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BARTŁOMIEJ GLINA*, ADAM BOGACZ**, HANNA PIKUS***, JAN PAWLUCZUK****

THE IMPACT OF ANTHROPOPREASSURE AND WEATHER CONDITIONS ON THE MINERAL NITROGEN CONTENT IN THE ORGANIC SOILS FROM FEN PEATLANDS (STOŁOWE MOUNTAINS, SW POLAND)

Abstract. At the turn of the 19th and 20th centuries large peatland areas of the Stołowe Mountains were drained for the forestry use. The aim of the study was to assess the real impact of the natural (climate) and anthropogenic (forestry drainage) factors on the actual nitrogen mineralization in the shallow organic soils in the Stołowe Mountains National Park (SMNP). For the needs of the study, two research transects were established on the fen peatlands located in the central part of the SMNP. Each transect consisted of three sampling plots. The soil samples for the basic soil properties analysis were sampled in April, while undisturbed soil samples for mineral nitrogen were collected in April (spring), July (summer) and October (autumn) to show the seasonal dynamics of nitrogen mineralization. The obtained results revealed that the currently investigated fen peatland soils were rather slightly affected by the drainage network remains. A vast domination of ammonium over the nitrate form observed in the study soils during the growing season might indicate a periodical soil moisture increase limiting the mineralization process. The amount of precipitation and soil moisture had dominant impact on the N mineralization process, especially on the N-NO_3 concentrations.

Keywords: nitrogen, fen peatlands, organic soils, drainage, The Sudetes

* Corresponding author: B. Glina, Ph.D. Department of Soil Science and Land Protection, Poznań University of Life Sciences, , Szydłowska 50, 60-656 Poznań, e-mail: glina@up.poznan.pl

** A. Bogacz, DSc., Institute of Soil Science and Environmental Protection, Wrocław University of Environmental and Life Sciences, Grunwaldzka 53, 50-357 Wrocław.

*** H. Pikus MSc., Department of Mathematics and Computer Science, University of Warmia and Mazury in Olsztyn, Słoneczna 54, 10-710 Olsztyn.

**** J. Pawluczuk, DSc., Department of Soil Science and Soil Protection, University of Warmia and Mazury in Olsztyn, Plac Łódzki 3, 10-727 Olsztyn.

INTRODUCTION

The peatland soils, primarily for the last two centuries, were exposed to drainage for agricultural or forestry use (Ferrati et al. 2005; Limpens et al. 2008). This harmful process also concerned mountain peatlands, drained mainly for forestry use (Bogacz et al. 2012; Łajczak 2013). At the turn of the 19^{th} and 20^{th} centuries peatland ecosystems in the Stołowe Mountains (Central Sudetes) were drained to obtain a new area for afforestation by spruce monoculture (Stark 1936; Jędryszczak and Miścicki, 2001). Due to artificial drainage, a rapid decrease of the groundwater table is observed (Ferrati et al. 2005). This phenomenon increases aerobic conditions in organic soils, which promotes physical and chemical changes (Sokołowska et al. 2005; Markiewicz et al. 2015). Particular the mineralization of soil organic matter resulted in great amount of biogenic components released are the most common phenomenon (Pawluczuk and Szymczyk, 2008). In the soil organic matter mineralization process mainly mineral nitrogen forms (N-NO_3 and N-NH_4) are release. Actual weather conditions (Jason et al. 2004), soil moisture (Devito et al. 1999), organic matter type (Purvanto et al. 2005) and type of peatland management mainly affect the intensity of the indicated process (Tripathi and Sighn, 2009). In Poland, up till then, the aforementioned problem was described mainly with respect to lowland peatlands drained for agriculture (e.g., Pawluczuk 2006; Pawluczuk 2008; Smólczyński and Orzechowski, 2009). However, it is also an important problem for degraded mountain mires ecosystems (e.g., Basiliko et al. 2005; Bayley and Thorman 2005; Gao et al. 2009).

The main objective of the study was to investigate which natural (climate) or anthropogenic (drainage, forestry use) factors have dominant impact on actual nitrogen mineralization in the organic soils from the fen peatlands in the Stołowe Mountains National Park. Additionally, the paper will tackle the problem of the marked organic soil horizons with mineral material admixture according to the Polish Soil Classification (PSC 2011).

MATERIALS AND METHODS

For the needs of the study two research transects were established on the fen peatlands (A and B) located on the northern slope of Skalniak ridge – the second highest elevation in the SMNP. Each transect consisted of three sampling plots (Fig. 1, Tab. 1). The study site A is a spring fen peatland supply in water by seepages of highly mineralized groundwater (soligenic), while the fen peatland B in the edge parts is also seasonally fed by a local stream (Czerwona Woda) – fluviogenic type (Glina, 2014).

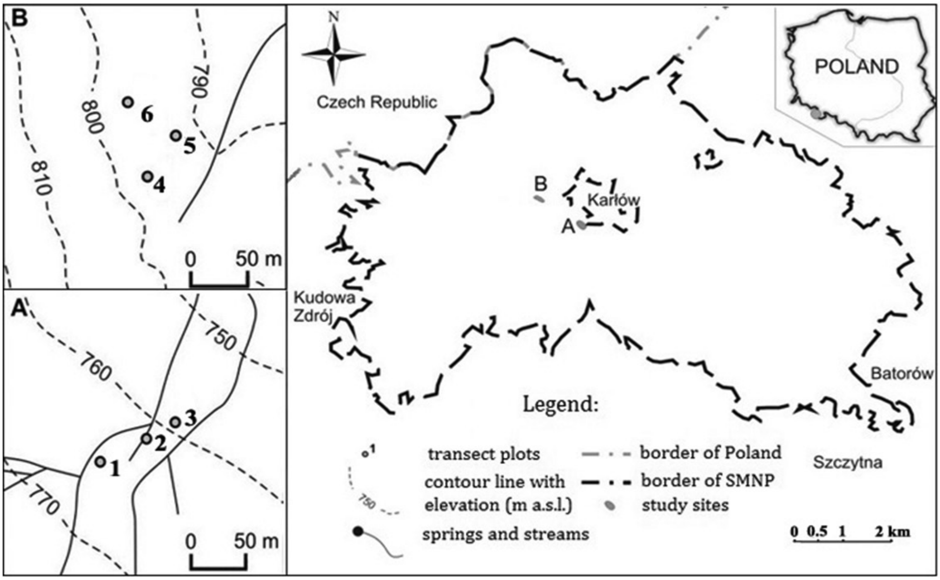

Fig. 1. Localization of the study area and transects sketch

The peatland B is covered by spruce monoculture, with addition of birch and beech. In the site A, all the tree species were cut down in 2010, nowadays the indicated peatland is covered mainly by sedge communities, grasses and shrubs. Both peatlands were developed over the sandstone-siltstone bedrock (Glina 2014). The field works were conducted and the samples were collected during the growing season in 2012, when the mean annual air temperature was 6.7°C, amounting to 17.0°C in the warmest month (July), and decreasing to -7.5°C in the coldest one (February). The annual sum of precipitation in 2012 was 786 mm, reaching a maximum level in July (169 mm) and a minimum one in March (14 mm) – the data come from the meteorological station in Kudowa Zdrój (Fig. 2).

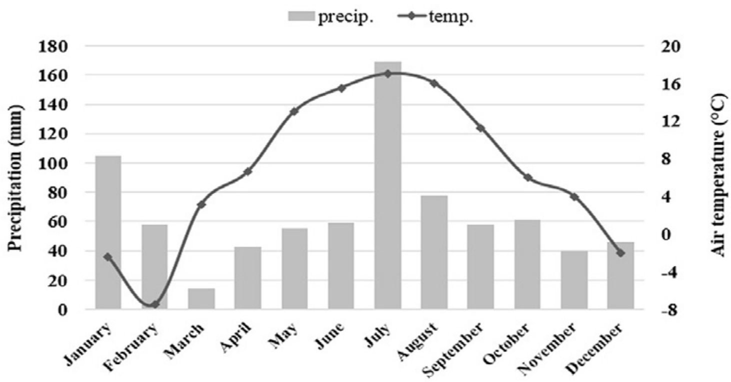

Fig. 2. Temperature and precipitation in the year 2012

The soil samples for the basic soil properties analysis (Tab. 2) were sampled in March. The undisturbed soil samples were collected in stainless steel rings (100 cm^3) in April (spring), July (summer) and October (autumn) to show the seasonal dynamics of nitrogen mineralization. Additionally, six piezometers were installed along the research transects for actual water table measurement. Before the laboratory analysis each soil sample was divided into two pieces. In fresh material the degree of peat decomposition was determined using the fiber volume method (Lynn et al. 1974). The remaining soil samples, after being dried at 105 °C, mixed and freed from plant remains facilitated the determination of the following soil properties: ash content after placing dried samples for 5h in a muffle furnace at 550^{o}C (Heiri et al. 2001), pH in distilled water and 1M KCl solutions (soil to water 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 contents of N-NO_3 and N-NH_4 were measured spectrometrically in 1% K_2SO_4 extracts

TABLE 1.STUDY SITES CHARACTERISTIC

Study site	Profile No.	Depth (cm)	Coordinates WGS 84 (N/E)	Elevation m.a.s.l.	Slope	Soil classification PSC 2011	Soil classification FAO-WRB 2015
A	1	54	50°28'06.8"/ 16°20' 25.2"	758	4°	gleba organiczna saprowo-murszowa	Orthoeutric Rheic Murshic Sapric Histosol
	2	80	50° 28' 06.3"/ 16°20' 23.9"	763	4°	gleba torfowa saprowa płytka	Orthoeutric Rheic Sapric Histosol (Lignic)
	3	80	50°28'05.6"/ 16°20'21.8"	767	4°	gleba organiczna saprowo-murszowa	Orthoeutric Rheic Murshic Sapric Histosol (Lignic)
B	4	43	50°28'19.7"/ 16°19'39.5"	799	2°	gleba torfowa saprowa płytka	Eutric Drainic Sapric Histosol
	5	49	50°28'20.9"/ 16°19'40.7"	792	2°	gleba torfowa saprowa płytka	Eutric Drainic Sapric Histosol
	6	54	50°28'21.8"/ 16°19'38.9"	794	2°	gleba organiczna saprowo-murszowa	Dystric Murshic Sapric Histosol

with Nessler's reagent (for NH_4) and phenol disulfonic acid (for NO_3) after 14 days incubations at 28°C (Gotkiewicz 1974) in climatic chambers (THe AG-1440), with daily controls of the soil moisture. All the soil samples were analyzed in triplicate. Based on the morphological features and physico-chemical properties, the soils were classified according to the Polish Soil Classification (PSC 2011) and FAO-WRB (IUSS Working Group WRB, 2015). The statistical analysis of variance (ANOVA) was made using the Statistica 12 software system (StatSoft Inc., Tulsa, OK). The obtained results of nitrogen mineralization were collated with the actual soil moisture and meteorological data (monthly mean air temperature and monthly sum of precipitation).

TABLE 2. BASIC PROPERTIES OF STUDY SOILS (MEAN VALUES)

Study site	Profile No.	Soil horizon	Depth (cm)	RF (%)	Ash (%)	pH		TOC (%)	TN (%)	TOC/ TN
						H_2O	KCl			
A	1	M1	0-12	-	28.2	5.8	5.2	34.6	1.93	17.9
		M2	12-25	-	34.4	5.7	5.2	31.5	1.82	17.3
		Oa1	25-40	5	51.0	5.7	5.3	23.2	1.16	20.0
		Oa/C	40-54	4	78.4	6.0	5.2	10.5	0.55	19.1
	2	Oe	0-7	10	16.3	6.2	5.9	40.1	2.87	13.9
		Oa1	7-22	9	17.9	5.8	5.5	40.4	2.69	15.0
		Oa2	22-37	6	16.9	5.9	5.3	41.8	2.44	17.1
		Oa3	37-55	6	20.9	5.8	5.3	39.7	1.89	21.0
		Oa4	55-80	5	19.4	6.0	5.4	40.8	2.06	19.8
	3	M1	0-12	-	16.9	6.0	5.7	39.8	2.73	14.6
		M2	12-20	-	18.6	5.8	5.3	39.5	2.67	14.8
		Oa1	20-35	4	19.8	5.7	5.2	40.8	2.76	14.8
		Oa2	35-50	5	16.3	5.8	5.2	42.4	2.44	17.4
		Oa3	50-80	8	30.2	5.9	5.3	34.5	1.61	21.4
B	4	Oe	0-7	38	11.3	4.5	3.7	20.2	0.69	29.2
		Oa1(+)	7-14	-	77.6	5.5	5.1	12.2	0.55	22.1
		Oa2	14-31	5	29.2	5.8	5.5	32.1	1.29	24.9
		Oa3	31-37	5	27.2	6.2	5.7	31.6	1.23	25.7
		Oa4	37-43	3	41.5	6.0	5.6	26.1	0.86	30.4
	5	Oa1	0-3	13	14.5	5.1	4.8	45.1	1.68	26.9
		Oa2	3-20	5	32.1	5.5	5.2	32.3	1.65	19.6
		Oa3	20-30	3	32.9	5.6	5.1	26.3	1.22	21.5
		Oa4	30-41	3	46.5	5.8	5.2	27.1	1.34	20.2
		Oa5	41-49	3	52.4	5.8	5.2	24.4	1.19	20.5
	6	Olf(+)	3-0	-	72.0	4.3	3.5	34.1	1.16	29.4
		M1	0-14	-	30.3	4.5	3.8	28.5	1.47	19.3
		M2	14-30	-	37.7	4.7	4.0	27.3	1.14	23.9
		Oa1	30-41	2	32.0	4.8	4.1	24.0	1.11	21.7
		Oa2/C	41-54	1	36.9	5.5	4.8	15.8	0.87	18.1

Explanation: RF – rubbed fiber content; TOC – total organic carbon, TN – total nitrogen

TABLE 3. STUDY SITE A - DYNAMICS OF NITROGEN MINERALIZATION (MEAN VALUES)

Pro-file No.	Soil horizon	Depth (cm)	spring				summer				autumn			
			$N\text{-}NO_3$	$N\text{-}NH_4$	Soil Moisture	Water level	$N\text{-}NO_3$	$N\text{-}NH_4$	Soil Moisture	Water level	$N\text{-}NO_3$	$N\text{-}NH_4$	Soil Moisture	Water level
			$mg \cdot dm^{-3}$		(% v/v)	m b.g.l.	$mg \cdot dm^{-3}$		(% v/v)	m b.g.l.	$mg \cdot dm^{-3}$		(% v/v)	m b.g.l.
1	M1	0-12	2.99	3.68	73.7	0.30	0.27	3.76	80.7	0.10	0.48	4.66	77.5	0.15
	M2	12-25	2.12	3.66	73.2		0.13	4.04	82.9		0.27	1.14	70.9	
	Oa1	25-40	1.48	7.75	75.7		0.22	6.75	78.8		0.28	1.13	70.0	
	Oa/C	40-54	1.20	10.2	76.6		0.07	10.80	80.7		0.39	4.76	69.5	
2	Oe	0-7	0.41	7.26	83.8	0.10	0.06	5.03	80.7	0.05	0.03	2.66	83.8	0.00
	Oa1	7-22	0.11	6.25	78.1		0.11	4.32	82.7		0.07	2.96	82.7	
	Oa2	22-37	1.21	4.08	84.7		0.20	4.59	86.6		0.02	4.90	84.7	
	Oa3	37-55	0.18	4.59	84.4		0.09	4.84	89.1		0.04	2.32	86.9	
	Oa4	55-80	0.12	4.85	89.1		0.05	7.87	88.3		0.06	4.21	88.3	
3	M1	0-12	0.58	3.93	81.1	0.15	0.05	4.71	85.0	0.05	0.04	1.55	81.9	0.10
	M2	12-20	0.14	4.93	81.5		0.48	5.03	83.3		0.28	3.55	80.3	
	Oa1	20-35	0.12	4.47	78.4		0.06	4.45	83.4		0.08	2.63	82.8	
	Oa2	35-50	0.10	2.83	83.0		0.05	5.43	70.4		0.04	1.54	83.1	
	Oa3	50-80	0.77	4.02	77.5		0.10	5.22	84.4		0.07	3.03	78.0	

TABLE 4. STUDY SITE B - DYNAMICS OF NITROGEN MINERALIZATION (MEAN VALUES)

Pro-file No.	Soil horizon	Depth (cm)	spring				summer				autumn			
			$N-NO_3$	$N-NH_4$	Soil Moisture	Water level	$N-NO_3$	$N-NH_4$	Soil Moisture	Water level	$N-NO_3$	$N-NH_4$	Soil Moisture	Water level
			$mg \cdot dm^{-3}$		(% v/v)	m b.g.l.	$mg \cdot dm^{-3}$		(% v/v)	m b.g.l.	$mg \cdot dm^{-3}$		(% v/v)	m b.g.l.
4	Oe	0-7	0.90	9.27	77.4	0.30	0.02	6.11	86.4	0.05	0.09	9.20	78.2	0.05
	Oa1(+)	7-14	0.19	9.89	83.1		0.03	15.9	70.1		0.03	17.2	73.6	
	Oa2	14-31	0.10	6.07	78.7		0.03	11.5	84.1		0.05	12.5	75.3	
	Oa3	31-37	0.13	6.93	89.2		0.02	10.6	87.4		0.04	11.2	72.4	
	Oa4	37-43	-	-	-		-	-	-		-	-	-	
5	Oa1	0-3	-	-	-	0.20	-	-	-	0.10	-	-	-	0.05
	Oa2	3-20	0.68	20.9	72.5		0.27	22.2	80.8		0.02	24.3	74.3	
	Oa3	20-30	0.04	5.15	71.7		0.03	5.58	72.5		0.05	6.40	69.5	
	Oa4	30-41	0.03	4.74	64.0		0.37	5.47	77.4		0.03	6.10	87.4	
	Oa5	41-49	0.03	3.96	54.5		0.12	4.38	70.5		0.02	4.60	64.6	
6	Olf(+)	3-0	-	-	-	0.15	-	-	-	0.35	-	-	-	0.10
	M1	0-14	0.07	4.12	68.0		0.74	3.93	60.5		0.02	4.00	81.7	
	M2	14-30	0.02	4.25	66.5		0.92	4.20	65.3		0.01	4.40	78.5	
	Oa1	30-41	0.02	3.95	65.4		0.05	3.91	64.3		0.01	4.00	75.6	
	Oa2/C	41-54	0.02	5.23	72.1		0.03	4.62	65.5		0.02	4.60	76.9	

RESULTS AND DISCUSSION

Soil classification and morphology

Based on the field survey and the basic laboratory analysis (Tab. 2) the investigated shallow organic soils were classified as Sapric Histosols, with addition of various principal and supplementary qualifiers (IUSS Working Group WRB, 2015). In the PSC (2011) soil profiles 1, 3 and 6 represented sapric murshic peat soils (in Polish: gleby organiczne saprowo-murszowe), while soil profiles 2, 4 and 5 were classified as shallow sapric peat soils (in Polish: gleby torfowe saprowe płytkie) (see Tab. 1). Moorsh horizons with aggregate structure observed in the topsoil of profiles 1, 3 and 6 constitute a visible effect in soil morphology of the long-term forestry drainage in SMNP. The indicated soils were under medium stage of mursh process – MtII (profile 1 and 3) and strong stage of mursh process – MtIII (profile 6) according to classification proposed by Okruszko (1993). The PSC (2011) assumes that admixture of fluvial mineral material in the organic soils should be marked as C. This symbol is also used for marking underlying mineral material of organic soils, which frequently have different texture and genesis than fluvial material in the topsoil. The described situation occurs in the study soil profiles 4 and 6, where underlying bedrock (C) is loamy textured material, while in the topsoil admixture of sandy material (derived from weathering of sandstones) transported by local stream "Czerwona Woda" is observed. The substantial admixture of mineral material in the surface horizons of organic soils from the Stołowe Mountains were also described by Bogacz and Roszkowicz (2010). According to the actual definition in the PSC (2011) the soil horizons should be marked as Oa/C, which indicates that admixture of underlying material occurs in the topsoil of the investigated soil profiles. For that reason, it is proposed to add „+" to organic horizon symbol with significant mineral material admixture in the upper 50 cm of the soil profile - Oa(+),which improves the readability of organic soil morphology. This proposal should be considered in the next development of the Polish Soils Classification update.

Seasonal dynamics of nitrogen mineralization

The organic matter mineralization, as indicated by the TOC/TN ratio, showed a differentiation between the studied soils (Tab. 2). The lowest ratios, mainly below 20, were observed in the shallow organic soils from the study site A. It indicates a periodical drying of soils and slightly organic matter mineralization (Bogacz and Roszkowicz, 2010). The values of TOC/TN ratio below 16 (upper 35 cm in the profile 3), according to Bieniek et. al. (2007) might indicate low susceptibility to further transformation of soil organic matter. In the soil profiles 4, 5 and 6 (site B) the measured ratios were slightly higher and ranged between 18.1 and 30.4. A lower TOC/TN value in the fen peatland A than that in the peatland B may be the result of local land relief. The rapid water outflow in the sloped (4°) treeless area (site A) might reinforce the drainage of peatland.

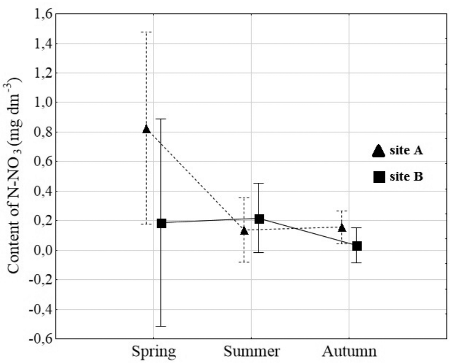

Fig. 3. Comparison of mean $N\text{-}NO_3$ content between sites A and B during the growing season

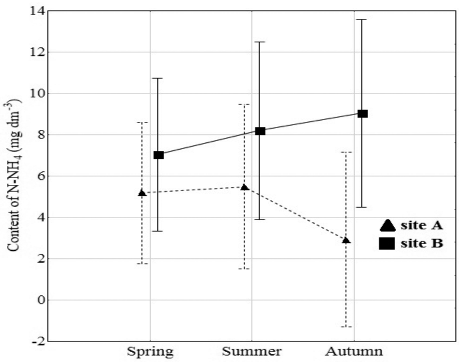

Fig. 4. Comparison of mean $N\text{-}NH_4$ content between sites A and B during the growing season

The results of seasonal dynamics of the measured mineral nitrate forms ($N\text{-}NH_4$ and $N\text{-}NO_3$) demonstrated weak seasonal variability of N mineralization. The recorded content of ammonium and nitrate forms in the fen peatlands soils from SMNP were very low, but vast domination of $N\text{-}NH_4$ over the $N\text{-}NO_3$ form was observed (Tab. 3 and 4). The highest mean content of $N\text{-}NO_3$ among study soils were found during the spring period, except soil profile 6, where the highest concentrations of nitrate forms were observed in summer (Table 4). In this work statistically weak and significantly negative correlations between nitrate form concentrations and precipitation ($r= -0.27$; $p<0.0001$) were observed. In the study A the mean concentration of $N\text{-}NO_3$ in spring (the lowest amount of precipitation) was significantly higher than in summer and autumn, while for the site B, seasonal dependency was not statistically proven (Fig. 3). No seasonal statistically significant effect on mean $N\text{-}NH_4$ concentration was found, both in soils form the study A and B (Fig. 4).

The comparison of study sites disclosed that during the growing season in 2012 the content of nitrate forms was higher in soils from the transect A, while the ammonium form displayed higher values along the transect B (Tab. 5). The ANOVA analysis showed statistically significant difference between the mean $N\text{-}NO_3$ ($F=7.96$; $p=0.001$) and $N\text{-}NH_4$ ($F=15.5$; $p=0.00001$) concentrations in different seasons (Tab. 5). The described results indicate that actual investigated organic soils undergo rather a weak mineralization process. It is confirmed by a great dominance of the ammonium $N\text{-}NH_4$ over the nitrate $N\text{-}NO_3$ forms (Gao et al. 2009). As it was reported by Smólczyński and Orzechowski, (2009), such situation is the effect of periodic high groundwater table, which limits the microbial activity (Bieniek et al. 2007; Makarov et al. 2010). Although it should be noted that the increase of the ammonium form in the topsoil layers may result from the atmospheric deposition in the mountain peatlands (Evans et al. 2000). The N-mineralization in study soils was strongly correlated with the soil moisture (r = -0,65; p<0.0001) and precipitation. The highest concentration of the N-NO_3 was noticed in spring, when low soil moisture level was observed (Tab. 3).

TABLE 5.COMPARISON OF SEASONAL NITROGEN MINERALIZATION BETWEEN STUDY SITE

	N-NO_3						N-NH_4					
	Spring		Summer		Autumn		Spring		Summer		Autumn	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
A	0.83	0.18	0.14	0.06	0.15	0.03	5.18	0.95	5.49	1.11	2.93	1.18
B	0.19	0.20	0.22	0.07	0.03	0.03	7.04	1.03	8.20	1.20	9.04	1.27
F	7.96						15.5					
p	0.001						0.00001					

Explanation: M – mean, SD - standard deviation; F – analysis of variance ANOVA; p - significance

Low precipitation and higher temperatures might stimulate microbial activity and thereby accelerate the mineralization process (Gao et al. 2009; Jonczak, 2013). Davenport and DeMorainvile (2004) reported in a laboratory experiment that the organic soil (peat or mursh), in higher temperature (above 18^{0}C) is associated with the increased N mineralization rate.

CONCLUSIONS

1. The weak nitrogen mineralization observed in the investigated soils indicated that currently the fen peatland soils in the Stołowe Mountains are under minor impact of the drainage network remains.
2. The vast domination of ammonium over the nitrate form indicates a periodical soil moisture increase, which limits the mineralization process.
3. The statistical analysis showed that the amount of precipitation and actual soil moisture had dominant impact on the N mineralization process, especially the N-NO_3 concentrations in organic soils.

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REFERENCES

[1] Basiliko N., Moore T.R., Lafleur P.M., Roulet N.T., 2005. Seasonal and inter-annual decomposition, microbial biomass, and nitrogen dynamics in a Canadian bog. Soil Science, 170: 902-912. **http://dx.doi.org/10.1097/01.ss.0000196765.59412.14**

[2] Bayley S. E., Thormann M. N., 2005. Nitrogen mineralization in western boreal bog and fen peat. Ecoscience, 12, 4: 455-465.

[3] Bieniek B., Karwowska J., Bieniek A., 2007. Chemical properties of extensively utilized muck soils in the "Siódmak" peatland. Soil Science Annual, 58, 1/2: 12-23.

[4] Bogacz A., Roszkowicz M., 2010. Influence of forest management on the changes of organic soil properties in marginal part of Kragle Mokradło Peatlands (Stołowe Mountains National Park). Soil Science Annual, 61, 2: 15-20.

[5] Bogacz A, Dzięcioł D., Glina B, Gersztyn L., 2012. Peat soils in the restoration Niknąca Łąka peatland in the Stołowe Mountains National Park. Soil Science Annual, 63, 2: 3-8. **http://dx.doi.org/10.2478/v10239-012-0015-2**

[6] Davenport J.R., DeMoranvile C., 2004. Temperature influences Nitrate Release Rates in Cranberry Soils. Horticulture Science, 39, 1: 80-83.

[7] Devito K.J., Westbrook C.J., Schiff S.L., 1999. Nitrogen mineralization and nitrogen catchments in upland and peatland forest soil in two Canadian Shield. Canadian Journal of Forest Research. 22, 11: 1793-1804. **http://dx.doi.org/10.1139/S08-024**

[8] Evans C.D., Jenkins A., Wright R.F., 2000. Surface water acidification in the South Pennines - Current status and spatial variability. Environmental Pollution, 109: 11-20. **http://dx.doi.org/10.1016/S0269-7491(99)00241-9**

[9] Ferrati, R., Canziani, G.A., Moreno, D.R. 2005. Estero del Ibera: hydrometeorological and hydrological characterization. Ecological Modelling, 186: 3-15. http://dx.doi.org/10.1016/j.ecolmodel.2005.01.021

[10] Gao J.Q., Ouyang H., Xu X.L., Zhou C.P., Zhang F., 2009. Effects of temperature and water saturation on CO_2 production and nitrogen mineralization in alpine wetland soils. Pedosphere, 19: 71-77. **http://dx.doi.org/10.1016/ S1002-0160(08)60085-5**

[11] Glina B., 2014. Spatial variability of the shallow organic soils in the Stołowe Mountains as a results of anthropogenic transformations. PhD thesis, Wrocław, p. 208

[12] Gotkiewicz J., 1974. Zastosowanie metody inkubowania próbek o nienaruszonej strukturze do badań nad mineralizacją azotu w glebach torfowych. Roczniki Nauk Rolniczych Seria F, 78, 4: 25-34.

[13] Heiri O., Lotter A. F., Lemcke G., 2001. Loss on ignition as a method for estimating organic and carbonate content in sediments: reproducibility and comparability of results. Journal of Paleolimnology, 25: 101–110.

[14] IUSS Working Group WRB., 2015. World reference base for soil resources 2014, update 2015. International Soil Classification System for Naming Soil and Creating Legends for Soil Maps. Food and Agriculture Organization of the United Nations, Rome, p. 190.

[15] Jason K., Keller, Jeffrey R., Bridgham S.D., Pastor J., 2004. Climate change effects on carbon and nitrogen mineralization; peatlands through changes in soil quality. Global Biology, 10, 7: 1053-1064. **http://dx.doi.org/10.1111/j.1529-8817.2003.00785.x**

[16] Jędryszczak E., Miscicki S., 2001. Forests of the Stołowe Mountains National Park. Szczeliniec, 5: 79–103.

[17] J o n c z a k J., 2013. Effect of peat samples drying on measured content of carbon and nitrogen fractions. Soil Science Annual, 64, 4: 130-134. **http://dx.doi.org/10.2478/ssa-2013-0020**

[18] L i m p e n s J., B e r e n d s e F., B l o d a u C., C a n a d e l l J.G., F r e e m a n C., H o l d - e n J., R o u l e t N., R y d i n H., S c h a p e m a n - S t r u b G., 2008. Peatlands and the carbon cycle: from local processes to global implications-a synthesis. Biogeosciences, 5: 1379-1419. **http://dx.doi.org/10.5194/bg-5-1475-2008**

[19] L y n n W.C., M c K i n z i e W.E., G r o s s m a n n R.B., 1974. Field laboratory test for characterization of Histosols. In: (Stelly M (ed.) Histosols: Their Characteristic and Use. SSSA Spec. Pub, 6 Medison, pp. 11-20.

[20] Ł a j c z a k A., 2013. Role of land relief and structure in the formation of peat bogs in mountain areas, as exemplified by the Polish Carpathians. Landform Analysis, 22: 61-73. **http://dx.doi.org/10.12657/ landfana.022.005**

[21] M a k a r o v M.I., L e o s h k i n a N.A., E r m a k A.A., M a l y s h e v a T.I., 2010. Seasonal Dynamic of the Mineral Nitrogen Forms in Mountain-Meadow Alpine Soil. Eurasian Soil Science, 43, 8: 905-913.

[22] M a r k i e w i c z M., M e n d y k Ł., G o n e t S.S., 2015. Soil organic matter status in agricultural soil sequence of former shoreline of disappearing Sumowskie lakes, North-Eastern Poland. Polish Journal of Soil Science, 48, 1: 65-78. **http://dx.doi.org/10.17951/pjss/2015.48.1.65**

[23] O k r u s z k o H., 1993. Transformation of fen-peat soils under the impact of draining. Zeszyty Problemowe Postepów Nauk Rolniczych, 406: 3–73.

[24] P a w l u c z u k J., 2006. Mineral components availability in gyttja-muck and peat-muck soil at Dymer object. Polish Journal of Environmental Studies, 15, 5D: 90-95.

[25] P a w l u c z u k J., S z y m c z y k S., 2008. Dynamics of mineral nitrogen mineralization in muck soils of dymerskie meadows and the content of nitrate and ammonium nitrogen in groundwater. Woda Środowisko, Obszary Wiejskie, 24, 2: 105-115.

[26] P a w l u c z u k J., 2008. Mineralization of organic nitrogen compounds in muck soils of Łąki Dymerskie at Mrągowo Lake district. Soil Science Annual, 59, 1: 183-191.

[27] P u r v a t o B.H., W a t a n a b e A., S h o o n J.F., K a k u d a K., A n d o H., 2005. Kinetic parameters of Gross N Mineralization of Peat Soils a Related to the Composition of Soil Organic Matter. Soil Science and Plant Nutrition, 51, 1: 109-115. **http://dx.doi.org/10.1111/j.1747-0765.2005.tb00013.x**

[28] Smólczyński S., Orzechowski M., 2009. Mineralization of nitrogen compounds in differently silted peat-muck soils in Young Glacial Landscape. Woda Środowisko, Obszary Wiejskie, 25, 1: 141-150.

[29] S o k o ł o w s k a Z., S z a j d a k L., M a t y k a - S a r z y ń s k a D., 2005. Impact of the degree of secondary transformation on acid–base properties of organic compounds in mucks. Geoderma, 127: 80 – 90. **http://dx.doi.org/10.10 16/j.geoderma.2004.11.013**

[30] S t a r k L., 1936. Zur Geschlichte der Moor und Walder Schliesens in postglazialer Zeit. Botanische Jahrbucher, 67: 494-640.

[31] Systematyka gleb Polski (The classification of Polish soils), 2011. Soil Science Annual, 62, 3: 1–193.

[32] T r i p a t h i N., S i g h n R.J., 2009. Influence on different land uses on soil nitrogen transformations after conversion from an India dry tropical forest. Catena, 77: 216-233. **http://dx.doi.org/10.1016/j.catena.2009.01.002**

WPŁYW ANTROPOPRESJI ORAZ WARUNKÓW POGODOWYCH NA ZAWARTOŚĆ AZOTU MINERALNEGO W GLEBACH ORGANICZNYCH Z OBSZARU STOKOWYCH TORFOWISK NISKICH W GÓRACH STOŁOWYCH

Na przełomie XIX i XX wieku znaczne obszary torfowiskowe Gór Stołowych zostały odwodnione w celu pozyskania nowych terenów pod zalesienia monokulturą świerka. Celem badań była ocena wpływu wybranych naturalnych (klimat) i antropogenicznych (drenaż, użytkowanie leśne) czynników na proces mineralizacji azotu w płytkich glebach organicznych z obszaru Parku Narodowego Gór Stołowych. W ramach badań zaprojektowano dwa transekty badawcze na obszarze stokowych torfowisk niskich zlokalizowanych na północnych stokach wierzchowiny Skalniaka. Każdy z transektów składał się z trzech powierzchni badawczych. Próbki glebowe do podstawowych analiz właściwości gleb pobrano w kwietniu. Próbki gleby o nienaruszonej strukturze do analizy zawartości mineralnych form azotu pobrano w kwietniu (wiosna), lipcu (lato) oraz w październiku (jesień),w celu wykazania sezonowej dynamiki mineralizacji azotu. Uzyskane wyniki wskazały, że obecnie badane płytkie gleby organiczne są raczej w niewielkim stopniu odwadniane przez starą sieć drenarską. Obserwowana zdecydowana dominacja amonu nad formą azotanową może wskazywać na okresowy wzrost wilgotności, co ogranicza proces mineralizacji. Aktualnie to zmienne czynniki pogodowe, głównie opady oraz wilgotność gleby determinują ilość uwalnianych form mineralnych azotu, co potwierdziła analiza statystyczna.