REMOVAL OF CHROMIUM (VI) FROM WASTEWATER USING COW BONE CHARCOAL

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Abstract: **The removal of chromium (VI), a heavy metal from aqueous system using cow bone charcoal was studied. The removal potential of the charcoal was investigated at 27°C using a particle size of 300µm. Batch experiments were conducted to examine the effects of the following parameters: adsorbent dosage (0.05-0.25g); contact time(1-25mins); pH (2-10). The results revealed that 0.1g of the adsorbent removed 88.7% of the adsorbate; that the equilibrium was achieved at 15 min of contact time and that 83% of the adsorbate was removed when the pH of the adsorbate was adjusted to pH = 6.**

Keywords: **Chromium, heavy metal, adsorbate, cow bone charcoal**

Introduction

Heavy metal pollution in the aquatic environment is a major health problem this is because they are toxic and non-biodegradable [1, 2]. Chromium is carcinogenic and is relatively wide spread in the environment [3, 4]. It is used in industries such as electroplating, fertilizer, tanning and wood preservation, dyeing and photography industries [5]. These metals found their way into the aquatic environment through wastewater discharge [6] .

Industrial waste water are contaminated by heavy metals, such as metal plating, mining operations, tanneries, chloralkali, radiator manufacturing, smelting, alloy industries, storage batteries industries [6].

Heavy metals are non-biodegradable, hence they tend to accumulate in aquatic organisms such as fish, crabs, etc, and using water contaminated by heavy metal can lead to metal poisoning in man. Heavy metals pose health hazards, if their concentration exceeds allowable limits. Even when these limits are not exceeded, there is still the potential of a long term poisoning, due to bioaccommodation in biological systems [7]. As per the World Health Organization standard, the maximum contaminant level of chromium for the drinking water is 0.05 mg/l [8], but usually effluent discharged from the industries contained levels above this quantity. Ingestion of chromium may cause nausea, vomiting, epigastric pain, and severe diarrhea. Due to carcinogenic and teratogenic characteristics of Cr (VI), it has become a serious health concern [9].

Because of the effect of heavy metal contamination in industrial wastewater, industrial waste water must be treated before discharge into the aquatic environment [8]. The most common and harmful heavy metals are chromium, lead, copper, nickel, and zinc. They are stable elements that cannot be metabolized by the body and get passed up in the food chain to human beings [10].

The methods are used for the removal of heavy metals from industrial effluents include chemical precipitation, coagulation, solvent extraction, electrolysis, membrane separation, ion exchange and carbon adsorption [11]. Most of the methods suffer with high capital and regeneration cost of the materials [12]. Therefore, there is currently a need for new, innovative and cost effective methods for the removal of toxic substances from wastewaters [13]. Adsorption process has been an area of extensive research because of the presence and accumulation of toxic carcinogenic effect on living organisms [7].

Bone char is used as effective adsorbent because of it large surface area and pore sizes hence it can be easily adopted as low cost adsorbent in the removal of heavy metals from industrial wastewaters.

Studies have shown that heavy metals can be removed from aqueous solution using plant materials such as *Xanthium pensylvanicum* [14], *Acacia Nilotica* leaf activated carbon [15],; activated carbon prepared from cashew nut shells [16] Banana and orange peels [1], Coconut Shell Based Activated Carbon [17], olive stone activated carbon [18].

Cow bone char is a porous, black, granules material produced by charring animals bones, its composition varies depending on how it's made; however, it consists mainly of tricalcium phosphate (or hydroxylapatite) it is primary used for filtration and decolourisation [19].

Materials and Method

Preparation of Bone Char

Cow bones bought at Obo Annang market was taken to Chemistry Laboratory, University of Uyo. The bones were boiled for 10 minutes and the meats attached on the bones were removed. The bones were crushed into small fragments and burned by pyrolysis in an electric muffle and carbonized at 800^0C for 4h. The residues were washed and dried in an oven at 60^0 C for 24 hours, bone char was powdered and sieved through a 300µm mesh sieve. Bone char with various masses ranging from 0.05g – 2.0g were added into 50ml of $25mgl^{-1}$ chromium solution in 5 different 250 volumetric flasks. The suspension was shaken at 150 rpm using mechanical shaker at room temperature (27^{o}C). After shaking, the solution was immediately filtered through 0.22µm Whatman filter paper. Post adsorption concentrations of Chromium were measured using atomic absorption spectrophotometer (AAS).

Effect of Contact Time

For the optimization of contact time, 50ml of aqueous solution of $25mg/dm^3$ of chromium was taken in a 250ml of conical flask and a fixed amount of adsorbent, 0.1g was added. The study was done at different time intervals of 1 min to 25 min at room temperature. After adsorption, the filtrates were analysed for residual chromium concentration using AAS.

Effect of pH

The effect of pH on chromium sorption to bone char was evaluated by adding 0.1g of adsorbent into flasks containing 50ml of $25mgl^{-1}$ chromium-bearing solution at different initial pH (2-10). pH of solutions was adjusted using 0.1M HCl/ 0.1M NaOH. Flasks were shaken at 150 rpm at 27^0C for 120 minutes. Initial and equilibrium pH of solution and residual chromium concentration were measured using AAS.

Result and Discussion

Table 1: Effect of activated carbon (AC) dosage, pH and contact time on the percentage of chromium removal

Effect of AC dosage		**Effect of pH**		**Effect of Contact time**	
Mass of adsorbent (g)	% Remove	pH	% Remove	Time (min)	% remove
0.05	88.4	2	82.00	1	86.67
0.1	88.7	4	82.40	5	89.87
0.15	88.7	6	83.00	10	95.00
0.2	88.7	8	82.90	15	99.86
0.25	88.6	10	82.80	20	99.86
-	-	-	-	25	99.86

The adsorbent dose is an important parameter in adsorption studies because it determines the capacity of adsorbent for a given initial concentration. Result in Figure 1 revealed that 0.1g of cow bone charcoal was able to remove 88.7% of chromium, after the dosage was increased to 0.15g and 0.2g the effect was the same but when it was increased to 0.25g the % removal dropped. Therefore in this study 0.1g of cow bone charcoal is the correct dosage for chromium removal. Result in Figure 2 also revealed that at 1min the percentage chromium removal was 86.67%, at 10 mins it was 95%, and that at 15 mins, it increased to 99.8% where it attained a constant value at equilibrium.

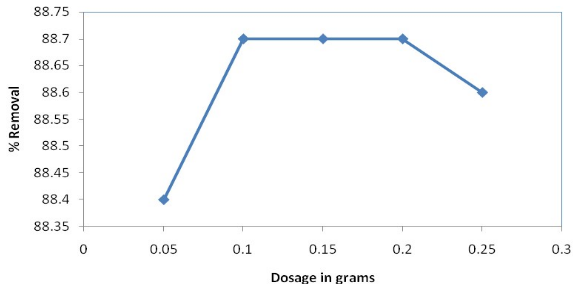

Figure 1: Effect of adsorbent dosage on the adsorption of chromium onto cow bone charcoal at room temperature, pH = 6, contact time = 15 minutes at agitation speed of 150 rpm

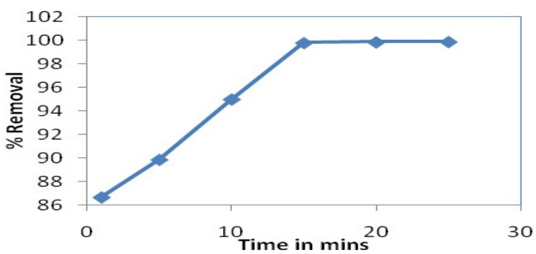

Figure 1: Effect of varying contact time (1-25 mins) on the adsorption of chromium onto cow bone charcoal at room temperature. Adsorbent dosage= 0.1g, pH of adsorbate = 6, agitation speed 150rpm

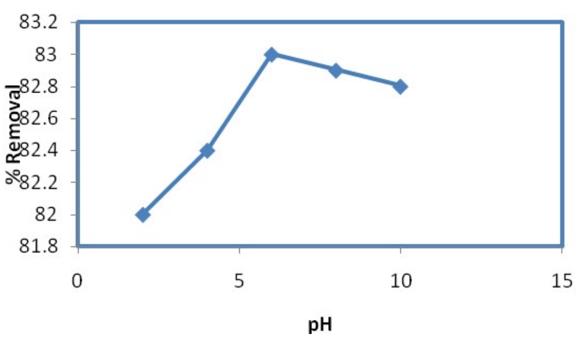

Figure 3: Effect of pH on chromium adsorption onto cow bone charcoal at room temperature, pH = 2 - 10, adsorbent dosage = 0.1g contact time 15 minutes, agitation speed 150rpm

This also revealed that the adsorption of chromium increased with increasing contact time. It was also observed that the uptake of the chromium was fast at the initial stages of contact time and thereafter becomes slower near equilibrium and reached a steady value at equilibrium. The effect of pH on the adsorption efficiency of cow bone charcoal was also studied (Figure 3) revealed that the percentage dye removal was 82% at pH = 2 but which increased to 83% at pH = 6. This result revealed that to have maximum removal of chromium in this study the pH should be kept at 6.

CONCLUSION

In this present study, adsorption of chromium on cow bone charcoal aqueous solution has been studied. The data obtained through this work supports that the cow bone charcoal is an effective low cost adsorbent for the removal of chromium in aqueous solution. Therefore, the adsorbent could find industrial applications for the treatment of industrial wastewater containing chromium before it is discharged into the aquatic environment.

REFERENCES

[1] Annadurai, G. Juang, R.S. and Lee, D.J (2003). Adsorption of heavy metals from water using banana and orange peels. *Water Science & Technology* p 186

[2] Uzun, Ilhan and Guzel, Fuat (2000)Adsorption of Some Heavy Metal Ions from Aqueous Solution by Activated Carbon and Comparison of Percent Adsorption Results of Activated Carbon with those of Some Other Adsorbents. *Turk J Chem* 24: 291-297

[3] Cieslak, G. M., (1996). Toxis and magnetic effects of chromium (VI) Polyhedron 3665

4]Karthikeyan T., Rajgopal S., Miranda L. R. (2005). *J. Hazard. Mater.*124 192.

[5] Cheung, C. W. (1998). Sorption Kinetics of Metal Ions on Bone Char. M.Phil. Thesis, Department of Chemical Engineering, The Hong Kong University of Science and Technology, Hong Kong. *Journal of Environmental Research*, *65*, pp 238-244.

[6] Gao H., Liu Y., Zeng G., Xu W., Li T., Xia W. (2007).*J. Hazard. Mater.* 150: 446.

[7] Etorki, Abdunnaser Mohamed, El- Rais, Mahmoud , Mahabbis, Mohamed Tahher, Moussa, Nayef Mohamed (2014). Removal of some heavy metals from waste water by using of Fava beans. *American Journal of Analytical Chemistry*, 5: 225-234

[8] Tare, V. Gupta, S. Bose, P. (2003). Case studies on biological treatment of tannery effluents in India. *J. Air Waste Manag. Assoc*. 53: 976 – 982,

[9] Gupta, V.K. Rastogi, A.,., and Nayak , A. (2010). Adsorption studies on the removal of haxavalent chromium from aqueous solution using a low cost fertilizer industry waste material. 342: 135–141

[10] Hutchins, R. A. (2003). New Methods Designed for Activated Carbon Systems. *Chemical Engineering*, *80*, pp 133-138. *Chemical Engineering Science*, *41*, pp 73-76

[11] Yiacoumi, S., & Tien, C. (1995). Kinetics of Metal Ion Adsorption from Wastewater. *Journal of Chemistry Technology*. Vol 70. pp. 131-140.

[12] Alexander, F., Poots, V. J. P., & McKay, G. (1998). Adsorption Kinetics and Diffusional Mass Transfer Processes during Colour Removal from Effluent using Silica. *Industrial and Engineering Chemical Process Design and Development*, *17*, pp 406-410.

[13] Manzoor, I. K. (1995). The Study of Heavy Metal Ions Adsorption on Activated Charcoal with Special Reference to Environmental Pollution Ph.D Dissertation. University of Karachi, Iran.

[14] Salehzadeh, Jaber (2013). Removal of heavy metals Pb^{2+}, Cu^{2+}, Zn^{2+}, Cd^{2+}, Ni^{2+}, Co^{2+} and $Fe^{3+}$from aqueous solutions using *Xanthium pensylvanicum*. Leonardo journal of sciences. 23: 97-104

[15] Thilagavathy, P. and Santhi T. (2014). Adsorption of Cr (VI) Onto Low-Cost Adsorbent Developed from *Acacia Nilotica* Leaf Activated with Phosphoric Acid: Kinetic, Equilibrium Isotherm and Thermodynamic Studies. International Journal of Science and Research

[16] Tangjuank, S., Insuk, N., Udeye, V. and Tontrakoon, J. (2009). Chromium (III) sorption from aqueous solutions using activated carbon prepared from cashew nut shells. *International Journal of Physical Sciences* 4 (8): 412-417

[17] Alaerts, G. J., Jitjaturant, V., & Kelderman, P. (1989). Use of Coconut Shell Based Activated Carbon for Chromium (VI) Removal. *Water Science and Technology*, *21*, pp 1701-1704.

[18] Pereira, M. R., Arroya, P. A., Dornellas de Barros, M. A., Sanches, V. M., da Silva E. A. Fonseca, I. M. and Lovera, R. G., (2006). Chromium adsorption in olive stone activated carbon. Adsorption 12(2):155

[19] Volesky, B. (1990). Removal of Metals from Electroplating Wastes using Banana Peels. *Bioresourse technology*. 51: 227