.34	4.3	0.15	64.0	9.6	12.8	119.2	854	191	10.2	3.1	806	4.6	106
CN5	O	0.05	6	90.6	2.73	3.57	43.3	1.75	33.1	80.8	38.5	24.0	48	35	1.1	0.3	136	1.2	18
CN5	A	0.07	8	59.9	2.66	3.43	28.2	1.10	23.2	48.7	24.1	33.5	231	60	5.5	1.0	110	0.7	42
CN5	E	0.06	40	7.8	3.15	3.83	3.3	0.14	12.3	6.3	3.6	49.9	612	101	12.3	2.3	268	1.8	101
CN5	B	0.10	83	7.5	3.33	3.97	2.5	0.12	21.0	6.3	5.4	123.1	619	85	11.4	2.4	883	3.1	103
CN5	C	0.19	135	4.6	3.81	4.45	0.8	0.02	14.4	3.2	9.0	242.7	747	107	11.3	2.9	860	7.2	96
CN6	O	0.04	4	87.4	3.02	3.90	40.4	1.56	35.0	66.5	39.9	44.9	93	41	1.6	0.3	102	2.2	13
CN6	A	0.20	23	87.6	2.58	3.20	40.8	1.40	23.8	64.3	40.6	21.5	80	56	1.5	0.4	77	0.6	11
CN6	E	0.03	5	15.5	3.02	3.71	7.0	0.25	16.4	12.7	76.1	68.0	452	557	10.6	2.5	343	2.6	85
CN6	B	0.04	31	17.4	3.06	3.67	7.3	0.31	20.7	16.0	66.0	152.8	471	503	9.9	2.6	679	4.0	102
CN6	C	0.09	37	11.0	3.82	4.34	3.7	0.17	18.2	12.8	69.4	413.9	589	515	9.8	3.2	925	8.1	92
CN7	O	0.05	8	91.6	2.90	3.52	43.6	1.59	30.4	64.1	65.5	21.4	41	21	1.1	0.2	55	3.0	9
CN7	A	0.25	57	26.5	3.04	3.64	11.6	0.56	34.0	28.8	43.9	109.2	669	443	8.4	3.0	372	3.2	118

**Appendix 1.** Chemical and biochemical properties of soil samples taken in profiles within the Černé (CN) and Certovo (CT) watersheds in the 1997–2001 period. For abbreviations of soil horizons and soil constituents see chapter "Sampling and analyses" and Table 2. Location of soil profiles is given in Table 1 and Fig. 1. Mixed sample from the grid sampling in CT watershed is CT-GS. All data are expressed per dry weight <2mm soil fraction. Not determined, n.

Profile	Horizon	Exchangeable cations										Oxalate and citrate-dithionite extracts						Biochemical properties			
		Ca <sup>2+</sup>	Mg <sup>2+</sup>	Na <sup>+</sup>	K <sup>+</sup>	Al <sup>3+</sup>	H <sup>+</sup>	CEC	CEC	SRP <sub>ox</sub>	P <sub>ox</sub>	Al <sub>ox</sub>	Al <sub>ox</sub>	Fe <sub>ox</sub>	Al <sub>ox</sub>	Fe <sub>ox</sub>	C <sub>sm</sub>	N <sub>sm</sub>	P <sub>sm</sub>	C <sub>bio</sub>	
		mmol kg <sup>-1</sup>										mmol kg <sup>-1</sup>						mmol kg <sup>-1</sup>			
CN1	O	78.3	23.4	1.9	15.6	15	88	222	n	4.6	7.4	25	12	18	78	n	n	n	51.3		
CN1	A	87.6	22.6	3.1	10.8	111	119	354	1327	2.6	4.8	90	34	91	56	222	30	3.0	11.1		
CN1	E	8.8	2.7	1.1	2.5	30	44	89	155	2.3	3.9	32	56	65	243	50	6.8	0.3	1.7		
CN1	B	4.0	1.4	1.0	1.4	109	37	154	505	9.6	13.1	192	569	226	814	23	5.4	0.2	1.5		
CN1	C	3.5	1.2	1.1	1.2	51	18	75	115	5.4	3.7	120	215	118	397	4.6	1.6	0.1	0.3		
CN2	O	79.3	21.8	2.0	15.0	50	84	252	n	4.9	8.5	60	49	28	26	n	n	n	42.3		
CN2	A	10.3	8.4	1.4	7.3	125	89	241	969	8.0	12.4	138	171	125	227	175	28	0.2	6.6		
CN2	Ae	3.3	2.9	0.7	2.1	75	32	116	350	8.2	15.4	185	307	146	367	37	6.8	0.6	1.4		
CN2	B <sub>sv</sub>	3.4	1.7	0.7	1.7	64	15	86	331	11.3	16.7	203	268	201	310	8.9	1.5	0.3	1.1		
CN3	O	82.0	17.6	2.0	14.4	64	77	257	n	5.1	10.2	77	71	69	105	n	n	n	25.3		
CN3	A	14.4	8.6	1.6	9.2	120	116	270	n	3.8	10.7	117	178	105	221	208	29	3.5	8.4		
CN3	Ae	4.7	3.9	1.0	3.0	97	72	182	n	6.9	8.7	180	509	205	580	46	7.5	0.6	2.2		
CN3	E	3.9	2.2	1.0	2.4	60	41	111	n	3.1	7.0	77	159	30	343	51	11	0.5	1.5		
CN3	B	3.4	2.9	0.8	1.8	88	109	206	n	10.0	7.8	218	564	251	715	25	3.3	0.1	1.0		
CN3	C	3.0	1.7	0.8	1.4	75	28	110	n	6.8	6.0	186	382	227	474	38	3.1	0.1	0.5		
CN4	A	12.6	8.0	1.5	7.4	68	78	175	n	7.0	19.2	79	168	74	221	166	23	2.4	7.3		
CN4	Ae	3.6	2.9	1.3	2.9	81	39	130	n	11.4	26.6	111	255	117	386	77	15	0.6	3.4		
CN4	C	2.2	0.7	0.8	1.0	67	12	84	n	30.0	51.9	194	401	242	633	0.0	0.0	0.0	0.1		
CN5	O	76.9	17.7	4.4	15.7	62	111	287	n	3.7	6.8	57	37	41	46	n	n	n	21.4		
CN5	A	41.1	8.4	2.0	8.6	73	92	225	346	2.4	5.5	59	29	63	30	158	24	2.5	12.4		
CN5	E	3.0	0.7	0.8	1.4	23	22	51	96	1.9	5.1	24	52	25	143	20	3.1	1.5	0.2		
CN5	B	2.7	1.2	0.8	1.2	42	30	78	186	5.5	9.1	99	269	141	598	15	1.4	0.7	1.4		
CN5	C	2.4	1.0	0.7	0.9	44	13	62	115	4.5	4.7	92	173	89	347	14	0.9	0.5	0.4		
CN6	O	78.9	21.7	2.6	22.2	18	81	224	n	5.7	7.2	35	26	15	20	n	n	n	51.2		
CN6	A	78.2	17.1	2.9	8.5	86	144	336	n	2.6	4.7	74	29	47	20	191	31	3.5	10.7		
CN6	E	3.6	1.5	0.6	1.6	42	48	97	n	2.8	6.7	47	93	55	197	42	6.5	0.5	0.6		
CN6	B	3.5	2.2	0.7	2.0	80	61	150	n	6.0	8.6	119	313	134	498	49	6.4	0.7	2.3		
CN6	C	3.1	1.7	0.6	1.5	77	29	112	n	9.9	7.1	251	210	236	337	29	3.8	0.4	1.5		
CN7	O	123	20.8	1.6	14.7	21	81	262	n	3.5	5.5	31	17	7	6	n	n	n	19.0		
CN7	A	6.0	4.0	10.1	3.8	77	64	166	n	4.4	21.9	104	165	70	168	93	15	0.9	4.7		

**Appendix 1.** Chemical and biochemical properties of soil samples taken in profiles within the Černé (CN) and Čertovo (CT) watersheds in the 1997–2001 period. For abbreviations of soil horizons and soil constituents see chapter “Sampling and analyses” and Table 2. Location of soil profiles is given in Table 1 and Fig. 1. Mixed sample from the grid sampling in CT watershed is CT-GS. All data are expressed per dry weight <2mm soil fraction. Not determined, n.

Profile	Horizon	Depth m	Basic soil properties					Total concentrations													
			Pool kg.m <sup>-2</sup>	LOI %	pH <sub>CaCl2</sub>	pH <sub>H2O</sub>	C mol.kg <sup>-1</sup>	N mol.kg <sup>-1</sup>	P	S	Ca mmol.kg <sup>-1</sup>	Mg mmol.kg <sup>-1</sup>	K	Na	Si mol.kg <sup>-1</sup>	Al	Fe	Mn mmol.kg <sup>-1</sup>	Ti		
CN7	Ae	0.23	88	11.9	3.56	4.17	4.7	0.26	24.0	12.7	45.2	196.1	725	513	10.2	3.2	556	4.6	114		
CN7	C	0.10	13	6.6	4.05	4.50	1.8	0.03	21.7	6.3	43.4	347.1	738	484	10.1	3.3	1091	7.6	117		
CN8	O	0.04	2	87.9	2.97	3.61	38.5	1.44	32.2	64.0	44.3	26.8	85	35	1.4	0.4	108	2.0	18		
CN8	A	0.05	10	67.2	2.70	3.33	30.4	1.13	26.3	56.6	24.8	45.0	276	100	3.8	1.2	160	1.7	45		
CN8	E	0.14	43	10.4	3.10	3.68	4.4	0.21	16.9	12.7	14.5	83.0	876	235	10.4	3.5	335	2.7	124		
CN8	B	0.19	32	24.2	3.43	3.66	5.9	0.29	38.2	19.3	7.3	142.8	779	169	7.6	3.2	955	4.5	142		
CN8	C	0.13	26	4.2	3.86	3.97	1.8	0.10	17.7	9.5	12.7	316.9	828	183	10.6	3.4	969	9.6	110		
CT1	O	0.06	4	93.7	2.99	3.58	45.0	1.83	29.8	64.2	61.8	21.5	46	28	0.8	0.1	51	2.7	11		
CT1	A	0.26	25	76.5	2.58	3.25	35.0	1.17	21.9	50.3	30.7	24.0	114	42	3.2	0.5	89	1.5	22		
CT1	E	0.14	25	10.3	3.06	3.78	4.4	0.18	7.9	6.3	21.6	47.4	510	166	12.0	2.4	126	1.8	98		
CT1	B	0.10	52	5.5	3.33	3.95	2.0	0.09	9.3	3.1	18.0	74.9	542	149	12.8	2.3	215	2.3	89		
CT1	C	0.13	12	4.1	3.58	4.17	1.1	0.02	11.1	3.1	25.2	259.9	560	149	12.1	2.3	771	4.4	88		
CT2	O	0.03	3	88.0	3.12	3.81	41.5	1.62	33.9	60.3	70.8	29.3	61	24	1.6	0.2	79	6.8	11		
CT2	A	0.04	7	55.3	2.86	3.52	26.0	1.02	29.5	49.4	41.4	47.0	221	65	5.9	1.1	267	3.7	40		
CT2	Ae	0.05	29	21.1	2.99	3.58	9.8	0.45	23.6	15.9	16.4	65.8	409	92	10.5	2.0	306	2.9	66		
CT2	Bav	0.35	202	5.0	3.56	3.94	1.9	0.09	13.6	3.1	9.0	112.4	515	81	12.8	2.1	424	4.8	68		
CT2	C	0.10	14	3.3	4.15	4.49	0.9	0.05	17.1	3.2	9.0	175.6	536	85	12.6	2.3	663	7.1	51		
CT3	O	0.05	9	89.2	2.75	3.50	41.5	1.60	31.8	70.3	38.3	23.9	52	28	1.3	0.3	129	2.4	13		
CT3	A	0.10	21	79.5	2.58	3.24	37.8	1.46	28.1	67.0	28.7	26.6	93	38	2.8	0.4	110	1.4	17		
CT3	E	0.09	48	7.1	3.23	3.75	2.8	0.12	10.2	3.1	9.0	45.0	436	91	12.9	2.2	165	2.7	71		
CT3	B	0.14	43	5.1	3.33	3.70	1.8	0.09	18.0	3.1	9.0	62.5	487	84	12.7	2.4	373	3.4	83		
CT4	O	0.05	3	87.8	3.08	3.68	39.3	1.72	34.5	70.3	53.6	23.9	71	35	1.6	0.2	75	2.9	15		
CT4	A	0.19	27	53.2	2.96	3.60	23.8	1.14	41.8	63.1	24.7	52.7	363	175	5.5	2.0	165	2.2	80		
CT4	E	0.32	83	9.4	3.39	4.00	3.6	0.19	17.0	6.3	56.0	100.4	607	421	10.9	3.3	335	5.1	133		
CT4	B	0.20	9	10.0	3.42	4.08	3.6	0.18	27.0	6.4	58.3	161.9	591	381	10.4	3.2	712	5.9	135		
CT5	O	0.06	4	81.9	3.27	3.86	37.4	1.44	36.7	60.3	57.4	53.2	105	62	2.3	0.4	163	3.6	19		
CT5	A	0.06	41	29.6	3.23	3.78	12.3	0.66	41.4	32.3	51.7	171.8	423	347	8.1	2.6	536	3.5	70		
CT5	Ae1	0.18	40	19.8	3.53	4.09	8.8	0.47	35.3	19.2	60.4	216.3	525	433	9.1	2.9	612	4.6	81		
CT5	Ae2	0.20	118	14.1	4.14	4.60	4.9	0.24	32.6	16.0	54.9	282.5	551	390	9.3	3.1	1021	6.6	85		
CT5	Ae3	0.20	37	12.2	4.42	4.80	4.2	0.17	28.7	12.8	51.3	290.3	560	384	9.7	3.3	900	6.5	84		



**Appendix 1.** Chemical and biochemical properties of soil samples taken in profiles within the Černé (CN) and Čertovo (CT) watersheds in the 1997–2001 period. For abbreviations of soil horizons and soil constituents see chapter “Sampling and analyses” and Table 2. Location of soil profiles is given in Table 1 and Fig. 1. Mixed sample from the grid sampling in CT watershed is CT-GS. All data are expressed per dry weight <2mm soil fraction. Not determined, n.

Part 1 (4 of 6)		Exchangeable cations										Oxalate and citrate-dithionite extracts						Biochemical properties			
Profile	Horizon	Ca <sup>2+</sup>	Mg <sup>2+</sup>	Na <sup>+</sup>	K <sup>+</sup>	Al <sup>3+</sup>	H <sup>+</sup>	CEC	CEC <sub>1</sub>	SRP <sub>15</sub>	P <sub>15</sub>	Al <sub>15</sub>	Al <sub>15</sub>	Fe <sub>15</sub>	Al <sub>15</sub>	Fe <sub>15</sub>	C <sub>sub</sub>	N <sub>sub</sub>	P <sub>sub</sub>	C <sub>sub</sub>	
		meq kg <sup>-1</sup>										mmol kg <sup>-1</sup>						mmol kg <sup>-1</sup>			
CN7	Ae	2.5	1.5	0.7	1.7	59	27	93	n	5.3	11.8	80	150	78	206	33	4.1	0.3	2.8		
CN7	C	2.4	1.0	0.5	0.9	44	14	62	n	9.8	11.5	182	345	206	557	12	3.3	0.2	0.4		
CN8	O	76.5	19.9	3.8	11.1	37	94	242	n	3.9	8.3	46	44	33	70	n	n	n	36.8		
CN8	A	31.3	10.5	3.3	5.8	81	96	227	n	2.4	6.5	77	48	73	102	188	43	2.9	11.4		
CN8	E	2.6	1.5	2.6	1.5	34	26	69	n	1.5	5.4	30	47	55	188	23	4.1	0.4	0.6		
CN8	B	1.8	1.6	2.3	1.4	65	40	112	n	10.8	27.1	195	482	214	749	29	5.7	0.7	0.9		
CN8	C	1.0	1.0	2.5	0.8	51	2	58	n	6.7	11.0	160	300	150	436	16	2.1	0.2	0.02		
CT1	O	80.8	21.9	14.2	14.6	19	104	255	n	4.0	6.5	28	18	24	38	n	n	n	36.8		
CT1	A	43.5	16.3	15.6	8.8	81	127	292	n	2.6	4.8	71	35	13	20	96	31	2.1	11.9		
CT1	E	3.1	1.0	0.4	1.1	26	26	58	n	0.8	2.2	25	13	63	41	11	4.2	0.2	0.8		
CT1	B	2.3	0.7	0.6	0.9	43	22	70	n	1.7	4.6	36	37	27	75	2.9	0.3	0.1	1.0		
CT1	C	2.4	1.0	0.7	1.3	66	22	93	n	3.7	5.2	91	163	60	304	4.3	0.7	0.00	0.7		
CT2	O	117	17.1	4.5	14.5	19	85	257	n	4.6	7.2	25	19	8	30	n	n	n	36.2		
CT2	A	46.0	9.0	1.0	6.8	61	93	217	n	4.0	11.9	67	59	42	51	104	31	2.9	8.9		
CT2	Ae	8.9	2.7	0.5	2.5	52	58	125	n	2.8	13.3	54	94	42	88	39	10	0.7	2.8		
CT2	B <sub>sv</sub>	2.1	1.0	0.4	1.0	52	15	71	n	6.0	8.0	56	103	57	193	14	2.5	0.1	1.3		
CT2	C	1.9	0.5	0.6	0.8	39	7	49	n	13.4	14.7	189	194	175	314	5.3	1.0	0.1	0.5		
CT3	O	60.4	17.0	4.9	10.4	64	126	282	n	3.3	6.6	57	38	35	12	n	n	n	19.6		
CT3	A	27.7	7.9	2.7	4.8	95	127	265	n	3.2	6.1	84	43	101	55	127	39	3.2	11.4		
CT3	E	1.8	0.5	0.4	1.2	20	24	48	n	2.4	4.7	68	29	7	1	13	3.1	0.3	1.1		
CT3	B	3.9	2.5	0.5	0.9	22	25	55	n	8.0	9.8	33	103	47	195	6.5	1.1	0.1	0.7		
CT4	O	83.1	15.9	3.7	12.2	33	91	239	n	4.2	7.3	35	21	0	0	n	n	n	34.0		
CT4	A	10.3	7.2	1.7	9.6	128	87	243	n	3.2	14.8	130	78	130	38	116	35	4.3	7.8		
CT4	E	2.3	1.2	1.1	2.1	73	24	104	n	3.5	8.8	63	101	63	152	19	6.7	0.3	1.6		
CT4	B	3.0	1.5	1.1	2.2	88	35	130	n	11.8	18.9	125	405	120	491	23	4.1	0.01	0.3		
CT5	O	82.2	37.6	2.5	35.3	38	84	279	n	6.0	10.7	44	43	35	26	n	n	n	59.8		
CT5	A	3.6	4.6	1.4	5.0	104	62	181	n	11.3	24.5	145	219	131	261	90	20	2.0	6.2		
CT5	Ae1	2.9	2.7	1.1	3.2	84	33	127	n	11.6	18.9	139	191	171	316	62	17	1.3	2.2		
CT5	Ae2	1.9	1.0	0.7	1.4	60	15	80	n	8.3	17.4	333	329	378	563	9	2.8	0.3	1.3		
CT5	Ae3	1.7	0.7	0.8	1.2	44	7	55	n	9.6	16.9	455	267	437	449	11	2.6	0.2	0.8		

**Appendix 1.** Chemical and biochemical properties of soil samples taken in profiles within the Černé (CN) and Čertovo (CT) watersheds in the 1997–2001 period. For abbreviations of soil horizons and soil constituents see chapter “Sampling and analyses” and Table 2. Location of soil profiles is given in Table and Fig. 1. Mixed sample from the grid sampling in CT watershed is CT-GS. All data are expressed per dry weight <2mm soil fraction. Not determined, n.

Profile	Horizon	Basic soil properties						Total concentrations												
		Depth m	Pool kg m <sup>-2</sup>	LOI %	pH <sub>CaCl2</sub>	pH <sub>H2O</sub>	C mol/kg	N mol/kg	P	S	Ca mmol/kg	Mg mmol/kg	K	Na	Si mol/kg	Al mmol/kg	Fe	Mn mmol/kg	Ti	
CT6	O	0.05	5	90.8	2.94	3.60	41.2	1.50	32.7	50.5	34.6	18.7	39	17	1.2	0.2	78	1.8	9	
CT6	A	0.07	22	40.7	2.86	3.50	18.4	0.75	39.2	35.7	29.6	69.5	262	184	7.6	1.6	325	2.5	60	
CT6	Ac	0.12	51	12.1	3.30	3.77	4.9	0.27	28.5	9.5	30.9	83.2	371	243	11.7	2.2	398	2.0	87	
CT6	B	0.54	76	15.4	3.66	4.19	5.8	0.24	48.1	12.9	33.1	189.0	395	249	9.8	2.6	1192	5.4	112	
CT7	O	0.05	4	90.0	2.85	3.58	43.4	1.54	33.1	71.6	37.0	18.9	49	18	1.3	0.2	106	1.8	11	
CT7	A	0.11	36	48.1	2.97	3.58	21.5	0.89	35.3	49.0	22.4	77.8	364	142	6.0	2.1	253	1.9	80	
CT7	E	0.23	168	8.5	3.55	4.13	3.6	0.16	12.9	6.3	32.4	80.0	612	312	11.5	3.0	165	2.8	105	
CT7	B	0.13	95	4.9	3.96	4.51	1.6	0.07	12.3	3.2	34.2	280.3	629	322	11.3	3.2	550	5.8	100	
CT7	C	0.58	527	4.3	4.16	4.69	1.1	0.05	15.2	3.2	36.1	368.4	645	332	11.0	3.3	794	7.3	87	
CT8	O	0.03	3	85.2	3.04	3.51	39.5	1.58	39.5	73.7	45.9	31.9	64	35	1.8	0.4	138	3.5	16	
CT8	A	0.07	10	54.6	3.06	3.60	24.6	0.99	34.8	52.3	31.7	67.5	184	128	5.5	1.4	378	2.9	42	
CT8	Ac1	0.10	85	12.1	3.66	4.11	4.5	0.18	23.3	9.5	34.5	154.0	391	276	10.6	2.6	857	5.0	88	
CT8	Ac2	1.10	756	8.3	4.02	4.48	2.3	0.09	19.1	6.3	29.0	186.3	416	259	10.9	2.8	885	5.6	85	
CT9	A	0.10	n	73.0	3.28	4.12	26.8	1.10	53.2	n	30.4	25.4	261	146	n	n	307	4.1	n	
CT9	E	0.11	n	6.2	3.74	4.58	2.8	0.09	14.8	n	52.8	87.7	669	375	n	n	299	18.2	n	
CT9	B	0.07	n	5.2	3.77	4.66	1.3	0.07	12.1	n	6.2	56.8	532	343	n	n	319	2.8	n	
CT9	C	0.10	n	7.3	4.24	4.85	1.0	0.04	13.6	n	22.1	87.4	418	225	n	n	341	2.1	n	
CT10	A	0.05	n	85.7	2.55	3.44	38.5	1.57	31.5	n	29.8	21.2	71	55	n	n	115	1.3	n	
CT10	Ac1	0.10	n	73.6	4.07	4.76	34.7	1.11	43.7	n	7.1	20.5	99	67	n	n	169	0.9	n	
CT10	Ac2	0.08	n	62.3	4.17	4.78	29.9	1.07	42.7	n	11.5	15.8	157	127	n	n	214	1.9	n	
CT10	C	0.32	n	7.4	4.46	4.92	2.4	0.08	15.0	n	7.0	89.8	290	259	n	n	551	3.9	n	
CT11	A	0.07	n	35.1	2.68	3.59	16.4	0.56	16.9	n	13.8	31.2	309	213	n	n	109	14.4	n	
CT11	E	0.12	n	6.7	3.28	4.16	2.4	0.12	13.6	n	21.9	40.6	419	234	n	n	147	2.0	n	
CT11	B <sub>h</sub>	0.08	n	21.3	3.23	3.96	8.2	0.37	71.1	n	18.9	26.7	320	271	n	n	732	3.8	n	
CT11	B <sub>l</sub>	0.15	n	16.8	3.82	4.54	6.3	0.16	43.0	n	8.6	8.5	253	244	n	n	834	5.9	n	
CT11	C	0.07	n	5.4	4.28	4.90	1.9	0.08	22.3	n	6.7	52.6	415	316	n	n	700	6.1	n	
CT-GS	O	0.09	n	71.4	2.99	3.89	32.4	1.18	30.3	n	54.3	40.7	51.2	150	74	3.6	0.7	183	2.8	34
CT-GS	A	0.11	n	47.7	3.09	3.75	21.4	0.85	32.2	n	43.2	68.7	271	137	6.6	1.5	257	2.4	60	
CT-GS	Ac	0.22	n	17.4	3.52	4.10	6.8	0.31	25.3	n	16.1	166.0	472	256	10.2	2.4	566	4.1	89	
CT-GS	E	0.10	n	4.6	3.45	4.15	1.8	0.10	9.0	n	3.1	18.0	89.9	508	179	12.9	2.2	279	3.3	87
CT-GS	B	0.13	n	8.6	3.71	4.35	2.9	0.15	21.4	n	6.4	29.1	255.6	220	11.0	2.5	890	6.5	93	
CT-GS	C	0.18	n	4.6	4.24	4.60	1.0	0.07	14.7	n	6.3	28.8	362.8	629	254	11.2	3.0	855	9.2	91

**Appendix 1.** Chemical and biochemical properties of soil samples taken in profiles within the Černé (CN) and Čertovo (CT) watersheds in the 1997–2000 period. For abbreviations of soil horizons and soil constituents see chapter “Sampling and analyses” and Table 2. Location of soil profiles is given in Table 1 and Fig. 1. Mixed sample from the grid sampling in CT watershed is CT-GS. All data are expressed per dry weight <2mm soil fraction. Not determined, n.

Profile	Horizon	Exchangeable cations										Oxalate and citrate-dithionite extracts										Biochemical properties				
		Ca <sup>2+</sup>	Mg <sup>2+</sup>	Na	K	Al <sup>3+</sup>	H	CHC	CHC <sub>1</sub>	SRP <sub>ox</sub>	P <sub>ox</sub>	M <sub>ox</sub>	Fe <sub>ox</sub>	Al <sub>1p</sub>	Fe <sub>cit</sub>	C <sub>ox</sub>	N <sub>ox</sub>	P <sub>ox</sub>	C <sub>u</sub>							
		mmol kg <sup>-1</sup>										mmol kg <sup>-1</sup>					mmol kg <sup>-1</sup>									
CT6	O	50.9	11.7	2.3	13.9	25	103	207	n	5.6	7.6	36	26	16	5	n	n	n	31.0							
CT6	A	8.0	4.6	1.5	6.0	68	92	179	n	10.2	19.2	6.3	135	67	187	79	19	1.9	5.3							
CT6	Ac	1.8	1.3	1.0	1.8	43	41	90	n	10.0	20.4	5.3	215	67	297	23	4.8	0.0	1.2							
CT6	B	1.9	1.5	1.2	1.6	100	35	141	n	15.7	31.6	286	716	249	862	20	2.0	0.3	3.1							
CT7	O	60.4	17.4	2.5	14.9	64	113	272	n	4.6	7.5	64	50	52	7	n	n	n	23.4							
CT7	A	9.3	5.5	1.9	6.0	128	97	248	n	4.7	15.3	130	134	119	106	90	28	2.3	8.1							
CT7	E	1.4	0.7	1.3	1.3	59	20	84	n	1.7	5.9	50	29	37	62	9	3.0	0.2	0.9							
CT7	B	1.1	0.3	0.6	0.9	68	14	84	n	6.4	8.8	110	35	75	98	6	0.6	0.2	0.6							
CT7	C	1.5	0.5	0.5	1.2	54	11	69	n	11.4	11.7	164	54	127	117	3	0.2	0.1	0.4							
CT8	O	63.3	14.1	1.3	11.2	98	89	277	n	4.3	11.7	132	42	82	1	n	n	n	21.7							
CT8	A	16.2	6.2	1.0	5.9	140	102	272	n	5.7	13.3	183	134	193	225	112	28	3.9	8.6							
CT8	Ac1	1.5	1.3	0.7	1.4	83	32	120	n	5.8	11.1	172	407	193	650	29	6.3	1.5	3.1							
CT8	Ac2	1.1	0.5	1.0	1.1	72	15	91	n	9.1	10.4	236	402	281	676	1	1.5	0.02	0.3							
CT9	A	10.4	8.2	3.0	6.2	198	80	305	n	4.4	4.4	300	151	442	173	n	n	n	n							
CT9	E	3.0	1.6	0.8	1.2	57	14	77	n	1.7	3.8	57	24	62	74	n	n	n	n							
CT9	B	2.6	1.2	1.1	1.9	71	22	100	n	3.0	5.4	83	40	74	102	n	n	n	n							
CT9	C	2.3	0.9	0.7	1.8	35	7	47	n	6.8	9.6	174	73	158	201	n	n	n	n							
CT10	A	23.9	12.0	0.5	12.0	199	168	415	n	3.0	5.4	181	43	224	74	n	n	n	n							
CT10	Ac1	3.1	3.1	0.2	3.6	97	23	130	n	10.0	12.3	1001	65	1037	124	n	n	n	n							
CT10	Ac2	3.6	3.0	0.3	3.0	92	16	118	n	9.8	15.5	n	49	778	114	n	n	n	n							
CT10	C	1.9	0.7	0.8	1.6	29	6	40	n	4.7	6.3	320	247	361	423	n	n	n	n							
CT11	A	17.7	5.2	1.5	3.2	62	65	155	n	1.7	3.7	39	31	47	62	n	n	n	n							
CT11	E	1.9	1.1	0.5	1.5	32	16	53	n	3.3	5.8	35	60	50	120	n	n	n	n							
CT11	B <sub>u</sub>	5.4	3.8	2.5	2.5	133	59	206	n	23.8	26.0	208	411	232	531	n	n	n	n							
CT11	B <sub>l</sub>	4.1	1.3	1.1	2.0	90	31	129	n	18.1	26.5	291	504	411	484	n	n	n	n							
CT11	C	2.7	0.6	1.0	1.4	38	10	54	n	9.5	9.5	228	135	304	309	n	n	n	n							
CT-GS	O	59.9	12.2	3.6	10.5	87	70	243	n	4.0	9.3	101	82	91	107	n	n	n	3.0							
CT-GS	A	22.1	5.8	3.7	6.3	96	61	195	566	3.7	12.6	122	111	110	126	86	18	1.4	2.5							
CT-GS	Ac	5.4	2.2	2.7	2.9	83	26	122	261	6.1	13.1	134	201	134	310	52	10	0.9	1.0							
CT-GS	E	1.1	0.5	2.7	1.4	36	14	56	72	2.0	4.2	33	43	21	79	12	1.5	0.2	0.4							
CT-GS	B	1.2	1.2	0.5	1.8	77	24	105	212	7.4	11.6	160	310	132	420	13	1.8	0.2	0.4							
CT-GS	C	1.1	0.5	0.5	1.5	44	8	55	74	4.8	5.9	136	117	0	272	44	0.5	0.0	0.3							