ECOLOGICAL CHEMISTRY AND ENGINEERING A

Vol. 16, No. 1–2 2009

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ESTIMATION OF THE NITRATE(V) CONTENT IN THE SURFACE WATERS OF AN AREA PARTICULARLY EXPOSED TO POLLUTION FROM AGRICULTURAL SOURCES

OCENA ZAWARTOŚCI AZOTANÓW W WODACH POWIERZCHNIOWYCH OBSZARU SZCZEGÓLNIE ZAGROŻONEGO ZANIECZYSZCZENIAMI ZE ŹRÓDEŁ ROLNICZYCH

Abstract: The aim of the research was to estimate the concentrations and loads of nitrate nitrogen(V) as well as their seasonal changes in the waters flowing from the catchments qualified as areas in particular danger of nitrate pollution from agricultural sources. The tests were conducted in the years 2005–2007 in the catchment of Dobskie Lake. The research covered four parts of the Dobskie Lake catchment, in which the discharges and properties of the waters were established. Water samples for laboratory tests were collected once a month. Nitrate nitrogen(V) content and physicochemical parameters such as temperature, pH reaction, oxygen saturation and electrolytic conductivity were evaluated in the samples.

The obtained results indicate that intensified agricultural utilisation of the area causes a marked increase in the concentrations of nitrate nitrogen(V), in surface waters, particularly in drainage waters. The highest concentrations of $N\text{-}NO_3$ occur in winter (on average 17.38 mg $\cdot$ dm^{-3}) in drainage waters flowing from the intensively utilised area, and the lowest in watercourses, particularly in spring and summer (0.13–0.25 mg $\cdot$ dm^{-3}). The load of $N\text{-}NO_3$ flowing from the agricultural catchment depends on the meteorological conditions, the type of drainage system and the intensity of the catchment utilisation. A substantial part (about 45%) of the yearly charge of $N\text{-}NO_3$ occurs in wintertime. It is a result of an intensive inflow of nitrogen with the thawing snow and precipitation in the period of limited bioaccumulation.

The results of research indicate a potential negative influence of the waters flowing from agricultural areas, mostly through drainage systems, on the waters of Dobskie Lake. Considering high concentrations and loads of nitrates in the waters flowing into the lake, we can qualify it as exposed to eutrophication. This confirms the legitimacy of regarding the area as one where the flow of nitrogen from agricultural sources ought to be limited.

Keywords: surface waters, drains, nitrates, agricultural pollution

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Numerous studies and tests indicate that in rural areas, agricultural activity is the main source of nitrates. Fertiliser components not fully utilised in farming, particularly nitrogen, can penetrate into ground and surface waters, causing their pollution. This pollution is of non-point type and can affect even 70% of the agriculturally utilised area of the country [1]. One of the first symptoms of pollution of the water environment by farming is the appearance of considerable, sometimes even large, amounts of nitrates in the groundwaters in rural areas [2–4]. The nitrogen excessively carried into waters causes an increase in their fertility, and as a result of eutrophication ie their unsuitability for consumption [5, 6].

The current regulations allow for nitrate concentrations not exceeding 50 mg $NO_3 \cdot dm^{-3}$ in the water suitable for consumption. In order to ensure proper quality of water supplies, actions have been taken to limit the inflow of nitrogen from agricultural sources [7]. These actions must be accompanied by monitoring the nitrate concentrations in waters as the first indicator of their effectiveness.

The aim of the research was to estimate the concentrations and loads of nitrates as well as their seasonal changes in the waters of the catchments qualified as areas particularly exposed to pollution from agricultural sources.

Material and methods of research

The research was conducted in the years 2005–2007 in the catchment of Dobskie Lake. Agricultural areas in the lake catchment are utilised by a farm which specialises in animal husbandry. The research covered four partial catchments of Dobskie Lake, which were different in terms of the intensity of utilisation, considering the fertilisation (intensive, moderately intensive and less intensive) and the type of a drainage system (ditches and drains – Fig. 1).

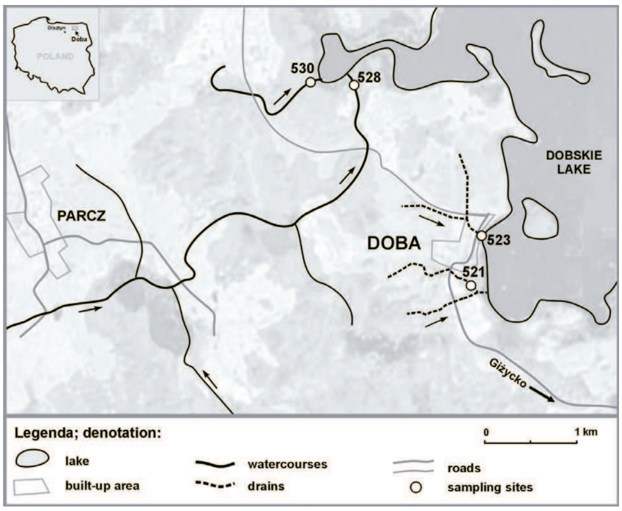

Fig. 1. Localisation of sampling sites in the catchment of Dobskie Lake

1) An intensively utilised area of a drainage catchment **(521)**, of 15.1 ha. In 2005, winter triticale was grown there. Mineral fertilisation (N – 61 kg $\cdot$ ha^{-1}) as well as organic fertilisation in the form of liquid manure in the amount of 20 $m^3 \cdot ha^{-1} \cdot year^{-1}$. In 2006, for the plantation of spring barley, the following fertilisation was used: 98 kg N $\cdot$ ha^{-1}, 46 kg $P_2O_5 \cdot ha^{-1}$, 60 kg $K_2O \cdot ha^{-1}$. In June 2006, it was observed that liquid manure was poured onto the land, which was not in accordance with good farming practice, and in fact against it. The catchment contains livestock buildings. In 2007, for the cultivation of winter rye 100 kg N $\cdot$ ha^{-1}, 52 kg $P_2O_5 \cdot ha^{-1}$, 50 kg $K_2O \cdot ha^{-1}$ were used. Arable lands are located on moderately compact soils (strong loamy sands) classified as soil quality class IIIb and IVa.

2) A drainage zone **(523)** utilised with moderate intensity, located near the buildings of the village of Doba and an agricultural farm. A drainage pipeline removes water from fertilised arable lands. The fields were fertilised with – 68 kg N $\cdot$ ha^{-1}, 40 kg $P_2O_5 \cdot ha^{-1}$ and 55 kg $K_2O \cdot ha^{-1}$ in 2005 for the cultivation of oats, in 2006 for the cultivation of rye: 88 kg N $\cdot$ ha^{-1}, 41 kg $P_2O_5 \cdot ha^{-1}$ and 54 kg $K_2O \cdot ha^{-1}$. In 2007, winter rye was sown in the fields and the following fertilisation was used: 140 kg N $\cdot$ ha^{-1}, 52 kg $P_2O_5 \cdot ha^{-1}$ and 50 kg $K_2O \cdot ha^{-1}$. Near this drainage zone, recreational plots and a village settlement are situated. The soils are light and classified as the quality class V. The catchment area is 41.7 ha.

3) An intensively utilised catchment of a watercourse (528) covers the areas supplied by the bay of Pilwa, situated in the western part of Dobskie Lake. The surface watercourse removes water from a substantial area of 1616 ha, covered with forests in 57 %. In the period from July to October 2005, a disappearance of flow in this watercourse was noted, as well as in July and August 2006. Arable lands located in this catchment are mainly light loamy sands (soil class IV b). On these lands, triticale was cultivated in 2005, in 2006 – winter rape, and in 2007 – winter wheat. In the test period, the following fertilization was used: in 2005 – 130 kg N $\cdot$ ha^{-1} and in spring liquid manure 20 $m^3 \cdot ha^{-1}$, in 2006 – 206 kg N $\cdot$ ha^{-1}. In 2007, for the cultivation of winter wheat, the following amounts of fertilisers were used: 130 kg N $\cdot$ ha^{-1}, 52 kg $P_2O_5 \cdot ha^{-1}$, 54 kg $K_2O \cdot ha^{-1}$.

4) The catchment of a watercourse (530) utilised with moderate intensity, removing water from the land of western part of the bay of Pilwa. The area of this territory is 109 ha and it is covered by forests in 60 %. The remaining part contains arable lands on light clay sands. In the analysed test period, a tendency of periodic disappearance of the water flow in the watercourse was noted in the summer and autumn. In 2005, only mineral fertilisation for the cultivation of oats was used in the amounts of 100 kg N $\cdot$ ha^{-1} and 60 kg $P_2O_5 \cdot ha^{-1}$, 50 kg $K_2O \cdot ha^{-1}$, and in 2006 and 2007 rye was cultivated using respectively 113 kg N $\cdot$ ha^{-1}, 44 $K_2O \cdot ha^{-1}$ and 136 kg N $\cdot$ ha^{-1}, 52 kg $P_2O_5 \cdot ha^{-1}$, 50 kg K $\cdot$ ha^{-1}.

According to the guidelines for the implementation of the Nitrates Directive [8], these catchments are a part of a particularly endangered area, where the discharge of nitrogen from agricultural sources should be limited. The area was delineated on the basis of nitrate concentration in underground waters reaching 95 mg $\cdot$ dm^{-3} [9].

Within the conducted on-site tests, physicochemical parameters of the water were measured: the pH reaction with a potentiometer, temperature with a thermometer integrated with an oxygen probe, oxygen saturation with a WTW Multiline P3 meter, electrolytic conductivity with a Hanna conductometer. The measurements of the discharge of drainage waters and watercourses supplying the lake were made during sampling with an electromagnetic VALEPORT flow-meter model 801. The water samples for laboratory analyses were collected once a month in the years 2005–2007 and the content of nitrate nitrogen(V) was determined in them using colorimetry with phenoldisulphonic acid. The test was conducted in accordance with the generally accepted method [10].

The seasonal variability of water flow and concentrations as well as the load of nitrate nitrogen(V) was calculated on the basis of a division of the collected samples according to the time of sampling: winter (January–March), spring (April–June), summer (July–September), autumn (October–December). The amount of the nitrate flow was calculated by multiplying the concentration by the volume of the water flow. Then, in order to calculate the amount of outflow from 1 ha, the previously calculated amount was divided by the area of the drained ground.

Results and discussion

Nitrate nitrogen(V) in the natural environment come mainly from the atmosphere and get into the surface waters with the rainfall and with the runoff of surface and groundwaters from the catchment. It was counted that, depending on the amount of precipitation, 1 ha of ground area is supplied with 2 to 6 kg of nitrogen a year, which is only a small fraction compared with fertilization and microbiological bonding of atmospheric nitrogen [11]. A part of the nitrogen from the soil flows into the water as well. Mineral nitrogen compounds are easily soluble, so they flow from the catchment mainly in the form of a solution [12]. The concentration of $N\text{-}NO_3$ in groundwaters in agricultural areas, coming from local sources, mainly from the soil, is reflected in the waters of drainage systems [13]. The amount and dynamics of water flow and the content of compounds depend largely on meteorological conditions (Fig. 2).

Considering the amount of precipitation[14], a normal year (2005 – 545 mm) and two wet years (2006 – 640 mm; 2007 – 646 mm) were distinguished.

Also a high variability of air temperature was noted – its average value in the subsequent years was 7.7, 8.1 and 8.8 ^{o}C, respectively.

During the whole test period, a tendency for the periodic drying out of some flows was observed in the summer and at the beginning of autumn. The subzero air temperatures, persisting from December 2005 to March 2006 and in February 2007, preserved the precipitation water on the ground surface in the form of snow and ice. It was activated in April 2006 and in March 2007, which was conducive for the nitrates being washed out of the ground into the drainage systems. As a consequence, in the waters from the drain removing water from the intensively utilised area, in the year 2005 (a normal one) in winter the average seasonal concentration of $N\text{-}NO_3$ was 30 % higher than in 2006 (a wet year) and 65 % higher in the summer. In sum, it should be

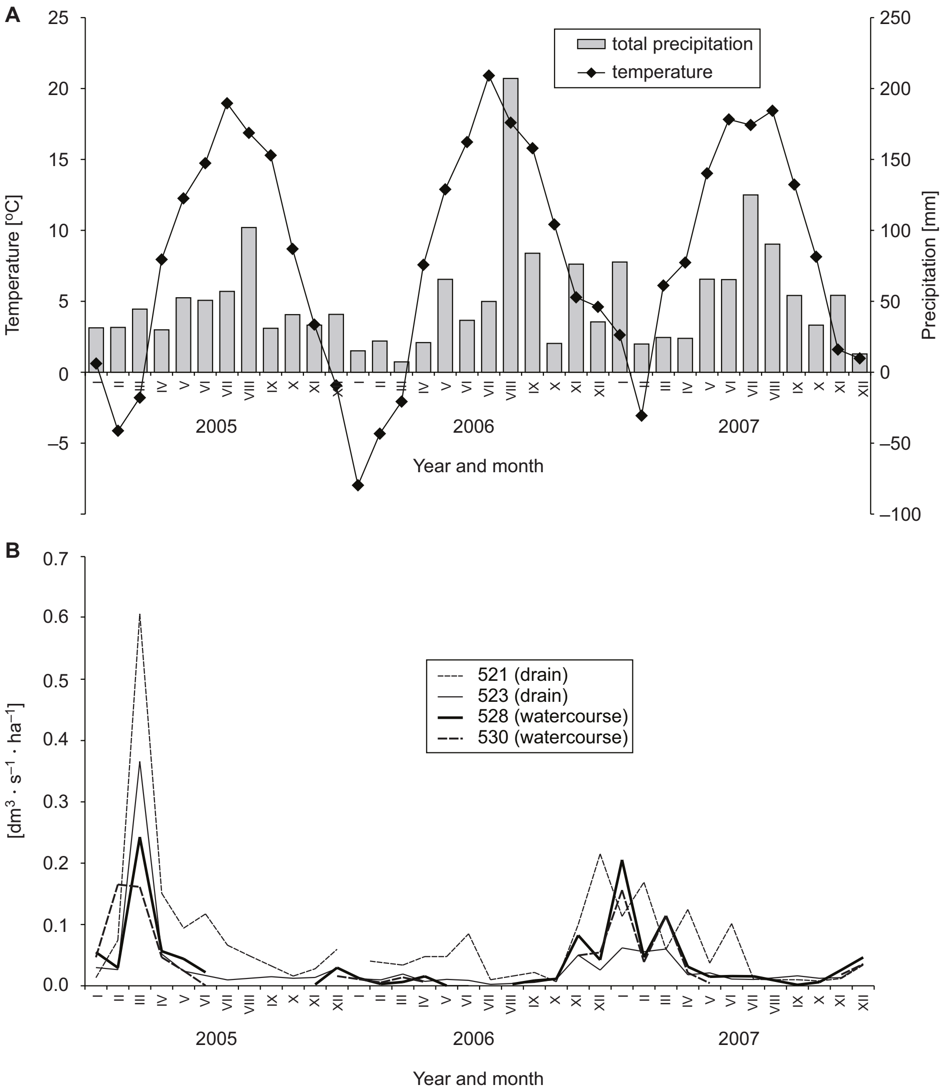

Fig. 2. Distribution of precipitation and air temperature (A) and the water runoff from the tested catchments (B) in the years 2005–2007

stated that water removal by means of drains increases the outflow of water within the year also in the summer. When water is removed by watercourses, the outflow is only slight, and sometimes it disappears.

The water from both the drains and the ditches was sufficiently saturated with oxygen throughout the whole test period, except for the water from a watercourse removing water from the area utilised with moderate intensity (no flow in the summer) which influenced the process of nitrification (Table 1).

Table 1

Seasonal variability of physicochemical parameters in the tributaries of Dobskie Lake in the years 2005–2007

Parameters / Inflow (way of land utilisation)	Season	Oxygen saturation [%]	Temperature [°C]	pH	Conductivity [μS/cm]
521 drain (intensive)	W*	58.3	4.5	7.2	762
	S	50.2	11.3	7.2	762
	Su	62.0	14.2	7.3	798
	A	62.0	7.5	7.3	815
	Y	58.1	9.1	7.3	782
523 drain (moderately intensive)	W	91.3	4.5	7.5	638
	S	84.4	9.6	7.6	672
	Su	92.4	13.6	7.6	681
	A	93.3	8.5	7.5	690
	Y	89.6	8.8	7.6	669
528 watercourse (intensive)	W	75.6	1.0	7.3	611
	S	73.0	17.0	7.8	612
	Su	86.0	15.4	7.7	550
	A	63.7	3.8	7.4	578
	Y	73.6	8.2	7.5	595
530 watercourse (moderately intensive)	W	89.2	1.3	7.7	580
	S	93.7	14.4	7.9	597
	Su	No flow			
	A	84.0	3.2	7.7	663
	Y	88.3	6.3	7.8	609

* W – winter; S – spring; Su – summer; A – autumn; Y – year

The saturation of water with oxygen corresponded with high variability of electrolytic conductivity of the water (550 – 815 $\mu S \cdot cm^{-1}$). Its variable values can be a sign of a high content of substances dissolved in water, particularly in autumn. Besides, the increased values of electrolytic conductivity of the waters flowing through drainage systems, particularly form the intensively utilised area, indicate that large amounts of mineral substances from local sources penetrate into them as a result of using mineral and organic fertilizer as well as of the decomposition of organic matter in the soil. The pH values during the test period were changing just slightly, as opposed to the electrolytic conductivity. The water reaction value in the intensively utilised areas is lower than in other test sites (on average pH = 7.3) which shows that soils are more prone to acidification, and the processes occurring in the soil are aimed at mineralisation, which was reflected in the increased electrolytic conductivity.

The variability of $N\text{-}NO_3$ concentrations in the waters flowing out of agricultural catchments is a result of numerous factors. The most important ones include the intensity of utilisation, the type of a drainage system and meteorological conditions. The above-mentioned factors in the analysed test period caused a high variability of $N\text{-}NO_3$

Table 2

Characteristics of N-NO_3 concentrations [mg · dm^{-3}] in the waters supplying Dobskie Lake in the years 2005–2007

Type of inflow Way of land utilisation	2005			2006			2007			Average from the test years		
	X average / range of values	SD standard deviation	Coefficient of variability [%] CV	X average / range of values	SD standard deviation	Coefficient of variability [%] CV	X average / range of values	SD standard deviation	Coefficient of variability [%] CV	X average / range of values	SD standard deviation	Coefficient of variability [%] CV
Drain (521) intensive	17.66 / 7.10–32.40	7.77	44.00	11.56 / 4.24–18.30	4.50	38.94	14.39 / 2.04–21.20	5.64	39.20	14.53 / 2.04–32.40	6.47	44.26
Drain (523) Moderately intensive	11.27 / 1.21–17.90	5.48	48.62	14.67 / 11.10–17.30	2.24	15.26	9.57 / 0.58–13.60	4.55	47.58	11.84 / 0.58–17.90	4.70	39.69
Watercourse (528) intensive	0.83 / 0.10–3.70	1.17	141.08	0.366 / 0.10–0.80	0.26	72.17	0.986 / 0.10–5.72	1.70	172.67	0.73 / 0.10–5.72	1.22	166.57
Watercourse (530) Moderately intensive	2.02 / 0.28–6.32	2.01	99.36	1.062 / 0.47–1.43	0.36	33.51	2.10 / 0.05–5.56	1.96	93.13	1.73 / 0.05–6.32	1.69	93.98

concentrations considering both the differences between particular years and the yearly distribution of values (Tables 2, 3).

Table 3

Average seasonal concentrations of $N\text{-}NO_3$ [$mg \cdot dm^{-3}$] in the inflows of Dobskie Lake in the years 2005–2007

Season	Type of inflow (way of land utilisation)	Year			Average from the test years
		2005	2006	2007	
Winter	521 drain (intensive)	19.23	13.90	19.00	17.38
	523 drain (moderately intensive)	10.90	14.60	8.39	11.30
	528 watercourse (intensive)	1.44	0.48	3.08	1.67
	530 watercourse (moderately intensive)	3.41	1.14	3.89	2.81
Average		**8.75**	**7.53**	**8.59**	**8.29**
Spring	521 drain (intensive)	12.17	7.41	11.90	10.49
	523 drain (moderately intensive)	9.34	15.83	5.79	10.32
	528 watercourse (intensive)	0.43	0.17	0.16	0.25
	530 watercourse (moderately intensive)	0.89	0.47	0.61	0.66
Average		**5.70**	**5.97**	**4.62**	**5.43**
Summer	521 drain (intensive)	24.10	8.88	16.90	16.63
	523 drain (moderately intensive)	9.25	15.50	12.15	12.30
	528 watercourse (intensive)	no water	0.13	0.13	0.13
	530 watercourse (moderately intensive)	no water	no water	no water	no water
Average		**16.68**	**8.17**	**9.73**	**9.68**
Autumn	521 drain (intensive)	17.27	15.93	10.58	14.59
	523 drain (moderately intensive)	14.93	13.03	12.80	13.59
	528 watercourse (intensive)	0.53	0.53	0.29	0.45
	530 watercourse (moderately intensive)	1.27	1.29	0.92	1.16
Average		**8.50**	**7.70**	**6.15**	**7.45**
Year	521 drain (intensive)	17.65	11.56	14.39	14.53
	523 drain (moderately intensive)	11.27	14.67	9.57	11.84
	528 watercourse (intensive)	0.83	0.37	0.99	0.73
	530 watercourse (moderately intensive)	2.03	1.06	2.10	1.73
Average		**7.95**	**6.92**	**6.76**	**7.21**

Considering the easy washing-out from the ground and the active participation in biogeochemical processes, the level of nitrates in waters is subject to substantial fluctuations during the test period [15]. Analysing the dynamics of $N\text{-}NO_3$ concentrations (in relation to the above-mentioned factors) in the drainage outlets, the greatest fluctuations from 7.10 to 32.40 $mg \cdot dm^{-3}$ (SD = 7.77, CV = 44.00 %) in 2005 and from 2.04 to 21.20 $mg \cdot dm^{-3}$ (SD = 5.64, CV = 39.20 %) in 2007 were noted in the waters from the drainage removing water from the intensively utilised area (Table 2). In the waters of the intensively utilised watercourse, the highest variability coefficient was noted – CV = 172.62 % with the concentrations from 0.10 to 5.72 $mg \cdot dm^{-3}$ in 2007.

Such high average seasonal concentration values from the three years were influenced by the situation in 2005, when liquid manure was used in the intensively utilised catchment area from which water was removed through a drainage network.

It was also noted that the agricultural utilisation of arable lands where water was removed by drains, in comparison with the watercourse removal, causes a more than sevenfold increase in $N\text{-}NO_3$ concentration in drainage outflows. During the whole test period, a noticeable seasonal variability occurred. The highest concentration of $N\text{-}NO_3$ was noted in winter and summer, respectively 17.38 and 16.63 $mg \cdot dm^{-3}$ on average in the waters of a drain removing water from the intensively utilised area (Table 3). Such high nitrate(V) concentrations during the three-year research period can be explained by the easy washing out of this compound from the ground and by its active participation in biochemical processes. During the whole test period, the lowest concentration of nitrates was observed in the summer – on average 0.13 $mg \cdot dm^{-3}$ in the water flowing into Dobskie Lake through a watercourse (528) characterised by the occurrence of marshy areas in the catchment, which separate it from agriculturally utilised fields.

The nitrate content in the waters of drainage systems is a result of not only hydrological and meteorological conditions, but also of plant growth intensity [16]. Therefore, a lower concentration of nitrates in the waters of the agricultural catchment was observed on the time of intensive plant growth, as a consequence of the running out of supplies of easily accessible forms of biogenic compounds in the soil and water.

A high concentration of nitrates(V) in the tested water, mostly from drainage sources, contributed to the lowering of the water quality class. The average concentration of $N\text{-}NO_3$ allows to qualify the tested water from the area from which water was removed by the drainage network and which was utilised intensively and with moderate intensity, to quality class V (bad), and the area drained with surface watercourses was qualified as water quality class II (good) [17].

Depending on the meteorological (seasonal) conditions, the intensity of farming (fertilization) and the drainage system in the area, the outflow of $N\text{-}NO_3$ ranged from below 0.02 $kg \cdot ha^{-1}$ in the summer (the watercourse) to 11.81 $kg \cdot ha^{-1}$ in winter (the drain – Table 4). Two processes contributed to it – a decreased outflow of waters, or even the disappearance of it in the summer, and a better utilisation of nitrogen by plants during the vegetation season. The bulk of the carried load (about 45 %) of $N\text{-}NO_3$ occurs in wintertime. It is a result of the catchment being supplied with freeze-thaw water, characterised by an increased content of this form of nitrogen. It is also due to the lack of vegetation, and therefore of phytosorption, including the sorption of nitrogen compounds.

However, considering the annual discharge of $N\text{-}NO_3$, its greatest load of 26.65 $kg \cdot ha^{-1}$ was noted in the waters from the drainage outlet in an intensively utilised area, and the lowest of 2.32 $kg \cdot ha^{-1}$ in the waters of a watercourse draining an intensively utilised area. In comparison with the watercourses, the annual load of $N\text{-}NO_3$ in the waters of the drainage network was on average 10 times higher. It was probably caused by the more intensive water removal and oxygen saturation of the soils, as well as the lower biological sorption of nitrogen in the drainage system [13]. The yearly distribution of meteorological conditions causing the variability of water runoff is also important. Therefore, in 2005 (on average 14.43 kg · ha^{-1}) the outflow was 30 % higher than in 2007 (on average 10.61 kg · ha^{-1}) and 3 times higher than in 2006.

Table 4

Seasonal and annual variability [kg · ha^{-1} · $year^{-1}$] of the specific runoff of N-NO_3 from the test area

Season	Type of inflow (way of land utilisation)	Year			Average from test years
		2005	2006	2007	
Winter	521 drain (intensive)	16.33	2.53	16.59	11.81
	523 drain (moderately intensive)	6.60	1.60	3.82	4.00
	528 watercourse (intensive)	2.49	0.02	3.96	2.16
	530 watercourse (moderately intensive)	3.70	0.06	3.41	2.39
Average		**7.28**	**1.05**	**6.94**	**5.09**
Spring	521 drain (intensive)	11.35	3.19	8.10	7.55
	523 drain (moderately intensive)	2.64	1.10	0.89	1.55
	528 watercourse (intensive)	0.14	0.01	0.02	0.06
	530 watercourse (moderately intensive)	0.26	0.01	0.05	0.10
Average		**3.60**	**1.08**	**2.26**	**2.31**
Summer	521 drain (intensive)	7.08	0.78	0.90	2.92
	523 drain (moderately intensive)	0.66	0.33	0.84	0.61
	528 watercourse (intensive)	no water	< 0.01	< 0.03	< 0.02
	530 watercourse (moderately intensive)	no water	no water	no water	no water
Average		**3.87**	**0.37**	**0.58**	**1.18**
Autumn	521 drain (intensive)	4.41	5.53	1.50	3.81
	523 drain (moderately intensive)	2.00	2.21	2.10	2.10
	528 watercourse (intensive)	0.03	0.18	0.08	0.09
	530 watercourse (moderately intensive)	0.05	0.15	0.17	0.12
Average		**1.62**	**2.01**	**0.96**	**1.53**
Year	521 drain (intensive)	39.16	13.70	27.09	26.65
	523 drain (moderately intensive)	11.90	5.87	7.65	8.47
	528 watercourse (intensive)	2.65	0.24	4.07	2.32
	530 watercourse (moderately intensive)	4.01	0.26	3.63	2.63
Average		**14.43**	**5.02**	**10.61**	**10.02**

Conclusions

1. The concentrations and loads of nitrates flowing from agricultural catchments depend on meteorological conditions and the drainage system, which affect the scale and dynamics of water flow, as well as on the intensity of land utilisation.
2. The draining increases the flow of water twice and of nitrates 4–13 times compared to the water removal with open watercourses.
3. The intensification of agricultural utilisation of the area causes a marked increase of nitrate nitrogen(V) concentrations in surface waters, particularly in drainage waters.

The highest concentrations of N-NO_3 occur in winter (on average 17.38 mg · dm^{-3}) in drainage waters flowing from an intensively utilised area, and the lowest in water-courses, particularly in spring and summer (0.13-0.25 mg · dm^{-3}).

4. A substantial part (about 45 %) of the annual load of N-NO_3 occurs in wintertime. It is a result of an intensive flow of nitrogen with freeze-thaw water and precipitation water in the period of limited bioaccumulation. During winter frosts and summer droughts the outflow is minimal because of a periodic disappearance of water flows.

5. The research results indicate a potential negative influence of waters flowing out of agricultural areas, mostly through drainage systems, on the waters of Dobskie Lake. Considering the high nitrate concentrations in the waters flowing into the lake, it can be said it is endangered with eutrophication. This confirms that this area should be regarded as one where the outflow of nitrogen from agricultural sources ought to be limited.

Acknowledgement

Presented study was supported by PhD grant no. N N305 1056 33.

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OCENA ZAWARTOŚCI AZOTANÓW W WODACH POWIERZCHNIOWYCH OBSZARU SZCZEGÓLNIE ZAGROŻONEGO ZANIECZYSZCZENIAMI ZE ŹRÓDEŁ ROLNICZYCH

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Abstrakt: Celem badań była ocena stężeń i ładunków azotu azotanowego(V) oraz określenie sezonowych ich zmian w wodach odpływających ze zlewni zakwalifikowanych do obszarów szczególnie narażonych na zanieczyszczenia wód azotanami ze źródeł rolniczych. Badania prowadzono w latach 2005–2007 w zlewni Jeziora Dobskiego. Badaniami objęto cztery zlewnie cząstkowe jeziora Dobskiego, w których określono przepływy i właściwości wód. Próbki wód do analiz laboratoryjnych pobierano raz w miesiącu i oznaczano w nich azot azotanowy(V) oraz parametry fizykochemiczne: temperaturę, odczyn, nasycenie tlenem, przewodność elektrolityczną.

Uzyskane wyniki świadczą o tym, że intensyfikacja rolniczego użytkowania terenu powoduje wyraźny wzrost stężeń azotu azotanowego(V) w wodach powierzchniowych szczególnie w wodach drenarskich. Największe stężenia N-NO_3 występują zimą (średnio 17,38 mg · dm^{-3}) w wodach drenarskich odpływających z obszaru intensywnie użytkowanego a najmniejsze w ciekach szczególnie wiosną i latem (0,13–0,25 mg · dm^{-3}). O ładunku N-NO_3 odpływającego ze zlewni rolniczej decydują warunki meteorologiczne, rodzaj systemu melioracyjnego oraz intensywność użytkowania zlewni. Zasadnicza część (około 45 %) rocznego ładunku N-NO_3 przypada na okres zimowy. Jest to skutkiem intensywnego odpływu azotu wraz z wodami roztopowymi i opadowymi w okresie ograniczonej bioakumulacji.

Wyniki badań wskazują na potencjalny negatywny wpływ wód odpływających z terenów rolniczych, szczególnie systemami drenarskimi na wody jeziora Dobskiego. Ze względu na duże stężenia i ładunki azotanów w wodach dopływających do jeziora można ocenić je jako narażone na eutrofizację. Potwierdza to zasadność uznania tego terenu za obszar, z którego odpływ azotu ze źródeł rolniczych należy ograniczyć.

Słowa kluczowe: wody powierzchniowe, dreny, azotany, zanieczyszczenia rolnicze