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BOD reduction using spent tea waste from Tannery wastewater

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Abstract

Leather tanning consumes a huge quantity of water which ultimately goes to the environment as wastewater and degrades the environment. The study deals with the utilization of spent tea leaves as the adsorbent for the reduction of Biochemical Oxygen Demand (BOD) from tannery wastewater. The characteristics of raw effluent like initial COD, BOD, pH, and EC were measured. The experiments were carried out in the batch process for simplicity. The maximum percentage of BOD reduction was found 85.88 at 05 mg/l dose of adsorbent. The results of BOD reduction follow the Langmuir and Freundlich adsorption isotherm.

Keywords: Leather Tanning, Adsorption, Batch, BOD, Spent Tea waste.

INTRODUCTION

In Bangladesh, the leather industry is well established and ranked fourth in terms of earning foreign exchange. This sector includes 220 tanneries, 3,500 MSMEs and 110 large firms of leather products controlling more than 90% of the export market [1]. The first tannery of Bangladesh established at Narayanganj by R.P. Shaha in the1940s. Later on, it was shifted to Hazaribagh area in Dhaka city. During the Pakistan period, in 1965 there were 30 tanneries in the then East Pakistan now Bangladesh [2]. Leather processing is an important economic activity around the world and uncontrolled release of tannery effluents to natural water bodies causes environmental degradation and increases health risks to human beings. The treatment of tannery effluent is a complex technological challenge because of the presence of high concentrations of organic and inorganic pollutants of both conservative and non-conservative nature [3].

In the present study, it was aimed to carry out experiments using spent tea leaves (STL) for the removal of organic contaminants especially BOD from the Tannery effluent. Organic pollution is caused by the release of organic compounds into the nearby water bodies. Tannery discharges wastes to the marshy land like rivers and canals which carry toxic chemical like H_2S (Hydrogen sulphide), NH_3 (ammonia), chromium (Cr), poisonous chlorine and nitrogen based gases, etc [4].

After water, tea is the most widely-consumed beverage in the world, as attested by the over 3,500,000 tons of tea leaves produced annually [5]. Tea beverages are typically available as green, black or Oolong tea, depending on the way of manufacturing [6]. Once the beverage has been brewed, tea leaves become a waste that must be disposed of. Like other biomass residues, tea wastes represent an unused resource and pose increasing disposal problems. For these reasons, strategies are being investigated to evaluate their possible use as an energy source or in other value-added applications [7]. The cell wall of waste tea consists of cellulose, lignin, and carbohydrate which have hydroxyl groups in their structures. One-third of total dry matter in tea leaves should have good potential as metal scavengers from solution and waste water because they contain functional groups. The responsible functional groups are lignin, tannin or other phenolic compounds are mainly carboxylate, aromatic carboxylate, and phenolic hydroxyl and oxyl groups and could be a good sorbent for contamination [8].

A number of conventional treatment technologies have been considered for treatment of wastewater contaminated with organic substances. Among them, adsorption process is found to be the most effective and economical method [9]. Adsorption as a wastewater treatment process has aroused considerable interest during recent years. Commercial activated carbon is regarded as the most effective material for controlling the organic load. However, due to its high cost and about 10 - 15% loss during regeneration, unconventional adsorbents like fly ash, peat, lignite, bagasse pith, wood, sawdust, periwinkle shells, etc. have attracted the attention of several investigations and adsorption characteristics have been widely investigated for the removal of refractory materials [10]. A low-cost adsorbent is defined as one which is abundant in nature, or is a by-product or waste from industry and requires little or no processing [11]. In this study, we have investigated the suitability of spent tea leaves (STL) to remove BOD from tannery wastewater.

MATERIALS AND METHODS

Sample Collection

The sample was collected at the point of discharge from a Tannery outlet near the Institute of Leather Engineering and Technology (ILET), Hazaribagh, Dhaka, during the time from November 2016 to January2017.Pre-washed plastic bottles were used for sample collection.

Preparation of the adsorbent

The tea waste was collected from teashops, restaurants, hotels, and offices, etc. Soluble and colored components were removed from tea by washing with boiling water. This is repeated until the water was virtually colorless. The tea leaves were then washed with distilled water and oven dried for 6-8 h at 105^0C.

Each specific chemical bond often shows a unique energy absorption band in FTIR analysis and it has been used as a useful tool to identify the presence of certain functional groups of the bio adsorbent [7]. The FTIR spectrum of STL is shown in Figure 2. The surface contains various functional groups. The distinct broad and elongated 'U' shape peak around 3311.3 cm^{-1} in the spectrum indicates the free O-H group on the surface of the adsorbent and confirms the presence of alcohols and polyphenols in cellulose and lignin. Peak 2919 cm^{-1} and 2851.4 cm^{-1} assigning the -CH stretching mode from the aliphatic. Peak around 1622.8 cm^{-1} corresponds to C=O group. The band appeared at 1032.1 - 1151.6 cm^{-1} can be due to C-O stretching in alcohols.

Experimental procedure

The experiment was performed in a batch process in a series of beakers equipped with stirrers by stirring the tannery effluent. The batch technique was selected for its simplicity [12]. At the end of predetermined time, the suspension will be filtered and the remaining concentration of BOD values in the aqueous phase will be determined. The effect of various controlling parameters such as contact time, pH, and adsorbent dose of tea waste were studied.

Adsorbent Dose

The studies were conducted with the varying amount of absorbent starting from 03 to 17 gm/l.250 ml of Tannery effluent was treated with the different amount of doses of tea waste adsorbent.

Contact time

These studies were conducted by agitating 250 ml sample for different time period 15-180 min. After the predetermined time intervals, the samples were filtered and then analyzed.

pH

pH effect was performed taking a specific concentration, adsorbent dose and contact time. The pH was varying using dilute NaOH/HCL solution. The samples were agitated for the specific time, filtered and then analyzed.

Glassware and Apparatus used

All glassware's (Beaker, Conical flask, Pipette, Measuring cylinder, Test tube, etc) used were of Borosil / Ranken. The instrument and apparatus used throughout the experiment were listed below the table.

Table 1: List of Used Instrument

SL	Instrument	Brand
1	pH meter	Hanna
2	Digital Weight Balance	ViBRA AJ
3	Whatman filter paper no.	40
4	Automatic Stirrer	Lovibond
5	BOD Incubators	SANYO

RESULTS AND DISCUSSION

The tannery effluent sample was characterized by the parameters of pH, COD, and BOD (Table 2).

Table 2: Characteristics of Sample

Parameter	Value
pH	5.4
BOD	1,700 mg/l
COD	2,490 mg/l
EC	18.3ms/cm

Effect of Adsorbent Dose

The effect of adsorbent dose on the adsorption process can be carried out by preparing the adsorbent-adsorbate solution with the different amount of adsorbents added to fix initial BOD concentration and shaken together. The percentage of BOD removal is decreasing as the dose increasing. From figure 3, it is shown that the highest % of BOD removal (about 85.88 %) was found at the dose of 5gm /l (Fig 3).When the dosage was increased beyond 5gm/l, the BOD reduction decreased gradually.

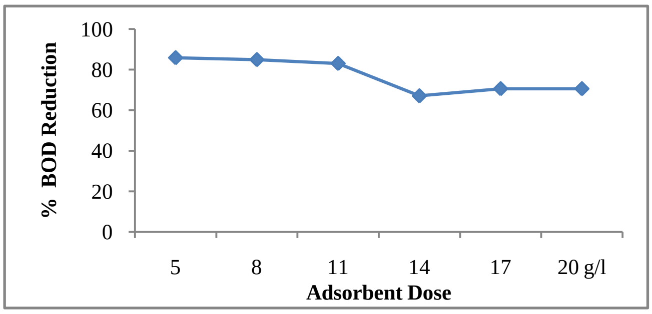

Figure 3: Effect of adsorbent dose on BOD removal

Effect of Contact time

The effect of contact time on adsorption of BOD can be carried out by preparing the adsorbent-adsorbate solution with fixed adsorbent dose and initial BOD concentration for different time intervals and shaken together. The rate of BOD removal increased with an increase in contact time to a certain extent. The highest BOD removal was achieved in time 120 min which was about 85.88% (Fig 4).

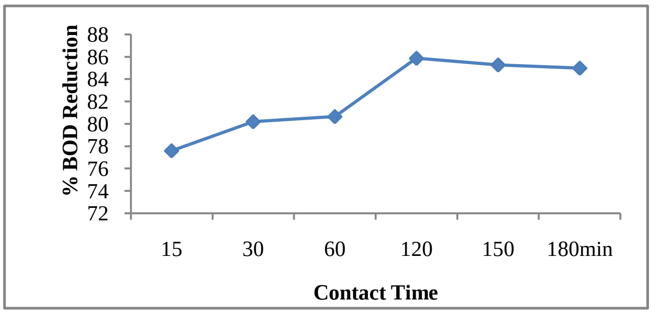

Figure 4: Effect of contact time on % removal of BOD by tea waste adsorbent

Effect of pH

The effect of pH on the BOD reduction from wastewater is shown in Fig 5.The highest BOD reduction was found at pH 4-6 which was about 87%.

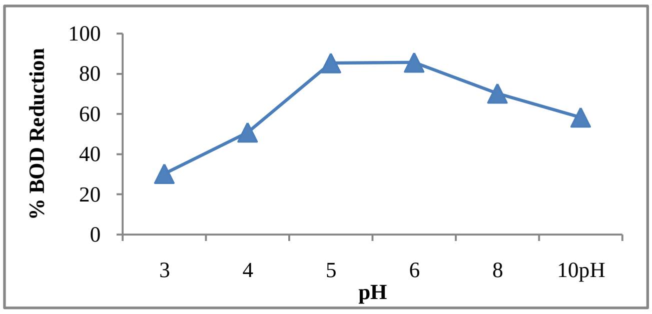

Figure 5: Effect of pH on % removal of BOD by tea waste adsorbent

Adsorption Isotherms

Equilibrium studies that give the capacity of the adsorbent and adsorbate are described by adsorption isotherms, which is usually the ratio between the quantity adsorbed and that remained in solution at equilibrium at fixed temperature [13,14]. Freundlich and Langmuir'sisotherms are the earliest and simplest known relationships describing the adsorption equation [14]. Adsorption isotherm was an equilibrium plot of the solid phase (*qe*) versus liquid phase concentration (*Ce*).

Table 3: Freundlich and Langmuir adsorption isotherm parameters

No	Ads. Dose,m, (gm/l)	Eq. conc. Ceq (mg/l)	Rev. x=Co-Ceq (mg/l)	qe=V(x/m) , (mg/gm)	Rev. %	Log Ceq	Log qe	1/ Ceq	1/qe
01	0	1,700	0	0	0	3.23	0	0.00059	0
02	5	250	1450	72.50	85.29	2.40	1.86	0.00400	0.01379
03	8	270	1430	44.69	84.12	2.43	1.65	0.00370	0.02238
04	11	295	1405	31.93	82.65	2.47	1.50	0.00339	0.03132
05	14	570	1130	20.18	66.47	2.76	1.30	0.00175	0.04956
06	17	520	1180	17.35	69.41	2.72	1.24	0.00192	0.05763
07	20	550	1150	14.38	67.65	2.74	1.16	0.00182	0.06957

Freundlich model with linear plotted log $q_e$versus log *Ce* shown in the following equation;

$$\log q_e = \log K_f + 1/n \log C_e$$

Where, *Kf* is, roughly, an indicator of the adsorption capacity(mg/g), C_e is the equilibrium concentration (mg/L) and 1/*n* is the adsorption intensity. A linear form of the Freundlich expression will yield the constants *Kf* and 1/*n*. Freundlich isotherm model assumes a non-ideal adsorption on heterogeneous surfaces in a multilayer coverage. It suggests that stronger binding sites are occupied first, followed by weaker binding sites. In other words, as the degree of site occupation increases, the binding strength decreases [15].

Langmuir model with linear plotted 1/*qe* versus 1/*Ce* shown in the following equation:

$$\frac{1}{q_e} = \frac{1}{q_{\max}} + \frac{1}{q_{\max} K_L C_e}$$

Where, q_e is the equilibrium adsorbate concentration in solution; q_{max} is the maximum adsorption capacity (mg/g) which is determined from the slope; C_e is the equilibrium concentration (mg/L) and K_L *is* Langmuir constant related to of the binding sites and determined from the intercept,(L/mg).The Langmuir isotherm model is valid for monolayer adsorption onto the surface containing a finite number of identical sorption sites. This model assumes that adsorbed molecules cannot move across the surface or interact with each other [15,16].

Freundlich adsorption isotherm

From the Freundlich isotherm model as shown in Fig. 6, constants obtained are: adsorption capacity, K_f, is 5.295and adsorption intensity, 1/n, is -1.486. The regression coefficient is 0.868.

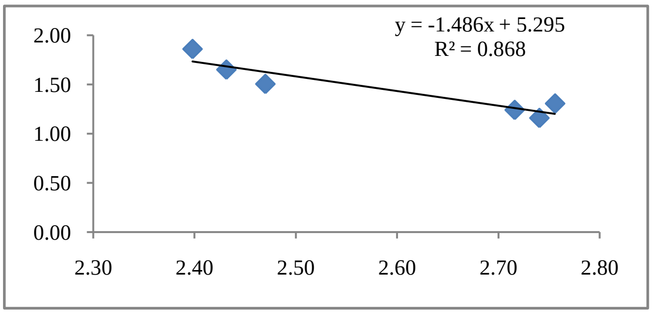

Figure 6: Freundlich isotherm of spent tea waste

Langmuir adsorption isotherm

From the Langmuir isotherm model as shown in Fig. 7, constants obtained are: Langmuir constant K_L is

0.0952and maximum adsorption capacity is 19.697. The regression coefficient is 0.896.

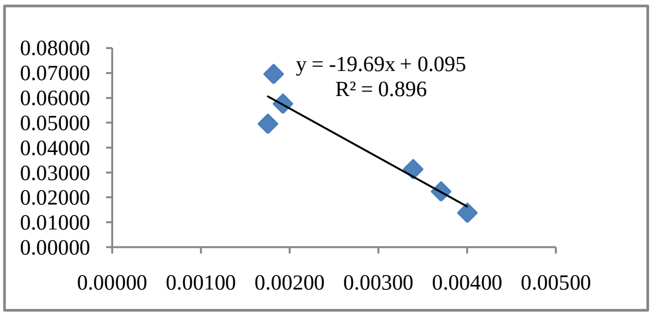

Figure 7: Langmuir adsorption isotherm of spent tea waste

The effect of isotherm shape is discussed from the direction of the predicting whether and adsorption system is "favorable" or "unfavorable". Hall et al (1966) proposed a dimensionless separation factor or equilibrium parameter, R_L, as an essential feature of the Langmuir Isotherm to predict if an adsorption system is “favorable” or “unfavorable”,which is defined as [17]:

$$R_L = 1 / (1+bC_0)$$

Where, C_0= reference fluid-phase concentration of adsorbate (mg/l) (initial concentration)

b = Langmuir constant (L/ mg)

The value of R_L indicates the shape of the isotherm accordingly as shown in Table 4 below. For a single adsorption system, *Co* is usually the highest fluid-phase concentration encountered.

Table 4: Characteristics of adsorption Langmuir isotherm

Separation factor, R_L	Characteristics of adsorption Langmuir isotherm
$R_L > 1$	Unfavorable
$R_L = 1$	Linear
$0 < R_L < 1$	Favorable
$R_L = 0$	Irreversible

The value of separation factor (R_L) for the present study is 0.0061 indicating that the shape of the isotherm is favorable.

Table 5: Adsorption Isotherm constants and coefficient of determination

Adsorbent	Langmuir Isotherm constants			Freundlich Isotherm constants		
	q_{max}(mg/g)	*KL* (L/mg).	R^2	K_f(mg/g)	1/n	R^2
Spent Tea waste	19.697	0.0952	0.896	5.295	-1.486	0.868

From the table 5, the correlation coefficient (R^2) of Langmuir (0.896) is slightly higher than that of Freundlich adsorption isotherm (0.868).

CONCLUSION

BOD reduction of tannery wastewater using spent tea leaves as adsorbent was investigated with the batch process. Both Langmuir and Freundlich adsorption isotherm were found to fit the experimental data. The correlation coefficient (R^2) of Langmuir (0.896) is slightly higher than that of Freundlich adsorption isotherm (0.868). These experimental studies on low-cost bio-adsorbent would be useful in developing an appropriate technology for the reduction of BOD from tannery wastewater.

No conflict of interest: Nil

REFERENCES

1. Technical Report: Leather Sector Includes a Value Chain Analysis andProposed Action Plans; January 2013;http://euinspired.org.bd/docs/grant_scheme/INSPIRED%20%20Leather%20Sector%20Report%20-%20Jan%2013.pdf
2. Leather industry of Bangladesh; http://emergingrating.com/wp-content/uploads/2016/08/Leather-industry-of-Bangladesh-Vol-I.pdf
3. Sabumon PC (2016) Perspectives on Biological Treatment of Tannery Effluent. Adv Recycling Waste Manag 1:104. doi:10.4172/2475-7675.1000104
4. Nur-E-Alam M,Sayid Mia MA, RahmanLutfor M and RahmanMahizurM,‘Impacts of Tanning Process on Surface Water Quality of Hazaribagh Tanning Area Dhaka, Bangladesh’,Journal of Environmental Science, Computer Science and Engineering & Technology (JECET),June 2017- August 2017; Sec. A;Vol.6. No.3, 176-186.
5. FAO, Statistics Division, 2009, http://faostat.fao.org/site/567/DesktopDefault.aspx?PageID=567#ancor.
6. Ho C.T., Lin J.K. and Shahidi F., Eds., 2008, Tea and Tea Products. CRC Press, BocaRaton, FL.
7. Laufenberg G., Kunz B., and Nystroem M., 2003, Transformation of vegetable waste into value added products: (A) the upgrading concept; (B) practicalimplementations, Bioresource Technol. 87, 167–198.
8. Nandal M., Hooda R. and DhaniaG.Tea Wastes as a Sorbent for Removal of Heavy Metals from wastewater, International Journal of Current Engineering and Technology, E-ISSN 2277 – 4106, P-ISSN 2347 – 5161
9. M.M. Lakdawala; M.J.Lakdawala, Comparative Study of Effect of PAC and GAC on Removal of COD Contributing Component of Sugar Industry wastewater.Research Journal of Recent Science.Vo.2(ISC-2012), 90-97(2013).
10. Aluyor O. Emmanuel and BadmusA. M. Olalekan, COD removal from industrial wastewater usingactivated carbon prepared from animal horns. African Journal of Biotechnology Vol. 7 (21), pp. 3887-3891, 5 November 2008.
11. Zuorro A., Santarelli L. M. and Lavecchia R., Tea Waste: A New Adsorbent for the Removal of Reactive Dyes from Textile Wastewater, Advanced Materials Research Vol. 803 (2013) pp 26-29,doi:10.4028/www.scientific.net/AMR.803.26
12. Bhavsar K and Patel P. Efficiency Evaluation of Tea Waste for Adsorption of Hexavalent Chromium from Industrial Effluent. International Journal of Science and Research (IJSR), Vol. 3 Issue 7, July 2014.
13. El-Halwany MM (2007) Development of Activated Carbon from EgyptianRice Hull: Evaluation of Adsorption Properties (Part I). International ChemicalScience Conference Sharm El-Sheikh 16-19 April.
14. Muhamad N, ParrJ, Smith DM, Wheathey DA (1998) Adsorption of heavymetals in show sand filters in Proceedings of the WEDC Conference Sanitationand Water for All Islamabad Pakistan 346-349.
15. JamhourM. A. Q. Rasheed, Ababneh S. Taher, Al-Rawashdeh I. Albara, Al-Mazaideh M. Ghassab, Al Shboul1, M. A TareqandJazzazi M. A Taghreed, Adsorption Isotherms and Kinetics of Ni(II) and Pb(II) Ions on New Layered Double Hydroxides-Nitrilotriacetate Composite in Aqueous Media, Advances in Analytical Chemistry 2016, 6(1): 17-33
16. Mostafapour F. K., Bazrafshan E., Farzadkia M. and Amini S. Arsenic Removal from Aqueous Solutions bySalvadorapersicaStemAsh,Journal of

Chemistry, Hindawi Publishing Corporation,Volume 2013, Article ID 740847

17. Dhanakumar S.,Solaraj G.,Mohanraj R. and Pattabhi S. Removal of Cr (VI) from aqueous solution by adsorption using cooked tea dust. Indian Journal of Science and Technology, Vol.1No.2 (Dec.2007), 1-6.