INVESTIGATION OF A NEW PEAT BASED MEDIA FOR THE CAPTURE OF METALS FROM WASTEWATER

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Introduction

Heavy metals are toxic, bio-accumulative and have a detrimental effect on the environment and on human health [1]. Metals of concern in waterbodies include: aluminum, chromium, manganese, iron, cobalt, nickel, copper, zinc, cadmium, mercury and lead. Metal bearing wastes enter waterbodies as a result of many diverse activities such as industrial manufacturing processes, resource mining, deterioration of infrastructure, and transportation activities. These wastes require special treatment because they do not decay and many of them are toxic. An environment friendly management strategy for toxic metals must revolve around capture and removal of metals from where they pose a threat, and then transfer to a more secure location for burial or recovery.

In this study, the potential of a newly developed peat based sorbent for the capture of heavy metals from wastestreams was evaluated. The filter media under investigation is a proprietary blend of organic humic material targeted for the capture of soluble metals from industrial and stormwater wastestreams. Four metals; cadmium (Cd), copper (Cu), nickel (Ni), and zinc (Zn), were chosen for media evaluation, due to their occurrence and abundance in a large percentage of point and non-point source wastestreams. Industrial discharges of these four metals into the environment by TRI (Toxic Release Inventory) industries alone totaled almost 9.5 million kg in 2001 [2]. This represented 54% of all metals discharges by TRI industries reported in 2001. The issue of effective heavy metals management in the aqueous environment is an ongoing challenge for scientists and engineers to seek out new, effective and economically viable technologies to treat wastewater polluted with heavy metals.

Experimental

In the initial phase of the research, physical and chemical characteristics of the media were investigated. This included elemental analysis, particle size distribution, bulk density, specific gravity, moisture content, void ratio, swelling, pH change and energy release during wetting, surface area, and pore volume.

The second phase of the study evaluated the sorption characteristics of the media. Sorption tests included the evaluation of the rate and capacity of the media for the metals, anion influence on sorption, single versus multicomponent metals uptake, pH, leaching effects, and the effect of media moisture content on uptake rate and capacity.

Results and Discussion

Elemental analysis revealed that that the media is made up of 39.93% carbon (C), 5.01% hydrogen (H), 2.62% nitrogen (N), and 0.71% sulfur (S). The C percentage compared to other media studied previously by Brown in 1993 [3], was the lowest, which makes MetalRx unfavorable for activation to Granular Activated Carbon (GAC). The media size distribution falls within the 'poorly graded' classification; a favorable attribute for filtration applications. The specific gravity is 1.625, and the bulk density 650 kg/m^3. The media surface area is 1.006 m^2/kg, and total pore volume 2.738 x 10^{-5} m^3/kg. In the internal surface structure slit shaped mesopores predominate. On wetting the media it swells (2-50%), releases approximately 12.56 kJ/kg of energy and increases pH. This buffering action serves to counteract the pH drop during metals capture.

Results from isotherm tests showed that the presence of multiple sorbing metals increases sorption capacity of the media (0.94 mol/kg) the single component metal capacity (for example single component Cu capacity is 0.42 mol/kg) Figure (1). Though, the capacity of an individual metal in a multicomponent metal system is reduced compared to the single component capacity, due to metals competition for sites.

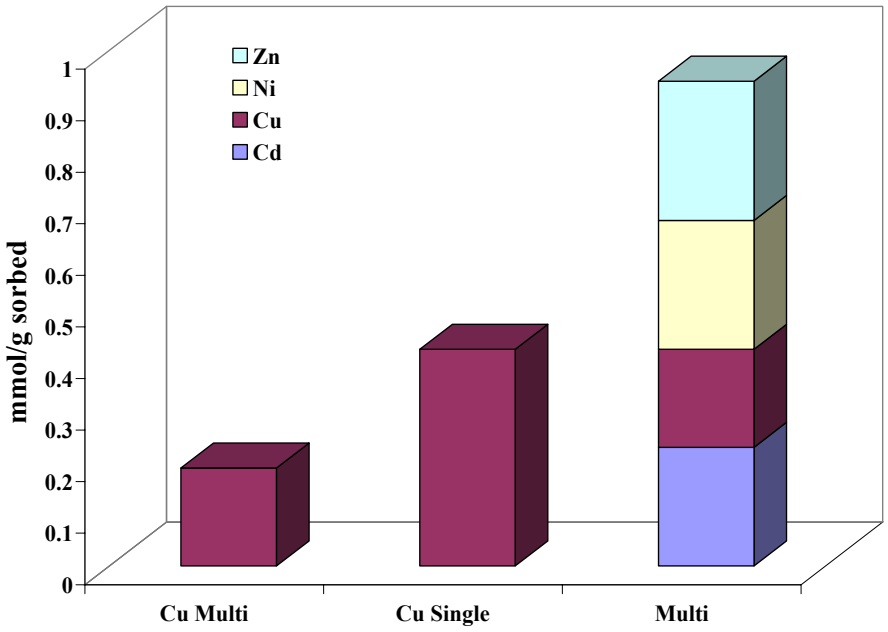

Figure (1) Comparison of the available sites for copper (nitrate) sorbed on 1 g of media in single and multicomponent systems under isotherm conditions [10 g media]

The increased leaching of cations in metal uptake tests compared to DI water is evidence of ion exchange behavior but does not account for all of the metals capture Figure (2). The increased metals sorption capacity of the media in multicomponent versus single component tests is likely due to selectivity of sites for individual ions. The media performance, compared to 17 media studied previously, revealed that although

MetalRx had comparatively low concentrations of exchangeable/leachable Ca, Mg, and Fe it ranked 6th in copper uptake.

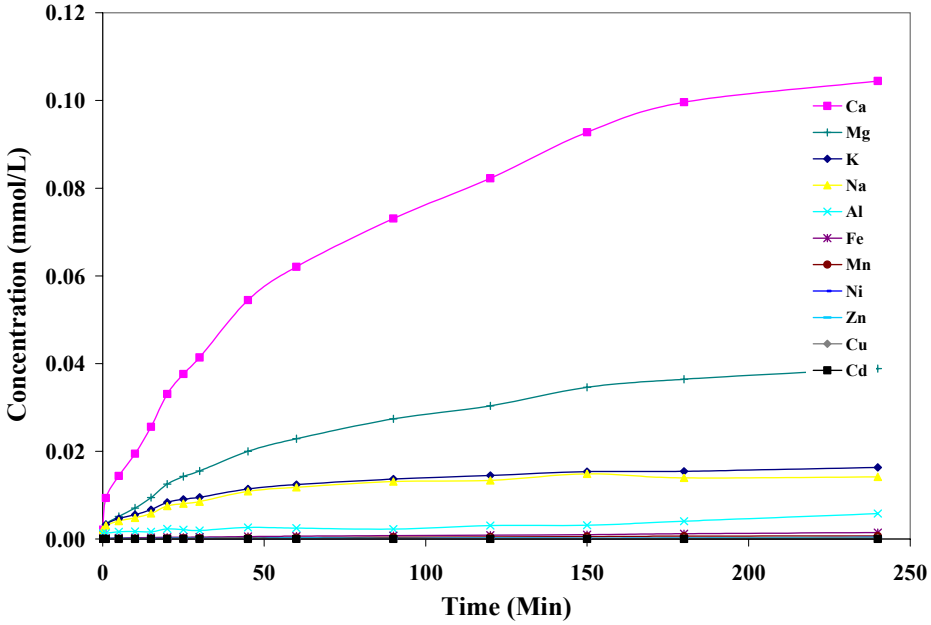

Figure (2) Metals leaching from media over time during kinetic test in DI water. Molar basis [1.8 L, 10g air-dry media]

Conclusions

By studying the media characteristics, the elemental analysis revealed that the carbon content of the media does not make a favorable candidate to be transformed into GAC, both the particle size distribution analysis and hydraulic conductivity test indicated that MetalRx has favorable physical characteristics for filter design, the void ratio of the media before and after being soaked in water was compared. This showed that the media provides extra area for sorption after being soaked in water. Swelling characteristic was one of the most important parameters that were studied. The swelling results gave no clear understanding of the nature and extent of swelling of the media. Therefore, swelling should be further investigated.

The sorption characteristics concluded from the pH studies on the media that ion exchange was occurring during metals capture and that it has been a major influence in adsorption and the exchange of ions between media and solution. During sorption tests metals' leaching was observed especially calcium and it was concluded that calcium release is correlated to metals sorption and this confirmed previous studies.
The isotherm and kinetic studies concluded that the nature of the anion did not affect the saturation capacity of the media. Langmuir and Freundlich isotherms were successful in representing metals sorption for concentrations greater than 10 mg/L. Freundlich was better than Langmuir in representing the data for the concentrations less than 10 mg/L, where the accuracy for Freundlich was around 92%.

The media has more available sites for multicomponent system than single component. The rank of the metals (molar bases) in the saturation capacity tests were Zn > Cd > Ni > Cu. The rate of removal of metals in a multicomponent system was Cd> Zn> Ni, Cu. Finally, comparing the media sorption with other types of media, it can be concluded that the media has good potential for sorption of heavy metals.

References

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