REMOVAL OF HEAVY METALS AND FLUORIDE FROM CONTAMINATED GROUNDWATER USING LOCALLY AVAILABLE MATERIALS

J.L.Hallagodage, J.M.M.U. Jayapadma, G.G.Tushara Chaminda and T.Kawakami

ABSTRACT

Groundwater being the prominent freshwater source that fulfills more than 80% of the rural water demand in Sri Lanka, maintaining groundwater quality parameters at permissible levels is very important as far as consumer’s health is considered. On the other hand, extreme concentrations of heavy metals in effluents of industrial wastewater or leachate to water bodies is another issue that should be addressed. This study is focused on comparing the fluoride adsorption capacities of locally available adsorbents; coconut charcoal, drumstick seeds, saw dust, rice husk and burnt bricks with that of Chicken Bone (CBC) Char and evaluating the removal efficiency of heavy metals (As, Pb, Zn) from industrial wastewater using CBC. Results revealed that fluoride removal efficiencies of Coconut charcoal, Saw dust, Rice husk, Burnt bricks and Drumstick seeds are very low when compared with that of CBC. It was observed that Zn, Pb and As could successfully be removed using CBC with removal efficiencies 97%, 93%, and 42% respectively.

1. INTRODUCTION

Groundwater is the most commonly found fresh water source of water on earth. Therefore, maintaining the water quality parameters within the standard levels is very important as the presence of heavy metals and fluoride in water has adverse effects on human health (WHO, 2009). Treating high concentrations of heavy metals in industrial wastewater effluents discharged to surface water bodies is another issue that should be addressed, as the concentrations of As, Pb and Zn in effluents of industrial wastewater and leachate are high and well above the allowable limits (Sewwandi, et al., 2012).

Adsorption has been identified as an advantageous technique over the common de-fluoridation mechanisms. Fluoride adsorption capacity of Chicken bone char (CBC) is to be 2.8 and 36 times greater than that of commercially activated alumina (F-1) and commercially activated carbon (F-400) respectively (Medellin-Castillo, et al., 2007). But the perception of public towards consuming water treated using CBC is not satisfactory especially in Asian countries.

Therefore this study is focused on comparing the fluoride adsorption capacities of locally available adsorbents; coconut charcoal, drumstick seeds, saw dust, rice husk and burnt bricks with that of CBC and evaluating the removal efficiency of heavy metals (As, Pb, Zn) from industrial wastewater using CBC.

2. METHODOLOGY

2.1 Materials

Adsorbents selected for de-fluoridation were coconut charcoal, drumstick seeds, saw dust, rice husk and burnt bricks. Coconut charcoal was washed and broken into small particles and was ignited at 600 °C for 1 hour. Other materials were also broken into smaller particles, washed and oven dried for 24h. CBC used for the heavy metal removal was obtained from Toyama Prefectural University, Japan.

2.1 Isotherm modelling for Fluoride

A stock solution of NaF (10mg/L) was prepared and different masses (0.1g, 0.2g, 0.3g, 0.4g, 0.5g) of each adsorbent were added to 100 ml of the stock solution separately. The sample containers were shaken thrice a day for a duration of 30 minutes to facilitate the equilibrium.

Equilibrium fluoride concentrations of the samples prepared were measured by the Fluoride Ion Selective Electrode (Thermo Fisher Scientific) and isotherms were modelled using the results obtained.

2.2 Isotherm modelling for heavy metals

Separate 10mg/L solutions of As, Zn and Pb were prepared and different masses of CBC (0.5g, 1g, 2g, 3g, 4g) of size 0.08mm were added to 100ml of the heavy metal solutions separately for the equilibrium studies. The flame method of the atomic absorption spectrometer (TRACE 1200, SN- 1200-142109) was used to measure the equilibrium concentrations of the samples prepared.

2.4 Batch column experiment for heavy metal removal

A synthetic wastewater sample was prepared by spiking As, Zn and Pb to de-ionized water so that the final concentration of the solution was 5mg/L of each heavy metal. It was found that the highest concentrations of As, Zn and Pb in leachate and industrial wastewater is less than 5mg/L in Sri Lanka (Sewwandi, et al., 2012).
3. RESULTS AND DISCUSSION

3.1 Fluoride removal
Equilibrium concentrations of different specimens are compared in Figure 1. It was found that CBC has the highest removal efficiency compare to that with other materials. The fluoride removal were varying in the order of; CBC > Drumstick seeds > Burnt bricks > Coconut charcoal > Rice husk > Sawdust with 84%, 13%, 12%, 10%, 8% of removal efficiency respectively.

![Figure 1: Comparison of Equilibrium Concentrations](image)

3.2 Heavy metal removal in industrial wastewater using CBC
Isotherm analysis results revealed that Freundlich isotherm described the equilibrium of CBC with the heavy metals very well. The removal efficiencies of Zn, Pb and As of CBC for the synthetic wastewater sample treated were 97%, 93%, and 42% respectively. With this isotherm results, it was found that, 1 kg of CBC would be effectively used to remove Zn, Pb and As in 100 L/d of industrial or leachate wastewater for 4 days with removal efficiencies shown in Table 1.

4. CONCLUSIONS
From this study it could be concluded that CBC has the highest adsorption capacity of fluoride when compared with other locally available materials. Fluoride removal efficiency of the materials vary in the following sequence

<table>
<thead>
<tr>
<th>Influent concentration (mg/l)</th>
<th>Effluent concentration (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Zn</td>
</tr>
<tr>
<td>0.1</td>
<td>0.3</td>
</tr>
<tr>
<td>Removal Efficiency (%)</td>
<td>97</td>
</tr>
</tbody>
</table>

CBC could also be used to treat wastewater (industrial or leachate) containing heavy metals; Zn, Pb and As, effectively with removal efficiencies 97%, 93% and 42% respectively.

This study could be extended to optimize the filter design by taking the particle size distribution of the materials into consideration. The effect of the ion budget and presence of chemical compounds in real wastewater, on the heavy metal removal efficiency could be evaluated in future studies.

REFERENCES