Impact of the mining industry on the water environment in the Lubin-Głogów Copper Region (LGOM)

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Abstract: Trends and nature of hydrodynamic and hydrochemical alterations in water environment arising under the impact of mining and associated industrial activity are shown in the paper. Hydrodynamic and hydrochemical alterations are caused by: dewatering of mines and rock mass surrounding deposit, surface deformations caused by mining exploitation using roof collapsing method, hydrotechnical objects operating, e.g. flotation waste pools and big water intakes, accepted and carried out mine water and waste management, water pumped out from mines and that used in the technological process.

1 INTRODUCTION

Copper ores extraction, processing and smelting in the Lubin-Głogów Copper Region (south-west Poland) causes the antropogenic transformation within all environmental media. This transformation is also present in the underground and surface water.

The core of copper industry consists of three underground mines, three processing plants and three copper smelters and refineries. The cooper industry has also well developed infrastructure. Some of its more important elements are, among others, tailings storage impoundments and big underground water intakes. As the result of mining activity, about 450 million tons of copper ore are extracted every year and the electrolytic copper production, exceeds 26 million tonnes. It puts Poland on the 5th place among the world copper producers.

Main factors causing hydrodynamic and hydrochemical transformation of the underground and surface water in this region are connected with:

- process of dewatering the deposit and rock-mass surrounding the mine workings,
- development of the surface deformation as the result of mining activity using caving method,
- operation of hydrotechnical facilities i.e. tailings impoundments and big underground water intakes,
- generally considered water-sewage management, especially specific circulation of mine and technological water.

2 HYDROGRAPHIC AND HYDROGEOLOGICAL CONDITIONS

The Lubin-Głogów Copper Region is located within the left-bank basin of the middle Odra river, encompassing drainage basins of three rivers: Zimnica, Rudna and Szprotawa. In the hydrogeological profile of the copper-bearing area, there are two main water-bearing complexes (Figure 1):

- Cainozoic – including loose Quarternary and Tertiary formations,
- Triassic and Permian – occurring in compact, porous and fractured rocks of the Tertiary, Zechstein and Rotliegendes.

Those complexes differ from each other by their lithology, method of underground water supply, hydrogeological parameters of the water-bearing rocks and water chemism.

In the Cainozoic complex, Quaternary stage encompasses the water-bearing horizons of the Holocene and Pleistocene. In the Tertiary stage three water-bearing horizons occur: over-lignite, inter-lignite and sub-lignite. In the Triassic and Permian complex we can separate the following water-bearing horizons: Triassic of the Buntsandstein, Zechstein of the main W-2 dolomite (so called "Lubin" dolomite), Zechstein limestones and dolomites W-1 as well as horizon of the Rotliegendes sandstone in the lower Permian. The water-bearing horizons are divided by the isolating beds or they remain in the hydraulic connection. On the area of the copper ore mines, Quaternary water-bearing horizons are separated from the older stages by the layer of Pliocene clays from the Poznań series. The second continuous isolating level is the Miocene clay layer, separating the Tertiary water-bearing horizons – over-lignite, inter-lignite from the sub-lignite horizon and horizons in the Triassic and Permian. The water-bearing horizon in the sub-lignite formation on the whole area, is in the wide hydraulic connection of the sedimentation type, with the Bunsandstein horizon. Both horizons in the north part of copper-bearing area do not have the hydraulic connection with horizons in the Permian formation. The isolation gives the layer of Upper-Zechstein clay shale and mudstone and the anhydrite series occurring below.

The mentioned above horizon of sub-lignite Tertiary formation in the south part of the region occurs on the Zechstein outcrop of the insulation type – anhydrite and clay shale series and contacts directly with water-bearing Zechstein limestones and dolomites (W-1) as well as with Rotliegendes sandstone. The essential role in creating the hydraulic connection of this horizons plays also faults tectonics. The detailed characteristic of the hydregeological conditions is presented in the earlier reports of the paper authors (Bocheńska, 1988, Bocheńska, Limisiewicz, Poprawski 1995, Bocheńska, Fiszer, Kalisz 2000).

Mainly Zechstein limestone and dolomite (W-1) and Tertiary sub-lignite water bearing horizons affect the water inflow into the mine. However the amount of inflow is determined by the location of the mine towards two main part of the deposit area – the north, covering zone of low water inflow of

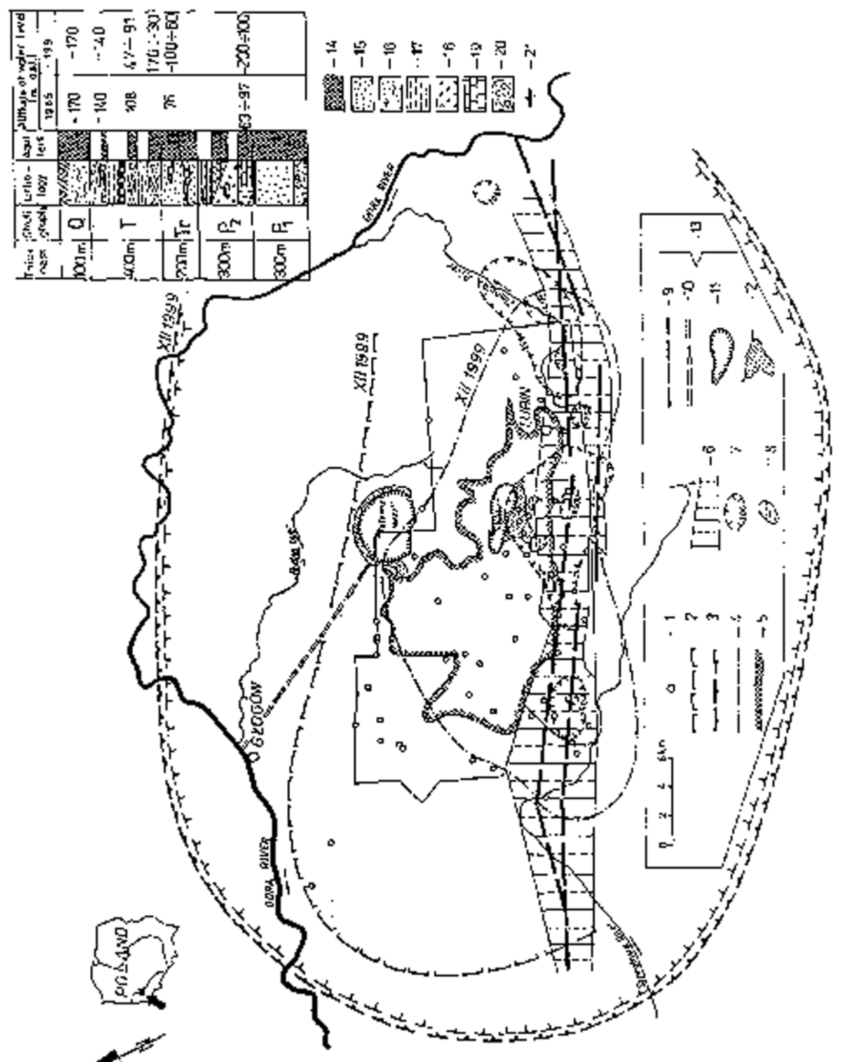

Figure 1 Hydrogeological and geological settings in Lubin-Głogów Copper Region
1-"deep" piezometers 2- limits of depression zone in Zechstein limestone (W-1) 3- limits of depression zone in aquifer below-coal horizons 4- limits of depression zone in aquifer between coal horizons 5- zone of mined and dewatered area of Zechstein limestones (W-1) 6- zone of hydraulic contacts between Tertiary and Zechstein aquifers 7- local overdeeping in the wide-radius subsidence basin 8- flooded areas on the surface 9- faults 10- pipe discharging salt waters from mines 11- floation tailing reservoir 12- the groundwater pollution area 13- underground working areas 14- aquifer 15- sands 16- sands and till 17- clays 18- anhydrites 19- limestones and dolomites 20- extrusives and conglomerate 21- mine excavation.

Zechstein limestones and dolomites (W-1), where the deposit occurs at the depth of 700-1200 m and the south equal to the zone of sub-tertiary outcrops of Zechstein formation, showing intensive water inflow within deposit surrounding rocks, with the deposit occurring at the depth of 500-700 m below the surface. Therefore water inflows into the mines cutting the deposit in the north region are not big, and the mines workings in the south region have high water inflow.

By the end of 1999, due to mining drainage from the copper mines in the Lubin-Głogów Copper Region, about 661.03 million cubic meters of water were piped away, including about 37.3 million cubic meters from the north region and about 623.7 million cubic meters from the south region.

3 GENERAL CHARACTERISTIC OF THE WATER MONITORING SYSTEM

The basis for the assessment of the mining activity influence on the underground and surface water in LGOM is the monitoring, carried out almost from the beginning of the copper industry existence. Its main task is the recognition and the constant control of the water dynamic and quality. In order to achieve this target, the system of water measurements and sampling within the sampling and research network was arranged and laboratory tests with special frequency using adequate methodology are carried out.

Variety of needs served by the monitoring results from the factors listed at the beginning, generating hydrochemical and hydrodynamical transformations. The monitoring is carried out within several organisational and methodological options. The monitoring includes the following:

- monitoring of the sub-Quaternary water-bearing horizons, mostly covered by the dewatering activity of mines,
- monitoring of the Quaternary water-bearing horizon with regard to the mining areas and mining infrastructure facilities like tailing reservoirs, supply areas of big underground water intakes and secondary landscape forms like large and local subsidence basins or waste rock dumps,
- surface water monitoring within the influence of the "Żelazny Most" tailings reservoir.

Monitoring tests are carried out using the points of measuring and research network, which, depending on their location in the geological profile and their function, can be grouped as follows:

- hydrogeological (active) tests and drainage boreholes on the level of mining workings located on the contour of the deposit opening. They form non-stationary network of hydrostatic pressure bench-marks of changeable quantity, mostly from several to more than ten points in one mine,
- piezometers located on the surface of mining areas and in their neighbourhood forming stationary network of the measuring and testing points. Among them we can find the "deep" piezometers, screening sub-Quaternary water-bearing horizons and the "shallow" piezometers installed

in the Quaternary formations (sub-surface water-bearing bed and utilitarian level). The "shalow" piezometers form local networks gathered around the facilities and the secondary landscape forms mentioned above,

- measuring and testing points of the surface water (hydrogeological and hydrochemical cross-sections) in the neighbourhood of the "Żelazny Most" reservoir.

In December 1999 the stationary monitoring network of underground water consisted of 771 measuring and testing points. On the surface streams 86 points of this type exists. Their amount in all types of network and overall scope of monitoring activities carried out on their basis are presented in table no 1 and the "deep" piezometers location is shown on the Figure 1.
In the LGOM region the described measuring and testing networks fulfil the requirements of the monitoring in the different extend.

4 HYDRODYNAMIC CHANGES IN THE ROCK-MASS COVERED BY THE MINES DRAINAGE

The substantial changes in the natural hydrodynamic conditions within the water-bearing horizons, which take part in the mine inflows formation are the natural consequence of the long-term drainage of the rock-mass carried out by the copper mines in the Lubin-Głogów Copper Region. Those changes are clearly evident in the horizon of the Zechstein limestones and dolomites (W-1), drained directly by the mine headings and in indirectly drained horizons - mostly Tertiary, due to the hydraulic connections (Table 2).

In the piezometric surface of the Zechstein carbonate (W-1) water-bearing horizon, a big depression cone, with asymmetric, elliptic shape, elongated in parallel to the Middle Odra fault zone, was formed (Figure 1). In the central part

Table 1 Structure of the stationary monitoring network of the underground and surface water as for December 1999

A. UNDERGROUND WATER

- "deep" piezometers

Water-bearig horizon	Tertiary over-lignite	Tertiary inter-lignite	Tertiary sub-lignite	Buntsandstein	Zechstein main dolomite (W-2)	Zechstein limestones and dolomites (W-1)
Number of working piezometers	5	12	22	8	2	9
Monitoring type	$\underline{\nabla}$ – 4 x/year	$\underline{\nabla}$ – 4 x/year	$\underline{\nabla}$ – 4 x/year	$\underline{\nabla}$ – 4 x/year	$\underline{\nabla}$ – 4 x/year	$\underline{\nabla}$ – 4 x/year

- **"shallow" piezometers**

	Piezometers				Farm wells
	Types of measuring and testing point networks				
	Farm wells within the tailings reservoirs impact zone	In source areas of big water intakes	In agriculture and forest complexes	In regions of waste rock dumps	On mining areas
Quaternary – sub-surface beds	352	-	20	17	275
Quaternary – utility bed	-	49	-	-	
Types of monitoring activity	∇ – 1 x/month	∇ – 1 x/month	∇ – 4 x/year	∇ – 3,4 x/year	∇ – 4 x/year
	CH-2x/year	CH-1x/year	-	CH-2x/year	-

B. SURFACE WATER

Region of monitoring tests	Hydrogeological measurements			Hydrochemical sampling
	Parshal flune	Thompson overfall	Non stationary section	
Measuring and test point in the zone of "Żelazny Most" reservoir impact	9	10	35	32
Frequency of measurements and sampling for chemism testing	1 per month	1 per month	1 per month	18 points. – 1 per month 14 points. – 2 per year

∇ – water table measurement; CH– hydrochemical sampling

Table 2 Groundwater table depression in the LGOM Cainozoic and Mesozoic aquifers

Aquifer	Number of observation boreholes	Groundwater table ordinate in m above sea level		Groundwater table depression in m
		before mining operations	as for XII 1999	
over-lignite Tertiary	4	127.50 ÷ 148.80	126.85 ÷ 150.20	None
inter-lignite Tertiary	12	99.10 ÷ 111.32	47.00 ÷ 90.80	2.42 ÷ 45.86
sub-lignite Tertiary	18	73.18 ÷ 80.00	- 170.71 ÷ 21.80	53.03 ÷ 242.21
Bundsandstein	10	67.80 ÷ 92.00	- 100.37 ÷ 60.15	8.85 ÷ 177.35
main dolomite (W-2)	2	78.00	- 198.50 ÷ 19.80	58.20 ÷ 276.50
limestones and dolomites (W-1)	9	75.00 ÷ 91.70	-200.00 ÷ 10.00	80.30 ÷ 485.80

of the cone this level was dried as a result of mine works, therefore the dried zone is similar to the form of the area covered by the mining cut. In the direct neighbourhood of this zone we can record the biggest decrease of the piezometric surface, i.e. from 400 to 600 meters in the south part to 850 –1050 meters in the north part. In the marginal parts of the under-Tertiary outcrops of the Zechstein formation the depression is from 100-500 meters in the south-west to about 400 meters in the south-east. The range of depression zone in the described water-bearing horizon is surely bigger that the boundaries of the mine areas, only in the south part it agrees with those boundaries and goes along the contact zone between the Zechstein carbonates and the metamorphic rocks of Fore-Sudetic block. This range cannot be determined precisely in the west, north and east parts due to the lack of observation boreholes beyond mine boundaries. On the basis of different premises and the extrapolation of the piezometric observation results it is estimated that the depression zone in parallel to the Zechstein outcrops has the span exceeding 50 kilometres and the perpendicular direction has 17-18 kilometres. The overall area covered by the drainage in the horizon of Zechstein limestones and dolomites (W-1) is estimated at 800 square kilometres.

The influence of mining drainage is clearly marked in the Tertiary water-bearing horizons and in the Bundsandstein. The special attention should be paid to the regional depression of the underground water encompassing sub-lignite Tertiary and Bundsandstein formation. Connection between those two horizons is confirmed by the measurements in the piezometers within the mining areas. The central part of this depression is clearly marked in the under-Tertiary outcrops of Zechstein formation, where the water table depression comparing to the original level are from the few dozens to 250 meters.

Since there are not piezometers in the peripheral part of the area of the regional depression we can only conclude about its approximate range assuming that it agrees with the area of the large-size subsidence basin, being the result of rock-mass dewatering. Therefore it is estimated that the area of the water-bearing horizons drainage covers the surface of about 2200 square kilometres.

Widespread depression occurs also in the inter-lignite water-bearing horizon of the Tertiary formation (Figure 1) The biggest decreases of the piezometric surface in this horizon comparing to the state before the mining activity are 70 meters and are located within the zone of hydraulic connections between this horizon and the sub-lignite water-bearing horizon, especially in the south-west part of the copper region.

The effect of mining drainage in the water-bearing horizon of the Rotliegendes and the Zechstein main dolomite (W-2) are described as slight. The depression zone in the sandstones of Rotliegendes has the similar to the deposit cut shape and water table depressions in the main dolomite (W-2) occur only locally, because the water occurrence in this horizon is local too, and is mostly connected with depression zones in shaft regions of the north part of mines.

Observations in piezometers shows that the water-bearing horizons in the Quaternary and over-lignite Tertiary within the mine areas are beyond the influence of the copper deposit dewatering. The are separated from the lower horizons by the continuous layer of the aquifers and aquicludes built of so called Pliocene Poznań clays.

Interpretation of the measurement resulting from the “deep” piezometers shows that the hydrodynamic conditions in the water-bearing horizons, which strongly respond on the mining drainage, are not stable yet. The occurring hydrodynamic changes do not have the practical effects. The water from those horizons has not been and in the future will not be taken into account as a potential source of the water supply due to its bad quality and the occurrence at the big depth.

The reduction of piezometric pressures in the water-bearing horizons of the Tertiary formations has started and is the main reason of the development of observed for more than 30 years the large-scale subsidence basin in the LGOM region (Figure 1). The biggest depressions i.e. local cone centres are concentrated in the zone of under-Tertiary Zechstein outcrops, and saying more precisely in the vicinity of hydraulic connection of the water-bearing horizons of the Tertiary sub-lignite and Zechstein carbonates (W-1). The surface depressions reach there respectively: 650, 450, 400 and 400 mm. It should be stressed that those depressions have not had yet the influence on both water conditions in the subsurface zone and the facilities located within their range.

5 HYDRODYNAMIC AND HYDROCHEMICAL CHANGES IN THE WATER ENVIRONMENT OF THE QUATERNARY FORMATIONS

The direct influence of the mining is manifested in the form of subsidence basins over the caving areas. In the LGOM this influence only in the small scale change the water conditions within the Quaternary formations. The reasons are: large thickness of the rock-mass occurring above the caving areas, relatively deep ground water table, especially in the area of moraine hills as well as proper mining technology. This technology takes into consideration the rules of prevention with reference to the surface protection.

Currently on the areas of mines only in three regions, the evident influence of the exploitation subsidence basins on the water conditions in the sub-surface water-bearing horizon is marked (Figure 1). Two regions are within the valley areas with shallow groundwater table. Changes of the water conditions consists mainly of relative increase of the subsurface water table and transformations in the flora. The terrain there is marshy and smaller overflow land appeared. In the third area there is surface overflow land and the surface regarded as flooded occupies the area of 40 hectares. It should be underlined in this region aside from active subsidence basin caused by the mining activity there are also surface deformations brought about by earlier earth works (excavations, humus exploitation etc.) what with no doubt intensified the extend of damage.

At present in every area the prevention activity is carried out in order to regulate disturbances in the water and ground conditions what should result in at least partly removal of the hydrogeological mining damages.

The deposit dewatering in the LGOM mines causes the permanent need of the water drainage from mines and from the technological circuit on the surface. This water has in general high and diversified mineralization what causes that with the water the substantial charge of salt is transferred onto the surface. Only in 1999 the charge was determines as 547 936 tonnes (Table 3).

This water is used on the surface in the technological processes of ores concentration and therefore influences the water environment, contributing to creating regions of particularly high degree of water degradation in the Quaternary formation environment. Those region are mainly located in the vicinity of "Żelazny Most" tailings reservoir and already closed "Gilów" reservoir (Figure 1).

The source of hydrogeochemical and hydrodynamic transformations in the "Żelazny Most" region is its water pond infiltrating on its foreland (Witczak, Duda 1995).

This water is of Cl-SO_4-Na-Ca type with mineralization up to 21400 mg/l. The concentration of chlorine ions (Cl^-) is about 8000 mg/l and sodium (Na^+) ions is up to 4500 mg/l. In its composition there are also heavy metals including copper (Cu)amounting 0.085 mg/l and lead (Pb) – 0.100 mg/l. The scale of infiltration at the end of the nineties was between 0.8 to 3.5 m^3/min.

Table 3 Mine water chemism and salt charges transferred onto the surface from the LGOM copper mines in 1999

Region of deposit	Main underground water chemical factors in g/l			Groundwater Inflows	Salt charge in tonnes		
	Overall min.	Cl^-	SO^-_4	in 1999 in milion m^3	Min.	Cl^-	SO^-_4
South	3.61	0.62	1.57	24.9	900497.010	15465.601	39162.893
North	107.80	64.88	2.52	2.46	265.898	160.092	6.235

The influence of the reservoir on the underground eater dynamics is marked by the occurrence of its table local damming up zones. sometimes up to several meters comparing to the initial level and by the local overflows and self-flows in the 1m kilometre belt along the reservoir dam. Changes of the chemical composition of the underground water in the reservoir neighbourhood are manifested mainly in the change of the initial chemical background of HCO_3-Ca type into Cl-SO_4-Ca type in the places of the referenced filtration direction of the salt water from the reservoir towards its foreland. The result of this process is the presence of zone of enlarged mineralization in the underground water in the zone of 250 to 1000 meters wide bordering on the reservoir dams. In 1999 the degraded water zone (M $\geq$1000 mg/l) occupied the area of about 300 hectares.

The abandoned tailings reservoir "Gilów" left the zone of degraded water. which boundary runs 1200 to 2300 meters south from the dam axis and its area is almost 700 hectares. Within this zone occurs the source area of one of the biggest underground water intakes. Therefore this intake was actually excluded from the operation. On the foreland of abandoned "Gilów" reservoir we can observe slow reclamation of the water conditions towards the state before this facility operation and weak trend to sweeten both underground and surface water. However the water environment chemism in this region substantially differs from the initial level and overall mineralization is up to 8530 mg/l.

The negative influence of tailings reservoirs on the underground water of Quaternary formation is limited by the different methods. One of the most interesting is selective tailings deposition in the reservoir bowls. It leads to the progressive silting-up of the reservoir bottoms and thus limits infiltration of the brines into their subsoil. The important element of the prevention is carried out for many years continuous water monitoring in the surroundings. especially of the "Żelazny Most". The monitoring results are used when the preventive action like vertical drainage of the dams. optimisation of the horizontal drainage. arranging the small retention on the streams as well as melioration on the dams foreland are taken.

Describing the influence on environment of the big underground water intakes in the LGOM. It should be stressed in none of them water consumption is not bigger than the approved reserves. and in many of them the amount of the taken water is significantly
lower than the special water-legal permission. The summary water consumption from those intakes makes up 70 % of the approved reserves. The recorded hydrodynamic changes within screened usable horizons do not cause the exceeding the acceptable depressions and are present only within the limits of source areas of those intakes.

We do not observe any impacts of the water intakes on the water conditions in the subsurface zone. The only exception is the "Retków-Stara Rzeka" intake (Figure 1) located in the north part of the Lubin-Głogów Copper District. where one can observe its adverse impact on the water taken by the farm wells in the neighbouring villages. The depressions of water table are there from 0.9 to 2.6 m comparing to the initial levels.

The tests on the water quality of the subsurface horizon in the LGOM has been carried out since the beginning of the copper industry operation in this region. The tests are performed in the hydrogeological basins of the three rivers: Zimnica. Rudna and Szprotawa. Those basins cover actually mining areas of the all three mines.

During the period before the mining activity the hydrochemical background concerning the overall mineralization of shallow water in the Quaternary formation was as follows: the Zimnica river drainage basin: 300-800 mg/l. the Rudna river drainage basin 200-900 mg/l. the Szprotawa river drainage basin: 400-1200 mg/l (Sieroń. 1986). After the foregoing we can conclude that then there were values higher than standard ones in the drinkable water. The state of the current water quality in the described water-bearing horizon after about 30 years of mining activity is illustrated by the present hydrochemical background within the scope of overall mineralization. This background is: the Zimnica river drainage basin: 240-960 mg/l. the Rudna river drainage basin 500-1100 mg/l. the Szprotawa river drainage basin: 460-1140 mg/l.

Comparing the both states shows the slight decrease of the water quality in the sub-surface horizon in the Zimnica. Rudna and Szprotawa drainage basins. It should be stressed that the copper industry impact is here insignificant at least by the mid of eighties. when the closed cycles of technological water were implemented. where sewage water from mines and surface facilities was also dumped.

The deterioration of the described water quality should be connected with the impact of such sources of hazard like: agriculture. mostly unordered water-sewage management. and external factors like gases and dust emission from the neighbouring areas.

6 THE INFLUENCE OF COPPER ORE MINING AND ITS INFRASTRUCTURE ON THE ODRA RIVER

The mine technological water. which mostly comes from the mines drainage is in the constant circulation and is used in the ore processing and for hydrotransport of tailings from the concentrators to the "Żelazny Most" reservoir. This circuit has a positive balance. therefore the water surplus from the reservoir is piped away to the Odra river – the second biggest river in Poland. The dump takes place in Głogów (Figure 1) and in 1999 it reached the level of 15.691 million cubic meters of water with the salt charge of 263714.9 tons what is about 12 % of the overall Odra river salinity.

The discharge does not cause the surpassing of the water salinity factors in the Odra river by the transferred salt (chlorides and sulphates) charge. Adhering strictly the binding legal water permission we can limit the negative effects of this dump.

It should be stressed that the surplus mine and technological water drainage system is being continuously improved. First of all the efforts on the increase of the "Żelazny Most" tailings reservoir pond capacity are made. Moreover the current modernisation of the dump system guaranties the uniform distribution of the salt charge in the whole river section. what speeds up its partial neutralisation.

7 FINAL REMARKS

The Lubin-Głogów Copper Region due to the variety of hydrogeological problems appearing during the copper ore extraction and its processing. is a very good training field to carry out tests on technological impact on the natural water environment. The copper mines will continue their operation for almost 50 years. Thus their influence on the environment will be significant towards the regional economy for a long time. The research results on this influence expansion will be the basis for effective counteractions against its negative effects on the environment.

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Wpływ działalności górniczej na środowisko wodne w Lubińsko - Głogowskim Obszarze Miedzionośnym (l-g-o-m)

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Streszczenie: Artykuł prezentuje charakter i kierunki przeobrażeń hydrodynamicznych i hydrochemicznych w środowisku wodnym powstających pod wpływem działalności górniczej i towarzyszącej jej działalności przemysłowej. Przeobrażenia hydrodynamiczne i hydrochemiczne zachodzą pod wpływem takich czynników jak: odwadnianie wyrobisk górniczych kopalń i górotworu otaczającego złoże, deformacje powierzchni terenu w związku z eksploatacją górniczą złoża na zawał stropu, funkcjonowanie obiektów hydrotechnicznych takich jak zbiorniki odpadów poflotacyjnych, i dużych ujęć wodnych, przyjęty i realizowany model gospodarki wodno - ściekowej kopalń, obieg wód wypompowywanych z kopalni i wykorzystywanych w procesie technologicznym. W l-g-o-m zaznaczają się dwa rejony złoża różniące się zawodnieniem: północny, gdzie zawodnienie złoża jest słabe południowy, gdzie zawodnienie jest znacznie wyższe. Wieloletni górniczy drenaż górotworu spowodował wytworzenie się rozległego leja depresji w poziomach wodonośnych objętych drenażem bezpośrednim i pośrednim W rezultacie lej w przestrzeni ma układ kilkupoziomowy, a zasięg o skali regionalnej. Rozwój leja depresji w poziomach wodonośnych trzeciorzędowych spowodował powstanie niecki obniżeń powierzchni terenu o zasięgu kilku tysięcy km^2 z maksymalną głębokością do 650 mm. Pojawiły się też lokalne niecki obniżeń poeksploatacyjnych. Zmieniły one stosunki wodne w strefie

przypowierzchniowej. Infiltracja wód nadosadowych ze zbiorników osadów poflotacyjnych na przedpola spowodowała zmiany stosunków wodnych w otoczeniu zbiorników w postaci zmian składu chemicznego wód podziemnych i podtopień na powierzchni terenu. Stosowana jest szeroka profilaktyka tych zjawisk. Nadmiar wód kopalniano - technologicznych o dużym stopniu zasolenia odprowadzany jest poprzez zbiornik osadów poflotacyjnych do rzeki Odry, wywołując zmianę składu chemicznego jej wód. System odprowadzania modernizuje się, by zminimalizować negatywny wpływ zrzutu wód kopalniano-technologicznych na czystość Odry.