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The use of cassava waste in the removal of cobalt, chromium and vanadium metal ions from synthetic effluents

Seepe, Lizzy

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ABSTRACT

This study investigated the removal of Co^{2+}, Cr^{3+} and V^{3+} from synthetic effluent using untreated and acid treated cassava waste biomass. Cassava waste biomass is a cellulosic material which possesses hydroxyl groups and sulfhydryl groups (or thiol groups) when untreated and treated with thioglycollic acid, respectively. Both these functional groups can act as binding sites for metal ions. Test works were carried out in batch flasks; semi-continuous counter current system and packed bed column.

The cassava waste biomass was characterized by using FTIR and BET. The effects of pH ranging from 2 to 7, and temperature from 30 to 50°C on the removal of metal from the solutions were investigated in a batch process. Metal concentrations from 50 to 250 mg/L, agitation speed of 50 to 200 rpm and biomass of 0.05 to 0.3g were used.

FTIR analysis proved that the thiolation process added a sulfhydryl (-SH) group onto the cassava waste resulting in an improved metal removal performance of the biomass. In the preliminary batch test works metal uptake was generally found to increase with an increase in pH, agitation speed, biomass and initial metal concentration. Adsorption of metal ions was observed to increase with pH, with an optimum removal obtained at pH of 6.0, 3.0 and 3.0 for Co^{2+}, Cr^{3+} and V^{3+}, respectively. Metal adsorption increased with an increase in temperature from 30 to 40°C at an initial metal concentration of 100 mg/L. However, there was a reduction in adsorption beyond 40°C for all the metal ions. The rate of removal of the metal ions in this study increased with an increase in dosage of the sorbent. This was attributed to the increase in surface area and in the number of available active sites for the sorption of Co^{2+}, Cr^{3+} and V^{3+}. It was found that the biomass that had been treated with a modifying agent had higher adsorption rates. Furthermore, the results showed that an increase in the concentration of the modifying reagent improved the adsorptivity of the cassava waste biomass. The capacity for the sorption of the three metal ions was found to be lower in ternary solution systems as compared to single ion systems suggesting the prevalence of a competitive adsorption effect in mixed solutions.

The presence of cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}) in aqueous solution decreased the amount of Co^{2+}, Cr^{3+} and V^{3+} adsorbed by cassava. The presence of Ca^{2+} was observed to have the most negative impact on the adsorption of the three metal ion systems. The equilibrium biosorption data could be described by both Freundlich and Langmuir models, with the Freundlich isotherm describing the data better. Desorption experiments showed that at low H_2SO_4

concentration; it is possible to remove the metal ions bound to the biomass and to regenerate the biosorbent allowing its successive use. The cassava-peel biomass retained its original metal removal capacity up to six adsorption- desorption cycles. This is a good indication of cassava-peels' potential as a biosorbent material since they can be reused several times while maintaining high overall process efficiency.

Semi continuous counter current experiments showed that the adsorption of Co^{2+} needed 8 stages to meet the targeted limit of 0.05 mg/L set by the EPA. The Cr^{3+}system needed 6 stages to obtain the targeted limit of 0.05 mg/L. whilst for the V^{3+}system required 4 stages to attain the target limit of 0.1 mg/L.

The performance of the packed bed column was analysed using the effluent concentration versus time curves. The packed bed column was found to perform better with lower influent rate and high bed depth. The uptake analysis revealed a high selectivity for V^{3+}over Cr^{3+} and Co^{2+} at all conditions tested. The adsorption zone parameters and column design parameters have been determined using BDST and Thomas models. The experimental data best fitted with BSDT model than with the Thomas model for all the conditions tested with high linear correlation coefficient. This shows that the rate of adsorption is controlled by surface reaction and the unused capacity of the adsorbent. The adsorption-desorption results showed that the biosorbent can be used repeatedly without significant loss in sorption capacity reflecting its feasibility for commercial application.