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Research Article

HYDROCHEMICAL CONDITIONS OF THE ŁOSOSINA RIVER WATER MANAGEMENT IN THE AREA OF TYMBARK

Agnieszka Policht-Latawiec[1], Włodzimierz Kanownik[1]

[1] Department of Land Reclamation and Environmental Development, University of Agriculture in Krakow, Mickiewicza Av. 24-28, 30-059 Krakow, Poland, e-mail: a.policht@ur.krakow.pl; rmkanown@cyf-kr.edu.pl

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ABSTRACT
Sustainable use of waters requires not only determining the amount, but primarily the quality of the available water resources and developing a long-term programme of their protection. The analysis of the Łososina river water in the area of Tymbark city was presented in the paper. The water was tested in a view of the requirements as the natural fish habitat and its potential use for people supply in potable water. The river water samples were taken in 2014 at randomly selected dates, once a month in 5 measurement points. 21 physicochemical indices were assessed in the samples. The assessment of the Łososina river water quality was made on the basis of the results of both: on site and laboratory testing, which were compared with the Regulation of the Minister of Environment of 23 October 2014. The utility values were assessed on the basis of the Regulations of the Minister of Environment of 27 November and 04 October 2014. The analysis of the results demonstrated that the Łososina river water met the requirements of quality class I water in points 1, 2 and 3. Below Tymbark the Łososina river water was polluted, so due to high BOD_5 in points 4 and 5, and phosphate concentrations in point 4, it was classified as class II, i.e. good state. Pollution coefficients computed according to Burchard and Dubaniewicz classify the Łososina river water as clean along the whole investigated stretch. Below Tymbark city (points 4 and 5) the Łososina river water cannot be used for drinking water supply because of high BOD_5 and iron concentrations. In the other points it could be used for water supply following appropriate physical and chemical treatment. The water does not meet the requirements for salmonid or cyprinid fish along the whole stretch because of high nitrite concentrations, except point 3, where the Łososina river water provided a proper natural habitat for carp.

Keywords: water quality, physicochemical indices, water management, the Łososina river, Tymbark city.

INTRODUCTION

Water management plays a crucial role in stimulating sustainable development of rural areas [Bourne 2002, GLP 2005, EEA 2010, Ahiablame et al. 2012, Mladenović-Ranisavljevića et al. 2012, Radu et al. 2013]. It is also a major element of the natural environment protection [Zampella and Procopio 2009, Erle and Robert 2010, Zieliński et al. 2012, Chomutowska and Wilamowski 2014]. Proper quality water available to the community may considerably affect the development of tourist and leisure activities [Grochowska and Tandyrak 2007], agricultural and food industries, fish farming, organic farming or construction of hydro power plants [Bodgał et al. 2012]. The intended water use poses requirements for its appropriate characteristics [Policht-Latawiec et al. 2014]. The highest requirements characterise potable water, whereas waters destined for other purposes (agriculture, industry or leisure activities) should also meet appropriate criteria, such as values characterizing chemical, physical and biological water properties [Kruk 2007, Czaban 2008, Kanownik et al. 2011, Bogdał et al. 2015]. Human activity, climatic conditions and natural components, such as the substratum or vegetal cover, considerably influence the development of water properties in the catchment [Derwich et al. 2010, Raczyńska et al. 2013, Kanownik and Policht-Latawiec 2015]. Deterioration of water quality in the catchment may be caused by pollutants from industrial and municipal sewage, chemicals used in agriculture and forestry or transport pollution [Schoonover et al. 2006, Kiryluk and Rauba 2011, Policht-Latawiec and Kanownik 2013]. A number of collective activities, aimed at ensuring rational management of surface waters leads to protection of water resources [Ostrowski 2010, Albrecht 2013]. An important objective is preventing the disturbance of natural balance and any changes which would cause water uselessness for people, animals or vegetation [Zhang et al. 2013, Policht-Latawiec et al. 2015]. According to hydrochemical research, smaller rivers (excluding the rivers flowing through the industrial and urbanised areas) have waters of significantly better quality than bigger rivers [El-Guamri and Belghyti 2006, Sojka and Murat-Błażejewska 2009]. Unfortunately, owing to untreated sewage discharges from farms and rural areas and area pollution due to farming, a vast portion of these rivers is considerably polluted [Kuźniar et al. 2009, Policht-Latawiec 2012, Radu et al. 2014].

MATERIAL AND METHODS

The hydrochemical research of the Łososina river was conducted in 2013. The river is 56.915 km long with average bottom slope 9.5‰. The Łososina springs are located in the Beskid Wyspowy Mts., at the altitude of about 960 m a.s.l. It flows from the north-eastern slopes of Jasień in Półrzeczki village and flows into Czchów Lake in Witowice Dolne village. The lake was formed as a result of the Dunajec river damming on the dam in Czchów. The watercourse is flowing in the bed composed of pebbles, gravels, sands and sandy alluvions [Paczyński and Sadurski 2007]. According to the surface waters typology, the Łososina to the Słopniczanka river is a flysch stream, whereas from the Słopniczanka to its mouth is a small flysch river. The river catchment, of 410.60 km^2 is situated at the altitude of 233–1052 m a.s.l. in the Malpolskie voivodship. According to Kondracki's [2013] geographical division, almost whole catchment is situated in the Beskid Wyspowy Mts, only a small north-eastern part belongs to the Wiśnicz Upland.

Water for analyses was sampled on 11 dates from 3845 m of the Łososina river stretch in the Tymbark city [ISO 5667-6], in 5 measurement points (Figure 1): above the city at km 41+022 (point 1) and at km 40+272 (point 2), in the city area at 39+322 (point 3) and below the city at km 37+972 (point 4) and at km 37+172 (point 5). Both the upper and the lower part of the investigated catchment are used as farmlands and forests, whereas the central part are urban and settlement areas posing a potential pollution hazard.

Water pH was assessed on site using CP-104 pH meter, electrolytic conductivity by means of CC-102 conductometer, dissolved oxygen concentration and the degree of water saturation

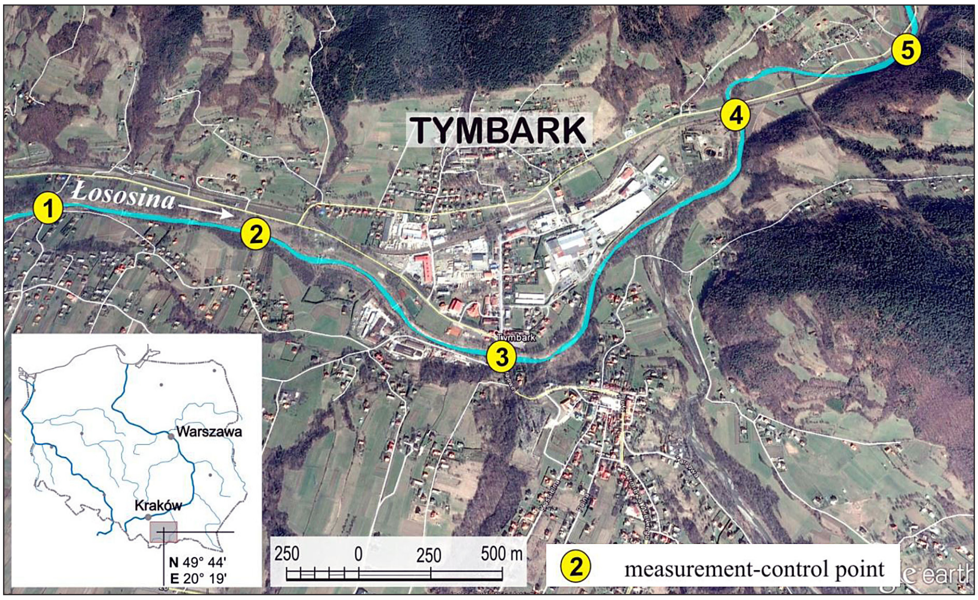

Figure 1. Location of measurement and control points on the investigated section of the Łososina river

with oxygen – using CO-411 oxygen meter, and total dissolved solids using TDS meter (HACH LANGE).

In the laboratory, total suspended solids were determined by drying and weighing method and concentrations of Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Fe and Mn ions by means of atomic absorption spectrometry (ASA) on UNICAM SOLAR 969 spectrometer. Biochemical oxygen demand (BOD_5) was determined by Winkler's method and chemical oxygen demand (COD-Mn) by titration in $KMnO_4$. Concentrations of ammonium nitrogen ($N\text{-}NH_4^+$), nitrite ($N\text{-}NO_2^-$) and nitrate ($N\text{-}NO_3^-$) nitrogen, phosphates (PO_4^{3-}) and chlorides (Cl^-) were determined by flow colorimetry analysis on FIAstar 5000 apparatus, sulphates (SO_4^{2-}) by precipitation method [Rozporządzenie MŚ 2013]. Concentrations of NH_4^+, NO_2^- and NO_3^- were computed from the nitrogen forms determined in the laboratory.

While elaborating the results, the minimum and maximum values for individual indices were determined and arithmetic mean was computed. Water quality was assessed in compliance with The Regulation of the Minister of Environment of 22 October 2014 establishing the way of classifying the state of uniform parts of surface waters and environmental quality standards for priority substances [Rozporządzenie MŚ 2014], whereas the utility value through comparing the results of assessments with the values permissible for water intended for supply to people [Rozporządzenie MŚ 2002b] and for natural fish habitats [Rozporządzenie MŚ 2002a].

Water pollution was also assessed using Burchard and Dubaniewicz formula [1981]:

$$Wz = \frac{\sum_{1}^{2} \frac{SD_t}{SW_t} + \sum_{1}^{n-2} \frac{SW_{n-2}}{SD_{n-2}}}{n}$$

where: W_z – pollution coefficient,
SD_t – concentration of dissolved oxygen permissible for class I quality waters, in compliance with regulation of 2014,
SW_t – dissolved oxygen concentration, average for the research period,
SW_{n-2} – values of the other indices considered, average for the research period,
SD_{n-2} – values of the other indices considered, admissible for class I quality waters according to the regulation of 2014,
n – number of the indices considered in the calculation.

According to the pragmatics of the method, water is considered clean if the pollution coefficient W_z is lower than 0.75. For the coefficient values 0.76–1.00; 1.01–1.50; 1.51–2.00 and over 2, the water is regarded, respectively as: slightly polluted, clearly polluted, strongly polluted and sewage. The level of linear dependence between the electrolytic conductivity and concentrations of some water quality indices in the Łososina river was determined in the paper. The dependence was stated as Pearsons's linear correlation coefficient in the closed interval [-1,1] [Buda and Jarynowski 2010].

RESULTS

The Łososina river water temperature during the investigated period ranged from 1.9 to 16.3 °C and its pH from acid (pH 6.2) to alkaline (pH 8.5). Total dissolved solids content in point 2 sporadically exceeded the value permissible for class I and its average value (8.0 $mg\cdot dm^{-3}$) was the highest in comparison with other analysed points. Yet, it remained on the level of quality class I [Rozporządzenie MŚ 2014]. Over the whole investigated period the river water revealed very good oxygen conditions – average degree of oxygen saturation was over 94% and did not exceed 103%, while average concentration of dissolved oxygen was over 9.3 $mg\cdot dm^{-3}$. Only five-day biochemical oxygen demand (BOD_5) in points 4 and 5 (below Tymbark city) exceeded the limit value for class I – 3.0 $mg\cdot dm^{-3}$. On the other hand, COD-Mn was below the limit value for class I along the whole analysed length of the Łososina river. Electrolytic conductivity of water was the highest in points 4 and 5 – it did not exceed 448 $\mu S\cdot cm^{-1}$, whereas the maximum dissolved solids concentration was 340 $mg\cdot dm^{-3}$ (Table 1). These values were lower than the limit values for quality class I waters, which evidences a low mineral pollution of water. The Łososina river water salinity was on a low level; the highest concentration of sulphates (SO_4^{2-}) was 32 $mg\cdot dm^{-3}$, chlorides (Cl^-) – 27 $mg\cdot dm^{-3}$, calcium (Ca^{2+}) – 85 $mg\cdot dm^{-3}$, magnesium (Mg^{2+}) – 12.2 $mg\cdot dm^{-3}$, sodium (Na^+) – 47.5 $mg\cdot dm^{-3}$ and potassium (K^+) – 5.5 $mg\cdot dm^{-3}$. Average and maximum concentrations of ammonium nitrogen did not exceed the limit value for quality class I (0.78 $mg\cdot dm^{-3}$). In case of phosphates concentration, the average values did not exceed the

Table 1. Range and average values of physicochemical indices and water quality class in the Łososina river

Indices	Range					Average					Limit values for class [Rozporządzenie MŚ 2014]	
	Measurement-control point											
	1	2	3	4	5	1	2	3	4	5	I	II
Physical indices												
Temperature [°C]	2.3–15.4	1.9–15.5	2.0–15.9	2.4–16.3	2.5–15.6	12.1	11.8	12.0	12.5	12.3	≤ 22	≤ 24
Total suspended solids [mg·dm^{-3}]	1.8–22.5	1.1–28	1.2–12.5	1.0–13.9	1.2–13.0	7.7	8.0	5.1	4.5	4.4	≤ 25	≤ 50
Oxygen-related indices												
Dissolved oxygen [mg O_2·dm^{-3}]	8.4–10.6	8.6–10.4	8.2–10.5	7.2–10.7	7.4–12.5	10.2	9.7	9.3	9.4	9.8	≤ 7	≤ 5
Oxygen saturation degree [%]	92–108	90–122	71–112	81–122	83–144	102	103	94	98	103	–	
BOD_5 [mg O_2·dm^{-3}]	0.3–2.9	0.9–3.9	0.6–2.5	1.0–10.5	0.7–6.7	1.4	1.8	1.6	3.8	3.2	≤ 3	≤ 6
COD-Mn [mg O_2·dm^{-3}]	3.3–7.1	3.1–6.6	3.5–6.1	4.3–8.6	3.3–7.9	5.3	4.7	4.6	5.8	5.3	≤ 6	≤ 12
Salinity												
Electrolytic conductivity [µS·cm^{-1}]	202–288	173–277	177–352	209–448	207–414	240	235	253	294	293	≤ 1000	≤ 1500
Total dissolved solids [mg·dm^{-3}]	157–216	148–219	156–263	176–340	156–315	183	174	192	233	224	≤ 500	≤ 800
SO_4^{2-} [mg·dm^{-3}]	16–27	13–32	16–29	14–25	13–27	21	20	20	19	19	≤ 150	≤ 250
Cl^- [mg·dm^{-3}]	11–16	11–14	12–21	13–27	12–25	14	13	16	17	16	≤ 200	≤ 300
Ca^{2+} [mg·dm^{-3}]	29–42	24–68	24–85	28–59	27–43	33	34	38	39	32	≤ 100	≤ 200
Mg^{2+} [mg·dm^{-3}]	5.6–10.2	4.8–10.0	4.9–11.4	6.0–12.2	6.0–12.1	7.4	7.1	7.6	8.4	8.3	≤ 50	≤ 100
Na^+ [mg·dm^{-3}]	6.0–10.0	6.8–9.7	6.9–30.1	9.2–47.5	8.4–41.3	8.4	8.4	11.3	20.8	18.5	–	
K^+ [mg·dm^{-3}]	2.9–4.0	2.7–3.7	2.9–4.6	3.0–5.5	3.0–5.2	3.5	3.1	3.5	4.2	3.9	–	
Acidification												
Reaction (pH)	7.4–8.4	7.4–8.5	6.2–8.3	7.4–8.4	6.6–8.5	7.7	7.8	7.5	7.6	7.6	6–8.5	6–9
Biogenic												
PO_4^{3-} [mg·dm^{-3}]	0.03–0.17	0.01–0.28	0.02–0.23	0.01–0.63	0.00–0.17	0.08	0.10	0.09	0.25	0.10	≤ 0.2	≤ 0.31
N-NH_4^+ [mg·dm^{-3}]	0.00–0.21	0.00–0.70	0.00–0.66	0.00–1.18	0.00–0.87	0.07	0.14	0.25	0.37	0.29	≤ 0.78	≤ 1.56
N-NO_2^- [mg·dm^{-3}]	0.00–0.03	0.00–0.03	0.00–0.02	0.01–0.05	0.01–0.03	0.01	0.01	0.01	0.03	0.02	–	
N-NO_3^- [mg·dm^{-3}]	0.1–1.8	0.2–1.5	0.1–1.5	0.4–1.8	0.4–1.5	0.7	0.8	0.9	1.2	1.1	≤ 2.2	≤ 5
Metals												
Fe [mg·dm^{-3}]	0.11–1.50	0.07–1.21	0.03–1.69	0.10–3.35	0.06–1.86	0.50	0.47	0.50	1.00	0.39	–	
Mn [mg·dm^{-3}]	0.01–0.42	0.00–0.59	0.04–0.39	0.03–0.64	0.02–0.11	0.18	0.19	0.15	0.23	0.06	–	

class I–status very good   class II–status good

standard for class I (0.2 mg·dm^{-3}) in four investigated points, while in point 4 the value was 0.25 mg·dm^{-3}. Throughout the period of research, the river water revealed low concentrations of nitrate nitrogen. The average concentration in all measurement points did not exceed the limit value for class I quality waters [Rozporządzenie MŚ 2014]. The highest concentration of total iron (3.35 mg·dm^{-3}) was registered in point 4, whereas the lowest (0.03 mg·dm^{-3}) in point 3. the average Fe concentration ranged from 0.39 – 1.00 mg·dm^{-3}. Manganese (Mn) concentrations fluctuated from 0.01 to 0.64 mg·dm^{-3} and its average value – 0.23 mg·dm^{-3} was the highest in point 4. (Table 1).

The assessment of the river water usefulness for potable water supply revealed that among the 21 analysed indices, only 14 were included in the Regulation of the Minister of Environment [2002b]. In all measurement points a majority of the tested indices (the temperature, degree of oxygen saturation of water, COD-Mn, electrolytic conductivity, sulphates, chlorides and nitrates) classified the water to A1 category, i.e. water requiring a simple physical treatment (Table 2). As much as 86% of the samples did not meet the category A requirements, due to high concentration of total suspended solids and ammonium ion (NH_4^+) in point 2, pH in point 3, phosphates in point 4, and iron in point 5. In all the points manganese concentrations caused that the waters were classified to A3 category. The Łososina river water in this point would require a highly efficient physical and chemical treatment. Because of high values of BOD_5 and Fe, 10.5 and 3.35 mg·dm^{-3} respectively, only the water immediately below the city (point 4) could not be taken for potable water supply. High concentrations of manganese and iron are typical for the surface waters of the Malopolskie voivodship. Their origin is natural, associated with the catchment geological structure, chemical composition of rocks and soils in the catchment and riverbeds [Kanownik et al. 2013].

Waters of the Łososina river were assessed in the paper as natural habitat for the salmonid and cyprinid fish. On the basis of 7 physicochemical indices it was found that water in all points did not meet the requirements for the salmonids because of high nitrite concentrations. On the other hand, water fulfilled the requirements for cyprinid fish only in point 3 [Rozporządzenia MŚ 2014]. Below the city (points 4 and 5) the Łososina river water did not meet the requirements for fish, not only due to high nitrite concentrations but also because of BOD_5 values and ammonium nitrogen concentration. The other indices: water temperature, total suspended solids, dissolved oxygen and pH met the standards for the natural habitat for salmonid and cyprinid fish.

Surface water susceptibility to pollution may be determined using pollution coefficient W_z, which classifies waters to a given category. The analysis of 14 indices showed that the Łososina river water was clean, since the value of the pollution coefficient along the analysed river stretch did not exceed 0.75 (Table 3). A higher value of the coefficient in points 4 and 5 may be explained by a local pollution connected with these points location below the city of Tymbark. It is apparent particularly for oxygen (BOD_5 and COD-Mn) and biogenic (PO_4^{3-}) indices.

Correlations between electrolytic conductivity and individual water quality indices concentrations may be interpreted as strongly positive for TDS, Mg^{2+}, Na^+, K^+, strongly negative (TSS, Fe), weakly positive (Cl^-) and weakly negative for (SO_4^{2-}, Ca^{2+} and Mn^{2+}) indices. Statistically

Table 2. Frequency of occurrence [%] of indices used for assessment of water usefulness for potable water supply for people

Indices	Admissible values of indexes for individual water categories [Rozporządzenie MŚ 2002b]			Frequency of index values (% of samples) in normative range for a given water treatment category														
				Measurement-control point and quality categories														
				1			2			3			4			5		
	A1	A2	A3	A1	A2	A3	A1	A2	A3	A1	A2	A3	A1	A2	A3	A1	A2	A3
Temperature [°C]	25[1]	25[1]	25[1]		100			100			100			100			100	
Total suspended solids [mg·dm^{-3}]	25[2]	30[2]	35[2]		100		86	100			100			100			100	
Dissolved oxygen [mg O_2·dm^{-3}]	>70[2]	>50[2]	>30[2]		100			100			100			100			100	
BOD_5 [mg O_2·dm^{-3}]	<3[2]	<5[2]	<7[2]		100		71	100			100		71	71	86	57	86	100
COD-Mn [mg O_2·dm^{-3}]	25[2]	30[2]	30[2]		100			100			100			100			100	
Electrolytic conductivity [µS·cm^{-1}]	1000[2]	1000[2]	1000[2]		100			100			100			100			100	
SO_4^{2-} [mg·dm^{-3}]	250[1]	250[1]	250[1]		100			100			100			100			100	
Cl^- [mg·dm^{-3}]	250[2]	250[2]	250[2]		100			100			100			100			100	
Reaction (pH)	6.5–8.5[2]	5.5–9.0[2]	5.5–9.0[2]		100			100		86	100			100			100	
PO_4^{3-} [mg·dm^{-3}]	0.4[2]	0.7[2]	0.7[2]		100			100			100		86	100			100	
NH_4^+ [mg·dm^{-3}]	0.5[2]	1.5[1]	2.0[1]		100		86	100		57	100		71	86	100	71	100	
NO_3^- [mg·dm^{-3}]	50[1]	50[1]	50[1]		100			100			100			100			100	
Fe [mg·dm^{-3}]	0.3[1]	2[1]	2[2]	57	100		57	100		71	100		57	71	71	86	100	
Mn [mg·dm^{-3}]	0.05[2]	0.1[2]	1[2]	43	57	100	57	57	100	43	71	100	43	57	100	71	86	100

[1] for 95% samples, [2] for 90% samples, red type indicates that the index value does not meet the requirements for a given water treatment category.

Table 3. Usability of stream water as a natural environment for fish

Indices	Values required for inland waters as environment for fish [Rozporządzenie MŚ 2002a]		Frequency of index values (% of samples) in normative range for a given fish category									
			Measurement-control point									
			1		2		3		4		5	
	Salmonidae	Cyprinidae	salmon	carp	salmon	carp	salmon	carp	salmon	carp	salmon	carp
Temperature [°C]	21.5[2]	28.0[2]	100	100	100	100	100	100	100	100	100	100
Total suspended solids [mg·dm^{-3}]	average annual value ≤25		7.7[3]		8.0[3]		5.1[3]		4.5[3]		4.4[3]	
Dissolved oxygen [mg O_2·dm^{-3}]	50% ≥ 9	50% ≥ 8	86	100	71	100	86	100	71	86	71	86
	100% ≥ 7	100% ≥ 5	100	100	100	100	100	100	100	100	100	100
BOD_5 [mg O_2·dm^{-3}]	≤ 3[1]	≤ 6[1]	100	100	71	100	100	100	71	71	57	86
pH	6–9[1]		100		100		100		100		100	
N-NH_4^+ [mg·dm^{-3}]	≤ 0.78[1]		100		100		100		71		71	
NO_2^- [mg·dm^{-3}]	≤ 0.01[1]	≤ 0.03[1]	43	86	57	86	29	100	0	43	0	57

[1] for 95% of samples, [2] for 98% of samples, [3] average value, red type indicates that the index value does not meet the requirements

Table 4. Pollution coefficients (W_z) and pollution degree of stream water as determined on basis chosen indices of water quality

Indices	SD_t: SW_t , SW_{n-2}: SD_{n-2}					Norm
	Measurement-control point					SD_t . SD_{n-2}
	1	2	3	4	5	
Temperature [°C]	0.55	0.54	0.55	0.57	0.56	22
Total suspended solids [mg·dm^{-3}]	0.31	0.32	0.20	0.18	0.18	25
Dissolved oxygen [mg O_2·dm^{-3}]	0.69	0.72	0.75	0.74	0.71	7
BOD_5 [mg O_2·dm^{-3}]	0.47	0.60	0.53	1.27	1.07	3
COD-Mn [mg O_2·dm^{-3}]	0.88	0.78	0.77	0.97	0.88	6
Electrolytic conductivity [μS·cm^{-1}]	0.24	0.24	0.25	0.29	0.29	1000
Total dissolved solids [mg·dm^{-3}]	0.37	0.35	0.38	0.47	0.45	500
SO_4^{2-} [mg·dm^{-3}]	0.14	0.13	0.13	0.13	0.13	150
Cl^- [mg·dm^{-3}]	0.07	0.07	0.08	0.09	0.08	200
Ca^{2+} [mg·dm^{-3}]	0.33	0.34	0.38	0.39	0.32	100
Mg^{2+} [mg·dm^{-3}]	0.15	0.14	0.15	0.17	0.17	50
PO_4^{3-} [mg·dm^{-3}]	0.40	0.50	0.45	1.25	0.50	0.2
N-NH_4^+ [mg·dm^{-3}]	0.09	0.18	0.32	0.47	0.37	0.78
N-NO_3^- [mg·dm^{-3}]	0.32	0.36	0.41	0.55	0.50	2.2
W_z	**0.36**	**0.38**	**0.38**	**0.54**	**0.44**	–
Pollution degree	clear	clear	clear	clear	clear	–

W_z – water pollution coefficient calculated from the formula of Burchard and Dubaniewicz [1981],
SW_t, SW_{n-2}, SD_t, SD_{n-2} – see formula (1)

strong relationship occurs between electrolytic conductivity and concentrations of magnesium, sodium, total suspended solids, iron, dissolved solids and potassium (Table 5). In case of these correlations, it may be observed that with increasing concentrations of total suspended solids and iron, electrolytic conductivity decreases, whereas with an increase in their water quality indices, water electrolytic conductivity grows (Figure 2).

CONCLUSIONS

1. On the basis of physicochemical indices supporting biological elements, the state of the Łososina river above Tymbark city was determined as very good, whereas it deteriorated below the city where its water was classified as good state due to BOD_5 and phosphates concentrations.

Table 5. Parameters of electrolytic conductivity (EC) correlation with concentration of some quality indices of analyzed river water

Indices	r_{xy}	r^2	t	p	a	b
Total suspended solid (TSS)	**-0.63**	**0.40**	**-4.55**	**< 0.001**	**-4.47**	**280.7**
Total dissolved solids (TDS)	**0.56**	**0.31**	**3.72**	**< 0.001**	**0.78**	**102.8**
SO_4^{2-}	-0.27	0.07	-1.55	0.13	-2.58	302.7
Ca^{2+}	-0.22	0.05	-1.24	0.21	-0.77	279.6
Mg^{2+}	**0.78**	**0.61**	**6.97**	**< 0.001**	**24.8**	**67.1**
Cl^-	0.12	0.01	0.67	0.51	1.96	224.4
K^+	**0.48**	**0.23**	**3.01**	**0.005**	**34.1**	**132.5**
Na^+	**0.65**	**0.42**	**4.75**	**< 0.001**	**5.18**	**192.7**
Fe	**-0.58**	**0.33**	**-3.93**	**< 0.001**	**-33.6**	**273.2**
Mn^{2+}	-0.09	0.007	-0.48	0.64	-22.4	256.5

r_{xy} – Pearson correlation coefficient, r^2 – coefficient of determination, t – value Student's statistic, p – probability level, a – regression coefficient, b – free word, red indicates that the relationship is statistically significant

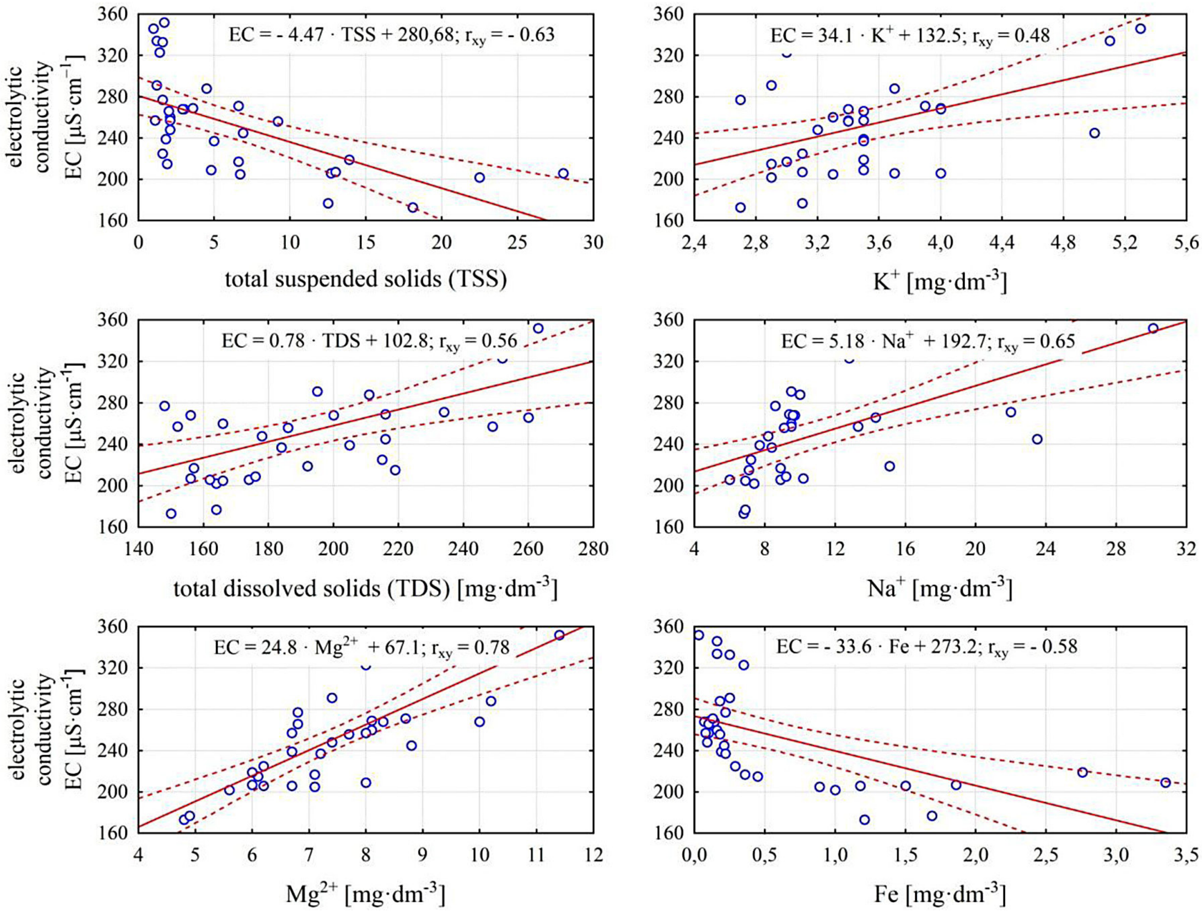

Figure 2. Dependence of electrolytic conductivity on the values of water quality indices

2. The Łososina river water above Tymbark city may be used for potable water supply to people, however, due to high manganese concentrations it must be subjected to an appropriate physical and chemical treatment. On the other hand, water analysed below the city (in points 4 and 5) did not meet the Ministry standards for A3 category of treatment for water supply to people.
3. Water on the investigated river stretch does not meet the requirements for inland waters, providing the natural habitat for salmonid and cyprinid fish because of exceeded nitrite concentrations. Only in point 3 the water may provide a natural habitat for cyprinid fish.
4. Correlation analysis revealed that electrolytic conductivity of the Łososina river water in-

creases with increasing concentrations of total dissolved solids, magnesium, potassium and sodium but it decreases when the total suspended solids and iron concentrations increase.

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