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Eucalyptus wood saw dust activated carbon powder for treating dairy industry wastewater

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ABSTRACT

Evaluated the *Eucalyptus* wood saw dust activated carbon powder for removing COD and TDS present in a dairy industry wastewater at different dosages, rapid mixing contact time and slow mixing contact time. An optimum dosage of 100 g/l, rapid mixing contact time of 15 min. and slow mixing contact time of 30 min. was observed in this study, for which maximum removal of COD and TDS in a dairy industry effluent occurred. The results showed that the maximum percentage reduction of COD and TDS in a dairy industry wastewater by *Eucalyptus* wood saw dust activated carbon powder is 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 for removing COD and TDS in a dairy industry wastewater.

KEY WORDS: Dairy industry wastewater, *Eucalyptus* wood saw dust activated carbon powder, COD, TDS, Process parameters.

1. INTRODUCTION

Milk and allied milk product is required in everyday life all human beings. The milk product manufacturing industry is producing huge amount of wastewater. Dairy industry wastewater contains high quantities of organic and inorganic matter and significant quantities of cleaning and sanitizing compounds. 6-10 litres of wastewater per litre of the milk is produced by the dairy industry. The management of the dairy industry wastewater remains a problematic issue because of management of large quantity. Improper disposal any wastewater on land and nearby water bodies leads to contamination of land and water environment (Sivakumar Durairaj, 2013; Sivakumar, 2011). Hence, it is necessary to reduce the pollutants present in the dairy industry wastewater (Sivakumar Durairaj, and Shankar Durairaj, 2012; Sivakumar, 2014). There are several methods like coagulation, filtration, reverse osmosis, chemical precipitation, electro-coagulation (Sivakumar, 2014), bioremediation (Sivakumar, 2013; 2014; Shankar, 2014) conducted by the various researchers to mitigate the industrial contaminants. Earlier works revealed the suitability of variety of agro-based materials like corncob, groundnut husk, rice husk (Sivakumar, 2014), rice husk silica, coconut coir pith (Shankar, 2014), tea leaves carbon, tamarind kernel (Sivakumar, 2014), *moringa oleifera* seed (Sivakumar, 2014; Sivakumar Durairaj, 2013), saw dust to treat the industrial wastewater. The present study focused to determine an effect of agro based *Eucalyptus* wood saw dust activated carbon powder for removing chemical oxygen demand (COD) and total dissolved solids (TDS) present in a dairy industry wastewater at different rapid mixing contact time, different dosages, 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

Adsorbent Preparation: Deionized water was used to remove the particulate material from *Eucalyptus* wood saw dust surface, then it was dried in sun light. The dried materials were ground using pulverizer. The ground *Eucalyptus* wood saw dust was then sieved to get uniform size of 200 microns, which is used for further study. Then, it was dried at 100°C for 3 h using hot air oven. Furthermore, 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.

Sample Collection and Analysis: The dairy wastewater samples were collected from dairy industry that located at Chennai, Tamil Nadu. The samples were collected using air tight sterilized bottles. The dairy industry wastewater samples were taken to the laboratory and stored for analyzing COD and TDS concentrations. The initial COD and TDS values for a dairy industry wastewater were determined as per standard procedure (APPA, 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 experimentation to remove COD and TDS present in a dairy industry wastewater. In this study, rapid mixing at the rotational speed of 100 rpm and slow mixing at the rotational speed of 20 rpm was maintained 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 for impurities with Whatman filter paper and then the cleared wastewater was taken for analyzing COD and TDS as per standard procedure (APPA, 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

Effect of Rapid Mixing Contact Time: Fig.1 indicates the effect of rapid mixing contact time for removing 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 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.

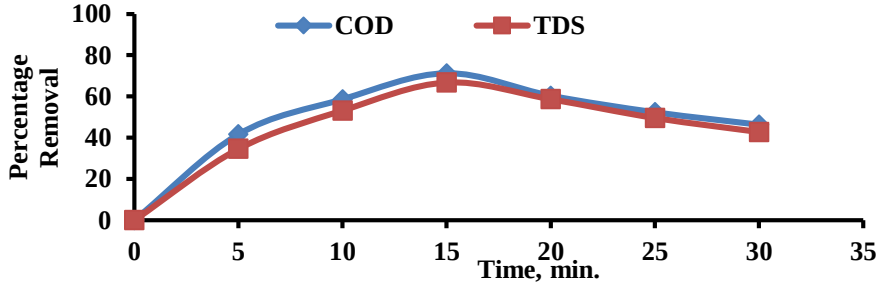

Fig.1. Effect of Rapid Mixing Contact Time by *Eucalyptus* wood saw dust activated carbon

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.

Effect of Slow Mixing Contact Time: Fig.2 shows the effect of slow mixing contact time for removing 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.

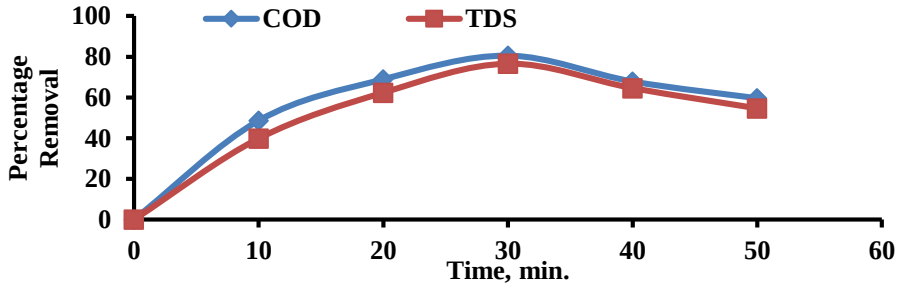

Fig.2. Effect of Slow Mixing Contact Time by *Eucalyptus* wood saw dust activated carbon

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). The maximum removal of COD and TDS in a dairy industry wastewater was found to be 6947.20 mg/l and 2424.81 mg/l respectively at an optimum slow mixing contact time of 30 min. and an optimum slow mixing contact time of 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.

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 for removing COD and TDS in a dairy industry wastewater against an optimum rapid mixing contact time of 15 min. and slow mixing contact time of 30 min. against different adsorbent dosage of 20, 40, 60, 80, 100, 120 and 140 g/l.

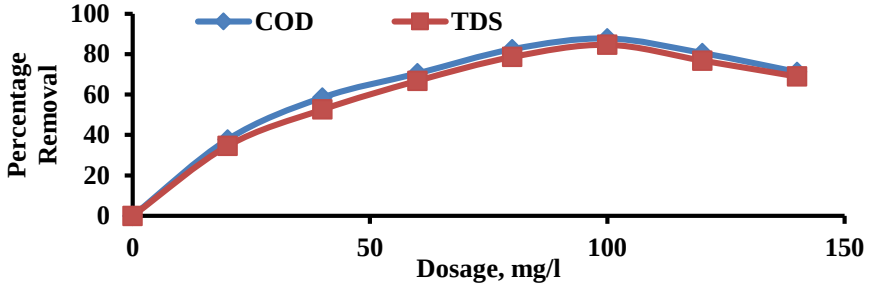

Fig.3. Effect of Adsorbent Dosage by *Eucalyptus* wood saw dust activated carbon

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.

Model Development: First order kinetic model is used in this study for fitting the experimental data. The first order model is given by

$$-\frac{dC}{dt} = k_1 C \qquad (2)$$

on integration the Eqn.2 becomes

$$\ln\left(\frac{C}{C_0}\right) = -k_1 t \qquad (3)$$

where C_0 is the initial concentration of COD and TDS in mg/l, C is the concentration of COD and TDS in mg/l at time 't', 't' is degradation time, days and 'k_1' is the first order rate constant, $days^{-1}$. The negative sign indicates as time increases the rate constant decreases.

The first order rate constant was calculated from the slope of the straight line by least square fit (Fig.4). The rate constant k_1 and R^2 values for the parameters COD and TDS in a diary indsutry wastewater (Fig.4) at an optimum rapid mixing contact time of 15 min., an optimum slow mixing contact time of 30 min. and an optimum adsorbent dosage of 100 g/l are presented in Table 1.

Table.1.The kinetic parameter and the regression equation for the parameters COD and TDS in a dairy industry effluent at optimum values of various parameters

Parameters	k_1	R^2
COD, mg/l	0.0454	0.9822
TDS, mg/l	0.0512	0.9943

From the Table 1, it may be observed that the R^2 value for COD and TDS respectively was 0.9822 and 0.9943. This R^2 value indicates that the ability of the first order kinetic model in describing the kinetics of the present work. In other words, the model is fitted well with the experimental data for both COD and TDS parameters. Thus, the kinetic study indicated that the reduction of COD and TDS in a dairy industry wastewater follows the first order kinetic model.

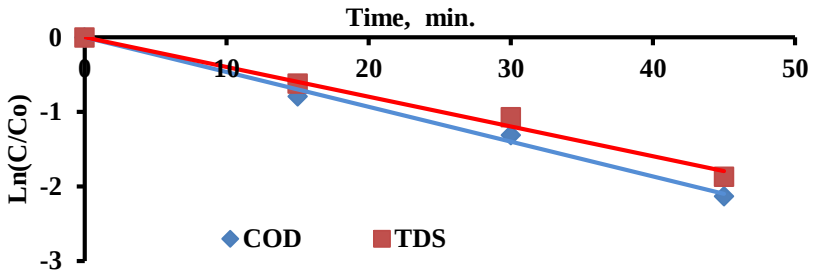

Fig.4. First order Kinetic Model for the parameters COD and TDS in a dairy industry effluent at optimum values of various parameters

4. CONCLUSION

The suitability of *Eucalyptus* wood saw dust activated carbon powder as an adsorbent for removing COD and TDS present in a dairy industry wastewater was studies in this study. The experiments were conducted for removing COD and TDS with different dosages, rapid mixing contact time and 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 first order kinetic 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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