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INFLUENCE OF INDUSTRIAL POLLUTION ON THE WATER QUALITY OF THE LOWER RIVER DOBRA

WPŁYW ZANIECZYSZCZEŃ PRZEMYSŁOWYCH NA JAKOŚĆ WÓD DOLNEGO ODCINKA RZEKI DOBREJ

Abstract: Between 2007 and 2008 water samples were collected from the River Dobra (right-side tributary of the River Widawa). The samples were gathered in four seasons from five sites of the Lower Dobra River. The following parameters were measured: temperature, water reaction, alkalinity, hardness, and oxygen, nitrites(III and V), ammonium, chlorides, calcium, phosphorus, sulfates and magnesium content.

The influence of contaminants from a plant on the quality of the Lower Dobra River was researched. Almost all examined parameters were on average higher on the site II in comparison with the other researched sites. The highest changes were observed in phosphorus (an increase of 192 %), chlorides (an increase of 155 %) and nitrates(V) (an increase of 153 %) concentration. No differences were determined in an average content of nitrates(III) but their concentration in sewage was different depending on the season. It was two-fold higher in summer and winter. There were no significant differences in water reaction between the River Dobra and sewage from the plant.

On the site II both higher significant increase in chlorides concentration and significant increase in phosphorus content as compared with other measurement sites were noted. These results cause higher significant increase of an electric conductivity of water. Despite the fact that many pollutants were introduced into the Lower Dobra River an average concentrations of magnesium (15 %) and nitrates(III) (7 %) were higher in water of the River Dobra near the Widawa (site V) than in water coming from the River Dobra above a sewage tributary (site I). Water conductivity was measured at higher level with the highest in autumn – 1345 $\mu S \cdot cm^{-1}$ and the lowest in winter – 706 $\mu S \cdot cm^{-1}$.

Keywords: water quality, Dobra River, sewage

Water contamination creates a considerable problem these days. However, natural environment plays a role of a limiting factor to an adverse antropogenic influence by the mobilization of purifying processes in water.

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Natural water environment as a very good dissolvent may contain different substances of both organic and inorganic origin as well as gases which enter into the water through hydrological cycle [1]. No natural water is chemically clean hence it should always be considered as a mixture of water and substances comprised of organic and inorganic contaminants and other substances [2]. Both substances that do not occur in ecosystems normally (eg pesticides, petroleum compounds) and compounds which flowing into the water causing their pollution are treated as contaminants. Such substances comprise of phosphorus, sulfates, nitrates etc. Too high amount of contaminants introduced to river course can contribute to the creation of open sewage channels. In spite of the fact that many sewage treatment plant have been established in the recent years there are still places supplying and discharging their effluents to the running and stagnant water [3]. Probably it is one of the most crucial factors influencing deterioration of water quality, although, rivers deal with this problem by mobilization of self-purifying processes. Self-purification is strongly related to biochemical transformation of the organic compounds into the simple, inorganic substances with the usage of microbial organisms operating on the oxygen taken directly from water and air [3]. Effective self-purification process can be observed if the ratio of the sewage to the surface water volume, where the effluents flow is not exceeding 1:50 ratio. The inflow of pollutants inhibits self-purification process by poisoning microorganisms causing a decay of organic compounds [4].

Big, pure rivers deal with contaminants a lot better than smaller ones. Due to the fact that sewage entering smaller rivers can lead to biological balance disturbance it was of the utmost importance to determine if water of the Lower Dobra River is capable of its self- purification. The aim of this research was to examine if self-purification processes allow contaminated water to return to the water of the previous cleanness condition before it flowed into the River Widawa.

Material and methods

The subject of the research was water obtained from the River Dobra which is also called the River Widawka and flows in the area of Lower Silesia being a right Widawa tributary. The source of the river is located at the height of 165 m above the sea level in the region of Bartków. The Widawa Basin is symmetrically built, fan-shaped with its lower part changing into parallel layout while the drainage area is getting asymmetric [5].

Analytic material was collected in four seasons between 2007 and 2008 on five different sites:

Site I – Pawłowice – above sewage inflow	59°09′42,95°N	17°06′56,32°E
Site II – Pawłowice – in the place of effluent inflow	51°09′42,07°N	17°06′55,71°E
Site III – Pawłowice – below sewage inflow	51°09′40,43°N	17°06′52,56°E
Site IV – Kłokoczycki bridge	51°09′17,70°N	17°06′17,25°E
Site V – Widawa Estuary – Kłokoczce	51°08′57,09°N	17°05′41,44°E

The following parameters were measured directly on the sites:
– temperature using using a Slandi TC 204 electronic thermometer;
– electrolytic conductivity [6];
– reaction using electrometric method [7];
– dissolved actual oxygen using Hanna Instruments 9143 oxygen probe [8].
The other parameters were measured under laboratory conditions:
– total hardness [9];
– calcium [10];
– magnesium as a difference between total hardness and calcium;
– nitrate(V) nitrogen [11];
– nitrate(III) nitrogen [12];
– ammonium nitrogen [13];
– phosphates [14];
– chlorides [15].
Obtained results were statistically analysed using Statistica 8.0 programme.

Results and discussion

Water temperature in the River Dobra was ranging between 4.5 ^oC and 21 ^oC which is a standard temperature for Polish waters. Temperature in surface water shows great variability depending on the season (in summer 20 ^oC and more while in winter 0 ^oC) [16].

Conductivity depends on the temperature and the kind of soluble ions contained in water. Conductivity in the River Dobra was ranging from 706 $\mu S \cdot cm^{-1}$ to 1345 $\mu S \cdot cm^{-1}$ (Table 1, Fig. 1). Exceeding standard values [4] the result is characteristic for water of the II class of water [17].

Table 1

Conductivity [$\mu S \cdot cm^{-1}$] of the River Dobra water between 2007–2008 year

	Min.	Max	Average	Standard deviation
Spring	908	1212	1028.2	128.02
Summer	748	1315	891.2	239.17
Autumn	834	1345	949.4	221.74
Winter	706	1043	785.6	145.48

Regardless of the season higher conductivity (up to 40 %) was measured in the place of sewage inflow introduction. The longer distance from the effluent inflow the lower conductivity. Above the place where sewage was introduced into the water of the River Widawa conductivity was achieving a level characteristic for water without effluent loading. Taking into account electric conductivity as the sole criteria for comparison it could be assumed that water of the River Dobra was considerably more polluted than

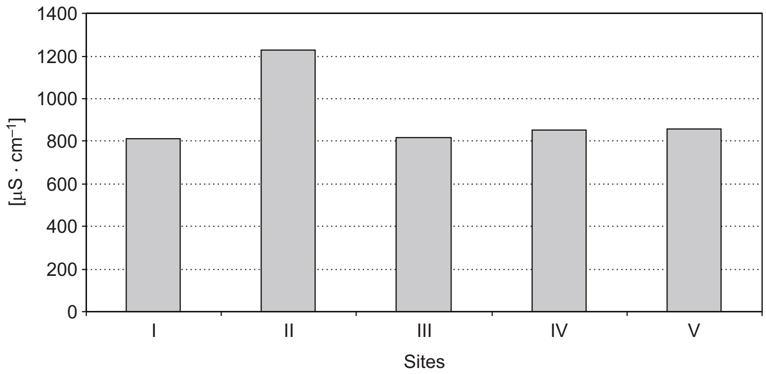

Fig. 1. Average water conductivity [$\mu S \cdot cm^{-1}$] on five sites of the River Dobra

mountain river [18]. However, its conductivity was similar to the conductivity of the Wisla flowing in lowland area near to Warsaw (380–1360 $\mu S \cdot cm^{-1}$) [19].

Water reaction of the River Dobra in the place where sewage was introduced ranged between 7.37 and 8.10 (Table 2). After sewage introduction reaction was increasing in all seasons except for winter (Fig. 2). Below the place of sewage inflow to the water no decrease in reaction was observed therefore it can be assumed that there were no salts of weak alkalis and strong acids in water on the II site with high probability of strong alkalis and weak acids occurrence. Water of the River Dobra are suitable for fish due to their favorable water reaction ranging from 6.5 to 8.5 [20] which is considered to be the most optimal for fish health and growth. Higher water reaction was noted in winter and autumn in comparison to other seasons. Similar phenomena was observed by Saleh et al [21]. When comparing the River Dobra waters in terms of their reaction it should be noted that they did not differ from other Polish waters [18, 22–24] and they could have been classified to the II class of water [17].

Table 2

Water reaction (pH) of the River Dobra water between 2007–2008 year

	Min.	Max	Average	Standard deviation
Spring	7.43	8.97	8.16	0.56
Summer	8.00	8.38	8.174	0.15
Autumn	7.33	7.72	7.49	0.17
Winter	7.75	8.09	7.974	0.14

Dissolved oxygen presence in water is an undeniable proof for water ability to self-purification by oxidation of organic compounds (or their decomposition in the presence of oxygen bacteria) [25]. Oxygen in such form is often used for the determination of water quality. An average concentration of oxygen in clean rivers in temperate climate ranges from 5 to 7 $mgO_2 \cdot dm^{-3}$ and such levels of an oxygen were measured in the Dobra in autumn and winter. Lower concentrations may result from

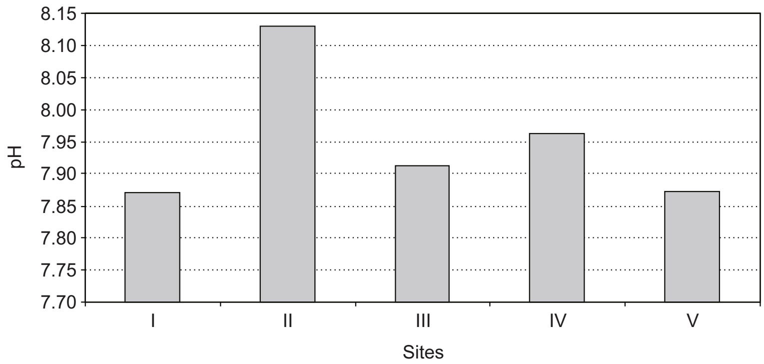

Fig. 2. Average water reaction (pH) on five sites of the River Dobra

higher water temperature or mineralization processes of organic compounds which use up oxygen [25]. In spring and summer it is undoubtedly for the increase in temperature why oxygen concentration is lower in the River Dobra. Dissolved oxygen was ranging from 0.00 $mgO_2 \cdot dm^{-3}$ to 13.90 $mgO_2 \cdot dm^{-3}$ (Table 3, Fig. 3).

Table 3

Dissolved oxygen [$mgO_2 \cdot dm^{-3}$] in the River Dobra water between 2007–2008 year

	Min.	Max	Average	Standard deviation
Spring	0.00	4.73	3.03	1.80
Summer	1.29	5.01	3.03	1.49
Autumn	3.05	5.75	3.96	1.04
Winter	9.55	13.9	11.38	1.71

Based on the Regulation from 2004 [26] waters of the Dobra were classified to V class mainly due to the lack of oxygen in the place of sewage introduction in spring.

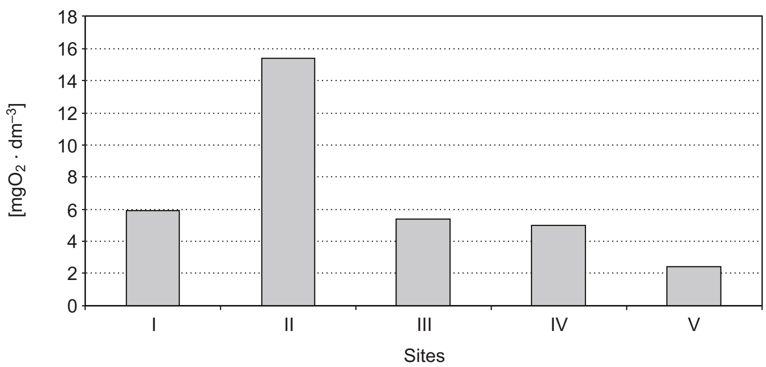

Fig. 3. Average dissolved oxygen [$mgO_2 \cdot dm^{-3}$] in water on five sites of the River Dobra

Current regulations do not allow for classification of the River Dobra waters to I nor II class. Temporary lack of oxygen in water is possible in other classes [17]. Low oxygen concentration may be influenced by the season as in spring due to higher activity of biota greater oxygen demand is noted. Oxygen concentration measured in the Dobra is low especially in spring and in water where sewage is introduced. The following rivers were compared in terms of oxygen concentration: the River Bystrzyca Dusznicka (7.5–10.6 $mgO_2 \cdot dm^{-3}$) [18], the Stream Topór (8.62–15.20 $mgO_2 \cdot dm^{-3}$) [22] and the River Nysa Szalona (7.47–14.93 $mgO_2 \cdot dm^{-3}$) [24]. Oxygen concentration in the Dobra was lower than in other rivers from Lower Silesia. In the River Dobra maximum amount of oxygen was noted in winter because of higher oxygen solubility in cold water [27]. After the introduction of sewage waters of the Dobra better oxygen concentration on nearby site III was noted. At the estuary of the River Dobra to the Widawa oxygen concentration was the same as before sewage introduction. It was only in the place of effluent introduction in spring and summer where water was inappropriate even for *Cyprinidae* fish [20].

Table 4

BOD_5 [$mgO_2 \cdot dm^{-3}$] of the River Dobra water between 2007–2008 year

	Min.	Max	Average	Standard deviation
Spring	1.05	3.57	1.96	1.03
Summer	0.98	4.67	2.41	1.53
Autumn	0.73	17.22	4.82	6.96
Winter	4.42	37.65	18.11	12.42

Biochemical Oxygen Demand (BOD_5) measured in the Dobra was very diverse depending mainly on a season (Table 4, Fig. 4). The parameter was ranging from 0.98 to 37.65 $mgO_2 \cdot dm^{-3}$. According to the Regulation of 2004 it allows for classification to V class [26]. In summer waters of the Dobra in terms of oxygen demand should have been classified to waters which were susceptible to contamination [28]. It could be

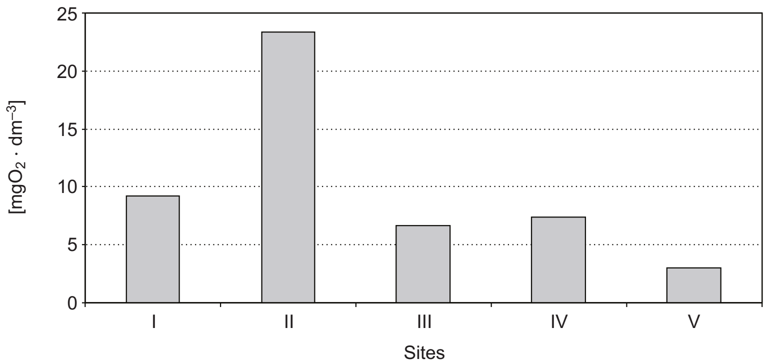

Fig. 4. Average BOD_5 [$mgO_2 \cdot dm^{-3}$] on five sites of the River Dobra

claimed that water on the site I in summer and autumn was not contaminated. Organic pollution occurred above the field of investigation in winter as even above the place of sewage introduction $BOD_5 > 5$ $mgO_2 \cdot dm^{-3}$. Any effluent introduction into the water of the River Dobra resulted in an increase in oxygen demand. At the Widawa estuary water may be classified to insignificantly contaminated. BOD_5 results obtained in summer were similar to that of the Nysa Szalona (0.48–8.14 $mgO_2 \cdot dm^{-3}$) [24], higher in the Bystrzyca Dusznicka (0.1–1.7 $mgO_2 \cdot dm^{-3}$) [18] and lower in the Topór Stream (5.26–7.00 $mgO_2 \cdot dm^{-3}$) [22]. However, in winter it was considerably higher in comparison with other rivers in the region.

Water hardness is a result of dissolved salts occurrence in water mainly calcium and magnesium, salts of iron, barium and manganese are less significant [29]. In 2007 in the Dobra hardness was ranging from 321.30 $mgCaCO_3 \cdot dm^{-3}$ to 1013.88 $mgCaCO_3 \cdot dm^{-3}$ (Table 5, Fig. 5). Hardness measured in the River Dobra at the estuary to the Widawa in 2006 was estimated to 298–490 $mgCaCO_3 \cdot dm^{-3}$ while in 2004 it was measured at 275–492 $mgCaCO_3 \cdot dm^{-3}$ [30]. Therefore, hardness of the Dobra was higher in 2007 in comparison with results from previous years especially in terms of maximum values. Except for the River Dobra high total hardness was also noted in the Topór Stream (913.92–963.90 $mgCaCO_3 \cdot dm^{-3}$) [22].

Table 5

The water hardness [$mgCaCO_3 \cdot dm^{-3}$] of the River Dobra between 2007–2008 year

	Min.	Max	Average	Standard deviation
Spring	321.3	414.12	367.71	43.87
Summer	571.2	1013.88	699.72	178.52
Autumn	703.29	963.90	774.69	111.62
Winter	714.0	874.65	753.27	69.59

According to Holden 1970 [19] water in the Dobra in terms of hardness was determined as very hard. The introduction of sewage into the water of the Dobra

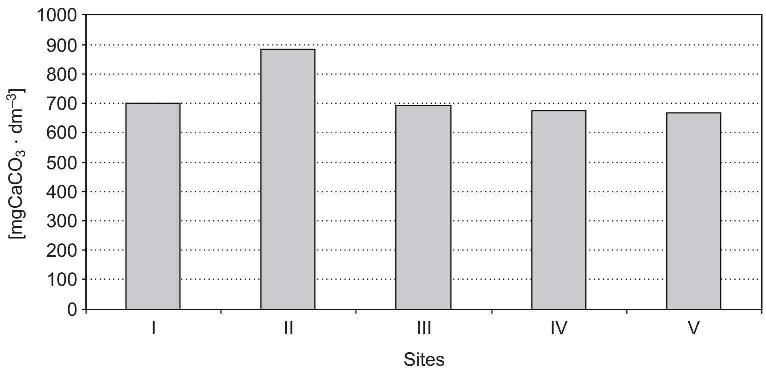

Fig. 5. Average water hardness [$mgCaCO_3 \cdot dm^{-3}$] on five sites of the River Dobra

changed the hardness of water so it can be suspected that effluent was rich in calcium, magnesium, iron and manganese salts introduced mainly as carbonates, sulfates and chlorides.

Calcium concentration in water of the River Dobra did not allow for classification to the I nor II class [17]. Higher calcium concentration was measured on the site II (Table 6, Fig. 6). However, on the site III a decrease in calcium content to preliminary values was apparent. An increase in Ca and Mg content in both the River Dobra and the Basin during autumn–winter period is justified when taking into account presence of fish farms above the field of research. After autumn fish catches are stored in storehouses which are limed and filled with water only late in autumn or winter. It explains elevated reaction of water in this season.

Table 6

Calcium concentration [mgCa · dm^{-3}] in water of the River Dobra between 2007–2008 year

	Min	Max	Average	Standard deviation
Spring	112.97	155.87	124.97	17.53
Summer	168.74	211.64	182.75	17.41
Autumn	254.54	337.48	274.27	35.54
Winter	271.70	350.35	298.81	30.50

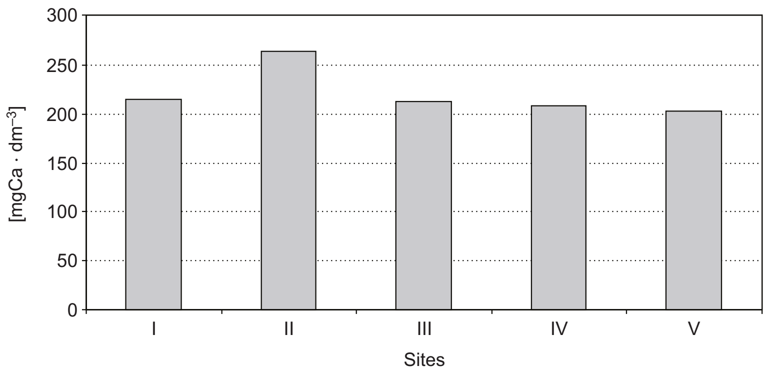

Fig. 6. Average calcium concentration [mgCa · dm^{-3}] in water on five sites of the River Dobra

Magnesium concentration in water of the Dobra in 2007 was ranging from 6.07 to 175.33 mgMg · dm^{-3} (Table 7, Fig. 7) which prevented it from classification to the I nor II class. Previous legally binding norms would allow for water classification to the IV class. Higher amount of magnesium may have been caused by sewage drop and processes of washing from soil. Effluent introduction (especially in summer) influenced higher Mg concentration in waters of the Dobra although 50 m from the place of introduction considerable decrease in Mg content was observed. No increase in Mg concentration in sewage was noted in spring and autumn. High level of Mg in winter was probably caused by mentioned earlier liming in fish storehouses which with calcium introduces magnesium compounds.

Table 7

Magnesium concentration [mgMg · dm^{-3}] in water of the River Dobra between 2007–2008 year

	Min.	Max	Average	Standard deviation
Spring	5.20	32.11	13.53	11.49
Summer	26.04	118.00	59.18	34.76
Autumn	15.62	31.24	21.87	7.82
Winter	143.22	175.33	151.03	13.91

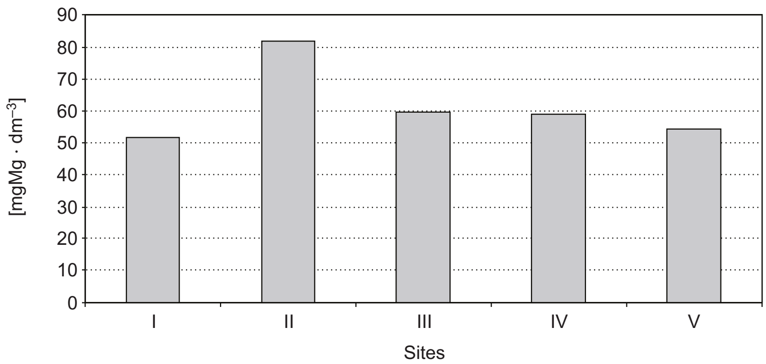

Fig. 7. Average magnesium concentration [mgMg · dm^{-3}] in water of on five sites of the River Dobra

Occurrence of nitric compounds in water indicates permanent organic contamination of water. Nitrates are an indicator of long and constant pollution [25]. In surface waters nitrates are usually determined at low concentration. They belong to organic and inorganic compounds of the highest oxidation degree and are present in sewage treatment effluents after the process of biological purification. Sources of nitrates comprise of urban, industrial sewage and flow from fields fertilized with nitric fertilizers which penetrate to water [1]. The highest nitrates concentration in the Dobra was measured in the place of effluent introduction (Table 8, Fig. 8).

Table 8

Nitrates(V) concentration [mgNO_3 · dm^{-3}] in water of the River Dobra between 2007–2008 year

	Min.	Max	Average	Standard deviation
Spring	0.04	0.07	0.046	0.01
Summer	0.04	0.06	0.048	0.01
Autumn	0.15	1.05	0.340	0.40
Winter	0.10	0.14	0.112	0.02

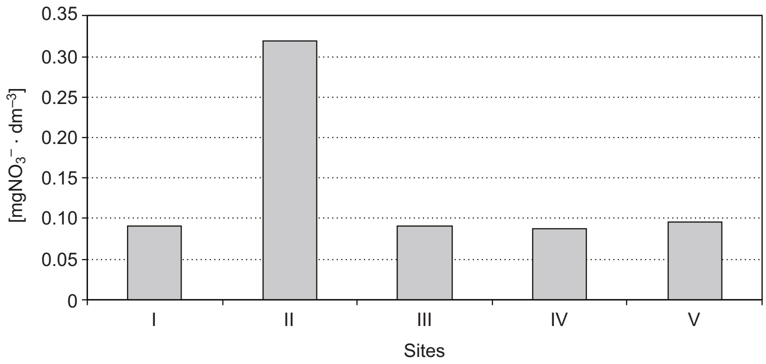

Fig. 8. Average nitrates concetration [$mgNO_3 \cdot dm^{-3}$] in water on five sites of the River Dobra

Presence of all these nitric compounds in water may indicate constant contamination of water with sewage also from surrounding fields and meadows. Nitrates levels were ranging from 0.10 to 1.05 $mgNO_3 \cdot dm^{-3}$ and despite an increase in their concentration on the site II they still were determined at low levels which allowed for classification of water to the I class according to both current and expired norms [17, 26]. Higher nitrates concentration was observed in spring, summer and autumn, however, it was not considerable.

Nitrates(V) concentration in the River Dobra in comparison with the mountain stream Brzęczek (8.63 $mgNO_3 \cdot dm^{-3}$) was considerably lower [31]. Waters of the Dobra at the estuary to the Widawa in 2006 indicated higher nitrates concentration up to 30 % (3.14–31.3 $mgNO_3 \cdot dm^{-3}$) while in 2004 up to 50 % (5.67–51.2 $mgNO_3 \cdot dm^{-3}$). High concentration of this parameter (6.38–17.3 $mgNO_3 \cdot dm^{-3}$) was noted in water of the researched River Dobra below Dobroszyce in 2007 [30]. Approximate levels of nitrates were measured also in other rivers such as the Postomia (0.01–0.74 $mgNO_3 \cdot dm^{-3}$) [32], the Topór Stream (0.14–0.17 $mgNO_3 \cdot dm^{-3}$) [22] and the Nysa Szalona (0.00–5.24 $mgNO_3 \cdot dm^{-3}$) [24].

In terms of minimum nitrates(III) concentration of water Dobra River was similar to water of the Widawa (0.00–0.03 $mgNO_2 \cdot dm^{-3}$) [33], the Bystrzyca Dusznicka (0.00–0.25 $mgNO_2 \cdot dm^{-3}$) [18] and the Topór Stream (0.00 $mgNO_2 \cdot dm^{-3}$) [22]. A bit higher concentration was noted in water of the Dobra flowing into the Widawa in 2006 (0.006–1.41 $mgNO_2 \cdot dm^{-3}$) and in 2004 (0.115–1.06 $mgNO_2 \cdot dm^{-3}$) [30]. The River Brzęczek in Sudety showed similar nitrites concentration (0.23 $mgNO_2 \cdot dm^{-3}$) [23] to the Dobra in winter and spring although it was lower in other seasons. Diverse nitrites concentration in the River Dobra and the lack of their clear connection with the introduction of sewage may lead to assumption that there was an insignificant amount or complete lack of nitrites in the sewage.

Nitrates(III) concentration was ranging from 0.00 $mgNO_2 \cdot dm^{-3}$ to 5.87 $mgNO_2 \cdot dm^{-3}$ (Table 9, Fig. 9) what allowed for classification of the researched water to the V class (according to The Regulation from 2004) [26]. There are no current norms regulating the amount of nitrates(III) in Polish rivers.

Table 9

Nitrates(III) concentration [mgNO_2 · dm^{-3}] in water of the River Dobra between 2007–2008 year

	Min.	Max	Average	Standard deviation
Spring	0.002	0.210	0.09	0.10
Summer	2.950	5.870	3.98	1.18
Autumn	< 0.002	1.500	0.58	0.55
Winter	0.150	0.300	0.21	0.05

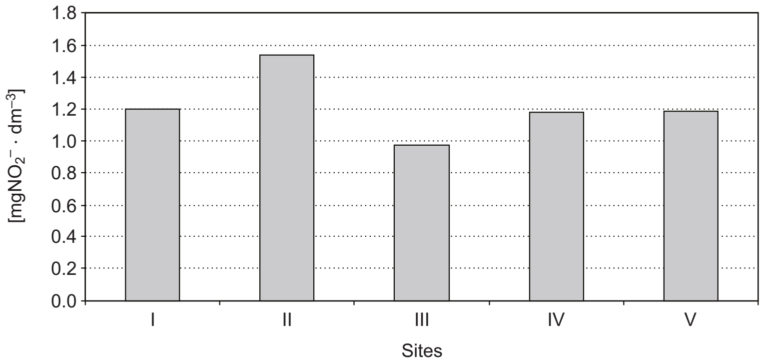

Fig. 9. Average nitrates(III) concentration [mgNO_2 · dm^{-3}] in water on five sites of the River Dobra

During the year ammonium values were changing with the lowest concentration occurring in summer when ammonium in higher temperature was used by plants in nitrification processes. In winter higher concentration was observed due to the lower temperature and the inhibition of life in waters as there were no nitrification processes. The highest ammonium concentration in the Dobra was noted in spring [19]. Ammonium concentration was ranging from 0.00 mgNH_4 · dm^{-3} to 7.32 mgNH_4 · dm^{-3} (Table 10, Fig. 10).

Table 10

Ammonium concentration [mgNH_3 · dm^{-3}] in water of the River Dobra between 2007–2008 year

	Min.	Max	Average	Standard deviation
Spring	2.76	7.32	4.04	1.86
Summer	2.16	2.89	2.42	0.28
Autumn	0.60	3.00	1.26	0.98
Winter	< 0.04	3.00	1.80	1.44

According to the Regulation from 2008 waters with such parameters can not be classified to the I nor II class but to the III, IV or V class where no limiting

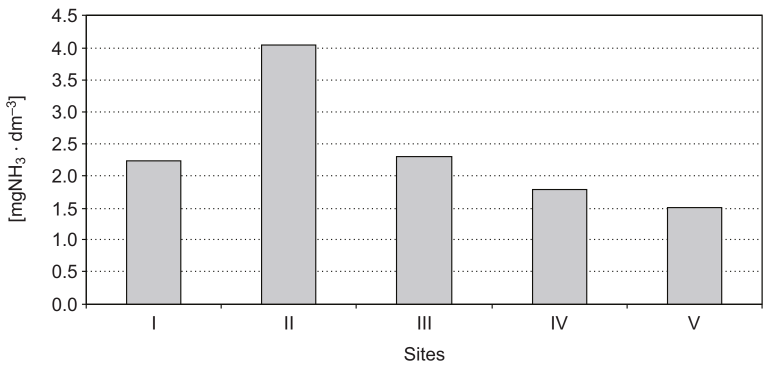

Fig. 10. Average ammonium concentration [mgNH_3 · dm^{-3}] in water on five sites of the River Dobra

concentrations are defined [17]. The lowest concentration 0.00 mgNH_4 · dm^{-3} was measured at the estuary to the Widawa. Water on this site may be classified to I class [17]. Small amounts of ammonium may have been caused by nitrification processes and its consumption by water organisms. The highest values were always measured in the same place (sewage introduction) regardless of a season. Therefore, it can be assumed that effluent introduced to the water contained ammonium. Another source of ammonium are flows from the nearby fields. An increase in ammonium concentration was noted in the place of sewage introduction throughout the whole year. In spring an increase was up to 100 % while in autumn it was higher than 100 %. On the site II a considerable decrease in ammonia concentration was measured. Ammonium content in this place was lower from the values obtained on the site I. Lower ammonium amounts were measured up with the flow of the Widawa. In spite of the fact that ammonium concentration in the Dobra was low, in comparison with other rivers such as the Nysa Szalona (0.02–0.76 mgNH_4 · dm^{-3}) [24], the Topór Stream (0.20–0.41 mgNH_4 · dm^{-3}) [22] and the Bystrzyca Dusznicka (0.02–0.22 mgNH_4 · dm^{-3}) [18] it was still higher.

Phosphates concentration in waters of the River Dobra was ranging from 0.10 to 5.70 mgPO_4 · dm^{-3} (Table 11, Fig. 11). Maximum values were noted on the site II (place of sewage introduction) regardless of a season. Obviously the sewage was responsible for their high content in water. An increase in phosphates concentration may be contributed tofield runoffs. The River Dobra is surrounded by arable fields which may have been fertilized by fertilizers containing phosphorus. Higher phosphates amount was reported on the site II during the whole year. It was mainly an increase of 50 %. However, below the place of sewage introduction a considerable decrease of 50 % or a return to preliminary values in PO_4^{-3} content was measured. In the surface water phosphorus concentration was measured at 0.06 mg P in 1 dm^3 [29] and its occurrence was periodical. In summer the lack of phosphorus in water was noted as it was assimilated by microorganisms, which used it for an optimal growth. On the contrary, in winter when microorganisms disappeared an increase in phosphorus concentration was noticed [3].

Table 11

Phosphates concentration [$mgPO_4^{-3} \cdot dm^{-3}$] in water of the River Dobra between 2007–2008 year

	Min.	Max	Average	Standard deviation
Spring	1.13	2.2	1.41	0.44
Summer	3.20	5.7	3.82	1.07
Autumn	0.70	5.0	1.98	1.78
Winter	0.10	5.0	1.28	2.10

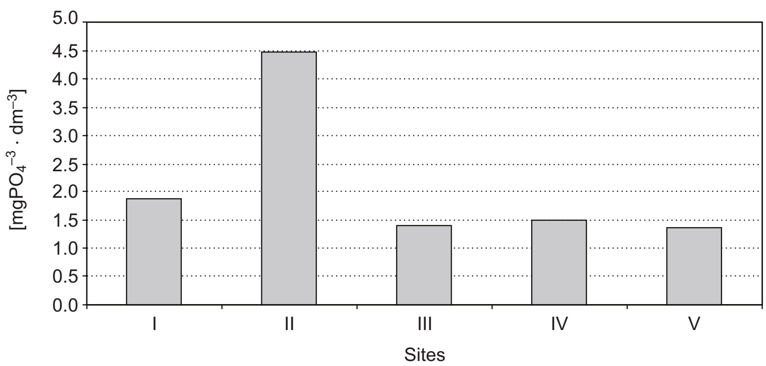

Fig. 11. Average phosphates concentration [$mgPO_4^{-3} \cdot dm^{-3}$] in water on five sites of the River Dobra

Water of the Dobra was defined as rich in phosphates with much higher phosphorus concentration in comparison with other rivers of the Lower Silesia [18, 24, 32]. However, similar phosphates concentration as in the Dobra was measured in summer in the Widawa (0.18–1.52 $mgPO_4^{-3} \cdot dm^{-3}$) [33]. An analysis of the Dobra in 2006 at the estuary to the Widawa showed phosphates concentration ranging from 0.31–3.34 $mgPO_4^{-3} \cdot dm^{-3}$, the same amount as in 2007.

Chlorides in uncontaminated waters were measured at trace quantities or up to hundreds of $mgCl^{-} \cdot dm^{-3}$ [31]. According to the Regulation [17] water in terms of chlorides occurrence was classified to the class I. Waters were defined of good quality which means that sewage did not contain chlorides. Although maximum chlorides concentration occurred on the site II (place of effluent introduction) the values were statistically higher significant (Table 12, Fig. 12) independent of seasonality but they were introduced at low levels. Below the place of sewage introduction a constant decrease in chlorides concentration up to values obtained above the place of introduction was measured. However, an increase in chlorides content may have been observed on the site V. It is possible that this growth in chlorides concentration was a result of chlorides flows from the urbanization especially during winter. An analysis of the Dobra at the estuary of the Widawa in 2006 showed 47.7–98.1 $mgCl^{-} \cdot dm^{-3}$ while in 2004 35.8–81 $mgCl^{-} \cdot dm^{-3}$. The result of 2004 was similar to that of 2007 [30].

Table 12

Chlorides concentration [mgCl$^-$ · dm^{-3}] in water of the River Dobra between 2007–2008 year

	Min.	Max	Average	Standard deviation
Spring	40	96	58.8	21.71
Summer	40	116	62.0	30.72
Autumn	44	140	65.2	41.94
Winter	46	98	67.2	25.56

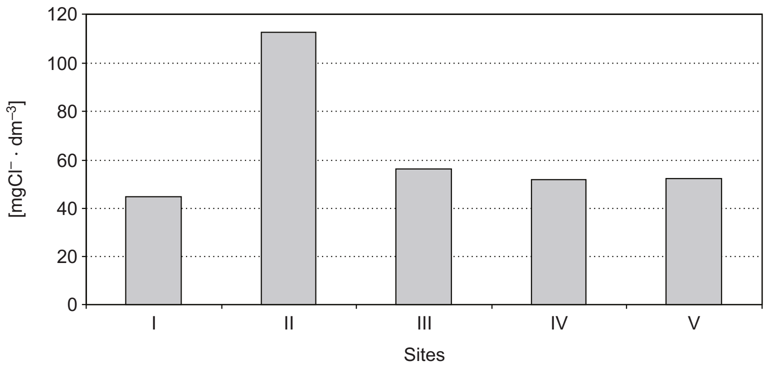

Fig. 12. Average chlorides concentration [mgCl$^-$ · dm^{-3}] in water on five sites of the River Dobra

Among the other researched physicochemical indicators an increase in ammonium, nitrates(V), sulfates, calcium and magnesium concentration were measured below the place of sewage introduction. However, the results were statistically insignificant. Elevated concentrations of the researched compounds in the place of effluent flow on the site II return to their previous values measured before sewage was introduced to the water.

Conclusion

Both statistically higher significant increase in chlorides and statistically significant increase of phosphates content was noted on the site II which resulted in statistically higher significant increase of electric conductivity. An increase in these compounds content was a consequence of detergents usage in the nearby industrial plant.

Contaminants flowing into the water of the River Dobra do not influence limitation of purification processes in the river. The amount of sewage is not too high and its composition is not toxic for water environment. Water of the Dobra at the estuary of the Widawa shows similar chemical composition to water above the place of effluent introduction.

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WPŁYW ZANIECZYSZCZEŃ PRZEMYSŁOWYCH NA JAKOŚĆ WÓD DOLNEGO ODCINKA RZEKI DOBREJ

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Abstrakt: W latach 2007–2008 zebrano próbki wody z rzeki Dobrej (prawostronnego dopływu Widawy). Próbki zebrano w 4 porach roku z 5 miejsc – dolnej rzeki Dobrej. Określono: temperaturę, odczyn, zasadowość, twardość, zawartość: tlenu, azotynów(III i V), amoniaku, chlorków, wapnia, fosforanów, siarczanów i magnezu.

Celem tej pracy było określenie wpływu zanieczyszczenia ściekami przemysłowymi dolnego odcinka rzeki Dobrej na jakość wody rzeki Widawy. Prawie wszystkie badane parametry były średnio większe na stanowisku II niż na pozostałych stanowiskach w rzece Dobrej. Największe średnie zmiany były w koncentracji fosforanów (wzrost o 192 %), koncentracji chlorków (wzrost o 155 %), koncentracji azotanów(V) (wzrost o 153 %). Nie było żadnych średnich różnic w zawartości azotanów(III), ale ich koncentracja w ściekach była zróżnicowana (latem i zimą dwukrotnie większa niż w rzece Dobrej). Nie było większych różnic pomiędzy odczynem pH rzeki Dobrej i ścieków z zakładu (3 % więcej).

Na stanowisku II zanotowano zarówno duży wzrost koncentracji chlorków, jak i wzrost zawartości fosforanów powodujący duży wzrost przewodności elektrolitycznej. Chociaż wiele związków było zawartych w ściekach wprowadzonych w dolnym odcinku rzeki Dobrej, jednakże tylko średnie koncentracje magnezu (15 %) i azotanów(III) (7 %) były większe w wodzie z rzeki Dobrej w pobliżu Widawy (stanowisko V) niż w wodzie pochodzącej z rzeki Dobrej powyżej dopływu ścieków (stanowisko I). Większa była także przewodniość elektrolityczna, ale ten parametr był bardzo zróżnicowany. Największa przewodniość była jesienią (max 1345 $\mu S \cdot cm^{-1}$), a najmniejsza zimą (min. 706 $\mu S \cdot cm^{-1}$).

Słowa kluczowe: jakość wody, rzeka Dobra, ścieki