ISSN 1644-0765
DOI: http://dx.doi.org/10.15576/ASP.FC/2017.16.3.57
www.formatiocircumiectus.actapol.net/pl/

SCIENTIARUM POLONORUM ACTA Acta Sci. Pol. Formatio Circumiectus 16 (3) 2017, 57–71

THE EFFECT OF AGRICULTURAL ACTIVITY ON OF WATER QUALITY IN THE JASIENIANKA FLYSCH STREAM

Agnieszka Policht-Latawiec, Wioletta Żarnowiec
University of Agriculture in Krakow

Abstract. The paper presents the results of hydrochemical research conducted on the Jasienianka flysch stream, a left bank tributary to the Biała Tarnowska river. The submontane catchment of the stream, with area of 94.40 m^2 is situated in the Malopolska province. The stream catchment area is covered mainly by agricultural lands (68.3%) and to a lesser degree by forests (25.5%), built-up and urbanized areas (6.2) located along the banks of the Jasienianka and its tributaries. The investigations were conducted in 2014. 21 selected physicochemical indices were determined in the stream water at five control-measurement points situated along the 13 km long stream reach. Along the analyzed stream section, only the water temperature, dissolved oxygen, BOD_5 and $N\text{-}NH_4^+$ allowed to classify the waters to quality class I (maximum potential), whereas ChZT-Mn, EC, SO_4^{2-}, Cl^-, Ca^{2+}, Mg^{2+}, water pH and $P\text{-}PO_4^{3-}$ did not fulfill the requirements for class II. The other indices, in compliance with the Minister of Environment Regulation of 2016, classified water to quality class II. Statistical analysis conducted using Kruskal-Wallis test revealed statistically significant differences in the indices values between the investigated measurement-control points for SO_4^{2-}, Mg^{2+}, K^+, $N\text{-}NO_3^-$ and PO_4^{3-}. The assessment of water usable values revealed that it may be used for supply of water intended for human consumption only in the upper and middle reach. The Jasienianka did not meet the requirements for a natural habitat salmonid fish along its whole length because of high NO_2^- concentrations.

Keywords: agricultural lands, flysch stream, agricultural area pollution

INTRODUCTION

Surface water quality formation is influenced by numerous physiographic, natural [Kanownik 2005] and anthropogenic factors, whose share is different and variable in time [Ostrowski et al. 2005, Kanownik et al. 2013]. Land use and catchment management

Adres do korespondencji – Corresponding authors: dr inż. Agnieszka Policht-Latawiec, mgr inż. Wioletta Żarnowiec, Department of Land Reclamation and Environmental Development, University of Agriculture in Krakow, al. Mickiewicza 24-28, 30-059 Kraków, Poland, e-mail: a.policht@ur.krakow.pl, w.zarnowiec@ur.krakow.pl.

[Policht-Latawiec and Kanownik 2013, Policht-Latawiec et al. 2015], and associated intensification of water erosion from the soil surface [Pytka et al. 2013] are considered as the main factors. Water pollution is connected with agricultural activity [Hunter et al. 1999, Wiatkowski et al. 2012] and precipitations [Bogdał et al. 2012], inadequately treated household sewage [Lewandowska-Robak et al. 2011] or industrial wastewater and with runoffs from communication routes [Wiśniowska-Kielian and Niemiec 2008].

Identification of the mechanism of water quality formation in a catchment, characterized by different soil and climatic conditions leads to a proper management of the water resources [Kowalik et al. 2009]. It allows to maintain biodiversity and aquatic biotopes, which is directly connected with improvement of the water usable values, as well as landscape, aesthetic and recreational qualities of the adjoining areas [Kanownik and Kowalik 2010]. High quality water influences living standards and human health, but also improves the tourist attractiveness of the region, therefore affecting the development of some branches of economy. On the other hand, poor water quality negatively affects all aspects of human life and activities.

The paper presents changes of the values of physicochemical indices of water quality in the 13 km long Jasienianka stream in 2014. The choice of the watercourse was determined by anthropogenic factors occurring in the catchment area, which is used mainly for agriculture. The paper aims to demonstrate the interrelations between the catchment and water flowing through its area but in the first place the effect of agricultural management of the catchment on the quality and potential use of the Jasienianka water. In order to reach the planned objective, analysis of the analyzed stream hydrochemical profile was conducted from the perspective of its potential use for life and development of the salmonid fish and its usability for drinking water supply to people. Determining the effect of anthropogenic factors, understood as agricultural management of the catchment area, on the stream water quality will allow for a sustainable utilization of waters, which requires specification of not only the quantity, but in the first place quality of the available water resources and developing a long-term programme of their protection [Pawłowski 2011].

MATERIAL AND METHODS

The stream is 13 km long, with a mean bed slope 16.2%. The Jasienianka sources are located north of Jasienna village at the altitude of about 490 m a.s.l. It is flowing in a narrow gorge to the south-east, towards Korzenna village and then to the east towards Wojnarowa village, where it flows into the Biała Tarnowska river at the altitude of 282 m a.s.l. [Policht-Latawiec et al. 2015]. The stream catchment covers the area of 94.40 km^2 and is situated at the altitude of 280–716 m a.s.l. in the Malopolska province, within the boundaries of the Nowy Sącz and Gorlice counties, in the area of Korzenna, Bobowa and Grybów districts.

68.3% of the catchment area is managed for agriculture, the other part is covered by forests. Clusters of built-up areas in the catchment are situated along the course of the stream and its tributaries constituting 6.2% of its total area. The catchment geological base is composed of flysch deposits with prevailing shales and alluvial deposits, which belong to the hilly area of the Rożnów Foothills. These are mostly loam-silt or silt deposits with low sand content. Medium quality soils prevail in the catchment. Good quality soils constitute 14.6% and poor soils 5% of the farmland total area. Agricultural management of the catchment area favours erosion process [Kondracki 2013].

Hydrochemical research was conducted on the Jasienianka stream in 2014. Water for analyses was sampled in 5 measurement-control points: point 1 – at km 13+448m, point 2 – at km 12+228, point 3 – at km 7+293, point 4 –at km 3+134 and point 5 – at 0+493 of the stream course (Fig. 1). The measurements conducted on site comprised: electrolytic conductivity (EC) measured using CC-102 meter, dissolved oxygen content and degree of water saturation with oxygen by means of CO-411 oxygen meter. In the laboratory, total suspended solids (TSS) were assessed by evaporation and concentrations of Ca^{2+}, Na^{+}, K^{+}, Mg^{+}, Mn^{2+}, Fe^{2+} and Fe^{3+} (total iron) ions by means of atomic absorption spectrometry (AAS) on UNICAM SOLAR 969 spectrometer. Concentrations of ammonium nitrogen ($N–NH_4^+$), nitrite nitrogen ($N\text{-}NO_2^-$) and nitrate nitrogen ($N\text{-}NO_3^-$), phosphate phosphorus ($P\text{-}PO_4^{3-}$) and chlorides (Cl^-) were determined using continuous flow colorimetric analysis on FIAstar 5000 apparatus, and sulphates (SO_4^{2-}) by precipitation method [Rozporządzenie… 2016a]. Concentrations of NO_2^- and NO_3^- ions were computed from nitrogen forms determined in the laboratory. The Jasienianka stream water quality class

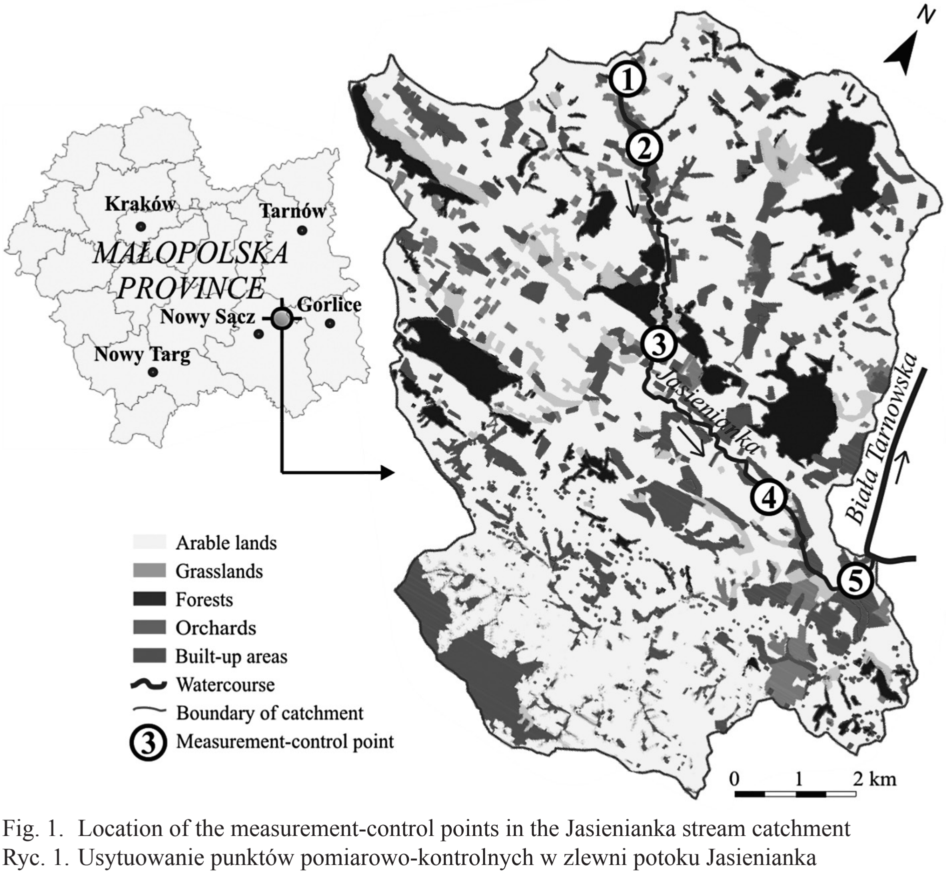

Fig. 1. Location of the measurement-control points in the Jasienianka stream catchment
Ryc. 1. Usytuowanie punktów pomiarowo-kontrolnych w zlewni potoku Jasienianka

in the measurement-control points was assessed according to the Minister of Environment Regulation on classification of ecological status, ecological potential and chemical status of homogeneous parts of surface water [Rozporządzenie… 2016b], whereas its usable values – by comparison of the assessment results with the values permissible for the water used for supply of water intended for human consumption [Rozporządzenie… 2002a] and for natural fish habitats [Rozporządzenie… 2002b]. Descriptive statistics were presented, i.e. minimum and maximum values, arithmetic mean and medium value (median) presented for the individual indices. Changeability of selected indices in the analyzed measurement-control points was presented for the period of investigations. Statistical inference about the significance of indices values differences among the control-measurement points was conducted by means of Kruskal-Wallis test. The non-parametric test was selected due to a lack of normality of distribution for a majority of the analyzed indices, according to the results of Shapiro-Wilk test and a lack of equality of variances determined by Fisher-Snedecor test. The analysis using U Mann-Whitney test was conducted in order to determine between which points significant differences of the indices values occurred. The significance level $\alpha = 0.05$ was assumed for all tests [Stanisz 2007].

RESULTS AND DISCUSSION

Mean temperature of water in the Jasienianka stream during the period of investigations fluctuated from 12.0 to 14.0°C and its pH from neutral (pH 6.6) to alkaline (pH 8.6). Total suspended solids content in water was low, on average from 2.0 to 8.0 mg · dm^{-3}, on the level of quality class I, except for water in point 4, where mean value exceeded 8.0 mg · dm^{-3} [Rozporządzenie… 2016b]. Over the whole period of investigations water in the stream was characterized by very good oxygen conditions, on the level of quality classes I and II – mean degree of water saturation was above 85% but did not exceed 95%, while the lowest mean concentration of dissolved oxygen was 9.0 mg · dm^{-3}. BOD_5 value was below the limit value for class I, whereas COD-Mn values below the norm for class II. Mean electrolytic conductivity of water in all points exceeded the limit value of 309 µS · cm^{-1} for class II stated for the abiotic type 12 in the Minister of Environment Regulation of 2016. These values were much lower than the ones obtained by Attoui et al. [2016]. Mean concentrations of dissolved solids fluctuated from 251 mg · dm^{-3} in the headwater area to 272 in the middle part of the stream (Table 1, Fig. 2). The highest mean concentration of sulphates (SO_4^{2-}) was 35.0 mg · dm^{-3}. Mean concentration of chlorides (Cl^-) in the lower (point 5) part of the stream remained above 13.0 mg · dm^{-3}, which caused that the water did not meet the requirements for class II. Chloride concentrations in the upper and middle parts of the stream did not exceed 12.0 mg · dm^{-3}. Mean Ca^{2+} concentration was on the level of class I, except for the upper stream reach, where its mean value was exceeded (53.0 mg · dm^{-3}). On the other hand, mean Mg^{2+} concentration in water along the whole length of the stream exceeded the normative value for class II. In small river catchments used for agricultural practices, a hazard for water is posed by dissolved nitrogen form, which together with plant and organic fertilizer residue migrate to waters with surface runoff [Ostrowski et al. 2008, Kiryluk and Rauba 2009, Kowalik et al. 2012, Dąbrowska et al. 2016]. Ammonium nitrogen concentrations in the

Jasienianka water was from 0,00 to 0.84 mg · dm^{-3} (Table 1, Fig. 2). On most dates higher concentration of ammonium nitrogen occurred in water of the upper and middle reach of the stream. The exception was the concentration registered in July, where in the lower course of the stream it was 0.84 mg · dm^{-3}. The decrease in the concentrations with the stream course may be associated with the Jasienianka water dilution by her tributaries. The analysis of seasonality revealed the highest concentrations of ammonium nitrogen in the control points in the summer period, i.e. in June and July. Higher concentration of this compound in the summer period is caused by the application of natural fertilizers, such as liquid manure and farmyard manure on grasslands during the springtime and starting cattle grazing on pastures at the beginning of May [Pietrzak and Sapek 1998]. Differences in ammonium nitrogen concentrations among the water sampling points were not statistically significant. Concentration of nitrite nitrogen in the analyzed water samples ranged from 0.00 to 0.06 mg · dm^{-3}. The highest content of nitrite nitrogen in each measurement-control point was registered in May and September. A similar distribution of values was noted for the concentrations of nitrate nitrogen and phosphate phosphorus V. Maximum concentrations of nitrite nitrogen (0.06 mg · dm^{-3}) and phosphate phosphorus V (0.6 mg · dm^{-3}) were registered in the headwater part, whereas nitrate nitrogen concentrations (2.2 mg · dm^{-3}) in the middle reach of the stream. High concentrations of compounds in waters of these reaches might have been caused by intensive fertilization of field crops. Intensive vegetation which starts in May is supported by fertilization and some part of the fertilizers if washed off to the stream bed. The differences in concentrations of nitrate nitrogen and phosphate phosphorus V between the sampling points were statistically significant. Higher values of nitrate nitrogen were observed in the middle course in relation to the mouth part, while phosphorus values were higher in the upper course in relation to the values registered in the middle and lower reach.

In points 1., 4. and 5. the highest (0.40 mg · dm^{-3}) mean total iron concentration was registered and the lowest (0.20 mg · dm^{-3}) was noted in point 2. Manganese (Mn^{2+}) concentrations fluctuated on average from 0.06 to 0.14 mg · dm^{-3} (Table 1).

In order to determine water usability for consumption, values of selected physicochemical indices were compared with the limit values in compliance with the Regulation of the Minister of Environment of 27 November, 2002. The assessment revealed that the temperature, pH, electrolytic conductivity, degree of water saturation with oxygen, COD-Mn, concentrations of nitrates, sulphates and chlorides in all measurement points classified water to A1 category, i.e. water requiring simple physical treatment (Table 2). Concentrations of the analyzed metals – iron and manganese, as well as total suspended solids considerably worsened the assessed water usability for consumption. Due to high iron concentrations in point 4. and 5. water was unfit for consumption exceeding the limit values permissible for A3 category. On the other hand, manganese concentrations in water in all analyzed points led to the water classification to A3 category, i.e. water requiring high performance physical and chemical treatment. Water in measuring-control point 1., because of pH and PO_4^{3-} and in point 2., due to total iron content obtained A2 category, i.e. water requiring a typical physical and chemical treatment. Water in all analyzed measurement-control points was classified to A2 category due to BOD_5 value [Rozporządzenie… 2002a].

Table. 1. Range and mean values of physicochemical elements and water quality class in the Jasienianka stream
Tabela 1. Zakres i średnie wartości elementów fizykochemicznych oraz klasa jakości wody potoku Jasienianka

Index – Wskaźnik	Range – Zakres					Mean – Średnia					Limit value for abiotic type 12 Wartość graniczna dla typu abiotycznego 12	
	Measurement-control point – Punkt pomiarowo-kontrolny											
	1	2	3	4	5	1	2	3	4	5	I	II
Indices characterizing physical status – Wskaźniki charakteryzujące stan fizyczny												
Temperature – Temperatura, °C	4.0–21.0	3.0–21.0	3.0–21.0	2.0–22.0	3.0–22.0	13.0	12.0	13.0	14.0	14.0	≤ 22	≤ 24
Total suspended solids Zawiesina ogólna, mg · dm^{-3}	1.0–9.0	1.0–13.0	1.0–18.0	1.0–44.0	0.0–37.0	2.0	4.0	5.0	8.0	6.0	≤ 7.0	≤ 17,3
Group of indices characterizing oxygen conditions – Grupa wskaźników charakteryzujących warunki tlenowe												
Dissolved oxygen Tlen rozpuszczony, mg · dm^{-3}	7.0–11.0	7.0–13.0	7.0–12.0	8.0–13.0	8.0–12.0	9.0	10.0	10.0	10.0	9.0	≥ 9.3	≥ 8,9
Degree of saturation with oxygen – Stopień nasycenia tlenem, %	77–99	83–98	82–98	90–98	84–99	88	90	90	94	90	–	
BOD_5, mg O_2 · dm^{-3}	1.0–4.0	0.0–3.0	1.0–3.0	1.0–4.0	1.0–3.0	2.0	2.0	1.0	2.0	2.0	≤ 2.3	≤ 2,9
COD-Mn, mg O_2 · dm^{-3}	4.0–11.0	2.0–9.0	2.0–8.0	1.0–9.0	1.0–9.0	6.0	5.0	4.0	4.0	4.0	≤ 2.5	≤ 3,4
Group of indices characterizing salinity Grupa wskaźników charakteryzujących zasolenie												
Conductivity at 20°C Przewodność w 20°C, µS · cm^{-1}	332–619	353–615	378–600	354–596	308–669	433	492	512	510	491	≤ 192	≤ 309
Dissolved solids – Substancje rozpuszczone mg · dm^{-3}	215–304	222–302	229–300	216–301	197–336	251	268	272	268	261	–	–

SO_4^{2-}, mg · dm^{-3}	18.0–29.0	9.0–46.0	14.0–39.0	10.0–45.0	22.0–46.0	23.0	27.0	29.0	35.0	34.0	≤ 17.2	≤ 28,2
Cl^-, mg · dm^{-3}	7.0–19.0	9.0–24.0	7.0–13.0	8.0–18.0	7.0–33.0	11.0	12.0	9.0	12.0	13.0	≤ 3.0	≤ 12,8
Ca^{2+}, mg · dm^{-3}	43–69	44–69	43–59	41–70	40–72	53	53	50	50	49	≤ 50	≤ 51
Mg^{2+}, mg · dm^{-3}	17.0–27.0	19.0–29.0	20.0–30.0	14.0–28.0	14.0–27.0	23.0	26.0	28.0	24.0	22.0	≤ 5.3	≤ 11,7
Na^+, mg · dm^{-3}	7.5–14.2	8.2 –15.4	7.6–11.9	7.1–13.4	6.8–13.2	11.5	11.8	10.3	11.3	11.1	–	
K^+, mg · dm^{-3}	6.9–10.6	4.7–8.7	3.8–6.2	4.5–6.6	4.5–22.3	8.7	6.3	4.9	5.3	7.5	–	
Index characterizing acidity Wskaźnik charakteryzujący zakwaszenie												
pH water – pH wody	6.6–8.6	6.6–8.5	6.8–8.5	6.8–8.5	6.7–8.5	–	–	–	–	–	7.8–8.4	7,4–8,4
Group of indices characterizing nutrient conditions Grupa wskaźników charakteryzujących warunki biogenne												
P-PO_4^{3-}, mg · dm^{-3}	0.00–0.60	0.00–0.30	0.00–0.30	0.00–0.40	0.00–0.30	0.20	0.10	0.10	0.10	0.10	≤ 0.016	≤ 0,067
N-NH_4^+, mg · dm^{-3}	0.00–0.14	0.00–0.44	0.00–0.14	0.00–0.23	0.00–0.84	0.06	0.09	0.05	0.05	0.12	≤ 0.16	≤ 0,42
N-NO_2^-, mg · dm^{-3}	0.00–0.06	0.00–0.03	0.00–0.03	0.00–0.04	0.00–0.04	0.02	0.01	0.01	0.01	0.01	≤ 0.01	≤ 0,025
N-NO_3^-, mg · dm^{-3}	0.8–1.8	1.1–1.7	1.0–2.2	0.8–1.5	0.7–1.7	1.1	1.3	1.5	1.1	1.0	≤ 1.0	≤ 1,5
Metals Metale												
Fe, mg · dm^{-3}	0.10–1.20	0.00–0.90	0.00–1.10	0.10–2.50	0.00–2.20	0.40	0.20	0.30	0.40	0.40	–	
Mn, mg · dm^{-3}	0.02–0.41	0.02–0.58	0.02–0.35	0.03–0.14	0.02–0.11	0.14	0.12	0.08	0.07	0.06	–	

quality class I – maximum potential I klasa jakości – maksymalny potencjał	quality class II – good potential II klasa jakości – potencjał dobry	does not meet requirements for class II – potential below good niespełnienie wymogów klasy II – potencjał poniżej dobrego

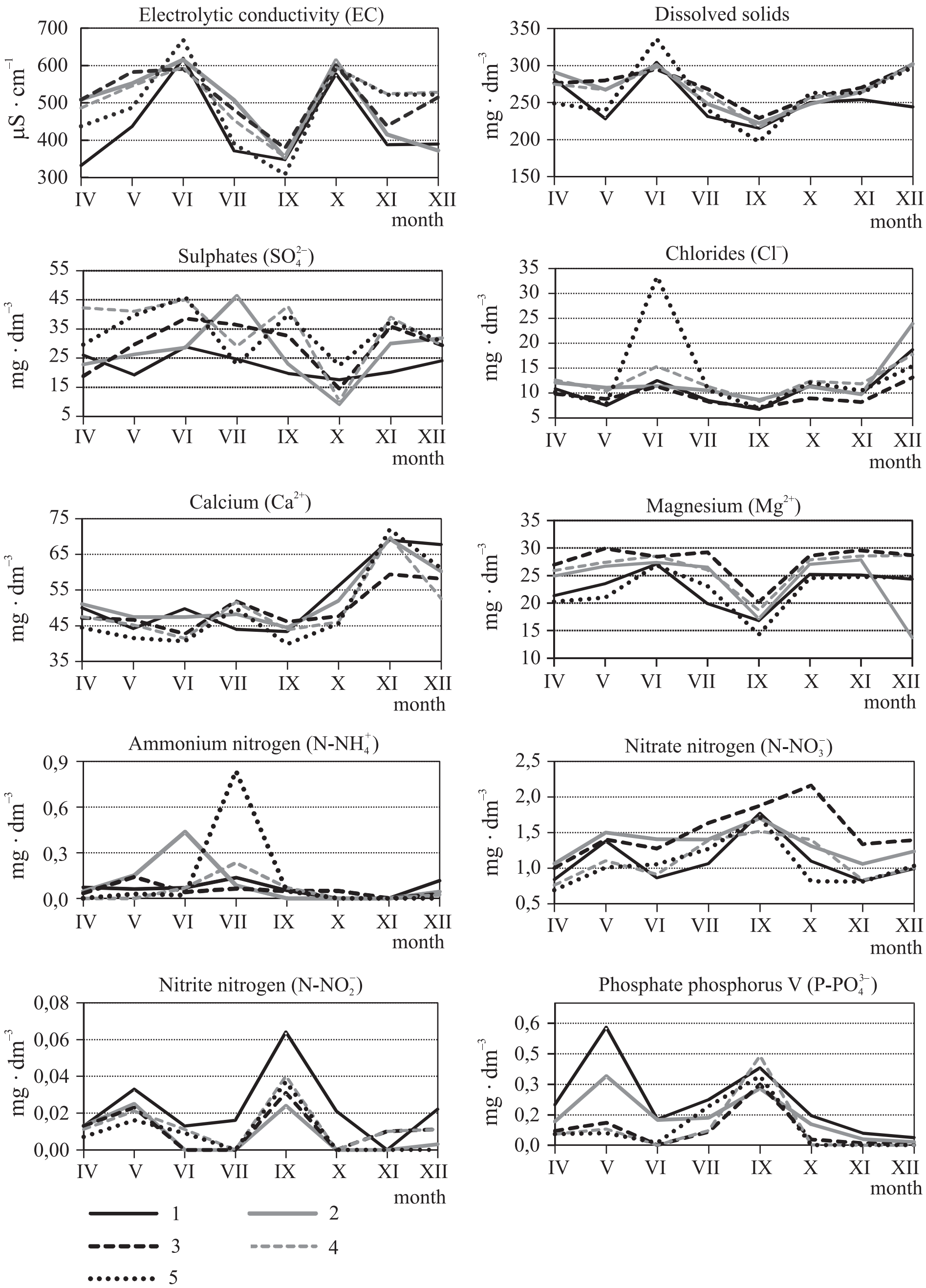

Fig. 2. Variability of indicators characterizing biogenic conditions and salinity
Ryc. 2. Zmienność wskaźników charakteryzujących warunki biogenne i zasolenie

Table 2. Assessment of the usable values of the Jasienianka stream water
Tabela 2. Ocena walorów użytkowych wody potoku Jasienianka

Index Wskaźnik		Water usability for – Przydatność wody do									
		consumption – spożycia					the salmonid fish habitat bytowania ryb łososiowatych				
		Measurement-control point Punkt pomiarowo-kontrolny									
		1	2	3	4	5	1	2	3	4	5
Temperature – Temperatura, °C		A1					YES			U	
Total suspended solids, $mg \cdot dm^{-3}$ Zawiesina ogólna, $mg \cdot dm^{-3}$		A1			NU		YES				
pH		A2	A1				YES				
Electrolytic conductivity, $\mu S \cdot cm^{-1}$ Przewodność elektrolityczna, $\mu S \cdot cm^{-1}$		A1					–	–	–	–	–
Degree of saturation with oxygen, % Stopień nasycenia tlenem, %		A1					–	–	–	–	–
Dissolved oxygen, $mg \cdot dm^{-3}$ Tlen rozpuszczony, $mg \cdot dm^{-3}$		–	–	–	–	–	YES				
BOD_5	$mg \cdot dm^{-3}$	A2					NU	YES		NU	YES
COD-Mn		A1					–	–	–	–	–
$N\text{-}NH_4^+$		–	–	–	–	–	YES				NU
NO_3^-		A1					–	–	–	–	–
NO_2^-		–	–	–	–	–	NU				
PO_4^{3-}		A2	A1				–	–	–	–	–
SO_4^{2-}		A1					–	–	–	–	–
Cl^-		A1					–	–	–	–	–
Total iron (Fe)		A3	A2	A3	NU		–	–	–	–	–
Mn^{2+}		A3					–	–	–	–	–

A1 – water requiring simple physical treatment, particularly filtration and disinfection – woda wymagająca prostego uzdatniania fizycznego, w szczególności filtracji oraz dezynfekcji,
A2 – water requiring a typical physical and chemical treatment, particularly primary oxygenation, coagulation, flocculation, decantation, filtration and disinfection (final chlorination) – woda wymagająca typowego uzdatniania fizycznego i chemicznego, w szczególności utleniania wstępnego, koagulacji, flokulacji, dekantacji, filtracji, dezynfekcji (chlorowania końcowego)
A3 – water requiring high performance physical and chemical treatment, particularly oxygenation, coagulation, flocculation, decantation, filtration, activated carbon adsorption and disinfection (ozonation and final chlorination) – woda wymagająca wysokosprawnego uzdatniania fizycznego i chemicznego, w szczególności utleniania, koagulacji, flokulacji, dekantacji, filtracji, adsorpcji na węglu aktywnym, dezynfekcji (ozonowania, chlorowania końcowego)
NU – water unfit for treatment – woda nienadająca się do uzdatniania

In the paper, the Jasienianka stream waters were assessed as a natural habitat for the salmonid fish. On the basis of 7 physicochemical indices it was determined that water in all points did not meet the requirements for the salmonid fish because of high nitrite concentration (Table 2). Nitrite concentration in each water sample was above 0.01 mg · dm^{-3}. The water temperature, BOD_5 and ammonium nitrogen values registered in the stream upper course also exceeded the limit values. On the other hand, such indices as: total suspended solids, dissolved oxygen and pH were suitable for the water providing a natural habitat for the salmonid fish [Rozporządzenie… 2002b].

The Kruskal-Wallis nonparametric test revealed statistically significant differences for sulphates, magnesium, potassium, nitrate nitrogen and phosphate phosphorus, where the test probability was lower than 0.05 (Table 3). Statistically significantly higher values for SO_4^{2-}, as compared with the other segments of the analyzed stream, occurred by its inflow into the Biała Tarnowska river (Table 4). For the other mentioned parameters the differences between the analyzed points were noted along the whole length of the watercourse, but they were insignificant.

Table 3. Comparison of analyzed water indices values between the measurement-control points using Kruskal-Wallis nonparametric test

Tabela 3. Porównanie wartości badanych wskaźników wody pomiędzy punktami pomiarowo-kontrolnymi testem nieparametrycznym Kruskala-Wallisa

Index Wskaźnik	Measurement-control point Punkt pomiarowo-kontrolny					Results of Kruskal-Wallis test Wyniki testu Kruskala-Wallisa	
	1	2	3	4	5	Test value Wartość testu	Test probability (*p*) Prawdopodobieństwo testowe (*p*)
	Median – Mediana						
Temperature, °C Temperatura, °C	13.0	12.0	13.0	14.0	14.0	0.995	0.911
Total suspended solids, mg · dm^{-3} Zawiesina ogólna, mg · dm^{-3}	1.0	2.0	3.0	3.0	1.0	3.776	0.437
Degree of water saturation with oxygen, % Stopień nasycenia wody tlenem, %	88	89	89	94	89	4.420	0.352
Dissolved oxygen, mg · dm^{-3} Tlen rozpuszczony, mg · dm^{-3}	9.0	9.0	10.0	9.0	9.0	1.120	0.891
BOD_5, mg · dm^{-3}	2.0	2.0	1.0	2.0	2.0	3.308	0.508
COD-Mn	6.0	5.0	4.0	4.0	4.0	8.472	0.076
EC, µS · cm^{-1}	389	508	512	526	504	3.308	0.508
Dissolved solids, mg · dm^{-3}	247	266	273	266	256	3.397	0.494
SO_4^{2-}, mg · dm^{-3}	**22.0**	**27.0**	**31.0**	**40.0**	**34.0**	**10.151**	**0.038**

Table 3. cd.
Tabela 3. cont.

Index Wskaźnik	Measurement-control point Punkt pomiarowo-kontrolny					Results of Kruskal-Wallis test Wyniki testu Kruskala-Wallisa	
	1	2	3	4	5	Test value Wartość testu	Test probability (*p*) Prawdopodobieństwo testowe (*p*)
	Median – Mediana						
Cl^-, mg · dm^{-3}	10.0	11.0	9.0	12.0	11.0	5.264	0.261
Ca^{2+}, mg · dm^{-3}	50.0	50.0	47.0	47.0	45.0	2.369	0.669
Mg^{2+}, mg · dm^{-3}	**24.0**	**28.0**	**29.0**	**27.0**	**24.0**	**16.065**	**0.003**
Na^+, mg · dm^{-3}	12.0	12.0	11.0	12.0	12.0	3.946	0.413
K^+, mg · dm^{-3}	**9.0**	**6.0**	**5.0**	**5.0**	**6.0**	**18.745**	**0.001**
N-NH_4^-, mg · dm^{-3}	0.07	0.04	0.04	0.01	0.01	3.199	0.525
N-NO_2^-, mg · dm^{-3}	0.02	0.00	0.01	0.01	0.00	5.514	0.239
N-NO_3^-, mg · dm^{-3}	**1.03**	**1.36**	**1.40**	**1.05**	**1.02**	**10.556**	**0.032**
P-PO_4^{3-}, mg · dm^{-3}	**0.17**	**0.12**	**0.05**	**0.03**	**0.03**	**9.632**	**0.047**
Fe, mg · dm^{-3}	0.28	014	0.12	0.18	0.15	4.015	0.404
Mn, mg · dm^{-3}	0.08	0.03	0.04	0.07	0.06	3.427	0.489

Statistics value in bold means that the differences are statistically significant at $p < 0,05$ – Wytłuszczona wartość statystyki oznacza, że różnice są statystycznie istotne przy $p < 0,05$

Table 4. Significance of differences of water indices between the individual measurement-control points on the Jasienianka stream – U Mann-Whitney nonparametric test
Tabela 4. Istotność różnic indeksów wody pomiędzy poszczególnymi punktami pomiarowo-kontrolnymi na strumieniu Jasienianka – test U Manna-Whitneya

Point	SO_4^{2-}					Mg^{2+}				
	1	2	3	4	5	1	2	3	4	5
1		0.161	0.083	**0.010**	**0.010**		**0.015**	**0.007**	0.234	0.798
2			0.442	0.161	0.382			0.105	0.130	**0.015**
3				0.195	0.279				**0.015**	**0.007**
4					0.645					0.161
5										

Table 4. cd.
Tabela 4. cont.

Point	K^+					$N\text{-}NO_3^-$				
	1	2	3	4	5	1	2	3	4	5
1		0.083	**0.001**	**0.001**	**0.010**		0.279	**0.028**	0.798	0.505
2			0.050	0.130	0.505			0.505	0.130	**0.028**
3				0.382	0.130				0.05	**0.021**
4					0.574					0.645
5										

	$P\text{-}PO_4^{3-}$				
	1	2	3	4	5
1		**0.010**	**0.038**	**0.038**	0.379
2			0.083	0.065	0.130
3				0.798	0.878
4					0.878
5					

* Statistics value in bold means that the differences are statistically significant at $p < 0,05$
* Wytłuszczona wartość statystyki oznacza, że różnice są statystycznie istotne przy $p < 0,05$

Test probability (p)

CONCLUSIONS

The following conclusions were formulated on the basis of obtained results:

1. In compliance with the Minister of Environment Regulation of 21 July 2016, the ecological potential of the Jasienianka stream water during the period of the analyzes was below good in all points due to excessively high values of water pH, electrolytic conductivity, magnesium and phosphorus. The concentrations of Ca^{2+} in the upper course and Cl^- in the lower course, but also SO_4^{2-} values in the middle and lower course of the stream did not meet the standards stated for water quality class II.
2. Analysis of the Jasienianka stream water test results revealed that because of exceeded total suspended solids and total iron, water by the stream inflow into the Biała Tarnowska river could not be used for supply of water intended for human consumption.

3. The water in the analyzed watercourse did not meet the requirements for the salmonid fish habitat due to exceeded concentrations of nitrites along the whole length of the investigated stream.
4. Mean values of a majority of the investigated indices of salinity, acidity and nutrients were on a similarly high level in all measurement-control points, which may evidence a constant emission of area pollutants into the stream originating from agricultural practices in the catchment area.
5. Statistically significant differences of the indices values between the points occurred only for sulphates, magnesium, potassium, nitrate nitrogen and phosphate phosphorus. Statistically higher concentrations of potassium and phosphate phosphorus were noted in the upper course of the stream in comparison with the values registered in the middle and lower course, whereas sulphate concentrations were higher in the lower course of the stream in relation to the ones determined in the upper reach. Magnesium concentrations were higher in the middle course of the stream than in its other parts.

REFERENCES

Attoui, B., Toumi, N., Messaoudi, S., Benrabah, S. (2016). Degradation of water quality: the case of plain West of Annaba (Northeast Algeria). J. Water and Land Develop., 31, 3–10.

Bogdał, A., Kowalik, T., Kanownik, W., Ostrowski, K., Wiśnios, M. (2012). Ocena stanu fizykochemicznego wód opadowych i odpływających ze zlewni potoku Wolninka. Gaz, Woda Tech. Sanit., 8, 362–365.

Dąbrowska, J., Lejcuś, I., Moryl, A., Kucharczak-Moryl, E., Żmuda, R. (2016). Zawartość związków azotu w wodach rzeki Strzegomki powyżej zbiornika Dobromierz. Acta Sci. Pol., Formatio Circumiectus, 15(6), 57–69.

Hunter, C, Perkins, J., Tranter, J., Gunn, J. (1999). Agricultural land-use effects on the indicator bacterial quality of an upland stream in the Derbyshire peak district in the U.K. Water Res., 33, 17, 3577–3586.

Kanownik, W. (2005). Impact of mountainous areas management system upon biogenes content in surface waters. EJPAU, 8(2), #11.

Kanownik, W., Kowalik, T. (2010). Variability of water resources flowing away from small agricultural catchment. Polish J. Environ. Stud., 19(1), 65–71.

Kanownik, W., Kowalik, T., Bogdał, A., Ostrowski, K. (2013). Quality Categories of Stream Water Included in a Small Retention Program. Pol. J. Environ. Stud., 22(1), 159–165.

Kiryluk, A, Rauba, M. (2009). Zmienność stężenia związków azotu w różnie użytkowanej zlewni rolniczej rzeki Ślina. Woda Środ. Obsz. Wiej., 9, 4(28), 71–86.

Kondracki, J. (2013). Geografia regionalna Polski. Wydawnictwo Naukowe PWN, Warszawa.

Kowalik, T., Bogdał, A., Kanownik, W., Borek, Ł. (2012). Sezonowość zmian wartości wybranych właściwości fizykochemicznych wody odpływającej z małej zlewni rolniczo-leśnej. Gaz Woda Tech. Sanit., 8, 354–357.

Kowalik, T., Kanownik, W., Bogdał, A., Ostrowski, K., Rajda, W. (2009). Jakość i cechy użytkowe wody potoku Bąbola w aspekcie jej przyszłego magazynowania w zbiorniku retencyjnym. Acta Sci. Pol., Formatio Circumiectus, 8(3–4), 17–23.

Lewandowska-Robak, M., Górski, Ł., Kowalkowski, T., Dąbkowska-Naskręt, H., Miesikowska, I. (2011). Wpływ ścieków oczyszczonych odprowadzanych z Oczyszczalni Ścieków w Tucholi na jakość wody w strudze Kicz. Inżyn. Ochr. Środ., 14, 3, 209–221.

Ostrowski, K., Policht, A., Rajda, W., Bogdał, A. (2008). Zmiany przewodności elektrolitycznej i stężeń biogenów w wodzie z biegiem cieku odwadniającego małą zlewnię rolniczą. Zesz. Probl. Post. Nauk Rol., 528, 123–131.
Ostrowski, K., Rajda, W., Bogdał, A., Policht, A. (2005). Wpływ zabudowy miejskiej na jakość wody w potoku podgórskim. Zesz. Nauk. AR Kraków, 420, Inżynieria Środowiska, 26, 21–29.
Pawłowski, L. (2011). Role of Environmental Monitoring in Implementation of Sustainable Development. Rocznik Ochrona Środowiska, 13, 333–345.
Pietrzak, S., Sapek, A. (1998). Monitoring jakości wody gruntowej w zagrodzie wiejskiej i jej otoczeniu. Zesz. Probl. Post. Nauk Rol., 458, 495–504.
Policht-Latawiec, A., Kanownik, W. (2013). Jakość i walory użytkowe wody rzeki Jabłonicy w aspekcie jej retencjonowania w zbiorniku. Gaz Woda Techn. Sanit., 2, 79–82.
Policht-Latawiec, A., Żarnowiec, W., Majewska, M. (2015). The analysis of variability in water quality in the Biala Tarnowska River. Ecolog. Engin., 44, 217–226.
Pytka A., Jóźwiakowski K., Marzec M., Gizińska M., Sosnowska B. (2013). Ocena wpływu zanieczyszczeń antropogenicznych na jakość wód rzeki Bochotniczanki. Infrastr. Ekol. Ter. Wiej., 3, 2, 15–29.
Rozporządzenie Ministra Środowiska z dnia 19 lipca 2016 r. w sprawie form i sposobu prowadzenia monitoringu jednolitych części wód powierzchniowych i podziemnych. Dz.U. z 2016 r., poz. 1178 [Rozporządzenie… 2016a].
Rozporządzenie Ministra Środowiska z dnia 21 lipca 2016 r. w sprawie sposobu klasyfikacji stanu jednolitych części wód powierzchniowych oraz środowiskowych norm jakości dla substancji priorytetowych. Dz.U. z 2016 r., poz. 1187 [Rozporządzenie… 2016b].
Rozporządzenie Ministra Środowiska z dnia 27 listopada 2002 r. w sprawie wymagań, jakim powinny odpowiadać wody powierzchniowe wykorzystywane do zaopatrzenia ludności w wodę przeznaczoną do spożycia. Dz.U. z 2002 r. Nr 204, poz. 1728 [Rozporządzenie… 2002a].
Rozporządzenie Ministra Środowiska z dnia 4 października 2002 roku w sprawie wymagań, jakim powinny odpowiadać wody śródlądowe będące środowiskiem życia ryb w warunkach naturalnych. Dz.U. z 2002 r. Nr 176, poz. 1455 [Rozporządzenie… 2002b].
Stanisz, A. (2007). Przystępny kurs statystyki z zastosowaniem STATISTICA PL na przykładach z medycyny. Analizy wielowymiarowe. StatSoft Poland, Kraków.
Wiatkowski, M., Rosik-Dulewska, Cz., Gruss, Ł. (2012). Profil zmian wskaźników jakości wody w rzece Stobrawie. Infrastr. Ekol. Ter. Wiej., 3, 4, 21–35.
Wiśniowska-Kielian, B., Niemiec, B. (2008). Zanieczyszczenia metalami ciężkimi wód spływających z dróg pobranych ze zbiorników odparowujących. Inżyn. Ekol., 20, 57–63.

WPŁYW DZIAŁALNOŚCI ROLNICZEJ NA JAKOŚĆ WODY POTOKU FLISZOWEGO JASIENIANKA

Streszczenie. W pracy przedstawiono wyniki hydrochemicznych badań potoku fliszowego Jasienianka, lewobrzeżnego dopływu rzeki Biała Tarnowska. Zlewnia potoku, o powierzchni 94,40 km^2, ma charakter podgórski i położona jest w województwie małopolskim. Obszar zlewni potoku zajmują głównie tereny rolnicze (68,3%), w mniejszym stopniu lasy (25,5%) oraz usytuowane wzdłuż biegu Jasienianki i jej dopływów tereny zabudowane i zurbanizowane (6,2%). Badania prowadzono w 2014 roku. W wodzie oznaczono 21 wybranych wskaźników fizykochemicznych w pięciu punktach pomiarowo-kontrolnych zlokalizowanych na odcinku potoku o długości 13 km. Na analizowanym odcinku potoku tylko temperatura wody, tlen rozpuszczony, BZT$_5$ oraz N-NH$_4^+$ pozwoliły zakwalifikować wody do I kasy jakości (potencjału maksymalnego), natomiast wskaźniki: ChZT-Mn, EC,

SO_4^{2-}, Cl^-, Ca^{2+}, Mg^{2+}, pH wody oraz P-PO_4^{3-} nie spełniały norm dla II klasy. Pozostałe wskaźniki, zgodnie z obowiązującym rozporządzeniem MŚ z 2016 roku, kwalifikowały wodę do II klasy jakości. Przeprowadzona analiza statystyczna testem Kruskala-Wallisa wykazała, że istotnie statystyczne różnice wartości wskaźników pomiędzy badanymi punktami pomiarowo-kontrolnymi wystąpiły w przypadku SO_4, Mg, K, N-NO_3 i PO_4. Ocena walorów użytkowych wody potoku wykazała, że może być ona wykorzystywana do zaopatrzenia ludności w wodę przeznaczoną do spożycia tylko w górnym i środkowym odcinku. Na całej długości Jasienianka nie spełnia warunków naturalnego siedliska do bytowania ryb łososiowatych ze względu na wysokie stężenie NO_2.

Słowa kluczowe: grunty rolne, potok fliszowy, rolnicze zanieczyszczenia obszarowe

Accepted for print – Zaakceptowano do druku: 1.09.2017

For citation: Policht-Latawiec, A., Żarnowiec, W. (2017). The effect of agricultural activity on of water quality in the Jasienianka flysch stream. Acta Sci. Pol., Formatio Circumiectus, 16(3), 57–71.