Ca-bentonite/polymer blends to compose GCLs for effective containment of mining leachates

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Abstract. This study investigates the swelling potential of blends of a Brazilian sodium-activated calcium bentonite with linear structure polymers and a cross-linked structure polymer in contact with aggressive mining solutions (sodium hydroxide, calcium chloride, simulated bauxite liquor, copper tailing and gold tailing leachates). Results showed that the polymer addition contributed to the swelling of the bentonite under aggressive solutions. The effectiveness of the polymers varied with the permeant liquid and concentration. Sodium Polyacrylate and Carboxymethyl Cellulose proved the most effectiveness in bentonite swelling capacity. Research presents valuable insights into the chemical compatibility of bentonite-polymer blends when exposed to aggressive liquids.

The availability of high-quality Sodium bentonites (NaB) to compose GCLs is very limited world-wide. Instead, Calcium Bentonite (Ca-B) deposits are found in various parts of the globe, with significant reserves in, China, India, Brazil, and many European countries. In Brazil, the reserves of Ca-B are approximately 54 million metric tons, with 74% of the extraction concentration in Paraiba state. Nonetheless, this type of bentonite is not commonly preferred to compose GCLs since it is typically characterized by poor hydrophilicity and low swell capability, thus being more difficult to be preferred as barrier material. On the other hand, Ca-B are more stable and economical than NaB and might be better suited to aggressive leachates [1]. Therefore, the exploration of Ca-B is necessary to expand the range of available bentonites for GCL composition and, thus, providing alternatives for the containment of hazardous leachates. Wang et al. [2] investigated a polymer-modified Ca-B and demonstrated that the GCLs provided superior barrier property under high ionic strength conditions than Ca-B. According to Tian et al. [3], the polymer granules can somehow swell in leachates to form hydrogels, which compensate the swelling deficiency of the bentonite. It is important to note that the swell index might not directly correlate with hydraulic compatibility in polymer-modified bentonites. This study investigated the swelling potential of different blends of a Brazilian activated Ca-B with linear structure polymers (Sodium Polyacrylamide - PAM and Carboxymethyl Cellulose - CMC) as well as a cross-linked structure polymer (Sodium Polyacrylate - PAAS) in contact with aggressive solutions: Sodium hydroxide (NaOH) of 1mol/L and pH 14, Calcium chloride ($CaCl_2$) in the concentrations of 50 Mm and 250 mM, simulated Bauxite liquor, simulated Gold tailing leachate and a Copper tailing

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leachate. Polymer additions of 2, 4, 6, 8 e 10% in relation to the dry weight of the bentonite were evaluated, considering air drying process as in Razakamanantsoa et al. [4]. Both materials were manually mixed at bentonite as-received moisture content. The swell index (SI) of bentonite-polymer blends were tested according to ASTM D5890 and ASTM D6141. To prevent polymer retention in sieves, the bentonite-polymer blends were intentionally left unground and unsieved. Wireko et al. (2020) observed higher SI values in specimens that had not undergone prior crushing and sieving. Additionally, the blends were not subjected to oven drying before tests. For comparison purposes, activated Ca-B and bentonite-polymer blends were tested with deionized (DI) water to verify minimum requirements to compose GCLs (24 mL/2g). Results showed that activated Ca-B exhibited 31 mL/2g of SI value in DI. In Figure 1a, after the addition of polymers, blends swelled significantly in DI water, reaching values of 93 mL/2g. PAAS proved to be the most effective polymer in DI water, achieving greater expansion with only 2%, in comparison to PAM and CMC. In Figure 1b, is noticeable the impact of aggressive liquids on the swelling capacity of the bentonites and blends.

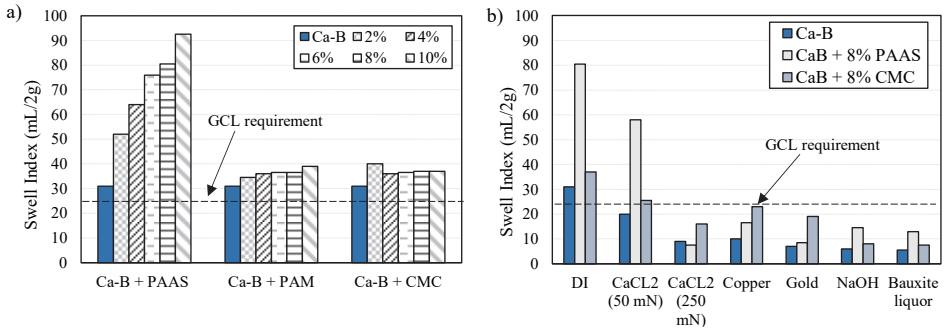

Fig. 1. Results of swell index for the different combinations of activated Ca-B and polymers: (a) different of percentages of PAAS, PAM and CMC in Di water; (b) tests using aggressive liquids.

Alkaline solutions, such as bauxite liquor and NaOH, was observed to significantly affect the swelling capacity of Ca-B. Polymer addition assisted in the bentonite swelling capacity in contact with aggressive liquids; however, the effectiveness of the polymers varied depending on the permeating liquid and its concentration. Note that the CMC showed better performance with cooper leachate than PAAS, while in alkaline liquids, the PAAS demonstrated better responses. This study aims to help formulations of bentonite–polymer mixtures for the industry, particularly geotechnical field.

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