TRENDS IN UTILIZATION OF MINE WATERS IN THE UPPER-SILESIAN COAL BASIN

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ABSTRACT

As a result of mining in the Upper-Silesian Coal Basin over 340 millions cubic meters of water are pushed up onto the surface anually. These waters originate from drainage of underground workings and are characterized by very differentiated mineralization. Conventionally, these waters have been divided into 4 groups in accordance with global contents of ions CI^- and SO_4^{2-}. Inclusion of water to particular group is made with regard to actual technical possibility of its selective intake and pushing it out to the surface. Mine waters are used for drinking water, supply for colliery baths, supply for steam and water boilers, completion of water circulation for mechanical coal processing, supply for fire precaution pipelines and watering of places of high dustiness, supply for cooling water circulation in power stations, etc. Utilization of these waters is of key significance because of utility and technological water deficit in this area as well as protection of water environment against detrimental impact of saline mine waters.

The majority of collieries is located at the springs of Polish main rivers - Vistula and Oder. These rivers have their sources in the Carpathian mountains and they run across whole Poland. With their tributaries they are the only water supply for the whole country. At the springs of Vistula and Oder rivers is located the Upper-Silesian

Industrial Region. This region is characterized by industrialization and density of population of the highest degree in Europe. These two facts cause on one side a very high demand of water for economic-social and industrial purposes and on the other side they contribute to formation of large quantities of sewage discharged to surface water. Water conditions of Oder and Vistula rivers are particularly disadvantageous in the industrial area for the water economy and waste water disposal as for Vistula and Oder rivers the design flows in the coal basin amount per annum only to some 16 cu.m/sec.

Coal mining, which caused such a remarkable industrialization of this region, exerts also a vital influence on the water economy and waste water disposal of the whole basin. This is resulting from the fact that at such high quantities of waters which are discharged by the collieries from the underground working drainage the coal mining requires significant quantities of utility waters for social and technological purposes.

In 1980 the collieries pushed out onto the surface some 930 thousands of cubic meters of waters per 24 hrs, i.e. annually approx. 340 millions of cubic meters of waters constituting natural inflows to the underground workings. Degree of mineralization of these waters in highly differentiated beginning with insignificant mineralization occurring in water for municipal purposes, up to highly saline waters, with salt concentration amounting to 200 g/cu. decimetre.

Collieries consume considerable quantities of water for social purposes. In 1980 collieries consumed for own needs 520 mill.cu.m. of water.

Increasing deficit of utility water in the Upper Silesian Coal Basin imposes on the coal industry the obligation of a maximum utilization of waters originating from drainage of underground workings for drinking and industrial purposes, with a simultaneous introduction of indispensable surface water protection against mine waters.

Mine waters pollute the surface waters with suspended solids and dissolved mineral salts. Removal of suspension makes no major technical problems whereas removal of the excessive mineralization is technically difficult and economically arduous.

Implementation of mine water utilization for utility purposes and at the same time protection of the surface water courses against excessive pollution required an elaboration of mine water division, in accordance with its purpose. As an usability index of waters their degree of mineralization was accepted, expressed by global concentration of chloride and sulphate ions.

First group covers waters of which the ion $Cl^{-} + SO_4^{-2}$ concentration lies below 600 mg/cu.dec. Water of this group is assigned to conditioning for drinking water, for supply for colliery baths, supply for steam and water boilers and for other purposes where water of low mineralization degree is required.

Polish regulations specifying conditions for drinking water and water for utility purposes indicate that contents of ions Cl^- must not exceed 300 mg/cu.dec. and that of ions SO_4^{2-} - 200 mg/cu.dec., at global contents of dissolved salt of 600 mg/cu.dec.

Utilization of mine waters included to group I, mineralization of which is higher than it is set for drinking water, takes place after previous dilution with water collected from the municipal water-pipe network. This procedure does not totally eliminate the consumption of water from the municipal water-pipe network by the collieries, but nevertheless, it permita to limit the consumption to a high degree.

The second group includes water of an ion $Cl^- + SO_4^{2-}$ concentration within the range of 600-1800 mg/cu.dec. These waters, after previous partial conditioning are used in the coal mining for completion of water circulation for mechanical coal processing, supply for fire-precaution pipings and for watering places of high dustiness, such as places of mining with heading machines, dumpings, etc. According to Polish regulations concerning watering in coal mining waters of unrestricted mineralization can be used for this purpose and the only condition the waters have to satisfy is bacteriological purity, which should comply with drinking water standards. Degree of mineralization of waters used for watering is set by practical consideration, as an increased contents of salt exert an influence mainly on the corrosive deterioration of metal parts.

Power stations are the main receivers of waters of group II, where they are used for completion of cooling water circulation.

The next group includes waters of a chloride and sulphate ions concentration ranging from 1800 to 42000 mg/cu.dec. These waters are conventionally called brackish waters. Suitability of these waters for utility purposes is limited whereas they form troublesome waste and contribute to salinization of surface water-courses.

The last group, called "mine brines", includes waters of an ion $Cl^- + SO_4^{2-}$ concentration higher than 42000 mg/cu.dec. Quantitatively this group is a small part of waters pushed out of the collieries but quite a considerable one in respect of amount of salt, as with these waters up to 50 % of salt contents are being led off to the rivers.

The degree of mineralization of these waters allows to treat them as a raw material for production of salt and utility water in a way which is not troublesome and ensures protection of rivers against excessive salinization. A compilation of waters pushed out of collieries in 1977, together with division into individual groups, is presented in Table 1.

Exploitation of mine brines as a chemical raw material has been elaborated in details in a paper presented by Mr. I.Motyka and Mr. L.Skibiński, named "Utilization of salt mine waters in the means of environment protection".

Waters classified to groups I, II and IV find an application whereas waters of group III can be hardly utilized and they are only a source of river pollution. It should be emphasized that the division of underground waters into individual groups does not mean that these waters are are selectively taken in and pushed out onto the surface. Inclusion of underground waters into individual groups takes place with regard to technical possibilities of selective pushing out waters onto the surface.

Degree of mineralization of waters from the drainage of underground workings is very diversified depending on the depth of exploitation, condition and kind of rock mass and location area of the colliery. Generally, it can be said that waters from collieries situated in the south-west region of the Upper-Silesian Coal Basin are enriched with $Na^+ + Cl^-$ ions as the depth of their occurrence increases, with an inconsiderable participation of sulphates, carbonates, calcium, magnesium and potassium.

Waters originating from the other areas of the coal basin, at shallower levels are characterized by insignificant contents of chlorides but they contain significant concentration of sulphates. At levels below 400 metres the waters are in substance mineralized by chloride compounds at decreasing participation of sulphate salts. As the water mineralization increases the occurrence of ammonium salts can be noticed concentration of which amounts to 30 mg/cu.dec. in conversion to ion NH_4^+.

In some collieries the underground waters are deprived of sulphates and in these waters presence of barium and strontium has been ascertained.

As it was already stated selection of waters is carried out in such a way that it is technically easy for implementation and at the same time it is possible to take-in the highest quantity of utility waters.

In collieries where the underground working started at shallow coal beds and now it is carried out deep below 500 m waters of all 4 groups occur.

In these cases selection is made at individual levels and waters are pushed out to the surface by separate pipings. If at several levels waters are of similar characteristics they are being mixed at the lowest level and then pushed out onto the surface. At grouping of these waters the principle is followed that the global contents of salt are within the range of given group. For this reason, if an insignificant quantity of high quality waters occur these are mixed with other waters from the same level with giving up this way these high quality waters. Similar procedure is accepted in case of low quality waters. Quite a wide range of mineralization of underground water of the individual groups justify such procedure. In case of collieries with high quantities of waters at individual levels it is payable to adopt separate intakes and push the waters out in two different groups from one level.

In collieries where underground working begins at levels deeper than 500 metres most frequently waters of poor and high mineralization occur. Fresh waters occur in these collieries only in pit shafts and these are taken-up separately, via a system of dripping troughs.

Balance of underground waters, worked out in 1977, proved that coal mining, at total quantity of pushed out underground waters, has the possibility of selective intake and pushing out of first group waters - 43 %, second group waters - 30 %, third group waters - 25 % and of fourth group - 2 %.

Waters of the first group of waters were selectively pushed out in 55 % and utilized for own purposes in 29 %. The remaining quantity of water was delivered to the municipal drinking water-pipe network or to neighbouring industrial works.

In the II-nd group 24 % of waters were covered by selection. From the above quantity the collieries consumed 52 % for own needs and the remaining quantity was mainly delivered to power stations.

Waters of group III were used in 18 %, from this amount by collieries in 74 % and by other users in 26 %.

Perspective data in inflow of underground waters worked out up to 1990 foresee a considerable increase of quantity as well as quality of waters, particularly in groups III and IV. It will be connected with development of collieries and mining of coal from deeper coal beds.

It is anticipated that water inflows will increase by 12 % whereas the load of chlorides led off to the rivers will increase by 29 % and that of sulphate by 13 %.

Selective intake and pushing out of underground waters is being introduced in existing collieries as they are developed and mainly in those regions where the lack of utility waters is particularly acute. In collieries in the stage of design and erection the selection of waters is being introduced already in the stage of design.

It is anticipated that up to 1990 a full utilization for utility purposes of waters of groups I, II and IV will take place, whereas waters of group III will be led off to rivers via a system of main drains and storage-proportioning reservoirs.

The purpose of this system will be to protect the surface waters against excessive salinization. Exploitation waters of group IV as chemical raw material containing table salt, will fulfill two tasks - a decrease to a high degree of salt load discharged to rivers and supply water and utility salts for national economy.

Further reduction of water deficit will be achieved by repeated utilization of water. In coal mining the tendency is first of all towards repeated utilization of colliery bath waters led off the colliery baths. These waters form the decisive majority of waters of high quality which are used by collieries. Purified colliery after-bath waters can be used for completion of steam and water boiler cooling circulation, for supply for fire precaution pipings and for watering. It is the aim of the present research work to recondition the after-bath waters to such a degree that they could be used repeatedly for the colliery baths. Application of this method in an industrial scale is supposed to take place in 1984 in one of the coal mining plants.

REFERENCES

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Table 1

Compilation of underground waters pushed out in 1977 and division of these waters into groups according to global concentration of chloride and sulphate ions

Quantity of pushed out underground waters thou.cu.m/24 hrs	Charge of anions: Chlorides Cl^- t/24 hrs	Charge of anions: Sulphates SO_4^{2-} t/24 hrs
930	3,320	560

Waters of group I - $Cl^- + SO_4^{2-}$ 600 mg/cu.dec.

Total quantity thou.cu.m/24 hrs	including utilized waters thou.cu.m/24 hrs
400	220

Waters of group II - $Cl^- + SO_4^{2-}$ = 600-1800 mg/cu.dec./24 hrs

Total quantity thou.cu.m/24 hrs	including utilized waters thou.cu.m/24 hrs
280	68

Waters of group III - $Cl^- + SO_4^{2-}$ = 1800-42000 mg/cu.dec.

Total quantity thou.cu.m/24 hrs	including utilized waters thou.cu.m/24 hrs
230	41

Waters of group IV - $Cl^- + SO_4^{2-}$ 42000 mg/cu.dec.

Total quantity thou.cu.m/24 hrs	including utilized waters thou.cu.m/24 hrs
20	2.4