XXXVIII IAH Congress

Groundwater Quality Sustainability
Krakow, 12–17 September 2010

Extended Abstracts

Editors:
Andrzej Zuber
Jarosław Kania
Ewa Kmiecik

University of Silesia Press 2010

abstract id: **278**

topic: **1**
Groundwater quality sustainability

1.1
Evaluation and management of groundwater — sustainable exploitation

title: **Water management in abandoned lignite open pits in Poland**

author(s): **Jacek Szczepiński**
Poltegor-projekt Sp. z o.o., Poland, j.szczepinski@poltegor.pl

Janusz Fiszer
Politechnika Wrocławska, Poland, janusz.fiszer@pwr.wroc.pl

Zbigniew Stachowicz
Poltegor-projekt Sp. z o.o., Poland, z.stachowicz@poltegor.pl

Paweł Szczepanik
Poltegor-projekt Sp. z o.o., Poland, p.szczepanik@poltegor.pl

keywords: water management, open pits

INTRODUCTION

In Poland approximately 2400 open pits of different rock materials are operated, and some 60 million tons of lignite are mined by surface method. The most rational method for reclamation of open pits is filling the voids with ground water, supported by surface water. The objective of this paper is to acquaint the participants of the XXXVIII IAH Congress held in Poland with reclamation by flooding of abandoned lignite open pits in the host country. Besides, it provides also some data on hydrogeological conditions of lignite mines in Poland.

HYDROGEOLOGICAL CONDITIONS OF POLISH LIGNITE MINES

Lignite is one of two main sources for electric energy production in Poland. The operated lignite open pit mines are Tertiary age and occur in the Central (Bełchatow Region), Western (Konin-Adamów Region) and South-Western (Turów Region) part of Poland (Fig. 1). Presently the lignite output is in range of 57–60 millions tons per year. The floor depth of seams below the terrain surface varies from 40 to 260 m. The thickness of lignite occurring in 1 to 3 seams is from 5 to 60 m and overburden thickness is from 30 to 240 m. The overburden constitutes Tertiary and Quaternary formations consisting of silt and clays (30%–75%) and sands (70%–25%). All deposits are below the natural groundwater table that occurs most frequently right under the terrain surface (from 1 down to 5 m) and have different hydrogeological conditions (Libicki, 1987). Annual precipitation in the regions of lignite basins varies from 500–700 mm/year, the climate is moderate with the average annual temperature about 8°C. Groundwater is drained by deep wells with submersible pumps.

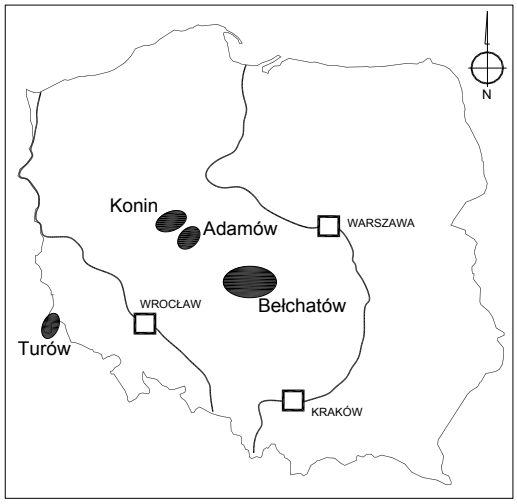

Figure 1. Lignite production in Poland.

In the **Konin-Adamów Basin** the most important are the confined aquifers (Tertiary and Mesozoic) with average permeability 3 m/d, but it may increase until 40 m/d in the cretaceous marls (Fig. 2). Depending on the open pit, the groundwater table is lowered from 40–100 m, and the radius of cone of depression is 4–9 km. The mine water inflow for all open pit mines in the region is in average 310 m^3/min.

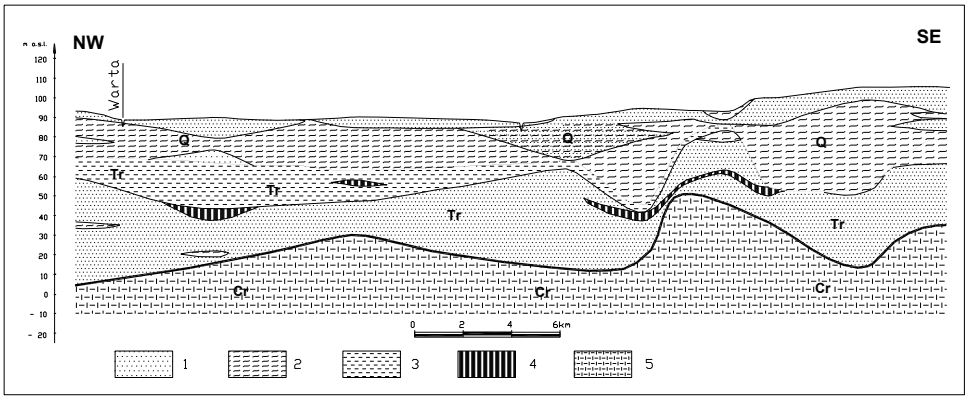

Figure 2. Simplified geological cross-section through the Adamów-Konin Lignite Basin. Explanations: 1 — fine and medium sands, 2 — clays, 3 — silts, 4 — lignite, 5 — marls, Q — Quaternary, Tr — Tertiary, Cr — Cretaceous.

Turów Lignite Basin has a shape of real basin (tectonic depression), having thickness from 50 m on the boundary to 300 m in the middle. The bed constitutes impermeable Palaeozoic rock filled with two lignite seams inside (Fig. 3). The overburden (Quaternary and Tertiary) consists of clays and sands which occur in form of closed lenses from 1 to 30 m thick with average permeability of 13 m/d. They contain static groundwater under pressure of 2–20 Ba depending on the depth. The mine water inflow is 20–30 m^3/min and the cone of depression is about 2 km.

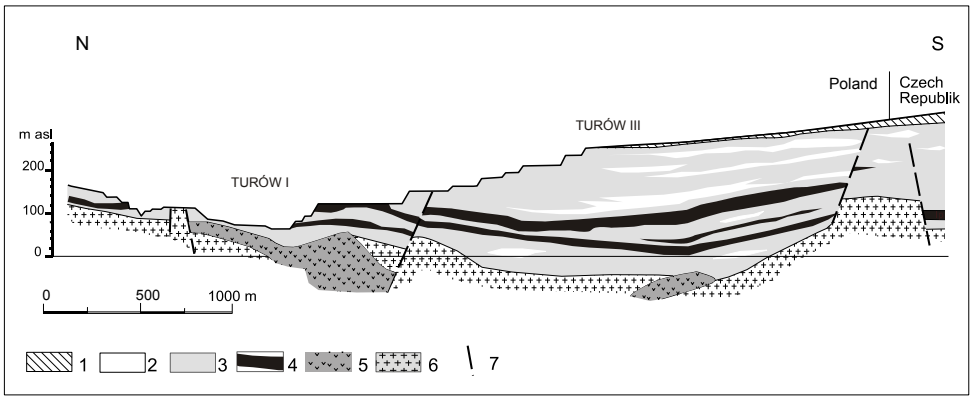

Figure 3. Simplified geological cross-section through the Turów Lignite Basin. Explanations: Quaternary: 1-gravels, sands and silts; Tertiary: 2-gravels and sands, 3-clays and silts; 4-lignite; 5-basalts; Palaeozoic: 6-granitoid and decomposed rocks, 7-main faults.

Bełchatów Lignite Basin is deposited in the tectonic rift valley. The aquifers occurring in the particular stratigraphic series (Mesozoic, Tertiary and Quaternary) have many geological and hydraulic connections, so the whole complex of the permeable rocks creates one huge and heterogeneous aquifer in the whole region (Fig. 4). The hydraulic conductivity for Mesozoic aquifers (fractured limestone, marls and sandstone) is very diversified, the highest is in the karstified limestones. The average hydraulic conductivity for Quaternary sand-gravel series is 20 m/day. The mine water inflow for two working open pits amounts to 500 m^3/min. The groundwater table is lowered about 300 m, and the radius of cone of depression is 3-9 km.

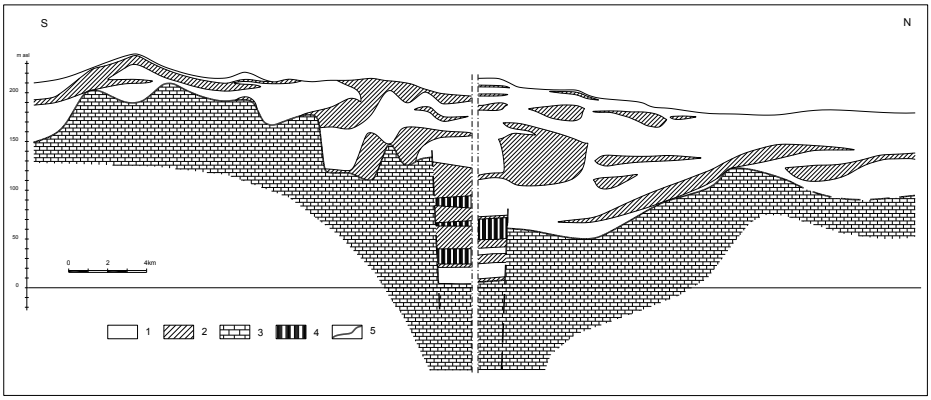

Figure 4. Simplified geological cross-section through the Bełchatów Lignite Basin. Explanation: 1 — porous, permeable formations, 2 — impermeable and slightly permeable formations, 3 — fissured-karstic formations, 4 — lignite, 5 — faults.

RECLAMATION OF ABANDONED LIGNITE OPEN PITS BY FLOODING

The final reclamation of abandoned lignite open pits in Poland faced no major problems as yet, owing to small depth and size of open pits (between 15 m and 40 m) changed into water reservoirs and, due to the possibility of their complete or partial backfilling by the overburden from adjacent open pits, and also due to a relatively simple water regime as well. Pit lakes (Tab. 1) are formed deliberately as a planned part of the after-use of a lignite mine voids and they can be used as wildlife habitats, fisheries, water sports venues or other forms of amenity. In **the Adamów Lignite Mine** the water reservoirs have been a part of the Bogdałów, Koźmin (Janiszew) and Adamów (Przykona) post mining areas (Fig. 5) with a total capacity of 12 mln m^3.

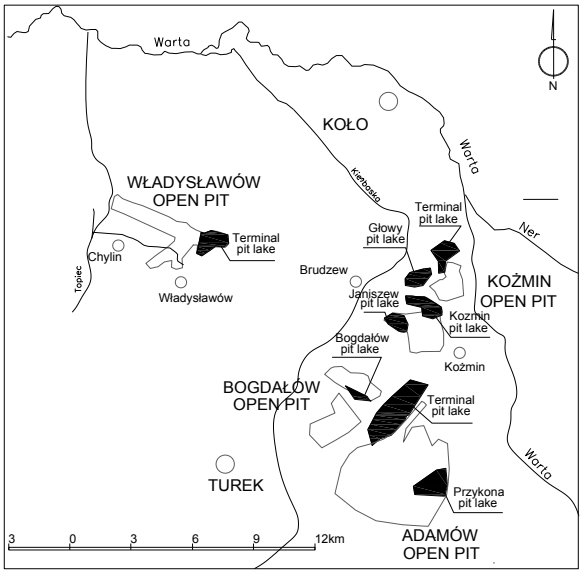

Figure 5. Site map of pit lakes in the Adamów post mining area (courtesy of the Adamow Lignite Mine).

Table 1. Reclamation of abandoned lignite open pits by filling with water in Poland.

Lignite mine	Lignite production	Number open pits	Pit lakes total area (km²)	Pit lakes total volume millions m³)
Adamów	1964–2023	4	1.1	252
Konin	1946–2037	12	3.1	968
Bełchatów	1981–2038	2	38.9	3 100
Turów	1904–2040	1	16.9–18.7	1 220–1 600

In the near future, the next pit lakes are planned to be built in the post mining areas of the Koźmin, Władysławów and Adamów mines with a total volume of 239 mln m³. The flooding of the Koźmin and Władysławów post mining voids is likely to take 2-3 years, but in case of the Adamów voids 15-20 year (information from the Adamow Lignite Mine). In each case the surface mine voids will be flooded by natural groundwater inflow, water pumped out from dewatering of the neighboring open pits and water courses. As regards to **the Konin Lignite Mine** in the final excavations of the five abandoned open pits (Morzysław, Niesłusz, Pątnów Gosławice, Kazimierz S) the pit lakes were established (Fig. 6). Presently the Lubstów post mining void is under flooding. No problems shall also be faced with future filling with water of the other open pits having average depth from 50 to 65 meters.

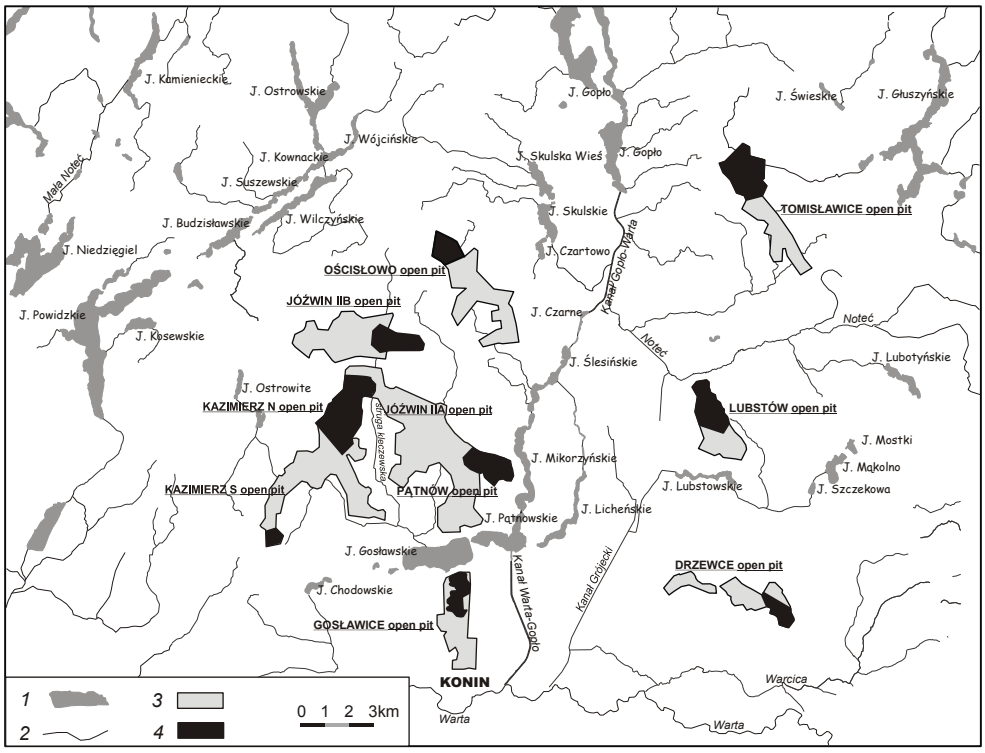

Figure 6. Site map of pit lakes in the Konin post mining area. Explanation: 1-natural lakes, 2-rivers and courses, 3- internal dumping sites, 4-pit lakes.

Modeling studies reveal that the flooding the next post mining excavations in the Konin Lignite Mine using only natural groundwater inflow is likely to take between 10 - 30 years. It will finish

in 2069 (Fiszer et al., 2009). To speed up this process it is provided to use water from dewatering of neighboring open pits or from surface waters.

Considerably much more difficult will be the solution of problems associated with the reclamation of final excavations of the Turów Lignite Mine in the south-west part of Poland and **the Bełchatów Lignite Mine** in the central part of Poland. An effect of lignite mining in these areas will be large-space abandoned open pits whose volume will exceed one billion cubic meters. In 2019, it is planned to cease lignite production in the Bełchatów open pit and in 2038 at the adjacent Szczerców open pit. As a result of reclamation works the Bełchatów and Szczerców voids will be formed, which area will reach 16.9 km^2 and 22.0 km^2 and volume of 1.3 billion m^3 and 1.8 billion m^3 respectively (Fig. 8).

The process of filling the post-mining excavations with water in the Bełchatow void will start in 2027 and in the Szczerców void it will start in 2049. Two conceptions of flooding have been taken into consideration (Kasztelewicz et al., 2008). For the first one the assumption was that the water reservoirs will be filled with groundwater in a natural way, by additional recharge with water from the well barriers located around the open pits. Calculations reveal that the process of flooding will be finished after 2100 (Fig. 7).

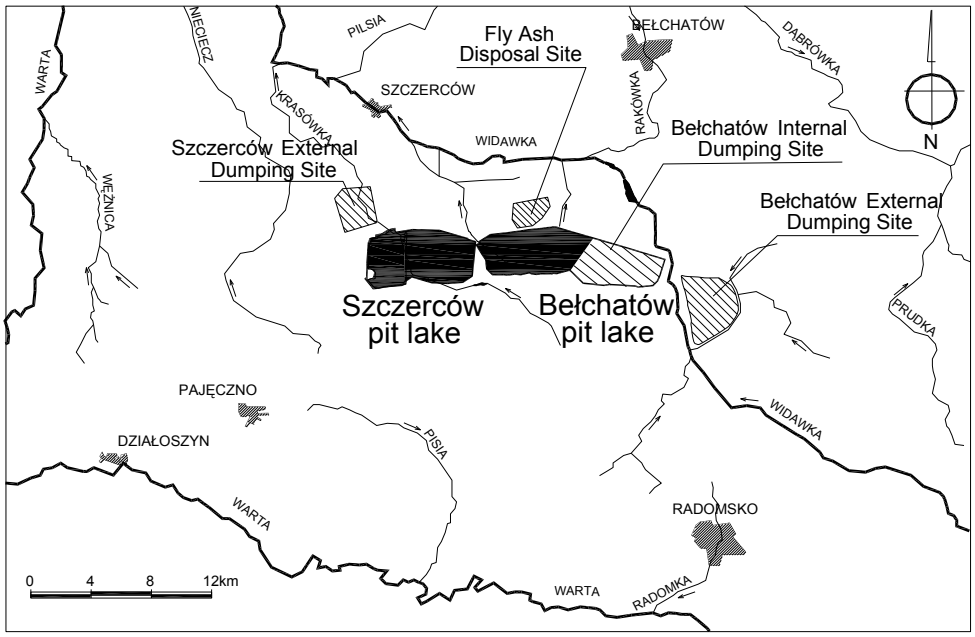

Figure 7. Site map of pit lakes in the Bełchatow post mining area.

In the second conception the assumption was that the voids will be filled with groundwater in a natural way, but aided by additional recharge from the Warta river and the Widawka river at a rate of 2.25 m^3/s or 4 m^3/s. The results of calculations have shown that the flooding will last until 2072 and 2062 respectively. Water from the pit lakes will discharge into the Widawka river.

Lignite production in the **Turów Lignite Mine** is planned to cease in 2040. The preparation of void for flooding will be completed in 2050. In order to estimate the time of flooding the void the following assumption has been made: (1) the reservoir will be flooded only with surface water from the Nysa Łużycka river and the Miedzianka river at a rate of 3.87 m^3/s, (2) groundwater inflow into the void, average 20 m^3/min, will be prevented by water collected in it, causing excess pressure on the groundwater in the vicinity of the void, (3) precipitation on the pit lake surface supplements the losses associated with evaporation.

The calculations made for average hydrological conditions reveal that the time of filling the void will reach 10 or 13 years depending on the final excavation shallowing (Fiszer et al., 2005). Therefore the flooding will finish between years 2060–2063 (Fig. 8).

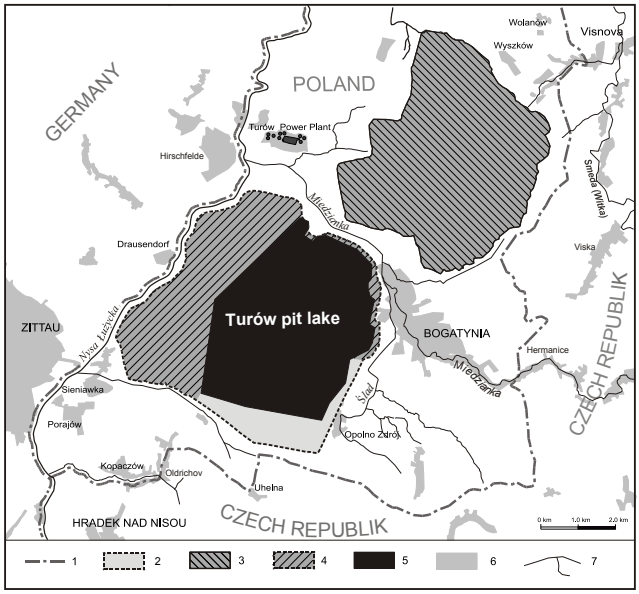

Figure 8. Site map of the Turów pit lake. Explanation: 1-state border, 2-post mining areas, 3-internal dumping site, 4-external dumping site post-mining areas, 5-pit lake, 6-villages, 7-rivers and courses.

After filling the reservoir the water, in order to compensate for evaporation losses, the pit lake will be feed by water from the Nysa Łużycka river in an amount of 0,075 m^3/s. Water from the pit lake will discharge into the Miedzianka river.

It should be noted, that in the existing and abandoned Polish lignite open pits there are favorable conditions in terms of water quality formation (Polak, 2004). An analysis of geologic profiles in the Pątnow open pit indicates on the carbonate rocks and low content of pyrite in the overburden. The results are that acidic water are largely neutralized. However, the studies indicate a potentially threat to the water quality in flooding voids, where they are recharged only by groundwater. In many cases, what is crucial for the chemistry of the pit lakes is flooding the voids using water from outside of the pit. Filling the void with surface water or even water pumped out from dewatering well reduces the probable pit lakes deterioration.

REFERENCES

Fiszer J., (Ed.), 2009: *Numeryczny model hydrogeologiczny dla KWB Konin w zasięgu oddziaływania systemu odwadniania wraz bilansem wodno-gospodarczym (Hydrogeological numerical model for the area of dewatering influence with the water economy balance for the Konin Lignite Mine),* Politechnika Wrocławska (not published).

Fiszer J., Batog A., Tomaszewski J., 2005: *Wstępna koncepcja napełniania zbiornika wodnego w wyrobisku poeksploatacyjnym kopalni „Turów" (Preliminary concept of filling with water the Turów post mining excavation)*. BUHiKAŚ „HYDROS" (not published).

Kasztelewicz Z. (Ed.), 2008 - Koncepcja rekultywacji i zagospodarowania wyrobisk końcowych Zakładu Górniczego KWB Bełchatów (Concept of reclamation and management the final excavations of the Bełchatów Lignite Mine), AGH Kraków (not published).

Libicki J., 1987: *Hydrogeological conditions of lignite basin in Poland and their changes caused by dewatering lignite open pits.* In: Proc. of the Int. Symp. Hydrogeology of Coal Basin: pp. 525 – 536.

Polak K., 2004: *Zagrożenia jakości wód w zbiornikach poeksploatacyjnych kopalń węgla brunatnego (Water quality endangering in post lignite mining lakes).* In Proc. of the. Symp. Problematyka zagrożeń naturalnych w górnictwie węgla brunatnego, IGSMiE PAN, 62: pp. 225 – 267.

International Association of Hydrogeologists

AGH University of Science and Technology

2-vol. set + CD
ISSN 0208-6336
ISBN 978-83-226-1979-0