CZASOPISMO TECHNICZNE Ch
WYDAWNICTWO POLITECHNIKI KRAKOWSKIEJ

z. 2-Ch/2008
ISSN 0011-4561
ISSN 1897-6298

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METHODS FOR REMOVAL OF HEAVY METALS FROM ACID MINE DRAINAGE

METODY USUWANIA METALI CIĘŻKICH Z ZAKWASZONYCH WÓD KOPALNIANYCH

A b s t r a c t

Acid mine drainage (AMD) is considered as one of the worst environmental problems associated with mining activity. Runoff from abandoned mines can have negative impact on the surrounding aquatic environment including heavy loads of suspended solids, decreased pH levels and increased levels of heavy metals. The abandoned Smolník mine belongs to an environmental loading in the east of Slovakia, with AMD production and contamination of the Smolník Creek catchment. The paper is focused on using active methods such as adsorption processes and precipitation methods to reduce the negative AMD impact on the environment.

Keywords: *heavy metals, acid mine drainage, adsorption, precipitation*

S t r e s z c z e n i e

Zakwaszone wody kopalniane zaliczane są do najpoważniejszych zagrożeń środowiska naturalnego związanych z procesami wydobywczymi. Odcieki ze zlikwidowanych kopalni mogą wywierać negatywny wpływ na środowisko wodne poprzez zwiększenie ładunku zawiesiny, obniżenie poziomu pH oraz podwyższenie zawartości metali ciężkich. Zakwaszone wody kopalniane pochodzące ze zlikwidowanej kopalni Smolník, leżącej we wschodniej Słowacji, powodują zanieczyszczenie zlewni potoku Smolník. W artykule przedstawiono możliwości wykorzystania metod adsorpcyjnych oraz procesów wytrącania w celu zmniejszenia negatywnego pływu zakwaszonych wód kopalnianych na środowisko naturalne.

Słowa kluczowe: *metale ciężkie, zakwaszone wody kopalniane, adsorpcja, precypitacja*

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1. Introduction

Acid Mine Drainage (AMD), resulting from the oxidation of sulphide-bearing rocks, is one of the most significant environmental challenges facing the mining industry worldwide. AMD affects stream and river ecosystems by increasing acidity, depleting oxygen, and releasing heavy metals.

The Smolník deposit is a typical example of AMD occurrence and generation. It is situated in the southeastern Slovakia between the villages of Smolník and Smolnícka Huta in the valley of the Smolník creek, 11 km south–west of the village Mníšek nad Hnilcom. It is a historical Cu, Fe, Ag, Au-mining area that was exploited from the 14th century to 1990. The mine system represents a partly opened geochemical system into which rain and surface water drain. Waters from the earth surface that penetrated the mine are enriched with metals and their pH values decrease. Acidity is caused mainly by the oxidation of sulphide minerals. The whole mine complex produces large amounts of AMD with the pH of 3–4 that contain high metal concentrations, fluctuating depending on rainfall intensity (e.g. Fe 500–400 mg/l; Cu 3–1 mg/l; Zn 13–8 mg/l and Al 110–70 mg/l). This AMD acidifies and contaminates the Smolník creek water, which transports pollution into the Hnilec River catchment [1, 2]. Such polluted water can be treated by e.g. neutralisation, ion exchange, precipitation, sorption, membrane processes and filtration.

2. Material and methods

Based on our previous results, where various sorbents were tested [1], PEATSORB turf brush (REO AMOS Slovakia) was used for our study of Cu, Fe, Al, Zn ions removal from acid mine drainage by **adsorption**. The dependence of the decrease in Cu, Fe, Al, Zn concentration on time (1; 3; 5; 10 min) was investigated under dynamic conditions using PEATSORB turf brush. To intensify the adsorption process, a sample of AMD was continuously stirred with 5g of PEATSORB turf brush. The pH (METTLER TOLEDO) and Cu, Fe, Al, Zn were determined in the filtrate by the colorimeter DR 890 (HACH LANGE).

The test of Cu, Fe, Al, Zn **precipitation** in AMD was carried out with raw AMD samples of 100 ml, each was titrated to the pH end points ranging from 4 to 8 using NaOH (0.5 mol/l). During the titration, the AMD solution was continuously stirred and the pH was monitored. When the preset pH end point was reached, the titrated solution was filtered to remove the precipitated metals. The filtrate was used for the characterization of Cu, Fe, Al, Zn solubility as a function of the pH.

3. Results and discussion

The results of the pH measuring in the AMD-turf brush mixture depending on time are presented in Fig. 1. The influence of adsorption processes on Cu, Fe, Al, Zn concentrations in individual samples are given in Figs 2 to 5.

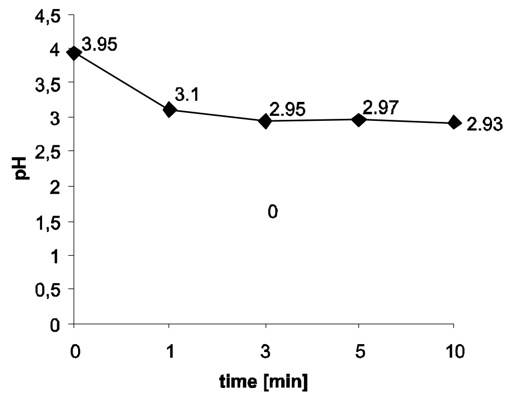

Fig. 1. Dependence of pH change during Cu, Fe, Al, Zn removal from AMD by PEATSORB

Rys. 1. Zmiany pH w czasie podczas usuwania Cu, Fe, Al, i Zn z zakwaszonych wód kopalnianych z wykorzystaniem PEATSORB

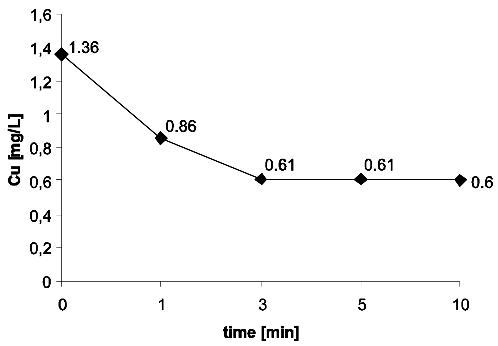

Fig. 2. Dependence of Cu removal from AMD versus adsorption time

Rys. 2. Wpływ czasu adsorpcji na usuwanie Cu z zakwaszonych wód kopalnianych

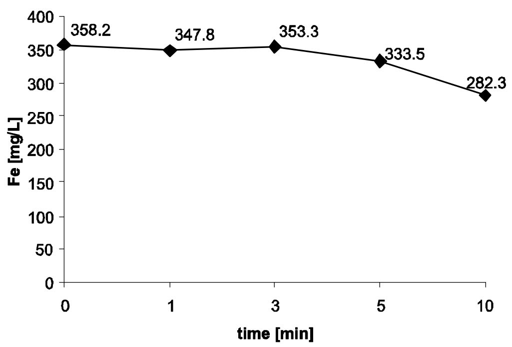

Fig. 3. Dependence of Fe removal from AMD versus adsorption time

Rys. 3. Wpływ czasu adsorpcji na usuwanie Fe z zakwaszonych wód kopalnianych

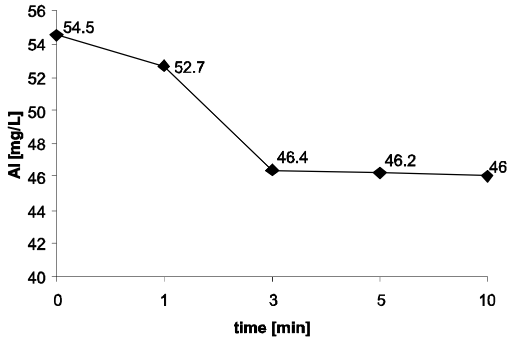

Fig. 4. Dependence of Al removal from AMD versus adsorption time

Rys. 4. Wpływ czasu adsorpcji na usuwanie Al z zakwaszonych wód kopalnianych

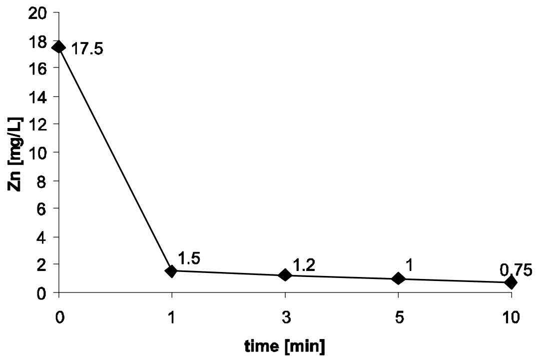

Fig. 5. Dependence of Zn removal from AMD versus adsorption time

Rys. 5. Wpływ czasu adsorpcji na usuwanie Zn z zakwaszonych wód kopalnianych

It follows from the results that it is possible to decrease the Cu, Fe, Al and Zn concentrations in the polluted surface water by physical adsorption. The highest turf brush efficiency was observed for zinc removal, where the decrease in concentration in the solution was 95.71%. Then follows copper (decreasing in AMD by about 55.88%), iron (21.19%) and aluminium (15.6%). Basing on the experimental results, we can also state that the chosen adsorbent has not influenced the pH increasing above 4 (Fig. 1) because the pH above 4 is connected with the precipitation of metals.

The precipitation of Cu, Fe, Al depending on the pH change was monitored. The precipitation of zinc was not monitored due to its efficient removal by sorption. The results are given in Figs 6 to 8.

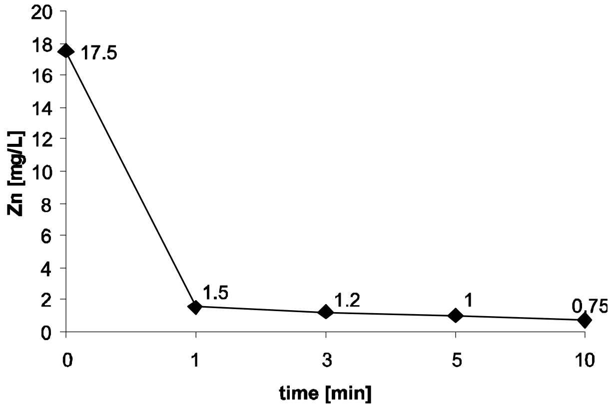

Fig. 6. Influence of pH on Cu precipitation from AMD

Rys. 6. Wpływ pH na wytrącanie Cu z zakwaszonych wód kopalnianych

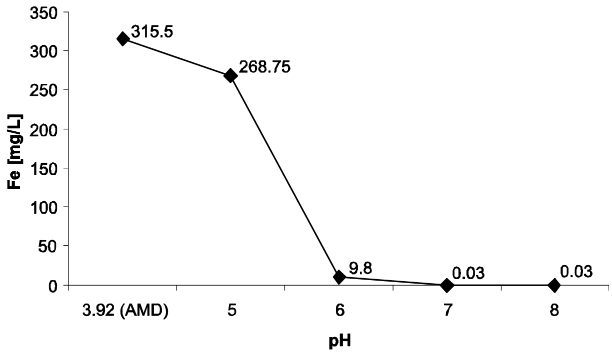

Fig. 7. Influence of pH on Fe precipitation from AMD

Rys. 7. Wpływ pH na wytrącanie Fe z zakwaszonych wód kopalnianych

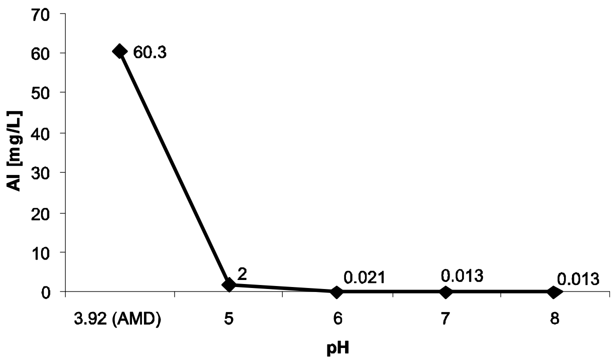

Fig. 8. Influence of pH on Al precipitation from AMD

Rys. 8. Wpływ pH na wytrącanie Al z zakwaszonych wód kopalnianych

The Figures 6–8 present the influence of the pH increase on the decrease of the concentration of metals. As it is seen from the given figures, aluminium was precipitated at pH = 5 and copper and iron were precipitated at pH = 6. The initial assumption about the precipitation of the following metals up to pH = 8 has been confirmed.

4. Conclusion

This study shows the possibility of the natural adsorbent utilization for Cu, Fe, Al and Zn removal from acid mine drainage. The PEATSORB turf brush was the most efficient for zinc removal; the decrease in Zn concentration in AMD was about 95.71%, for copper it was 55.88%, iron 21.19% and 15.6% aluminium was removed.

The removal of metals by precipitation is possible up to pH = 8. These results can be used for the suggestion of technology for a selective metal recovery from acid mine drainage from Smolník.

This work has been supported by the Slovak Research and Development Agency under the contract No. APVV-51-027705 and by the Slovak Grant Agency for Science (Grant No. 1/0613/08).

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