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Research Article

VARIABILITY OF PHYSICOCHEMICAL PROPERTIES OF WATER OF THE TRANSBOUNDARY POPRAD RIVER

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ABSTRACT
The results of five-year (2008–2012) hydrochemical research of the Poprad river, the right bank tributary to the Dunajec, were analyzed in the paper. The Poprad, 167 km long and with the catchment area of 2077.3 km^2, flows for over 100 km through the territory of Slovakia, along the length of 31.1 km is a transboundary river, whereas its 31.0 km long reach is situated in Poland. Concerning its abiotic character, it is an eastern upland river of type 15. The research was conducted in three measurement-control points: 1) located in Leluchów on the Polish-Slovak border at 61.1 kilometer of the river course, 2) in Piwniczna-Zdrój – 23.9 km and 3) in Stary Sącz – 2.9 km before the Poprad outlet to the Dunajec. 21 physicochemical indices and 2 microbiological indicators were assessed in the water samples once a month using referential methods. The paper assesses changes of water quality classes and its usable values along the analyzed Poprad river reach. Moreover, statistical differences between the values of individual indices assessed in various measurement-control points were estimated by means of Mann-Whitney U nonparametric test. On the basis of the conducted analyses of the empirical data it was stated that due to the physicochemical indices, water quality along the whole length of the analyzed river reach was good (class II) – in points 1 and 3 it was determined by mean concentration of total suspended solids, whereas in point 2 COD-Mn values.

Keywords: the Poprad river, physicochemical indices, ecological state, water pollution.

INTRODUCTION

Surface waters may be polluted by substances originating from anthropogenic sources [Grochowska and Tandyrak 2007, Bojakowska et al. 2010, Húska et al. 2013] and due to natural processes occurring in the environment [Moniewski and Stolarska 2007]. Natural sources may comprise various pollutant agents, such as plant remnants and humus substances, clay and silt particles of soils or rocks, compounds of iron and manganese, etc. However, pollution caused by various human activities is far more dangerous to the environment [Dąbrowska 2008, Policht-Latawiec and Kanownik 2013]. These may be either liquid or gaseous substances. They find their way directly to the waters, most frequently with various types of sewage, either municipal [Gromaire-Mertz et al. 1999, Göbel et al. 2007, Napieralska and Gołdyn 2013], industrial [Lewandowska-Robak 2011] or rural [Monaghan 2007]. Such pollutants are also in post-cooling waters, salinated mining wastewaters, surface runoffs from industrial and agricultural areas [Bogdał and Ostrowski 2007, Wiatkowski et al. 2012], leachates from industrial and municipal landfills [Kukuła and Bylak 2010]. Dangerous substances may find their way to surface waters also directly from the atmospheric air, to which dusts and gases are emitted by various industries [Vicario 2012]. The pollutants finding their way directly to waters are divided into three kinds, according to the way of their inflow: point source, line source and area source pollution [Paredes et al. 2010, Kleiber 2012]. Point source pollution reaches waters in a concentrated form in a specific place (e.g. municipal or industrial sewage discharge). Line source pollution is connected with the effect of pollutants along some course (e.g. streets with very heavy traffic) [Bąk et al. 2012, Wiśniowska-Kielian et al. 2013]. The area source pollution originates from rainwater runoff from urban areas without sewer system, from agricultural areas [Kanownik et al. 2011] or forest areas [Bogdał and Ostrowski 2009, Kowalik et al. 2012]. Disadvantageous changes of physical, chemical and biological properties of surface waters caused by anthropogenic factors lead to environmental changes, which unfavorably influence living organisms. Such a situation makes necessary undertaking a number of endeavors to prevent further degradation, which are preceded by research monitoring of rivers and water reservoirs threatened with anthropopressure, which allows to identify the hazards to surface waters in the catchments [Lampart-Kłużniacka et al. 2012, Brankov et al. 2012].

The aim of the paper was determining the changes of water quality along about 60 km long reach of the transboundary Poprad river. The authors strived to reach the objective through comparing the values of several dozen physicochemical indices and two microbiological indicators determined in 3 measurement-control points, which proved a basis for the assessment of water classes and usable values of the surface water.

MATERIAL AND METHODS

The object of analysis were values and concentrations of physicochemical and microbiological indices of the Poprad river water quality, investigated in 2008–2012 by the Regional Inspectorate of the Environmental Protection in Krakow. Water was sampled in three measurement-control points: the first located in Leluchów (on the Polish-Slovakian border) at km 61.2 of the river course, the second in Piwniczna-Zdrój (23.9 km) and the third in Stary Sacz at 2.9 km of the Poprad river course (Figure 1).

The Poprad is a transboundary river flowing from Slovakia to Poland. Concerning the abiotic factors, it is classified s eastern upland rivers, type 15. It has its source in the High Tatra Mts. in Slovakia, whereas the confluence of the Hińczowy Stream with the Krupa Stream is regarded as its headwaters. The Poprad river has numerous tributaries, among which the larger ones are the following streams: the Lipnik, the Suliński, the Granastowski, the Smereczek, the Muszynka with the Kryniczanka, the Wierchomlanka, the Łomniczanka, the Czerecz, the Wielka Roztoka and the Przysietnicki stream, in Biegionice village, situated about 2.9 km below Stary Sącz, the Poprad flows into the Dunajec on the right bank side (Figure 1).

The Poprad river is 167 km long and for over 100 km flows through the territory of Slovakia, on the 31.1 km reach it is a transboundary river (from Leluchów and Legnava to Piwniczna-Zdrój) and along 31.0 km it is situated on the territory of Poland. The catchment area is 2077.3 km^2, of which 77% is situated in the area of Presov county in the Slovak Republic, whereas only 482.8 km^2 in the southern part of the Nowy Sącz county in the Malopolska Voivodeship (Poland). The Slovak part of the catchment is situated in the Central part of the Western Carpathians (514) and partly comprises geographical regions such as the Eastern Tatra Mts. (514.53), Liptovsko-Spiska Depression (514), the Pieniny Mts. (514.12) and Spisko-Gubałowskie Foothills (514.13). On the Polish side its catchment belongs to the Outer Western Carpathians (513) and comprises almost whole Beskid Sądecki Mts. (513.54) and a part of Sącz Basin (513.53).

The Poprad flows through some larger cities, towns and villages, including: Poprad, Kežmarok and Stara L'ubovla (Slovakia) and Leluchów, Muszyna, Żegiestów-Zdrój, Piwniczna-Zdrój, Rytro and Stary Sącz (Poland). Therefore, the river water is drawn for municipal water supply, but at the same time the Poprad is a direct or indirect receiver of treated sewage, which is discharged from 8 sewage treatment plants: in Rytro (km 12+320), Piwniczna (km 21+580, the Borownice stream), Andrzejówka (the Andrzejówka stream), Żegiestów (km 35+500 and 40+400), Muszyna (km 51+350) and in Krynica (the Kryniczanka stream).

21 physicochemical indices and two microbiological indicators were determined in the water samples using referential methods [Rozporządzenie MŚ 2011b]. For each analyzed index minimum, maximum value, arithmetic mean, median, standard deviation and coefficient of variance were determined for the period of in-

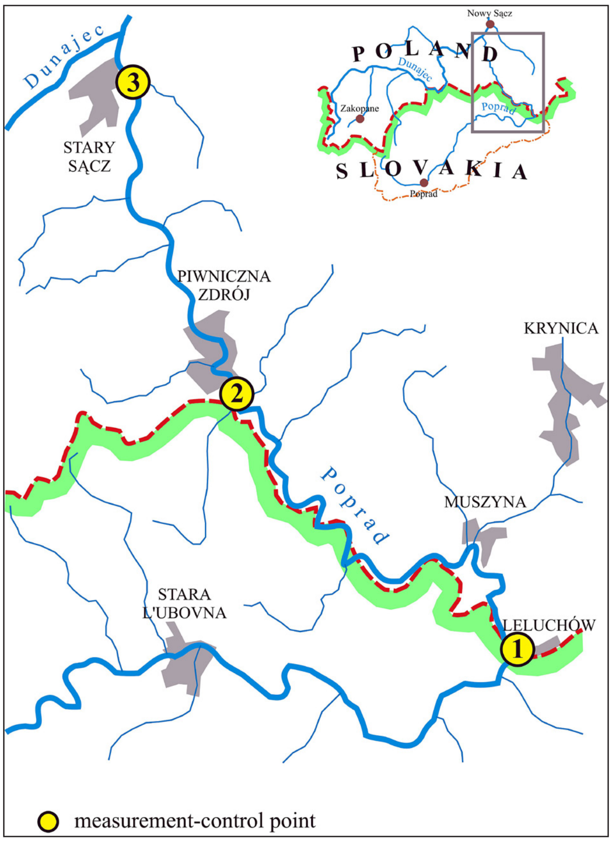

Figure 1. Location of water measurement-control points on the Poprad river

vestigations. Moreover, the empirical data sets were subjected to a comprehensive statistical analysis. It relied on previous testing the normality of distributions using Shapiro-Wilk test and regarding different numbers of samples, and estimation using non-parametric Mann-Whitney U test (on the significance level $\alpha = 0.05$) of the significance of differences between the values of respective indices assessed in 1., 2. and 3. measurement-control points. A median, extreme values and 10–90 percentile were presented in box and whiskers diagrams for selected physicochemical water indices whose values differed significantly between the points.

The assessment of the Poprad water quality in each measurement-control point was conducted in compliance with the Resolution of the Minister of the Natural Environment of 9 November 2011 on the classification of uniform parts of surface waters [Rozporządzenie MŚ 2011a]. Usable values of water were assessed on the basis of the Resulution of the Minister of the Natural Environment of 27 November 2002 on the requirements for surface water used for drinking water supply [Rozporządzenie MŚ 2002b] and in compliance with the Decree of the Minister of the Natural Environment of 4 October 2002 on the requirements for fresh waters which are the fish habitat under natural conditions [Rozporządzenie MŚ 2002a].

RESULTS

The temperature of the Poprad river in points 2. and 3. On all dates of measurements did not exceed the value permissible for class I (22°C), in point 1. The maximum value was 23.5°C. Mean value in two first points was almost identical, on the level of respectively 9.3 and 9.4°C, whereas in the by-the-mouth point the water temperature was on average about 1°C higher. Therefore, water was classified to the first quality class (Table 1). Mean concentrations of total suspended solids in the subsequent measurement-control points were on the level of: 31.9, 24.0 and 29.5 $mg \cdot dm^{-3}$, therefore the permissible value for class I waters, i.e. 25 $mg \cdot dm^{-3}$ was not exceeded only in point 2. [Rozporządzenie MŚ 2011a]. In other two points average values of this physical index allowed to classify water to class II (Table 1). At the respective dates of measurements the changes of quality caused by total suspended solids were dynamic, because in quite numerous water samples (1 – 14.4%, 2 – 15.0% and 3 – 18.35%) they did not

Table 1. Selected descriptive statistics for physicochemical indices and microbiological indicators, and quality water class

Indicator			The values specified by standards[1]		Point 1 Leluchów			Point 2 Piwniczna-Zdrój			Point 3 Stary Sącz		
			I	II	range mean	SD	CV [%]	range mean	SD	CV [%]	range mean	SD	CV [%]
Physical	Temperature	°C	≤22	≤24	0.0–23.5 9.3	7.0	75	0.0–21.5 9.4	7.1	76	0–19.3 8.4	6.4	76
	Suspended solids	mg·dm^{-3}	≤25	≤50	2.5–332.0 31.9	55.6	174	2.5–165.0 24.0	32.3	135	2.5–324.0 29.5	48.3	164
Oxygen-related and organic pollution	Oxygen saturation degree	%	–	–	71–137 108	12	11	65–145 109	16	15	71–119 97	10	10
	Dissolved oxygen	mgO$_2$·dm^{-3}	³7	³5	8.1–17.0 12.2	2.3	19	8.3–19.0 12.1	2.4	20	7.7–16.0 11.0	2.1	19
	BOD$_5$		≤3	≤6	0.9–6.3 2.5	1.1	44	0.9–6.3 2.3	1.1	48	1.0–8.3 2.4	1.2	50
	COD–Mn		≤6	≤12	1.2–17.7 3.8	2.9	76	1.1–24.0 6.7	5.3	79	1.7–26.0 5.8	4.8	83
	Total organic carbon	mgC·dm^{-3}	≤15	≤20	0.5–5.8 2.3	1.1	48	0.4–6.4 2.1	1.1	52	0.5–4.5 2.1	0.9	43
Salinity	EC	µS·cm^{-1}	≤1000	≤1500	201–967 340	123	36	160–491 324	78	24	178–506 322	82	26
	Dissolved solids	mg·dm^{-3}	≤500	≤800	101–385 222	48	22	150–318 224	42	19	141–341 224	45	20
	SO_4^{2-}		≤150	≤250	17.1–41.1 27.2	6.2	23	15.2–46.0 27.7	7.0	25	16.1–53.2 28.6	7.8	27
	Cl^-		≤200	≤300	2.5–15.2 7.8	3.1	40	2.5–26.4 8.7	4.1	47	5.0–27.9 9.5	4.4	46
	Ca^{2+}		≤100	≤200	38.0–79.0 51.7	11.2	22	33.3–82.8 53.2	10.6	20	25.4–86.5 52.5	11.7	22
	Mg^{2+}		≤50	≤100	7.1–15.6 11.1	2.3	21	6.7–18.6 11.5	2.6	23	5.9–19.4 11.5	2.9	25
	Total hardness	mg $CaCO_3$·dm^{-3}	≤300	≤500	105–285 176	40	23	107–275 179	38	21	98–292 179	40	22
Acidification	pH	[–]	6–8.5	6–9	7.4–9.0 8.3	0.4	5	7.4–9.1 8.3	0.3	4	7.5–8.8 8.1	0.3	4
Biogenic	PO_4^{3-}	mg·dm^{-3}	≤0.2	≤0.31	0.015–0.283 0.083	0.063	76	0.011–0.249 0.096	0.059	62	0.015–0.510 0.110	0.081	74
	P_{total}		≤0.2	≤0.4	0.021–0.175 0.059	0.029	49	0.023–0.162 0.069	0.029	42	0.032–0.220 0.075	0.038	51
	N_{total}		≤5	≤10	0.780–3.670 2.023	0.647	32	0.790–3.320 1.936	0.571	30	0.957–3.700 2.013	0.567	28
	$N_{Kjeldahla}$		≤1	≤2	0.020–1.310 0.250	0.309	124	0.020–0.993 0.240	0.252	105	0.020–1.250 0.262	0.275	105
	$N–NO_3^-$		≤2.2	≤5	0.230–2.440 1.298	0.461	36	0.450–2.390 1.276	0.424	33	0.570–2.640 1.365	0.435	32
	$N–NO_2^-$		–	–	0.002–0.052 0.017	0.010	59	0.007–0.058 0.019	0.010	53	0.002–0.075 0.022	0.012	55
Micro-biological	Faecal coliforms bacteria	MPN·cm^{-3}	–	–	930–23000 7185	9585	133	20–8000 1427	1530	107	200–26000 3484	4033	116
	Total coliforms bacteria		–	–	2300–93000 18225	27911	153	150–35000 5727	6707	117	300–145000 14019	20627	147

EC – electrolytic conductivity, SD – standard deviation, CV – coefficient of variance, [1] – according to the Minister Decree of 9 Oct. 2011 [Rozporządzenie MŚ 2011a]

to Minister Decree of 2011a: [cyan] class I; status very good [green] class II; status good

was most frequent in point 1. (Figure 2). An average value and median of chemical oxygen demand (COD-Mn) was clearly the highest in the central measurement-control point, particularly in comparison with point 1 (Table 1, Figure 3), as evidenced statistically on α = 0.05 level (Table 2). For these reasons, physicochemical status of water on the border of the two countries (1) and in by-the mouth point (3) was very good, whereas in Piwniczna-Zdrój it was good (Table 1).

The values of seven investigated salinity indices (electrolytic conductivity, dissolved solids, sulfates, chlorides, calcium, magnesium and total hardness) were similar in all analyzed points and remained on a low level with reference to the values permissible for class I waters. They did not

Table 2. The significance of differences between the values of water measurement-control points – the median values and the probability of the Mann-Whitney U test

Indicator	Unit	Medians in measurement-control point			The test value (*Z*) and the probability of the test (*p*) in the variants calculation					
		Point 1	Point 2	Point 3	Point 1–2		Point 2–3		Point 1–3	
					Z	*p*	*Z*	*p*	*Z*	*p*
Temperature	°C	9.1	9.7	8.7	-0.03	0.98	0.82	0.41	0.78	0.43
Suspended solids	$mg\cdot dm^{-3}$	11.3	9.6	12.0	0.28	0.78	-0.85	0.39	-0.43	0.67
Oxygen saturation degree	%	107	107	96	-0.11	0.91	**4.84**	**0.00**	**4.87**	**0.00**
Dissolved oxygen	$mgO_2\cdot dm^{-3}$	12.3	12.0	10.7	0.18	0.86	**2.50**	**0.01**	**2.51**	**0.01**
BOD_5		2.3	2.0	2.2	1.06	0.29	-0.10	0.92	0.92	0.36
COD–Mn		3.1	5.0	4.2	**-3.44**	**0.00**	1.11	0.27	**-2.38**	**0.02**
Total organic carbon	$mgC\cdot dm^{-3}$	2.4	2.2	2.2	1.46	0.15	-0.15	0.88	1.27	0.20
EC	$\mu S\cdot cm^{-1}$	319	315	308	-0.04	0.97	0.39	0.70	0.34	0.74
Dissolved solids	$mg\cdot dm^{-3}$	221	224	220	-0.26	0.80	0.14	0.89	-0.12	0.90
SO_4^{2-}		27.5	27.5	29.0	-0.31	0.76	0.46	0.64	-0.70	0.48
Cl^-		7.9	8.2	8.6	-0.75	0.45	-1.19	0.23	-1.61	0.11
Ca^{2+}		27.9	53.3	51.9	-1.04	0.30	0.32	0.74	-0.83	0.41
Mg^{2+}		11.4	11.9	11.7	-0.78	0.44	0.11	0.91	-0.68	0.50
Total hardness	$mgCaCO_3\cdot dm^{-3}$	167	181	178	-0.59	0.55	0.15	0.88	-0.61	0.54
pH	[–]	8.4	8.3	8.2	0.79	0.43	**3.31**	**0.00**	**3.38**	**0.00**
PO_4^{3-}	$mg\cdot dm^{-3}$	0.072	0.086	0.087	-1.40	0.16	-0.83	0.41	**-2.17**	**0.03**
P_{total}		0.056	0.063	0.063	**-2.05**	**0.04**	-0.56	0.58	**-2.44**	**0.02**
N_{total}		1.937	1.804	1.900	0.86	0.39	-0.84	0.40	0.27	0.79
$N_{Kjeldahl}$		0.134	0.155	0.165	-0.67	0.51	-0.70	0.49	-1.26	0.21
$N–NO_3^-$		1.200	1.200	1.300	0.45	0.65	-1.24	0.22	-0.64	0.52
$N–NO_2^-$		0.015	0.017	0.018	-1.29	0.20	-1.20	0.23	**-2.20**	**0.03**
Fecal coliform bacteria	$MPN\cdot cm^{-3}$	2300	930	2300	**2.85**	**0.00**	**-4.12**	**0.00**	0.78	0.44
Total coliform bacteria		4300	2750	9050	**2.03**	**0.04**	**-3.92**	**0.00**	-0.47	0.64
Bold type indicates significant differences (α = 0.05)										

meet the requirements for class II – below the good state. A great dynamics of changes was evidenced also by high values of the coefficient of variance (135–174%). Like in case of the temperature, medians of total suspended solids did not differ statistically between the measurement-control points (Table 2).

Concentrations of oxygen dissolved in water along the studied Poprad river reach ranged from 7.7–19.0 $mgO_2\cdot dm^{-3}$. Means in points 1 and 2 differed slightly and were respectively 12.2 and 12.1 $mgO_2\cdot dm^{-3}$, whereas in point 3 the amount of oxygen in water was much smaller – 11.0 $mgO_2\cdot dm^{-3}$. All research values and mean concentrations were higher than 7 $mgO_2\cdot dm^{-3}$, i.e. they met the requirements for class I. Also water saturation with oxygen was high in all measurement-control points because the average values in the subsequent points were on the level of 108, 109 and 97% (Table 1). Values of dissolved oxygen and water saturation with oxygen did not differ statistically between points 1. and 2., but between 2. and 3., and between 1. and 3. values of Mann-Whitney U test confirmed significant differences (Table 2, Figure 3). A significant decrease in oxygen content in water between Piwniczna-Zdrój and Stary Sącz is mainly affected by a lower longitudinal rive profile along this reach, thus a less turbulent water flow, which does not favor intensive oxygen diffusion from the atmospheric air.

Mean BOD_5 and total organic carbon (TOC) values were on a very similar level in all analyzed profiles and allowed to classify water to class I (Table 1). In case of the first index mentioned above, the values exceeding permissible levels for classes I and II were registered in single water samples with various frequency over the whole period of investigations. A worse water quality

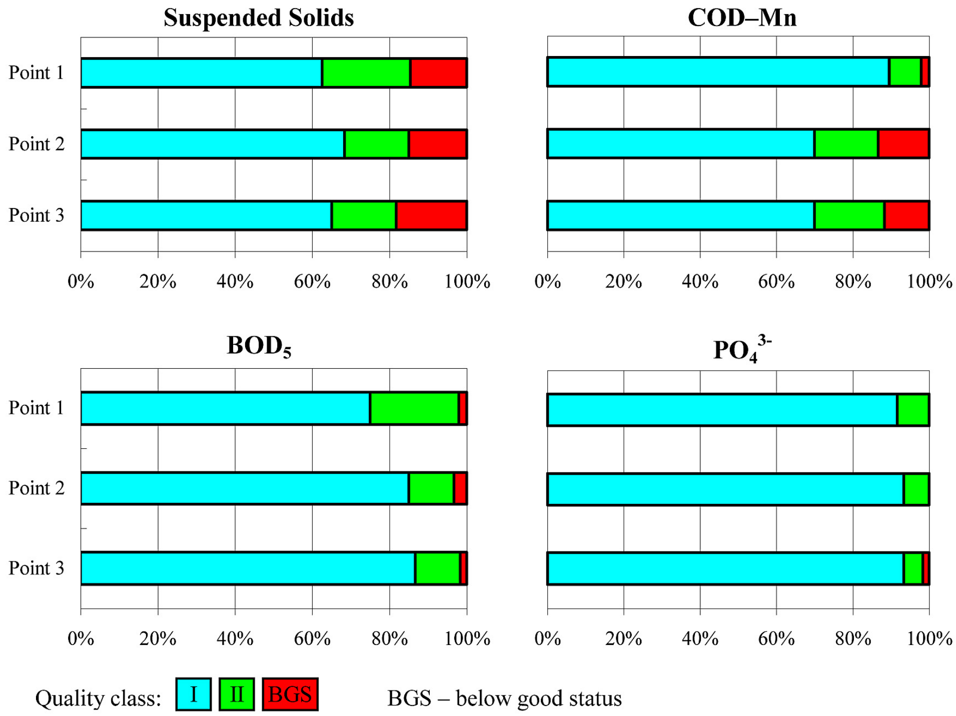

Figure 2. Proportion (%) of values of individual water indices in water quality classes

differ statistically significantly either between the points (Table 1 and 2). Water flowing in the Poprad river may be considered as soft or medium hard because its total hardness in various months of the investigations fluctuated mostly from 100 to 300 $CaCO_3 \cdot dm^{-3}$ (Table 1).

On the basis of pH value intervals from 7.4–9.0, 7.4–9.1 and 7.5–8.8, respectively in the first, second and third measurement-control points, water pH may be stated between neutral and alkaline. Despite significant differences of pH values between points 2 and 3 and 1 and 3, water reaction in all points and at all dates of research met the requirements for class I (Table 1 and 2, Figure 3). In Stary Sącz (point 3) mean concentrations of the analyzed biogenic indices, except total nitrogen, were higher than in the two other points (Table 1). Significant differences between points 1 and 3. occurred for nitrite nitrogen, phosphates and total phosphorus, and between points 1. and 2 for total phosphorus (Table 2, Figure 3). On account of biogenic substances, the state of the Poprad river along the investigated reach was very good, because mean values of total, Kjeldahl and nitrate nitrogen, as well as phosphates and total phosphorus met the requirements of class I. Only in very few water samples (6.7–8.3% at all sampling dates) phosphate concentrations exceeding values permissible for class I (0.2 $mg \cdot dm^{-3}$) were registered (Figure 2).

The analysis of microbiological indicators revealed the lowest amounts of coliform bacteria and fecal coliform bacteria in water in point 2. (Table 1 and 2). Therefore, it may be said that along the reach from the Polish-Slovak border to Piwniczna-Zdrój water parameters improved, whereas along the river reach to Stary Sącz the Poprad water became again polluted with these bacteria (Figure 3).

Water in all studied measurement-control points did not meet the requirements for surface water used for drinking water supply because of too frequent turbidity caused by high concentrations of total suspended solids exceeding 35 $mg \cdot dm^{-3}$ (Table 3). On the other hand, microbiological conditions in the Poprad river might make possible water use for consumption after a high performance physical and chemical treatment, appropriate for waters of A3 category. Moreover, usable values in all investigated points slightly worsened the values of biochemical oxygen demand (BOD_5) and pH value in point 1, which allowed for water classification to category A2 [Rozporządzenie 2002b]. Other indices met the requirements for the best quality surface waters, i.e. category A1 (Table 3).

Water of the investigated reach of the Poprad river is unsuitable as a habitat for Salmo-

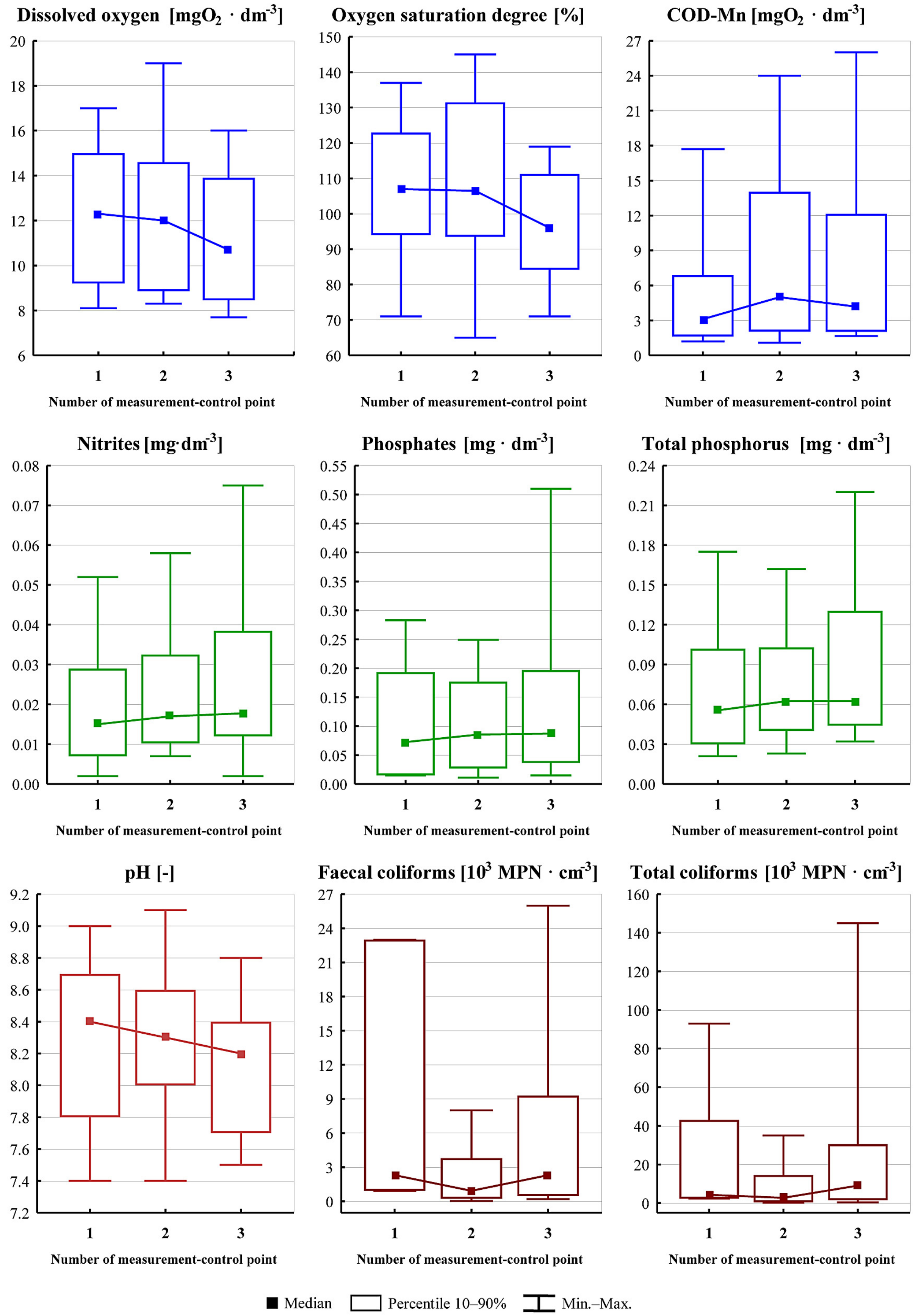

Figure 3. Variability of selected water quality indices along the analyzed Poprad river reach

Table 3. Assessment of suitability for drinking water supply

Indicator	Unit	Permissible values for water treatment category[3]:			Frequency of index values (% of samples) in norm range for a given water treatment category								
		A1	A2	A3	Point 1			Point 2			Point 3		
Temperature	°C	25[1]	25[1]	25[1]	96			97			100		
Suspended solids	mg·dm^{-3}	25[2]	30[2]	35[2]	71	77	79	80	83	85	65	68	70
pH	–	6.5–8.5[2]	5.5–9.0[2]	5.5–9.0[2]	77	100		90			95		
Oxygen saturation degree	%	>70[2]	>50[2]	>30[2]	100			100			100		
BOD_5	$mgO_2·dm^{-3}$	<3[2]	<5[2]	<7[2]	73	98		83	97		82	97	
COD–Mn		25[2]	30[2]	30[2]	98			100			100		
PO_4^{3-}	mg·dm^{-3}	0.4[2]	0.7[2]	0.7[2]	100			100			98		
$N_{Kjeldahl}$		1[2]	2[2]	3[2]	96			100			97		
NO_3^-		50[1]	50[1]	50[1]	100			100			100		
EC	µS·cm^{-1}	1000[2]	1000[2]	1000[2]	100			100			100		
SO_4^{2-}	mg·dm^{-3}	250[1]	250[1]	250[1]	100			100			100		
Cl^-		250[2]	250[2]	250[2]	100			100			100		
Faecal coliform bacteria	MPN·cm^{-3}	20[2]	2000[2]	20000[2]	0	33	100	2	77	100	0	43	98
Total coliform bacteria		50[2]	5000[2]	50000[2]	0	67	98	0	65	100	0	35	98

EC – electrolytic conductivity, [1] – for 95% of samples, [2] – for 90% of samples, red type indicates that the index value does not meet the requirements for a given water treatment category, [3] – according to the Minister Decree of 27 Nov. 2002 [Rozporządzenie MŚ 2002b],

Table 4. Assessment of water usability as a natural habitat for fish

Indicator	Unit	Values required for fresh waters as habitat for fish[4]:		Frequency of index values (% of samples) in standard range for a given fish category					
				salmonids			cyprinids		
		salmonids	cyprinids	point 1	point 2	point 3	point 1	point 2	point 3
Temperature	°C	21.5[2]	28.0[2]	98	100	100	100	100	100
Suspended solids	mg·dm^{-3}	mean annual value ≤25		31.9[3]	24[3]	29.5[3]	31.9[3]	24[3]	29.5[3]
pH	–	6–9[1]		100	98	100	100	98	100
Dissolved oxygen	mg $O_2·dm^{-3}$	50%≥9	50%≥8	95%≥9	90%≥9	95%≥9	100%≥8	100%≥8	93%≥8
		100%≥7	100%≥5	100%≥7	100%≥7	100%≥7	100%≥5	100%≥5	100%≥5
BOD_5		≤3[1]	≤6[1]	80	85	87	98	97	98
P_{total}	mg·dm^{-3}	≤0.2[1]	≤0.4[1]	100	100	97	100	100	100
NO_2^-		≤0.01[1]	≤0.03[1]	2	0	2	15	2	5

[1] – for 95% of samples, [2] – for 98% of samples, [3] – average value, [4] – according to the Minister Decree of 4 Oct. 2002 [Rozporządzenie MŚ 2002a]

requirements fulfilled | requirements not fulfilled

nid and Cyprinid fish under natural conditions in all studied points, due to high concentrations of nitrites and total suspended solids in points 1. and 2. Also, due to BOD_5 researched water does not create conditions suitable for Salmonid fish. Values of the temperature, pH, dissolved oxygen and total phosphorus fulfilled the requirements stated for fresh waters which are the habitat of Salmonid and Cyprinid fish under natural conditions (Table 4).

CONCLUSIONS

1. From among 19 investigated quality indices, 17 meet the requirements for water quality class I – very good state in each measurement-control point. The Poprad river along the whole 60 km – long investigated reach reveals a good state due to total suspended solids concentrations in points 1. and 3., and chemical oxygen demand (COD-Mn) in point 2.

2. Due to too frequent occurrences of total suspended solids concentrations, waters of the Poprad river do not fulfill the requirements for surface waters used for drinking water supply to people. Because of a high number of coliform and fecal coliform bacteria, a high performance water treatment processes should be applied (category A3) in order to obtain water for consumption.
3. Along the studied river reach water did not meet the requirements for natural habitat of Salmonid fish of *Salmo* spp., *Coregonidae* (*Coregonus*) family or for *Thymallus thymallus*, fish from the Cyprinid family, or other species, such as *Esox Lucius*, *Perca fluviatilis* or *Anguilla anguilla*, mainly due to high concentrations of nitrites.
4. Statistical analysis revealed significantly elevated concentrations of nitrite nitrogen, total phosphorus, phosphates and COD-Mn, but the values of pH, oxygen content and water saturation declined along the whole investigated river segment.

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