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Analysis of Dairy Waste Water Treatment Using Electrocoagulation Process

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Abstract: ***The electrocoagulation process was conducted to know the removal efficiencies of COD for dairy wastewater. Different volumes of wastewater were taken and effects of initial pH, electrolysis time, voltage were examined in batch studies. The results obtained by the experiments were used to prepare a MATLAB program to predict the efficiency of COD removal, optimum voltage required and required electrolysis time interval. The prediction program provides information on the best working conditions that can be applied for the treatment of dairy wastewater by using the electrocoagulation process.***

Keywords: Electrocoagulation, COD, pH, MATLAB

1. Introduction

Dairy industry is one of the agro based industry found all over the world. Each section of industry produces wastewater of a characteristic composition, which depends on the kind of product that is produced from milk.

Large quantity of wastewater originates due to their different operations. The organic substances in the wastes comes either in the form in which they were present in milk, or in a degraded from due to their processing. As such, the dairy wastewater, though biodegradable, are very strong in nature. The other techniques used to treat the diary wastewaters are conventional aerobic purification and anaerobic processes. However, others techniques have also been used, e. g. coagulation flocculation, Nano Filtration (NF), reverse osmosis (RO) and use of membrane bioreactors. Biological processes require big spaces and long - time of treatment and generate great amount of sludge. The physico - chemical processes suffer the disadvantage that reagent costs are high and the soluble COD removal is low. Besides, chemical treatments could induce a secondary pollution due to the fact that chemical additives may contaminate the treated water. Among physico - chemical methods, electrocoagulation technique is one of the processes which offer high removal efficiencies in compact reactors, with simple equipment for control and relatively moderate operating cost.

Electrocoagulation (EC) process can be other alternative process for treating dairy waste effluents. This technology has been very successfully employed in removing oil/grease and suspended solids from a variety of industrial effluents and is a combined coagulation and flotation process induced by the passage of electric current. It was tested successfully to treat drinking water and other industrial wastewaters.

1.1 Electrochemical reactor

The EC unit consists of two electrodes in a cell and a DC power supply. The iron cathode and aluminum anode are separated by a space of 1 cm and dipped in the wastewater. The EC of dairy wastewater was carried out in the reactor for different volumes using magnetic stirrer to agitate the solutions. The experiment was carried out for 1L, 2L, 3L and 5L. The total area of electrodes plates was submerged. A stirring intensity of 100 rpm was used in order to get correct homogenization of the wastewater–flocs mixture. EC experiments were carried out at 298 K.

2. Wastewater samples and experimental procedure

The synthetic dairy wastewater (SDW) was prepared in the laboratory using dry milk powder. The used milk powder was composed of proteins (12.5 g/100 g powder), carbohydrates (54 g/100 g), fat (28 g/100 g), and inorganic matters (3 g/100 g, including Na 175 mg, K 480 mg, Ca 340 mg, Cl 300 mg, P 190 mg, Mg 41 mg, Fe 6 mg, Zn 3.8 mg, Cu 400 µg, Mn 30 µg,). The actual COD values have been verified each time before initiation of experimental work. The composition of the wastewater is shown in Table 1. The pH was adjusted to a desirable value using HCl and NaOH solutions. The conductivity of the wastewater was adjusted to the desired levels by adding an appropriate amount of boric acid (H_3BO_3).

Table 1: Characteristics of Dairy wastewater

Parameter	Value
pH	6.0
Conductivity	0.4ms/cm
Color	whitish
COD	1100mg/l
Turbidity	125 NTU

The electrolyte boric acid of 5g/L was used to increase conductivity. At the beginning of a run, the wastewater was fed into the reactor and the pH and conductivity were adjusted to a desired value. The electrodes Iron as cathode and Aluminum as anode were placed into the reactor. The reaction was timed starting when the DC power supply was switched on. Initially 1L of wastewater was taken and trials were carried out for different pH 6.0, 7.0, 8.0 with different voltages 3V, 5V, 7V and 9V. At pH 7.0 and voltage 5V the maximum removal was found at 88.90%. For second set of experiment for 2L wastewater pH 7.0 was maintained and trials carried out for voltages 4V, 6V, 8V and 10V. The maximum removal efficiency was found at 8V (88.54%). For third set of experiment with 5L wastewater at pH 7.0, trials were carried out for voltages 7V, 9V, 11V and 13V. The maximum removal efficiency was found at 11V

(88.18%). The electrodes were rinsed in the diluted 15 - 20% HCl solution and detergent wash after each experiment. Samples were periodically taken from the reactor. The particulates of colloidal ferric oxyhydroxides gave yellow - brown colour into the solution after EC. Sludge generating during treatment was separated from the solution by filtration using Whatman filter paper and then the solution was analyzed. COD analysis was carried out according to the standard methods for examination of water and wastewater.

3. Statistical modeling using MATLAB software

The data obtained from each set of experiment was used to prepare MATLAB program. A MATLAB code was written for developing a model which predicts the maximum removal efficiency of COD, optimum voltage and electrolysis duration given the volume of wastewater to be treated. The quantity of wastewater (Q) is the input variable and output variables are voltage (V), electrolysis duration (t) and final COD.

4. Results and Discussions

The results obtained from different sets of experiments are given in table 2. After completion of first set of experiment with 1L of wastewater it was found that the removal efficiency was maximum at pH 7.0. Hence next two sets of experiment were conducted for the same pH. The graphical comparisons of predicted and experimental values of COD removal efficiency are shown in figure 1.

Table 2: Characteristics of Dairy wastewater

Working volume=1L		Working volume=2L		Working volume=5L	
Voltage=5V		Voltage=8V		Voltage=11V	
Time (min)	COD (mg/L)	Time (min)	COD (mg/L)	Time (min)	COD (mg/L)
0	1100	0	1100	0	1100
2	900	5	973	10	942
4	704	10	798	20	781
6	500	15	521	30	602
8	284	20	323	40	390
10	122	30	126	60	130

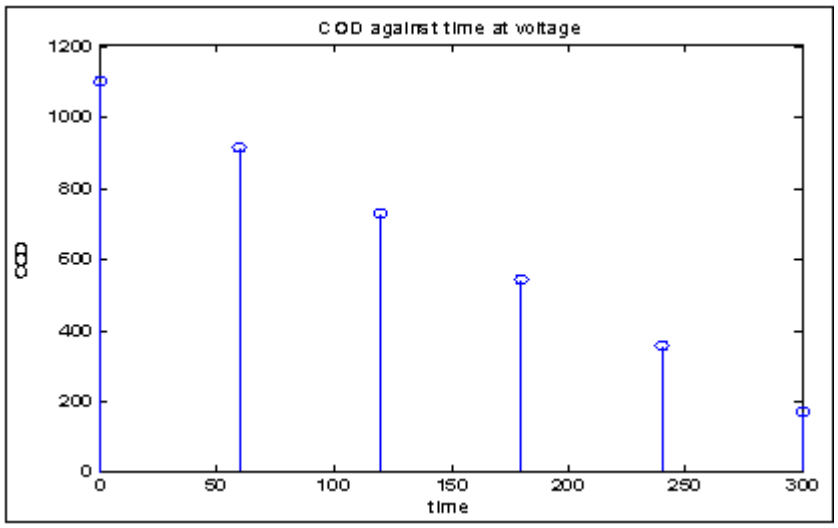

Figure 1: COD removal efficiency

The values of COD removal efficiency from the experiment and the values predicted by the MATLAB algorithm are given in table 3.

Table 3: Predicted and Experimental values of the COD removal efficiency

S. No	Quantity of water in litres	Experimental values of COD removal, %	Predicted Results of COD removal, %
1	5	88.29	88.32
2	6	87.9	88.00
3	7	87.6	87.81
4	8	87.5	87.63
5	9	87.38	87.45
6	10	87.09	87.27

4.1 Correlation Coefficient

Correlation coefficient is used to measure the strength of a linear association between experimental values of COD removal (%) and predicted results of COD removal (%). The value of correlation coefficient (r) is 0.9904. This is a strong positive correlation, which means that high experimental values of COD removal values scores go with high predicted Results of COD removal values scores (and vice versa). The value of r^2, the coefficient of determination, is 0.9809.

The linear regression relationship between experimental and predicted values through an equation of a straight line is calculated and shown in figure 2.

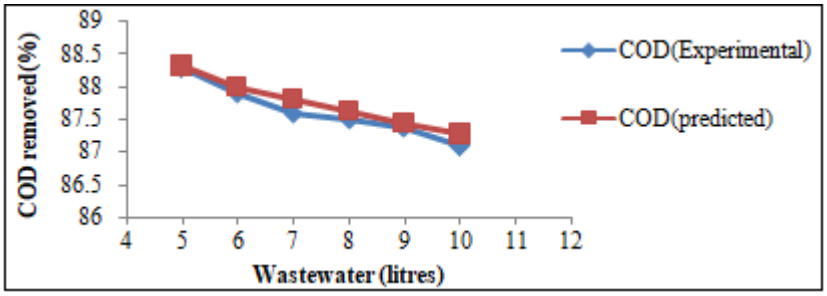

Figure 2: Comparison of predicted and experimental COD removal efficiency values

5. Conclusion

Electrocoagulation process can be efficiently utilized for the dairy wastewater treatments. It is a simple method using minimum electricity and an economic method applicable to industries for the treatment of wastewater. Algorithm is developed using MATLAB was efficiently used to predict the resulting COD values. When the number of wastewater is given, the given algorithm can predict the best voltage, time interval for efficient removal of COD.

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