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Investigation of Optimum Operating Parameters for Pollutant Removal from Distillery Spent Wash

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***Abstract*— Several individual studies for the removal of pollutants and heavy metals have been conducted using different adsorbents and techniques. The present study aimed to compare the low cost adsorbents for pollutants removal from distillery spent wash and to find the best adsorbent. Therefore, two low cost adsorbent materials such as activated carbon and fly ash are used as a low cost adsorbent material. In this study it is also found that 50% concentration of distillery spent wash is most feasible for investigation. In this experimental work, different operating parameters such as effect of adsorbent dose and treatment time are selected for adsorption. This study also includes adsorption isotherm analysis by analyzing the Langmuir and Freundlich adsorption isotherm models. The results showed that Activated Carbon has more BOD and COD removal efficiency than Fly Ash for all samples. Isotherm studies indicate that Activated Carbon had higher adsorption for BOD and COD than Fly Ash at all dosages used. The data fitted very well to Freundlich isotherm model. The result of investigation indicates that utilization of 50% concentration distillery spent wash in agriculture not only improved the productivity of agricultural land but also save the environment from its degradation through their disposal in the near by vicinity of the distillery industries.**

Keywords- Adsorption, BOD, COD, Isotherm models, Kinetic models.

I. INTRODUCTION

India is a major producer of sugar in the world and contributes substantially to economic development. Distillery Spent Wash (one of the important byproducts of sugar industry) is the chief source for the production of ethanol & Alcohol in distilleries by fermentation method. About eight (08) liters of waste water is discharged for every liter of production in distilleries. Distillery Spent Wash, which characterized by high BOD,COD, low pH and dark brown colour with foul smell creates toxic conditions in the receiving streams.[1]

Activated carbon is one of the major adsorbents used for treatment of distillery wastes to reduce BOD and COD [2, 3]. Ideal adsorbents must obey the following characteristics; a solid, with high surface area, high porosity, inertness and stability to withstand chemical, thermal and climatic changes, cost effective and good physicochemical properties similar to that of commercial activated carbon. An adsorbent possessing the above properties, would be considered as a good adsorbent in water and wastewater treatments [4, 5].

Several individual studies have been done to identify low cost adsorbents for the treatment of industrial effluents to reduce BOD and COD. The low-cost adsorbents such as activated carbon and fly ash have been effectively used for the treatment of wastewater. It is important to note that the adsorption capacities may vary, depending on the characteristics of the individual adsorbent, surface modification and the initial concentration of the adsorbate. In general, technical applicability and cost effectiveness are the key factors that play major roles in the selection of the most suitable adsorbent to treat effluent.

Further, use of absorbents for BOD and COD reduction has the advantage of easy sludge disposal when compared to conventional precipitation technique. In the present study activated carbon which are belonging to low cost category, have been investigated as the possible adsorbents for the reduction of BOD and COD from distillery effluents. Several parameters like adsorbent dosage and contact time were optimized and validated for isotherm models.

II. MATERIALS AND METHODOLOGY

The physical adsorption is one of the new removal mechanisms in the adsorption method. In this the adsorbate adheres on the surface of adsorbent only through Van der Waals (weak intermolecular) interactions.

A. *Materials*

1. *Distillery Waste (Spent Wash)*

For the present study, the effluent of the Sanjivani Sugar Factory & Distillery Ltd, at Kopargaon, Dist- Ahmednagar is collected when the factory was running at full capacity. The sample was collected from the discharge channel outlets of distillery and immediately used for testing.

2. *Activated Carbon*

Activated carbon is widely used for adsorption of pollutants from gaseous and liquid streams. Heavy pollutants are toxic both to the humans and other living beings due to their presence beyond certain limits. Relatively greater efficiency of activated charcoal as adsorbent was due to its organophillic character. The important characteristics of activated carbon provided by the manufacturer are: greater active surface area $0.9x10^6$ m^3/kg, particle density 175 kg/m^3, Iodine value of 1000 and moisture content was 5.8%. and thus making it suitable for adsorption. Activated Carbon will be procured from local suppliers of the city.

3. Selection of Seeds

Seeds of wheat INDO-US-GW-496C/F (Triticum aestivum L.) were chosen for the experimental work.

B. Experimental Procedure

Activated charcoal and fly ash were procured from the local supplier. Experiment consisted of two adsorbents, 50% concentration of distillery spent wash and plastic pots. The capacities of pots are 3 kg soil and were filled with sand of 49%, clay of 18% and silt of 33%. Wheat will be grown in the pots and the pots will be kept in atmosphere in natural sunlight at atmospheric temperature. After 10 days of growth, adsorption experiments were conducted in different batches for the adsorbents, where the adsorbent dose and adsorbent treatment time were changed for the different sets of experiments.

The colour, pH and temperature of the wastewater samples were measured on collection site. BOD and COD were analyzed in laboratory according to the methods prescribed in Guide Manual for Water and Wastewater Analysis by CPCB [6]. Titrimetric method is used for analysis of BOD and Open Reflux method is used for the analysis of COD. The BOD and COD of the wastewater samples were measured in laboratory before and after treatment with the adsorbents. The experiments were carried out under different experimental conditions.

C. Adsorbent Dose

The studies were conducted by varying the amount of adsorbent. To determine the contribution of the adsorbent dose to BOD and COD reduction, 100 ml of sample was treated with different doses of adsorbent ranging between 0.5 to 3.0 gm/100ml., the other conditions includes, initial BOD concentration: 36600mg/l, initial COD concentration: 108100 mg/l, treatment time: 30 days, pH 4.8 for BOD and COD. The samples were saturated in the soil for specific time interval of 360 min, treatment-wise leachate was collected, brought to the laboratory and analyzed for the residual BOD and COD concentration.

D. Adsorbent Treatment Time

Effect of adsorbent treatment time (contact time) of the adsorbents with wastewater sample was investigated by agitating 100 ml sample and adding 3.0 gm adsorbent for different time periods varying between 05 to 30 days. Initial BOD concentration: 36600 mg/l, initial COD concentration: 108100 mg/l, adsorbent dose: 3.0 gm/100ml, pH: 4.8 for BOD and COD. The samples were saturated in the soil for specific time interval of 360min, treatment-wise leachate was collected, brought to the laboratory and analyzed for the residual BOD and COD concentration.

E. Langmuir Isotherm Model

The adsorption data is analyzed according to a linear eq. of Langmuir Isotherm Model [7,8] as follows.

$$\frac{1}{q_e} = \frac{1}{Q_o k_L}\,\frac{1}{C_e} + \frac{1}{Q_o} \qquad (1)$$

Where,

q_e = Amount of adsorbate in the adsorbent at equilibrium i.e. amount of BOD and COD removed/adsorbed per unit mass of adsorbent (mg/g),

C_e = Equilibrium concentration (mg/L),

Q_o = Maximum monolayer coverage/adsorption capacity i.e. maximum amount of BOD and COD adsorbed per unit mass of adsorbent to form a complete monolayer on the surface (mg/g),

k_L = Langmuir isotherm constant related to the affinity of the binding sites (L/mg).

For Langmuir isotherm model, a plot of *($1/q_e$)* vs. *($1/c_e$)* is employed. A linear equation is used to generate the values of constants *(Q_o)* and *(k_L)* and coefficient of regression.

F. Freundlich Isotherm Model

The adsorption data is analyzed according to a linear eq. of Freundlich Isotherm Model [7,8] as follows.

$$\log q_e = \frac{1}{n}\log C_e + \log k_F \qquad (2)$$

Where,

q_e = Amount of adsorbate in the adsorbent at equilibrium (mg/g)

C_e = Equilibrium concentration (mg/L)

k_F = Freundlich isotherm constant (mg/g) $(dm^3/g)^{1/n}$ related to adsorption capacity of the adsorbent,

n = Indicates favorability of adsorption i.e. if n>1 it indicates favorable adsorption condition.

For Freundlich isotherm model, a plot of *($\log q_e$)* vs. *($\log C_e$)* is employed. A linear equation is used to generate the values of constants *(1/n)* and *(k_F)* and coefficient of regression.

G. Pseudo first-order Kinetic Model

The adsorption data is analyzed according to a following equation.

$$\log(q_e - q_t) = \log q_e - \frac{K_1 t}{2.303} \qquad (3)$$

For Pseudo first-order kinetic model, a plot of log *(q_e-q_t)* vs. *(t)* is employed for wastewater sample using activated carbon for BOD and COD.

H. Pseudo second-order Kinetic Model

The adsorption data is analyzed according to a following equation.

$$\frac{t}{q_t} = \frac{1}{K_2 q_e^{\,2}} + \frac{t}{q_e} \qquad (4)$$

For Pseudo second-order kinetic model, a plot of t/q_t vs t is employed for distillery spent wash sample using activated carbon.

III. RESULTS AND DISCUSSION

The wastewater was treated under batch mode operation using activated carbon and BOD and COD concentrations were measured before and after treatment with the adsorbent. The important operating parameters taken into consideration for the present study are adsorbent dose and adsorbent treatment time (contact time).

A. Effect of Adsorbent Dose

A study was done on the effect of adsorbent dose on percentage reduction of COD and BOD with activated carbon as shown in Fig. 1. Equilibrium was reached corresponding to 3.0 gm/100ml adsorbent dose for the optimum percentage reduction of 88.99% in BOD and 91.08% in COD. After equilibrium, further addition of adsorbent results in constant removal of BOD and COD. Initial BOD concentration: 36600 mg/l, initial COD concentration: 108100 mg/l, treatment time: 30 days, pH 4.8 for BOD and COD.

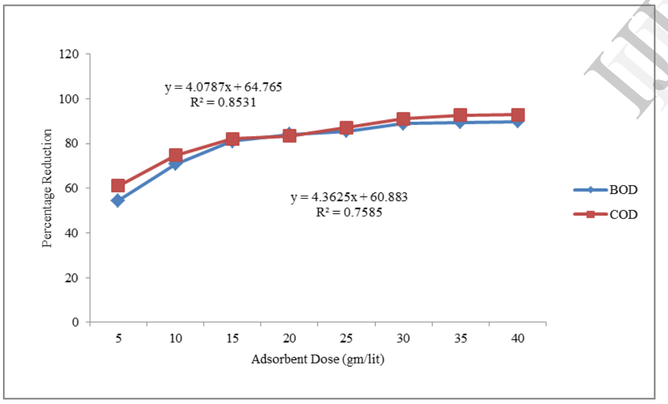

Fig. 1. Effect of adsorbent dose on percentage BOD and COD

B. Effect of Adsorbent Treatment Time

The absorption increases with increase in time and reaches saturation according to its capability. Fig. 2 shows optimum percentage reduction of BOD and COD was 86.10% and 89.12% respectively after a treatment time of 30days. As the treatment time progressed, the adsorbent sites had the tendency towards saturation. Initial BOD concentration: 36600 mg/l, initial COD concentration: 108100 mg/l, adsorbent dose: 3.0 gm/100ml, pH: 4.8 for BOD and COD.

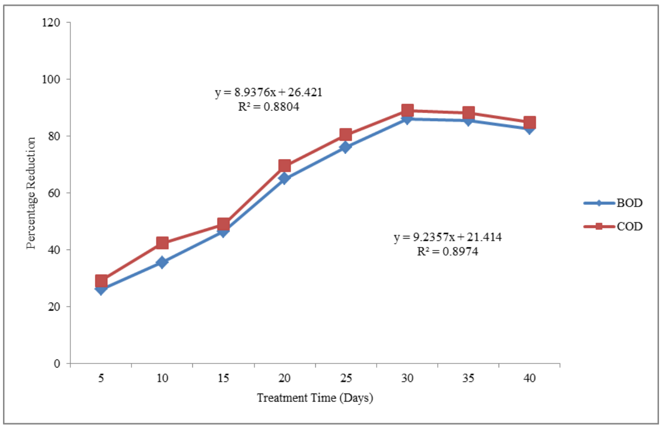

Fig. 2. Effect of treatment time on percentage BOD and COD reduction

C. Langmuir Isotherm Model

From the Langmuir isotherm model as shown in Fig. 3 and Fig. 4 for BOD and COD resp., constants *(Q_o)* obtained are: is -11.389 and 2.7647 for BOD and COD resp. while *(K_L)* is -0.021 and 0.1310 for BOD and COD resp. The regression coefficient is 0.9633 and 0.9754 for BOD and COD resp.

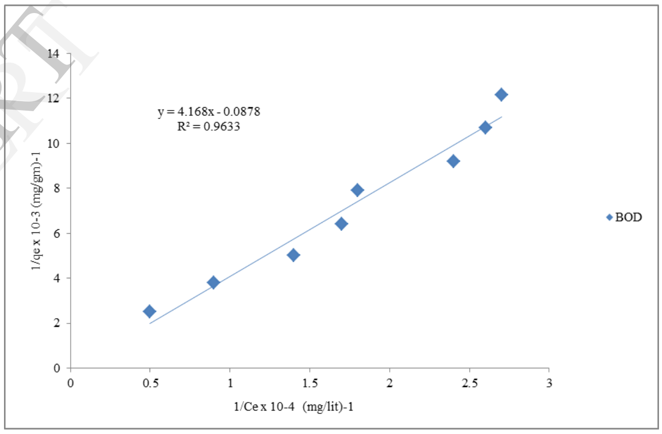

Fig. 3. Langmuir Isotherm Model for BOD

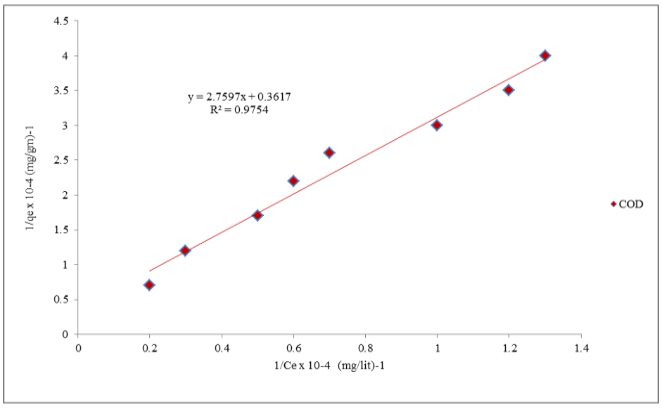

Fig. 4. Langmuir Isotherm Model for COD

D. Freundlich Isotherm Model

From the Freundlich isotherm model as shown in Fig. 5 and Fig. 6 for BOD and COD resp., constants *(1/n)* obtained are: is 1.0077 and 0.9097 for BOD and COD resp. while *(K_F)* is 0.2342 and 0.7360 for BOD and COD resp. The regression coefficient is 0.9732 and 0.959 for BOD and COD resp. Here the value of *(1/n)* is greater than one for both BOD and COD which indicates favorable adsorption.

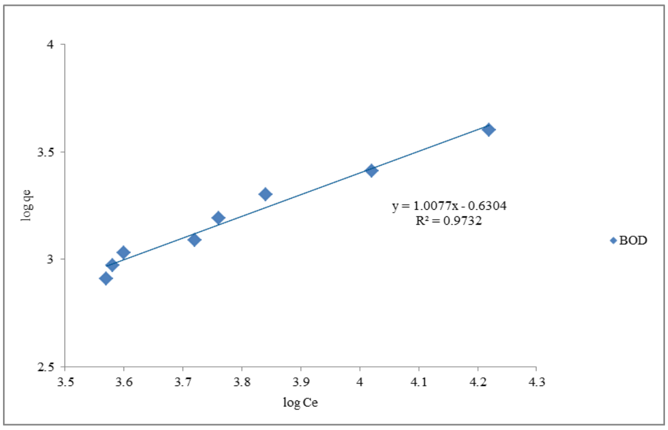

Fig. 5. Freundlich Isotherm Model for BOD

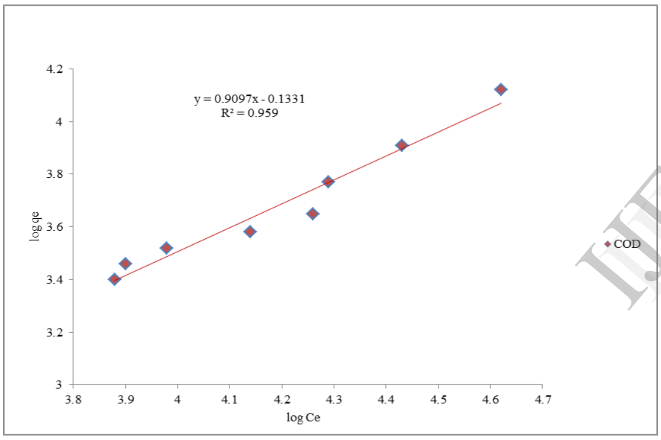

Fig. 6. Freundlich Isotherm Model for COD

E. Pseudo first-order Kinetic Model

From the Pseudo first order kinetic model as shown in Fig. 7 for BOD and COD constants *(q_e)* obtained are: 1406.37 and 4265.77 for BOD and COD resp. while *(k_1)* is 0.0890 and 0.09480 for BOD and COD resp. The regression coefficient is 0.9195 and 0.9043 for BOD and COD resp.

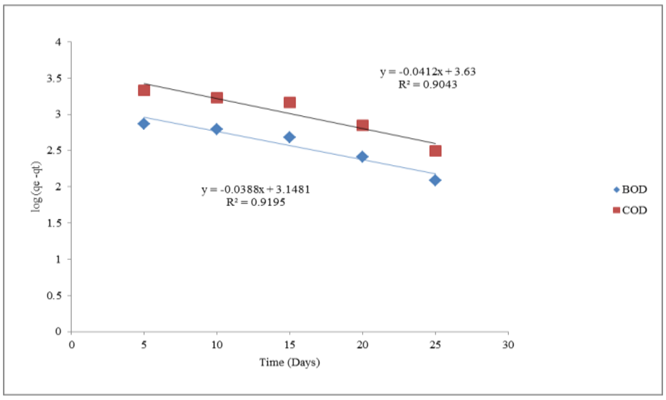

Fig. 7. Pseudo-first order Kinetic Model for BOD and COD

F. Pseudo second-order Kinetic Model

From the Pseudo second order kinetic model as shown in Fig. 8 for BOD and COD constants (q_e) obtained are: 2000 and 3000 for BOD and COD resp. while (k_1) is 0.000016 and 0.0000097 for BOD and COD resp. The regression coefficient is 0.8846 and 0.8903 for BOD and COD resp.

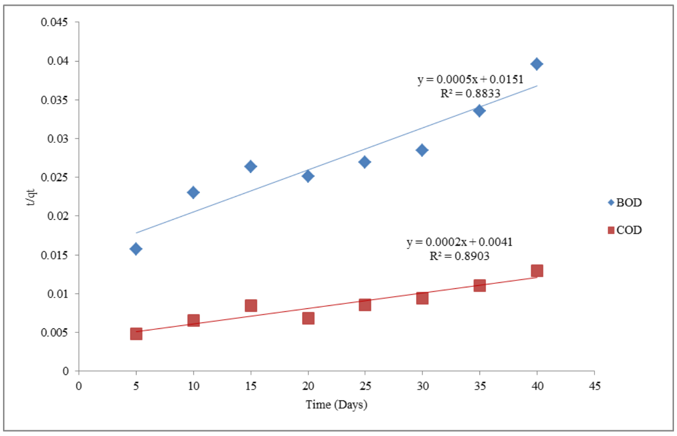

Fig. 8. Pseudo-second order Kinetic Model for BOD and COD .

IV. CONCLUSION

This study shows that Activated carbon has good efficiency in BOD and COD reduction of distillery industrial wastewater i.e. spent wash. The effect of various parameters such as adsorbent dose and adsorbent treatment time showed a significant impact on percentage removal of BOD and COD. The optimum operating parameters for maximum BOD and COD reduction are, Adsorbent dose: 3.0gm/100ml of sample, Treatment time: 30 days.

The regression coefficient of Langmuir isotherm models are 0.9633 and 0.9754 for BOD and COD resp., and regression coefficient of Freundlich isotherm models are 0.9732 and 0.959 for BOD and COD resp. Hence, Freundlich isotherm model is the best fit for BOD adsorption and Langmuir isotherm model is the best fit for COD adsorption. Also from Freundlich isotherm model the value of 1/*n* is greater than one for both BOD and COD which indicates favourable adsorption. The Adsorption Kinetic study for Distillery industry wastewater concluded that the adsorption rate follows pseudo first-order kinetic model and gives best fit model for BOD and COD adsorption using activated carbon

Therefore, it can be concluded that activated carbon could be used as an efficient and cost effective adsorbent in treating distillery spent wash for BOD and COD reduction.

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