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Extended Abstracts

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General hydrogeological problems

6.4
Cost-effective measures to control and contain groundwater contamination

Low-cost permeable barriers for acid rock drainage prevention and control

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Sulfidic waste rock or tailings from coal and metalliferrous ore mining and enrichment processes, which constitutes the largest waste stream in the world, is an environmentally problematic material due to acid generation potential resulting from sulfide oxidation and formation of sulfate- and metal-rich leachate called Acid Rock Drainage (ARD). In accordance with Directive 2000/60/EC and legislation of other countries with developed extractive industries, the operator of a waste facility is obliged to prevent or minimize leachate generation and groundwater from being contaminated. The basis of preventive measures might be either minimization of the oxygen transport to sulfide minerals, or treating contaminated water and leachate to the appropriate standard, or applying both these measures to efficiently mitigate groundwater deterioration. The biggest problem with environmentally safe management of ARD generating waste rock is the scale of extractive waste facilities, which involves the need of large amounts of a material to be applied as oxygen transport barrier (in covers or intrinsic layers) or as a material preventing contaminant transport (e.g. metal sorbent). Such materials, besides efficiency in long-term applications, are thus to be abundant, easily available and cost-effective. These requirements may be fulfilled, if appropriate waste materials are used in an effective and environmentally safe way.

Considering the availability, abundance and required properties, two kinds of waste materials were selected as potentially applicable in barriers: (A) dense mixture of low-quality water with fly ash from coal combustion (FA); (B) sewage sludge (SS) from municipal sewage treatment facilities (MSTF). Both studied materials originated from the Upper Silesia coal basin (USCB) in Poland, the coalfields of the highest hard coal output and the highest concentration of sulfidic wastes in the EU. A series of laboratory batch experiments confirmed high penetration resistance of solidified FA dense mixtures (I) ranging from 1100 to 1990 kPa, high hydraulic conductivity and low permeability to air; SS showed high binding capacity for metals comparable to natural sorbents such as peat, which for Me–SO_4 systems ranged from 24600 mg/kg (Ni) through 49 200 mg/kg (Cr), up to 181 450 mg/kg (Pb).

Further long-term bench experiments in columns φ 0.30 m and H =1.5 m simulated high-metal ARD (Tab. 1) migration through a layer of sulfidic waste with protective layers of FA dense mixtures and stabilized SS in different configurations. A composition of input solution reflected environmentally relevant contents of metals reported in different ARD, while infiltration rate was computed for local weather conditions with use of WHI UnSat Suite Plus v. 2.2.0.3 program.

Table 1. Mean concentrations of ions [mg/L] in the simulated ARD applied to columns.

pH	Fe	Mn	Cd	Cr(III)	Cu	Ni	Pb	Zn	SO_4	NO_3
1.5	680	242	48.3	179	221	241	1.094	230	18276	620

Comparative results of simulated ARD application in 1-year's infiltration cycle onto sulfidic coal mining waste layer 1.0 m high without (I) and with protective barriers (II) showed high efficiency of trace metal binding onto barriers (example — Fig. 1).

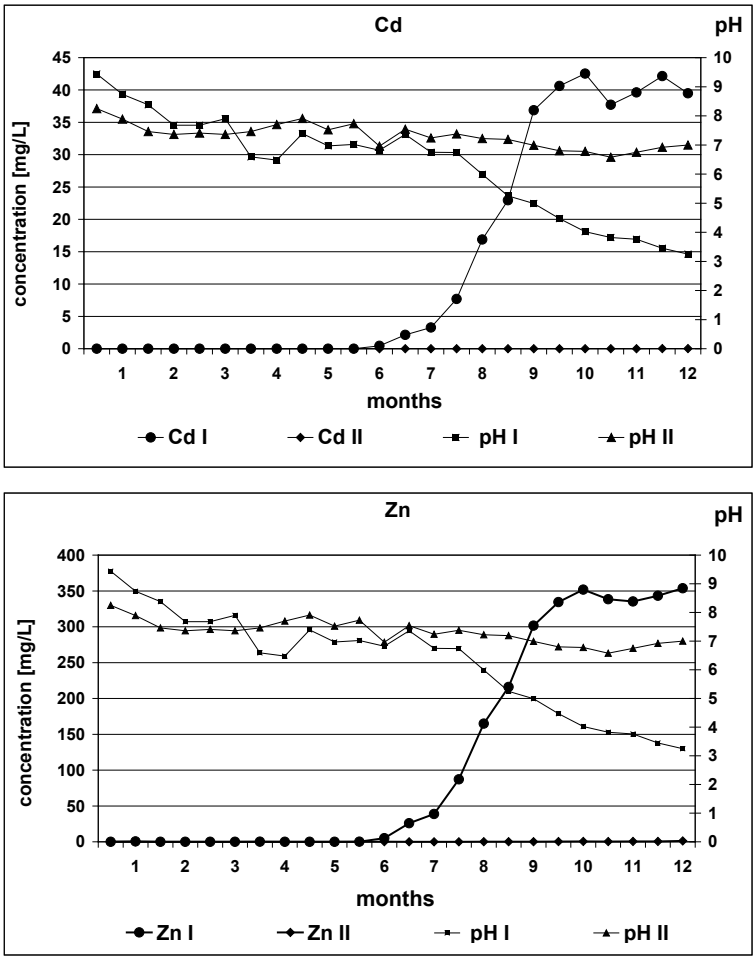

Figure 1. Concentrations of metals (Cd and Zn) in leachate from ARD infiltration through coal mining waste layer 1 m thick: (I) reference column without protective barriers; (II) column with protective barriers.

Besides trace metals, a significant reduction of sulfate (for about 30%) and Fe loads (for almost 100%) released in leachate from the column with barriers (II) compared to the reference column (I) due to attenuation of pyrite oxidation in coal mining waste was observed.

The studies confirmed high efficiency of studied abundant and inexpensive waste materials application in permeable barriers for groundwater protection against contaminant release from sulfidic waste, in particular against deterioration of groundwater resources by Acid Rock Drainage.

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