# Mine Waters and Their Usage in the Upper Silesia in Poland. Examples from Selected Regions

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**Abstract**
In the Upper Silesia 162.8 million $m^3$ of mine waters are pumped from the operating and abandoned coal mines, but only 32.4 % of these waters is used. Mine waters are used as a source of drinking water, for sanitations, technological processes and in the hydraulic transport and the deposition of fumitory dusts in the abandoned mine workings. Mine waters should not be considered as a significant source of drinking or technological waters as their quality and quantity are not stable and even predictable in such a big and complicated coal basins as the Upper Silesia. Mine waters may be regarded as an alternative source of water in the extreme circumstances.

**Key words:** mine waters**,** groundwater, water supply, Carboniferous aquifer, Poland

## Introduction

The Upper Silesian Coal Basin is located in the southern Poland and in the region of Ostrava-Karvina in the Czech Republic (Fig. 1). It covers an area of 7,250 $km^2$. This is the major coal basin in Poland, and also one of the largest in Europe. Mining activities of Carboniferous hard coal deposits have been conducted here for over 200 years. As a result, the region has become highly urbanized and industrialized which caused a big needs for drinking and industrial waters. The Upper Silesia is a big metropolitan area which consists of 37 towns with the population reaching 3 mln.

The Upper Carboniferous coal-bearing formations are the most significant in the geological structure of the Upper Silesian Coal Basin. There are Precambrian, Cambrian, Devonian and Carboniferous formations occurring in their basement. The Carboniferous overburden includes Quaternary, Miocene and Triassic rocks, and, in the southernmost part also, rocks of the Carpathian overthrust; Permian and Jurassic deposits occur to a lesser extent.

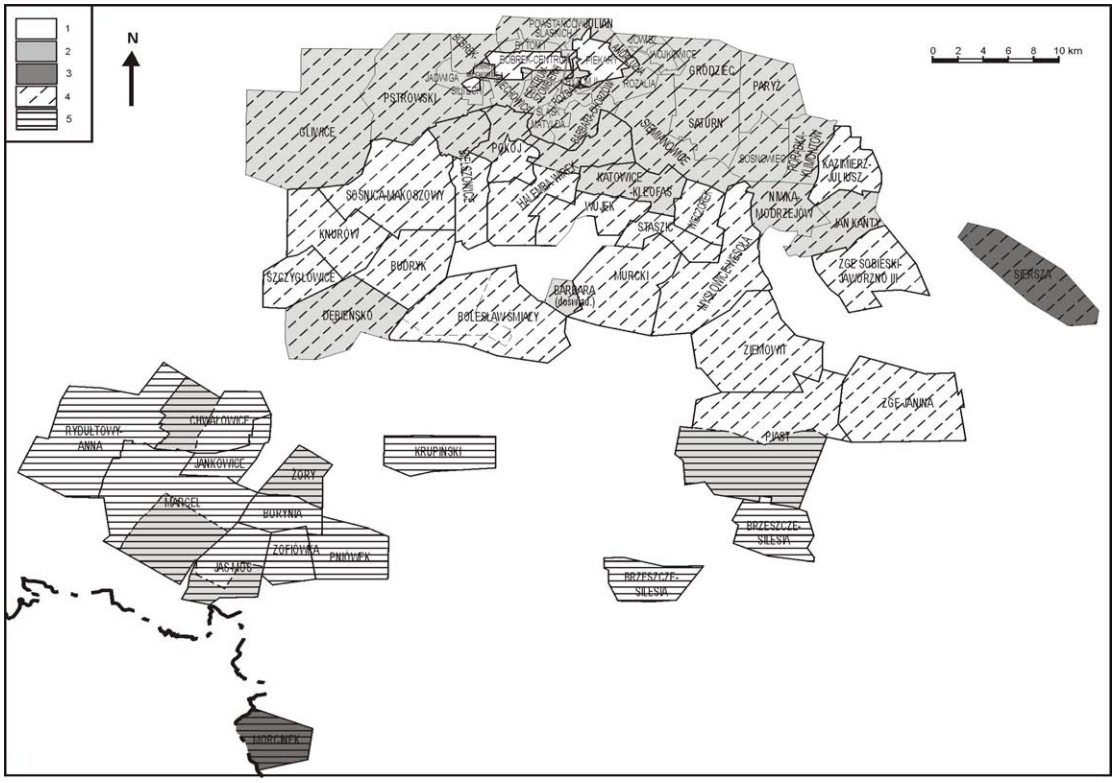
The coal-bearing formations of the USCB include several lithostratigraphic series, reaching 8,500 m of thickness. These series are featured by a gradual reduction of their thickness toward the east and southeast. The Carboniferous aquifer is recharged on the outcrops of the Carboniferous sediments. The drainage takes place by the coal mines. In the profile of the carboniferous, four separate aquifers are identified with the lithostratigraphic series. Two of them are built of rocks with higher permeability and conductivity (fractured sandstones), separated by series of low permeability (mudstones and siltstones) (Rozkowski, 2004).

According to the geological structure and recharge conditions of the Carboniferous aquifer, two hydrogeological sub-regions are distinguished in the Upper Silesia: “exposed” (northeastern) and “covered” (southwestern). In the southwestern sub-region, carboniferous aquifer is covered by thick, impermeable Neogene clays formation, and groundwaters are of high TDS (saline or brines) with an insignificant resources. In the “exposed” sub-region, water resources of the Carboniferous aquifer are much higher with small TDS values (below 3g/L) making waters more suitable for the drinking and industrial purposes.

There are 30 operating and 32 abandoned coal mines, among them 2 are flooded and 30 partially flooded in order to protect the adjacent operating mines. Due to a great number of coal seams in the sequence, the mine operations are carried out simultaneously at several levels, the depth of mine workings varies from 270 to 1160 m.

The mining is accompanied by inflows of large amount of groundwaters (Table 1). One of the most important problems connected with the hard coal mining is the utilisation of mine waters including saline waters and brines.

***Figure 1*** *Coal Mines in the Upper Silesian Coal Basin (after Jureczka et. al, 2008)*




Explanations: 1 - Operating coal mines 2 - Abandoned, pumping mine waters coal mines, 3 - Abandoned, flooded coal mines, 4 - "Exposed" hydrogeological sub-region, 5 - "Covered" hydrogeological sub-region

***Table 1*** *Mine waters pumped from the coal mines in the US in 2006 (Przenioslo, Malon, 2006)*

| Pumping of mine waters | | Usage of mine waters [$m^3$/h] | |
|---|---|---|---|
| Type of waters and TDS | Total [$m^3$/h] | Discharges to the rivers | Mine waters used |
| Fresh waters < 1 g/L and Industrial waters 1 – 3 g/L | 9 203 | 5 650 | 3 553 |
| Saline waters 3- 70 g/L | 7 972 | 5 621 | 2 351 |
| Brines > 70 g/L | 1 413 | 1 303 | 110 |
| **Total** | **18 588** | **12 574** | **6 014** |

The table 1 is based on a simplified classification of mine waters used in Polish coal mining (Rogoz, Posyłek, 2000).
In 2006 year 162.8 million $m^3$ of mine waters were pumped from the coal mines in the Upper Silesia. The amount of waste waters requiring treatment discharged to rivers by coal mining in the Silesia was 82.2 million $m^3$. Pumped mine waters with a TDS below 3 g/L (49.5 %) may be used for the drinking and industrial needs, but now only 38.6 % of these waters is used. Saline waters and brines are discharged to rivers of the Vistula and the Odra river basins (Razowska-Jaworek, 2005) causing the increase of salinity of the Vistula and the Odra river waters above accepted ecological standards.

**The quality of mine waters in the Upper Silesia**
Coal-mines, from the beginning of the mining activities, have been the main centres of the drainage of groundwaters in the Upper Silesia. Groundwaters inflow to the coal mine workings in the Upper Silesia on the different depths reaching maximum 1160 m. The quantity and quality of waters depend on the depth to the mine workings and the area of mine excavations. The quality of pumped mine waters is different from the quality of natural waters inflowing to the mine workings (with TDS

ranging from 0.3 to 372 g/L). This difference is a result of the mixing of the natural waters (inflowing on the different levels) and the technological waters which are determined by the water circulation scheme in the mine. Each mine has its own water management system.

Fresh waters (TDS<1g/L) are used as a source of drinking water (purified from iron, manganese and disinfected), for sanitations and clean technologies such as chilling, the circulation in central heating, air-conditioning, fire-fighting pipelines. These are waters pumped from the shallow levels (to 300-400 m) of the mines, but their quality changes due to penetration of mine workings especially flooded old workings as well as due to mixing with old waters from deep levels and technological waters. In order to obtain good quality waters from the mines pump stations should be located close to inflows and waters should be pumped separately from each level.

Industrial waters are used only for the technological processes: the hydraulic gob, the mechanical reshaping, the supply of fire-fighting pipelines and to switch off the burning heaps on the surface (Rogoz, 2000). These waters originate from the natural inflow to the shallow levels (to 500 m) and are usually pumped to the surface separately.

Saline waters and brines come from the natural inflow to deep levels of mines. These waters are used in the hydraulic transport and the deposition of fumitory dusts in the abandoned mine workings.

Resources of usable waters from the coal mines, may be used as an alternative source of drinking waters in the situation of the extreme circumstances (eg. contamination of the water supplies by terrorism or chemical weapon or damage of water supplies). However, considering the instability of their quantity and quality these waters may be regarded as the alternative only in a case of the inability of using of waters from the other sources. In the extraordinary situations, waters with TDS 2-3 g/L can be used for industrial needs and as a source of drinking water after the treatment.

Mine waters from abandoned and flooded mine workings could be a source of drinking waters only if the water chemistry is stable. The treatment station should always be accessible in case of the deterioration of the quality of these waters.

## The examples of usage of mine waters in Silesia

### *The eastern part of Silesia*

WUJEK Coal Mine

This is an operating mine, with the coal resources estimated to 2038 year. Hydrogeological conditions are good. Mine waters inflow to the mine from the Quaternary and Carboniferous aquifers. Pumping stations are located on the level 80 and level 370 m. Mine waters are used for technological needs in the mine as well as drinking water for workers in the mine, after the treatment using inverse osmosis method (1500 $m^3$/d). The mine is listed as an alternative source of drinking water for Katowice city.

WESOLA Coal Mine

This is an operating mine, with the coal resources estimated to 2064 year. To the all open space in the mine waters inflow from the Carboniferous and Triassic aquifers. Pumping stations are located on the levels 230 and 465 m. Mine waters are used for technological needs in the mine as well as drinking water for workers in the mine after the treatment. The analysis of these waters showed that mine waters inflowing to this levels could be utilised. Present technical conditions in the mine allow for the usage of waters for the technological and sanitation purposes. The water treatment station with the efficiency for obtaining of 10 000 $m^3$/d of drinking water is located in the mine, treating only 3 000 $m^3$/d of water only for the mine needs. The remaining quantity of water is discharged, but it could also be treated and sold by the mine.

The management (pumping and usage) of mine waters stored and flowing from the **abandoned coal mines** is performed by Central Station of Mine Drainage located near Katowice. In 2007 year 83.7 million $m^3$ of mine water were pumped from the abandoned coal mines, but only 4.7 million $m^3$ (5%) were used for drinking and technological needs. The remaining water was discharged to the rivers. In the shaft of the abandoned "Saturn" mine 1,45 million $m^3$ water is pumped from the level 50 m. This water, after treatment, is sent to the water works providing drinking waters for Czeladz town.

### *The southern part of Silesia*

In the majority of coal mines in this part of the Upper Silesia mine waters are utilised. Due to the quality (high TDS and salinity) majority of these waters is used only for the technological mining processes (tab. 2). In most of the coal mines changes of the chemical composition are observed.

***Table 2*** *Chemical composition of mine water used in mining technologies in coal mines in the southern part of the Upper Silesia*

| Sampling point | Year of sampling | pH | TDS | $Cl^-$ mg/L | $SO_4^{2-}$ mg/L | $Fe_{total}$ mg/L | $NH_4^+$ mg/L |
|---|---|---|---|---|---|---|---|
| Shaft depth 32..4 m | 2000 | 4.9 | 3814 | 2430 | 34 | 154 | 13.8 |
| Shaft depth 32..4 m | 2007 | 4.7 | 4050 | 2546 | 2.9 | 270 | 24.1 |

**Conclusions**

Mine waters pumped from the coal mines in the Upper Silesia are of variable quality, from extreme brines to fresh waters. This variability depends not only on the depth of mining but also on the location of mine within the Upper Silesia Basin. Hence only 32.4 % of these waters are used, mostly for the technological processes or for the coal mine needs, always after the treatment.

Mine waters should not be a significant source of drinking or technological waters in the Upper Silesia as their quality and quantity are not stable and even predictable in such a big and complicated coal basins. But mine waters may be regarded as an alternative source of water in the extreme circumstances.

If the chemical composition of mine waters meets the requirements for drinking water they may be used as a source of drinking waters (Statute Journal No. 61 item 417 of 2007) or for bottled drinking or mineral waters of natural origin (Statute Journal No. 120 item 1256 of 2004). It is also possible to use the mine waters from the Upper Silesia as medical waters or in agriculture if they meet the criteria determined for such waters.

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