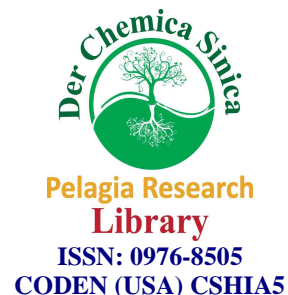




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Removal of BOD contributing components from Sugar Industry Waste water using Bagasse Fly Ash-Waste material of Sugar Industry

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ABSTRACT

Rapid globalization lead us on the way to industrialization. Sugar industry is one of the biggest consumer of water, and can also introduce serious pollutant to the environment. To minimize this industrial wastewater pollution, advanced wastewater treatment techniques, such as adsorption are economically and environmentally essential in the removal of organic and inorganic compounds. The present study focuses on the use of low cost adsorbent sugarcane bagasse fly ash to adsorb BOD content of the combined wastewater of sugar industry. Bagasse Fly ash with specific surface area of $2637.784 \text{ cm}^2/\text{gm}$ is used as a clarifier to the combined waste water of Sugar mill at room temperature. The different dosage of bagasse fly ash is kept in contact for 24 hours and analyzed before and after treatment. The results of BOD removal follow the Freundlich and Langmuir adsorption isotherm.

Key words: Adsorption isotherm, Adsorption intensity ($1/n$), Adsorption energy ($b \times 10^3$), Adsorption capacity (K, Θ_0).

INTRODUCTION

Environment is a complex and dynamic system in which all life forms are interdependent. The effect of industrial waste on plant and animal life in closed bodies of water in nature is catastrophic. Industries are the largest user of water so causes water pollution. Some of the waste problems in nature are taken care of by the large amount of living spaces, unfortunately where living space becomes limited, dilution is no longer a satisfactory solution, and other means must be taken to reduce the ratio of waste to space [1,2]. It is difficult to separate industrial growth from environmental pollution but it can be minimized through cost-effective approaches of pollution abatement. To reach the full objectives of zero pollution, adoption of alternative technologies which suit the situation of low capital availability, minimum man-power and limited energy consumption are necessary. Adsorption through agricultural products such as rice

husk, sugarcane bagasse, soybean hulls, saw dust, coconut shell, groundnut shell, apple-waste, fly-ash etc., has been demonstrated to be a useful alternative to the conventional treatment systems for the removal of toxic metals such as dyes/colour, chromium (Cr), mercury (Hg), copper (Cu), nickel (Ni), etc., from aqueous solution. It could be considered as an eco-friendly device to the existing relatively more expensive treatment technologies [3]. The activated carbon adsorbent prepared from *Euphorbia antiquorum* L wood [4], *Alternanthera Bettzichiana* (Regel) Nicols plant material [5] and neem leaf powder [6] can be used as an efficient low cost adsorbent for Cr (VI) and organics removal from aqueous solution.

For removal of the organic contaminants from industrial waste water adsorption has become one of the best effective and economical method, thus this process has aroused considerable interest during recent years. Current research has focused on modified or innovative approach that more adequately address the removal of organic pollutants [7]. In the present study, it was aimed to carry out experiments using low cost material like bagasse fly ash from Sugar manufacturing unit for the removal of organic contaminants especially BOD contributing components from the combined waste water of Sugar Industry itself. Sugar cane bagasse is an industrial waste which is used worldwide as fuel in the same sugar-cane industry. The combustion yields ashes containing high amounts of unburned matter, silicon and aluminum oxides as main components. These sugar-cane bagasse ashes (SCBA) have been chemically, physically and mineralogically characterized, in order to evaluate the possibility of their use as a cement-replacing material in the concrete industry and as an adsorbent in surface chemistry [8]. One of the research group have used bagasse fly ash as an adsorbent which is a byproduct of cane sugar industry, itself causes a great disposal problem and it is currently being used as filler in building materials. The effect of various operating variables, viz., solution pH, contact time, concentrations of metal ions, adsorbent dose and particle sizes have been studied for the removal of cadmium and nickel ions. The material exhibits good adsorption capacity and follows both the Langmuir and the Freundlich models [9].

The possibility of utilizing bagasse fly ash and activated carbon for the removal of resorcinol and phenol from aqueous solution has been evaluated and the equilibrium data were fit well to Freundlich adsorption model [10,11]. Gupta et al studied the removal of lead from waste water using bagasse fly ash. This adsorbent has been satisfactorily used for the removal of lead from the effluent of metal finishing plant [12]. The removal of lead from synthetic wastewater using sugar factory wastes, bagasse and bagasse fly ash like low cost material were well studied. Adsorption by these wastes can be used as an alternative to conventional treatment methods. Bagasse was treated under acidic condition while bagasse fly ash was untreated. Batch study indicated that the removal efficiency increased with increasing solution pH and adsorbent dose. Adsorption isotherms revealed that the Freundlich equation fitted the isotherm data better than the Langmuir. Bagasse fly ash was more favorable than bagasse in removing lead and thus was a better adsorbent [13]. Sugarcane bagasse proved to be a better adsorbent than coal fly ash in the uptake of direct red dyes from textile wastewater. Direct red 80 (DR 80) was the highest adsorbed dye by both sugarcane bagasse (6.536 mg/g) and coal fly ash (1.560 mg/g). Equilibrium data for metal removal conformed well to the Freundlich isotherm whereas phenol and direct dye removal complied with the Langmuir adsorption isotherm model [14].

MATERIALS AND METHODS

During the production of Sugar, bagasse Fly ash is obtained as a waste product in large quantities from Sugar mill. The total amount and physico-chemical characteristics of Fly ash which is occurred on burning Bagasse generated in boiler varies from boiler to boiler depending upon the boiler's efficiency. Bagasse Fly ash used in present research work is collected from Sahakari Khand Udhog Mandali Ltd, Bardoli (Gujarat). It was washed to remove excess fines and oven dried at 100⁰C for 24 hours before its use in experiments. It is light black colored material having specific surface area 2637.784 cm²/gm. Bagasse Fly ash mainly consists of unburned carbon, SiO₂ - 51 to 55%, Al₂O₃ – 10 to 11%, CaO -5 to 6 %, Fe₂O₃ - 4 to 5%, and trace of MgO. The known quantity (1 liter) of sample is treated with different amount of fly ash viz 2, 5, 10, 15, 20, 40 and 100gm/L stirred well and kept in contact for 24 hours at room temperature. Then the samples were filtered and analyzed for various physico-chemical characteristics. This study was especially concentrated on BOD removal. The method for determination of BOD practicable is 5 day Incubation method followed from 'Standard methods for the water and waste water'[15]. The results for each dose are presented in Table I, II and figure 1, 2.

RESULTS AND DISCUSSION

Table I shows the effect of different dosages of Bagasse Fly ash onto various physico-chemical characteristic of the combined Waste Water Sugar Industry at room temperature. It is clear from the data that the pH and conductivity is increased alkalinity and hardness is decreased with increase in adsorbent concentration. pH increases from 6.5 initial to 8.82, conductivity increases from 3.05 m mho to 5.04 m mho, whereas alkalinity and hardness first drops and then increases from 1660 mg/L (initial) to 800 with 2gm/L adsorbent and further to 1250 mg/L at 100 gm/L and hardness decreases to 600 mg/L (2 gm/L) from 2075 mg/L (initial) and then increases upto 860 mg/L at 100gm/L of bagasse fly ash. The chloride content of the sample remains constant upto 15gm/L of adsorbent dose and then increases rapidly i.e. 204.936 mg/L (initial) to 167.448 mg/L upto 15 gm/L to 424.868 mg/L (100 gm/L). The initial COD content 5089.56 mg/L decreases to 3695.16 mg/L with 40 gm/L of bagasse fly ash and remains constant at higher dose. The initial BOD content is 1581 mg/L is decreased to 328.6 mg/L with same dosage 40gm/L and remains constant for higher dose.

The effect of different dose of bagasse fly ash on various physico-chemical characteristics is presented in table I indicate continuous increase in pH, conductivity, alkalinity, hardness and also of chloride content after 15 gm/L of dose suggest addition of some soluble inorganic material and ionic species causes the increase of results. Early at the first stage of the reaction the values seen to be decreased suggest adsorption of contaminants causing alkalinity, hardness and chloride content which is then shifts towards desorption with increase in dose. The COD and BOD content are adsorbed on the bagasse fly ash surface and removed by simple filtration, after optimum dose equilibrium condition attained and then no further removal is found even with higher dose.

Table II represents the data for Freundlich and Langmuir adsorption isotherms along with percent removal of BOD exerting components. There is a considerable decrease in adsorption per unit weight of adsorbate with increase in adsorbent concentration. The removal of BOD

contributing components is found to decrease from 496 mg/gm to 12.524 mg/gm with varying amounts of Bagasse fly ash from 2 gm/L to 100gm/L. The percent removal of BOD increase upto 79.21% with 40gm/L of adsorbent and remain constant for higher dosages. The logarithmic and inverse values of equilibrium concentration and removal per unit weight are used for plots of isotherm.

Table II represents the data for Freundlich and Langmuir adsorption isotherms along with percent removal for BOD onto bagasse fly ash. These information are used to prove the adsorption isotherm model and from that the Adsorption intensity, Adsorption energy and Adsorption capacity can be calculated. The percent removal of BOD seems to be increased with increase in dose of adsorbent. The logarithmic and inverse values of C_{eq} and x/m are used for plot of isotherm.

The logarithmic value of equilibrium concentration and removal per unit weight gives the linear plot for BOD by bagasse fly ash confirm the applicability of Freundlich adsorption isotherm. It is the most widely used mathematical description of adsorption in aqueous systems. The equation is an empirical expression that covers the heterogeneity of the surface and exponential distribution of sites and their energies. With the purpose of linearization the equation is represented in logarithmic form as—

$$\log x/m = \log K + 1/n \log C_{eq}$$

The plot of $\log C_{eq}$ versus $\log x/m$ gives straight line with a slope of $1/n$ and $\log K$ is the intercept of $\log x/m$ at $\log C_{eq} = 0$ which indicates that Freundlich adsorption isotherm model is applicable.

The same table shows the Langmuir adsorption isotherm for BOD by bagasse fly ash. Langmuir isotherm is a plot of the amount of impurity adsorbed by bagasse fly ash against the amount of impurity that remains in solution. It is a preliminary test to check the efficiency of particular material.

These mode of action can be explained on the basis of Langmuir's model, i.e. 'Ideal localized monolayer model' according to which:

1. The molecules are adsorbed at definite sites on the surface of the adsorbent.
2. Each site can accommodate only one molecule (monolayer).
3. The area of each site is a fixed quantity determine solely by the geometry of the surface.
4. The adsorption energy is the same at all the sites.

Such behavior on the basis of kinetic consideration, presuming that the adsorbed molecules cannot migrate across the surface of the interact with another neighboring molecules can be mathematically expressed as under

$$1/q_e = 1/\Theta_0 b \times 1/C_{eq} + 1/\Theta_0$$

Where-

q_e = amount of solute adsorbed per unit weight of adsorbent(mg/gm)

= x/m i.e. x is amount of adsorbate adsorbed (mg/L)

m is weight of adsorbent (gm/L)

C_{eq} = equilibrium concentration of the solute (mg/L)

Θ_0 = Langmuir constant related to adsorption capacity (mg/gm)

b = Langmuir constant related to adsorption energy (L/mg)

Fig. 1 represents the plot of $\log C_{eq}$ Vs $\log x/m$ for BOD on bagasse fly ash. The straight line nature of the plot corresponds to slope $1/n$ and intercept K . $1/n$ is related to adsorption intensity whose value is 4.7642 for BOD while intercept K on Y-axis related to adsorption capacity is found to be 1.41

Plot of $\log C_{eq}$ versus $\log x/m$ is a straight line in nature, presented in figure 1 suggests the applicability of this isotherm and indicate a monolayer coverage of the adsorbate on the outer surface of the adsorbent. The steep slope indicates high adsorptive intensity at high equilibrium concentration that rapidly diminished at lower equilibrium concentration covered by the isotherm. As Freundlich equation indicates the adsorptive capacity x/m is a function of the equilibrium concentration of the solute. Therefore, higher capacity is obtained at higher equilibrium concentrations.

Fig. 2 represents the plot of Langmuir parameters viz, $1/C_{eq} \times 10^3$ and $1/q_e \times 10^3$. The nature of the curve for BOD onto bagasse fly ash from sugar industry is linear however the intercept on X-axis related to adsorption energy (L/mg) i.e. $b \times 10^3$ is 1.89 L/mg for BOD exerting components. These values can be used to calculate the adsorption capacity Θ_0 i.e 221.048 (mg/gm).

The plot of Langmuir adsorption isotherm for BOD contributing components onto bagasse fly ash presented in fig. 2 is a straight line in nature which confirms the applicability of the Langmuir model and also the monolayer coverage. The Langmuir constant Θ_0 in mg/gm related to adsorption capacity indicate availability of more surface active region onto adsorbent site and $b \times 10^3$ L/mg related to adsorption energy in terms of x/m is a characteristic of the system.

Table I The effect of different dosages of Bagasse Fly ash onto various physico-chemical characteristic of the combined Waste Water Sugar Industry

Adsorbent: Bagasse Fly ash

Specific Surface Area: 2637.784 Cm²/ gm

Room temperature: 25± 1°C

Contact duration: 24 Hours

Parameter	Untreated	2 gm/L	5 gm/L	10 gm/L	15 gm/L	20 gm/L	40 gm/L	100 gm/L
pH	6.5	8.17	8.47	8.64	8.67	8.70	8.78	8.82
Conductance(m mho)	3.05	2.10	2.14	2.41	2.59	2.98	3.48	5.04
COD (mg/L)	5089.56	4950.12	4601.52	4392.36	4183.2	4043.76	3695.16	3695.16
BOD (mg/L)	1581	589	496	434	403	372	328.6	325.6
Alkalinity(mg/)	1660	800	820	860	920	1060	1175	1250
Hardness(mg/L)	2075	600	625	675	700	725	860	860
Chloride (mg/L)	204.936	167.448	167.448	167.448	167.448	192.44	237.426	424.868

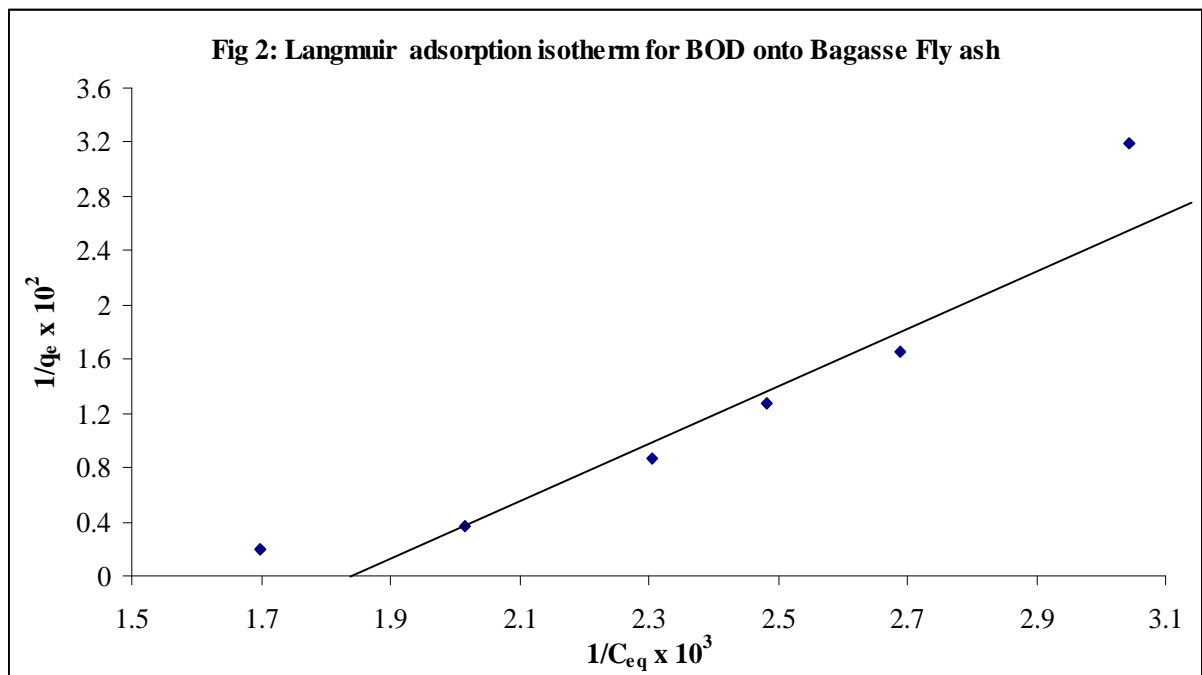
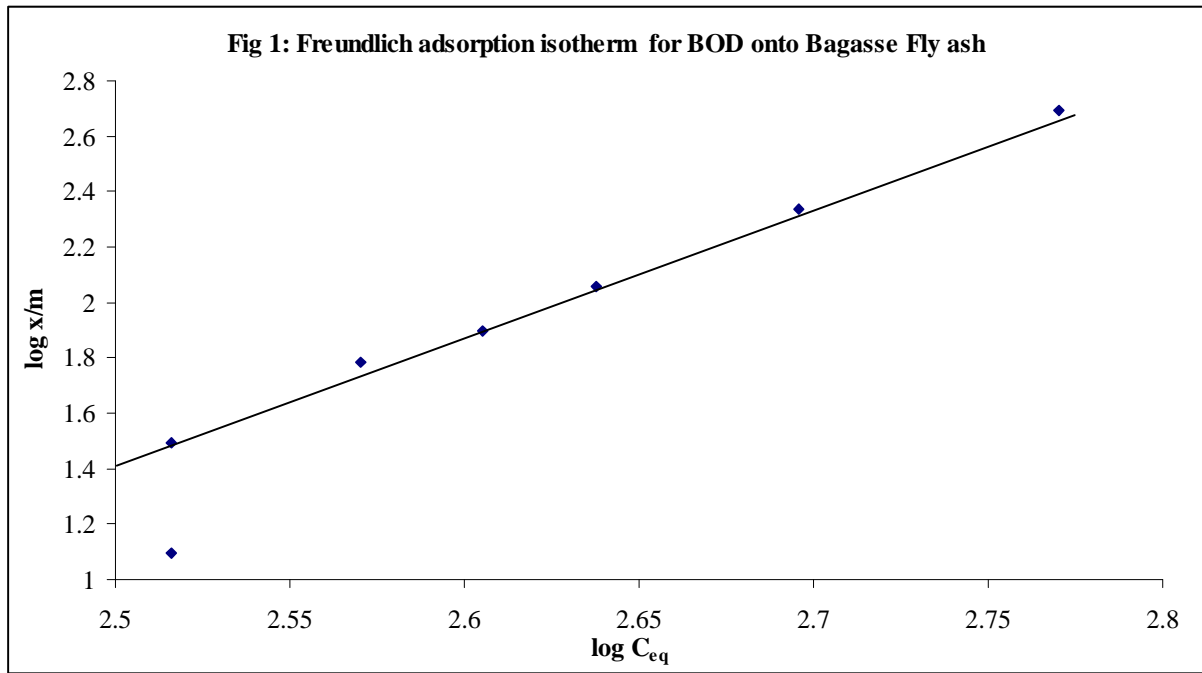


Table II Freundlich and Langmuir adsorption isotherm parameters for BOD contributing component along with percent removal of BOD onto Bagasse Fly ash*Adsorbent: Bagasse Fly ash**Room temperature: 25 ± 1°C**Specific Surface Area: 2637.784 Cm²/ gm**Contact duration: 24 Hours*

No	Adsorbent Dosage m(gm/L)	Eq. Conc. C _{eq} (mg/L)	Removal x=C ₀ -C _{eq} (mg/L)	q _e =x/m (mg/gm)	Removal %	logC _{eq}	logx/m	1/C _{eq} ×10 ³	1/q _e ×10 ²
1	0	1581	-	-	-	3.1989	-	0.6325	-
2	2	589	992	496	62.74	2.7701	2.6955	1.6978	0.2016
3	5	496	1085	271	68.62	2.6956	2.3364	2.0161	0.3690
4	10	434	1147	114.7	72.55	2.6375	2.0596	2.3041	0.8718
5	15	403	1178	78.53	74.51	2.6053	1.8950	2.4814	1.2734
6	20	372	1289	60.45	76.47	2.5705	1.7814	2.6882	1.6542
7	40	328.6	1252.4	31.31	79.21	2.5159	1.4957	3.0432	3.1938
8	100	328.6	1252.4	12.524	79.21	2.5159	1.0977	3.0432	7.9846

CONCLUSION

This study leads us to the conclusion that the final combined waste water of Sugar manufacturing unit is highly polluted having higher BOD value. Due to some practical limitation only BOD parameter is emphasized in this paper when the final combined waste water of Sugar mill is treated with finely divided low cost material bagasse fly ash at room temperature for 24 hours of contact duration the following results are achieved.

- i. The maximum COD removal is found at 40gm/L of bagasse fly ash concentration i.e. 27.4%
- ii. Bagasse Fly ash of sugar industry itself is a pollutant removes BOD contributing components upto 79.21% of the combined waste water.
- iii. The alkalinity, hardness and chloride content of the sample first decreased and then increases with increasing amount of bagasse fly ash.
- iv. At room temperature bagasse fly ash works as an adsorbent and follow Freundlich and Langmuir isotherm models. The results give straight line which confirms the applicability of isotherm.
 - a. The Freundlich constant K an intercept on X axis is related to adsorption capacity is found to be 1.41 while the slope 1/n is related to adsorption intensity is found to be 4.7642
 - b. The straight line of the Langmuir plot gives intercept on Y axis called b x 10³ L/mg i.e. adsorption energy is 1.89 L/mg and the calculated adsorption capacity Θ₀ mg/gm is 221.048

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