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RESEARCH ARTICLE

PREPARATION OF ACTIVATED COW BONE CHARCOAL FOR ABATEMENT OF WATER POLLUTION CAUSED BY TANNERY EFFLUENTS

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ABSTRACT

Tannery effluents such as chrome and dye liquor are mostly responsible for water pollution. At present, there is growing interest in using low cost, commercially available adsorbent for the adsorption of contaminants. Activated cow bone adsorbent was prepared and characterized by infra-red (IR) spectroscopy and scanning electron microscopy (SEM). Different parameters of chrome and dye liquor such as BOD, COD, TDS, TSS and electrical conductivity were measured before and after adsorption with activated cow bone charcoal. From the experimental results, it reveals that BOD, COD, TSS, TDS and electrical conductivity (EC) of chrome and dye liquor were reduced significantly after adsorption with activated cow bone charcoal. Thus the activated cow bone charcoal may be used for treating the tannery effluents to mitigate environmental pollution.

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INTRODUCTION

Bangladesh is a developing country and leather industry has great impact on its economy. A plenty of chemicals are used to process leather. After completion of different steps of production tanneries discharge these effluents. Precisely, these tannery effluents are most hazardous for the people of Hazaribagh, Dhaka, Bangladesh (Azom *et al.,* 2012). For the leather production, there are three steps which are wet-blue, crust and finishing. In the chrome tanning, tannery produce chrome liquor which is harmful for the environment including its high value of BOD and COD. In crust section, tannery uses dye with other detrimental chemicals and finally cede dye liquor that is responsible for water pollution. Recently adsorption has become interesting for removal of pollutants from industrial effluents (Gupta, *et al.,* 2009). Cow bone adsorbents are potential candidates to be used as adsorbents. Cow bone charcoal is called bone char, is a granular material produced by charring animal bones. Animal bones are having different composite parts that form the body of animals. Cow bone charcoal produced by carbonization process of Cow bones contains 10% carbon and 90% of hydroxyapatite (Medellin-Castillo *et al.,* 2014). The bone charcoal also contains tricalcium phosphate and calcium carbonate (Cheung *et al.,* 2001). Bone charcoal is usually porous with a high surface area that can adsorb substances into its surface by intermolecular forces (Bansal and Goyal, 2005). Activated charcoal as an amorphous form of carbon can be produced from any form of carbonaceous material or organic precursor; raw materials such as mangrove wood (Astuti *et al.,* 2017), animal bone (Djilani *et al.,* 2016), coconut shell (Mizan *et al.,* 2016) and palm kernel shell, bamboo (Ademiluyi *et al.,* 2009), nut (Viboon *et al.,* 2008) and groundnut shell (Tangiuank *et al.,* 2009). Many researchers have studied simplified and cost effective methods for preparing activated carbon. The most widely used process for activation of carbon is the treatment of carbonaceous materials with oxidizing gases such as air, steam or carbon dioxide (Sivakumar and Palanisamy, 2010; Ajemba, 2013; Mane *et al.,* 2000). Charcoal may also be activated by treating it with zinc chloride, magnesium chloride, calcium chloride or phosphoric acid (Mizan *et al.,* 2016; Sahira *et al.,* 2013). Adsorption is the collection of substance on to the face of the adsorbents. It is a removal process in which certain particles are bound to an adsorbent particle surface by either chemical or physical attraction and is often confused with absorption where the substance being absorbed penetrates into the other solid (Reynolds and Richards, 1996). In contact with

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a solution, the solid surface has the tendency of accumulating substances because of the difference in surface attractions resulting in adsorption. Often an equilibrium concentration is soon formed at the surface and is normally followed by slow diffusion onto particles of the adsorbent (Ttreybal, 1981). Bone char as an adsorbent can be an effective and versatile means and can be easily adopted to remove pollutants from large amount of industrial wastewaters. Its availability and cost make it suitable candidate compared to other adsorbents. It is well understood that particle size of the adsorbent has a great effect on its adsorption capacity. Namely, adsorption increase with a decrease in particle size. Therefore, in this study it is envisioned to prepare activated cow bone charcoal of different sizes for treating chrome and dye liquor of tanneries.

MATERIALS AND METHODS

Preparation of activated cow bone charcoal

Cow bones were collected from local markets at Hazaribagh, Dhaka, Bangladesh. The bones were thoroughly washed and sun-dried for a week. The bones were then further oven-dried for 72 hours at 110°C and calcined in a muffle furnace at 400°C for one hour in absence of air. Figure 1 shows the preliminary treated cow bone and calcined cow bone. The obtained charcoal was ground and graded into two different size fractions of <300 µm and 300 - 600 µm using US standard sieves (ASTM E-11). Finally the sample was chemically activated with 2 M Hydrochloric acid for 24 h and was washed with water and finally dried at 100°C until free from moisture.

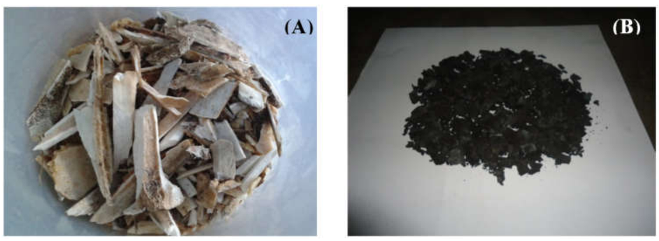

Figure 1. Cow bone after preliminary treatment (A) and after calcination in muffle furnace at 400°C (B)

Characterization of activated cow bone charcoal

Activated cow bone charcoal prepared in this study was characterized by IR spectroscopy and SEM. Some physical parameters of activated cow bone charcoal such as moisture content, bulk density, pore volume were studied by standard methods.

Collection of chrome liquor and dye liquor

Chrome and dye liquor samples were collected from Apex Tannery and Crescent Tannery, Hazaribagh, Dhaka, respectively. Both the tanneries use standard amount of different chemicals for leather processing. The samples were collected in clean plastic bottles without air gap and were preserved in a refrigerator at 4°C.

RESULTS AND DISCUSSION

A good adsorbent should possess a porous structure resulting in high surface area and the adsorption time should be short so that the contaminant can be removed in fewer times (Gupta *et al.,* 2009). Activated carbon is extensively used as adsorbent in wastewater treatment all over the world. It is used for purifying wastewater and of course reducing pollution. Table 1 reveals the adsorbents features in several criteria such as ash contents, moisture contents, pore volume and also bulk density etc. Ash contents of cow bone activated carbon after activation were 14.73% and 14.43% for <300µm and 300-600µm samples, respectively. Moreover, moisture contents after activation were 1.19% and 1.07% for <300µm and 300-600µm, respectively. The quality of activated carbon used to remove organic matter, solid, nutrients, chromium, dye, metals and other contaminant depends on the features of prepared activated carbon.

Table 1. Characterization of calcinated cow bone before and after activation

Test Name	Before Activation		After Activation	
	300 µm	600 µm	300 µm	600 µm
Ash Content (%)	15.08	15.01	14.73	14.43
Moisture Content (%)	1.1	1.02	1.19	1.07
Pore volume (g/cm^3)	0.11	0.09	0.25	0.20
Bulk Density	0.98	0.98	0.99	0.99

Biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), total dissolve Solid (TDS), total suspended solid (TSS), electrical conductivity (EC) have been indicated as parameters for characterizing of chrome and dye liquor. The Chrome liquor sample was blue and dye liquor was reddish. Moreover they were heavily turbid with bad odor. Both of the liquor were contained a high amount of solids (mainly organic matter) that were treated with activated cow bone adsorbent. It is assumed that the pore volume act as a vital part for adsorption. Waste water of tannery contains high volume of metals (Kosinska and Miskiewicz, 2012). After adsorption with activated cow bone charcoal of <300µm and 300-600µm size in column filtrating system, chrome and dye liquor reduced its BOD_5, COD, TDS, total suspended solid (TSS) and Electrical Conductivity (EC) in different amount, which value are amiable for water and Environment. For the presence of significant quantities of proteins, fatty matter, tannins and inorganic substance increases the amount of oxygen demand. Due to high acidity, high amount of dissolved solid (on an average 7100mg/l), metals are harmful for aquatic life. These substances also affects physical, chemical and biological characteristics and may turn the receiving water less acceptable for drinking, industrial and agricultural purposes (Paul *et al.,* 2013).

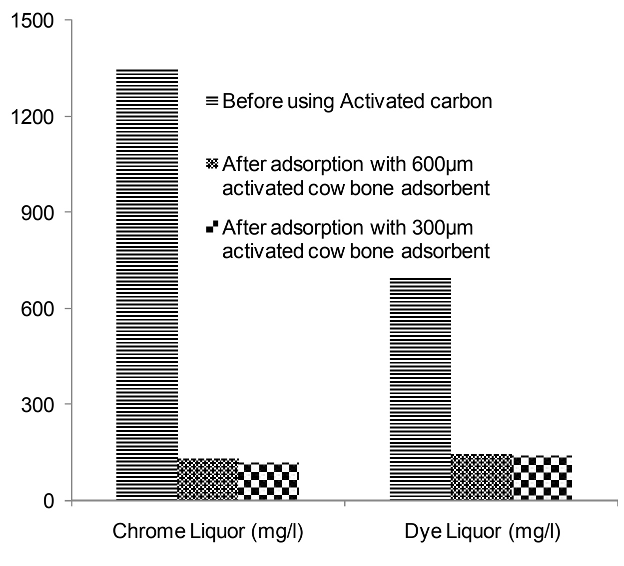

Figure 2. BOD_5 of collected samples before and after adsorption

It has been observed that BOD_5 values of chrome liquor and dye liquor of tanneries were 1350mg/l and 700 mg/l. By treating the liquors with activated cow bone charcoal, BOD values of chrome and dye liquor were found to be decreased to 130 mg/l and 140 mg/l, respectively (Figure 2). COD of water is another important parameter to measure its quality. Figure 3 represents the COD values of chrome and dye liquor of tannery before and after adsorption with activated cow bone adsorbents having <300 µm and 300-600µm sizes. It is evident that COD values of chrome and dye liquor of tanneries decreased significantly. Namely COD of chrome liquor was reduced from 3405 mg/l to 213 mg/l after treating with <300 µm activated cow bone charcoal. COD of dye liquor was reduced from 1486 to 232 mg/l. COD values of the liquors after treatment with activated cow bone charcoal was found to be below the permissible limit.

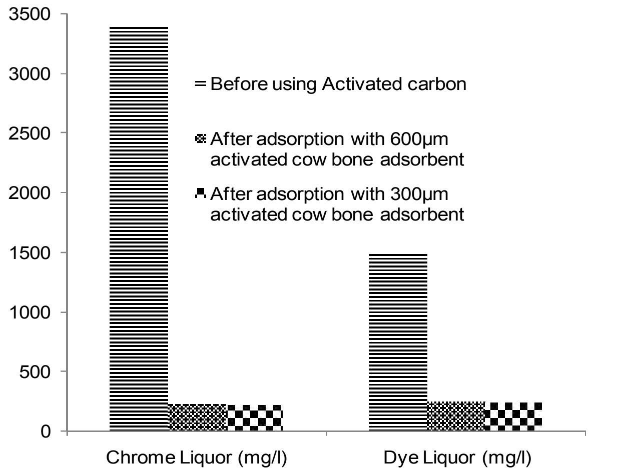

Figure 3. COD of collected samples before and after adsorption

Figure 4 shows total suspended solid content of chrome and dye liquor before and after adsorption. Dye liquor showed higher TSS content compared to chrome liquor. TSS content of both chrome and dye liquor reduced to approximately 85% after adsorption with activated cow bone charcoal. As expected activated carbon having lower particle size showed better adsorption compared to higher particle size.

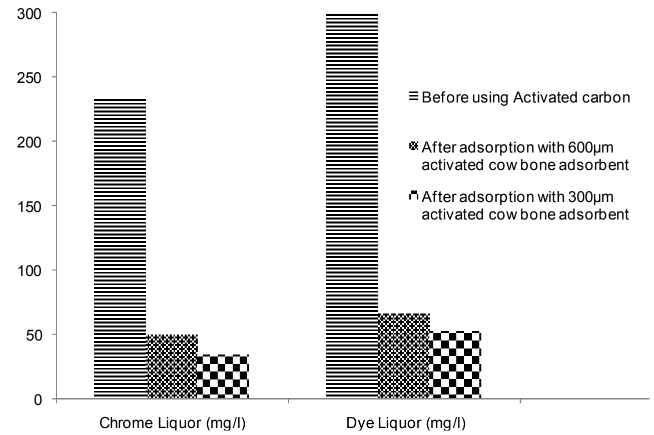

Figure 4. TSS of chrome liquor and dye liquor before and after adsorption with cow bone

TDS content is defined as residue left upon evaporation at 103ºC to 105ºC. TDS contents of chrome liquor and dye liquor samples were almost similar around 2800 mg/l which represents the amount of metalic ion present in the samples and reduced to about 800 mg/l after adsorption with activated cow bone charcoal. Figure 5 reveals that TDS contents of the samples were found to be reduced significantly after adsorption with cow bone charcoal. In this case the size of the adsorbent did not show any significant effect.

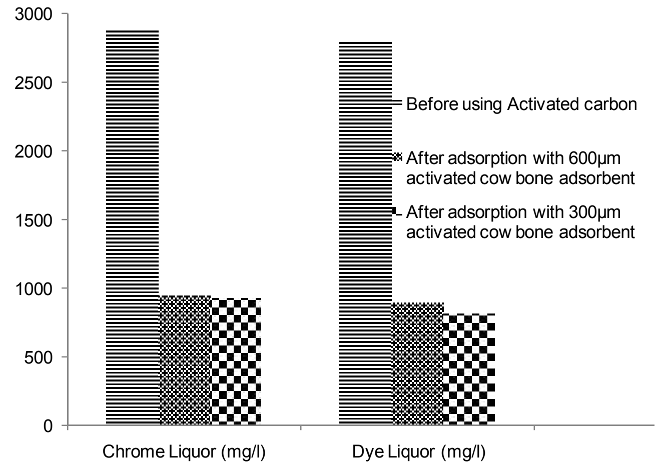

Figure 5. TDS of collected sample before and after adsorption

Electrical conductivity of chrome and dye liquor of tanneries before and after adsorption with activated cow bone charcoal is shown in Figure 6. Electrical conductivity of chrome liquor before adsorption was 58.7 ms/cm. After adsorption with activated cow bone charcoal it reduced to about 0.44 ms/cm. Again, electrical conductivity of dye liquor before adsorption was 8.91 ms/cm which reduced to 1.12 ms/cm and 2.04 ms/cm after adsorption with activated cow bone charcoal having particle size of <300 µm and 300-600 µm, respectively.

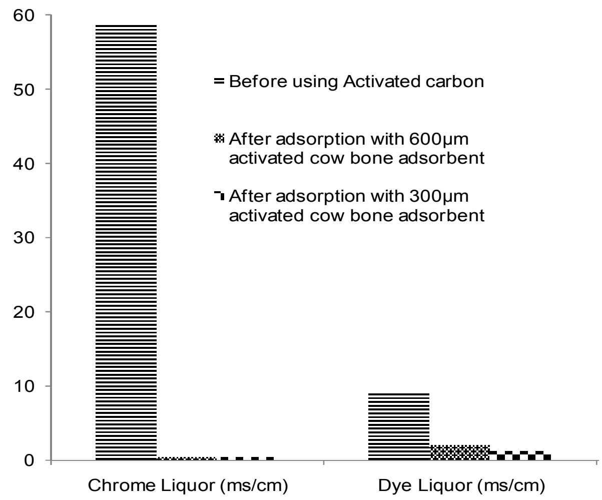

Figure 6. Electrical conductivity of collected sample before and after adsorption

Characterization of Activated Cow Bone Charcoal by Infrared spectroscopy

The IR absorption spectrum of cow bone adsorbent in Figure 7 shows the bands located between 1473 and 1629 cm^{-1}. The methylene group is detected by –CH stretching at a wave number of 2927 cm^{-1}, which is in a good agreement with the literature reported earlier (Viboon *et al*., 2008). Aromatics groups are shown by a peak around 1376 and 1457 cm^{-1}. The band 1035 cm^{-1} belongs to the calcium phosphate group. The spectrum at 3569 cm^{-1} indicated the presence of $–NH_2$ group of amine.

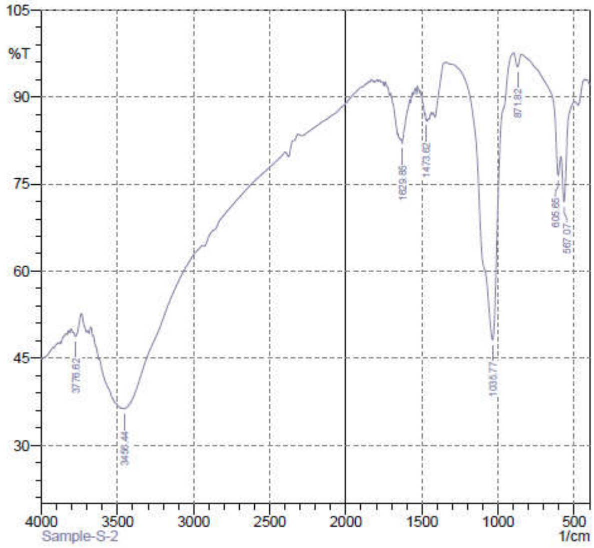

Figure 7. IR spectra of activated cow bone charcoal

Scanning Electron Microscopic (SEM) Observation

Surface structure of cow bone charcoal was studied by Scanning Electron Microscope before and after activation at 2000X magnifications. Figure 8 (A and B) preview the SEM images of cow bone charcoal before and after activation, respectively. SEM images show the surface topography of bone charcoal. A fluffy structure was developed after activation of the cow bone charcoal. Moreover, porosity was found in the activated cow bone charcoal that aids in adsorption of pollutants from chrome and dye liquor of tanneries.

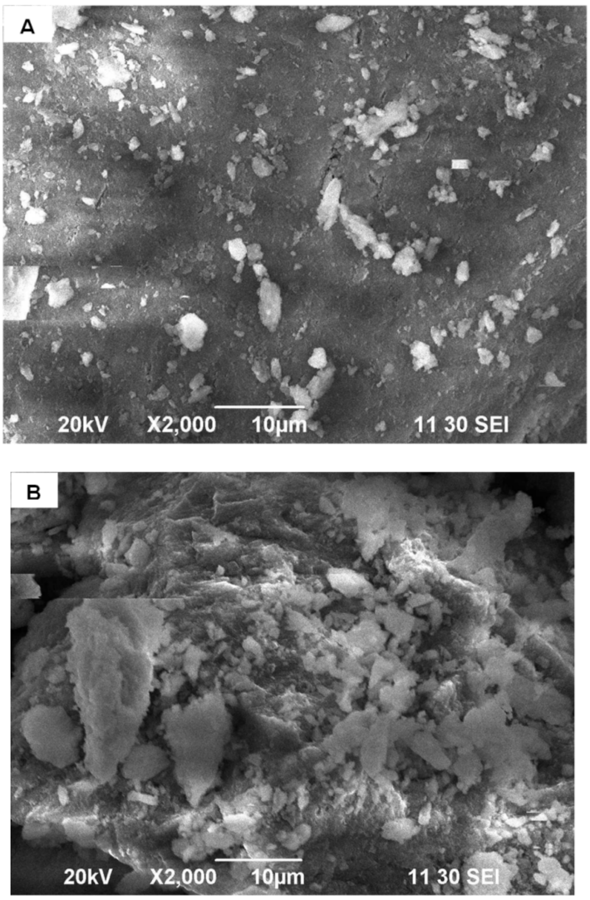

Figure 8. Scanning Electronic Microscopic (SEM) images of cow bone charcoal before activation (A) and after activation (B)

Conclusion

Activated cow bone charcoal was prepared and characterized by IR spectroscopy and SEM. IR spectra of cow bone charcoal confirmed the presence of its different constituents and SEM images revealed its porosity. Activated cow bone charcoal of <300 µm showed better adsorption compared to that of 300-600 µm. Different parameters of chrome and dye liquors such as BOD, COD, TDS, TSS and EC were decreased significantly after adsorption with activated cow bone charcoal. BOD and COD were reduced to 10%. About 70% of TDS and 90% of TSS were removed by adsorption with activated cow bone charcoal, and electrical conductivity was almost completely removed. Thus, hydrochloric acid activated cow bone charcoal may be potential candidate as a low cost adsorbent for reducing water pollution of tanneries.

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