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Examination of naturally occurring clay in Pannala for removal of Cr(III), Pb(II), Cd(II), Ca(II) and Mg(II) from aqueous solution

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Over the recent years, research on the clay minerals to evaluate their adsorption capacity to remove contaminants from drinking water has progressed. This research targeted the study of the usage and efficiency of the adsorbent prepared from natural clays in Pannala, North Western Province, Sri Lanka and its ability to remove Cr(III), Pb(II), Cd(II), Mg(II) and Ca(II) from aqueous solution, as a function of initial metal ion concentration, contact time and pH. A representative sample of clay was characterized using soil pH, moisture content, organic matter content and x-ray diffraction (XRD). Both original and treated (with acetic acid and hydrogen peroxide) clay samples were converted into Na⁺ homo-ionic clay materials and were used as the adsorbent for the analysis.

This research includes the studies of adsorption capacities for solutions of single metal element and the studies of ion competition in a mixed system. Adsorption of metals in a single-metal solution was in the order of: Cr [69.09 (± 0.19) mg/g] > Pb [55.91 (± 0.82) mg/g] > Cd [50.84 (± 1.62) mg/g] > Mg [47.43 (± 3.07) mg/g] > Ca [38.52 (± 3.49) mg/g]. Adsorption of metals in a mixed-metal solution was in the order of: Pb [25.51 (± 0.15) mg/g] > Cr [24.96 (± 0.58) mg/g] > Cd [24.86 (± 0.20) mg/g] > Mg [18.78 (± 0.56) mg/g] > Ca [15.20 (± 0.25) mg/g]. Adsorption increases with the pH of the initial metal ion solution. In the multi-element system, the adsorption of metal elements is severely suppressed due to the competitive effect. Adsorption is arguably the most important physicochemical processes responsible for the retention of inorganic and organic substances in the soil environment. Factors such as pH, nature and concentration of substrate and adsorbing ion affect the extent of adsorption. The correlation between metal properties and its removal capacity by natural clay samples seemed to be very important. The results of the statistical analysis revealed that the physicochemical properties of the metal ions are different depending on whether they are present in a single or multi-element system. The results of this study showed that the adsorption process has a greater dependence on the physicochemical properties of the metals than on the adsorption characteristics.

The results obtained suggest that the studied clay samples from Pannala can be effectively used as natural adsorbents for the removal of the examined toxic heavy metals in aqueous systems.

Keywords: Adsorption, heavy metals, natural adsorbent