

## INTERACTIONS OF IONIC SPECIES AT THE BRICK – SOLUTION INTERFACE

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### Introduction

Lead and chromium, among many heavy metals, are commonly encountered in polluted water bodies in Sri Lanka (Ileperuma, 2000). Adsorption appears to be the most widely used remedial methodology available for the removal of such metal ions. Several recent studies revealed that brick clay has excellent properties as a highly effective adsorbent for the removal of toxic heavy metals from waste water. Removal of Hg (II) from aqueous solution by waste brick has been reported with the maximum removal capacity of 87 mg g<sup>-1</sup> (Labidi, 2008). It has also been reported that burnt brick particles have a strong ability to remove heavy metals including Cr(III), Pb(II), Mn(II), Fe(II), Co(II), and Cd(II) from aqueous solutions under experimental conditions (Priyantha and Keerthiratne, 1997). Although it has been demonstrated the applicability of brick clay for removal of heavy metals from aqueous media, investigation of brick-ion interactions at the interface has not been widely addressed.

The goal of this research is to investigate the brick clay-ion interactions as an attempt to understand the mechanism of the ion removal process. The ions, Cr(III),

Cr(VI), Pb(II) and F<sup>-</sup> have been used in this study.

### Materials and Methods

**Materials:** Raw brick clay samples were obtained from a kiln located in Geliyoa, which were crushed and fired at different temperatures (100 °C to 900 °C,) for 4 h as needed. Stock solutions of each ion were prepared from analytical grade reagents in distilled water.

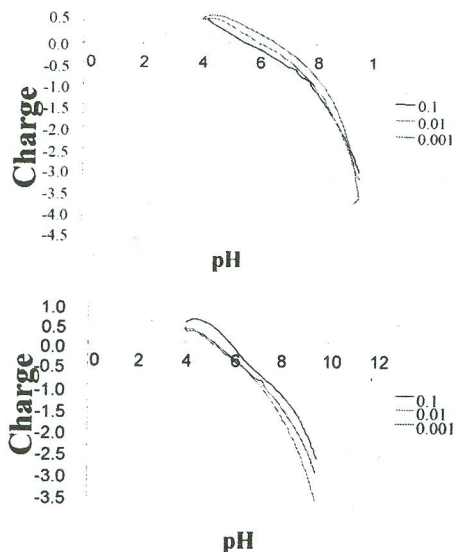
**Instrumentation:** An Atomic Absorption Spectrophotometer (Thermo M, USA) was employed for the absorbance measurements. pH at each point of the surface titration was determined with an Autotitrator (Orion Model 960, USA).

**Research design:** A sample of brick particles (d < 1 mm, 5.0 g) fired at different temperatures was mixed with 100 ppm Pb(II) solution (50.0 cm<sup>3</sup>), shaken for 15 min and allowed to stand for 15 min to reach equilibrium. The above procedure was repeated with Cr(VI), Cr(III) and F<sup>-</sup> solutions (20.0 ppm each) with 10 min shaking time and 2 h settling time. Each supernatant solution was analyzed for the total metal content. For surface titrations, a brick clay suspension of fine powder (5 g dm<sup>-3</sup>) in a NaNO<sub>3</sub> solution was stirred for 12 h in a closed container to form a

homogeneous suspension. The initial pH of the suspension was lowered to a known pH (~ 4.0) using HNO<sub>3</sub>. The resulting solution was then titrated with a standard NaOH solution until the pH reached 9.5. A back titration was carried out using the same HNO<sub>3</sub> solution to ensure the same changes in pH during the titration. The entire procedure was repeated for two more ionic strengths.

### Results and Discussion

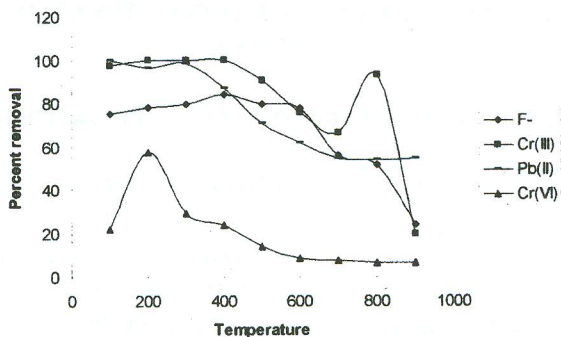
Surface titration is a valuable tool used to investigate surface charges under different experimental conditions. Titrations conducted by the addition of small amounts of NaOH and HNO<sub>3</sub>, indicate that brick clay surfaces are negatively charged at pH > 5 regardless of the firing temperature (Figure 1).



**Figure 1. Surface titration curves of brick clay suspensions as variation of surface charge at different additions of NaOH for unfired clay (top) and clay fired at 200 °C (bottom).**

This is a clear evidence for strong interactions of cations and brick clay surfaces. This is supported by almost 100 % removal of Cr(III) and Pb(II) ions by brick particles fired at temperatures up to 400 °C. The percentage removal of Pb(II) is not significantly decreased even if the concentration of Pb(II) solution is increased up to 100 ppm (Figure 2). Lower removal of Cr(VI), which is present as Cr<sub>2</sub>O<sub>7</sub><sup>2-</sup>, a negatively charged species and that of F<sup>-</sup>, can be accounted partly for having negative charges on brick particles. Nevertheless, higher F<sup>-</sup> removal ability by brick clay fired at temperatures above 400 °C cannot be explained by surface charges alone.

Careful analysis of the shapes and trends of surface titration curves indicates that those for unfired brick clay show a typical trend corresponding to a surface of pH dependent surface charges. The curves constructed for different ionic strength (0.1 M NaNO<sub>3</sub>, 0.01 M NaNO<sub>3</sub>, 0.001 M NaNO<sub>3</sub>) intersect at a common point of pH 9.5, which is the point of zero charge. However, the curves are parallel to each other in the titration obtained with fired clay indicating that the charges on the clay surfaces are pH independent. Further the three curves obtained with these three ionic strengths are very close to each other for brick fired at 200 °C, indicating that the surface charge does not significantly depend on the ionic strength of the medium. This is supported by observing ionic strength independent Cr removal by brick fired at 200 °C.



**Figure 2. Percentage removal of ions by brick particles fired at different temperatures. The concentration of each solution is 20.0 ppm except 100 ppm for Pb<sup>2+</sup>**

### Conclusions

The surface characteristics of brick particles depend on the pH and the ionic strength of the medium. The variation of surface charges with pH depends on the firing temperature of brick according to surface titration curves. The importance of optimizing the firing temperature for the most efficient removal of a cation or an anion is thus demonstrated. Further experiments on the correlation of surface charge and the extent of ion removal are underway.

### Acknowledgments

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