GOSPODARKA SUROWCAMI MINERALNYMI

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Hydrological, geological and geochemical conditions determining reclamation of post – mine land in the region of Łęknica

Introduction

Strip mining brings about the transformation of the land surface as well as quantitative and qualitative changes in water resources. As a result of lignite mining in the areas, which are galcitectonically disturbed, numerous isolated open casts are formed on the surface of the earth, which after the end of mining often get filled with water and form the characteristic anthropogenic lake districts. The chemical composition of waters filling up such reservoirs most frequently differs from the typical composition of surface waters, in particular as far as the pH value and the contents of iron, sulfates and heavy metals are concerned.

This problem is well-known all over the world. For example, in the United States the mining industry spends approximately 1 million dollars on purifying the waters of operating and non-operating coal mines and metal ore mines. In Germany, lignite mining caused considerable changes in the topographic profile and disturbances in water relations in the territory of Saxony and Branderburg, among others in the region of the Berzdorf deposit, where currently reclamation is carried out by means of flooding the open casts with surface waters and formation of a water reservoir of the capacity of 350 million m^3 (Kołodziejczyk 2004).

The specific problems related to reclamation of post-mining areas occur in glacitectonnically disturbed regions, where as a consequence of geological processes the deposit lenses and then the mining areas as well as the surface water reservoirs filling them became isolated. The largest Polish group of post-mining open casts of such an origin can be found in the Lubuski administrative province, along the German border in the region of Łęknica

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(Fig.1). There are more than 100 artificially formed reservoirs, whose formation dates back to the period from the second half of the 19th century to the late 70ties of the 20th century. Lignite mining left a great deal of the land devastated and transformed, totalling to the area of approximately 420 hectares. Differently than in the USA or Germany, the land has never been reclaimed nor have the waters been recultivated (Kołodziejczyk 2004). Only recent research (Jędrczak, Jachimko, Najbar 1998; Asani, Kołodziejczyk 2004) showed that due to coal mining the quality of underground and surface waters, mainly as far as acidification is concerned, was considerably degraded in this region. In the development strategy of the Lubuski administrative province, the area under consideration has been included into the most attractive tourist areas, which border with the Park von Muskau entered onto the UNESCO list of World Heritage Sites. Thus an urgent need arises to reclaim this area and restore its environmental values.

The results of research presented herein concern the largest and the most acidified reservoir of the anthropogenic lake district in the region of Łęknica , marked with the number 54 (Gontaszewska et al 2006; Asani, Kołodziejczyk 2006). The research aimed at examining the geological and hydrogeological structure, hydrography of the reservoir and changes in the chemical composition of underground and surface waters caused by lignite mining.

1. Methodology

The hydrographic examinations of the catchment area and water balance of the reservoir were performed based on the principles given by E. Bajkiewicz-Grabowska and Z. Mikulski (1999). The bathymetry of the reservoir was performed employing the method of continuous echo sounding survey with the use of the echo sounder Cuda 250s/map (Eagle) M-52 (Lowrance).

The geological structure and hydrological conditions in the region of the reservoir were investigated on the basis of geologic examinations which were carried out observing the provisions of the geologic and mining law.

Soil samples for geochemical analyses were taken along the boreholes made while building the piezometers , in the passage from 0,0 to 25,0 m below the ground level, with the frequency of every 1,0 m.

Underground water samples were taken from piezometers, whereas surface water samples – along the vertical profile localized at the maximum depth of the reservoir.

The content of aluminium, iron, calcium compounds was determined by employing adsorbtion spectroscopy, after etching dry samples in the mixture of 3 parts HCl and 1 part HNO_3. The content of organic carbon was calculated from the difference between total carbon (TC) and total inorganic carbon (TIC); the values of TC and TIC were established using the SSM Shimadzu-Alalyser TOC upon previous drying the samples at the temperature of 105°C.

2. Hydrography of the anthropogenic reservoir

The natural hydrographic network in the region of Łęknica is made up of the Lusatian Neisse together with its right-bank tributaries, which drain almost the whole area of the said anthropogenic lake district.

In the area under consideration, there are watersheds of the 3rd order formed by the catchment area of the following rivers: Skroda, Chwaliszówka, Trzewna and the catchment area of the Lusatian Neisse. These are the so called certain watersheds, but only locally, for example in the flatland of the catchment area of the Skroda river, where the drainage network got transformed, there are the so called water gates. Within the strongly transformed topographic profile of the Muskau Embankment, in the watershed zone of the Skroda, Chwaliszówka and Lusatian Neisse, an area without a run-off of an evapotranspirational character was formed, where the reservoir under consideration is situated (No. 54).

The reservoir is of an anthropogenic origin. It was created in 1973 as a result of inundating the open casts formed after strip mining of lignite. It is surrounded by high, steep and strongly eroded slopes. It does not have any surface tributaries and is fed with rainfall waters, surface run-off and the inflow from underground waters.

The basic hydrographic parameters of the reservoir are as follows: area $F_0 = 0.198$ [km^2], length $L = 0.905$ [km], width: mean $B_{śr} = 0.21$ [km], maximum $B_{max} = 0.432$ [km], circumference $P_j = 2.817$ [km], elongation index $\gamma = 4.33$, shoreline development factor $K = 1.82$, capacity determined by means of the bathymetric curve method $V_0 = 1\ 808\ 262.5$ [m^3], capacity calculated by using Penck's formula $V_0 = 1\ 811\ 419.967$ [m^3], maximum depth $h_{max} = 22.0$ [m], mean depth $h_{śr} = 8{,}7$ [m].

The bathymetry of the reservoir showed that it is the deepest one in the north-eastern part (22.0 m).

The water balance of the reservoir is slightly positive: mean precipitation is $Pi = 666$ mm/year, evaporation $Ei = 460$ mm/year, underground inflow Hd pod – 338 mm/year, underground outflow Hw pod = 544 mm/year, the value of the outflow coefficient is close to unity $\alpha = H/P = 0.82$. Therefore, it can be assumed that in this particular case we deal with the so called 3rd hydrological type. The indicators and results of the balance suggest a possibility of reclaiming the reservoir (positive balance, relatively high humidity), however only to a limited extent (slightly positive balance).

3. Geological structure and hydrogeological conditions in the region of the reservoir

The area under analysis is situated in the tectonic unit called *Łuk Mużakowa (*Muskauer Faltenbogen), formed by the Southern Polish glacial lobe moving along the valley of the prehistoric Lusation Neisse and then the Mid-Polish glacier (stadial of the Warta river glaciation). The hills of the *Łuk Mużakowa (*Muskauer Faltenbogen) are an end moraine which are raised up to the ordinate of 153.0 m above the sea level. Glacitectonic disturbances reached here the depth of 140 m below the ground level (Dyjor, Wróbel 1978).

The geological structure in the region of the reservoir No. 54 was examined by means of three boreholes of the depth of 25 m below the ground level made for the piezometers (Fig. 1).

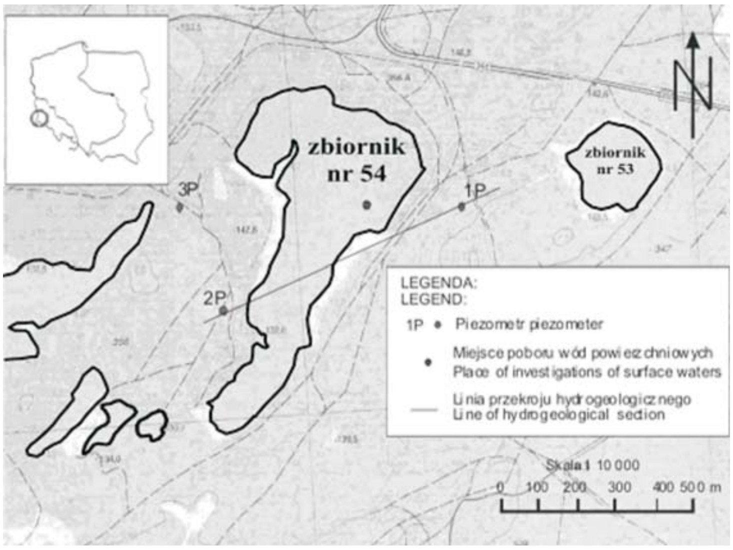

Fig. 1. The area of study

Rys. 1. Teren badań

Tertiary formations were found in the boreholes made. They were formed at the surface of the ground in the form of sands, fine and medium-sized, sometimes interbedded with loamy sand or dust of the thickness of several meters (Fig. 2). Under the sands there are Tertiary cohesive soils in the form of loamy sands, dusts or dusty clays of the thickness ranging from 0,0 to 10,0 m interbedded with lignite strata. Below there is a uniform stratum of lignite of the thickness of 1.5–1.0 m, and underneath – a stratum of sands, fine and dusty, of the thickness anging from 3.0 to 14.0 m, which constitutes the water-bearing layer. The floor of the water-bearing layer is made up of different types of lignite or dusts (of undetermined thickness).

The water-bearing layer has a tense free surface of water which stabilizes at the ordinates close to the water level of the lake (130.5–132.0 m above the sea level).

The quality of underground waters is highly affected by the presence of lignite, which can be found both in the roof and floor of the water-bearing layer (Stachura, Ratajczak 2004). Before lignite mining was started, the underground waters were protected from the influence of external factors by a stratum of cohesive soils. As a consequence of mining and the formation of open casts the water-bearing layer became uncovered in numerous post-mining troughs, including also the largest excavation (No. 54) and thus the water is now exposed to a great number of external pollutants.

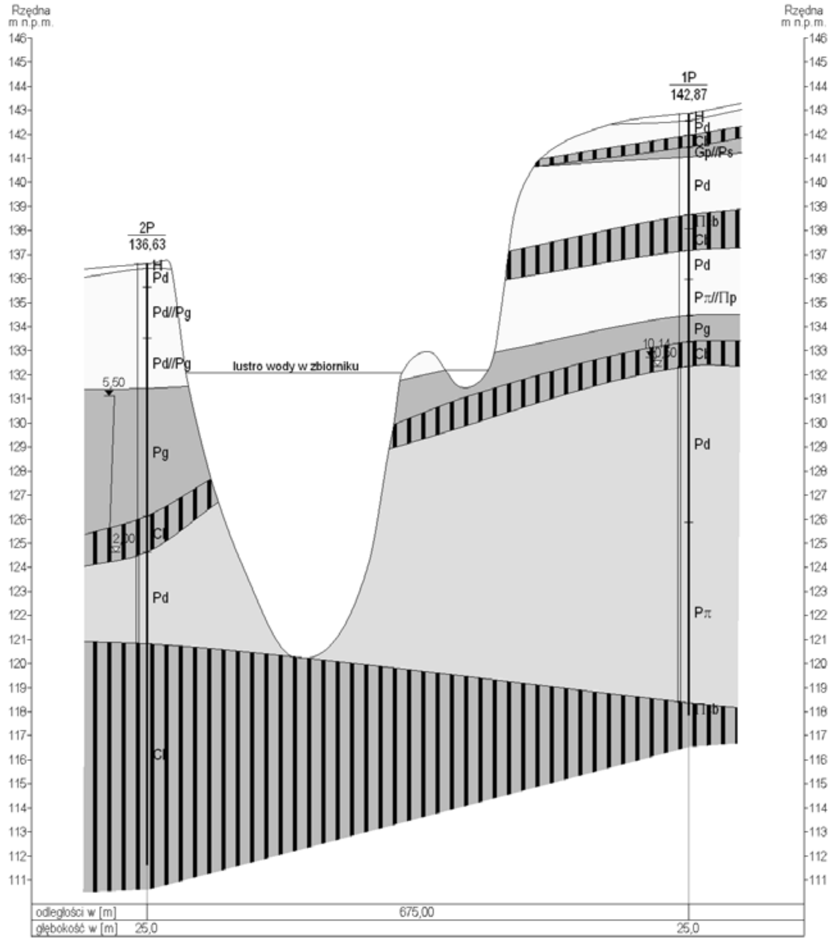

Fig. 2. Hydrogeological section
P – piezometer, H – humus, P_d – fine sand, P_g – loamy sand G_p – dusty clay, C_b – lignite, P_Π – dusty sand, Π_p – sandy dust

Rys. 2. Przekrój hydrogeologiczny
P – piezometr, H – humus, P_d – piasek drobnoziarnisty, P_g – piasek gliniasty, G_p – glina piaszczysta, C_b – węgiel brunatny, P_Π – piasek pylasty, Π_p – pył piaszczysty

The examination of the quality of underground waters proved that it is characterized by an acid reaction (from pH 2.8 in borehole 2P up to pH 5.15 in borehole 1P) and contains considerable amounts of overall iron (from 273 mg/ dm^3 in borehole 1P up to 619 mg/ dm^3 in borehole 2P) and Fe II (from 220 mg/ dm^3 in borehole 3P to 590 mg/ dm^3 in borehole 2P). The content of sulphates is also high and ranges from 185 mg/dm^3 in borehole 3P to 2163 mg/dm^3 in borehole 2P. The values of other components do not differ significantly from the values used for the classification of underground waters.

According to the *Enactment of the Ministry of the Environment on the classification for presenting the condition of surface and underground waters, monitoring and interpretation of the results as well as on the presentation of the condition of these waters*, the waters under consideration are in class 1 as to the content of phosphates, nitrites, nitrates, chlorides, magnesium, calcium, potassium and sodium, in class 2 as to conductivity and in class 5 as to the content of sulfates, manganese (partially), aluminium, overall iron, OWO (Total Organic Carbon) (partially) and pH value. However, the waters do not satisfy the provisions of the Enactment of the Ministry of the Environment on the requirements pertaining to the quality of drinking water for people as far as the pH value, the content of iron, manganese and sulfates are concerned.

The examinations carried out showed distinct differences in the chemism of underground waters in different parts of the reservoir. For instance, the water in borehole 3P, as opposed to the water in the remaining boreholes, showed considerable differences as to the pH value, acidity (general and mineral), content of iron (overall and Fe II). aluminium and sulfates. This can probably be explained by lithological differentiation of sediments in the floor and roof of the water-bearing layer (in borehole P3 no lignite was found in the direct neighbourhood of the water-bearing layer) and the direction of flow of underground waters (from the East to the West).

4. Geochemistry of the soil and water environment

The soil around the reservoir constitutes a three-phase centre, composed of the soil skeleton, air and water. The soil skeleton is made up of the following: clay minerals, non-clay minerals and organic matter. Kaolinite ($Al_4[(OH0_8Si_4O_{10}$) and montmorillonite ($(1/2Ca,Na)0,7(Al,Mg,Fe)4(OH)_4(SDi,Al)_8O_{20}nH_2O$) are predominant in the group of clay minerals. This is due to a low concentration of hydrogen ions ($pH <= 5$), where for example at $6,5<pH<6,0$ mainly halloysite is precipitated, whereas at $9.5<pH<7.8$ – illite. The grains of clay minerals, in accordance with the definition, have a diameter of $d<0.002$ mm and are composed of silicon dioxide (SiO_2), aluminium oxide (Al_2O_3) and water (H_2O), and moreover of compounds of potassium, iron and magnesium. Non- clay minerals are represented by: feldspars – mainly orthoclase($KAlSi_3O_8$), minerals from the silica group – quartz (SiO_2), cristobalite (SiO_2), tridimite (SiO_2), calcium carbonates – calcite ($CaCO_3$), aragonite ($CaCO_3$), magnesite ($MgCO_3$) and dolomite ($MgCO_3 \cdot CaCO_3$), sulfates – gypsum ($CaSO_4 \cdot 2H_2O$), phosphates – fluoroapatite ($CaFCa_4[PO_4]_3$) and hydroxyapatite ($CaOH \cdot Ca_4[PO_4]_3$), sulfides of metals – pyrite (FeS_2), metal oxides – hematite (Fe_2O_3), magnetite (Fe_3O_4), hydroxides of metals – gibbsite ($Al_2[OH]_6$), goethite ($Fe[OH]_2$) and others. The macroscopic and microscopic examinations carried out proved that the mineral substance occurs in lignite in various forms; the substance of syngenetic origin forms crystallites non-uniformly placed in the coal mass, whereas the substance of an epigenetic origin forms shapeless polymineral aggregates, including concretions, lenticles, lamellas, efflorescence and dripstones. The predominant components are clay minerals represented mainly by kaolinite, illite and montmorillonite. The forms of their occurrence suggest that they got to the bottom layer of the reservoir while organic matter was deposited, and later processes, connected with diagenesis and consolidation of coal deposits, only to a small extent affected the change of their character. Iron sulfides constitute another group of important mineral components of lignite. They are mainly in the form of pyrite, and occasionally markasite. Pyrite forms the most morphologically differentiated aggregates and even though it most frequently assumes a crystalline form, however fully developed monocrystals are rarely found and most frequently there are cryptocrystalline forms: granular or dripstone aggregates, and even widespread colonies of pyrite of bacterial origin. On the other hand, markasite does not form separate concretions, but only inclusions in crystalline aggregates of pyrite. Sulfides are most frequently accompanied by sulfates: gypsum and melanterite. These are secondary minerals which are formed as a result of oxidation of pyrite and markasite. From among carbonate minerals, calcite and aragonite are found. Quartz and native sulphur are common minerals in lignite. The organic substance occurs in the soil in the form of humus (where the content of organic substance is $2\% < Iom < 30\%$), peat ($30\% < Iom < 50\%$) or lignite ($50\% < Iom < 75\%$).

The interactions between soil particles and also the intensity of chemical reactions are a function of soil particle shape, size and properties of the specific surface and also the distance between individual particles. In the soils under examination the processes are additionally determined by the crystalline structure of clay minerals and sorption between the particles of water and soil in specific physical and chemical conditions. For example, in the presence of calcium, clays are only slightly transformed, whereas in places poor in calcium they are transformed to kaolinite clays. The ion exchange capacity is of crucial importance here, which for kaolinite is 0.03–0.15 mval/s, for illite 0.10–0.40 mval/s and for montmorillionite 0.8–1.4 mval/s, respectively. The properties of clay soils are particularly affected by the type of exchangeable cations; clays rich in sodium ion expand and swell considerably stronger than the remaining rocks, and moreover they are characterized by smaller permeability, i.e., susceptibility to migration of underground waters and the elements contained therein.

The waters which are found in the region under analysis were examined with respect to the physical and chemical composition at the following measuring points (Fig. 1): a/ piezometer P1 – waters feeding the reservoir, b/ piezometer P2 – underground waters flowing out of the reservoir, c/ surface waters – in a vertical profile, localized at the maximum depth of the reservoir (22 m), where samples were taken from the surface of the reservoir, and then every 2 meters until the bottom of the reservoir was reached.

The examinations performed showed that the composition of underground waters feeding the reservoir No. 54 is under the influence of chemical reactions connected with the presence of pyrite in the soil (Fig. 3). The underground water is characterized by a low pH value (within 4.5–4.6), it contains sulfates in the amount of 80 mg/dm^3, iron II – 11mg/ dm^3 and the concentration of calcium ions does not exceed 11.2 mg/dm^3. Thus, they are sulfate-calcium-ferrous waters. The OWO (Total Organic Carbon) values do not point to an increased content of organic substances. The concentration of dissolved substances is relatively low

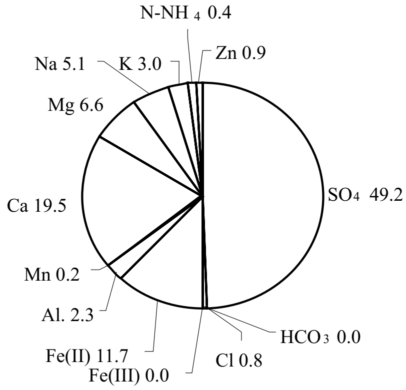

Fig. 3. Chemical composition of underground waters flowing into the reservoir [%]

Rys. 3. Skład chemiczny wód podziemnych zasilających zbiornik [%]

and amounts to 117 mg/dm^3 and the value of neutralization potential confirms small acidification of the waters.

Underground waters flowing out of the reservoir are of a different composition (Fig. 4). They are characterized by almost ten times greater mineralization as compared to the waters feeding the reservoir (1044 mg/dm^3) and they are more acidified (pH 3.2). Their neutralization potential amounts to 8.7 mmol/dm^3. The concentration of sulfates, iron and calcium is almost ten times higher than in the waters feeding the reservoir. The effect of this is an increase in concentration of dissolved substances up to the value of 1044 mg/dm^3. The quotient of molar concentration of calcium and magnesium as well as sulfates is similar in both types of waters and amounts to 0.45 and 0.46, respectively.

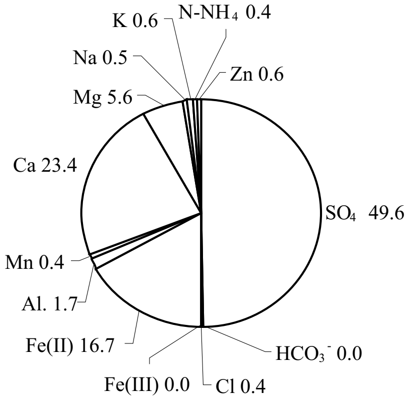

Fig. 4. Chemical composition of underground waters flowing out of the reservoir [%]

Rys. 4. Skład wód podziemnych wypływających ze zbiornika [%]

The composition of surface waters differs considerably from that of underground waters (Tab. 1).

TABLE 1

Indices of saturation of compounds in underground and surface waters

TABELA 1

Indeksy nasycenia związków w wodach podziemnych i powierzchniowych

The area of study	$Al(OH)_{3\ am}$	$KAl(SO_4)_2(OH)_6$	$CaSO_4$	$Fe(OH)_3$	$Al(OH)_3$	FeOOH	$CaSO_4 \cdot 2H_2O$	$KFe_3(SO_4)_2\ (OH)_6$	$FeSO_4 \cdot 7H_2O$
Piezometer 1 – depth 12.0 m	-2.43	3.37	-2.59	-4.33	0.41	0.95	-2.34	-14.8	-4.62
Surface reservoir – depth 5.0 m	-8.28	-6.22	-1.02	-1.11	-5.52	4.11	-0.77	2.57	-4.71
Surface reservoir – depth 11.0 m	-3.75	3.19	-0.45	-3.2	-0.88	-20	-0.19	-12.39	-1.89
Piezometer 2 – depth 10.5 m	-7.36	-5.42	-1.01	-7.85	-4.53	-2.51	-0.76	-19.09	-3.07

In the mixolimnion stratum, mineralization of the reservoir's waters increases together with the depth of the reservoir and is within the range of 1502 to 1565 mg/dm^3, whereas in the monimolimnion stratum it ranges from 3484 mg/dm^3 at the depth of 9 m to 5509 mg/ dm^3 at the bottom (at the depth of 21 m below the ground level). In the line of the hydrogeological section the maximum depth of the reservoir is 11 m, the monimolimnion stratum thickness is approximately 3 m and the concentration of dissolved substances at the bottom is 4156 mg/dm^3. The pH value of surface layers of the reservoir's water is within the range of 2.54 to 2.6, whereas in the deeper layers from 4.13 to 4.78. The values of neutralization potential show that acidification of the reservoir's water increases together with the depth. Surface and underground waters maintain a very similar ion composition. They are sulphate waters with a small concentration of chlorides (from 1 to 5 mg/dm^3). Calcium and iron are predominant among cations. The degree of iron oxidation depends on the amount of oxygen dissolved in the water. In the surface layers of the reservoir's water, aluminium additionally makes up for 8% of the total number of ions. In underground waters this contribution decreases to the value below 2.3%. The contribution of iron ions increases together with the depth of the reservoir (from about 20 to 35%). The contribution of calcium does not change in the vertical profile of the reservoir and remains on the level of 13–14% (smaller than in the underground waters). In the mixolimnion stratum, an increased concentration of zinc is observed which is within the range of 3 to 4 mg/dm^3. The contribution of this element in the ion composition of surface waters, which are in the oxygenated zone, is 0.1 mg/dm^3, whereas in underground waters, with the concentration of the order of 1 mg/dm^3, it is 0.9 mg/dm^3 in piezometer P1 and ranges from 4.49 mg/dm^3 to 0.6 mg/dm^3 in piezometer P2.

The composition of underground waters feeding the reservoir was disturbed due to pyrite weathering, according to the reactions:

$$FeS_2 + {}^7/_2O_2 + H_2O = Fe^{II} + 2SO_4^{2-} + 2H^+ \tag{1}$$

$$Fe^{II} + {}^1/_4O_2 + H^+ = Fe^{III} + {}^1/_2H_2O \tag{2}$$

$$Fe^{III} + 3H_2O = Fe(OH)_3 + 3H^+ \tag{3}$$

The products of pyrite weathering are Fe II ions and sulfates which develop at pH<4 in the stoichiometric ratio of 1:2 (Schopke et al. 2001). In underground waters feeding the reservoir the content of iron is lower that it follows from the stoichiometry of pyrite weathering reaction. Due to the fact that the soils around the reservoir are poor in calcium compounds, only a partial neutralization of released protons took place up to the pH value of approximately 4.4 and the water was slightly enriched in calcium.

Trace amounts of aluminium indicate a small intensity of aluminosilicate weathering. An increase in the pH value of the water above 4 created positive conditions for the precipitation of goethite (Tab. 1) according to the reaction:

$$Fe^{3+} + 2H_2O = FeOOH + 3H^+ \tag{4}$$

whose easy solubility most likely determines the content of iron in the water.

Oxygenation of underground waters as a result of contact with the surface waters resulted in acceleration of pyrite weathering processes due to an increase in the concentration of Fe III ions in accordance with the mechanism described by Nordstrom. The effect of this is a considerable decrease in the water pH value up to conditions favouring aluminosilicate weathering. In the surface layers of the reservoir’s water conditions which favoured the precipitation of alkaline iron sulfates were created (jarosite K). It allowed the migration of precipitated iron sulfates to the deeper layers of the reservoir. There jarosite was dissolved, iron ions were reduced, OH ions were released into the solution and the pH value increased. A change in the pH value created favourable conditions for the precipitation of alkaline aluminium sulfate from the water and for the migration of this compound into the bottom layer of the reservoir. An increase in water density resulting from the migration of iron and sulfate ions into deeper layers of the reservoir determined meromixis.

A small content of organic substances in monimolimnion waters is a factor which limits the processes of biochemical reduction of sulfates and precipitation of iron sulfide from the water. These processes most likely occur in the soil only when the water flows between the reservoir and piezometer P2. A considerable decrease in the concentration of iron and sulfates as well as a decrease of neutralization potential (reduction of acidification) point to the above. Since the ratio of concentrations of the sum of calcium and magnesium ions in underground waters is by 0.1 higher than in surface waters, weathering processes of minerals rich in calcium also take place to a small extent and the concentration of calcium is limited mainly by the solubility of calcium sulfates. Oxygenation of underground waters in the area under investigation due to their outflow onto the surface of the area and contact with the surface waters of the reservoir caused essential changes in their physical and chemical composition. Additional factors which determine such a large degree of underground waters degradation are the chemical changes going on in the reservoir, which led to meromixis.

Conclusions

— Strip mining of lignite brings about significant changes in the soil and water environment.

— Physical and chemical conditions in the zone of soils weathering, formed due to strip mining, determine the great differentiation of the mineral composition of soils, particularly with respect to the content of clay fractions and pyrite decomposition.

— The interactions between soil particles and also the intensity of chemical reactions are a function of soil particles shape, size and properties of the specific surface and dependences between individual particles which follow from the crystalline structure of clay minerals and sorption between water and soil particles.

— Lignite deposits are accompanied by various forms of iron sulfates (mainly pyrite and markasite), whose weathering causes a change in the physical and chemical composition of surface and underground waters.

— The composition of waters is determined both by the presence of pyrite and the transformations going on in the reservoir's waters due to meromixis.

— The direction of underground water flow has a significant effect on the water quality. If there are surface waters on the way and direction of underground waters flow, their composition is determined by geochemical properties of soil and underground waters.

— Identification of geochemical conditions in the catchment area of an anthropogenic reservoir can be helpful in analysing the direction of migration of elements and in indicating further transformations of the chemical composition of soils and waters. On this basis we can determine a method for reclaiming the waters of the reservoir under consideration as well as other areas degraded due to mining of mineral resources.

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HYDROLOGICAL, GEOLOGICAL AND GEOCHEMICAL CONDITIONS DETERMINING RECLAMATION OF POST – MINE LAND IN THE REGION OF ŁĘKNICA

Key words

Lignite, pyrite, acidified post-mine waters

Abstract

Strip mining brings about the transformation of the land surface as well as quantitative and qualitative changes in water resources.

Strip mining of lignite in the region of Łęknica (SW Poland) has resulted in the formation of the largest anthropogenic lake district in Poland.

As a result of lignite mining in the areas, which are galcitectonically disturbed, numerous isolated open casts are formed on the surface of the earth, which after the end of mining often get filled with water and form the characteristic anthropogenic lake districts. It consists of more than 100 reservoirs of the area ranging from 0.01 to 20.20 hectares, which are spread over the area of approximately 40 hectares.

In order to study the effect of lignite mining on the land and water environment detailed hydrographic, geological and chemical examinations were carried out within a selected reservoir of the above mentioned lake district. The examinations revealed that lignite mining resulted in the formation of reservoirs and changes in the water relations and then consequently led to the degradation of water quality, which consists among others in the acidification of surface waters up to the pH value of 2,5 and in the enrichment of underground waters in iron and sulfates.

HYDROLOGICZNE, GEOLOGICZNE I GEOCHEMICZNE UWARUNKOWANIA REKULTYWACJI OBSZARÓW POEKSPLOATACYJNYCH W REJONIE ŁĘKNICY (SW POLSKA)

Słowa kluczowe

Węgiel brunatny, piryt, zakwaszone wody pokopalniane

Streszczenie

Górnictwo odkrywkowe powoduje przekształcenie powierzchni ziemi oraz zmiany ilościowe i jakościowe zasobów wodnych.

Eksploatacja odkrywkowa węgla brunatnego w rejonie Łęknicy (SW Polska) doprowadziła do utworzenia największego w Polsce pojezierza antropogenicznego, złożonego z ponad 100 zbiorników o powierzchni od 0,01 do 20,20 ha, zgromadzonych na obszarze o powierzchni około 420 ha.

W celu zbadania wpływu eksploatacji węgla brunatnego na środowisko gruntowo-wodne tego rejonu przeprowadzono szczegółowe badania hydrograficzne, geologiczne i chemiczne w obrębie wybranego zbiornika pojezierza (nr 54). Badania te wykazały, że wskutek eksploatacji węgla brunatnego doszło do utworzenia zbiorników powierzchniowych, a następnie zmiany stosunków wodnych i degradacji jakości wody powierzchniowej, polegającej m.in. na zakwaszeniu wód powierzchniowych do pH 2,5 oraz wzbogaceniu wód podziemnych w ponadnormatywne zawartości żelaza i siarczanów.