

Using of Mine Tailings in Treatment of Mine Waters in the Upper Silesian Coal Basin (Poland)

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Abstract

Natural mine waters in the Upper Silesian Coal Basin (Poland) frequently have high salinity and contain the barium and radium isotopes. Waters with these substances discharged from coal mines cause contamination of surface waters: streams, rivers and their sediments. Therefore, purification of mine waters from hazardous substances is a necessity. This paper shows the use of mine wastes- mine tailings in mining technologies and methods applied in coal mines and deriving from coal mines for reduction of barium and radium isotopes. This is an example of the most favourable reduction of pollution "at the source" of its arising, in mine workings and connection between ecological and mining interests.

Key words: Mine waters, mining technologies, barium, radium isotopes

Introduction

In the Carboniferous formations of the Upper Silesian Coal Basin (USCB) natural mine waters occur with different chemical composition from fresh water to brines. Some of them contain high concentration of barium and radium isotopes which are hazardous in the water environment. Often frequently their amounts are among the highest levels appearing in underground waters in the world (Pluta, Pałys 1999). Concentration of barium in waters flowing into mine workings exceed even more than one thousand times the threshold values, determined for mine waters pumping from mines in Poland (Pluta, Pałys, 1999; Pluta 2005; Order of the Minister of Environment 2006). Ba content in mine waters causes technical problems ("overgrowth" in pumps, pipe, pipelines) of water transport systems. Waters discharged from coal mines in the USCB cause contamination of surface waters: streams, rivers and their sediments (Czaja, Jankowski 1992; Bojakowska, Sokołowska 1998; Lebecka et al. 1996; Pluta 2001a,b, 2005). Therefore, purification of mine waters from these substances is a necessity.

This paper explains the processes that reduce levels of barium and radium isotopes. Particular attention is drawn to the use of mining technologies and methods applied in coal mines of the USCB.

Proposed treatment of mine waters with barium and radium in coal mines of the USCB

The simplest and simultaneously the most effective method of removal of barium and radium from waters is their precipitation in the form of practically insoluble deposits, mainly sulphates. Thus the factors purifying the natural mine waters are first of all sulphates. Their source in mines can constitute different sulphur compounds contained in the Upper Carboniferous strata or in covering deposits, as well as substances used in mining operations. Sulphates get into mine waters as the result of dissolving, leaching and oxidation,

It is preferred to carry out the treatment of mine waters "at source" (reduction "at source"). The substance causing mine water contamination should be reduced or removed in the mine workings. The treatment of mine waters on the surface, for instance in reservoirs, settling ponds is possible, but the process requires special control, waste disposal or costly management. For these reasons the purification of mine waters in reservoirs or settling ponds is not recommended (Pluta 2005).

The use of special chemical or biological methods treatment mine waters in mine workings, where space is limited and there are only small possibilities for transportation, is difficult, and first of all expensive. In connection with the above, most adequate is the use of processes which support the self-purification of mine waters, i.e. physical, chemical or biological processes, taking place during their flow in mine workings. The best method is the initiation of these processes in places where natural mine waters get into mine workings, resulting in the removal of harmful substances *in situ* in the water-bearing layer or limitation of their amount during flow through a "protective barrier", "purifying

barrier". Attention was drawn to the possibility of purifying mine waters by means of the mining methods and technologies applied in coal extraction (Pluta et al. 1997).

Possibilities of using mining technologies in treatment of mine waters

The coal extraction is connected with the necessity to obey rigours in mine safety. The mining is characterised by a relatively high diversity and therefore mining technologies are used mainly to combat such risks as rockburst, water, fire and gas hazards. The assurance of safe work in coal mines requires suitable fire prevention, ventilation conditions making impossible the exceeding of the permissible methane concentration, reduction of the impact of mining operations on the surface as well as execution of works resulting in methane and mine waters drainage. Therefore it is necessary to carry out many operations, among them: filling of underground cavities caused by the extraction, installation of roadside packs, construction of water and gas-stopping dams. In these works different substances are used. Some of them contain components, which can cause precipitation, oxidation or sorption of some substances contained in natural mine waters, among them barium and radium.

In mining technologies, among others in hydraulic filling, solidified filling, sealing of old mine workings etc., process waters are used. These waters contain different components. In most of them, components may be present which can cause favourable changes after their mixing with natural mine waters, consisting in the decrease of the amounts (contents) of pollutants.

Mining technologies in treatment of mine waters with barium and radium isotopes

From the 80's of the past century, the fine-grained industrial wastes have been utilized in coal mines. They have been used in different mining technologies, among others for self-consolidating filling, for sealing of longwalls and roadways, for forming plugs and dams as well as roadside packs. The post-extraction cavities, gobs and old mine workings are filled with mining wastes. They contain Carboniferous barren rocks, separated from the extracted coal in the coal cleaning preparation. In these processes the fine-grained wastes originate from flotation and washing processes, as well as sediments from drainage roads. In these wastes sulphates occur. They derive from oxidation processes of sulphur minerals contained in the Upper Carboniferous deposits. From these wastes sulphates get into mine waters in mine workings.

Sulphates contained in waters leaching from the places of mining wastes – flotation tailings used in different technologies cause barium and radium precipitation from natural mine waters flowing into mine workings. This favourable effect was observed during the storage of mine tailings with fly ashes in the majority of coal mines. Such a situation takes place in coal mines of the south-western part of the USCB where the natural mine waters contain barium and radium isotopes (Pluta 2001b). In the Borynia Coal Mine the technologies of emplacing fly ash have been especially optimised in order that maximum quantities of sulphates should be released into natural mine waters (Pluta, Piotrowski 2002).

Table 1 Concentrations of sulphates and quantities of mine tailings are using in two coal mines of the south-western part USCB

Name of coal mine	Year	Mean concentration of sulphates in mine water soluble from mine tailings mg/kg	Quantities of mine tailings storage in mine workings Mg/year	Mean yearly load of sulphates from mine tailings kg/year
Krupiński CM	1991-1999	300	40766-117710 (average 74800)	22440
Borynia CM	1999	500	43200	21600

Conclusions

Natural mine waters containing substances hazardous to the water environment flow into mine workings of the Upper Silesian Coal Basin and the rivers of the Upper Silesia in Poland. Among them barium and radium isotopes constitute the most essential components, because their concentrations in mine waters exceed the maximum permissible values in polish Water Law (Order of Minister of Environment 2006). Therefore, their contents should be reduced.

Special treatment methods are not necessary for removing or decreasing of barium and radium levels. The mining methods and technologies applied in mines can be used. They are an example of the most favourable reduction of pollution "at the source" of its arising, in mine workings, and they do not need any capital outlays.

The use of mining methods and technologies and application of wastes from coal mines- flotation tailings in the purification of mine waters enabled a unique solution on the world scale. This is an example of connection between ecological and mining interests.

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