Evaluating the Effectiveness of Sepiolite Clay in the Removal of Heavy Metals from Freshwater Systems

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ABSTRACT

This project evaluated the effectiveness of sepiolite clay, as an adsorbent in the removal of some heavy metals from freshwater systems. Sepiolite, which is relatively cheap,, abundant and readily available fibrous clay mineral was tested in this research as a potential adsorbent for the removal of manganese (Mn), Iron (Fe), Zinc (Zn), Copper (Cu) and Chromium(Cr) from water.

Batch adsorption studies were carried using 1 mg/L solution of these metals to optimize experimental conditions and access the effects of change in pH,dosage, and contact time. The competitive ions effect was also assessed.

The removal efficiency of 88 % for Zn, 90 % for Cr, 79% Mn, 77% for Cu and 37% of Fe were obtained when 25 mg of natural sepiolite clay was exposed to 1 mg/l of these heavy metals solutions at an optimum pH of 3.5 and contact time of 5 to 15 minutes.

INTRODUCTION

As the world population increases rapidly, various forms of pollution have compromised potential water sources. The elevated levels of heavy metals in surface water are found to have detrimental effects on the ecosystem, and it is vital to develop methods for their reduction in water. For this reason, researchers are putting much effort in studying materials that have the potential of adsorbing metals and can therefore, be used as cheaper alternative to costly freshwater treatment methods. Adsorption has drawn much interest due to the possibility of using low-cost adsorbents. Although sportive capacities of sepiolite clay have been studied elsewhere, these studies did not focus on the removal of some heavy metals that are of interest in the Namibian context .

METHODS AND MATERIALS

Sampling method and analysis

Targeted sampling sites were freshwater systems that are at a known risk of heavy metals contaminations. Sepiolite clay was obtained from a farm southeast of Gobabis for free. It was characterised by SEM and FTIR. In addition an ICP-OES was used to detect and quantify the concentration of these metals before and after adsorption,

1. Composition of Sepiloite

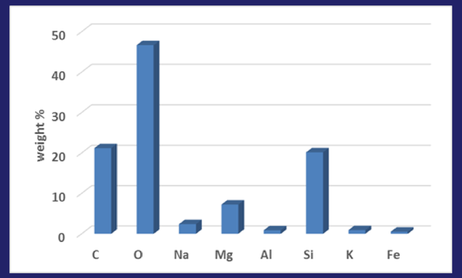


Figure 1: Sepiloite clay composition

Sepiolite is a magnesium-silicate type of clay, and the results shown in Figure 1 shows oxygen at 46.6 wt% to be the highest constituent, followed by Carbon, Silicon and Magnesium.

RESULTS AND DISCUSSION

1. Effects of pH

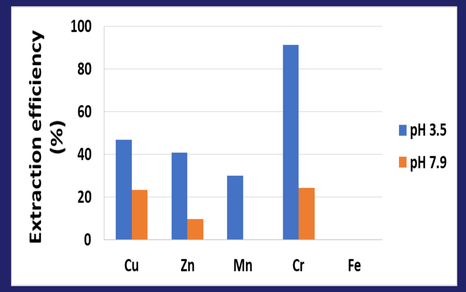


Figure 2. Effects of PH

Figure 2- Change in pH affects the adsorptive process through dissociation of functional groups on the adsorbent surface-active sites. Better extraction efficiency was observed at PH 3.5 compared to PH 7.9. This resulted because at very low pH example pH 1 there is a huge competition for binding sites between metal ions and hydronium ions(H+) therefore as pH increases there is a reduction in hydronium ions making space for metal ions to bind.

2. Effects of dosage

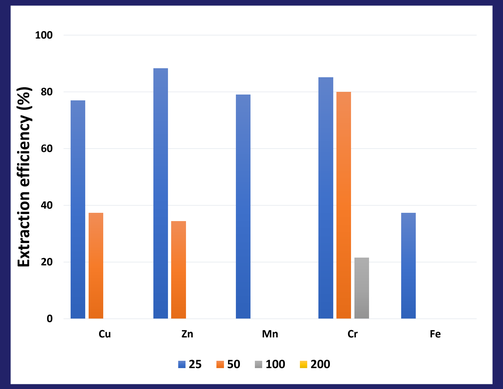


Figure 3:Etraction efficiency of Sepiolite at different dosage

Figure 3- The extraction efficiency of 77% Cu, 88% Zn, 79% Mn, 85% Cr and 37 % Fe were obtained at 25 mg of sepiolite. The results shows higher extraction efficiencies at a lower dosage. However, as the sorbent mass is increased the adsorption efficiency of all element except Cr gradually decreased with metals leaching out from sorbent from 50 to 200 mg .The higher the dosage the more concentration of metals found in the natural clay are introduced in the solution and the faster saturation is reached.

3. Effects of contact time single solution

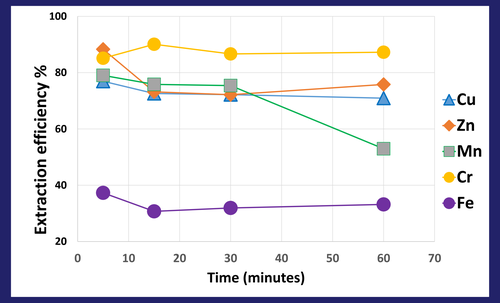


Figure 4. Effects of contact time

Figure 4 –The maximum extraction efficiency was observed at the contact time of 5 to 15 minutes for most elements. The removal efficiency of 37% Iron, 79% Manganese, 88 % Zinc and 77% for Copper were obtained at shaking time of 5 minutes.90% removal was obtained for Cr at 15 minutes of contact time . Cr, Cu and Zn reached equilibrium within 15 to 60 minutes as the % removal remained constant.
Poor adsorption was observed for Fe and Mn as they started leaching out due to the saturation of the adsorbent with these metal ions.
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4. Competeive ions effects

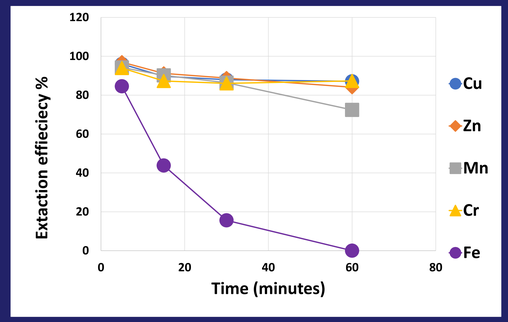


Figure 5. Effects of contact time on competitive ions

Figure 5 – In comparison to Figure 4(single component solution) The removal efficiency for all elements increased in a multi component solution adsorption with copper from 76% to as high as 96% , Iron from 37% to 84%. Zinc 88 to 97%, manganese from 79% to 94%, and 85% to 94% for chromium within 5 minutes of contact time.

APPLICATION OF SEPIOLITE

Environmental samples –Okapuka Tannery & Berg Aukas

Heavy Metals	Initial Concentration (mg/l)	Final Concentration (mg/l)	Adsorption Capacity (qe)
Mn	0.36	0	0.2
Zn	1.59	0.12	0.8
Fe	20.7	14.0	3.8
Cr	3661	2612	617.1

CONCLUSION

The effectiveness of Sepiolite clay as a low cost adsorbent was evaluated on the removal of heavy metals from freshwater system. The removal efficiency of 90% Cr , 79% Manganese, 88 % Zinc, 77% for Copper and 37% Iron were obtained when 25 mg of sepiolite was exposed to 1 mg -1 of spiked water samples at contact time of 5-15 minutes. The sepiolite used was rich in iron which explains the lower removal of iron due to saturation . Higher extraction efficiency was observed in a multi elemental solution which results shows potential for competition between metals.

The results obtained have demonstrated that sepiolite clay could be a suitable material to remove heavy metals from freshwater samples impacted by acidic drainage and can further be applied as an alternative method for effluent and wastewater treatment..