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Bangladesh J. Sci. Ind. Res. **51(3)**, 215-220, 2016

BANGLADESH JOURNAL OF SCIENTIFIC AND INDUSTRIAL RESEARCH

E-mail: bjsir07@gmail.com

Low cost adsorbent for mitigation of water pollution caused by tannery effluents at Hazaribagh

A. Mizan[1], F. T. Zohra[1], S. Ahmed[1], M. Nurnabi[2] and M. Z. Alam[2]*

[1]Institute of Leather Engineering & Technology University of Dhaka, 44-50, Hazaribagh, Dhaka-1209, Bangladesh

[2]Department of Applied Chemistry and Chemical Engineering, University of Dhaka, Dhaka-1000, Bangladesh

Abstract

Tanneries at Hazaribagh use a large number of chemicals during processing and discharge their effluents to the river Buriganga without appropriate treatment and aggravate its pollution level. This study focuses on a plausible way for the abatement of pollution level of Buriganga river water using low cost adsorbent. Activated carbon prepared from coconut shell was used as a low cost adsorbent. The samples were collected from three different points of the river at three different layers from the surface of water. The collected samples were passed through the activated carbon and a remarkable amount of pollutants were found to be adsorbed. TSS, TDS, BOD_5, COD and chromic oxide content of polluted water were reduced significantly.

Keywords: Environmental pollution; Tannery effluent; Adsorbent; Activated carbon; COD.

Introduction

The leather sector is one of the most important foreign exchange earners of our country. A large number of chemicals and auxiliaries are used for processing leather in tanneries at Hazaribagh and discharge their effluents to the river Buriganga without appropriate treatment. Therefore, the characteristics of effluents are far from the acceptable level (UNIDO, 2005) and contain heavy metals like chromium. These effluents also contain compounds such as protein, fatty acids, tannins, sulphates, hydrocarbons, phenol, detergent, oil and grease. Leather industries release effluents directly to the agricultural land or surface water bodies which eventually leaches to groundwater that lead to contamination of toxic metallic components and result in a series of well documented problems in living beings (Dillon, *et al.,* 1997).

Activated carbon is very porous and has the property of removing many of the dissolved impurities in water (DUGGAL, 1996; Sai *et al.*, 1997; Iqbaldin *et al.,* 2013) and a microporous adsorbent that can be produced from a variety of carbonaceous materials, including coconut shells, wood, coal, lignin and sugarcane. Its unique adsorption properties result from its high surface area, micropores and broad range of surface functional groups (Tanju Karanfil and James E. Kilduff 1999). Due to its high degree of microporosity, just one gram of activated carbon has a surface area in excess of 500 m^2, as determined by gas adsorption (Shoba Jhadhav, 2015).

Active carbon in its present efficient form is a relatively new comer in the field, particularly in its employment on a commercial scale for a number of purposes, for example, effluent treatment pollution control (Pontius, 1996, 1999), gas-phase application (Vandevivere *et al.,* 1999) liquid-phase application (Corbitt, 1990; Dimotakis *et al.*, 1995), application as molecular sieving (Sing, 1989), application as shape-selective catalyst as well as catalyst support (Rodovic *et al.,* 1997), chromatographic application (Rodovic and Rodriguez-Reinoso, 1996), ion-exchange application (Zhong-ru *et al.,* 2001), energy conservation (Leboda *et al.,* 1997) and removal of zinc (Ali and Mohammad, 2014) from aqueous solution. In this study initiative was taken to observe the mitigation of pollution levels of Buriganga river water by using activated carbon as an adsorbent.

*Corresponding author. e-mail: zahangir@du.ac.bd

Materials and methods

Preparation of activated carbon from coconut shell

Coconut shells were collected from the local market and were stripped off, washed thoroughly with clean water and dried completely. The shells were burnt until turned into charcoal. After cooling it was crushed to 5-10 mm and transferred to a clean plastic pail. A 25% calcium chloride solution was added sufficiently to the charcoal with intermittent stirring and left it for 24 hours with the pail covered for complete soaking. During this process, the chemicals were impregnated into the charcoal transforming it into activated carbon. It was filtered, washed and rinsed repeatedly with distilled water. Eventually this activated carbon was baked in an oven at 105°C for three hours.

Collection of samples

Total nine samples were collected from Buriganga river adjacent to Hazaribagh. Sampling was carried out according to USEPA (USEPAS and ESDA, 2013). The samples were been collected from three different point of the river, namely at the meeting point of the discharged effluents, 100 meters upstream and 100 meters downstream from that point and were designated by m, u and d respectively. Triplicate samples were collected from each point at three different layers, i.e. from surface, 100 cm deep and 200 cm deep from the surface of water and were designated as S, M and G respectively.

Results and discussion

Water quality is determined by some parameters such as biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), total suspended solids (TSS), total dissolved solids (TDS), Cr_2O_3 content, chloride content, etc. In this study we reported the important parameters BOD_5, COD, TSS, TDS and Cr_2O_3 content of Buriganga river water. pH of the collected samples were found to be 7.2 and 7.5. The samples were acidified with 0.1 N HCl to maintain its pH at a value of 3.8 - 4.0 since it is reported that adsorption is increased with an increase in pH from 2.0 to 4.0 (Siraj *et al.*, 2012).

Table I depicts BOD_5 of collected samples from Buriganga River. BOD_5 of the samples were found to be 100-350 mg/L which are above the permissible levels recommended by World Health Organization (WHO) and the Department of Environment (DoE), Bangladesh. BOD_5 were found to be significantly reduced after passing the samples through the prepared adsorbent.

Table I. BOD_5 of Buriganga River wastewater before adsorption and after adsorption

Sample	BOD_5 (mg/L)	
	Before adsorption	After Adsorption
G_m	100	00
M_m	150	50
S_m	200	100
G_u	350	200
M_u	100	00
S_u	150	00
G_d	100	50
M_d	150	100
S_d	150	50

COD of water is another important parameter to measure its quality. COD of collected samples were determined and are tabulated in Table II. It is observed that COD of the samples before adsorption ranges between 1440 mg/L to 9120 mg/L and after adsorption it was reduced to 840-5280 mg/L. In case of sample M_u and S_u COD were dramatically reduced compared to other samples. Whereas in case of sample G_m, S_m and M_d COD was reduced to about 50%.

Table II. Data of COD before adsorption and after adsorption

Sample	Before adsorption (mg/L)	After adsorption (mg/L)
G_m	4800	2400
M_m	2880	2034
S_m	7680	3840
G_u	3840	3360
M_u	5760	960
S_u	5280	1920
G_d	1440	840
M_d	1920	960
S_d	9120	5280

Most of the tanneries at Hazaribagh use basic chromium sulphate for tanning. Therefore, the wastewater discharged from tanneries contain a significant amount of Cr_2O_3 which cause environmental pollution. Cr_2O_3 content of the samples were found to be 0.003-0.3521 mg/L (Table III). After adsorption with activated carbon Cr_2O_3 content of the samples S_m,G_u, S_u, G_d and M_d were reduced to nil and the other three samples (G_m, M_m and M_u) were reduced significantly.

Table III. Data of Cr_2O_3 content before adsorption and after adsorption

Sample	Cr_2O_3 content (mg/L)	
	Before adsorption	After Adsorption
G_m	0.3521	0.255
M_m	0.3231	0.256
S_m	0.003	Nil
G_u	0.0105	Nil
M_u	0.3010	0.256
S_u	0.0062	Nil
G_d	0.0061	Nil
M_d	0.004	Nil
S_d	0.0071	Nil

The discharged effluents from leather industries contain a high TSS. Fig. 1 shows the TSS contents of the collected samples before and after adsorption. The values were 9-79 ppm before treatment and they were reduced to 4-40 ppm after adsorption

TDS contents of water and wastewater are defined as residue left upon evaporation at 103ºC to 105ºC (CHHATWAL, 1997). TDS value of different samples are shown in Fig. 2. TDS were found to be 529 - 2105 ppm which represents the amount of metalic ion present in the water system. TDS contents of collected samples were also significantly reduced after passing the samples through the designed adsorbent.

Adsorption of activated carbon depends largely on porosity, pore volume, particle size etc. Porosity and pore volume of the activated carbon from cocnut shell were determined by saturation method described elsewhere. Porosity and pore volume of the activated carbon developed in this study were found to be 0.56 and 0.59 ml respectively which are in good agreement with some published data.

Scanning electron micrographic analysis

The surface structure of the prepared activated carbon was observed by Scanning Electron Microscope before and after adsorption at 1000X magnifications. Fig. 3 represents the

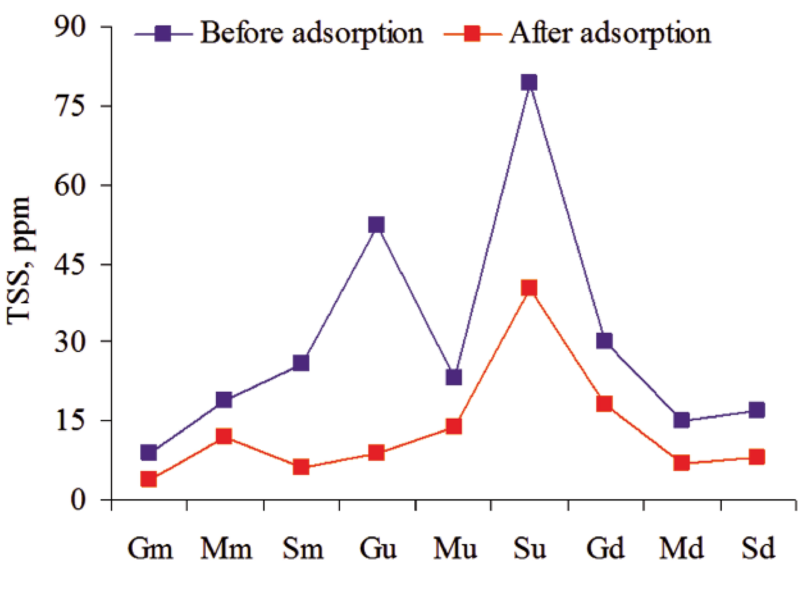

Fig. 1. TSS values of wastewater samples of Buriganga river before adsorption and after adsorption using activated carbon

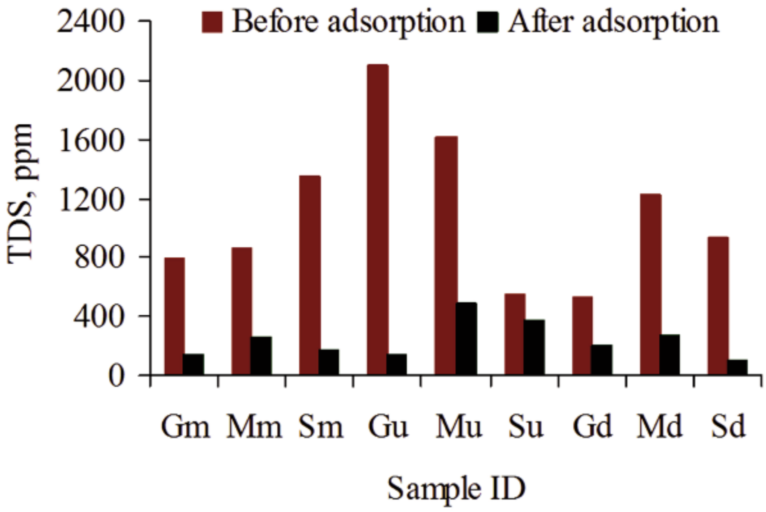

Fig. 2. TDS values of wastewater samples of Buriganga River before adsorption and after adsorption using activated carbon.

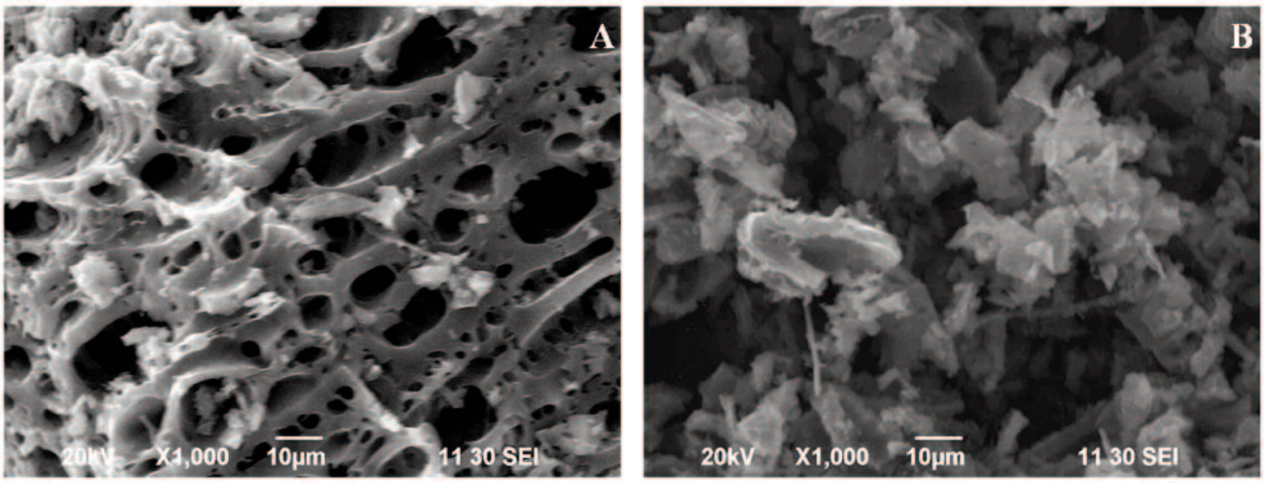

Fig. 3. SEM Micrograph of activated carbon before adsorption (A) and after adsorption (B)

SEM images of the activated carbon before and after adsorption. A plenty of porosity was observed in the activated carbon before adsorption (3A) and after passing through the adsorbent most of the pores of activated carbon were filled with the pollutants (3B). Therefore, the developed adsorbent may be used for adsorption of the pollutants discharged from tanneries.

Conclusion

Leather industries are labor intensive export oriented indigenous raw material based important sector in our country. The full flourish of this sector is essential with cleaner technologies and proper waste management system. This study reveals that quality of Buriganga River water is very poor and it should be minimized for the betterment of the mankind and aquatic lives. Activated carbon prepared from coconut shell showed significant results in adsorbing the pollutants from the collected samples. Cr_2O_3 content was reduced more than 90% and other pollutant content were also reduced from 50 to 90%. The developed adsorbent demands low cost as the raw material is easily available and inexpensive in Bangladesh. Thus the activated carbon from coconut shell could be an attractive option for the mitigation of pollution levels of Buriganga river water caused by the effluents of leather industries at Hazaribagh, Dhaka.

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Received: 17 February 2016; Revised: 01 March 2016; Accepted: 24 April 2016.