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Research Article

THE EFFECT OF TREATED SEWAGE OUTFLOW FROM A MODERNIZED SEWAGE TREATMENT PLANT ON WATER QUALITY OF THE BREŃ RIVER

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ABSTRACT
The paper aimed at determining the effect of treated sewage discharged from a sewage treatment plant, modernized in 2007–2008, on the quality of the receiving water – the Breń river. The mechanical-biological sewage treatment plant is situated in the northern part of Dąbrowa Tarnowska town (Malopolskie voivodship). The treated sewage is disposed of by means of a collecting pipe to the Breń river, which abiotically is a lowland sandy stream, type 17. The hydrochemical analyses were conducted monthly, from May 2014 to April 2015 in three measurement points. The first and the third were situated on the Breń river, 30 m above and 400 m below the treated sewage outlet respectively, whereas the second one was on the outflow collecting pipe from the sewage treatment plant. In the analysed water, 17 physicochemical water quality indices were determined by means of reference methods. On the basis of the data analysis it was found that pollutant concentrations in the treated sewage discharged into the Bren river did not exceed the values stated in the water permit and only sporadically did not meet the requirements stated in the Regulation of the Minister of Environment regarding ammonium nitrogen concentrations in the winter-spring period. Slight dynamics of seasonal changes of physicochemical indices values in the treated sewage evidences a high proficiency of the sewage treatment plant operation, irrespective of the air or water temperature. The treated sewage affected the increase in 12 from among 17 analysed physicochemical indices in the Breń river, of which the dependencies were statistically significant in 8 cases. BOD_5 and ammonium nitrate caused a change of water quality class from I to II, and in case of phosphates a decline of ecological state from very good to below good. Despite a negative effect of the sewage treatment plant, the water quality state in the Breń river would be much worse if untreated municipal waste flowed into the receiving water.

Keywords: sewage treatment plant, eutrophication, quality indices, ecological state.

INTRODUCTION

Human economic activity and increasing urbanisation are among the main reasons of worsening the quantitative and qualitative state of surface waters. The rate and scale of resulting anthropogenic changes more and more frequently exceed the natural processes occurring in the environment. The outcome of the changes may be either a deficit or excess of water and pollution of extensive areas, which very often are difficult to reverse [Kanownik and Rajda 2011a, Kanownik et al. 2012, Policht-Latawiec et al. 2013, Kowalik et al. 2014].

One of the causes of river pollution is sewage discharged into them, which poses a serious hazard to water quality [Bugajski and Kaczor 2008, Chmielowski 2008, Lewandowska-Robak et al. 2011]. Incorrect operation of sewage treatment plants may change natural physical characteristics and chemical composition of water, among others by increasing the amount of organic and biogenic substances. Elevated concentrations of biogenic compounds (in the first place phosphorus and nitrogen compounds) increase water trophicity, therefore contributing to the development of eutrophication process. Eutrophication disturbs water treatment process and decreases water saturation with oxygen leads to worsening of water utility values and negatively affects aquatic and water dependent ecosystems [Chmielowski 2008, Neverova-Dziobak and Cierlikowska 2014, Kowalik et al. 2014, Makowska 2014].

The degree of river degradation depends on the volume of sewage discharge, which differs with the load and quality of drained pollutants. How fast they will be mixed with river water depends on the flow rate and water velocity, as well as on the depth and width of the receiving water [Kanownik and Rajda 2011b, Policht-Latawiec and Grzesik 2013]. Pollutants become diluted in the river with a high flow rate. In this case the river is able to receive big pollutant loads and dispose of them efficiently due to self-purification process. On the other hand, in the river with a low flow rate, the identical load leads to a degradation of the receiving waters.

Potential water use to satisfy various needs is among others determined by the quantity and kinds of the substances it contains. Poor water quality limits the use of its resources for recreational, ecological or socio-economic purposes [Kanclerz et al. 2008, Kanownik and Kowalik 2008, Królak et al. 2011, Bogdał et al. 2012]. The amount and quality of drained sewage must be regulated to diminish the losses caused by them as much as possible. Therefore, it is necessary to care about good quality of water through a constant monitoring of its purity, limiting pollution and efficient sewage treatment [Macrae et al. 2007, Gromiec 2014].

The aim of the paper was to determine the effect of treated sewage outflow from the modernized mechanical-biological treatment plant on the water quality in the Breń river.

MATERIAL AND METHODS

The Breń river catchment area of 717 km^2 spans the north-eastern part of the Malopolskie voivodship and north-western part of the Podkarpackie voivodship. According to Kondracki's [2011] geographical division, it is situated in the Sandomierz Basin (512.4) on the border of two mesoregions: the Vistula Lowland (512.41) and Tarnów Plateau (512.43). The Breń river is about 52 km long and as the right bank tributary to the Vistula is order II watercourse. From its source to the Żabnica tributary, i.e. along the stretch under investigation, the Breń river is abiotically classified to type 17 watercourses, i.e. to lowland sandy streams. It flows mainly through agricultural area and Dąbrowa Tarnowska town (Dąbrowa county) where treated sewage is discharged to it from the mechanical-biological treatment plant.

The sewage treatment plant is situated on the right bank of the Breń river, in the northern part of Dąbrowa Tarnowska town, at 53 Zazamcze street (Figure 1). It was constructed in the sixties of the 20th century but because of low efficiency and inability to meet the EU standards, it was modernized and extended in 2007–2008.

Currently the treatment plant throughput during rainless periods is $Q_{dśr.}$ = 3000 m^3·d^{-1}, $Q_{dmax.}$ = 3750 m^3·d^{-1}, whereas during the rainy periods: $Q_{dśr.}$ = 4600 m^3·d^{-1}, $Q_{dmax.}$ = 5550 m^3·d^{-1}. The sew-

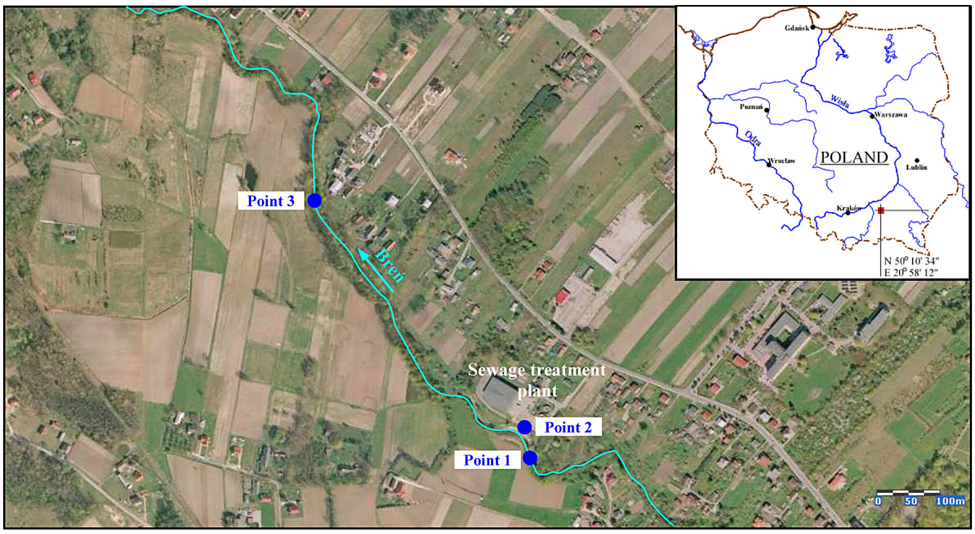

Figure 1. Location of measurement-control points in Dąbrowa Tarnowska town

age treatment plant is an installation designed to receive the pollutant load up to 20000 RLM [Pozwolenie wodno-prawne 2005]. It is composed of one modern building housing all technological equipment, a hydroponic lagoon, administrative and social facilities, and installation for sludge hygienisation and dewatering. The mechanical section is composed of: a screen basket, sewage pumping station, grit/sand removal component, hygienisation of screenings station and sand washer. Biological treatment process uses activated sludge circulation chambers, secondary sedimentation tanks, a tank for stabilisation and condensing of surplus activated sludge and a sludge dewatering station.

The sewage treatment plant in Dąbrowa Tarnowska uses the water permit for a particular use of water through disposing of the treated municipal sewage to the Breń river at km 12+030. In compliance with the Water permit [2005] the sewage discharged from the treatment plant cannot contain chlorinated hydrocarbons or solid waste. Moreover, it must meet the requirements concerning the maximum values of temperature – 35 ^{o}C, pH – 6.5–9.0, COD–Cr – 125 mg $O_2 \cdot dm^{-3}$, BOD_5 – 25 $mg \cdot dm^{-3}$ and total suspended solids – 35 $mg \cdot dm^{-3}$, as well as the requirements for total phosphorus and total nitrogen – reduction higher than respectively 40 and 35%.

Monthly hydro-chemical analyses were conducted from May 2014 to April 2015 in three measurement points. The first and third points were situated on the Breń river, respectively 30m above (km 12+060) and 400m below (km 11+630) of the treated sewage outlet (km 12+030). The second point was located on the outflow collecting pipe from the sewage treatment plant (Figure 1).

The reference methods [Rozporządzenie MŚ 2005] were used to assess the following indices on site: water temperature, pH, dissolved oxygen concentrations and electrolytic conductivity (EC). Other indices: five day biological oxygen demand (BOD_5), permanganate chemical oxygen demand (COD–Mn), phosphates (PO_4^{3-}), total phosphorus (P_{total}), ammonium nitrogen ($N–NH_4$), nitrites (NO_2^-), nitrate nitrogen ($N–NO_3^-$), nitrates (NO_3^-), dissolved solids, sulphates (SO_4^{2-}), chlorides (Cl^-), calcium (Ca^{2+}) and manganese (Mg^{2+}) were determined in the laboratory of the Department of Land Reclamation and Environmental Development, University of Agriculture in Krakow.

For each analysed physicochemical index of water quality its minimum and maximum values were determined for the whole yearly investigation period, its arithmetic mean and coefficient of variance (CV) were computed. Moreover, the median and average value in the winter period (October-March) and summer period (April-September) were calculated separately for each index and measurement point. The analysis of the significance of differences between the values of indices measured in points 1 and 3 was conducted using U Mann-Whitney test ($\alpha = 0.05$) to assess the effect of treated sewage on water quality in the Breń river. The same non-parametric significance test was used to compare, separately for each measurement point, the values of individual indices medians between the winter and summer half-year.

In order to assess the efficiency of sewage treatment, the values of selected physicochemical indices of waters leaving the treatment plant (point 2) were compared with the permissible values stated in the water permit [2005] and in the Regulation of the Minister of the Environment of 18 November 2014 on the conditions which should be fulfilled while discharging sewage to water or to land and on the substances particularly harmful for the aquatic environment [2014b]. Moreover, the ecological state, usefulness for fish and eutrophication hazard were assessed at each measurement point on the basis of the following legal acts:

- Regulation of the Minister of Environment dated 22 October 2014 establishing the way of classifying the state of uniform parts of surface waters and environmental quality standards for priority substances [2014a].
- Regulation of the Minister of Environment dated 04 October 2002 establishing the requirements which should be met by inland waters which are the natural fish habitats [2002a].
- Regulation of the Minister of Environment dated 23 December 2002 on the criteria for designation of waters sensitive to pollution by nitrogen compounds from agricultural sources [2002b].

RESULTS

Sewage discharged into the receiving water must meet the requirements stated in the Water permit [2005] for individual sewage treatment plants and in the Regulation of the Minister of Environment establishing the conditions which must be fulfilled while discharging sewage into waters or land [2014b]. Regarding the first document, the requirements were met on each date of analyses (Table 1), whereas ammonium nitrogen concentrations during the winter-spring period exceeded the permissible values, i.e. 10 mg·dm^{-3} in three samples of treated sewage (February – 20.01 mg·dm^{-3}, March – 11.70 mg·dm^{-3} and April – 19.41 mg·dm^{-3}) [Rozporządzenie MŚ 2014].

With reference to the Regulation of the Minister of Environment establishing the way of classifying the state of uniform parts of surface waters and environmental quality standards for priority substances [2014a], it may be noticed that treated sewage (point 2) disposed into the Bren river did not meet the requirement of water purity class II, which means that its quality was below good ecological state (Table 1). It was caused by average values of BOD_5, PO_4^{3-}, N–NH_4^+ and N–NO_3^- which exceeded class I standards respectively by: 243%, 539%, 594% and 398%. Average values of COD–Mn, total phosphorus, dissolved solids and electrolytic conductivity met the requirements of II quality class (Table 1).

Statistical analysis conducting using non-parametric Mann-Whitney U test revealed that the differences between the values of some of the investigated water indices from point 1 above and 3 – below the sewage collecting pipe from the treatment plant were statistically significant on significance level $\alpha = 0.05$. Significantly bigger differences in point 3 were registered for PO_4^{3-}, P_{total}, N–NH_4^+, NO_2^-, EC, dissolved solids, Cl^- and Mg^{2+} (Table 1). The obtained results confirm the fact that sewage discharge has a major negative effect upon physicochemical state of the receiving water.

Ecological state of the Breń river determined on the basis of selected physicochemical elements above the sewage treatment plant (point 1) was good owing to average values of COD–Mn and N–NO_3^- which exceeded the permissible standards for quality class I waters respectively by: 0.4 mg O_2·dm^{-3} and 1,08 mg·dm^{-3}. Increase in the average values of most investigated water quality indices was registered after the discharge of treated sewage in point 3, including: BOD_5 values – by 1.4 mg O_2·dm^{-3}, COD–Mn by 1.4 mg O_2·dm^{-3}, PO_4^{3-} by 0.186 mg·dm^{-3}, P_{total} by 0.061 mg·dm^{-3} and N–NH_4^+ by 0.769 mg·dm^{-3}. A decrease in the average concentrations was noted only for sulphates – by 1.7 mg·dm^{-3}. Due to increased water pollution in the Breń river, below the discharge of treated sewage (point 3), the water had ecological state below good – due to average values of BOD and N–NH_4^+ the water changed its quality class from I to II, whereas because of average PO_4^{3-} concentration, its very good ecological state worsened to below good (Table 1).

Table 1. The statistical parameters describing the values of selected indicators of water quality in the Breń river (point 1 and 3) and the outflow from sewage treatment plants (point 2)

Indicator	Unit	The values specified by standards*		Point 1			Point 2			Point 3			The values of test point 1–3	
		I	II	range	mean	CV [%]	range	mean	CV [%]	range	mean	CV [%]	U	p
Temperature	°C	≤22	≤24	1.8–22.8	11.9	60	11–20.1	15.0	24	1.9–22.9	12.0	60	70.0	0.91
pH	–	6–8.5	6–9	6.52–7.90	7.36	6	6.8–7.7	7.28	4	6.91–7.77	7.35	3	67.5	0.80
O_2	mg O_2·dm^{-3}	≥7	≥5	6.77–11.39	8.86	17	7.01–10.15	8.44	10	7.29–11.09	8.90	13	69.0	0.85
BOD_5	mg O_2·dm^{-3}	≤3	≤6	1.00–4.10	2.3	48	2.2–11.0	7.3	37	1.2–11.0	3.7	76	49.0	0.18
COD–Mn	mg O_2·dm^{-3}	≤6	≤12	1.9–8.8	6.4	36	7.3–13.3	10.3	14	5.0–13.0	7.8	31	54.0	0.30
PO_4^{3-}	mg·dm^{-3}	≤0.20	≤0.31	0.031–0.214	0.138	46	0.104–4.100	1.077	119	0.016–1.240	0.324	107	**37.5**	**0.04**
P_{total}	mg·dm^{-3}	≤0.20	≤0.40	0.010–0.070	0.045	47	0.034–1.340	0.352	119	0.005–0.405	0.106	107	**37.5**	**0.04**
N–NH_4^+	mg·dm^{-3}	≤0.78	≤1.56	0.010–0.376	0.113	89	0.115–20.01	4.632	167	0.034–3.824	0.882	129	**27.0**	**0.01**
NO_2^-	mg·dm^{-3}	–	–	0.049–0.348	0.144	75	0.627–1.997	1.072	38	0.112–3.223	0.594	160	**35.0**	**0.03**
N–NO_3^-	mg·dm^{-3}	≤2.2	≤5.0	2.18–4.89	3.28	28	2.72–15.26	8.76	38	2.79–4.85	3.75	18	47.0	0.15
NO_3^-	mg·dm^{-3}	–	–	9.64–21.65	14.53	28	12.04–67.55	38.78	38	12.37–21.48	16.62	18	47.0	0.15
EC	μS·cm^{-1}	≤1000	≤1500	350–488	427	10	860–1340	1130	14	430–568	497	10	**24.0**	**0.01**
Dissolved solids	mg·dm^{-3}	≤500	≤800	200–264	231	8	515–717	622	9	234–299	270	7	**9.5**	**0.00**
SO_4^{2-}	mg·dm^{-3}	≤150	≤250	42.5–91.6	63.5	25	79.9–236.8	126.5	40	18.1–99.6	61.8	42	69.0	0.86
Cl^-	mg·dm^{-3}	≤200	≤300	11.8–30.0	22.0	21	83.5–184.8	136.5	22	18.8–41.4	31.1	21	**19.0**	**0.00**
Ca^{2+}	mg·dm^{-3}	≤100	≤200	39.0–68.9	51.4	21	64.3–110.5	87.5	20	40.9–71.2	54.1	18	58.0	0.42
Mg^{2+}	mg·dm^{-3}	≤50	≤100	8.6–16.9	11.5	19	16.5–26.0	21.8	13	11.4–17.9	13.0	14	**33.0**	**0.02**

* according to the Minister Decree [Rozporządzenie MŚ 2014a], O_2 – dissolved oxygen, CV – coefficient of variance, U – the value of U Mann-Whitney test, p – the probability of the test, **bold type** indicates significant differences ($\alpha = 0.05$).

quality class I – very good ecological status | quality class II – good ecological status | bgp – below good ecological status

On the basis of the coefficient of variance (CV) value, which is the measure of empirical data deviations from average values, for a majority of the analysed water quality indices, one may speak of low (CV ≤ 20%) and medium (21 ≤ CV ≤ 40%) random variation. The greatest dynamics of changes, with some exceptions, occurred for phosphate concentrations, total phosphorus, ammonium nitrogen and nitrites – V ≥ 60% (Table 1).

Analysis of the significance of differences between water quality indices in the winter and summer half-years revealed that in some cases the natural seasonal processes occurring in clean water were disturbed in all measurement points. However, as might have been supposed, the greatest seasonal changes were noted in the water above the treated sewage discharge (point 1), where more favourable oxygen conditions occurred in the winter half-year, which is connected with better oxygen solubility in cold water. Significantly higher concentrations of nitrites were registered in points 1 and 3 in summer months, which is affected by intensive nitrification processes of ammonium compounds occurring at higher temperatures. Moreover, in both points higher values of COD–Mn were noted in the summer half-year and calcium in winter season. A similar dynamic was registered in points 1 and 2 for sulphates, whose markedly higher concentrations were observed in the winter months. Owing to the air temperature, higher water temperatures were registered in all measurement points in the summer half-year (Table 2).

The lowest dynamics of seasonal changes was noted in treated sewage, which speaks in favour of the sewage treatment plant, whose efficiency

Table 2. Results of U Mann-Whitney test significance of differences between the values of water quality indices in winter and summer seasons

Indicator and unit	Point 1				Point 2				Point 3			
	Median (mean)		U	p	Median (mean)		U	p	Median (mean)		U	p
	winter	summer			winter	summer			winter	summer		
Temperature [°C]	5.9 (6.5)	17.4 (17.3)	**1.0**	**0.01**	11.9 (12.5)	18.8 (17.6)	**2.5**	**0.01**	5.7 (6.5)	17.5 (17.4)	**1.0**	**0.01**
pH [–]	7.50 (7.45)	7.37 (7.26)	15.0	0.63	7.38 (7.27)	7.23 (7.29)	17.0	0.87	7.22 (7.24)	7.52 (7.46)	7.0	0.08
Dissolved oxygen [mg O_2·dm^{-3}]	9.85 (9.72)	7.89 (8.00)	**5.0**	**0.04**	8.86 (8.68)	8.28 (8.21)	11.0	0.26	9.34 (9.42)	8.30 (8.39)	9.0	0.15
BOD_5 [mg O_2·dm^{-3}]	2.6 (2.5)	1.7 (2.1)	12.5	0.38	8.5 (8.7)	6.1 (6.0)	6.0	0.06	4.2 (3.4)	2.2 (4.0)	17.5	0.94
COD–Mn [mg O_2·dm^{-3}]	5.2 (5.0)	8.2 (7.9)	**4.0**	**0.03**	9.8 (10.0)	10.7 (10.6)	8.0	0.11	5.8 (6.2)	8.6 (9.4)	**4.0**	**0.03**
PO_4^{3-} [mg·dm^{-3}]	0.117 (0.113)	0.189 (0.164)	8.0	0.11	0.431 (0.850)	0.715 (1.304)	15.0	0.63	0.173 (0.159)	0.374 (0.488)	8.0	0.11
P_{total} [mg·dm^{-3}]	0.038 (0.037)	0.062 (0.054)	8.0	0.11	0.141 (0.278)	0.233 (0.426)	15.0	0.63	0.057 (0.052)	0.122 (0.160)	8.0	0.11
N–NH_4^+ [mg·dm^{-3}]	0.105 (0.140)	0.082 (0.086)	17.0	0.87	1.035 (5.668)	0.490 (3.595)	16.0	0.75	0.219 (0.543)	0.627 (1.221)	13.0	0.42
NO_2^- [mg·dm^{-3}]	0.064 (0.063)	0.214 (0.224)	**1.0**	**0.01**	0.921 (1.106)	1.091 (1.038)	17.0	0.87	0.143 (0.158)	0.388 (1.031)	**4.0**	**0.03**
N–NO_3^- [mg·dm^{-3}]	3.13 (3.24)	3.31 (3.32)	17.0	0.87	10.14 (9.33)	8.63 (8.19)	12.0	0.34	3.60 (3.63)	3.91 (3.87)	13.0	0.42
NO_3^- [mg·dm^{-3}]	13.86 (14.37)	14.66 (14.69)	17.0	0.87	44.89 (41.29)	38.22 (36.27)	12.0	0.34	15.96 (16.09)	17.29 (17.15)	13.0	0.42
EC [μS·cm^{-1}]	433 (432)	430 (423)	17.0	0.87	1201 (1200)	1060 (1061)	10.0	0.20	485 (493)	485 (501)	15.0	0.63
Dissolved solids [mg·dm^{-3}]	239 (237)	226 (226)	11.0	0.26	646 (651)	607 (594)	7.0	0.08	273 (273)	268 (267)	14.0	0.52
SO_4^{2-} [mg·dm^{-3}]	74.6 (73.7)	50.5 (53.2)	**4.0**	**0.03**	148.8 (157.1)	90.3 (95.8)	**4.0**	**0.03**	83.9 (69.6)	53.3 (53.9)	12.0	0.34
Cl^- [mg·dm^{-3}]	22.7 (22.5)	21.3 (21.4)	13.0	0.42	155.8 (146.9)	120.6 (126.0)	8.0	0.11	33.3 (31.8)	29.6 (30.4)	14.0	0.52
Ca^{2+} [mg·dm^{-3}]	61.0 (59.6)	41.0 (43.2)	**1.0**	**0.01**	99.2 (100.1)	70.2 (75.0)	**4.0**	**0.03**	61.5 (60.5)	46.1 (47.7)	**2.0**	**0.01**
Mg^{2+} [mg·dm^{-3}]	11.5 (12.3)	10.8 (10.7)	13.0	0.42	21.3 (22.3)	21.3 (21.3)	14.0	0.52	12.7 (13.4)	12.4 (12.6)	14.0	0.52

U – the value of U Mann-Whitney test, p – the probability of the test, **bold type** indicates significant differences (α = 0.05).

only to some extend depends on water temperature. Only the values of pH in all measurement points, total phosphorus and ammonium nitrogen in point 1 and water temperature in point 2 met the requirements for inland waters which are the natural salmonid habitat. Due to constantly raised nitrite concentrations, the investigated water does not create a habitat favourable for the salmonids or cyprinids. However, if it were not for high concentrations of NO_2^-, water tested in the point above the treated sewage discharge (point 1) would meet the requirements for cyprinid habitat (Table 3).

High average annual nitrate and ammonium nitrogen concentrations show that at the present physicochemical state of water, there is a hazard of eutrophication process in the Breń river. Moreover, a high trophicity characterises treated sewage, where also average concentration of total phosphorus exceeded the critical value, i.e. 0.25 $mg \cdot dm^{-3}$ (Table 3).

CONCLUSIONS

The analysis of the research results allowed to formulate the following conclusions:

1. Concentrations of pollutants in the treated sewage discharged into the Breń river did not exceed the values stated in the water permit. On the other hand, the requirements of the Regulation of Minister of Environment [2014b] were not met for ammonium nitrogen during the winter season.
2. Low dynamics of seasonal changes of physicochemical indices in the treated sewage evidences a high proficiency of the treatment plant, independent on the air or water temperature.
3. The Breń river water above the treated sewage discharge, was classified to II quality class, i.e. to good ecological state, which was affected by high average values of COD–Mn and nitrate nitrogen. On the other hand, below the treatment plant, the river water revealed the ecological state below good, which was determined by phosphate concentrations.
4. Treated sewage affected increase in the value of 12 from among 17 analysed physicochemical indices in the Breń river, of which in 8 cases the dependencies were statistically significant. BOD_5 and ammonium nitrogen caused a change of the quality class from I to II, whereas in case of phosphates a decline in ecological state from very good to below good.
5. Considerable nitrite concentrations cause, that water along the whole analysed stretch of the Breń river does not meet the requirements for the salmonid or cyprinid fish, however, much better habitat conditions were in the point above the treated sewage discharge.

Table 3. Results of assessment of water usability as natural habitat for fish and eutrophication hazard

Indicator and unit	Walues reguired for fresh warers as habitat for fish[1]		Frequency of index values (% of samples) in standard range for a given fish category						Eutrophication			
	salminids	cyprinids	point 1		point 2		point 3		the limit values[2]	average annual value of indicator		
	S	C	S	C	S	C	S	C		point 1	point 2	point 3
Temperature [°C]	≤21,5[3]	≤28,0[3]	83	100	100	100	83	100	–	–	–	–
pH [–]	6–9[4]		100		100		100		–	–	–	–
Dissolved oxygen [mg $O_2 \cdot dm^{-3}$]	50%≥9	50%≥8	42%≥9	67%≥8	25%≥9	67%≥8	42%≥9	100%≥8	–	–	–	–
	100%≥7	100%≥5	92%≥7	100%≥5	100%≥7	100%≥5	75%≥7	100%≥5	–	–	–	–
BOD_5 [mg $O_2 \cdot dm^{-3}$]	≤3,0[4]	≤6,0[4]	67	100	8	33	50	92	–	–	–	–
P_{total} [$mg \cdot dm^{-3}$]	≤0,2[4]	≤0,4[4]	100	100	58	75	83	92	>0,250	0,045	0,352	0,106
$N–NH_4^+$ [$mg \cdot dm^{-3}$]	≤0,78[4]		100		67		58		–	–	–	–
NO_2^- [$mg \cdot dm^{-3}$]	≤0,01[4]	≤0,01[4]	0	0	0	0	0	0	–	–	–	–
$N–NO_3^-$ [$mg \cdot dm^{-3}$]	–		–	–	–	–	–	–	>2,20	3,28	8,76	3,75
NO_3^- [$mg \cdot dm^{-3}$]	–		–	–	–	–	–	–	>10,00	14,53	38,78	16,62
	requirements fulfilled for fish; no eutriophication hazard						requirements not fulfilled for fish; eutriophication hazard					

[1] – according to Minister Decree [2002a], [2] – according to Minister Decree [2002b], [3] – for 98% samples, [4] – for 95% of samples.

6. Because of elevated concentrations of nitrate compounds, the Breń river water is threatened with eutrophication processes.
7. Despite a negative effect of the sewage treatment plant, if municipal sewage were drained to the receiving water untreated, the water quality state would undoubtedly be much worse.

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