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QUANTITY OF NITROGEN DEPOSITED IN SOIL AS PRECIPITATED FROM ATMOSPHERE IN THE WROCLAW AREA DURING 2002–2007

ILOŚĆ AZOTU WNOSZONA DO GLEBY Z OPADAMI ATMOSFERYCZNYMI W REJONIE WROCŁAWIA W LATACH 2002–2007

Abstract: Nitrogen content was examined in total atmospheric precipitation in eastern outskirts of Wroclaw. Overall nitrogen content varied considerably and ranged from 0.8 to 16.8 mg N · dm^{-3}. Of substantial proportion in overall nitrogen was nitrate (V) nitrogen whose concentration in atmospheric precipitations ranged from 0.3 to 3.7 mg N · dm^{-3}. Also of diversity were both monthly as well as annual charges of nitrogen deposited in the soil along with precipitations. Annual charges of nitrogen deposited in the soil amounted from 33 to 42 kg N · ha^{-1}, and average multiyear charge amounted to 37.8 kg N · ha^{-1}, of which over 60 % can be assigned to growing season. These are quantities that should be taken into consideration in fertilization balance of agricultural farming.

Keywords: atmospheric precipitation, total nitrogen, nitrates

Nitrogen content as precipitated from atmosphere remains in strict correlation with air pollution and directions of its flow. Pollution of atmospheric precipitation with nitrogen compounds therefore depends on intensity of emission of these components from various sources and location of examination site with respect to such sources, as well as direction of flow of atmospheric air mass. Precipitations, participating in cycle of water and elements in nature, constitute among others the carrier of nitrogen. Through physical and chemical processes, they absorb nitrogen contained in atmospheric air pollution and carry it into the soil along with water.

The purpose of the paper presented is to examine the chemical composition of total atmospheric precipitation and to obtain data for balance of nitrogen, which is carried into the soil.

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Material and methods

The studies presented were conducted at the research centre of Institute of Land Reclamation and Grassland Farming (*IMUZ*), situated in the eastern outskirts of Wroclaw. Dominating in the place of measuring quantities of precipitation and sampling for examinations are westerly winds, displacing air mass mainly from the city area. Quantities of atmospheric precipitations were measured using the Hellman rain-gauge. In order to obtain sufficient volume of samples for laboratory analyses, additional precipitation was collected into vessels of increased surface area (approx. 0.3 m^2). Total precipitation was collected and examined, and hence wet precipitation along with the so-called dry precipitation. Samples for testing were taken after each precipitation and delivered immediately after drawing to the laboratory where, determined among others, was the content of total Kjeldahl nitrogen (colorimetrically, after mineralization according to Kjeldahl) and nitrate(V) nitrogen – colorimetrically, after the Devarde reaction [1, 2].

Results and discussions

Quantities of atmospheric precipitations, both monthly as well as yearly, were very diverse (Table 1). In general, it can be stated that in the first three years of studies, precipitations were lower than average multiyear precipitations for the Wroclaw region and higher in the subsequent three years. Also diverse were concentrations of total nitrogen as well as nitrate(V) nitrogen in atmospheric precipitations (Table 2). Dependence of nitrogen concentration in precipitations on their amounts cannot however be ascertained. Since nitrogen in atmospheric precipitations originates from numerous sources both natural as well as anthropogenic, and its quantity depends on intensity of emissions from these sources.

Contents (concentrations) of total nitrogen in atmospheric precipitations presented in Table 2 fluctuate from 3.2 to 16.8 mg N · dm^{-3}, and of nitrate(V) nitrogen from 0.3 to 4.0 mg N · dm^{-3}. On the basis of these contents and amounts of precipitations, charges of nitrogen carried into the soil along with the precipitations were calculated (Table 3). The results obtained showed large diversities in monthly charges of nitrogen carried into the soil along with atmospheric precipitations. The largest charges occurred in the spring and summer months, particularly in July and August. Average monthly charges from the years 2002–2007, during the spring-summer half-year fluctuated from 1.78 to 6.43 kg N · ha^{-1}, whereas during the autumn-winter period, they were more uniform and amounted from 2.28 to 2.70 kg N · ha^{-1}. Annual quantity of nitrogen carried into the soil fluctuated from 33.6 to 42.8 kg N · ha^{-1}, of which during the spring-summer half-year, it amounted to 58–65 % of total quantity. The increased concentration of nitrogen in atmospheric precipitations during the spring-summer period and its significantly larger deposition into the soil in comparison with the autumn-winter period may result from several causes. During the spring-summer period, increased emission of gaseous nitrogen compounds occurs, originating in biochemical processes of mineralization of organic substances in the soil and on its surface. Also occurring in this period, there is

Table 1

Precipitations at Research Station in Kamieniec Wroclawski in the years 2002–2007\

Year	Months and precipitations [mm]												Annual precipitation [mm]
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
2002	23.8	59.2	15.7	32.9	37.1	68.2	49.5	78.7	52.2	61.2	52.3	16.2	547.0
2003	40.0	2.8	18.7	11.9	80.5	24.3	58.8	55.3	42.4	51.5	27.8	47.3	461.5
2004	31.2	60.6	56.6	24.5	35.2	40.5	88.5	50.8	21.8	45.6	81.4	15.4	552.1
2005	46.2	51.2	11.5	27.0	150.8	46.8	122.6	54.4	24.9	6.7	31.0	106.4	679.5
2006	28.9	43.7	26.1	54.2	21.9	56.6	12.0	179.3	20.3	68.4	65.6	36.7	613.7
2007	64.6	53.3	55.5	3.6	57.6	79.5	124.1	42.0	51.6	26.5	56.0	27.9	642.0

Table 2

Contents of total nitrogen and nitrate(V) nitrogen in precipitations in the years 2002–2007

Year	Nitrogen form	Monthly and mean weighed content of nitrogen [mg N · dm^{-3}]											
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
2002	N_{tot}	—*	—*	—*	6.6	8.9	7.6	10.1	11.3	6.7	8.1	7.1	6.9
	$N\text{-}NO_3$	—*	—*	—*	1.1	0.8	2.3	2.0	1.4	1.4	1.1	0.9	0.9
2003	N_{tot}	6.4	9.0	9.5	6.8	8.1	7.3	12.4	9.9	7.0	6.0	7.5	7.7
	$N\text{-}NO_3$	0.8	0.8	2.5	0.9	1.2	1.1	1.4	1.8	1.7	0.5	3.3	1.4
2004	N_{tot}	6.1	6.8	8.6	8.5	9.7	7.8	11.4	10.0	5.6	6.4	3.8	6.6
	$N\text{-}NO_3$	0.8	1.4	2.8	2.2	2.8	3.7	1.2	4.0	1.1	1.4	1.4	1.0
2005	N_{tot}	5.0	5.2	9.4	9.2	5.5	5.4	5.3	4.9	6.0	5.7	5.9	4.9
	$N\text{-}NO_3$	0.9	0.8	2.0	0.8	1.2	0.7	1.0	0.8	1.6	1.0	1.2	0.6
2006	N_{tot}	5.0	5.0	2.1	5.2	5.2	5.1	16.8	6.0	6.9	3.7	3.8	5.0
	$N\text{-}NO_3$	1.0	1.2	0.8	1.3	1.2	1.7	3.0	1.4	2.1	0.6	0.6	0.5
2007	N_{tot}	5.4	4.7	3.2	7.4	5.6	5.0	6.2	4.7	6.3	5.8	5.4	5.3
	$N\text{-}NO_3$	0.8	0.8	0.3	1.4	1.3	0.8	0.7	0.7	1.7	1.2	0.9	0.9
Average for period 2002–2007	N_{tot}	5.58	6.14	7.74	7.28	7.17	6.37	10.37	7.80	6.42	5.95	5.58	6.06
	$N\text{-}NO_3$	0.86	1.00	1.94	1.28	1.42	1.72	1.55	1.68	1.60	0.97	1.38	0.88

* – lack of measurement.

Table 3

Monthly periodical and annual nitrogen charge deposited in the soil with precipitation

Year	Month and nitrogen charge [kg N · ha^{-1}]												Period IV–IX kg N · ha^{-1}	Period X–III kg N · ha^{-1}	Year kg N · ha^{-1}
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII			
2002	—	—	—	2.17	3.30	5.18	5.00	8.90	3.50	4.90	3.71	1.12	28.0	—	37.8*
2003	2.56	0.25	1.60	0.80	6.52	1.77	7.29	5.47	2.97	3.09	2.08	3.64	24.8	13.2	38.0
2004	1.90	4.12	4.86	2.08	3.41	3.16	10.1	5.08	1.22	2.74	3.09	1.02	25.1	17.7	42.8
2005	2.31	2.66	1.08	2.48	8.29	2.53	6.50	2.67	1.50	0.40	1.83	5.21	24.0	13.5	37.5
2006	1.44	2.18	2.08	2.82	1.14	2.89	2.02	10.76	1.40	2.53	2.49	1.84	21.0	12.6	33.6
2007	3.49	2.50	1.77	0.33	3.22	3.97	7.69	1.97	3.25	1.54	3.02	1.45	23.5	13.8	37.3
Average for years 2002–2007	2.34	2.34	2.28	1.78	4.31	3.25	6.43	5.80	2.31	2.53	2.70	2.38	24.4	14.15**	37.83**

* Nitrogen charge in period IV–XII; ** average for years 2003–2007.

much more pollution of air with organic dust (eg plant pollen) and there is larger absorption of gaseous nitrogen compounds by rainwater than by snow in winter. The studies of Burszta-Adamiak and Stodolak [3] showed that concentrations of ammonia nitrogen and nitrates in rainwater were significantly larger than in snow.

In spring and summer, intensification of motor transport emitting nitrogen oxide, is also considerably larger than in winter. At present, apart from electric power plants and also heat and power generating plants, the largest source of nitrogen oxides in the air and hence also in atmospheric precipitations, is motor transport. According to Zakrzewski [4], nitrogen oxides form 45 % of total quantity of atmosphere pollutions in large towns.

The quantity of nitrogen carried into the soil from atmospheric precipitations in the region of Wroclaw is comparable with the charge given by Sapek [5] deposited in Central Europe, exceeding 30 kgN · ha^{-1} · $year^{-1}$. Charges of nitrogen deposited in the soil on the outskirts of Wroclaw however were considerably higher than in some regions of Poland. According to relevant literature, charges in southern vicinities of Warsaw, or also in the region of Ostroleka amount to about 18 kg N · ha^{-1} · $year^{-1}$ [6, 7], and in south-eastern parts of Pomerania – from 16 to 26 kg N · ha^{-1} · $year^{-1}$ [8]. In these regions however, there is lesser pollution of air, eg annual emission of nitrogen oxides in the year 2007 amounted there to 500–1200 Mg, and in Wroclaw to 2700 Mg [9].

Conclusions

1. Annual quantity of nitrogen deposited in the soil from atmospheric precipitation in the region of large, industrialized urban area as is Wroclaw, is high and ranges from 33 to 42 kg N · ha^{-1}, and average multiyear charge amounted to 37.8 kg N · ha^{-1}.

2. More than 60 % of annual nitrogen charge is deposited in the soil with atmospheric precipitation during growing season. The largest monthly charges of nitrogen occur in July and August.

3. Quantities of nitrogen deposited in the soil with atmospheric precipitation are significant for fertility of soil and should be taken into consideration in the fertilization balance of ecological, agricultural farming particularly ecological farming producing so-called health food.

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ILOŚĆ AZOTU WNOSZONA DO GLEBY Z OPADAMI ATMOSFERYCZNYMI W REJONIE WROCŁAWIA W LATACH 2002–2007

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Abstrakt: Badano zawartości azotu w całkowitych opadach atmosferycznych na wschodnim obrzeżu Wrocławia. Zawartości azotu ogólnego były bardzo zróżnicowane i wahały się od 0,8 do 16,8 mg N · dm^{-3}. Znaczny udział w azocie całkowitym miał azot azotanowy, którego stężenie w opadach atmosferycznych wahały się od 0,3 do 3,7 mg N · dm^{-3}. Zróżnicowane były też, zarówno miesięczne, jak i roczne ładunki azotu wniesionego do gleby z opadami. Roczne ładunki azotu wniesionego do gleby wynosiły od 33 do 42 kg N · ha^{-1}, a średni wieloletni ładunek wynosił 37,8 kg N · ha^{-1}, z czego ponad 60 % przypada na okres wegetacyjny. Są to ilości, które powinny być uwzględniane w bilansie nawozowym gospodarstw rolnych.

Słowa kluczowe: opad atmosferyczny, azot ogólny, azotany