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Anthropogenic impact on concentration of selected trace elements pools in transformed organic soils in Trzcińskie Mokradła Peatland, SW Poland

Abstract: Drainage and peat extraction may have a negative impact on existing hydrological conditions and, consequently, on the conditions of wetland ecosystems. The aim of this study was to assess human impact on the studied Trzcińskie Mokradła Peatland by comparing the concentrations and trace element (Pb, Zn, Cu, Cr and Ni) pools in the study area (extracted vs. non-extracted areas of peatland). The concentration of trace elements in organic soils and their pools were analysed in relation to their depth in the soil profiles, content of organic matter, soil pH values and the degree of decomposition of organic materials (peat, mursh). Fifteen soil profiles (90 samples) were examined. The total soil elements content was determined after digestion in a mixture of $HCl+HNO_3$. The element pools were calculated and expressed in g m^{-2} of soil in 0–30 cm and 30–50 cm layers. Soils showed acidic or slightly acidic reactions. The high concentrations of Pb and Zn were mainly observed in the upper horizons. The deeper layers enriched with mineral fractions were also enriched in metals like Cr and Ni.

Keywords: organic soils, trace elements, peatland, mursh, peat extraction

INTRODUCTION

The majority of organic soils in peatlands can be preserved for thousands of years in good condition in North American and Eurasian lowlands (Lappalainen 1996), valleys (Van Bellen et al. 2016) and European mountain regions (Shotyk 1995). These situation are very important for the use these soils in paleoenvironmental works (Godwin 1981). Peatland soils are archives of natural peatland development and human activity and history (Shotyk et al. 1998). Trace elements in peat soils and the their different concentrations can be used as a database to understand and demonstrate both natural and human-induced changes of elements in the ecosystem air, soil and water (Shotyk et al. 2005). Organic soils and trace elements can be used as proxies to study climate change and paleoclimatic variation (Martinez Cortizas et al. 2002) and future climatic change scenarios (Martinez et al. 1997). They can also be useful for studying paleoindustry, smelting/mining (Chambers and Chaman 2004), agriculture (Chambers 2003) and forestry use (Pitman 2006) as well as pollution history (Fiałkiewicz-Kozieł et al. 2018), geoarcheology (Jenkins 1995) and reconstruction of vegetation changes (Monna et al. 2004).

For decades, the Jelenia Góra Basin has been a part of the industrial emission impact zone, which in many regions of the Sudetes is one of the main causes of changes in the soil environment (Brogowski et al. 1997). Trace element accumulation in peatlands were a result of air pollution and dust particles transported by the wind (Błaś and Sobik 2003), fuel combustions (Jones and Hao 1993) and sometimes genesis (Rood et al. 1995). Particles containing trace elements float in the air and are deposited on the plants and the soil in dry and wet conditions (Lin et al. 2009). Trace elements concentrations could also be the result of waterborne terrestrial mineral or biogenic particles (Bjork 1993). In the course of railway rolling stock operation soil material is subjected to abrasion and deposit of fuel burning products of diesel-electric locomotives (Wiłkomirski et al. 2011). High local concentration of trace elements could also be a result of the presence of wild waste dumps near studied peatland (Kaszubkiewicz et al. 2011).

Peat extraction (Silvola et al. 1996) and peatlands drainage (Wessolek 1999; Jutras and Plamandon 2005; Nieminen et al. 2005; Glina et al. 2016a, 2017a, 2018; Bogacz et al. 2017; Zawieja and Glina 2017) can lead to the changes of hydrological conditions, properties of organic soils and, consequently, soil nutrient status

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(Rydin and Jeglum 2006). The drainage of the Trzcińskie Mokradła Peatland started in the 19th century and was carried out due to forest cultivation and peat extraction (Staffa 1999). The interference in hydrological stability of peatland has often led to many changes in wetland soil properties (Bogacz 2005; Kucharczyk and Szary 2012; Glina et al. 2016b, Glina et al. 2019). The concentration and pools of trace elements could be also connected with peat soil transformation (Kabała and Szerszeń 1998; Glina and Bogacz 2013; Glina et al. 2016c, 2017b). The aim of this paper was to assess the variability of the concentrations of trace elements pools in two analysed layers (0–30 cm) and (30–50 cm) in organic soils of the previously pristine peatland partially transformed by human activities (drainage, and peat extraction).

MATERIALS AND METHODS

The study area included a part of Trzcińskie Mokradła peatland (Poland, N 50.52', E 15.54') covering the area of 36.64 ha at the altitudes 390 to 397 m a.s. l. The study area is administrated by the State Forests National Forest Holding (Śnieżka Forest District, Janowice and Śnieżka Forest Units). Similar peatlands, located in the Jelenia Góra mountain basin, have rarely survived because of medieval settlement and agricultural use (Staffa 1999).

The peatland studied has developed on the low to high impermeable, granite and greenstone clays and loam bedrock (Narkiewicz 1999) formed with solifluction and colluvial processes (Bogacz 2000). The high ground water levels were the result of this lithological and geological situation (Kondracki 1998). According to Tarasiewicz (2002), the genesis of the studied peatlands was influenced by the presence of several sources of groundwater (soligenous and lithogenous). Despite the abovementioned ground water system impact, nowadays rain and surface water play the leading role in forming of the hydrological conditions of the study area (Jezierski 2002). The northern peatlands areas are the headwaters for the Silnica stream (Narkiewicz 1999). Peatland was previously described as a transitional peatland (Schube 1903), the thickness of which only rarely exceeded 100 cm (Bogacz et al. 2016). Today Trzcińskie Mokradła Peatland represents two different trophic statuses: more oligotrophic in the larger part in the north, and more minerotrophic in the small part in the south. Based on the chemical composition of the water (Andrzejczak and Bogacz 2013), the peatland has been classified as a weakly minerotrophic fen according to the classification proposed by Rydin and Jeglum (2006).

The organic soils of the drained peatlands parts are currently influenced by forest and meadow communities (Andrzejczak and Bogacz 2013). We have observed the expansion of forest communities with predominating spruce and birch especially in more drained areas. The following peatland plant communities were identified in 2008: *Scheucherio-Caricetae, Vacinio-uliginosi-Betuletum pubescens, Sphagno recurvi-Eriophoretum angustifoli, Alnetea glutinosae,*

TABLE 1. Geographic coordinates and classification of the studied Trzcińskie Mokradła soils

Profile	Geographic coordinates	Soil units WRB 2015	Soil Type	Subtype
			proposal of English equivalents for the soil... (Świtoniak et al. 2016)	
TM 1	N 50°52'58.30" E 15°53'43.75"	Hemic Histosol Dystric	Hemic peat soils	Sapri-hemic peat soils
TM 2	N 50°52'59.66" E 15°53'59.24"	Hemic Histosol Dystric	Hemic peat soils	Sapri-hemic peat soils
TM 3	N 50°52'54.78" E 15°53'59.07"	Murshic Histosol Dystric	Murshic soils	Sapri-murshic soils
TM 4	N 50°52'46.47" E 15°53'46.98"	Murshic Histosol Dystric	Murshic soils	Sapri-murshic soils
TM 5	N 50°52'51.33" E 15°53'49.23"	Murshic Histosol Dystric	Murshic soils	Sapri-murshic soils
TM 6	N 50°52'39.90" E 15°53'57.57"	Fibric Histosol Dystric	Fibric peat soils	Limni-fibric peat soils
TM 7	N 50°52'41.81" E 15°53'58.53"	Murshic Histosol Dystric	Murshic soils	Sapri-murshic soils
TM 8	N 50°52'40.31" E 15°54'00.12"	Sapric Histosol Dystric	Sapric peat soils	Simni-sapric peat soils
TM 9	N 50°52'40.75" E 15°53'54.27"	Hemic Histosol Dystric	Hemic Histosol Distric	Sapri-hemic peat soils
TM 10	N 50°52'41.29" E 15°53'58.29"	Fibric Histosol Dystric	Fibric peat soils	Fibri-sapric peat soils
TM 11	N 50°52'44.97" E 15°54'04.42"	Sapric Histosol Dystric	Sapric peat soils	Fibri-sapric peat soils
TM 12	N 50°52'59.05" E 15°53'52.78"	Hemic Histosol Dystric	Hemic peat soils	Sapri-hemic peat soils
TM 13	N 50°52'43.41" E 15°54'00.86"	Fibric Histosol Dystric	Fibric peat soils	Fibri-sapric peat soils
TM 14	N 50°52'56.58" E 15°53'49.83"	Fibric Histosol Dystric	Fibric peat soils	Fibri-sapric peat soils
TM 15	N 50°53'00.12" E 15°53'47.70"	Fibric Histosol Dystric	Fibric peat soils	Fibri-sapric peat soils

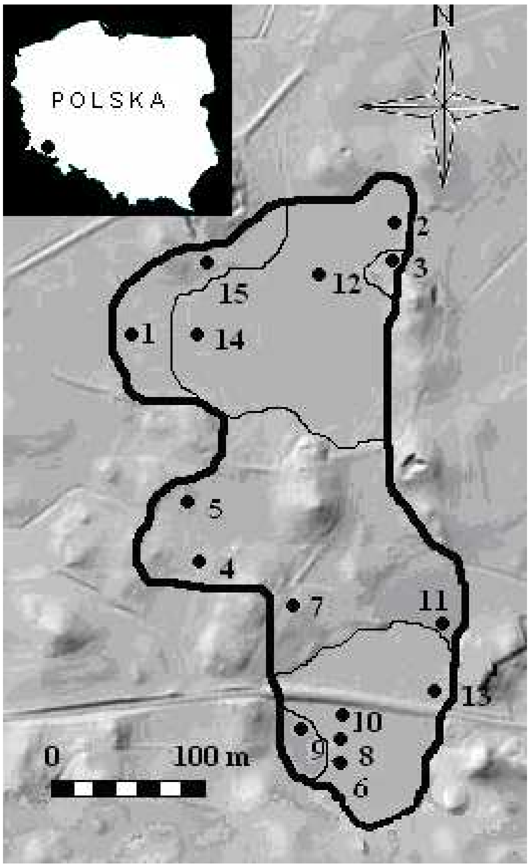

FIGURE. Location of study area within the border of Poland and examined profiles within the studied Trzcińskie Mokradła peatland. Profile N^{o} s 1, 3, 4, 5, 7, 9, 11, and 15 represent non-extracted areas. Profile N^{o} s 2, 6, 8, 10, 12, 13, and 14 represent extracted area, ▬border of peatland, —border of extracted/non extracted peatland area, (source: geoportal.gov.pl)

Filipendulion ulmarie and meadows with the Calthion group (Bogacz et al. 2016). No information exists regarding plant communities from the period prior to the peat extraction and drainage.

Exploitation of the examined peatland area was carried out on a small scale in the late 19th and early 20th centuries (Staffa 1999). Anthropogenic landscape modification in form of peat pits and ditch arrangements is documented in old maps (Zimmerman and Berg 1941). We can still observe these landscape changes in the self-restoring, central part of the peatland (Bogacz et al. 2016) and murshed organic soils along the peatland borders (Andrzejczak and Bogacz 2013). The major part of the peatland is still drained with a network of ditches (Woźniak 2007).

During field studies, 15 organic soil profiles were examined using an Instorf peat auger (Horawski 1987). Profiles N^{o}. 1, 3, 4, 5, 7, 9, 11 and 15 represent non extracted parts of the peatland and profiles N^{o}. 2, 6, 8, 10, 12, 13 and 14 represent the extracted parts of the peatland. Profile locations and borderlines of extracted peatland areas are identified on the LIDAR based image in Figure (Geoportal.gov.pl 2013). In many post-extraction sites, the restoration of peat-forming processes was observed. Peat extraction was also confirmed by C^{14} dating of profile N^{o}.14 (Bogacz et al. 2016). Peat transformation (mursh forming process) in drained areas of the non-extracted part of peatland is represented by profiles N^{o}. 3, 4, and 5. Ninety samples were collected (74 organic and 16 mineral samples). Peat samples were divided into two parts, of which one was dried at room temperature (18–20°C) and another one was preserved wet and refrigerated at 4°C. The part of soil samples in natural structure were collected in 100 cm^{-3} metal rings for measuring soil bulk densities. Dry samples were ground and sieved through an ø 2 mm sieve.

In the dry samples, the following properties were determined: ash content by ignition in furnace at 550°C for 4 hours, total organic carbon (TOC) by catalytic dry combustion at 600°C in Ströhlein CS-Mat 5500. The total content of trace elements (Zn, Pb, Cu, Ni, Cr) was determined after the microwave sample digestion in the mixture HNO_3 + HCl 3:1 and measured using atomic absorption spectrometry (AAS) (Soil Survey Staff 1998). In wet soil material, which had been refrigerated at 4°C, the following properties were determined: peat decomposition based on volume of unrubbed fibre (UF) isolated by the half syringe method (Lynn et al. 1974), and potentiometric soil pH in soil to water and soil to 1 mol dm^{-3} KCl solutions at 1:2.5 ratios (v/v) (PN-ISO 10390: 1998). The pools of trace elements in 0–30 cm and 30–50 cm layers were calculated based on the thicknesses of particular layers and their calculated bulk densities. The depths of sampling layers were connected with peat excavation depths which probably were about 30–40 cm (Bogacz et al. 2016) and organic soils depths. Selected elements pools M (g) accumulated in soil within each of soil layer on the surface S (S = 1 m^2) were calculated as:

$$M\ (g\ m^{-2}) = C\ (g\ kg^{-1})\ S\ (m^{2})\ d\ (cm)\ \sigma\ (g\ cm^{-3})$$

where: M is pools of element, C is element concentration (mg kg^{-1}), d is depth of soil layer, and σ is soil dry bulk density.

In this study, pools of trace elements were not used to determine the utility aim of these soils. Determination of elements pools in this case was used to compare soils of extracted and non-extracted areas of peatland.

Arithmetical means and Pearson's correlation coefficients for the relationships with environmental parameters were calculated based on laboratory analysis results. All calculations were conducted using

Statistica 10.0 software. Differences between pools of elements in 0–30 cm and 30–50 cm core depths were calculated using the mean standard deviation (SD) and basic analysis of variance coefficients (CV).

RESULTS AND DISCUSSION

Organic soils were classified to Histosols with the main qualifiers Fibric, Hemic, Sapric, Dystric, and Murshic, or Drainic and supplementary qualifiers Fluvic and Mineralic (IUSS-WRB 2015). According to the Proposal of English Equivalents for Polish Soils Classification soil system names (Świtoniak et al. 2016), they were described as Fibric, Hemic and Sapric peat soils or Murshic soils. Soil profiles with disturbed layer sequences and those not exploited were described by measuring the thickness of the layers from the current soil surface. During previous years, the organic matter accumulation has continued on most of the studied peatland surface (Bogacz et al. 2016). Soil morphology, genesis and properties of the studied profiles have already been partly presented (Andrzejczak and Bogacz 2013; Bogacz et al. 2016) and some of these results are briefly given in Table 2. The thickness of some of the organic soil profiles was strongly reduced by manual peat cutting (Zimmerman and Berg 1941). Organic soils profiles in historical mining areas have had a hiatus (Bogacz et al. 2016).

Unrubbed fibre (UF) is one of the most important organic material decomposition factors (Soil Survey Staff 1999). The content of unrubbed fibre ranged from 0% in mursh horizons to 87% in fibric peat horizons. (Table 2). The presence of strongly decomposed peat is sometimes connected with the water transport humic substances, mineral fraction and the fibric peat drainage (Paivanen and Hanell 2012). The degree of peat decomposition, expressed by volume of the unrubbed fibre (UF), significantly changed with depth ($r = -0.54^*$, $n = 90$, $p < 0.05$). Content of TOC ranged from 4.30 g kg^{-1} in the mineral horizon to 621 g kg^{-1} in organic horizons consisting of sapric peat (Table 2). The increase in carbon content in upper organic horizons was strongly associated with the presence of unrubbed fibre ($r = 0.45^*$, $n = 90$, $p < 0.05$) (Table 4). Reaction of peat soils was acidic or strongly acidic. Strongly silted organic soils were generally less acidic than the others (Bogacz et al. 2012). There was a significant negative correlation between the values of soil reaction pH and the content of TOC ($r = -0.43^*$, $n = 90$, $p < 0.05$, Table 4).

The lead content in the examined samples ranged from 2.0 to 136 mg kg^{-1} in organic horizons. Measured lead content was higher in upper horizons than in the deeper horizons (-0.38^*, $n = 90$, $p < 0.05$, Table 4).

TABLE 2. Basic soil properties and selected trace elements content in studied soil horizons

Soil horizon	Depth of horizon	UF	Ash content	Bulk density	pH H_2O	TOC	Pb	Zn	Cu	Cr	Ni
	(cm)	(%)		g cm^{-3}		g kg^{-1}	mg kg^{-1}				
Oi	2–28*	42–87	4.22–25.07	0.06–0.31	3.5–5.9	241–469	2.0–136	13.0–256	0.5–35.0	1.7–14.8	4.6–19.3
	13**	60	9.79	0.13	4.2	431	55.5	59.6	20.7	6.9	10.9
Oe	5–25	18–34	10.79–73.66	0.15–0.57	4.0–5.2	128–516	9.5–130	26.0–99.0	8.1–48.0	8.1–72.5	9.4–69.7
	13	23	28.62	0.37	4.4	316	63.7	54.3	26.5	34.0	23,0
Oa	3–45	0–16	8.89–75.30	0.21–0.37	2.6–5.3	121–621	6.8–119	11.0–91.0	2.0–67.0	4.7–56.3	6.9–29.0
	16	6	34.09	0.33	4.2	351	43.6	35.4	27.9	23.8	13.9
M	5–25	0–6	16.84–42.85	0.28–0.45	3.7–4.6	328–504	3.73–119	30.0–86.0	26.0–41.0	9.3–47.5	8.5–16.9
	11	3	31.64	0.32	4.2	407	89.3	46.0	34.6	20.0	14.0
C	13–25	n.d	n.d.	n.d.	3.7–6.8	4.3–113	8.9–16.7	26.0–62.5	6.0–22.5	20.6–65.1	8–24.0
	16				4.9	45.3	11.6	45.8	15.5	30.9	16.8

Explanation: O – organic, M – mursh, C – mineral bedrock, a – sapric peat, e – hemic peat, i – fibric peat, * range(minimum-maximum), ** arithmetic mean, nd – not determined, UF – unrubbed fibre

TABLE 3. Trace elements pools in soil horizons in Trzcińskie Mokradła Peatland

Profile	Layer cm	Trace elements (total forms) g m^{-2}									
		Pb		Zn		Cu		Cr		Ni	
TM1*	0–30	4.56		1.59		1.26		0.87		1.33	
	30–50	2.14	6.70	3.32	4.91	1.61	2.87	3.05	3.92	2.52	3.85
TM2	0–30	1.52		2.21		0.47		0.19		0.31	
	30–50	0.22	1.74	0.66	2.87	0.21	0.68	0.19	0.38	0.15	0.46
TM3*	0–30	13.0		5.41		3.39		1.70		1.21	
	30–50	3.97	17.0	7.44	12.8	4.05	7.44	7.50	9.20	3.06	4.27
TM4*	0–30	7.90		5.48		3.42		1.64		1.37	
	30–50	1.18	9.08	2.49	7.97	1.52	4.94	2.04	3.68	1.59	2.96
TM5*	0–30	5.49		2.08		2.27		0.69		0.90	
	30–50	1.23	6.72	1.05	3.13	1.69	3.96	1.05	1.74	1.01	1.91
TM6	0–30	1.68		5.67		0.99		1.53		0.64	
	30–50	1.94	3.62	4.88	10.55	2.48	3.45	6.74	8.27	2.45	3.09
TM7*	0–30	4.20		3.18		1.16		0.31		0.46	
	30–50	1.30	5.50	0.95	4.13	0.57	1.73	0.19	0.50	0.17	0.63
TM8	0–30	2.10		1.78		2.11		0.19		0.31	
	30–50	0.61	2.71	2.80	4.58	0.60	2.71	0.19	0.38	0.15	0.46
TM9*	0–30	3.14		2.04		0.70		0.26		0.29	
	30–50	2.32	5.46	2.04	4.08	0.25	0.95	0.18	0.44	0.27	0.56
TM10	0–30	0.39		1.07		0.64		0.12		0.22	
	30–50	4.83	5.22	4.06	5.13	3.81	4.45	2.43	2.55	1.62	1.84
TM11*	0–30	1.24		2.44		1.14		0.60		0.51	
	30–50	1.57	2.81	5.59	8.03	2.66	3.80	5.00	5.69	2.13	2.64
TM12	0–30	4.72		3.57		1.30		0.34		0.52	
	30–50	1.51	6.23	1.90	4.66	0.66	1.96	0.23	0.57	0.20	0.72
TM13	0–30	2.69		3.83		2.11		1.61		1.03	
	30–50	2.11	4.80	3.85	7.68	1.89	4.00	2.65	4.25	1.34	2.37
TM14	0–30	1.68		1.75		1.11		1.53		0.76	
	30–50	1.94	3.62	4.88	6.63	2.48	3.59	6.74	8.27	2.39	3.15
TM15*	0–30	0.36		1.13		0.60		0.12		0.20	
	30–50	3.07	3.43	2.44	3.57	2.30	2.90	1.26	1.38	0.93	1.13

Explanation: * extracted.

TABLE 4. Correlation coefficients between some properties of soils studied

Value	Pb	Cr	Ni	Cu	Zn	pH	TOC	UF
Depth	-0.384*	0.506*	0.318	-0.196	-0.226	0.337	-0.739*	-0.540*
Pb		-0.299	0.075	0.473*	-0.040	-0.319	0.445*	0.256
Cr			0.424*	0.130	-0.121	0.337	-0.694*	-0.437*
Ni				0.317	0.024	0.287	-0.383*	-0.286
Cu					0.031	0.164	0.210	-0.074
Zn						0.204	0.111	0.153
pH							-0.429*	-0.185
TOC								0.449*

Explanation: UF – unrubbed fibre, correlation coefficient significant at: $^{*}p<0.05$, n=90.

Organic horizons in many part of Sudetes Mountains showed a higher content of lead compared to zinc. This observation was related mainly to the Izera (Bogacz 2005; Glina and Bogacz 2013) and Stołowe Mountains (Glina et al. 2017b). This is, according to Strzyszcz and Magiera (2001), proof of the transport of contaminants over long distances. These phenomena cannot be observed in Trzcińskie Mokradła Peatland.

The Zn contents varied greatly and ranged from 11 mg kg^{-1} of soil in horizons consisting of sapric peat to 256 mg kg^{-1} of soil in fibric material (Tables 1, 2). Zinc showed a higher content in the subsurface soil layers, compared to the surface. This situation could be a result of high zinc mobility (McBride and Blasiek 1979).

The copper contents in organic horizons ranged from 0.5 to 67 mg kg^{-1}. It was strongly correlated with Pb content (0.47*, $n = 90$, $p < 0.05$, Table 4). This may indicate a wide variation in the levels of copper content of organic horizons, or it could be the result of anthropogenic impact on the examined soils. It is interesting that there was no significant correlation between the content of TOC and the total content of copper, which has a high affinity to organic substances (Kabata-Pendias and Pendias 1999).

The concentration of chromium in the analysed soil layers ranged from 1.7 mg kg^{-1} in fibric peat horizons to 72.5 mg kg^{-1} in hemic peat horizons. The same situation held for the concentration of nickel (from 4.6 mg kg^{-1} in fibric material to 69.7 mg kg^{-1} in hemic material). Chromium and nickel concentration in analysed soils samples were strongly positively correlated with TOC content: ($r = -0.69^*$, $n = 90$, $p < 0.01$ and $r = -0.38^*$, $n = 90$, $p < 0.05$ respectively). Moreover, Cr content correlated with depth ($r = 0.51^*$, $n = 90$, $p < 0.05$) and unrubbed fibre content ($r = -0.44^*$, $n = 90$, $p < 0.05$, Table 4). Silted soil horizons generally contained significantly higher concentrations of above-mentioned elements. This phenomenon was also observed by Borowiec and Urban (2001) in organic soils of the Ciemięga River Valley. Research carried out by Arkhipov et al. (2000) showed that, over large areas of Western Siberia, chromium is a good indicator of silting processes in peat soils. Generally, the highest contents of Zn and Cu and especially of Pb appeared in surface horizons, while the highest contents of Cr were observed in deeper silted layers (Table 2).

The largest differences in contents and pools of some metals were between the upper (0–30 cm) and deeper layers (30–50 cm, Tables 3, 5). Content of selected elements in upper soil horizons were probably connected with peat extraction and mixing with mining materials (Bogacz et al. 2016). The largest values for calculated pools differentiations were observed in case of zinc and chromium (Tables 3, 5). The concentrations and pools of Pb and Cu in surface layers (0–30 cm) were clearly higher in soil represented of profiles from non-exploited areas (Tables 3, 5). This was most probably related to the minor mobility of these elements in the soil. A completely different situation was observed for Zn, Cr and Ni. The higher element pools were calculated for deeper, usually more silted, horizons (Tables 3, 5). The pools of all determined metal contents in horizons 0–50 cm of non-extracted areas were generally larger than in surface horizons within the extracted parts of peatlands (Table 3). In the subsurface soil horizons (30–50 cm), the average metal contents and pools were similar for the exploited and unexploited areas (Table 5).

TABLE 5. Pools of trace elements in layers 0–30 cm and 30–50 cm of extracted and non extracted peatland parts

Metal (n=90)	Depth of layer (cm)	x	SD	dx	CV	Depth of layer (cm)	x	SD	dx	CV
Pb	0–30	2.11				30–50	2.09			
	0–30*	4.99	3.32	2.88	0.87	30–50*	1.88	4.17	0.21	0.05
Zn	0–30	2.84				30–50	3.29			
	0–30*	2.92	1.58	0.08	0.05	30–50*	3.16	1.01	0.13	0.07
Cu	0–30	1.25				30–50	1.72			
	0–30*	1.90	0.95	0.65	0.68	30–50*	1.83	1.57	0.11	0.07
Cr	0–30	0.79				30–50	2.74			
	0–30*	0.78	0.64	0.01	0.01	30–50*	2.53	2.64	0.21	0.8
Ni	0–30	0.54				30–50	1.18			
	0–30*	0.78	0.41	0.24	0.58	30–50*	1.46	1.01	0.28	0.28

Explanation: x – arithmetic means, SD – standard deviation, dx – differences of arithmetic means, CV – variance coefficient, * not excavated.

CONCLUSIONS

In general, Cu and Pb pools within the studied peatland indicated greater accumulations of those trace elements in the 0–30 cm surface layer. The opposite situation was observed for Zn, Cr and Ni pools. This phenomenon was related to different metal mobility and peat extraction.

The exploitation of peat led to a decrease in lead and copper pools in the upper layers (0–30 cm).

The statistically, significant differences of trace elements concentrations and pools were related to differences in soil pH (Cu, Ni, and Cr).

There was no correlation between the copper content and organic components (TOC) in the studied soils. This is an unusual phenomenon, which could be associated with disturbances of the soil horizons caused by human activity (drainage and peat extraction).

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Wpływ człowieka na zawartość i zasoby metali ciężkich w przekształconych glebach na torfowisku Trzcińskie Mokradła

Abstract: Odwodnienie i eksploatacja torfu wywierają negatywny wpływ na warunki hydrologiczne i w konsekwencji na kondycję ekosystemów mokradłowych. Celem podjętych badań było określenie wpływu człowieka (wydobywcza eksploatacja torfu) na gleby organiczne torfowiska Trzcińskie Mokradła (Kotlina Jeleniogórska), w tym na zawartości i zasób wybranych metali ciężkich (Pb, Zn, Cu, Cr, Ni). Zawartość metali ciężkich i ich zasoby w glebach organicznych analizowano w relacji do głębokości profilów glebowych, zawartości materii organicznej, pH gleby i stopnia rozkładu torfu. Zbadano 15 profilów glebowych (90 próbek). Zasoby metali ciężkich w glebie przeliczano i wyrażano w gramach na m^2 gleby w dwóch wyznaczonych poziomach (0–30 cm i 30–50 cm). Badane gleby wykazywały kwaśny lub lekko kwaśny odczyn. Duża zawartość Pb i Zn była obserwowana głównie w poziomach powierzchniowych. Głębsze poziomy wzbogacone we frakcje mineralną były także wzbogacone w metale, takie jak chrom i nikiel. Standardy jakości gleb nie zostały przekroczone na badanym torfowisku.

Słowa kluczowe: gleby organiczne, pierwiastki śladowe, torfowisko, mursz, eksploatacja torfu