

Assessment of water pollution by nitrates in the Middle Odra Basin

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Abstract: The objective of the study was to characterise the quality of surface waters in order to determine their vulnerability to pollution by nitrogen compounds from agricultural activity, as well as to specify the areas with increased exposure, where nitrogen runoff from agricultural sources has to be reduced. It was necessary to determine surface waters liable to pollution by these compounds due to the fact that agricultural production should be carried out in the way which limits and prevents water pollution by nitrogen compounds of agricultural origin. The study addressed the following issues: the concentration of nitrogen compounds in the surface waters of the Middle Odra Basin, and the extent of eutrophication in flowing inland waters (with nitrogen as the main nutrient). The results have been plotted in figures and gathered in tables.

Key words: eutrophication, nitrate, Odra River Basin, water quality

CHARACTERISATION OF THE AREA

In terms of length, the transboundary river Odra is the sixth longest river discharging into the Baltic Sea. In fact, the length of the river has not yet been defined unequivocally. According to the Report by the International Commission for the Protection of the Odra against Pollution (ICPO) (Report..., 2004), the total length of the Odra is 854.3 km (Podział..., 1983). The ICPO has not unified the river-kilometre on the Polish and Czech sides: the one in force dates from 1825 (Oder-Auen-Atlas, 2000) but the figures in Poland differ from relevant figures on the Czech territory. The Polish part of the transboundary river Odra is 741.9 km long, of which a 161.7 km stretch marks the boundary between Poland and Germany (Podział..., 1983).

The total area of the International River Basin District Odra (together with the Szczecin Lagoon and its tributaries) covers 122,512 km². The Odra Basin area that extends from the source to the Szczecin Lagoon encompasses 118,861 km², of

which 106,812 km² are part of Poland's territory; 6,453 km² and 5,587 km² belong to the Czech Republic and the Federal Republic of Germany, respectively (Report..., 2004). Geographically, the Odra Basin is divided into four areas: the source area of the Odra, the Upper Odra, the Middle Odra and the Lower Odra. In Poland, for the needs of water management, the Odra Basin has been divided into four water regions: the Upper Odra, the Middle Odra, the Warta, and the Lower Odra. In its Report for the European Union, the ICPO has established a division into six subbasins: the Upper Odra, the Middle Odra, the Nysa Łużycka, the Warta, the Lower Odra and the Szczecin Lagoon (Table 1) (Report..., 2004).

Table 1. Differences in the division of the International River Basin District Odra

Division of the basin	Name of the basin	Area under study	Surface area km ²
Geographical, according to Atlas (Oder-Auen-Atlas, 2000)	source area of the Odra	from source to the Olza (inclusive)	5 842
	Upper Odra	from the Olza to the Widawa (inclusive)	18 600
	Middle Odra	from the Widawa to the Warta	29 094
	Lower Odra	from the Warta (inclusive) to the Szczecin Lagoon	65 325
According to regions for the needs of water management in Poland (Rozporządzenie RM, 2002)	Upper Odra	from source to Koźle	9 173.6
	Middle Odra	from Koźle to the Nysa Łużycka (inclusive)	42 530.1
	Warta	from source to confluence to the Odra	54 528.7
	Lower Odra	from the Nysa Łużycka to the Szczecin Lagoon (without Warta)	12 628.6
According to the subbasins established for the ICPO Report (Report..., 2004)	Upper Odra	from source to the Nysa Kłodzka (inclusive)	18 000
	Middle Odra	from the Nysa Kłodzka to the Warta, without Nysa Łużycka	31 239
	Nysa Łużycka	Nysa Łużycka Basin	4 297
	Warta	Warta Basin	54 528
	Lower Odra	from the Warta to the Szczecin Lagoon	10 797
	Szczecin Lagoon	coastal waters with Szczecin Lagoon	3 651

The area under consideration is that of the Middle Odra as presented in the ICPO Report. The total surface area amounts to 31,239 km². 51% of the area are utilised for agricultural purposes (arable land, 40.5%; orchards, 0.3%; meadows, 6.7%; pastures, 3.5%), and 29.3% are forested (KOROL *et al.*, 2002).

In this area the Odra has the following tributaries: 7 small rivers (Table 2) and 12 small streams. In 5 river basins (Oława, Bystrzyca, Kaczawa, Obrzyca and Bóbr) 71 water intakes for municipal supply systems have been established. They serve a population of about 1,412,600, including large agglomerations: Wrocław, Legnica and Zielona Góra (KOROL *et al.*, 2003).

Water quality has been monitored by 53 stations since 1998 (Fig. 1).

Table 2. Characterisation of the tributaries of the Middle Odra

Name of tributary	Position	Length km	Basin area km ²	Km of confluence
Oława	left	91.7	1167.4	250.4
Bystrzyca	left	95.2	1767.8	266.5
Widawa	right	103.2	1716.1	266.9
Kaczawa	left	83.9	2261.3	315.9
Barycz	right	133.0	5534.5	378.1
Obrzyca	right	65.7	1808.4	496.4
Bóbr	left	269.6 ¹⁾	5829.8 ¹⁾	516.2

¹⁾ Within the boundaries of Poland.

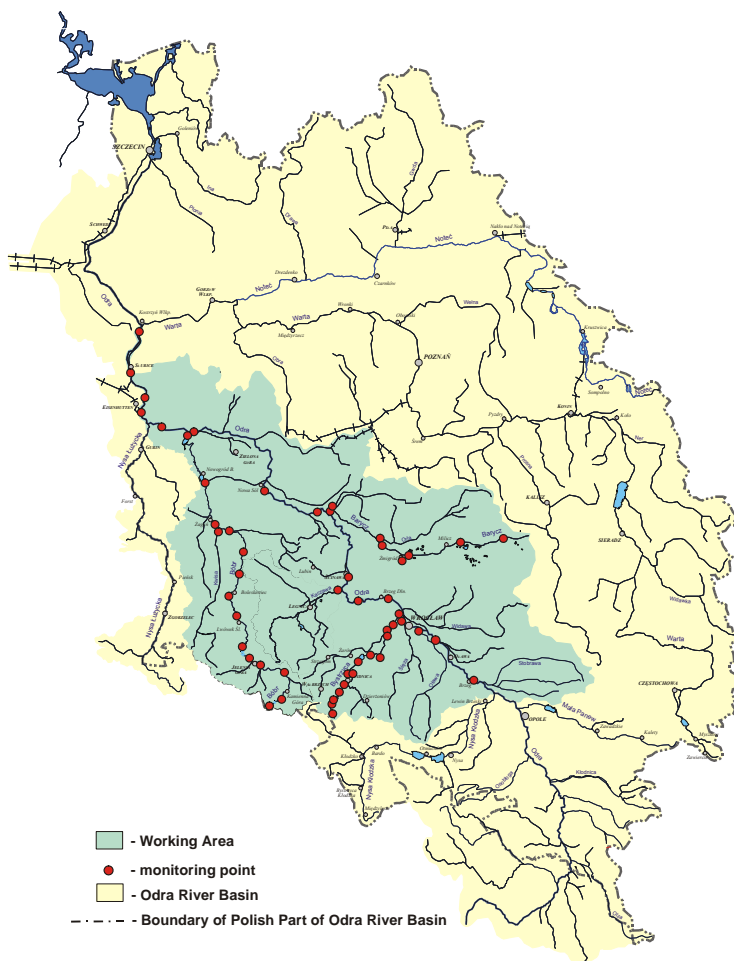


Fig. 1. Map of the Middle Odra with monitoring stations

SCOPE AND METHODS

The need to implement EU legislation as a result of Poland's access to this Community has necessitated the following actions: assessing the levels of riverine water pollution by nitrates, specifying the watercourses vulnerable to pollution by nitrogen compounds, and defining areas of particular vulnerability, where nitrogen discharge from agricultural sources should be reduced.

In the study reported in this paper use a data set was used from the monitoring stations investigated in the years 1992–2003. With the results collected in the data base it was possible:

- to assess (in terms of time and space) the occurrence of concentrations that did not exceed the limit values for tap water according to Directive 75/440/EEC (Council Directive, 1975) and Polish recommendations (Rozporządzenie MŚ z dnia 27 listopada 2002 r.): $25 \text{ mg NO}_3 \cdot \text{dm}^{-3}$ and $50 \text{ mg NO}_3 \cdot \text{dm}^{-3}$, respectively, and to classify the levels of pollution with nitrates in the monitored waters as (Rozporządzenie MŚ z dnia 23 grudnia 2002 r.):
 - high purity waters, $\leq 25 \text{ mg NO}_3 \cdot \text{dm}^{-3}$,
 - clean waters, $>25 - \leq 40 \text{ mg NO}_3 \cdot \text{dm}^{-3}$,
 - waters vulnerable to pollution, $>40 - \leq 50 \text{ mg NO}_3 \cdot \text{dm}^{-3}$,
 - polluted waters, $>50 \text{ mg NO}_3 \cdot \text{dm}^{-3}$;
- to analyse the trends of variations in the maximum concentrations of nitrates in the Middle Odra Basin in 1992–2005;
- to assess the extent of eutrophication in the investigated riverine water;
- to assess the monitoring programme developed so far and the one recommended by the Water Framework Directive (Directive 2000/60/EC) and Nitrates Directive (Council Directive 91/676/EEC) in order to find out whether it will suffice for calculating the annual loads at the “closing” stations of subbasins or water bodies.

Under Polish regulations (Rozporządzenie MŚ z dnia 23 grudnia 2002 r.) the notion ‘waters vulnerable to pollution with nitrogen compounds from agricultural sources’ includes polluted waters and waters vulnerable to pollution if no measures are taken to reduce direct or indirect discharge of nitrates and other agriculture-related nitrogen compounds that may convert into nitrates.

The extent of pollution was determined by analysing the plots of maximal nitrate concentrations along the watercourse and specifying the waters vulnerable to pollution and those polluted with nitrates. The extent of eutrophic and non-eutrophic waters was also determined in the profiles, taking into account the average concentrations of nitrates, total nitrogen, total phosphorus, and chlorophyll *a* (Podział..., 1983).

Eutrophication was assessed based on criteria included in the Decree of the Minister of Environment (Rozporządzenie MŚ z dnia 23 grudnia 2002 r.) (Table 3).

Table 3. Threshold values of basic water eutrophication parameters (in case of excess, eutrophication occurs)

Parameter	Unit	Lake water (vegetation season)	River water (mean annual concentration)	Transitional water	Coastal water
Total phosphorus	mg P·dm ⁻³	>0.1	>0.25	>0.3	>0.1
Total nitrogen	mg N·dm ⁻³	>1.5	>5	>7	>4
Nitrates	mg NO ₃ ·dm ⁻³	–	>10	>15	>8
Chlorophyll <i>a</i>	µg·dm ⁻³	>25	>25 ¹⁾	>50 / >30 ²⁾	>10

¹⁾ Refers to rivers of a water residence time sufficiently long for algal growth.

²⁾ In the section near the Odra estuary >50; in the near-estuary of other basins >30.

In our study we used the results obtained by the laboratories of the Environment Protection Inspectorates of the Lower-Silesian and Lubuskie voivodships. Analytical methods and research programmes were in compliance with the regulations of the National Environmental Monitoring System.

In the years 1992–2003, the national river monitoring programme underwent some changes, which included, inter alia, the number of stations and the frequency of analyses. Till 1997 analyses were carried out twice a month and since then sampling has been carried out once a month. Thus, over the period of 11 years, the number of nitrate analyses totalled 13,838 and the size of the set decreased from 2434 in 1992 to 643 analyses in 2005. Over the entire time period of interest, nitrates were determined with a frequency of no less than once a month, which complies with the frequency recommended in the Council Directive 91/676/EEC. The analytical method for determining nitrates in water bodies included in the Polish standard PN-87/C-04576/07 is in compliance with that in the Council Directive 75/440/EEC.

Over the period considered, water flow was measured when collecting water samples. The data sets collected in the base can be used to assess the loads discharged from the neighbour countries and the loads entering and leaving the study area.

The analysis of potential threats due to excess concentrations of nitrates was carried out for the whole 11-year set and for each year separately. Assessments are based on the maximal concentrations of nitrates that occurred in the data sets for the cross-section (KOROL *et al.*, 2002; 2003). When the maximal values exceeded 40 mg NO₃·dm⁻³, the period when excess values occurred was analysed in detail and the causes of occurrence were established.

Table 4. Comparison of the number and % of nitrate concentrations within the thresholds of water quality classes between 1992 and 2005

Year	Number of data	Concentration mg NO ₃ ·dm ⁻³		Number of data in ranges				% of data			
		Min.	Max.	ranges of concentrations, mg NO ₃ ·dm ⁻³							
				≤25	≤40	≤50	>50	≤25	≤40	≤50	>50
1992	2 434	0.04	102.6	2 258	127	20	29	92.76	5.22	0.82	1.20
1993	1 318	0.04	100.9	1 293	20	3	2	98.10	1.52	0.23	0.15
1994	1 381	0.04	107.9	1 280	76	12	13	92.68	5.50	0.87	0.95
1995	1 357	0.04	159.3	1 293	48	8	8	95.28	3.54	0.59	0.59
1996	1 293	0.09	54.86	1 222	66	4	1	94.51	5.10	0.31	0.08
1997	1 330	0.04	88.92	1 309	18	1	2	98.42	1.35	0.08	0.15
1998	934	0.35	70.70	879	42	8	5	94.11	4.50	0.86	0.53
1999	931	0.18	76.98	869	48	5	9	93.34	5.16	0.54	0.96
2000	723	0.49	102.1	670	39	5	9	92.67	5.40	0.69	1.24
2001	707	1.73	66.36	661	36	2	8	93.50	5.09	0.28	1.13
2002	716	0.31	57.07	673	36	6	1	93.99	5.03	0.84	0.14
2003	714	0.88	82.37	687	18	6	3	96.22	2.52	0.84	0.42
2004	646	0.90	79.00	611	27	5	3	94.60	4.20	0.80	0.40
2005	643	0.50	75.00	607	30	2	4	94.40	4.70	0.30	0.60
92-05	1 5127	0.04	159.3	14 312	631	87	97	94.61	4.17	0.58	0.64

1999–2001 data used for specifying zones particularly vulnerable to pollution (PVZ) by nitrates from agricultural sources.

2004–2005 data obtained after implementation of remedial programmes in particularly vulnerable zones (PVZ).

RESULTS

To find out whether the Middle Odra Basin really experienced the nuisance of water pollution with excess nitrate concentrations, a global assessment was carried out for the time period of 1992–2005. The results showed that the lotic surface waters of the Middle Odra Basin are only slightly polluted with nitrates. High purity water, clean water and water vulnerable to pollution accounted for 94.62%, 4.15% and 0.58% of the samples, respectively, while the percent of water vulnerable to pollution, where the concentrations of nitrates exceeded $50 \text{ mg NO}_3 \cdot \text{dm}^{-3}$, amounted to 0.65% only. In particular years the percent of concentrations exceeding the standard value varied from 0.08% to 1.24% (Table 4).

The results have also shown that the quality of surface waters used for municipal supply complied with the standards set in the Decree of the Ministry of Environment of 27 November 2002. This should be attributed to the implementation of the Council Directive 75/440/EEC.

As can be inferred from the detailed analysis of the results obtained at 49 monitoring stations in 1998, 1999 and 2003, 2004, 2005 (Table 5), water polluted with nitrates was detected in the basins of only two tributaries of the Middle Odra: in the Bystrzyca and Barycz (below the discharge of polluted waters from the Orla and Kopanica) The results obtained in 2003 revealed that the water of the Bóbr in the source area was polluted by nitrates discharged from the territory of the Czech Republic.

Table 5. The highest nitrate concentrations recorded at the monitoring stations of the Middle Odra and the assessment of eutrophication processes observed in these waters

River	Km	Monitoring station	Max. concentration, $\text{mg NO}_3 \cdot \text{dm}^{-3}$				
			1998	1999	2003	2004	2005
1	2	3	4	5	6	7	8
Odra	199.1	above Brzeg Opolski	19.47	21.59	15.30	16.10	13.86
Odra	249.0	Wrocław	19.25	24.42	17.20	12.43	26.01
Oława	2.0	discharge into the Odra	29.20	27.88	18.40	18.90	14.30
Śleza	2.4	discharge into the Odra	36.28	30.97	27.40	22.20	17.80
Bystrzyca	88.4	above Głuszyca	5.97	5.58	5.70	5.13	6.15
Bystrzyca	78.0	above the Lubachów reservoir	10.27	10.84	15.00	9.27	11.80
Bystrzyca	74.1	below the Lubachów reservoir	38.98	42.88	43.80	67.40	66.20
Bystrzyca	60.0	above discharge of the Pilawa River	26.15	24.21	48.70	33.50	37.00
Pilawa	0.5	discharge into Bystrzyca	45.58	76.98	48.70	56.10	62.20
Bystrzyca	50.7	above the Mietków reservoir	36.02	59.29	43.40	43.50	33.10
Bystrzyca	37.5	below the Mietków reservoir	17.21	17.48	21.90	14.30	21.39
Czarna Woda	0.5	discharge into the Bystrzyca	27.43	37.61	25.50	16.80	17.11
Strzegomka	0.2	discharge into the Bystrzyca	25.22	37.17	37.20	32.40	31.10
Bystrzyca	12.8	water gauge Jarnołtów	21.68	28.76	21.40	18.40	20.90

cont. table 5

1	2	3	4	5	6	7	8
Bystrzyca	1.2	discharge into the Odra	21.24	28.76	23.60	18.10	19.37
Odra	278.0	above ZP "Rokita" (Brzeg Dolny)	27.88	23.01	17.80	19.40	16.47
Odra	303.0	below ZP "Rokita"	22.12	21.68	18.60	18.60	17.85
Kaczawa	3.2	discharge into the Odra	20.81	19.91	23.00	18.00	21.00
Odra	330.0	above Ścinawa	18.14	23.45	19.90	20.00	17.00
Barycz	115.2	above discharge of the Złotnica River	21.42	28.76	19.60	41.14	16.70
Barycz	91.4	above Milicz	36.28	23.01	10.90	38.30	31.31
Barycz	55.9	above Żmigród	32.30	20.35	11.60	37.00	26.75
Sąsiedzchnica	0.5	discharge into the Barycz	24.78	19.47	13.90	26.90	28.52
Barycz	36.6	above discharge the Orla River	25.75	19.47	12.40	33.00	25.00
Orla	2.0	discharge into the Barycz	70.70	58.85	38.50	79.00	75.00
Kopanica	1.0	discharge into Barycz	58.67	63.27	62.00	18.10	29.80
Barycz	1.0	discharge into the Odra	56.90	48.67	55.70	28.10	32.50
Odra	382.5	below discharge of the Barycz	23.45	23.01	25.60	21.00	19.00
Odra	428.8	above Nowa Sól	23.89	21.33	22.60	22.20	18.46
Odra	511.0	above discharge of the Bóbr River	19.25	25.00	19.20	17.30	17.40
Bóbr	269.6	boundary monitoring station	12.35	15.31	82.40	21.79	15.32
Bóbr	248.0	above discharge of the Zadrna River	8.32	9.07	9.10	11.60	9.70
Bóbr	212.7	above Jelenia Góra	12.12	12.21	10.80	13.42	14.22
Bóbr	205.1	above "Celwiskoza"	9.82	10.71	9.40	9.43	12.84
Bóbr	191.9	below the "Pilchowice" reservoir	10.18	10.35	9.60	12.09	16.70
Bóbr	167.7	above Lwówek Śląski	11.95	11.90	10.90	12.58	18.16
Bóbr	143.5	above Bolesławiec	12.43	12.39	11.30	12.36	16.74
Bóbr	127.0	below discharge of the Bobrzyca River	12.61	12.65	11.80	12.67	16.78
Bóbr	111.2	above Leszno Górne	8.85	10.84	11.90	13.20	15.60
Bóbr	90.0	below discharge of the Szprotawa River	9.73	7.96	11.20	13.08	15.10
Kwisa	4.4	discharge into the Bóbr	7.96	9.34	13.50	10.00	14.00
Bóbr	77.4	above Żagań	8.85	8.72	12.60	13.90	16.10
Bóbr	47.9	Nowogród Bobrzański	8.85	8.94	11.20	13.70	15.20
Bóbr	2.0	discharge into the Odra	8.41	8.85	9.80	13.60	13.80
Odra	530.6	Połęcko (boundary)	19.91	20.88	23.70	19.38	22.60
Odra	552.0	above Eisenhüttenstadt (boundary)	20.13	26.37	19.00	19.49	25.26
Odra	566.0	below Eisenhüttenstadt (boundary)	19.51	24.82	19.50	18.42	23.23
Odra	581.0	above Słubice (boundary)	21.33	20.62	17.80	19.40	23.09
Odra	615.0	above discharge of the Warta (boundary)	21.42	23.63	18.30	18.38	23.40

– eutrophic water.

When analysing the sources of pollution of the Piława and Bystrzyca waters, it became obvious that nitrates enter the riverine water with the effluents from municipal sewage treatment plants. It is believed that the planned modernisation of the plants will upgrade the efficiency of nutrient removal and thus reduce the pollution of the said rivers. The assessment of sources of high nitrate concentrations in the Barycz and its tributaries (Orla and Kopanica) measured in the years 1998–2001 (i.e. before the zones particularly vulnerable to pollution by nitrates from agricultural sources were specified) showed that these pollutants came from agricultural activity. Based on the so obtained data the Orla and Kopanica Basins (Figure 2) were defined as particularly vulnerable zones where nitrogen discharge from

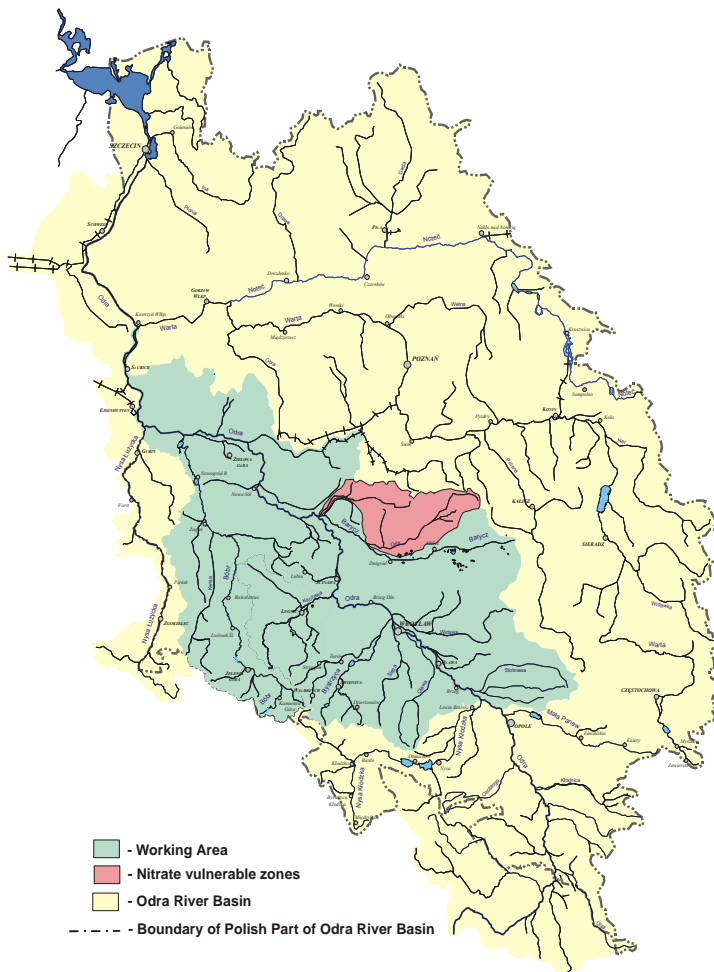


Fig. 2. Map of the Middle Odra with vulnerable zones from which nitrogen discharge from agricultural sources should be limited

agricultural sources must be reduced (Rozporządzenie Dyrektora RZGW, 2004; Rozporządzenie MŚ z dnia 23 grudnia 2002 r.). In 2003 additional monitoring of nitrates was implemented at 19 stations on the Orla and 8 stations on the Kopanica. Maximum concentration in the Orla and its tributaries were $110.9 \text{ mg NO}_3 \cdot \text{dm}^{-3}$, that in the Kopanica – $87.4 \text{ mg NO}_3 \cdot \text{dm}^{-3}$. The results allowed for the conclusion that the excess of riverine water pollution with nitrates was observed in spring (March, April) and autumn (September, October); in the other seasons the concentrations of nitrates did not exceed $10 \text{ mg NO}_3 \cdot \text{dm}^{-3}$. Monitoring data recorded in 2004 and 2005 showed that the concentrations of nitrates in the Orla did not change while those in the Kopanica and Barycz decreased notably and did not exceed $40 \text{ mg NO}_3 \cdot \text{dm}^{-3}$. This finding indicates that the remedial actions were successful only in the Kopanica Basin and contributed also to the reduction of nitrates in the Barycz.

Analyses of the river water for the presence of nitrates were accompanied by eutrophication assessments. According to the data obtained for the investigated rivers in 2003–2005, eutrophic river waters were detected at 32 out of the 49 monitoring stations. What seems to be of particular significance is that eutrophication occurred along the entire length of the Odra River. As for the tributaries, only the Oława and the Bóbr were not eutrophic (Table 5). Other tributaries showed eutrophication processes only in their middle and lower parts; the spring parts in mountainous areas being non-eutrophic.

CONCLUSIONS

Obtained results enable the following conclusions to be formulated:

1. The data set from river water monitoring obtained so far is sufficient for assessing the vulnerability to nitrates and the extent of eutrophication.

2. In river basins where surface water is taken for water supply systems, the water quality is very high and maximum concentrations of nitrates fall below $25 \text{ mg NO}_3 \cdot \text{dm}^{-3}$.

3. In the Middle Odra Basin, river water pollution with nitrates is very low: high purity waters, clean waters and water vulnerable to pollution accounted for 94.62, 4.15 and 0.58% of the samples, respectively; water samples where nitrate concentrations exceeded $50 \text{ mg NO}_3 \cdot \text{dm}^{-3}$ accounted for 0.65%. In particular years the percent of concentrations that exceeded the levels set by relevant standards varied from 0.08 to 1.24%.

4. With the results obtained it was possible to determine zones particularly vulnerable to pollution with nitrates from agricultural sources. These zones are in the Barycz Basin and cover:

- the Orla Basin of a surface area of 1546.5 km^2 ;
- the Rów Polski (Kopanica) Basin of a surface area of 827.6 km^2 .

5. The occurrence of eutrophication processes was detected in 32 out of 53 monitoring stations. Eutrophic waters occurred along the entire length of the Odra. Of the Odra tributaries, only Oława and Bóbr were not eutrophic; other tributaries were free from eutrophication processes only in the source areas.

6. To provide appropriate execution of the programme that enables the control of surface water pollution by nitrates, as well as the control of eutrophication processes, it is necessary to establish a monitoring network carrying out a precisely defined research programme. This monitoring system must be linked to a network that is capable to measure the water flow, thus enabling nutrient balances to be established in specified measuring and control cross-sections. The once-a-month frequency of sampling can be regarded as sufficient only for rivers carrying high purity and clean waters. Vulnerable waters, as well as water polluted with nitrates, should be sampled with a higher frequency

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10. Rozporządzenie Ministra Środowiska z dnia 27 listopada 2002 w sprawie wymagań, jakim powinny odpowiadać wody powierzchniowe wykorzystywane do zaopatrzenia ludności w wodę przeznaczoną do spożycia. (Directive of the Minister of Environment of November 27 2002 on the requirements that should be met by surface waters used as sources of drinking water). Dz. U. nr 204 poz. 1728.
11. Rozporządzenie Ministra Środowiska z dnia 23 grudnia 2002 r. w sprawie kryterium wyznaczania wód wrażliwych na zanieczyszczenia związkami azotu ze źródeł rolniczych. (Directive of the Minister of Environment of December 23 2002 on the criteria for estimating waters sensitive to pollution by nitrogen compounds from agricultural sources). Dz. U. nr 241 poz. 2093.
12. Rozporządzenie Rady Ministrów z 10 grudnia 2002 r. w sprawie przebiegu granic obszarów dorzeczy, utworzenia regionalnych zarządów gospodarki wodnej oraz podziału obszarów dorzeczy na regiony wodne. (Government order of December 10, 2002 on the route of catchment borders, on establishment of regional water management boards and on catchment division into water regions) Dz. U. nr 232 poz. 1953.

STRESZCZENIE

Ocena zanieczyszczenia azotanami wód w dorzeczu Odry Środkowej

Słowa kluczowe: *azotany, dorzecze Odry Środkowej, eutrofizacja, jakość wód, obszary szczególnie narażone na zanieczyszczenie azotanami z rolnictwa*

W pracy przeanalizowano wyniki opracowanej charakterystyki stanu jakości wód powierzchniowych, stanowiącej podstawę do określenia wód wrażliwych na zanieczyszczenia związkami azotu ze źródeł rolniczych oraz wyznaczenia obszarów szczególnie narażonych, z których odpływ azotu ze źródeł rolniczych należy ograniczyć. Szczegółowo scharakteryzowano zawartość związków azotu w wodach powierzchniowych na obszarze dorzecza Środkowej Odry, oceniono stopień eutrofizacji śródlądowych wód powierzchniowych płynących, w których czynnikiem decydującym jest azot. Przedstawiono wyniki wyznaczania wód powierzchniowych wrażliwych na zanieczyszczenia (zanieczyszczonych oraz zagrożonych zanieczyszczeniem) związkami azotu ze źródeł rolniczych i określono obszary szczególnie narażone, z których odpływ azotu ze źródeł rolniczych należy ograniczyć. Wyniki przedstawiono w ujęciu tabelarycznym i na rysunkach.

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