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Removal of Heavy Metals in Water with Adsorbents Derived from Pig Manure

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Extended Abstract

Heavy metals in natural waters such as lead, cadmium and nickel are considered to be toxic from a certain concentration and especially in a particular chemical form (speciation). The maximum allowable concentrations of these heavy metals in water are 0.01 mg/L for Pb, 0.003 mg/L for Cd and 0.02 mg/L for Ni (WHO). Heavy metals are removed from the environment through sand filters, ion exchangers, coagulation and activated carbon (AC).

AC's are very efficient as an adsorbent because of their high porosity, high specific surface area, and high degree of surface reactivity [1] but are suffering from high production costs (three kilos of high quality coal is needed per kg AC produced). The challenge is a conversion-route / method with a lower cost, techno-economically attractive and producing AC's with similar or superior characteristics then the commercial available AC's starting from suitable biomass rest streams like pig manure. Simultaneously, a reduction of waste disposal and protection of the environment will be achieved [2], [3]. There are three key steps in the production of AC from pig manure. First, dewatering of the pig manure is needed and is done by a reverse osmotic process. Next, a carbonization of the 30% wet material is performed at 450°C in the absence of oxygen. This material, biochar, can already be used as an alternative adsorbent for commercial AC's. And finally in the last step, the biochar is activated with steam at temperatures above 800°C [4] resulting in AC.

The biochar and the corresponding AC are investigated for adsorption of Pb, Cd and Ni compared with commercial ACs. This is performed by a simple but reliable two point method developed within our research group at Hasselt University. This method uses two different masses of adsorption material at two different pH's, but keeping the concentration of the heavy metal constant. The results reveal that pig manure based biochar adsorbs around 83% of Pb, 60% of Cd and 80% of Ni. Further activation to AC improves the adsorption to a level almost 100% of the Pb, Cd and Ni present at concentrations of 10 ppm each. The commercial AC's adsorbs only 5% of Pb and 48% of Cd at the same concentration levels. The percentage of adsorption for Ni is the same as for the biochar. Langmuir and Freundlich adsorption isotherms are explored to determine the adsorption behaviour. Adsorption kinetics are examined by first, second and n-th (mixed) order kinetics for a better understanding of the adsorption mechanism.

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