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DOI: 10.1515/ssa-2016-0009

SOIL SCIENCE ANNUAL
Vol. 67 No. 2/2016: 64–72

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Nitrogen mineralization in forestry-drained peatland soils in the Stołowe Mountains National Park (Central Sudetes Mts)

Abstract: The aim of this work was to determine the intensity of nitrogen mineralization in forestry drained ombrotrophic peatland soils in the Stołowe Mountains National Park, SW Poland. Additionally discussion about the shallow organic soils classification according to Polish Soil Classification (2011) is presented. For the study three research transects were established on forestry drained ombrotrophic peatlands in the Stołowe Mountains. Each of the transect consisted of four (site A and B) or five (site C) sampling plots. Sampling was conducted in the year 2012. The soil samples for the basic soil properties analysis were sampled in April, whereas undisturbed soil samples were collected in stainless steel rings (100 cm^3) every 10 cm in April (spring), July (summer) and October (autumn) to show the seasonal dynamics of nitrogen mineralization. Statistical analysis showed that the content of N-NH_4 was mainly determined by actual soil moisture and precipitation rate, whereas the content of N-NO_3 was positively correlated with air temperature. Among investigated peatlands the highest concentrations of mineral nitrogen forms was observed in the Długie Mokradło bog, situated on the Skalniak Plateau-summit. Additionally, the results obtained showed that implementation of new subtype: shallow fibric peat soils (in Polish: gleby torfowe fibrowe płytkie) within the type of peat soils (in polish: gleby torfowe) should be considered during developing of the next update of Polish Soil Classification.

Keywords: mineral nitrogen, forestry, drainage, peat bogs, Sudetes Mts

INTRODUCTION

The pressure on peatland ecosystems is likely to be mediated through changes in hydrology, direct and indirect effects of climate change, as well as land-use change (Ferrati et al. 2005). In most cases this phenomenon is the effect of strong human impact such as drainage for forestry or agricultural use of peatlands (Limpens et al. 2008). The human impact increased peatlands vulnerability to climate change, what exacerbated the negative effects of drainage (Charman et al. 2008). This process also concerned mountain peatlands, drained mainly for forestry use (Yallop and Clutterbuck 2009). In the Stołowe Mountains (Central Sudetes, SW Poland) large peatland complexes were drained to obtained a new area for spruce monoculture at the turn of 19th and 20th centuries (Stark 1936, Jędryszczak and Miścicki 2001). The decrease of the water table increases aerobic conditions in the surface layers of peatland soils, what promotes mursh-forming process connected with mineralization of organic matter (Markiewicz et al. 2015), including nitrogen compounds (Maljanen et al. 2007). Moreover, this phenomenon is reinforced by the increase of evapotranspiration from the afforested peatland surface (Gillooly et al. 2001). The intensity of mineralization process mainly depends on actual soil moisture (Weedon et al. 2012), type of organic matter (Schimel and Bennett, 2004), type of peatland management (Tripathi and Sighn 2009), soil fauna (Lappalainen et al. 1999 Weedon et al. 2012), and air temperature (Ehrenfeld and Shen Yu 2012). Furthermore, mineral nitrogen forms (N-NH_4 and N-NO_3) display seasonal variations, what indicates the necessity of measurement in different time period and weather conditions (Basiliko et al. 2005, Gao et al. 2009). In Poland, the problem of nitrogen mineralization in the peat soils was particularly discussed with respect to degraded lowland minerotrophic peatlands (e.g. Turbiak and Miatkowski 2006, Pawluczuk and Szymczyk 2008). However, this problem should be also considered in order to forestry drained peatland ecosystems in mountain areas, what will be described in the presented work.

The aim of this work was to determine the intensity of nitrogen mineralization in forestry drained peatland soils in the Stołowe Mountains National Park (SMNP), in the year 2012. Additionally, authors will discuss problems of shallow organic soils classification according to Polish Soil Classification (PSC 2011) which revealed during the preparation of this work.

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http://ssa.ptg.sggw.pl/issues/2016/672

MATERIALS AND METHODS

The study was conducted in the Stołowe Mountains National Park situated in the south-west of Poland (Figure 1). The mean annual air temperature in the sampling year 2012 was 6.7°C, in the warmest month (July) 17.0°C, whereas in the coldest (February) – 7.5°C. The annual sum of precipitation in 2012 was 786 mm with the maximum in July (169 mm) and minimum in March – 14 mm (Table 1). Growing period in SMNP begins in the second or in the third decade of April and lasts 190 days (Gałka et al. 2014).

TABLE 1. Temperature and precipitation during the growing season in 2012* (SMNP)

Months	III	IV	V	VI	VII	VIII	IX	X
Temperature (°C)	3.1	6.6	13.0	15.5	17.0	16.0	11.3	6.0
Precipitation (mm)	14	43	55	59	169	78	58	61

* data from the meteorological station in Kudowa Zdrój.

For the study, three research transects were established on forestry drained ombrotrophic peatlands (Figure 1). Each of the transect consisted of four (sites A and B) or five (site C) soil profiles (Figure 1, Table 1). Transect A was established along the ransitional bog situated on the Rogowa Kopa plateau in the southern part of SMNP. This peatland is characterized by mixed ombrogenous-soligenous type of water supply (Glina 2014). Research transects B and C were respectively established on Niknąca Łąka and Długie Mokradło bogs. Both study sites are typical omborogenous peatlands, developed over the sandstone bedrock (Bogacz et al. 2012, Glina 2014). The study site C is the most densely cut by drainage ditches among all of the described area. All of the peatlands are covered by forest communities with domination of spruces, pines and birches (Glina 2014). The field works and soil sampling campaigns were carried out during the growing season in the year 2012. To show the seasonal dynamics of nitrogen mineralization undisturbed soil samples were collected in triplicate into the stainless steel rings (100 cm^3) in April (spring), July (summer), and October (autumn), every 10 cm of profile (0–10 cm, 10–20 cm, 20–30 cm etc.). The amount of collected samples was conditioned by thickness of each soil profile. Additionally, in April soil samples were sampled from genetic horizons for the basic soil properties analysis (Table 2). For groundwater table control along the research transects thirteen piezometers were installed. Each soil sample was divided into two subsamples prior to laboratory analysis. In fresh material the degree of peat decomposition was determined following the procedure proposed by Lynn et al. (1974). The following properties were determined in the dry soil material: ash content after placing dried samples for 5 h in a muffle furnace at 550°C (Bojko and Kabała 2014), pH in distilled water (soil to water w/v ratio 1:2.5) potentiometrically, total organic carbon (TOC) by catalytic dry combustion at 600°C in Ströhlein CS-mat 5500 analyzer, and total nitrogen (TN) by Kjeldahl method using Büchii analyzer. The concentration of nitrate (N-NO_3) and ammonium (N-NH_4) forms were measured spectrometrically in 1% K_2SO_4 extracts with Nessler's reagent (for NH_4) and phenol disulfonic acid (for NO_3) after 14 days

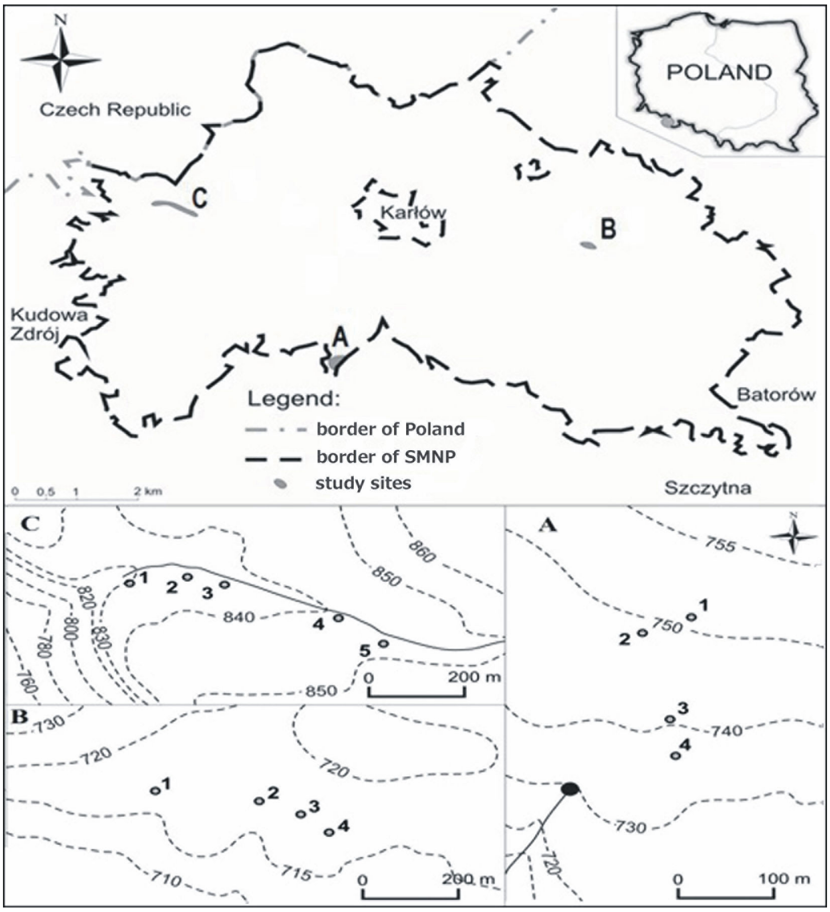

FIGURE 1. Location of the study sites and transects sketch

TABLE 2. Soil profile location and classification

Study site	Profile No.	Depth (cm)	Coordinates WGS 84 (N/E)	Soil classification	
				PSC 2011	FAO-WRB 2015
A	1	36	50°27'00.0"/ 16°20'12.7"	gleba torfowo-glejowa	DystricHistic Gleysol (Drainic)
	2	31	50°26'59.2"/ 16°20'10.1"	gleba torfowo-glejowa	DystricHistic Gleysol (Drainic)
	3	32	50°26'55.2"/ 16°20'11.8"	gleba torfowo-glejowa	DystricHistic Gleysol (Drainic)
	4	31	50°26'53.5"/ 16°20'12.2"	gleba torfowo-glejowa	DystricHistic Gleysol (Drainic)
B	1	43	50°27'58.5"/ 16°23'26.7"	gleba torfowa saprowa płytka	Dystric Ombric Drainic Sapric Histosol
	2	54	50°27'57.8"/ 16°23'37.7"	gleba torfowa fibrowa typowa	Dystric Ombric Drainic Fibric Histosol
	3	70	50°27'58.5"/ 16°23'26.7"	gleba torfowa hemowo-fibrowa	Dystric Ombric Drainic Hemic Fibric Histosol
	4	45	50°27'55.1"/ 16°23'45.2"	gleba torfowa fibrowa typowa	Dystric Ombric Drainic Fibric Histosol
C	1	40	50°28'27.8"/ 16°17'21.3"	gleba torfowa saprowa płytka	Dystric Drainic Sapric Histosol
	2	45	50°28'28.5"/ 16°17'27.5"	gleba torfowa hemowo-fibrowa	Dystric Ombric Drainic Hemic Fibric Histosol
	3	53	50°28'31.5"/ 16°17'27.9"	gleba torfowa fibrowo-saprowa	Dystric Ombric Drainic Sapric Fibric Histosol
	4	64	50°28'25.1"/ 16°17'43.8"	gleba torfowa fibrowa typowa	Dystric Ombric Drainic Hemic Fibric Histosol
	5	43	50°28'22.8"/ 16°17'48.8"	gleba torfowa fibrowa typowa	Dystric Drainic Fibric Histosol

incubations at 28°C (Gotkiewicz 1974) in climatic chambers (THe AG-1440), with daily controls of the soil moisture. All soil samples were analyzed in triplicate. Obtained results of nitrogen mineralization were statistically collated with actual soil moisture, groundwater level, monthly mean air temperature and monthly sum of precipitation. Statistical analysis was done using Statistica 10 software system (StatSoft Inc. Tulsa, OK).

RESULTS AND DISCUSSION

Classification of studied soils

Based on the morphological features and physicochemical properties, investigated soils were classified according to PSC (2011) and FAO-WRB (IUSS Working Group WRB 2015). According to WRB, studied soils belong to two reference groups: Gleysols (Profiles 1–4) and Histosols (Profiles 5–13) with addition of various principal and supplementary qualifiers (see Table 2). Criteria of PSC (2011) allowed to classify soil profiles along the transect A (profiles 1–4) as peat gleysols (in Polish: gleby torfowo-glejowe), whereas shallow organic soils from study sites B and C represented various types of peat soils (in Polish: gleby torfowe). In the author's opinion, shallow organic soils have been omitted in the actual PSC (2011). It is clearly stated that organic soils classification has to be done based on the dominant soil material in the center layer „piętro środkowe" (40–100 cm), while in some cases of shallow peat soils the organic layer thickness slightly exceed 40 cm. In such situations, the most sensible approach would be to determine the subtype of the shallow organic soils based on the dominant type of peat material (sapric, hemic, fibric) in the profile. Present version of PSC (2011) defined only the minimum organic layer thickness (≥ 40 cm) for shallow organic soils. In the author's opinion the depth limit should be also clearly define (the author's proposal is 80 cm). This proffers should be considered during developing of the next Classification of Polish Soils update. Additionally the new subtype within the type of peat soils (in Polish: gleby torfowe) should be implement to the classification: shallow fibric peat soils (in Polish: gleby torfowe fibrowe płytkie). This classification unit could include shallow organic soils (organic material thickness ≥40 cm and ≤80 cm) mainly consists of fibric peat material and lying directly on mineral bedrock. Above mentioned proposals have been presented based on the results obtained in this study. However, heterogeneous shallow organic soils consisting of various peat materials are present also in other parts of the Stołowe Mountains (Bogacz and Roszkowicz 2010, Bogacz and Rutkowska 2010, Glina et al. 2013) other ranges of Sudetes Mountains (Bogacz 2005, Bogacz and Ochej 2008, Glina and Bogacz 2013, Kabała (ed.) 2015), as well as in Polish part of Carpathian Mountains (Łajczak 2013).

Seasonal dynamics of nitrogen mineralization

The C/N ratio in the investigated soils was mainly above the 20 (Table 3). The C/N ratio in the case of soils form study site C was even above 30. The lowest values of C/N ratio was observed in the organo-mineral soil profile 2 from site A and organic soil profile 1, site C (Table 3). The obtained results testify the low rate of organic matter mineralization (Lucas 1982). The system of open drainage channels in the SMNP has not been maintained since several years (Kabała et al. 2011). Drainage ditches are partly overgrown by natural vegetation or infilling with sand (Bogacz et al. 2012, Sienkiewicz and Wójcik 2012). It could reduce the water outflow from the investigated peatland areas and increased soil moisture, as defined by Morison (2013).

Recorded concentration of ammonium (range 3.54–24.6 mg·dm^{-3}) and nitrate (range 0.03–1.70 mg·dm^{-3}) forms were very low. The analysis of seasonal nitrogen mineralization (N-NH$_4$ and N-NO$_3$) showed vast domination of N-NH$_4$ over the N-NO$_3$ form in the studied soils (Table 4). The highest mean content of N-NO$_3$ among study soils were observed in summer and autumn in soils from peatland C (Table 4).Concentration of NO$_3$ in the study site C in the summer was significantly higher than in other research transects in this period (Figure 2). Contents of N-NO$_3$ in soils from study site A and B measured during the growing season in 2012 was very low (Table 4, Figure 4). The amount of nitrate nitrogen in investigated soils was strongly positively correlated with air temperature (Table 5). The highest mean content of N-NH$_4$ in study

TABLE 3. Basic soil properties

Study site	Profile No.	RF (%)	Ash (%)	pH in H_2O	TOC (%)	TN (%)	C/N
A	1	6–75*	11.2–38.4	4.4–4.6	30.3–40.2	1.46–2.35	16.2–27.4
		35**	18.4	4.4	37.8	1.79	21.8
	2	5–13	11.0–34.6	3.9–4.5	33.2–40.9	1.79–2.23	14.9–22.9
		9	21.0	4.1	38.2	2.04	19.0
	3	5–9	11.9–59.6	4.3–4.6	16.9–40.2	0.88–1.54	19.2–31.1
		7	30.4	4.4	33.3	1.26	25.9
	4	5–10	11.2–64.7	3.9–4.4	23.6–40.5	1.01–2.31	14.0–26.9
		7	26.7	4.2	33.7	1.77	20.1
B	1	12–39	12.8–25.9	3.9–4.0	39.8–44.1	1.42–1.60	26.7–28.0
		21	18.6	3.9	42.0	1.53	27.4
	2	14–48	4.31–3.7	3.6–3.9	45.0–49.3	1.15–1.61	29.3–39.1
		38	8.80	3.8	47.5	1.44	33.3
	3	36–58	4.42–23.8	3.3–3.8	43.2–52.4	1.17–1.97	23.1–40.7
		48	11.1	3.6	47.1	1.55	32.0
	4	12–54	2.11–25.6	3.4–3.8	44.1–52.5	1.17–2.66	19.7–31.4
		42	10.8	3.5	47.4	1.79	28.2
C	1	3–39	27.4–82.2	3.4–3.9	14.5–28.4	0.60–1.50	14.2–25.0
		18	60.1	3.7	22.3	1.17	19.8
	2	35–67	4.62–27.9	3.7–4.2	32.5–43.2	1.04–1.69	19.3–41.4
		50	11.4	3.9	41.0	1.39	30.8
	3	8–85	3.60–43.3	3.8–4.0	29.1–45.0	0.97–1.55	25.4–37.9
		43	20.1	3.9	38.4	1.33	29.3
	4	10–70	7.80–65.9	4.0–4.2	18.1–41.9	0.70–1.39	25.7–42.1
		37	25.5	4.1	35.9	1.05	34.0
	5	10–45	12.4–63.5	3.5–3.7	17.6–43.6	0.67–1.16	26.5–40.5
		35	27.6	4.6	34.7	0.99	34.3

Explanation: * range; ** mean; RF – rubbed fiber content; TOC – total organic carbon; TN – total nitrogen.

TABLE 4. Seasonal dynamic of nitrogen mineralization

Study site	Soil profile	Spring				Summer				Autumn			
		N-NO$_3$	N-NH$_4$	SM	water level	N-NO$_3$	N-NH$_4$	SM	water level	N-NO$_3$	N-NH$_4$	SM	water level
		mg·dm^{-3}		(% v/v)	m b.g.l.	mg·dm^{-3}		(% v/v)	m b.g.l.	mg·dm^{-3}		(% v/v)	m b.g.l.
A	1	0.03–0.08** 0.05**	2.87–17.9 8.41	74.1–89.8 84.2	0.05	0.02–0.09 0.09	3.71–11.4 7.13	79.1–87.0 82.4	0.00	0.02–0.13 0.09	4.71–25.0 10.3	73.1–90.8 81.7	0.03
	2	0.05–1.01 0.33	2.33–28.1 10.0	84.0–89.9 81.2	0.00	0.01–0.09 0.04	4.08–8.71 5.65	76.8–85.9 82.8	0.00	0.04–0.11 0.07	4.40–8.64 5.99	78.5–89.0 83.7	0.00
	3	0.02–0.04 0.03	2.61–17.0 8.44	85.6–91.9 76.3	0.02	0.02–0.09 0.06	2.69–7.93 5.41	74.0–81.5 77.8	0.10	0.03–0.04 0.04	4.50–20.1 9.58	75.7–82.8 79.3	0.05
	4	0.32–0.44 0.36	4.02–24.9 12.7	83.7–86.5 79.1	0.05	0.04–0.08 0.05	1.35–12.3 7.84	68.6–86.3 77.9	0.20	0.02–0.06 0.04	3.20–20.5 8.75	72.1–81.0 76.2	0.08
B	1	0.02–0.13 0.06	6.45–16.9 12.2	77.2–81.6 79.7	0.10	0.03–0.07 0.06	7.75–18.0 11.4	76.6–80.4 78.9	0.08	0.02–0.04 0.03	3.95–7.13 5.49	76.0–81.3 79.5	0.10
	2	0.03–0.19 0.09	8.44–27.7 18.5	82.2–92.6 86.8	0.05	0.05–0.42 0.18	6.38–10.0 7.62	82.7–87.0 85.5	0.05	0.03–0.06 0.04	3.72–11.4 7.87	83.6–90.7 87.0	0.05
	3	0.03–0.61 0.22	2.16–21.4 11.8	62.0–92.2 88.2	0.15	0.03–0.62 0.23	2.27–29.3 13.5	86.0–90.8 88.9	0.05	0.03–0.05 0.04	4.59–21.2 10.1	75.2–91.0 86.0	0.15
	4	0.02–0.16 0.05	5.56–20.4 11.3	89.5–92.0 85.3	0.10	0.02–0.09 0.04	1.54–23.2 9.56	80.7–85.3 83.4	0.10	0.04–0.08 0.06	5.10–13.2 9.60	83.5–88.3 86.3	0.12
C	1	0.07–0.54 0.30	2.92–9.42 4.99	64.6–87.2 73.4	0.20	0.48–1.12 0.68	0.72–9.26 3.54	38.1–54.5 48.0	0.40	0.21–0.73 0.38	2.63–9.61 5.15	65.3–70.8 70.6	0.22
	2	0.04–0.05 0.04	7.36–23.3 14.7	82.2–92.6 89.0	0.10	0.59–0.95 0.83	5.69–27.8 14.1	83.5–90.7 86.3	0.15	0.42–0.68 0.54	6.38–20.5 13.6	84.0–9.18 89.1	0.13
	3	0.02–0.28 0.09	3.32–9.23 5.13	62.0–92.2 80.6	0.14	0.79–1.56 1.02	1.79–15.0 5.26	54.7–81.7 70.1	0.20	0.17–0.52 0.36	6.38–8.74 7.44	66.4–71.8 74.7	0.17
	4	0.10–1.01 0.37	7.85–24.1 16.4	89–91.8 91.2	0.10	0.58–3.00 1.21	14.7–30.0 22.5	88.8–90.9 90	0.07	0.35–1.05 0.55	18.0–29.4 24.6	73.0–92.9 84.8	0.10
	5	0.17–0.67 0.37	5.27–15.7 12.4	48.1–93.0 77.9	0.27	0.68–2.49 1.70	2.63–19.7 10.6	69.6–90.1 79.6	0.40	0.12–0.48 0.33	1.04–19.2 8.10	51.0–83.7 71.6	0.36

Explanation: *range, **mean value; SM – soil moisture; b.g.l. – below ground level.

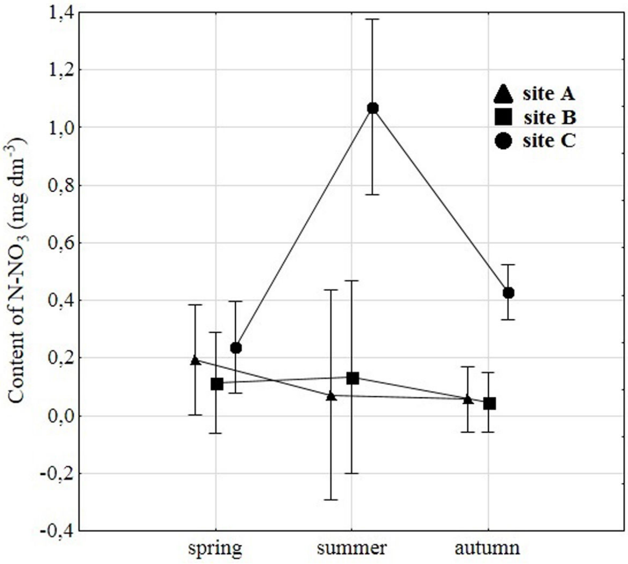

FIGURE 2. Comparison of seasonal variability of $N\text{-}NO_3$ content (mean values) between study sites

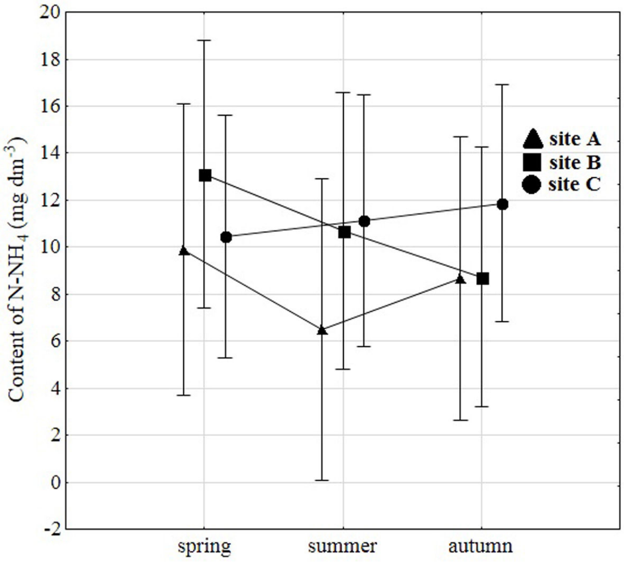

FIGURE 3. Comparison of seasonal variability of $N\text{-}NH_4$ content (mean values) between study sites

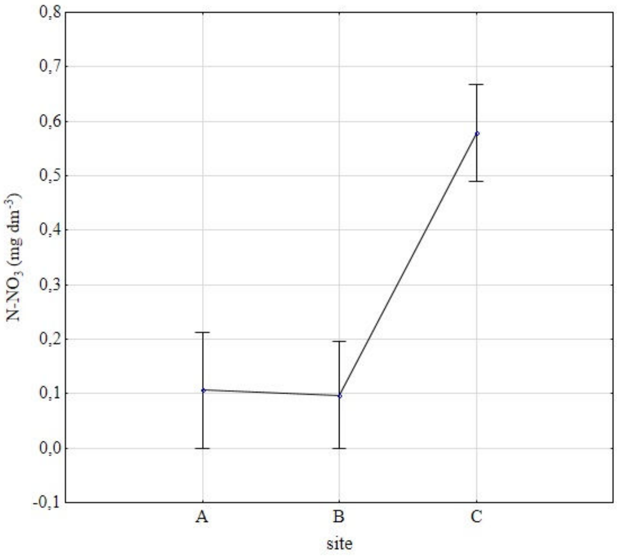

FIGURE 4. Mean content of $N\text{-}NO_3$ in each study site during the growing season 2012

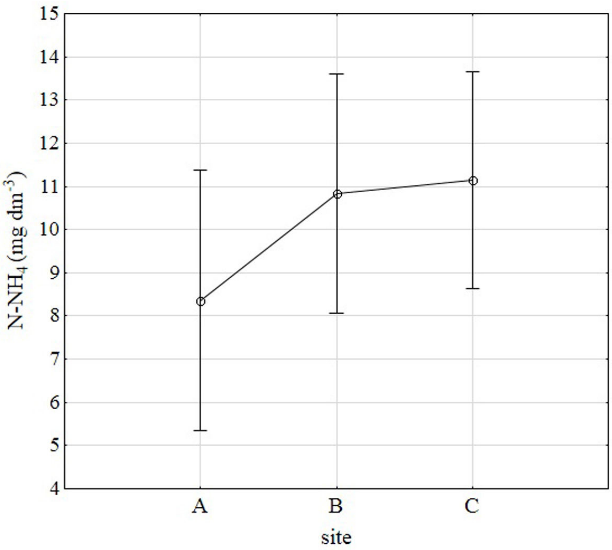

FIGURE 5. Mean content of $N\text{-}NH_4$ in each study site during the growing season 2012

soil profiles during the growing season 2012 was observed in peatland C (Figure 5). However, statistically significant seasonal differentiation among the study sites was not observed (Figure 3). The amount of ammonium nitrogen in investigated soils was strongly positively correlated with actual soil moisture (r=0.570) and groundwater level (r=0.544) (Table 5).

TABLE 5. Pearson correlation coefficient between mineral nitrogen forms and selected environmental factors (n=117)

	Soil Moisture	Temperature	Precipitation	Groundwater level
$N\text{-}NO_3$	-0.155	0.356*	0.253	-0.184
$N\text{-}NH_4$	0.570*	-0.139	-0.142	0.544*

*correlation significant at $p<0.05$.

Based on results described above, it can be stated that investigated organic soils are under weak mineralization process, what is confirmed by dominance of ammonium $N\text{-}NH_4$ over the nitrate $N\text{-}NO_3$ forms (Bayley et al. 2005, Gao et al. 2009). This might be the effect of high groundwater level appearing periodically in the year. The high soil moisture limits the microbial activity (Makarov et al. 2010), responsible for nitrogen mineralization (Lapalainen et al. 2013). On the other hand, the domination of ammonium over the nitrate form in the mountain peatlands, particularly in the surface soil layers often is the effect of atmospheric deposition (Evans et al. 2000). Higher $N\text{-}NO_3$

concentrations in soils along the research transect C than in the transects A and B, might be the effect of water discharged by drainage ditches. Długie Mokradło bog (site C) is the most densely cut by network of drainage ditches (spacing from 1 to 3 meters) among all of the investigated peatlands (Glina 2014). Moreover in the peatlands A and B the vast portion of ditches are overgrown by natural succession or filled with sand (Kabała et al. 2011, Bogacz et al. 2012, Glina 2014), what limits the water outflow (Parry et al. 2014). Furthermore, higher temperatures might stimulate microbial activity (Gao et al. 2009) and evapotranspiration (Morison 2013), thereby accelerate the nitrogen mineralization process (Keller et al. 2004, Jonczak 2013). Observed significant dependency between ammonium nitrogen concentrations in mountain peatland soils and actual soil moisture are in line with findings reported by Keller et al. (2004) and Bayley et al. (2005). Mentioned authors described significant positive correlations between soil moisture and N-NH_4 concentration in boreal peat bogs. In ombrotrophic peatlands, soil moisture is exclusively determined by precipitation rate, which plays an important role in controlling the N mineralization in the organic soils (Charman et al. 2008).

CONCLUSIONS

1. The weak nitrogen mineralization in the investigated soils is the result of limiting water outflow from peatland areas by infilling drainage ditches with mineral material and overgrowing by natural succession.
2. The highest concentration of nitrate nitrogen form was observed in the organic soils from Długie Mokradło bog (study site C), what is the effect of water discharged by dens net of drainage ditches.
3. The content of ammonium nitrogen (N-NH_4) was mainly determined by actual soil moisture and precipitation rate, whereas the content of nitrate form (N-NO_3) by air temperature and drainage.
4. The clear criteria for shallow organic soils classification and implementation of shallow fibric peat soils subtype (in Polish: gleby torfowe fibrowe płytkie) within the type of peat soils should be considered during developing of the next update of Polish Soil Classification.

ACKNOWLEDGMENTS

The research was co-financed by the European Union as part of the European Social Fund – „Grant Plus" program, Grant No. DG-G, 4170/13. Special thanks to Łukasz Mendyk for his help in preparation of location figure.

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Received: March 8, 2016
Accepted: July 14, 2016

Mineralizacja organicznych związków azotu w odwodnionych glebach z obszaru torfowisk użytkowanych leśnie w Parku Narodowym Gór Stołowych (Sudety Środkowe)

Streszczenie: Celem niniejszej pracy była ocena intensywności mineralizacji organicznych związków azotu w glebach torfowiskowych w Parku Narodowym Gór Stołowych zdrenowanych pod użytkowanie leśne. Dodatkowo w pracy poddano dyskusji problem klasyfikacji płytkich gleb organicznych według kryteriów zawartych w aktualnie obowiązującej Systematyce Gleb Polski (2011). W ramach badań zaprojektowano trzy transekty badawcze na obszarze torfowisk ombrogenicznych porośniętych głównie drzewostanem świerkowym. Każdy z transektów składał się z czterech (obiekt A i B) lub pięciu (obiekt C) powierzchni badawczych. Próbki gleby do podstawowych analiz właściwości gleb pobrano w kwietniu z każdego poziomu genetycznego. Natomiast próbki gleby o nienaruszonej strukturze do analizy sezonowej dynamiki mineralizacji azotu pobrano w kwietniu (wiosna), lipcu (lato) i październiku (jesień) roku 2012 z warstw 0–10 cm, 10–20 cm, 20–30 cm itd. Liczba próbek była warunkowana miąższością profilu glebowego. Analiza statystyczna wykazała, że zawartość N-NH_4 w badanych glebach było determinowane głównie przez aktualną wilgotność gleby oraz wielkość opadów. Zawartości N-NO_3 wykazywała tendencję wzrostową w okresach z wyższą temperaturą powietrza. Spośród badanych torfowisk najwyższe zawartości mineralnych form azotu zaobserwowano w glebach organicznych z obszaru Długiego Mokradła (obiekt C), położonego na wierzchowinie Skalniaka. Dodatkowo, przedstawiona praca wykazała potrzebę dodania nowego podtypu gleb torfowych fibrowych płytkich w obrębie typu gleb torfowych, co powinno być wzięte pod uwagę podczas opracowywania kolejnej aktualizacji Systematyki Gleb Polski.

Słowa kluczowe: azot mineralny, użytkowanie leśne, drenaż, torfowiska wysokie, Sudety