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Full Length Research Paper

Sorption of lead (ii) ions by granular activated carbon from animal horns: A comparative study

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The physico-chemical properties of wastewater effluent from the plants of a brewering industry in Nigeria have been analyzed. The lead ions removal capacity of Granular activated carbon from animal horns and its comparison with commercial granulated activated carbon (GAC) was studied. Batch kinetics and isotherm studies were carried out for the adsorption of Pb^{2+}. The equilibrium sorption data fitted well the Freundlich model. The experimental data, when applied to the first and second-order kinetic models, followed both kinetic models with r^2 = 0.898 for GAC from animal horns and r^2 = 0.973 for commercial GAC. The results obtained showed how animal horns, a solid waste from the abattoir at the Oshodi market in Lagos metropolis, was used as an effective adsorbent for the removal of Pb^{2+} ions; offering a cheap option for primary treatment of the brewery wastewater effluent.

Key words: Brewery, wastewater effluent, primary treatment, batch kinetics.

INTRODUCTION

Pollution of wastewater by organic and inorganic chemicals is of serious environmental concern. With the industrial revolution throughout the world, pollution has become worst (Hammer, 2001).

Sorption of pollutants from wastewater has long been studied. The rate at which sorption takes place is of the utmost importance when designing batch sorption systems, consequently it is important to establish the time dependence of such systems under various process conditions (Ho, 2006). The adsorption process using activated carbon and ion exchange resin as adsorbent is widely applied in the advanced treatment of wastewater (Cao et al., 1999). However, the high costs of adsorption restrict the extensive application of activated carbon and ion exchange resin. The main factors affecting the adsorption costs include adsorption rate and the capacity of the adsorbent. Therefore, improving the rate and capacity is an effective way to reduce the adsorption operating costs (Han et al., 2007).

Activated carbons are highly effective as adsorbents in the removal of heavy metals from wastewater (Reed and Arunachalam, 1994). Several workers have reported investigations on the adsorption of metal ions on commercial activated carbons (Bilinshi et al., 1977; Koshima and Onishi, 1986; Sigworth and Smith, 1972). Lead is fairly widespread in our consumer society and probably is the most serious toxic metal. Evidence of harmful effects in adults is rarely seen in blood where lead levels are below 80 mg per 100 ml. Human exposure to lead occurs through air, water and food. The passage of lead into and between these media involves many complex environmental pathways. There is a long history of human exposure to abnormally elevated levels of lead in food and drink, due to practices such as cooking in lead-lined or lead glazed pots and the supply of water through lead pipes (Ho et al., 2002).

This study compares the suitability of Granular activated carbon obtained from animal horn with that of commercial activated carbon for treatment of brewery wastewater effluent.

METHODOLOGY

Sample Collection

The animal horns (from cattle) were collected from the Abattoir at the Oshodi market in Lagos, Nigeria. The wastewater samples were collected from the reservoir of effluent from the plants of a brewery in Lagos, Nigeria and physicochemical analysis was carried out using AOAC method of analysis (APHA, 1989). Atomic absorption spectrometer (AAS): model Philips PU 9100x was used to measure the concentration of Pb^{2+} ions present in

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Table 1. Physico-chemical analysis of wastewater effluent.

Parameters	Concentration
pH	8.7
Electrical Conductivity (EC), m.h.c.g/cm	40.2
Temperature, °C	31.0
Turbidity, NTU	23.5
Total solids (TS), mg/l	96.0
Total Suspended Solids (TSS), mg/l	44.0
Total Dissolved Solids (TDS), mg/l	56.0
Chemical Oxygen Demand (COD), mg/l	692.57
Total Organic Carbon (TOC), mg/l	724.49
Biochemical Oxygen Demand (BOD), mg/l	112.49
Pb^{2+} ions, mg/l	12.30

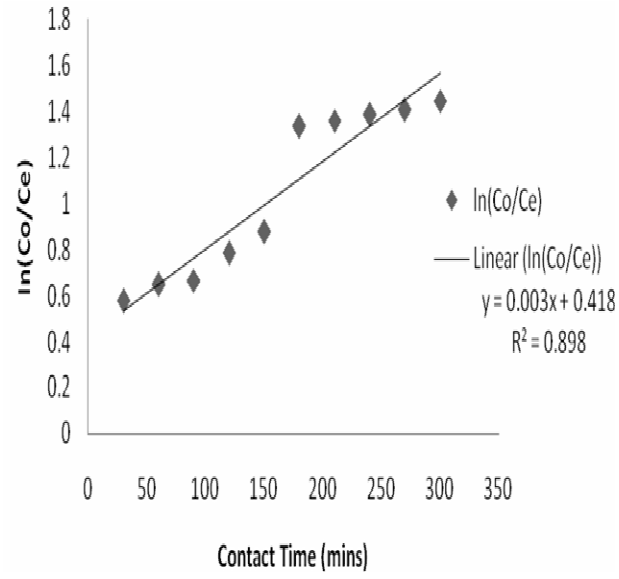

Figure 1. 1st order adsorption kinetics of Lead (Pb) ions using 90 g/l of animal horn GAC

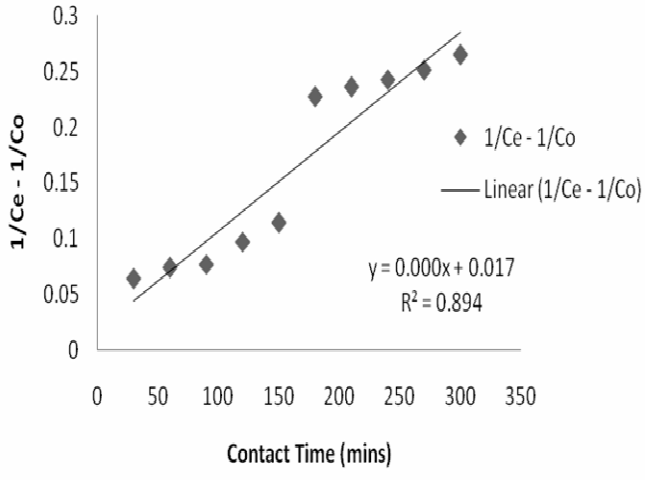

Figure 2. 2nd order adsorption kinetics of Lead (Pb) ion using 90 g/l of animal horn GAC.

the brewery wastewater.

Preparation of Granular activated carbon

The animal horns were cut to sizes of about 5 - l0 mm, washed to remove dirt then dried in an oven at 100°C and charred by carbonizing in a furnace at a temperature of about 560°C for 3 h and later cooled at ambient temperatures in desiccators.

2 Kg of the carbonized animal horns were mixed with 250 ml of 5.5 M HCl solution and refluxed by boiling for 3 h. After slight cooling, the slurry was filtered and washed using distilled water with pH near neutrality. The product was later dried at 120°C for an hour.

Determination of best adsorbent dose

The experiments were conducted by varying the amount of adsorbent. A known volume of the wastewater sample was treated with different doses of activated carbon ranging from 30 to 240 g/l. The samples were agitated for 60 min, filtered then analyzed for residual parameters.

Determination of contact time

The study for the contact time was carried out by agitating the best adsorbent Concentrations, 90 g /l for animal horn and 30 g/l for commercial activated carbon for the ranges of 30 to 300 min.

Determination of metal (Lead) ions concentrations

The metal concentrations were determined using the atomic absorption spectrophotometer (AAS).

RESULTS AND DISCUSSION

The physicochemical parameters of brewery wastewater on analysis before the sorption studies were carried out as shown in Table 1.The results obtained also indicated that the wastewater effluent of the brewery was alkaline with pH 8.7. The study of two different adsorption isotherms - Langmuir and Freundlich has been reported in literature (Domenico and Schwartz, 1990; Reddi and Inyang, 2000; Nitzsche and Vereeken, 2002). The data obtained for both models were represented graphically here in Figures 5a, 5b, 6a and 6b.

Kinetics studies carried out showed that the adsorption reaction was described by both first and second order. This was shown in Figures 1 to 4. It was observed that GAC obtained from animal horns, the regression value (r^2) for first order was 0.898 (Figure 1) which was higher than that for the second order which was 0.894 (Figure 2).

The kinetics studies for commercial GAC followed the same pattern as GAC produced from animal horns. The regression value (r^2) for first order was 0.973 (Figure 3) which was lower than that for the second order which was 0.954 (Figure 4).

When results in Figure 5a was compared to that in Figure 5b for GAC prepared from animal horns it was observed that the adsorption adhered to the Freundlich isotherm with the r^2 of 0.523 being greater than that of Langmuir with a r^2 of 0.278.

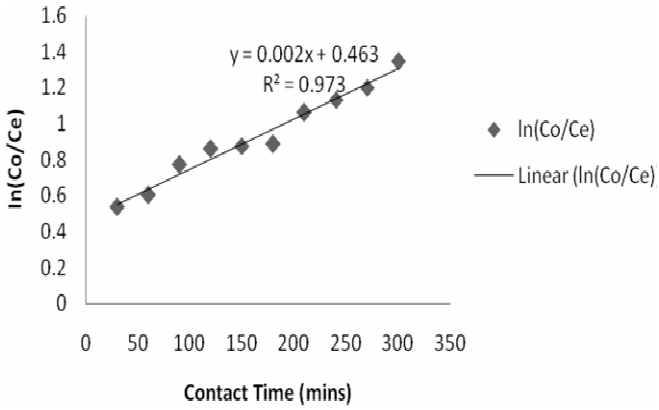

Figure 3. 1st order adsorption kinetics of Lead (Pb) ions using 30 g/l of commercial GAC.

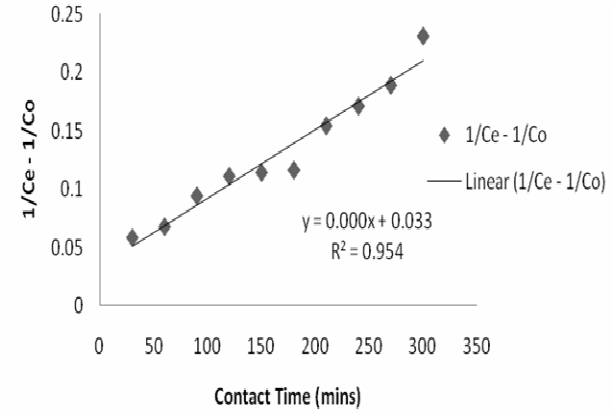

Figure 4. 2nd order adsorption kinetics of Lead (Pb) ions using 30 g/l of commercial GAC.

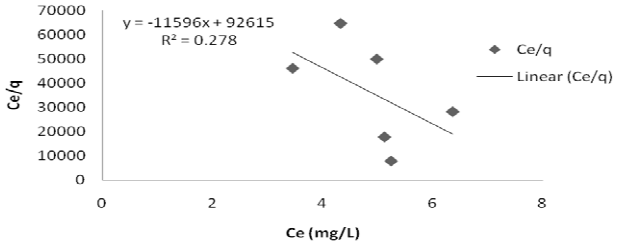

Figure 5a

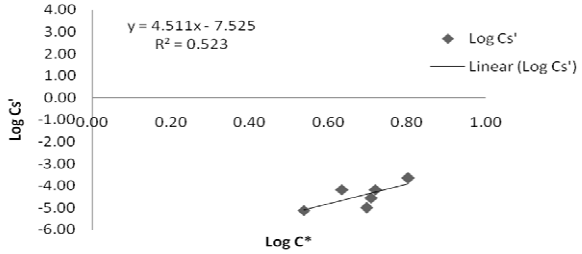

Figure 5b

Figure 5. (a) Langmuir isotherm for Lead ions using animal horns GAC. (b) Freundlich adsorption for Lead ions using aimal horns GAC.

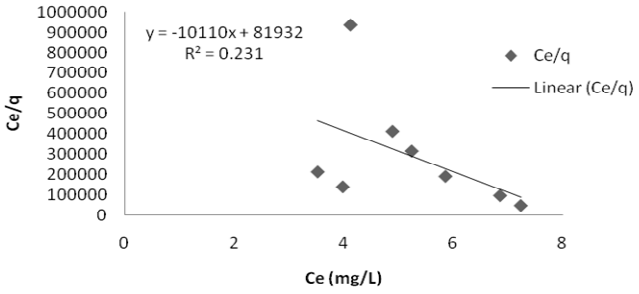

Figure 6a

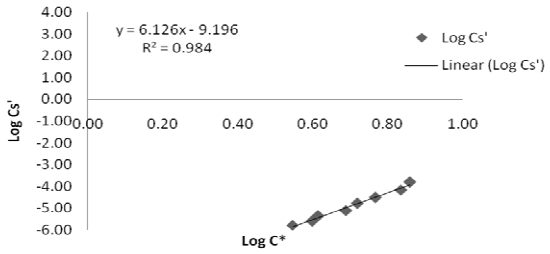

Figure 6b

Figure 6. (a) Langmuir isotherm for lead ion using comercial GAC. (b)Freundlich adsorption for Lead ions using commercial GAC.

The same pattern was also observed with that for commercial GAC. The r^2 of Freundlich isotherm was 0.984 when compared to that of Langmuir of r^2 of 0.231 as shown in both Figures 6a and 6b. Thus it can be concluded that adsorption using any of the two forms of activated carbon followed the Freundlich adsorption isotherm.

Conclusion

The removal of metal ions from effluents is of importance to many countries of the world both environmentally and for water re-use.

The experimental results obtained showed that of the two adsorption isotherms studied, the Freundlich adsorption isotherm had a higher regression than Langmuir for the two types of activated carbon considered. GAC from animal horns and commercial GAC both followed the first and second order reaction kinetics in the adsorption of Lead (II) ions.

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