EVALUATE AND COMPARE PEANUT HULLS FOR THE REMOVAL OF HEAVY METALS FROM WATER

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Introduction
The effectiveness of agricultural waste products as adsorption/ion exchange (sorption) media for metals has been known for some time[1,2,3]. It is unfortunate however that the research has never led to the development of full scale working filters. The main reasons for this has been the tremendous success of man made resins and widespread acceptance of precipitation technologies have cast shadows on the use of natural adsorbents in the past In addition poor physical characteristics of the that make them unsuitable for large scale filters.
The time has come to look once again at these natural adsorbents for the following reasons:

1. Technology now exists whereby agricultural waste products can be pelletized resulting in enhanced structural and physical properties and reduced handling and transportation problems.
2. With increasing NPDES standards for metals there is currently a need for low cost options for the removal of metals from dilute streams prior to discharge. Examples of where this technology would be applicable:
   - The treatment of urban/industrial stormwater runoff [pre-treatment legislation is pending];
   - A low cost polishing technology for metal bearing industrial wastewater;
   - A low technology, low cost treatment system for developing nations.
3. They are a renewable resource.

Background
Over four billion pounds of peanuts are produced annually in the United States. The vast majority, (over 95%) of this crop originates in the south - south eastern states. Peanut hulls are a waste product of this agribusiness and an estimated total of 1.50 billion pounds of hulls are produced annually in the United States [4]. Up until recently peanut hulls left after milling presented a problem for peanut farmers for several reasons:

1. The economics of hauling and landfill disposal charges for the large quantities of hulls is often cost prohibitive to farmers;
2. The accumulation of hulls poses a fire hazard;
3. Incineration or controlled burning of the hulls is highly regulated due to the large quantities of smoke and fly ash produced [(USDA 1979)].

The problems outlined above were also true for most other crop based agricultural by-products. Because of these problems, and, fueled by increasingly restrictive environmental regulations for burning and burial, and escalating landfill and haulage charges, substantial research over the past decade has focused on finding productive uses for agricultural waste products. In search of lucrative solutions to the hull problem various applications have been investigated. The main research in this field has examined the use of hulls in the following areas; a mulch/soil conditioner, anti-caking material, poultry food additive, poultry house litter, fuel source and adsorbent material. The most pertinent findings of the research have been adopted by the agricultural industry and developed into new applications for hulls namely their use in agriculture as a carrier for soil conditioning chemicals and pesticides and as litter material in poultry farming operations.

Research Objectives
The long term goal of this research project is the design and development of a low cost, low maintenance filter for the removal of metals from dilute aqueous waste streams. Peanut pellets are currently being investigated because of their effectiveness[5,6,7,] and widespread local availability. The initial study has assessed the ability of peanut hulls to capture metals from aqueous streams and the effect of process parameters on the rate and extent of copper uptake. This paper will outline the results of the initial study. Objectives of this stage of the research project :

I. Assess the ability of hulls to remove metals from wastewater and compare the results with commercial grade ion exchange resin and other effective sorbents: peat and lignite

II. Determine the effect of varying process conditions on the metal capture process.

Methodology

The adsorption/ion exchange processes for metals capture have been examined by kinetic studies of two process situations: equilibrium isotherm studies and standardized batch contact time studies. Future work will focus on continuous flow column studies. The rate controlling step(s) and hence the rate of metal uptake is influenced by the physical properties of the solid and the method of contact of the solid with the solution. Batch studies yield critical kinetic and capacity design data and highlight the influence of intraparticle diffusion on metal capture.

The uptake of copper by peanut hull pellets and pulverized pellets under steady state and transient rate batch conditions have been investigated. The parameters influencing the uptake of copper were identified and evaluated. Initial investigations were divided into two main sections namely batch contact time experiments and batch equilibrium isotherm studies. These procedures are detailed elsewhere [8,9]. Analysis of the samples for residual copper concentration in solution was performed using the ICP- OES (Perkin Elmer Optima 3000 DV).

Results

The effect of process conditions on the uptake of copper ions from solution were investigated. The parameters investigated for their influence on metal ion capture under stirred batch and equilibrium conditions were; hull particle size, metal ion concentration, pH (not reported) and contact time. The results were compared to those of a commercial grade ion exchange resin, peat and lignite [8,9].

Contact time: From previous batch studies[8] it was observed that for all adsorbents agitation speeds of 400 rpm or greater were necessary to minimize external boundary layer (film) resistance to mass transfer. For isotherm investigations it was determined experimentally that four hours was the sufficient contact time for the attainment of equilibrium with peat, however lignite and hulls required at least 24 hour contact time. For peat the rapid equilibration indicates that it may act as a weak cation exchange resin with whereas slower adsorption may predominate with on the less polar surfaces of lignite and hulls.

Particle Size: An inverse relationship was found between particle size, capacity and rate of uptake for copper. The capacity of the hulls for copper decreases as particle size increases. Capacity varies from 11mg/g at less than to equal to 20 mesh, to 17 mg/l at 80 mesh. Whereas for peat, lignite and the resin the relationship is independent; particle size has no effect on capacity for copper. In batch contact time studies the rate of uptake was found to vary with particle size for all adsorbents; the uptake rate increased with decreasing particle size. Adsorbent particle size controls the amount of surface area is available for reaction. For Peat, lignite and resin all internal as well as external surface sites are available to the metal. Whereas for hulls there is occlusion of sites on the internal micropores of the sorbent.

Metal Ion Concentration: The rate of metal ion capture was found to increase with increasing initial sorbate concentration. This is expected since the driving force for mass transfer has been increased and this increases the rate of intraparticle diffusion onto the solid

Capacity and Rate of Uptake: Isotherm capacity studies show commercial grade ion exchange resin, as expected has the highest capacity for copper at 80mg/g. Peat generally performs better than hulls although the heterogeneous nature of peat results in a large range in capacity depending on the type chosen[9]. Results on ten types of peat show that peat performs with the range of 75% to 10% resin capacity. Lignite performs at 23% of resin capacity. Peanut hulls perform in the range 23% to 12% of resin capacity depending on the particle size chosen, for reasons discussed above.

The Langmuir isotherm gave excellent correlation between theoretical and equilibrium data for all adsorbents.

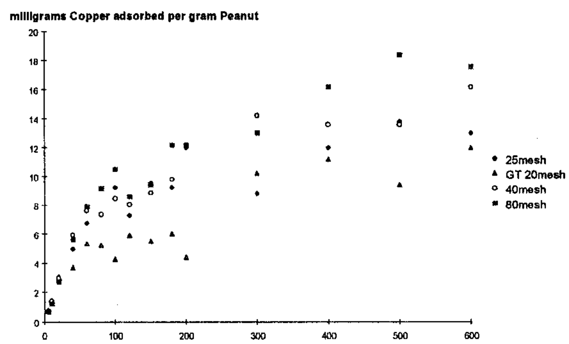

Fig. 1 The effect of particle size on capacity for copper

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