# Swelling compatibility test on a coarse type barrier (CTB) formulation to be use as a liner in MSW landfills

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## 1. Introduction

To avoid the transfer of contaminants from the landfill's waste containment area to the subsoil and underground water, landfills are required to have control systems such as low hydraulic conductivity liners and leachate collection systems. Swelling properties of bentonite in clay liners are of vital importance since they will determine properties of the barrier (Grim, 1968), e.g. hydraulic conductivity, absorption capacity, etc.

At a landfill site, the barriers are subject to be permeated by more than one liquid. The cations, pH, concentration, and/or the dielectric constant of the permeating fluid(s) will have a strong influence on the swelling ratio and therefore the hydraulic conductivity of the clay liner (Shackelford et al., 2000; Jo et al, 2001; Shan et Lai, 2002).

The Coarse type barrier (CTB) concept consists of a layer formed mainly of gravel rocks cover with clay (bentonite). This type of materials has proven to be very effective in isolating contaminated sediments in numerous aquatic (e.g. rivers, lakes, sea, wetlands, etc.) remediation projects. But, Can CTB's act as low hydraulic conductivity barriers at solid waste landfill sites? This work presents data regarding the swelling ability of a CTB formulation in different liquids.

This paper is part of a wider research program aim to investigate the effective use of CTB's as a new concept of barrier for MSW landfills.

## 2. Experimental Method

The CTB used for this research was AquaBlok™ 40BE (40% of clay per particle weight). As we were interested only in the swelling responses of the clay minerals to different liquids, the gravel core was removed, and only the clay shell was used in the tests. It is pertinent to mention that AquaBlok, Ltd. manufactures other formulations; 40BE is only one of many.

Following The Japanese Bentonite Association Standard JBAS-107-91, methylene blue adsorption (MBA) test was measured in order to estimate the quantity of montmorillonite. The test reveled a value of 142mmol/100g. The CEC analysis consisted of several cycles of batch washings, i.e. adding and replacing cations, shaking centrifuging and decanting the supernatant solutions. The CEC was determined by the Ammonium Acetate (pH 7) method (SSSA, 2001). The test reveled value of 3.26 meq/g.

For investigating the effects of valence and concentration, salt solutions of LiCl, NaCl, KCl, $MgCl_2$, $CuCl_2$, $ZnCl_2$, $CaCl_2$, $LaCl_3$, were used; the hydrated ionic radii of the cations are: $Li^+$ (0.6nm), $Na^+$ (0.45nm), $K^+$ (0.30nm), $Mg^{2+}$ (0.80nm), $Cu^{2+}$ $Zn^{2+}$ $Ca^{2+}$ (0.06nm), $La^{3+}$ (0.90nm) concentrations consisted of 0.05M, 0.10M, 0.25M, and 0.50M; for effect of pH, $HNO_3$, KOH, HCl, and NaOH were used at pH levels of 2, 5, 7, 9, and 12; raw leachate from two (2) different landfills (RLF, RLB), adjusted leachate (ALH) prepared from fresh bottom ash following Japanese Leaching Test JLT 46, seawater (SW) and tap water (TW), were also used. Mayor characteristics of the leachates are listed in Table 1, and characteristics of the seawater and tap water are listed in Table 2.

Free Swell tests, were conducted following procedures in ASTM D5890-02. The clay shell components were crushed and sieved in a #200 U.S. standard mesh. Samples were dried to a constant weight at 105 ± 5°C; 40 ± 0.2 g of finely dried clay were added to 2000-mL of reagent liquid in a clean graduated cylinder.

## 3. Results and Discussion

As it was expected, salt solutions of monovalent cations ($Li^+$, $Na^+$, $K^+$) swelled the most (Fig.1). Only monovalent cations are associated to osmotic swelling of bentonite clays, therefore, swelling will be grater in solutions dominated monovalent cations (+1), than in solutions saturated with bivalent (+2) and trivalent (+3) cations. Results are consistent with to those of Shackelford et al., 2000 and Jo et al., 2001.

Table 1 Quality data of the leachates

| | pH | EC (μS/cm) | NH4+ (mg/l) | TN (mg/l) | Cl- (mg/l) | SO42- (mg/l) | Na+ (mg/l) | K+ (mg/l) | Ca2+ (mg/l) | Pb2+ (mg/l) | Zn2+ (mg/l) | Cr3+ (mg/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RLF | 7.7 | 5.8 | 0.1 | 14.7 | 1834.0 | 90.3 | 757.7 | 320.1 | 594.8 | <0.01 | 0.07 | <0.01 |
| RLB | 7.8 | 5.9 | 0.1 | 75.3 | 1390.0 | 26.3 | 872.6 | 428.4 | 120.3 | <0.01 | 0.09 | <0.01 |
| RLH | 12.1 | 4.4 | 0.4 | 8.9 | 300.0 | 14.9 | 245.6 | 226.1 | 1100.0 | <0.02 | <0.05 | <0.05 |

Monovalent cations with larger hydrated ionic radii will cause the clay to swell more, as they occupy a larger volume in the interlayer region. Bivalent and trivalent are not associated to osmotic swelling therefore smaller swelling values can be expected.

Table 2 Quality of the TW and SW

| | Tap Water | Seawater |
|---|---|---|
| pH | 7.09 | 8.15 |
| EC (μS/cm) | 0.397 | 42.3 |
| $Na^+$ (mg/l) | 12.91 | $10.8x10^3$ |
| $K^+$ (mg/l) | 11.76 | 390.2 |
| $Ca^{2+}$ (mg/l) | - | 405.1 |

Regardless of the valence in all salt solutions, as the concentration increased, the swelling decreased (Fig.2). A high electrolyte concentration will affect the diffuse double layer (DDL), and it will be manifested in shrinkage of the clay, and therefore, an increment in the hydraulic conductivity.

Samples hydrated in low pH solutions presented low swelling ratio (Fig. 3), but swelling rapidly increased with incrementing pH, with high alkaline levels, swelling decreased considerably. The pH of a solution can affect significantly the soil fabric. The amount of concentrated solution required for adjusting pH levels of 2 and 12 is far more than that for adjusting levels of 5, 7 and 9, therefore, the high concentrations could've cause a shrinkage of the clay. Solutions with very low and high pH are known to affect the montmorillonite structure in the barrier, causing dissolution of the structure and exchangeability of $Al^{3+}$ respectively.

Because of the low EC of tap water, it was expected a high swelling ratio, on contraire to the high EC of seawater, less swelling was expected. Regarding the leachates, it was appreciated that even though both raw leachates had very similar EC, the difference in the concentration of monovalent cations, caused a difference in swelling ratios. This situations is also well notice in the ALH, were the concentration of monovalent cations are even lower than those in RLF and RLF, a greater swelling ratio is appreciated.

## 4. Conclusion

In this study, the swelling responses of a specific formulation of coarse type barrier (CTB) to different types of liquids were investigated. At a landfill site, liners will be subject to permeation to more than one type of liquid; by understanding how this liquids affect the barrier a better formulation can be attain. This simple but effective study helped to predict the interaction of the CTB formulation, with leachates find on the field. Free swell tests can be used to predict the effect that a liquid will have on the hydraulic conductivity of a clay barrier, although, this study does not include Hydraulic conductivity data, it is the intention to present such results in future papers, in order to corroborate that MSW landfill leachate will not affect in a great manner the hydraulic conductivity of this Barrier.

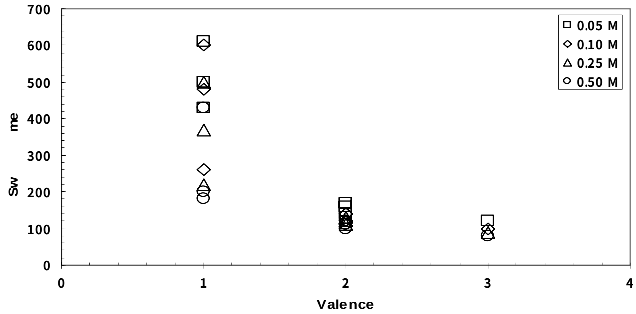



Fig.1 Results of valence on the swelling

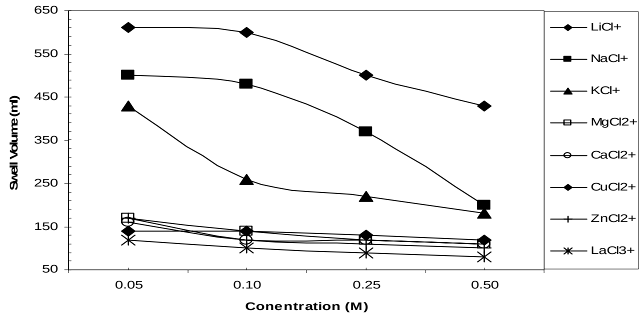



Fig.2 Results of concentration on the swelling

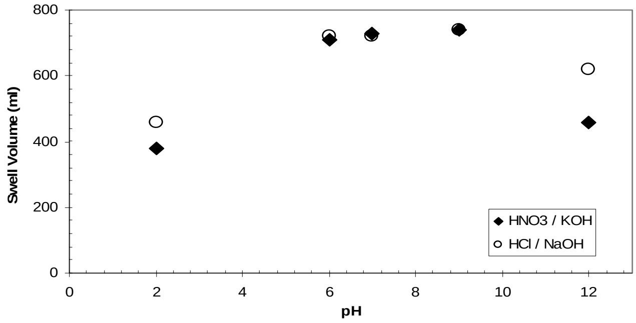
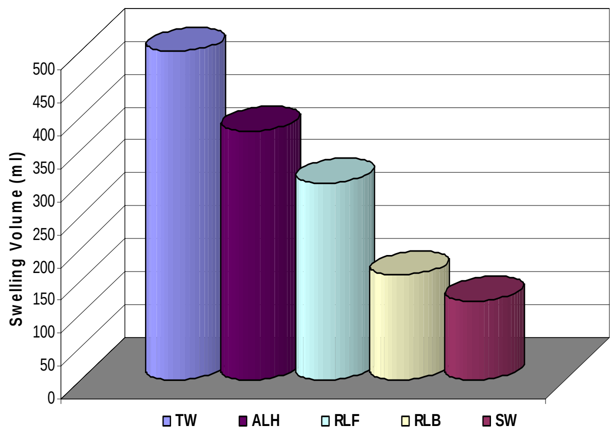



Fig.3 Results of different pH solutions on the swelling

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