ISSN: 0974-2115
www.jchps.com Journal of Chemical and Pharmaceutical Sciences

Treatment of Dairy Industry Waste Water using Eucalyptus Wood Saw Dust activated Carbon powder

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ABSTRACT

The effectiveness of Eucalyptus wood saw dust activated carbon powder, a cheap agro-based product, as an adsorbent was evaluated to remove COD and TDS present in a dairy industry wastewater. Experiments were carried out by adding Eucalyptus wood saw dust activated carbon powder to the dairy industry wastewater at different dosages, different rapid mixing contact time and slow mixing contact time. Maximum removal for COD and TDS in a dairy industry effluent was obtained at an optimum dosage of 100 g/l, an optimum rapid mixing contact time of 15 min. and an optimum slow mixing contact time of 30 min. The results showed that the percentage reduction in concentration of COD and TDS in a dairy industry wastewater by Eucalyptus wood saw dust activated carbon powder as an adsorbent is about 94.8 % and 89.2 % respectively. The model also developed to check the reproducing ability of the experimental investigations. The results of the experimental investigations and model studies indicated that the Eucalyptus wood saw dust activated carbon was effectively used as an adsorbent to remove COD and TDS present in a dairy industry wastewater.

KEY WORDS: Eucalyptus Wood, Activated Carbon, Dairy Industry Wastewater, Process Parameters.

1. INTRODUCTION

The dairy industry produces different products such as milk, butter, yoghurt, ice-cream and various types of desserts and cheese, the characteristics of these effluents also vary widely both in quantity and quality, depending on the type of system and the methods of operation used (Kannahi and Sangeetha, 2014).The dairy industry is a major source of food processing wastewater. Dairy industry wastewater generally contains a high organic load, due to the presence of diluted milk/milk products, and contains significant quantities of cleaning and sanitizing compounds. The dairy industry in India is generated 6-10 litres of wastewater per litre of the milk processed. Effluents are the wastes produced from industries and they differ with respect to the industry they are generated from. The volume and composition of treatment plant depends upon the type of wastes produced, types of cleansers. Different types of milk based products are produced and consequently waste streams may vary on a daily basis thereby, reflecting a change in physico-chemical parameters (Neha Sharma, 2013). Wastewater management in the dairy industry is well documented, but wastewater production and disposal remain a problematic issue, since, surface water and groundwater is contaminated due to industrial wastewater when it is not discharged properly (Sivakumar Durairaj, 2013c; Sivakumar, 2011). To enable the dairy industry to contribute to water conservation, an efficient and cost-effective effluent treatment technology has to be developed.

In recent years, increasing awareness of water pollution and its far reaching effects has prompted concerted efforts towards pollution abatement. Earlier works revealed the suitability of variety of agro-based materials like *moringa oleifera* seed, corncob, groundnut husk, rice husk, tea leaves carbon, saw dust to treat the industrial wastewater. The suggested treatment methods for the removal of pollutants from various dairy industries are adsorption (Sivakumar and Shankar, 2012; Sivakumar, 2013b; Sivakumar, 2014c; Sivakumar, 2014f; Sivakumar, 2014g; Sivakumar, 2014k; Shankar, 2014a; Sivakumar and Nouri, 2015), ion exchange, chemical precipitation, bioremediation (Shankar, 2014b; Sivakumar, 2014d, Sivakumar, 2014e), constructed wetland (Sivakumar, 2015; Turker, 2014; Sivakumar, 2013a; Sivakumar, 2014h; Ingole and Bhole, 2003; Soltan and Rashed, 2003) and electro-dialysis (Sivakumar, 2014i, Sivakumar, 2014j) etc.

The present study focused to determine an effect of Eucalyptus wood saw dust activated carbon activated carbon powder, a cheap agro-based product, as an adsorbent for removing chemical oxygen demand (COD) and total dissolved solids (TDS) present in a dairy industry wastewater at different dosages, different rapid mixing contact time and different slow mixing contact time. Also, the experimental values of dairy industry wastewater were simulated with the model and the same were compared for reproducibility.

2. MATERIALS AND METHODS

2.1. Adsorbent Preparation: Eucalyptus wood saw dust was washed with tap water and then deionized water to remove particulate material from their surface. After that, they were dried in sun. The dried materials were ground using pulverizer. The ground Eucalyptus wood saw dust was then sieved through 200 microns sieve to get

uniform geometrical size for use. Then, they were dried in an oven at 100 °C for 3 h. Further, the dried Eucalyptus wood saw dust powder was heated to the elevated temperature of 400 °C for 4 h to obtain the activated carbon. While preparing the activated carbon, there was 30 % to 40 % weight reduction from the original weight of Eucalyptus wood saw dust powder. Then, the activated carbon prepared from Eucalyptus wood saw dust was kept in air tight box at 4 °C in a refrigerator for the experimental use in later stage.

2.2. Collection and Analysis of Sample: For the present study, the wastewater samples were collected from dairy industry, Chennai, Tamil Nadu with the help of air tight sterilized bottles, took to the laboratory and then they were stored for analyzing COD and TDS concentrations in a dairy industry wastewater. The initial COD and TDS values for a dairy industry wastewater were determined as per standard procedure given by APHA, AWWA, and WEF (2005) and found to be 8320 mg/l and 3085 mg/l respectively. The Phipps and Bird jar test apparatus was used for evaluating and optimizing the coagulation process. This method consists of batch experiments involving rapid mixing at the rotational speed of 100 rpm and slow mixing at the rotational speed of 20 rpm for enhancing flocculation process. The sedimentation is allowed for a period of 60 min. Dairy industry wastewater was filled in four glass beakers of 1 litre capacity and was kept in the Phipps and Bird jar test apparatus for agitation.

The experiments were performed at different dosages (for Eucalyptus wood saw dust activated carbon powders varying from 20 to 140 g/l at an interval of 20 g/l), different rapid mixing contact time (varying from 5 to 30 min. at an interval of 5 min.) and different slow mixing contact time (varying from 10 to 50 min. at an interval of 10 min.). The top clear wastewater from each beaker after settlement of 60 min. was collected and further, filtered with Whatman filter paper for removing impurities and then the cleared wastewater was taken for analyzing COD and TDS as per standard procedure given by APHA, AWWA, and WEF (2005). The adsorption removal percentage of COD and TDS in a dairy industry wastewater by *Eucalyptus* wood saw dust activated carbon powder was calculated by using the following formula:

$$\text{Percentage Removal} = \frac{(C_1 - C_2)}{C_1} \text{ x } 100 \qquad (1)$$

in which C_1 is the concentration of COD in mg/l and TDS in mg/l before treatment with *Eucalyptus* wood saw dust activated carbon powder and C_2 is the concentration of COD in mg/l and TDS in mg/l after treatment with *Eucalyptus* wood saw dust activated carbon powder.

3. RESULTS AND DISCUSSION

3.1. Effect of Rapid Mixing Contact Time: Fig.1 shows the effect of rapid mixing contact time on removal of COD and TDS in a dairy industry wastewater with *Eucalyptus* wood saw dust activated carbon powder as an adsorbent of 20 g/l and a slow mixing contact time of 10 min. against the rapid mixing contact time of 5, 10, 15, 20, 25, and 30 min.

From Fig.1, it may be observed that up to 15 min. rapid mixing contact time, the reduction in concentration of COD and TDS increase, beyond which they decrease. The percentage reduction in concentration of COD for a rapid mixing contact time of 5, 10, 15, 20, 25, and 30 min. were found to be 44.6, 58.6, 64.2, 73.4, 58.1 and 49.3 % respectively. Similarly, the percentage reduction in concentration of TDS for a rapid mixing contact time of 5, 10, 15, 20, 25, and 30 min. were found to be 36.6, 56.8, 60.6, 69.7, 53.6 and 44.2 % respectively.

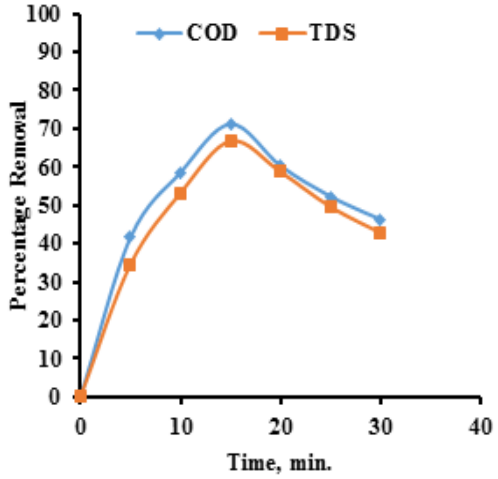

Fig.1.Effect of Rapid Mixing Contact Time by Eucalyptus wood saw dust activated carbon

Thus, an optimum rapid mixing contact time leading to maximum COD and TDS removal is 15 min. (Fig.1). Further, an optimum rapid mixing contact time (15 min.), at which maximum removal of COD and TDS in a dairy industry wastewater was 6106.88 mg/l and 2150.25 mg/l respectively and an optimum rapid mixing

contact time (15 min.), which is corresponding to the lowest residual COD and TDS obtained for a dairy industry wastewater was 2213.12 mg/l and 934.76 mg/l respectively.

3.2. Effect of Slow Mixing Contact Time: Fig.2 shows effect of slow mixing contact time on removal of COD and TDS in a dairy industry wastewater with a *Eucalyptus* wood saw dust activated carbon powder as an adsorbent of 20 g/l and an optimum rapid mixing contact time of 15 min. against the slow mixing contact time of 10, 20, 30, 40 and 50 min.

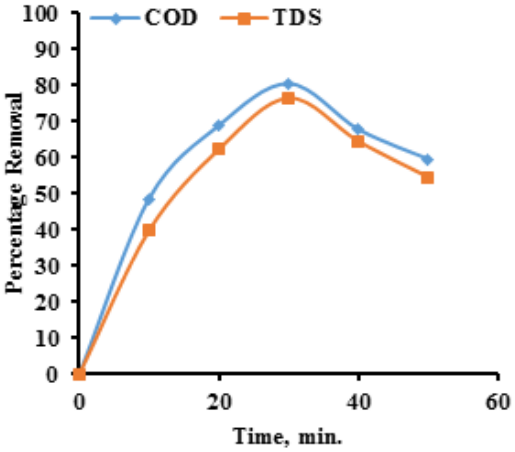

Fig.2.Effect of Slow Mixing Contact Time by Eucalyptus wood saw dust activated carbon

It can be observed from Fig.2 that up to 30 min. slow mixing contact time, the reduction in concentration of COD and TDS increase and beyond which they decrease. The percentage reduction in concentration of COD for a slow mixing contact time of 10, 20, 30, 40 and 50 min. were found to be 33.5, 51.2, 65.8, 83.5, 69.1 and 63.2 % respectively. Similarly, the percentage reduction in concentration of TDS for a slow mixing contact time of 10, 20, 30, 40 and 50 min. were found to 28.5, 42.6, 65.3, 78.6, 64.2 and 58.2 % respectively. Thus an optimum slow mixing contact time for which the maximum COD and TDS removal occurs is 30 min. (Fig.2). Further, an optimum slow mixing contact time (30 min.) at which maximum removal of COD and TDS in a dairy industry wastewater was 6947.20 mg/l and 2424.81 mg/l respectively and an optimum slow mixing contact time (30 min.), which is corresponding to the lowest residual COD and TDS obtained for a dairy industry wastewater was 1372.80 mg/l and 660.19 mg/l respectively.

3.3. Effect of Eucalyptus wood saw dust activated carbon Dosage: Fig.3 shows the effect of Eucalyptus wood saw dust activated carbon powder as an adsorbent on removal of COD and TDS in a dairy industry wastewater with an optimum rapid mixing contact time of 15 min. and an optimum slow mixing contact time of 30 min. against the different adsorbent dosage of 20, 40, 60, 80, 100, 120 and 140 g/l.

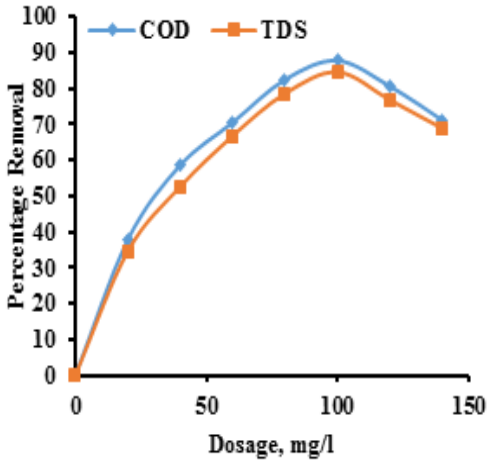

Fig.3.Effect of Adsorbent Dosage by Eucalyptus wood saw dust activated carbon

From Fig.3, it may be observed that up to 100 g/l of *Eucalyptus* wood saw dust activated carbon powder dosage, reduction in concentration of COD and TDS in a dairy industry wastewater increase, beyond which they decrease. The percentage reduction in concentration of COD for a *Eucalyptus* wood saw dust activated carbon powder dosage of 20, 40, 60, 80, 100, 120, 140 g/l, respectively were found to 32.7, 42.1, 61.5, 76.5, 86.5, 94.8, 83.4 and 76.2 % respectively. Similarly, the percentage reduction in concentration of TDS for the dosage of 20, 40, 60, 80, 100, 120, 140 g/l, respectively was found to be 29.3, 38.6, 55.2, 68.2 82.4, 89.2, 79.6 and 72.6 %

respectively. Thus, an optimum dosage for which the maximum removal of COD and TDS occurred at 100 g/l (Fig.3). Further, an optimum dosage (100 g/l) at which maximum removal of COD and TDS in a diary industry wastewater was 7887.36 mg/l and 2751.82 mg/l respectively and an optimum dosage (100 g/l), which is corresponding to the lowest residual COD and TDS obtained for a dairy industry wastewater was 432.64mg/l and 333.18 mg/l respectively.

3.4. Model Development: In this study, the experimental data are fitted with 2nd order polynomial regression model. The polynomial models are used to estimate and predict the shape of response values over a range of input parameter values. Polynomial models are a great tool for determining which input factors drive responses and in what direction. These are also the most common models used for analysis of designed experiments. The polynomial regression model is given by

$$Y=aX^2+ bX + c \quad (2)$$

in which 'y' is predicted value parameters, 'x' is experimental value of parameters, a, b, and c are the constants. The polynomial equation found from the experimental data for the removal of COD and TDS in a dairy industry wastewater by *Eucalyptus* wood saw dust activated carbon powder is

$$Y = -0.0383x^2 + 3.7883x + 0.975 \text{ (COD)} \quad (3)$$

$$Y = -0.0258x^2 + 3.0853x + 1.28 \text{ (TDS)} \quad (4)$$

The second order polynomial regression model data by Eucalyptus wood saw dust activated carbon powder as an adsorbent on removal of COD and TDS in a dairy industry wastewater is represented in Fig. 4. The R^2 values obtained from the Fig. 4 is 0.9963, and 0.9924 respectively for the parameters COD and TDS in a dairy industry wastewater by Eucalyptus wood saw dust activated carbon powder.

From Fig. 4, it may be found that the second order polynomial regression model is fitted well with the experimental data. Thus, from the model studies, it is concluded that the removal of COD and TDS in a dairy industry wastewater by *Eucalyptus* wood saw dust activated carbon powder follows the second order polynomial regression model.

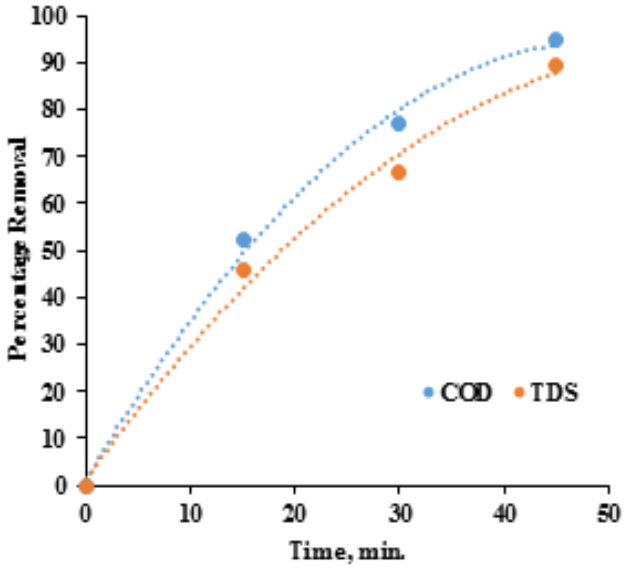

Fig.4.The second order polynomial regression model data for the removal of COD and TDS in a dairy industry wastewater by Eucalyptus wood saw dust activated carbon powder

4. CONCLUSION

In the present study, experiments were conducted to find out the suitability of *Eucalyptus* wood saw dust activated carbon powder as an adsorbent for removing COD and TDS present in a dairy industry wastewater. The experiments were conducted for removing COD and TDS with different dosages, different rapid mixing contact time and different slow mixing contact time. The results showed that maximum percentage removal was obtained at an optimum dosage of 100 g/l (*Eucalyptus* wood saw dust activated carbon powder), an optimum rapid mixing contact time of 15 min. and an optimum slow mixing contact time of 30 min. The results indicated that the *Eucalyptus* wood saw dust activated carbon is more beneficial in treating a dairy industry wastewater as adsorbent. Also, the experimental values of dairy industry wastewater were validated with the second order polynomial regression model and the model study concluded that the developed model is having reproducing capacity of the experimental data obtained from the dairy industry wastewater.

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