ECOLOGICAL CHEMISTRY AND ENGINEERING A

Vol. 18, No. 5–6 2011

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INFLUENCE OF MINE WATER ON WATER QUALITY OF PELCZNICA RIVER

WPŁYW WÓD KOPALNIANYCH NA JAKOŚĆ WÓD RZEKI PEŁCZNICY

Abstract: Pełcznica River is the right-bank tributary of the Strzegomka River. There is an inactive mine nearby which releases the outflow of mine waters. They connect with the Pelcznica River influencing its water quality. In 2007 five research localities were investigated: 1 – the source of the River on the eastern slope of Borowa massif approximately 625 m above sea level, 2 – 50 m above the point of mine waters discharge, 3 – the point of the mine waters drop, 4 – 50 m below the point of mine water drop and 5 – 200 m below the point of mine water drop and 50 m above the sewage treatment plant. The analysis of the results showed that mine waters have a considerable influence only on a few water parameters of the Pelcznica River especially related to electrolytic conductivity, nickel, chlorides, sulfates, calcium concentration and alkalinity or hardness.

Keywords: Pelcznica River, mine, water quality

Civilization development results in a considerable human influence on the natural environment [1]. An example of anthropopression may be found in the effect mine industry on the condition of surface waters. Mine industry results in topography, soil quality and fauna alternation along with the change of the amount of water and its quality [2]. Walbrzych region belongs to an area under great anthropopressure, where the contamination of local rivers and streams by industry is on the rise. Out-of-date technologies and the lack of human responsibility resulted in total degradation of the rivers in the region of Walbrzych. A few places at the bottom of the Pelcznica River were covered with thick sediment of coal dust which was a remnant of coal flotation. The Pelcznica River is reported to be the most polluted tributary of the Strzegomka River due to its long-term negligence.

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The collapse of Walbrzych mines posed another threat linked with possibilities of local undercuts. Creation of complex drainage system which would provide the drainage of inactive mines became necessary. The Friedrich-Wilhelm adit fulfilling a similar role till the middle of the XIX-th century was used. The adit was linked by the system of drifts with all the mines located in Walbrzych region allowing their drainage [3]. Mine waters flew into the Pelcznica River gravitationally without previous purification. An average flow of the Pelcznica River in the region of the mine waters drop was measured at 0.86 $m^3 \cdot sec^{-1}$ while an average flow of mine waters was 0.32 $m^3 \cdot sec^{-1}$ which comprised 59 % of an average flow of Pelcznica River [4]. Such a high contribution of mine waters in the River composition may have resulted in considerable change of physical and chemical properties.

Water Framework Directive 2000/60/WE obliges Poland to protection and improvement of water quality in Poland [5]. It would be advisable to conduct research on the types of contamination which flow into the water to determine possibilities of pollution prevention. The aim of the research was investigation of the mine waters influence on the condition of the Pelcznica River.

Materials and methods

The samples were assembled 3-fold in 2007 at five research sites: 1– the source of the River on the eastern slope of Borowa massif, 2– 50 m above the point of mine waters discharge, 3– the point of the mine waters drop into the Pelcznica River, 4–50 m below the point of mine water drop into the River and 5–50 m above the sewage treatment plant in the Piotrowski street. At each site 3 samples of water were taken. The water was examined in terms of the following physical and chemical parameters such as water reaction (pH-metr 204), electrolytic conductivity PN-EN 27888:1999, hardness (wersenian method PN-ISO 6059), alkalinity PN-90/ C-04540.03, calcium (versenate method PN-ISO 6058), magnesium PN-ISO 6059, copper, zinc, nickel, lead (using atomic absorption spectrometry with atomization in the flame PN-ISO 8288:2002), sulfates (titration method [6]), chlorides (argenometric Mohr method PN-ISO 9297, nitrates(III) using atomic absorption spectrometry method PN-EN 26777, nitrates(V) using atomic absorption spectrometry method PN-82/C-04576.08, ammonia (Nessler's solution method PN-C-04576-4), phosphates PN-EN 1189.

The results were verified statistically (calculation of average values, standard deviations, significance of differences) using Statistica ver. 8.0.

Results and discussion

Chemical substances comprised in mine waters resulted in the alternation of Pelcznica River reaction into more alkaline which confirmed the Pelcznica's tendency towards alkalinity [4, 7–9]. However, such tendency was not always common as Indian and American mines showed acid reaction [10]. An elevation of electrolytic conductivity was observed.

Although it was difficult to compare two different mines due to different location and variety of extracted fossils an elevation of electrolytic conductivity in the Pelcznica River was observed while in both the Indian and the American mines electrolytic conductivity was measured at a higher level [10]. A similar influence was observed in water hardness and alkalinity. It may suggest high concentration of dissolved salts [11] in mine water, especially calcium and magnesium, which was confirmed during the research (Table 1).

An elevation in nickel and zinc concentration was observed after the introduction of mine waters. Before the drop of mine water nickel content in the river was low and similar to the values occurring in the Scinawka River [12]. The mine water drop to the Pelcznica River resulted in a sharp increase in nickel concentration up to 0.105 mg $Ni \cdot dm^{-3}$ which was the highest reported value occurring in mine waters flowing into the Pelcznica in the last years [13]. Such a considerable growth in nickel content may have been caused by a ceramic plant where it is used. Despite the fact that zinc concentration rose 2-fold it was still measured at lower level in comparison with the zinc content in the Klodnica River which plays the same role –0.9 mg $Zn \cdot dm^{-3}$ [12] in a different region.

Copper concentration in the Pelcznica River was higher above the point of the mine water discharge than at the point of discharge. The Pelcznica River contained equalized concentration of cadmium and lead. It suggested a lack of fossil influence on these metals' concentration in the River.

Elevated sulfate content was characteristic for the mine water discharge, however, it was still considerably lower than in Klodnica or Bierawka Rivers where mine sewage was dropped too. It was measured for the Klodnica and the Bierawka at a maximum value of 766.6 mg $SO_4 \cdot dm^{-3}$ and 1009 mg $SO_4 \cdot dm^{-3}$, respectively, with the maximum concentration in the mine water discharge at 154 mg $SO_4 \cdot dm^{-3}$ [12] or even 5000 mg $SO_4 \cdot dm^{-3}$ [7]. In comparison to the previous years when sulfates content was measured at 927.3 $SO_4 \cdot dm^{-3}$ [13] it decreased (in mine waters). Sulphates could dissolve sulphides and created sediments, which are below the point of discharge. The research showed the discharge of mine waters was low in chloride content. In the Klodnica River it ranged from 685 to 2760 mg $Cl^- \cdot dm^{-3}$ while in the Bierawka River – 1265 to 6150 $Cl^- \cdot dm^{-3}$. Fisher [4] and Kowalski [13] reported a considerable growth in sulfates in mine waters. According to Kowalski [13] mine contamination may occur in the environment for ages. It provokes a duty of mine waters purification.

Both waters of the Pelcznica River and the discharge of mine waters was not reported rich in nitrate(III), however, the highest concentration of nitrate (12.0 mg $NO_3^- \cdot dm^{-3}$) was measured in mine water discharge. Although mine waters may be the reason for elevation of nitrate concentration other discharges show greater content of nitrates. The growth of nitrates concentration below the point of mine waters discharge may have been caused by a decrease in the ammonia content which transforms to nitrates during the nitrification process occuring in that point.

Before the introduction of mine waters into the Pelcznica River, phosphates concentration was quite high and mine waters discharge resulted in phosphate content decrease.

Table 1

Physical and chemical properties of the Pelcznica River at 5 surveyed sites

Water parameters	Uunit	Site no.									
		1		2		3		4		5	
		$\bar{x} \pm s$	range	$\bar{x} \pm s$	range	$\bar{x} \pm s$	range	$\bar{x} \pm s$	range	$\bar{x} \pm s$	range
Electrolytic conductivity	$\mu S \cdot cm^{-1}$	220 ± 69	154–292	1142 ± 250	854–1300	3597 ± 455	3290–4120	3287 ± 326	2950–3600	3140 ± 352	220 ± 69
Reaction	pH	7.2 ± 0.6	6.6–7.9	7.5 ± 0.4	7.1–7.9	7.4 ± 0.6	6.9–8.0	7.4 ± 0.5	6.9–8.0	7.4 ± 0.5	7.2 ± 0.6
Hardness	mg $CaCO_3 \cdot dm^{-3}$	85 ± 72	25–165	386 ± 275	127–675	1028 ± 109	904–1109	969 ± 56	931–1033	892 ± 56	85 ± 72
Alkalinity	mg $CaCO_3 \cdot dm^{-3}$	28 ± 0.0	28–28	112 ± 28	84–140	289 ± 56	280–392	289 ± 16	280–308	298 ± 16	28 ± 0.0
Calcium	mg $Ca \cdot dm^{-3}$	17 ± 10	6–24	78 ± 32	41–100	180 ± 55	144–243	91 ± 47	51–143	95 ± 59	17 ± 10
Magnesium	mg $Mg \cdot dm^{-3}$	10.3 ± 13.3	2.5–25.7	47.2 ± 54.9	6.1–109.5	140 ± 59.7	72.1–182.0	179.9 ± 32.7	142.4–202.3	159.1 ± 48.9	10.3 ± 13.3
Ammonnia	mg $NH_4^- \cdot dm^{-3}$	0.3 ± 0.2	0.2–0.6	7.1 ± 0.8	6.6–8.8	2.9 ± 0.3	2.8–3.6	2.7 ± 0.2	2.5–3.3	3.2 ± 0.3	0.3 ± 0.2
Nitrates	mg $NO_3^- \cdot dm^{-3}$	6.2 ± 0.6	5.5–6.7	8.0 ± 0.5	7.6–8.5	11.5 ± 0.5	11.0–12.0	9.5 ± 0.6	8.9–10.0	9.3 ± 0.7	6.2 ± 0.6
Nitrites	mg $NO_2^- \cdot dm^{-3} \cdot 10^{-3}$	3.0 ± 0.1	3.0–3.1	4.9 ± 0.3	4.6–5.2	6.1 ± 0.2	5.9–6.3	16.8 ± 1.9	14.6–18.1	31.7 ± 20.2	3.0 ± 0.1
Copper	mg $Cu \cdot dm^{-3} \cdot 10^{-3}$	22 ± 31	0–43.5	44 ± 36.5	18–70	5 ± 0.5	4.5–5.5	10 ± 2	9–11.5	11 ± 2.5	22 ± 31
Lead	mg $Pb^- \cdot dm^{-3} \cdot 10^{-3}$	3.9 ± 5.4	0.05–7.8	6.1 ± 2	4.2–7.9	6.1 ± 0.1	6.1–6.2	6.93 ± 0.01	6.8–6.9	4.0 ± 1.8	3.9 ± 5.4
Nickel	mg $Ni^- \cdot dm^{-3} \cdot 10^{-3}$	3.9 ± 5.4	0.05–7.8	0.75 ± 0.9	0.23–1.25	71.8 ± 40.5	38.2–105.8	78.2 ± 20.4	63.6–91.0	73.6 ± 22.7	3.9 ± 5.4
Cadmium	mg $Cd^- \cdot dm^{-3} \cdot 10^{-3}$	2.5 ± 3.5	0.0–4.9	3.6 ± 0.1	3.7–3.8	3.6 ± 0.1	3.9–3.6	4.1 ± 0.2	3.9–4.2	3.5 ± 1.2	2.5 ± 3.5
Zinc	mg $Zn^- \cdot dm^{-3} \cdot 10^{-3}$	29.3 ± 40.4	0.7–57.9	28.2 ± 37.6	1.6–54.8	50.8 ± 47.6	17.1–84.5	47.3 ± 41.4	18.0–76.5	50.5 ± 49.3	29.3 ± 40.4
Chlorides	mg $Cl^- \cdot dm^{-3}$	19.6 ± 0.4	16.0–23.0	33.7 ± 0.3	32.0–37.0	45.0 ± 0.3	42.0–47.0	43.7 ± 0.2	41.0–45.0	42.7 ± 0.2	19.6 ± 0.4
Phosphates	mg $PO_4^{-3} \cdot dm^{-3} \cdot 10^{-3}$	26.7 ± 20.8	10.0–50.0	693.4 ± 475	150–1030	60.0 ± 20	40–80	143.3 ± 160.9	0–300	450 ± 160.9	26.7 ± 20.8
Sulfates	mg $SO_4^{-3} \cdot dm^{-3}$	72.6 ± 21.4	54–96	74.6 ± 26.6	52–104	482 ± 167.6	308–642	422 ± 134.9	290–560	387 ± 87.2	72.6 ± 21.4

Conclusions

Mine waters chemical compound depend on types of mine minerals. That was the cause of huge differences among chemical compounds of mine waters [8–10, 14, 15]. The analysis of the obtained results revealed that mine waters have considerable influence only on some physical and chemical parameters especially connected with salinity of the Pelcznica waters such as elevation of the electrolytic conductivity, alkalinity, hardness, nickel, chlorides, sulfates and calcium content. The examinated mine waters do not cause higher cadmium, copper, lead, ammonia or phosphate contamination as the research showed a decrease in their content below the point of the mine water discharge. Constant monitoring of such waters should be advised.

References

[1] Lonc E. and Kartowicz E.: Ekologia i ochrona środowiska. Wyd. Państ. Wyż. Szkoły Zawod. w Wałbrzychu, Wałbrzych 2005.
[2] Wójcik J.: *Wpływ przemysłu na jakość wód powierzchniowych Wałbrzycha*. Prace Inst. Geograf., Wrocław 1998.
[3] Fiszer J.: Koncepcja odprowadzenia wód sztolnią Friedrich-Wilhelm do rzeki Pełcznica. Maszynopis, Wrocław 1997.
[4] Fiszer J.: Ocena oddziaływań na środowisko likwidacji wałbrzyskich kopalń węgla kamiennego. Maszynopis, Wrocław 1998.
[5] Ramowa Dyrektywa Wodna 2000/60/EC z dnia 23 października 2000.
[6] Pokojska U.: Przewodnik metodyczny do analizy wód. Wyd. Uniw. M. Kopernika w Toruniu, Toruń 1999.
[7] Meinck F., Stoft N. and Korishütter N.: Ścieki przemysłowe. Arkady, Warszawa 1997.
[8] Lee C.H., Lee H.K. and Lee J.C.: Environ. Geol. 2001, **40**(4–5), 482–494.
[9] Tiwary R.K.: Water, Air, Soil Pollut. 2000, **132**, 185–199.
[10] Gammons Ch.H.: Mine Water Environ. 2006, **25**, 114–123.
[11] Podgórski W., Żychiewicz A. and Gruszka R.: Badanie jakości wody i ścieków. Wyd. Akad. Ekonom. im. Oskara Lanego we Wrocławiu, Wrocław 2006.
[12] Raport o stanie środowiska w województwie dolnośląskim w 2006 roku. Bibliot. Monit. Środow. Wojewódzki Inspektorat Ochrony Środowiska we Wrocławiu, Wrocław 2007.
[13] Kowalski A.: Eksploatacja górnicza a ochrona powierzchni: doświadczenia z wałbrzyskich kopalni. Główny Instytut Górnictwa, Katowice 2000.
[14] Geldenhuis S. and Bell F.G.: Environ. Geol. 1998, **40**, 482–494.
[15] Jiries A., El-Hasan T., Al-Hweiti M. and Seiler K.-P.: Mine Water Environ. 2004, **23**, 133–137.

WPŁYW WÓD KOPALNIANYCH NA JAKOŚĆ WÓD RZEKI PEŁCZNICY

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Abstrakt: Rzeka Pełcznica stanowi prawobrzeżny dopływ Strzegomki. Z nieczynnej kopalni położonej nieopodal tej rzeki wypływają wody kopalniane. W roku 2007 zdecydowano się na przebadanie wody pobranej na pięciu stanowiskach badawczych: 1 – źródło rzeki na zachodnim stoku masywu Borowej ok. 625 m n.p.m, 2 – 50 m przed zrzutem wód kopalnianych, 3 – miejsce zrzutu wód kopalnianych, 4 – 50 m poniżej zrzutu wód kopalnianych oraz 5 – 200 m poniżej zrzutu wód kopalnianych, 50 m przed oczyszczalnią ścieków. Analiza uzyskanych wyników wykazała, iż wody kopalniane mają istotny wpływ tylko na niektóre parametry wód rzeki Pełcznica, związane z zasoleniem wody: konduktywność (przewodnictwo elektrolityczne), chlorki, azotany, siarczany, zasadowość, twardość, wapń, a także nikiel.

Słowa kluczowe: rzeka Pełcznica, kopalnia, jakość wody