MINE WATER AND THE ENVIRONMENT, VOL. 13, JUNE-DECEMBER ISSUE, 1994 , PP 49 - 58

GROUNDWATER QUALITY AFFECTED BY MINING IN THE EAST BORSOD BROWN COAL BASIN, HUNGARY

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SUMMARY

In almost all Hungarian coal basins, mining can be carried out only with active underground water protection. Intensive dewatering lowers the hydrostatic pressure of aquifers, reduces their water resources, unbalances water management of the given area. Recently, as more and more underground coal-mines are being closed, the attention is directed toward the environmental problems of the abandoned mines. In this paper the original and secondary effects on groundwater quality by mining in the East-Borsod Coal Basin are discussed.

INTRODUCTION

The East-Borsod Brown-Coal Basin is situated in the East-Northern part of Hungary (Figure 1).

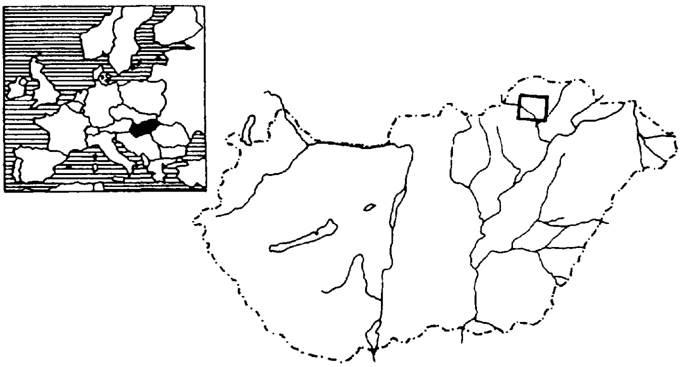


Figure 1 Location Map of East Borsod Brown Coal Basin

The heavy industry of the region was based on and developed together with brown-coal mining. During the last few years the Hungarian underground mining proved to be unprofitable, as a consequence many mines closed and the public attention has been focused towards the environmental problems of closed mines. In the basin Miocene, Ottnangian brown-coal beds are mined with active prevention against groundwater. Water resources of the sandy aquifers developed in the coal bearing strata were reduced by about a constant 3.6 m^3/min. flowrate in the intensive period of mining, caused a depression of 10 meters order of magnitude. As in Hungary 90 % of drinking water comes from groundwater, the groundwater of this region is also regarded potential drinking water resource, protection of its quality and quantity has primary importance. This importance is increased by the fact that in the NE part of the basin mineral water is mined and bottled coming from one of the aquifers.

GEOLOGICAL, HYDROGEOLOGICAL CONDITIONS

The examined East-Borsod Basin - about a 28 x 20 km^2 territory - is a Kainozoic basin with a maximum depth of 1500 m. Basement of the basin is formed by the Paleozoic and *Mesozoic* formations of the surrounding mountains. These rocks moved down into the crust and were broken into blocks by the tectonic movements at the end of Mesozoic and in the beginning of Tertiary. Simultaneously with their subsidence in Oligocene undisturbed sedimentation was going on in the basin (although lately Oligocene formations have been considered to be Early Miocene - Eggenburgien).

In the Alpian orogenic phase at the border of Oligocene and Miocene the basement of the basin had elevated and created a rough surface onto which the formations of the so called *lower rhyolitic tufff* were settled down in the *Savian phase*. A shallow sea was developed with lagoons and islands having only a limited connection toward the ocean, began to change to brackish, then fresh. Shallow water and rich vegetation covered the area, so the possibilities for coal formation were developed. In the East Borsod basin *five coal beds* were formed with accompanying thin coal-lines. The coal beds - 0.5-2.5 m thick, having 10-14 thousand kJ heatvalue - have already been worked out or are even today being exploiting. Clayey - silty - sandy or redeposited tuff layers can be found between them.

During other orogenic phases of Miocene the basin was broken into blocks, the independent blocks began to move down or to elevate. Depending on the movement of a given block in a certain area the formations of later Miocene can be or cannot be found (Carpathian, Badenian, Sarmatian). After the elevation an intensive denudation has begun somewhere even the upper layers of coal formation had been eroded (e.g. Sajo Valley, see Figure 2.). In Pannonian - except some small areas - the region was the part of the continent. In Quartier river terraces and soil were deposited.

Hydrogeological research of the territory was executed only where it was necessary for preventive dewatering. Thus hydrogeological information are distributed heterogeniously.

The coal bearing strata of the basin are constituted from aquifer and aquitard formations. The aquifers are mainly *well sorted fine sands with small uniformity coefficient* (u = 2 - 6) that means they are susceptible to move with water. Beside this average property grain size distribution of the aquifers is extremely variable both in horizontal and in vertical direction.

In a deeper position at the southern, south-eastern part of the basin the rate of finer grains and clay increases.

According to grain size distribution hydraulic conductivity of aquifers is between 5×10^{-5} - to 5×10^{-7} m/s, the typical values are 2×10^{-5} -5×10^{-6} m/s.

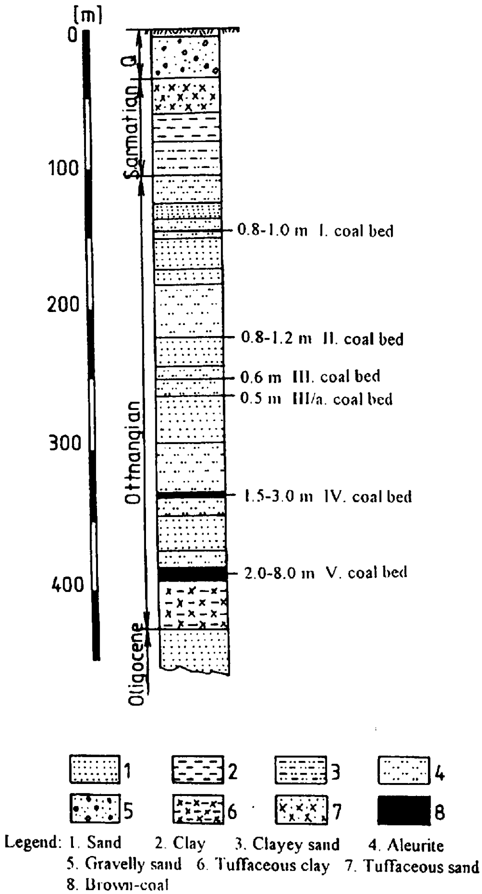


Figure 2. Schematic sequellce of strata in East-Borsod Basin

Miocene sand layers are usually *confined aquifers* with *negative piezometric level* - except some areas in special topographic position. The reasons of this are the geographic position of recharge areas, the tendencies in change of grain size distribution, the inclined deposition of sand layers and the dissolved CO_2 gas in groundwater.

Recharge of the aquifer is from the gravel terrace of the Sajo river. With the occurence of a hydraulic gradient created by the drainage of sand layers terrace water infiltrates into the contacting groundwater aquifers.

The overlying Pliocene-Pleistocene strata of the coal bearing formation also contain groundwater aquifers, most significant of them is 5-20 m thick unsorted gravelly sand, sandy gravel terrace layers of Sajo river deposited under 1-2 m thick Holocene clay soil and having 3.5×10^{-3} - 1.3×10^{-4} m/s hydraulic conductivity. This aquifer is important source of drinking water of the region, more water-works are established on this layer.

Hydrogeological role of *tectonics of the basin* is complex and not clearly known even in mined blocks. The faults can be impermeable - depending on their slip, material of the faultzone and pressure differences between the two sides of the fault; however other mining operations verify the permeability of faults.

PRIMARY (ORIGINAL) QUALITY OF GROUNDWATER

In the brown-coal basin chemical analysis of groundwater samples has been executed since 1950. Origin of water samples are different, they can be:

- water of seepage or inrush from underground mine openings,
- water from surface wells, drilled for hydrogeological purpose,
- S.G. mine water collected in mine.

Due to the difficulties caused by the differences of time, place, method and purpose of sampling and analysis the processing and interpretation of water chemical data has not been executed yet. In order to examine the original groundwater quality of the basin results of 250 chemical analyses of water samples taken from surface hydrogeological wells were chosen. The aim of the study was the determination of tendencies in space and depth in groundwater quality.

The curiosity of groundwater quality of the basin is the water yielded by a well in the protective zone of Edeleny IV. shaft from the sand layers between IV. and m/a. coal beds. It was classified as " *mineral water of alkaline-bicarbonate. sulphate type. containing also calcium and magnesium*" (Table 1.). The process resulting mineral water quality can probably be the effect of inorganic CO2 coming from the metamorphic carbonate rocks from the basemant of the basin.

In other part of the basin in their primary state Ottnangian aquifers contain groundwater with 500-700 mg/l TDS, Ca-Mg-Na-bicarbonate type of water with various rates of cations and with high sulphate content. The main processes resulting the chemistry of groundwater can be summarized as follows:

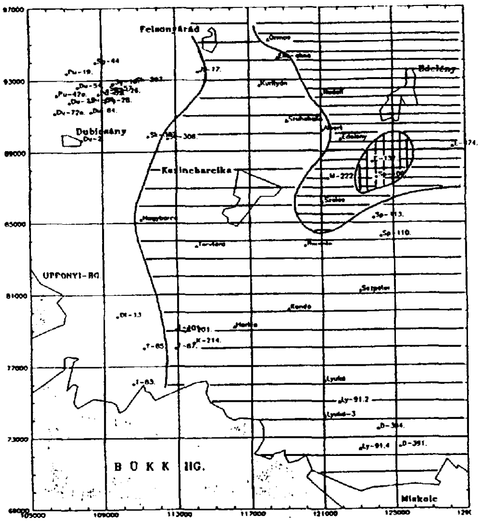
1. Presence of higlh concentration of probably inorganic origin CO_2 must be *essential* in quality development of mineral water. *The surplus CO2 increases the dissolving capacitv* of groundwater, bicarbonate content increases, thus water can dissolve cations from the material of aquifer. TDS in water increases. This process is justified by the fact that in the mineral water there appears an increased quantity of Na ion parallel with higher concentration of other main ions (Ca^{2+}, Mg^{2+}, HCO_3^-, Cl^-, SO_4^{2-}, Figure 3.). The centre of the process is Edeleny, and getting closer to Edeleny from the south or west, TDS of groundwater increases, east of Edeleny TDS decreases again.

Table 1 Results of chemical analysis of mineral water (OKI, 1959)

Ions	**Symbol**	**mg/L**	**m_{val}/L**	**Than ekv.%**
Potassium and sodium expressed as sodium	Na^+	944.84	41.08	63.13
Ammonium	NH4+	-	-	-
Calcium	Ca^+	153.66	7.67	12.72
Magnesium	Mg^+	140.36	11.54	19.14
Iron	Fe^+	0.250	0.008	0.01
Manganese	Mn^+	-	-	-
Cations:		1239.11	60.298	100%
Nitrate	NO3-	-		
Nitrite	NO2-	-		
Chloride	Cl^-	336.00		
Bromide	Br^-	1.82		
Iodide	I^-	0.14		
Fluoride	F^-	0.80		
Sulphate	SO_4^{-2}			
Biocarbonate	HCO3-			
Anions		3158.47	60.301	100%
Metaboric acid	HBO_2	31.00		
Metasilicic acid	H_2SiO_3	23.92		
Total		**4452.50**	**120.599**	

2. It can be seen in given parts of the basin - where we have data from different depths - that Ca and Mg quantity decreases proportional to the occurence and increase of Na concentration. This fact refers to *ionexchange* between water and rock (Figure 4.).

3. Although Na^+, Cl^-, SO_4^{2-} concentration usually increases with depth, groundwater in some territories has Ca^- Mg^- bicarbonate type (Figure 5.). This type of water refers to special conditions with intensive *flushing* from precipitation or connection



Legend: sampling points
towns, bordering mountains

< 10 mval/l alkalinity
10 - 20
20 - 40
> 40

Figure 3 Spatial changes of alkalinity of groundwater

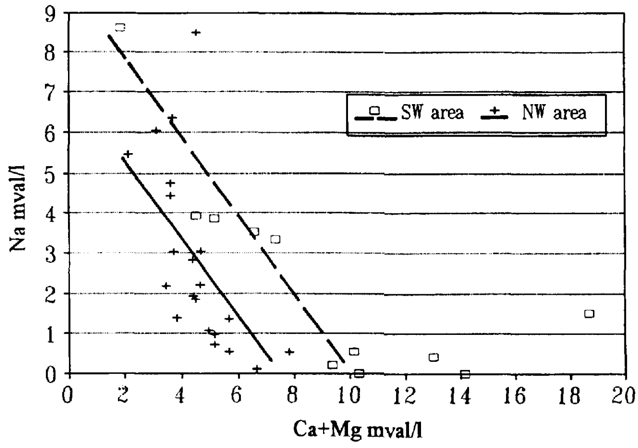
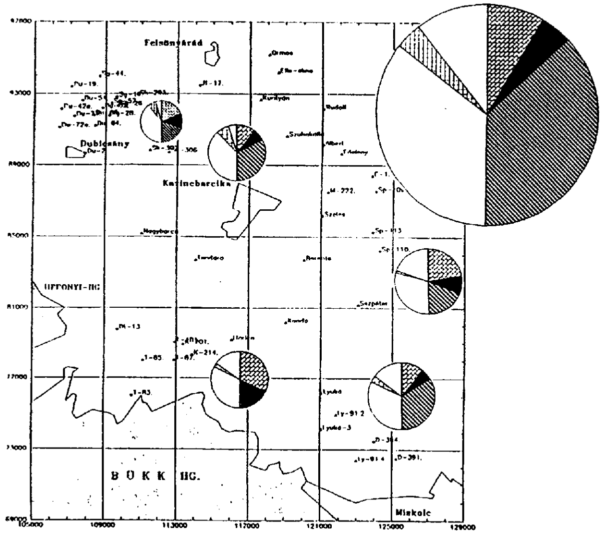


Figure 4 Effect of cation exchange



Legend: Main anions and cations (radius of the circles is proportional to TDS)

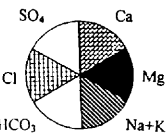


Figure 5. Groundwater types of the basin

with different type of groundwater (e.g. karstic water). Na^{+} in aquifers in bigger depth can be the residue of the original fossile water of rock sedimentation.

4. The origin of the significant quantity of sulphate can be probably occur in disused mining excavations. Near mining activities groundwater can mix with water percolating through collapsed zones and dissolving pyrite content of coal. In other territories sulphate content increases with depth, but in large areas of the basin sulphate content has no importance (Figure 6.).

WATER QUALITY CHANGIES

Quality of groundwater collected in underground mines and pumped to the surface changes comparing with primary quality by (1) intercommunicating by seepage in fine grain layers and coal beds, (2) getting in touch with human effects in mine. According to our experiences in this basin the most significant changes are increasing of total hardness, alkalinity and oxigen demand (COD).

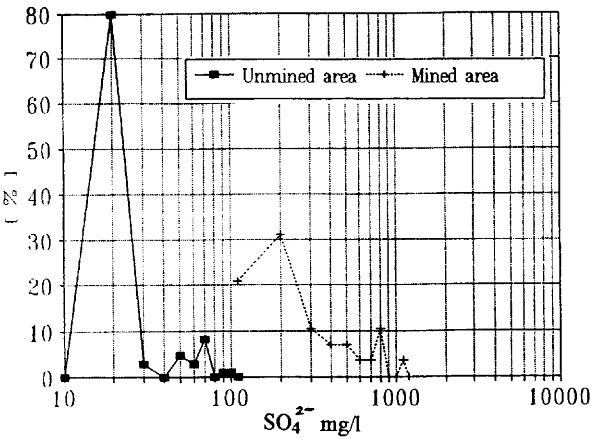


Figure 6. Distribution of sulphate data

Groundwater quality can be contaminated due to water level recovering after mining activities partly by the high sulphate content of water of old mining cavities, partly by organic contaminants of human origin as fats, oils, etc. According to the prediction of water balance examination for the region, the degree of expected pollution will not exceed the standard limits for drinking water.

The East-Borsod basin being one of the heavy industrial centres is one of the most contaminated area of Hungary. Chemical plants in Sajo valley have already contaminated the soil and the shallow groundwater aquifer with their unprofessionally deposited byproducts and wastes. As the disposal sites are situated on undermined territory deep groundwater is in potential hazard due to the fissured zone at break off of mining operations and decrease of piezometric pressure of deep aquifers. Prediction of time and dimension of this process is very complicated, in order to eliminate the genuine harmful effects continuous control and data processing of groundwater quality are essentially important.

CONCLUSIONS

Summarizing the results of the study of original and secondary quality of groundwater in the East-Borsod Brown-Coal Basin it can be stated that the effects of miniing (sulphate, human contamination) are only some - having less importance - of the harmfill effects for groundwater quality. Protection of the drinking water reserves of the region requires first cancelli,ng the surface contamination sources.

REFERENCES

1. M. BARTHA (1993): Hydrogeology and quality of groundwater of Borsod Brown-Coal Basin Univ. Doct. thesis, Miskolc

2. R JAMBRIK - Z. NEMEDI VARGA (1987): Geological and hydrogeological review of Duzsnok brown-coal territory Banyaszati es Kohaszati Lapok -

Banyaszat 120. evf. 2. szam pp. 48-88.

3. R JAMBRIK - M. BARTHA (1990): Hydrogeological conditions of Edeleny IV. coal area Foldtani Kutatas xxxm. evf. 4. szam pp. 25-35.

4. A. JUHASZ (1975): Correlations between depth and groundwater quality; an example from the East-Borsod Brown-Coal Basin MTA X. Osztalyanak Kozlemenyei 8/3-4. pp. 345-353.

5. Z. VARSANYI (1991): Geochemical modelling of chemical changes of water quality during groundwater movement HidrologiaiKozlony71. evf. 5. szampp.300-309.

6. Hydrogeological investigation of "Borsodi viz" mineral water occurence Research report, Dep. of Hydrogeology and Engineering Geology, University of Miskolc, 1989.

7. Qulality of Miocene Groundwater in the Borsod Basin Research report, Department of Hydrogeology and Engineering Geology, University of Miskolc, 1990.