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Identification of hazards for water environment in the Upper Silesian Coal Basin caused by the discharge of salt mine water containing particularly harmful substances and radionuclides

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ABSTRACT

The Upper Silesian urban-industrial agglomeration is one of the most industrialized areas in Europe. The intense industrialization should be attributed mostly to the presence of coal and other minerals deposits and its extraction. Mining areas of hard coal mines comprise approximately 25% of the total catchment area of watercourses in the area of Upper Silesian Coal Basin, including the river basin of the Upper Oder River and the Little Vistula River. The mining, its scope and depth, duration of mining works, extraction systems being used and the total volume of the drainage fundamentally affect the conditions of groundwater and surface water in the studied area. In this paper, an overall characteristics of the coal mining industry in the area of USCB was made, including the issues of its influence on water environment in the light of the requirements of the Water Framework Directive (WFD) and its guidelines transposed into Polish law. An analysis of the collected data, obtained from collieries, relating to the quantity and quality of water flowing into the workings and discharged to surface watercourses, was performed. An approach to the requirements for wastewater discharge into the environment by these enterprises was presented regarding the physicochemical parameters, possible harmful substances and radionuclides measured in mine waters. The main goal of the paper is to recognize the condition of surface water bodies in the area of Upper Silesian Coal Basin and to make the assessment of the biological condition using Ecological Risk Assessment and bioindication methods.

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1. Introduction

Upper Silesian Coal Basin (USCB) with an area of 7500 km^2, including 5500 km^2 within Poland, is one of the largest mining areas in Europe in terms of mineral resources, especially hard coal (Różkowski, 2004). The development of mining in the Upper Silesian Coal Basin on an industrial scale was visible at the turn of 18th and 19th century. The oldest coal mines were "Murcki" (at present hard coal mine "Murcki-Staszic" and the "Boże Dary" mining zone), where the start of mining was estimated even at 1657, "Wawel" Colliery from 1752 (part of hard coal mine "Pokój"), "Reden" from 1785 (part of the former hard coal mine "Paryż") and the former hard coal mine "Siemianowice" from 1786. Mining areas of hard coal mines are grouped essentially in two main districts: the Upper Silesian and Rybnik District. Initially, the exploitation of coal seams was carried out exclusively at the outcrop areas with open-pit and underground system in the north-eastern part of the basin, above the water table of underground water. Then, after their exploitation and with the advances in mining technology, parts of deeper coal seams were started to be exploited in the area of watered rock mass (Różkowski, 2004). The most intensive exploitation of the USCB has been performed in the 70s–90s of 20th century, when coal production reached about 140 million tons per year (http://stat.gov.pl/statystyka-miedzynarodowa/porownania-miedzynarodowe/tablice-o-krajach-wedlug-tematow/przemysl-i-budownictwo/) access on 09/10/2014). In 1993, the restructuring of the mining industry in Poland and adaptation of this branch of industry to market economy conditions, was started. It was connected with the processes of the merging or liquidation of mines and ownership changes, which was caused by the economic results, i.e. the so-called unprofitability of mines or running out of mineral resources. Currently, the annual productivity in the Upper Silesian Coal Basin is at around 76.5 million tonnes per year (http://stat.gov.pl/statystyka-miedzynarodowa/porownania-miedzynarodowe/tablice-o-krajach-wedlug-tematow/przemysl-i-budownictwo/, access on 09/10/2014). The process of liquidation and reduction of coal mining is important in relation to the pressure on water environment since it turned out that drainage of the abandoned mine workings is still necessary for the security of neighbouring deposits in the mines still performing the exploitation of coal.

In recent years, there is a visible phenomenon of returning to coal extraction in some mining areas and formerly abandoned mines, moreover new licenses are issued for prospecting and exploration of coal deposits in the USCB. According to the Ministry of Environment (List of licences for searching, exploration and mining of hard coal deposits in Poland www.mos.gov.pl, access on 01.12.2014), the number of issued licenses for searching and exploration of coal deposits in the USCB as of 1st December 2014 is 34, while the number of currently existing licenses for coal extraction is 63. This information is not irrelevant in terms of the influence of mining on the water environment in the Upper Silesian Coal Basin, particularly with regard to time horizons specified in the Polish regulations and the Water Framework Directive (Directive 2000/60/EC), i.e. the planning periods of water management in 2015, 2021 and 2027. The continuation of coal mining, the resumption of exploitation in the abandoned mines, or a construction of new collieries are connected with inevitable drainage of underground aquifers and the discharge of mine water to surface watercourses. The pressure on the water environment will not stop even in the case of liquidation of mines due to the necessity of their drainage to protect neighbouring workings of active collieries against the water hazard. The authors of this paper, however, are far from creating scenarios for the development or reduction of coal mining in the region, because from the point of view of the pressure on the water environment, these two processes are of equal importance.

Fig. 1 shows the mining areas of active and liquidated coal mines (according to the data obtained from the last license) in the Upper Silesian Coal Basin.

In the Upper Silesian Coal Basin, in line with the proposed division, 16 mines (or mining zones) do not carry out the dewatering, and 49 (active and abandoned but still being drained) discharges mine water to the environment, i.e. bodies of surface water which are therefore subject to the pressures on the ecological and physiochemical condition and change of hydrological regime. The purpose of the study presented in this paper is to prepare basement monitoring data about mine water (chemistry parameters and concentrations of radionuclides) in relation to preliminary assessment of the biological condition of water bodies using Ecological Risk Assessment and bioindication methods.

2. Research methods

Changes in physicochemical parameters and chemical characteristics of mine water because of its origin (Kleczkowski & Wilk, 1964; Pluta, 2002), the first classification of mine water for its suitability for development (Bromek & Żmij, 1992) and the total content of chloride and sulphate ions due to the possibility of their utilization (Budaszewski, 1964; Magdziorz, 1993; Marchacz, Malinowski, Orczyk, & Sieradzki, 1966; Pluta, 2004; Rogoż, 1997), have already been started in the 60s of the last century and reported in the scientific literature of Polish researchers. The dependence of physiochemical parameters on the depth from which water is pumped (Cowart, 1981; Dickson, 1985; Moise, Starinsky, Katz, & Kolodny, 2000; Wiegand & Feige, 2002; Różkowski, 2006), changes in water chemistry due to flooding of inactive workings (Gzyl, Banks, 2007; Pluta, 2004), the age of mine waters from different geological formations (Pluta, 2007) were examined by numerous authors. The results of their investigations have been published in the period from the post-war years, showing the development of hydrogeological and hydro-geochemical (Różkowski, 2004; Różkowski, Pacholewski, & Witkowski, 2005) studies in the Upper Silesia. Increase in the intensity of hard coal mining and its impact on the environment was reflected also in the scientific research related to the regional issues as determination of resources and water quality (Adamczyk, 1999), the interpretation of threat and protection of utility water (Adamczyk & Haładus, 1994) and the impact of salty water on these