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Evaluation of the Efficiency of Selected Adsorbents in the Removal of Hardness from Gammams Effluent

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ABSTRACT

The efficiency of three natural, cheap and locally available adsorbents, namely: Fly ash, *Moringa oleifera*, and Sepiolite clay, were studied for hardness removal in Gammams effluent water. Upon conducting a pilot study, various parameters such as the influence of contact time, effect of adsorbent dosage and the effect of competition between the cations was conducted for sepiolite.

A rapid uptake of Ca^{2+} and Mg^{2+} was displayed, whereby sepiolite removed these ions in an optimum 15 minutes contact time. Extraction efficiency of 90% for Ca^{2+} and 43% for Mg^{2+} were obtained when the effluent water was exposed to 500 mg and 250 mg of sepiolite, respectively.

Competition adsorption studies showed that sepiolite performed better at removing Ca^{2+} than Mg^{2+} , with Mg^{2+} leaching out in some cases. These results identified sepiolite clay to be a suitable material for hardness removal in Gammams effluent.

METHODS AND MATERIALS

Sampling method and analysis

15 effluent samples at 5 set sites, as shown in Figure 1. XRF analysis was performed on the adsorbents for phase identification. An ICP-OES was used to detect and quantify trace elements in the various samples.



Figure 1: Windhoek wastewater treatment plant and sampling locations

RESULTS AND DISCUSSION

1. Equilibrium adsorption capacity of adsorbents

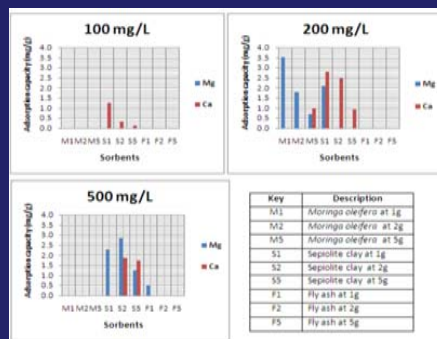


Figure 2. Adsorption capacity of Moringa, Fly ash and Sepiolite

RESULTS AND DISCUSSION

2. Extraction efficiency of adsorbents

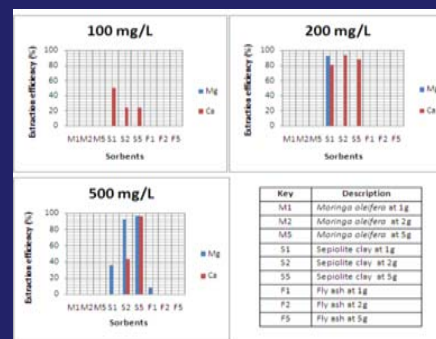


Figure 3: Extraction efficiency of Moringa, Fly Ash and Sepiolite

Figure 3 - Sepiolite reduced most of the Ca^{2+} and Mg^{2+} under all conditions (100, 200, and 500 mg/L hardness), with an extraction efficiency of approximately: 97% reduction for Mg^{2+} and 96% for Ca^{2+} in a 500 mg/L hard water solution (i.e. 250 mg/L Ca and Mg) and; 93% reduction for Mg^{2+} and 94% for Ca^{2+} in a 200 mg/L solution, respectively. The extraction efficiencies of fly ash and *Moringa oleifera* were very poor, with fly ash was only able to remove about 9% of Mg from the 500 mg/L solution.

RESULTS AND DISCUSSION

3. Kinetics – optimum dosage of sepiolite

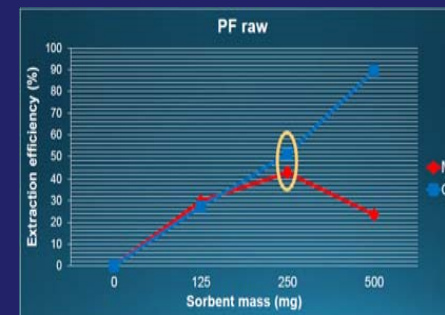


Figure 4. Optimum sepiolite dosage in Gammams effluent at 15 minutes

Figure 4 – The extraction efficiencies were 53% for Ca^{2+} and 43% for Mg^{2+} at 250 mg. Sepiolite removes Mg^{2+} at lower masses, but as the sorbent mass is increased beyond 250 mg, the adsorption efficiency of Mg^{2+} drops, whereas Ca^{2+} extraction gradually increases with mass. This indicates competition between the two elements - as Mg^{2+} leaches out, the performance of sepiolite towards Ca^{2+} is improved.

RESULTS AND DISCUSSION

4. Kinetics – optimum contact time of sepiolite

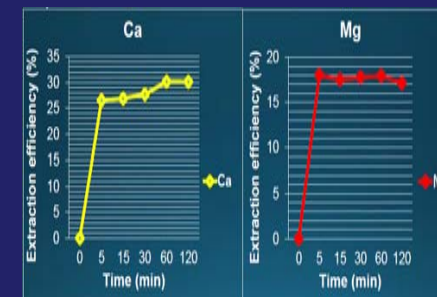


Figure 5. Optimum sepiolite contact time in spiked sample

Figure 5 - Ca^{2+} and Mg^{2+} concentrations decreased within the first 5 min, attaining an optimum of approx. 27% and 18%. The initial phase is due to slow attainment of equilibrium as a large number of vacant binding sites were available for sorption. Thereafter, the remaining binding sites were difficult to occupy due to the repulsive forces between the Ca^{2+} and Mg^{2+} on the solid mineral surfaces.

SUMMARY

Sepiolite % hardness reduction

	Mg (mg/L)	Ca (mg/L)	TOTAL HARDNESS (mg/L)	Percentage removal (%)
INITIAL CONCENTRATION	15.8	44.3	60.1	
125 mg	11.1	32.2	43.3	28
250 mg	9.1	21.6	30.7	49
500 mg	12.1	4.6	16.7	72

CONCLUSION

The extraction efficiencies of Fly ash, *Moringa oleifera*, and Sepiolite clay for calcium and magnesium in effluent were determined using ICP-OES. Comparative analysis results obtained in this study pointed out sepiolite clay to be the most efficient adsorbent and cheap material for effluent treatment. The removal of up to 72% of hardness demonstrates the efficiency of sepiolite as an adsorbent for calcium and magnesium in drinking water.

The results also revealed a potential for competition between target metals and other metals present in the effluent, or preferential adsorption of the cations. Magnesium is removed better than calcium in a multi-component solution, whereas calcium is removed better in a single component solution. The ability of sepiolite to remove hardness in the first 5-15 minutes of contact time makes it a good sorbent for Gammams effluent, which must be treated to meet the fast demand for drinking water.