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Orange Peel Activated Carbon Powder for Treating Dairy Industry Wastewater

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ABSTRACT

The effectiveness of orange peel 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 orange peel 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 120 g/l, an optimum rapid mixing contact time of 20 min. and an optimum slow mixing contact time of 40 min. The results showed that the percentage reduction in concentration of COD and TDS in a dairy industry wastewater by using orange peel activated carbon powder as an adsorbent is about 92.3 % and 88.8 % respectively. Also, the experimental values of dairy industry wastewater were validated with model and the model study concluded that the developed model is having reproducing capacity of the experimental data obtained from the dairy industry wastewater. Thus, the results of the present study concluded that the use of orange peel activated carbon powder is effective as an adsorbent to remove COD and TDS present in a dairy industry wastewater.

KEY WORDS: Orange peel activated carbon powder, COD, TDS, Process Parameters

1. INTRODUCTION

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. Wastewater management in the dairy industry is well documented, but wastewater production and disposal remain a problematic issue (Sivakumar, 2013c). In recent years, increasing awareness of water pollution and its far reaching effects has prompted concerted efforts towards pollution abatement (Sivakumar, 2011). Earlier works revealed the suitability of variety of agro-based materials like *moringa oleifera* seed (Sivakumar, 2013b; Sivakumar, et al., 2014i), corncob, groundnut husk, rice husk (Sivakumar and Nouri, 2015; Sivakumar, 2014f), coconut coir pith (Shankar, 2014a), tamarind kernel (Shanthi, and Mahalakshmi, 2012; Sivakumar, 2014c), tea leaves carbon, saw dust and other biomaterials to treat the industrial wastewater (Sivakumar, 2012). The bioremediation studies (Shankar, 2014b; Sivakumar, 2014d; Sivakumar, 2014e; Sivakumar, 2014g) and constructed wetland studies (Sivakumar, 2013a; Sivakumar, 2014h; Sivakumar, 2015) also done by several researchers to mitigate the industrial contaminants. The present study focused to determine an effect of orange peel 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. METHODS AND MATERIALS

2.1. Adsorbent Preparation: The study area selected for the study is west Irumbuliyur village. It is located at Tambaram Taluk of the Kancheepuram district in Tamil Nadu at 12° 55' 4" N latitude, 80° 6' 33" E longitude. Figure 1 depicts the location of Irumbuliyur. The WDS of Irumbuliyur village is located at West Tambaram, under ward number 28 and 29 is taken up as study area. The total village extent is 244.48 ha with 1500 households. The total population of this village as per 2011 census is 5900.

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 7895 mg/l and 3055 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, slow mixing at the rotational speed of 20 rpm for enhancing flocculation process and sedimentation 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 orange peel activated carbon powder 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 60 min. at an interval of 10 min.). Clear wastewater from each beaker after settlement of 60 min. was collected and filtered further 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 orange peel 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 orange peel activated carbon powder and C_2 is the concentration of COD in mg/l and TDS in mg/l after treatment with orange peel activated carbon powder.

3. RESULTS AND DISCUSSION

3.1 Effect of Rapid Mixing Contact Time: Fig. 1 shows effect of rapid mixing contact time on removal of COD and TDS in a dairy industry wastewater with orange peel activated carbon powder as an adsorbent of 20 mg/l and a slow mixing contact time of 15 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 20 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 36.4, 49.6, 65.3, 79.2, 66.3 and 60.1 % 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 32.5, 45.3, 59.2, 75.3, 68.9 and 62.6 % respectively. Thus, an optimum rapid mixing contact time leading to maximum COD and TDS removal is 20 min. (Fig. 1). Further, an optimum rapid mixing contact time at which maximum removal of COD and TDS in a dairy industry wastewater was 7384.07 mg/l and 2656.91 mg/l respectively and an optimum rapid mixing contact time, which is corresponding to the lowest residual COD and TDS obtained for a dairy industry wastewater was 1152.42 mg/l and 559.68 mg/l respectively.

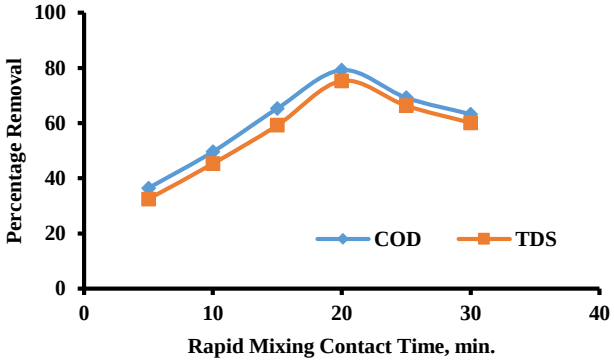

Fig. 1 Effect of rapid mixing contact time by orange peel activated carbon powder

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 an orange peel activated carbon powder as an adsorbent of 20 mg/l and an optimum rapid mixing contact time of 20 min. It can be observed from Fig. 2 that up to 40 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, 50, and 60 min. were found to be 43.1, 56.2, 69.2, 83.4, 76.3 and 70.1 % respectively.

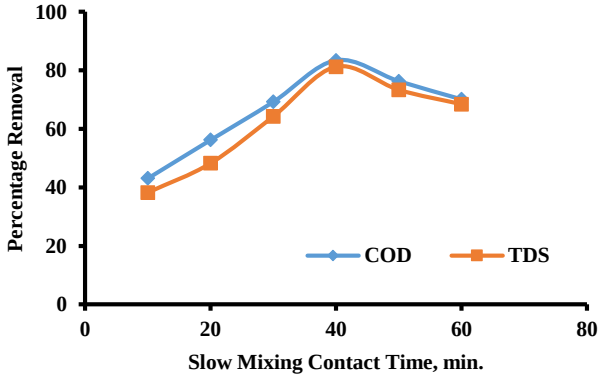

Fig. 2 Effect of slow mixing contact time by orange peel activated carbon powder

Similarly, the percentage reduction in concentration of TDS for a slow mixing contact time of 10, 20, 30, 40, 50, and 60 min. were found to be 38.2, 48.2, 64.2, 81.2, 73.3 and 68.4 % respectively. Thus an optimum slow mixing contact time for which the maximum COD and TDS removal occurs is 40 min. (Fig. 2). Further, an optimum slow mixing contact time at which maximum removal of COD and TDS in a dairy industry wastewater was 7546.26 mg/l and 2718.02 mg/l respectively and an optimum slow mixing contact time, which is corresponding to the lowest residual COD and TDS obtained for a dairy industry wastewater was 990.23 mg/l and 498.57 mg/l respectively.

3.3 Effect of Orange peel activated carbon powder Dosage: Fig. 3 shows the effect of orange peel activated carbon powder as an adsorbent on removal of COD and TDS in a dairy industry wastewater with a rapid mixing contact time of 20 min. and a slow mixing contact time of 40 min. against the different adsorbent dosage of 20, 40, 60, 80, 100, 120 and 140 g/l. From Fig.3, it may be observed that up to 120 g/l of orange peel activated carbon powder dosage, the 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 orange peel powder dosage of 20, 40, 60, 80, 100, 120, 140 g/l, respectively were found to be 49.1, 62.3, 74.2, 83.2, 88.2, 92.3 and 84.2 %.

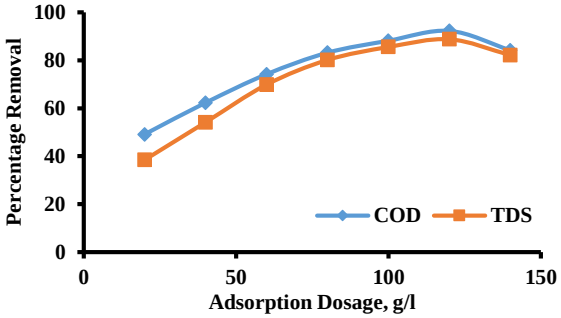

Fig. 3 Effect of adsorbent dosage by orange peel activated carbon powder

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 38.5, 54.2, 69.9, 80.2, 85.6, 88.8 and 82.2 %. Thus, an optimum dosage for which 120 g/l (Fig. 3). Further, an optimum dosage at which maximum removal of COD and TDS in a diary industry wastewater was 7879.19 mg/l and 2782.35 mg/l respectively and an optimum dosage, which is corresponding to the lowest residual COD and TDS obtained for a dairy industry wastewater were 657.31 mg/l and 434.24 mg/l respectively.

3.4 Model Development: In this study, the experimental data are fitted with second 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. A quadratic (second-order) polynomial model for two explanatory variables has the form of the equation below. The single x-terms are called the main effects. The squared terms are called the quadratic effects and are used to model curvature in the response surface. The cross-product terms are used to model interactions between the explanatory variables. 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 orange peel activated carbon powder is

$$y = -0.0076x^2 + 1.5887x + 8.3625 \text{ (COD)} \quad (3)$$

$$y = -0.007x^2 + 1.5277x + 4.15 \text{ (TDS)} \quad (4)$$

The second order polynomial regression model data by orange peel activated carbon powder in treating the dairy industry wastewater is represented in Fig. 4.

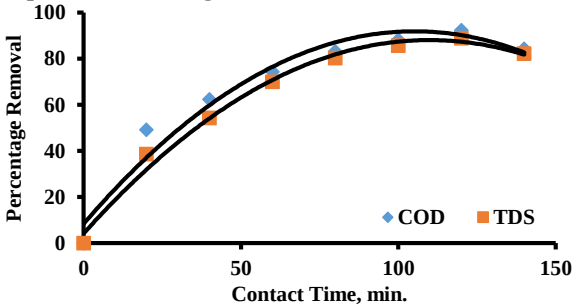

Fig. 4 The second order polynomial regression model data by orange peel activated carbon powder

The R^2 values obtained from the Fig. 4 is 0.9603, and 0.9894, respectively for the parameters COD and TDS in a dairy industry wastewater by orange peel 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 various parameters in a dairy industry wastewater follows the second order polynomial regression model.

4. CONCLUSIONS

In the present study, experiments have been conducted to find out the suitability of orange peel 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 for COD (92.3 %) and TDS (88.8 %) was obtained at an optimum dosage of 120 g/l (orange peel activated carbon powder), an optimum rapid mixing contact time of 20 min. and an optimum slow mixing contact time of 40 min. The results indicated that the orange peel activated carbon powder is more beneficial in treating a dairy industry wastewater as adsorbent. Also, the experimental values of dairy industry wastewater were validated with 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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