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Pit lakes of the Central German lignite mining district: Creation, morphometry and water quality aspects

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ABSTRACT

About 140 pit lakes exist in Central Germany. These have resulted from lignite mining and are important parts of the post-mining landscape in the Central German lignite mining district. Their water quality is mainly influenced by the consequences of pyrite oxidation, i.e., acidification or results of natural or artificial neutralization. The major way of filling as well as a cheap and successful measure against acidification was the diversion of river water into the lakes or their filling with neutral water from mines still operating. Eutrophication, contamination by industrial pollutants and infection with pathogens imported with river water were found to be unimportant threats for the pit lakes in the Central German lignite mining district. Intrusion of naturally saline groundwater from deeper underground resulted in some cases in elevated concentrations of sodium chloride and in meromixis. The diverse uses of the lakes (e.g. recreation, nature conservation, water management) indicate that the pit lakes fulfil widely the typical functions of lakes in a landscape. The creation, the current state of water quality and lessons learned in water quality management are reported upon for the pit lakes of the Central German lignite mining district.

Introduction

Lakes and rivers are dominant inland surface waters and important parts of the landscape. Because of their properties, lakes have particular ecological and socio-economic functions as habitat for aquatic organisms, sites for fishery and recreation, etc. Artificial lakes and reservoirs should fulfil those functions as far as possible.

The region called "Central Germany", i.e., the area described by circles around Leipzig and Halle/Saale of about 150 km in diameter, is poor in natural lakes. Surface mining has changed this situation, mainly within the last 120 years. Many artificial lakes formed in former excavations of clay, sand and gravel, in former quarries and in former open-cast lignite mines when the respective operations ceased. This paper deals only with lakes in former open-cast lignite mines. For simplification, these lakes are generally called pit lakes in this paper.

There are about 140 pit lakes in the Central German lignite mining district today, i.e., about 28% of the pit lakes in all German lignite mining districts. Fig. 1 shows a map of the mining district including the lakes which are planned to form in the currently operating lignite mines.

When managing pit lakes, one may be faced with one or more of the following concerns with respect to water quality (Klapper and Schultze, 1995):

- Acidification caused by pyrite oxidation and the accompanying mobilization of acidity, iron and sulphate.
- Eutrophication caused by excessive import of phosphorus and nitrogen via river water for filling or flushing the lake or inappropriate lake use (e.g. excessive feeding in aquaculture).
- Contamination with industrial pollutants caused by groundwater inflow from industrial sites or waste deposits in the vicinity of pit lakes.
- Salinization by highly saline ground water.
- Infection by import of pathogens via river water which in turn was impacted by waste water.

In this paper, we report on the creation and the current characteristics of the lakes in the former lignite open-cast mines of the Central German lignite mining district. In addition to the description of the current conditions, lessons learned are presented.

Data sources

The data presented below originate from lake monitoring in spring 2007, as far as possible. Morphometric data were taken

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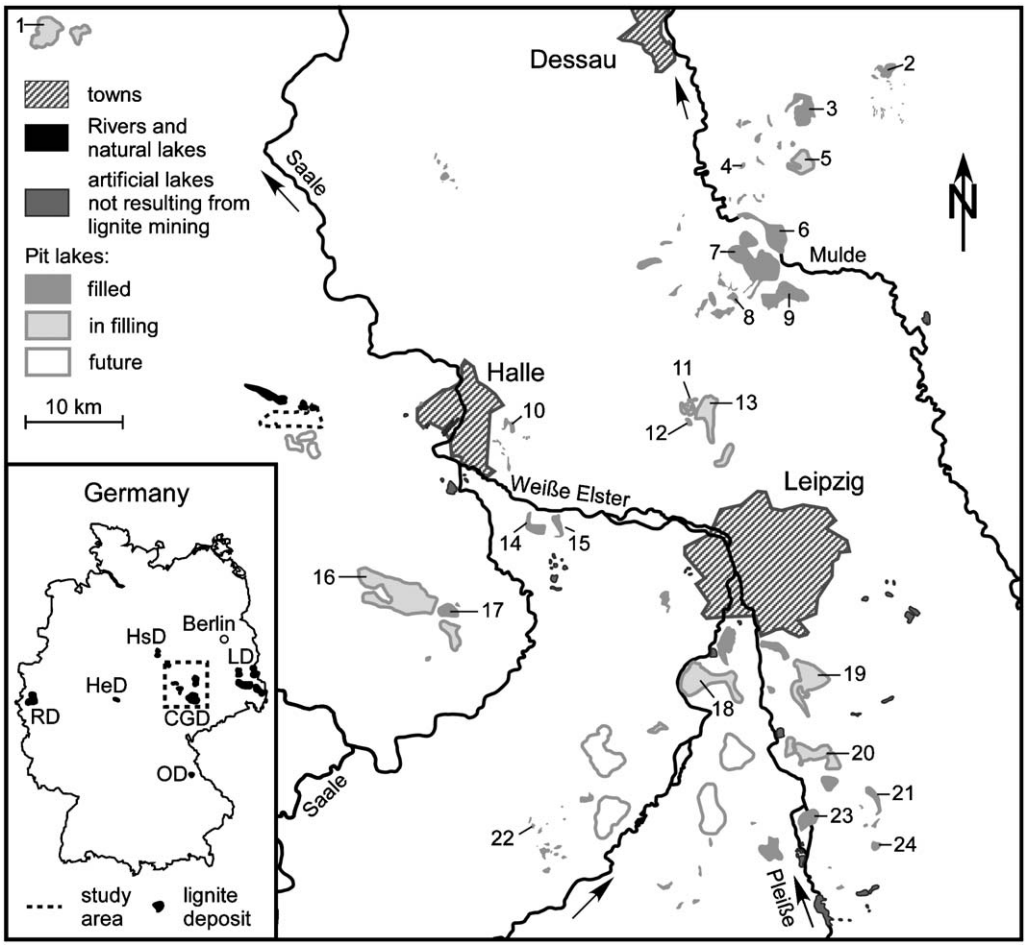

Fig. 1. Map of the Central Germany mining district showing the pit lakes resulting from lignite mining, the major rivers and some towns for orientation. The lakes mentioned in the text are: 1 – Lake Concordia, 2 – Lake Bergwitz, 3 – Lake Gremmin, 4 – Lake Golpa IV, 5 – Lake Gröbern, 6 – Muldereservoir, 7 – Lake Goitsche, 8 – Lake Paupitzsch, 9 – Lake Seelhausen, 10 – Lake Hufeisen, 11 – Lake Grabschütz, 12 – Lake Zwochau, 13 – Lake Werbelin, 14 – Lake Wallendorf, 15 – Lake Rassnitz, 16 – Lake Geiseltal, 17 – Lake Runstedt, 18 – Lake Zwenkau, 19 – Lake Störmtal, 20 – Lake Hain-Haubitz, 21 – Lake Bockwitz, 22 – Lake Vollert Süd, 23 – Lake Borna, 24 – Lake Harthsee. The dotted black line west of Halle indicates the natural Lake Salziger See, which disappeared in 1890 due to dewatering operations of underground mining for copper. Dewatering of the lake basin is still performed although copper mining ceased and the underground galleries are flooded. The lake will be re-established in the future. Lignite mining districts in Germany: RD – Rhineland district, HeD – district of Hessen, HsD – district of Helmstedt, OD – district of Oberpfalz, CDG – Central German district, LD – Lusatian district.

from the web sites of Mitteldeutscher Seenkatalog (community of governmental and non-governmental institutions concerned with and interested in the sustainable development of lakes in Central Germany; www.mitteldeutscheseen.de) and of Lausitzer und Mitteldeutsche Bergbau-Verwaltungsgesellschaft (LMBV; state company responsible for the remediation of the former lignite mines in eastern Germany; www.lmbv.de). Water quality data were provided by the LMBV as far as the LMBV was responsible for water quality monitoring in 2007. The Landestalsperrenverwaltung des Freistaates Sachsen (authority of the federal state of Saxony responsible for the management of reservoirs and lakes in Saxony) provided data for pit lakes according to its responsibility. Data of other lakes were taken from web-published results of lake monitoring in the federal state of Saxonia-Anhalt in 2007 (www.sachsen-anhalt.de/LPSA/index.php?id=27953) or for some cases from a report on the status of German pit lakes by Nixdorf et al. (2001). The data from Nixdorf et al. (2001) can still be considered as representative since the respective pit lakes are older and show mainly seasonal variations in water quality but nearly no inter-annual trends. Less data were available from small and/or old lakes. Therefore, the small and/or old pit lakes are generally underrepresented in this study.

Creation

In the 19th century or in some cases even earlier, lignite mining began where lignite seams reached the surface. The exploitation was performed by hand with very simple technical devices. Accordingly, the first surface mines were very small. The same applies for the first pit lakes forming in such abandoned mines at the end of the 19th or at the beginning of the 20th century, e.g. the Gniester lakes south of Lake Bergwitz. The surface areas of these lakes are in the range of some 100 m^2 only and the depths are in the range of 10 m or less. The pressure of Pleistocene glaciation resulted in folding of Tertiary layers including lignite seams in the region of the Gniester lakes. The tops of the lignite folds reached the surface (Litt and Wansa, 2008). Larger excavators and improved dewatering technology resulted in larger mines and, consequently, larger pit lakes. However, relatively small lakes may form due to technical reasons and efficient overburden handling even today, e.g. Lake Zwochau and Lake Grabschütz.

Until the 1970s, the filling of the lakes was exclusively based on local runoff and rebound of the groundwater level in the Central German lignite mining district after ceasing