

**ABSTRACT****Removal Of Heavy Metals From  
Waters Using Low-Cost Adsorbents: Process Development**

Clint Sutherland

The objective of this study is to utilize high sorption capacity, low-cost adsorbents for removal and recovery of heavy metals from contaminated waters. Specific goals are: (1) to develop a media-screening protocol to evaluate adsorption potential for removal of heavy metal ions; (2) to study the batch and continuous flow sorption behavior of metal ions as a function of solution parameters (e.g. pH, ionic strength etc) and sorbent/sorbate parameters; (3) to study the potential for regeneration of adsorbents; (4) to represent mathematically the adsorption characteristics for process design.

From an environmental protection point of view, heavy metal ions should be removed, at source, in order to prevent pollution of natural waters and subsequent biomagnification of pollutants in the food chain. Adsorption, using low-cost, abundantly available media, promises to be a more efficient method of metal ion removal than existing methods, particularly if the sorbed ions can be recovered. Additionally, it presents an affordable alternative treatment ideal for industries, especially smaller downstream industries unable to sustain exorbitant treatment costs.

Categories of media evaluated are anthropogenic, non-viable biological and viable biological adsorbents. These materials are examined to determine their ability to bind

Cu(II) (model cation), Pb(II) and Cr(VI) (model anion). Quantitative evaluation through application of selected kinetic and equilibrium models identified peat moss as the most promising adsorbent for cations and activated carbon for anions. These and other selected adsorbents were further examined.

A semi-empirical kinetic equation is proposed. A more accurate simulation of the adsorption kinetics for all adsorbents was observed over that of the existing kinetic equations tested. Equilibrium behaviour of non-viable media is best modelled by the Langmuir isotherm, while viable biological media are best represented by Freundlich isotherm. A three-parameter equation is developed which can generate both Langmuir and Freundlich isotherm parameters. Closeness of fit to the experimental data is tested against other popular two and three parameter equations. The fit using the proposed equation was found to be superior.

A reasonably accurate simulation of adsorption breakthrough characteristics is necessary for process design and prediction. The Bohart-Adams equation is combined with an empirical formulation which is developed in this study and successfully applied to simulating the entire breakthrough profile of peat moss adsorption of Cu(II).

**Keywords:** Heavy Metals; Adsorption; Batch studies; Column studies; Empirical equations; Langmuir Isotherm; Freundlich Isotherm; Sorption Kinetics; Breakthrough Curves