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MINERAL NITROGEN IN SOILS OF DIFFERENT LAND USE

MINERALNE FORMY AZOTU W GLEBACH O RÓŻNYM SPOSOBIE UŻYTKOWANIA

Abstract: Different land use influences both quantity and quality of soil nitrogen, especially its mineral forms. We conducted our study in Pruszkow soils of four different land using: fields (at the edge of town border), allotment gardens, lawns and fallows, 36 samples together. The town is part of the Warsaw agglomeration. It is small but densely populated.

Soil was sampled on July, from 0–20 cm depth. The textures of these soils were sands, loamy sands and silts.

Amount of total nitrogen in all studied soils was diverse and ranged from 0.33 to 1.91 g $\cdot$ kg^{-1} dry matter of soil. The highest average content of this element was found in soils of allotment garden (1.1 g $\cdot$ kg^{-1} dry matter of soil), and the lowest one in fallow soils (0.5 g $\cdot$ kg^{-1} dry matter of soil). Allotment garden soils were characterized as richest in N-NO_3 too (average 22.76 mg $\cdot$ kg^{-1} dry matter of soil). We observed slightly lower accumulation of this element in field soils (average 21.52 mg $\cdot$ kg^{-1} dry matter of soil). In individual cases the quantity of N-NO_3 exceeded even 40 mg $\cdot$ kg^{-1} dry matter of soil. Significantly lower amount of this element was found in lawns (average 8.79 mg $\cdot$ kg^{-1} dry matter of soil) and fallows (average 3.22 mg $\cdot$ kg^{-1} dry matter of soil). Different land use had no effect on ammonia amount in Pruszkow soils. The biggest share of N-NO_3 in N total was in fields, then in allotment gardens, lawns and smallest in fallows. Share of N-NH_4 in N total decreased in the following order: fields, fallows, lawns, allotment gardens. N-NO_3 forms prevailed in fields and allotment garden, while N-NH_4 predominated in lawns and fallows. Soil reaction had no effect on N-NO_3 and N-NH_4 amount and N–NO_3/N-NH_4 ratio.

We assumed that actual way of land use affects total nitrogen content and N-NO_3 content in soil. In town environment soils of allotment garden can contribute to water pollution.

Keywords: mineral nitrogen, land use, ammonia, nitrate

Organic compounds are the substantial part of soil nitrogen. Mineral forms account only for 1–2 % of total nitrogen, but these compounds take part in plant nutrition. If their amount exceeds the plant needs, they can be leached to water and cause its pollution. Nitrogen from fertilizers is utilized by plants only in 50–70 % [1]. Ammonia ions can be absorbed by the soil sorption complex. Nitrate ions are rinsed predominant-

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ly [2]. The attention of scientists is mainly focused on different fertilizers effects, different doses in various times, under different plants on nitrogen mineralization – its process and efficiency [3–11]. In natural environment chemical and physical properties of soil are the main factor controlling nitrogen turnover and mineralization [7, 12].

Our objective was to find how strongly different using of soils in Pruszkow area affects N mineral and if there exists the risk of water enrichment with N compounds.

Material and methods

Samples of soils were taken in July 2005 from Pruszkow area. This town is part of the Mazowia province, Pruszkow district, near river Utrata. This is the smallest but densely populated district in the province. Big concentration of people may cause a problem to environmental protection of this region. During soil sampling the weather was sunny and it was very hot (beyond 30 ^{o}C) and dry. These situation lasted more than the month.

We have chosen: arable soil (at the town edge) – 9 samples, soils from allotment garden – 11 samples, lawns – 12 samples and fallows – 4 samples (36 points together). Soil was taken from 0–20 cm depth (mixed samples) – surface layer is the most important part of soil profile in N mineral accumulation, and where turnover of N is most dynamic [3, 13–15].

Total nitrogen was measured by Kjeldahl method, $N\text{-}NO_3$ and $N\text{-}NH_4$ after extraction in 1 % K_2SO_4 by the colorimetric method using the SAN plus SYSTEM analyzer, pH in H_2O and 1 M KCl – electrometrically, C organic using the TOC 5000A Shimadzu analyzer. The texture of soils was determined according to Cassagrande'a procedure – modified by Proszynski [16]. Sum of mineral forms percentage in N total, share of $N\text{-}NO_3$ and $N\text{-}NH_4$ in N total and $N\text{-}NO_3/N\text{-}NH_4$ ratio were calculated. Multiple sample comparisons between soils of different land use were made using Statgraphics Plus 4.1. software.

Results and discussion

According to Pruszkow District Office data [17] soils prevailed on study area were leached brown soils and typical lessivés soils – by Polish Classification [18] or Dystric Cambisols and Haplic Luvisols – by WRB [19].

Majority of study soils were sands with small amount of clay particle (< 0.02 mm) or silts (Table 1).

The amount of total nitrogen in all studied soils varied greatly and ranged from 0.33 to 1.91 g · kg^{-1} dry matter of soil (Table 2). The biggest average content of this element was found in soils of allotment garden, 0.63 – 1.91 g · kg^{-1} dry matter of soil (average 1.11 g · kg^{-1} dry matter of soil). Average content of total nitrogen in other soils was considerably lower and it was rather similar among groups and the smallest was in fallow soils (0.48 g · kg^{-1} dry matter of soil – Table 3). It is known that stable bulk soil N pool is positively correlated with soil C content [20]. Usually owners of allotment garden improve their soils with organic matter such as compost, manure or different organic waste. Soils enriched with organic matter and lime usually have neutral or close to neutral soil reaction (pH in allotment garden usually was over 7). This conditions favour the nitrification process. This is reflected in the quantity of nitrate forms.

Table 1

Soils textures

Way of land use	Sample No.	>1 mm	1–01 mm			0.1–0.02 mm		< 0.02 mm		
			1.00– –0.50	0.50– –0.25	0.25– –0.10	0.10– –0.05	0.05– –0.02	0.02– –0.006	0.006– –0.002	< 0.002
Arable fields	1	1.36	0.39	7.32	32.29	8	52	0	0	0
	2	1.72	0.69	14.04	38.27	34	0	9	4	0
	4	7.47	1.47	14.23	60.30	9	11	4	0	0
	5A	1.12	0.62	11.03	41.36	11	36	0	0	0
	5B	1.65	0.30	13.93	49.78	11	25	0	0	0
	6	1.26	0.65	12.66	42.69	8	35	1	0	0
	8	1.41	0.71	10.93	52.36	7	17	8	4	0
	28	1.59	0.33	7.49	46.18	12	34	0	0	0
	30	1.27	0.49	10.05	49.46	14	26	0	0	0
Lawns	15A	3.37	0.85	24.59	60.56	11	3	0	0	0
	15B	10.77	1.63	17.52	55.85	11	10	4	0	0
	15C	3.54	0.35	10.51	52.14	11	24	2	0	0
	16	3.24	0.55	25.12	61.32	11	2	0	0	0
	17	2.39	1.43	19.68	63.89	6	6	3	0	0
	18	2.71	0.83	20.95	53.22	11	11	3	0	0
	29	2.55	0.39	11.04	59.58	13	16	0	0	0
	32	5.72	0.56	18.33	53.11	12	12	4	0	0
	33A	12.65	0.46	8.55	57.00	7	27	0	0	0
	33B	2.89	1.08	10.72	38.20	13	21	12	2	2
	35	3.00	0.58	6.97	43.46	9	18	12	4	6
	36	1.94	0.78	11.45	40.77	12	18	13	2	2
Allotment gardens	19A	1.38	0.66	12.37	47.97	15	17	7	0	0
	19B	1.08	0.72	17.1	53.18	14	11	4	0	0
	19C	1.37	0.79	9.13	49.08	15	22	4	0	0
	20A	0.63	0.31	8.48	37.21	14	40	0	0	0
	20B	3.13	0.58	13.01	32.42	13	22	10	8	1
	20C	5.66	0.48	12.92	30.60	15	41	0	0	0
	22A	1.66	0.61	17.5	52.90	10	15	4	0	0
	22B	2.34	0.56	11.36	35.08	13	40	0	0	0
	31A	3.43	0.90	11.89	33.21	17	18	12	7	0
	31B	1.11	0.45	6.92	28.63	11	33	12	7	1
	31C	0.50	0.26	8.49	24.26	11	30	17	4	5
Fallows	3	1.58	0.75	12.56	46.69	8	20	8	4	0
	7	4.20	0.83	15.15	40.03	13	24	5	2	0
	9	5.68	0.47	18.66	60.86	6	14	0	0	0
	34	2.97	0.69	21.35	56.96	7	6	6	2	0

Table 2

Content of C organic, N total and soil reaction

Way of land use	Sample No.	pH		C_{org} [g · kg^{-1} dry matter of soil]	N_{tot} [g · kg^{-1} dry matter of soil]	C/N
		H_2O	1 M KCl			
Arable fields	1	5.50	4.80	6.86	0.43	15.8
	2	5.48	4.45	9.02	0.49	18.3
	4	6.56	6.30	8.95	0.40	22.7
	5A	5.64	4.85	7.81	0.48	16.4
	5B	6.28	5.51	6.73	0.40	16.9
	6	5.61	4.70	9.32	0.53	17.4
	8	6.91	6.47	29.23	1.36	21.5
	28	7.69	7.16	24.93	0.71	35.0
	30	6.33	5.44	11.88	0.44	27.3
Lawns	15A	6.58	6.23	18.27	0.79	23.1
	15B	5.42	4.55	27.56	0.78	35.6
	15C	7.05	6.41	20.39	0.76	26.9
	16	7.01	6.44	35.17	1.21	29.2
	17	7.64	7.29	19.65	0.82	23.9
	18	7.91	7.55	24.18	0.71	34.1
	29	6.76	6.41	14.46	0.53	27.4
	32	4.47	3.68	24.31	0.99	24.6
	33A	6.69	6.44	17.89	0.55	32.4
	33B	6.80	6.01	13.70	0.61	22.4
	35	6.99	6.82	19.71	0.74	26.6
	36	6.85	6.52	11.05	1.46	7.6
Allotment gardens	19A	7.72	7.19	22.25	1.07	20.9
	19B	7.42	7.06	20.42	1.01	20.1
	19C	6.59	5.92	24.23	1.35	17.9
	20A	7.76	7.29	30.73	1.50	20.5
	20B	6.96	6.38	22.38	1.15	19.5
	20C	6.94	6.40	36.94	1.91	19.3
	22A	7.45	7.16	12.46	0.63	19.8
	22B	7.49	7.25	17.27	0.80	21.5
	31A	7.35	6.92	22.87	1.21	18.8
	31B	7.54	7.24	16.12	0.81	19.8
	31C	7.15	6.78	12.96	0.75	17.3
Fallows	3	6.25	5.56	13.34	0.67	20.0
	7	6.60	6.15	9.48	0.45	20.9
	9	5.18	4.55	10.70	0.47	22.9
	34	7.45	7.34	7.94	0.33	24.2

Table 3

Multiple sample comparisons

Way of land using		Arable fields	Lawns	Allotment gardens	Fallows
Count		9	12	11	4
Statistics for N_{tot} [g · kg^{-1}]	Minimum	0.40	0.53	0.63	0.33
	Maksimum	1.36	1.46	1.91	0.67
	Average	0.58	0.83	1.11	0.48
	Variance	0.09	0.07	0.14	0.02
	Standard deviation	0.31	0.27	0.38	0.14
	Coefficient of variation	0.53	0.33	0.34	0.29
Statistics for $N_{mineral}$ [mg · kg^{-1}]	Minimum	12.22	10.61	7.67	5.39
	Maksimum	59.31	33.78	50.70	19.49
	Average	34.66	20.10	32.69	11.41
	Variance	403.75	62.76	191.27	31.38
	Standard deviation	20.09	7.92	13.83	5.60
	Coefficient of variation	0.58	0.39	0.42	0.49
Statistics for $N_{mineral}$ in N_{tot} [%]	Minimum	1.4	1.4	0.7	1.2
	Maksimum	14.7	6.4	4.4	5.8
	Average	7.3	2.6	3.0	2.7
	Variance	26.28	2.19	1.17	4.41
	Standard deviation	5.13	1.48	1.08	2.10
	Coefficient of variation	0.70	0.56	0.36	0.77
Statistics for N-NO_3 in N_{tot} [%]	Minimum	0.0	0.0	0.2	0.0
	Maksimum	10.8	4.0	3.6	3.3
	Average	4.6	1.2	2.0	0.9
	Variance	18.35	1.41	1.07	2.52
	Standard deviation	4.28	1.19	1.03	1.59
	Coefficient of variation	0.92	1.02	0.52	1.71
Statistics for N-NO_3 [mg · kg^{-1}]	Minimum	0.00	0.00	1.80	0.00
	Maksimum	43.30	21.80	43.50	10.70
	Average	21.52	8.79	22.76	3.22
	Variance	322.29	58.26	197.29	25.16
	Standard deviation	17.95	7.63	14.05	5.02
	Coefficient of variation	0.83	0.87	0.62	1.56
Statistics for N-NH_4 [mg · kg^{-1}]	Minimum	6.28	7.76	1.33	5.39
	Maksimum	17.60	15.25	13.40	9.70
	Average	13.14	11.31	9.94	8.19
	Variance	16.32	4.62	12.79	3.90
	Standard deviation	4.04	2.15	3.58	1.97
	Coefficient of variation	0.31	0.19	0.36	0.24

Comparing soils of different land use in mineral compound enrichment ($N\text{-}NO_3$ + $N\text{-}NH_4$) we can notice that agricultural soils and allotment garden soils are significantly more abundant than soils of lawns and fallows (average in sequence was: 34.66; 32.69; 20.10 and 11.41 $mg \cdot kg^{-1}$ dry matter of soil – Table 3). The differences were statistically significant ($p = 0.05$). The share of N mineral in N total was the biggest in fields too. It amounted to over 7 %. It was only 2.6 % to 3.0 % in the rest of soils.

Land use form influenced the domination of $N\text{-}NO_3$ or $N\text{-}NH_4$ forms. Nitrate prevailed in samples collected from fields and allotment gardens while ammonia dominated in fallows and lawns (even in park). $N\text{-}NH_4$ is usually a main form in forest soils [21, 22] and in orchard too [23]. Acid reaction of soil favoured this phenomenon [21, 22]. We did not prove the influence of soil reaction on $N\text{-}NO_3/N\text{-}NH_4$ ratio.

Share of $N\text{-}NO_3$ in N total was the biggest in fields (average 4.6 %), smaller in allotment garden soils (2.0 %), lawns (1.2 %) and in fallow (0.9 %) – Table 3. Probably, fertilizing favours big percentage of this form. Bielinska and Domzal [24] claimed that $N\text{-}NO_3$ amounted 1–5 % of N total in top layer in orchard with fertilizers, and only 0.1–0.5 % without fertilizers.

As it was mentioned previously, convenient conditions to nitrification existed in soils of allotment gardens. It was why allotment garden soils were characterized as most abundant in $N\text{-}NO_3$ (average 22.76 $mg \cdot kg^{-1}$ dry matter of soil). It was about 68 kg per hectare in 0–20 cm layer. This amount could not be used by plant and is subject to leaching to groundwater [25]. Slightly lower accumulation of this element was observed in field soils (average 21.52 $mg \cdot kg^{-1}$ dry matter of soil). In individual cases the quantity of $N\text{-}NO_3$ exceeded even 40 $mg \cdot kg^{-1}$ dry matter of soil. The nitrate quantity in fields soils was significantly higher than in the others (Table 3). Applied fertilizers promote intensive nitrification [5, 15, 26].

Turnover of nitrogen lead to acidification of environment [25]. In this study it led to decrease in field soils pH (Table 2).

Different land use had no affect on ammonia amount in Pruszkow soils. Average content of $N\text{-}NH_4$ was 8.19 – 13.14 $mg \cdot kg^{-1}$ dry matter of soil. The share of $N\text{-}NH_4$ in N total was in the following order: fields, fallows, lawns, allotment gardens. Fertilizing had not affected this form's content. The same result obtained Bielinska and Domzal [24].

Conclusions

1. Way of land use affected total nitrogen content and $N\text{-}NO_3$ content in soil. The biggest accumulation occured in soils under agricultural use and in allotment garden.
2. Soil reaction did not influence $N\text{-}NO_3$ and $N\text{-}NH_4$ amount and $N\text{–}NO_3/N\text{-}NH_4$ ratio in studied soils.
3. Different land use had no affect on ammonia amount in Pruszkow soils. This is rather a stable environmental element.
4. Soils of allotment garden could become source of water pollution in town environment in the same range as fields.

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MINERALNE FORMY AZOTU W GLEBACH O RÓŻNYM SPOSOBIE UŻYTKOWANIA

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Abstrakt: Sposób użytkowania wpływa na ilość i jakość związków azotu, w szczególności połączeń mineralnych. Badano gleby Pruszkowa będące w użytkowaniu: rolniczym (na obrzeżach miasta), gleby ogródków działkowych, gleby trawników w parkach i zieleńców przyulicznych oraz nieużytków (łącznie 36 próbek z terenu całego miasta). Miasto to jest częścią aglomeracji warszawskiej i charakteryzuje się dużym zaludnieniem.

Glebę pobierano w lipcu, z głębokości 0–20 cm. Były to głównie piaski, piaski pylaste (od luźnych do gliniastych) i pyły zwykłe.

Ilość azotu ogółem w badanych glebach znajdowała się w granicach 0,33–1,91 g $\cdot$ kg^{-1} s.m. gleby. Największą średnią zawartością tego pierwiastka charakteryzowały się gleby ogródków działkowych (1,1 g $\cdot$ kg^{-1} s.m. gleby), a najmniejszą gleby nieużytków (0,5 g $\cdot$ kg^{-1} s.m. gleby). Gleby ogródków działkowych zawierały również średnio największe ilości azotu azotanowego (22,76 mg N-NO$_3$ $\cdot$ kg^{-1} s.m. gleby). Nieznacznie mniejszą ilość tej formy stwierdzono w glebach pól (średnio 21,52 mg N-NO$_3$ $\cdot$ kg^{-1} s.m. gleby). W pojedynczych przypadkach ilości te były znacznie większe i przekraczały 40 mg N-NO$_3$ $\cdot$ kg^{-1} s.m. gleby. Istotnie niższą ilość tej formy stwierdzono w glebach trawników (średnio 8,79 mg N-NO$_3$ $\cdot$ kg^{-1} s.m. gleby) i nieużytków (średnio 3,22 mg N-NO$_3$ $\cdot$ kg^{-1} s.m. gleby).

W przypadku azotu amonowego nie wykazano wpływu różnego użytkowania na zawartość tej formy w glebie. Udział azotu azotanowego w ogólnej ilości azotu największy był w glebach pól uprawnych, następnie ogródków działkowych, trawników i najmniejszy w glebach nieużytków. Udział N-NH_4 w N ogółem występował kolejno w glebach: pól, nieużytków, trawników, ogródków działkowych. W glebach pól i ogródków działkowych przeważała forma azotanowa, natomiast forma amonowa przeważała w glebach trawników i nieużytków. Nie stwierdzono wpływu odczynu gleby na ilość form N-NO_3 i N-NH_4 oraz na wartość stosunku N-NO_3 /N-NH_4.

Na podstawie przeprowadzonych badań i analiz możemy stwierdzić, że sposób użytkowania gleby na terenie Pruszkowa wywiera istotny wpływ na zawartość azotu ogółem i azotanów w glebie. Gleby ogródków działkowych mogą być potencjalnym źródłem zanieczyszczenia wód tym elementem.

Słowa kluczowe: azot mineralny, sposób użytkowania terenu