BARRIER PERFORMANCE OF MINERAL MATERIALS AGAINST HEAVY METALS AND ACID DRAINAGE FROM EXCAVATED ROCKS

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1. BACKGROUND

Excavated soils and rocks from construction works, mining operations, and other activities have become important geo-environmental issues recently due to growing interest and need to reuse soils and save space in landfills[1]. Until now, expensive measures have been needed in order to prevent acid drainage and/or leaching of heavy metals; so, there is need for a more cost-effective and readily available solution.

The use of minerals (bentonite, zeolite and ferrihydrate) as barriers seems to be a good solution, since previous studies suggest that they have large specific surface areas, high metal sorption capacities, and low hydraulic conductivities. Therefore, this research aims to investigate the barrier performance of bentonite, zeolite and ferrihydrate when exposed to extreme conditions of pH and metal concentration. For this purpose, swelling tests, hydraulic conductivity tests, and sorption tests were conducted.

2. MATERIALS AND METHODS

Experiments were conducted using bentonite (from the geosynthetic clay liner–GCL–Bentofix® NSP 4900), zeolite, and ferrihydrate. Different metals (Al, Fe, Zn, Cu, As, and Pb), metal concentrations (1 μM to 100 mM), bi-metal solutions (1 mM each metal), natural rock leachates (9 cases), and an artificial acid rock drainage or ARD (Al: 259.2 mg/L, Fe: 4330.2 mg/L, Cu: 86.9 mg/L, Zn: 493.1 mg/L, As: 49.1 mg/L, and Pb 2.9 mg/L; pH: 3; EC: 1195 mS/m) were analyzed, as described in Table 1.

Table 1 Performed tests

Test	Description	Study Case
Sorption Test	See Figure 1	Single metal Bi-metal Natural ARD Artificial ARD
Swelling Test	ASTM D 5890	Single metal Bi-metal Artificial ARD
Hydraulic Conductivity Test	ASTM D 5084 ASTM D 7100	Water* Water-ARD** ARD-ARD***

* water permeation (control)
** water prehydration and artificial ARD permeation
*** artificial ARD prehydration and permeation

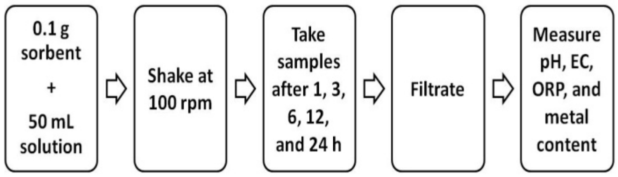

Figure 1 Time-step batch sorption test procedure

3. RESULTS AND DISCUSSION

Sorption test results showed that equilibrium was reached after 6 hours in all cases. In addition, it was observed that bentonite has higher sorption capacity against Fe, Cu, Zn, and Al than zeolite and ferrihydrate, except in case of As, for which ferrihydrate was more suitable. Additionally, sorption mechanisms (ion exchange for bentonite and zeolite, and surface complexation for ferrihydrate) were studied and metal selectivity was determined from bi-metal tests (for bentonite: Al > Pb > Fe > Cu > Zn > As).

The free swelling test on bentonite showed that low pH (lower than 3) and high metal concentrations affect the swell index.

Hydraulic conductivity (k) of GCL when permeated with water was 2.2×10^{-11} m/s. The k of GCL prehydrated and permeated with ARD was 5.0×10^{-10} m/s, five times higher than the k of GCL prehydrated with water before ARD permeation. Evaluation of effluents showed that the GCL tested has high affinity for metals and therefore, can retard metal transport, but with a limitation because of its buffering capacity.

4. CONCLUSIONS

From the results of all tests, it can be inferred that sorption on minerals seem to be a good solution against ARD. However, other factors such as mineral-metal interaction, transport of metal ions through minerals, pH effects, desorption processes, among others should be thoroughly studied before field application.

REFERENCE

1) Katsumi, T., Inui, T., Mogami, H., Dejima, A., and Kamon, M. (2010): GCLs against acid drainage from excavated rocks discharged through construction works, *Proceedings of the 9th International Conference on Geosynthetics*, pp.967-970.