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ELECTROCOAGULATION PROCESS FOR TREATMENT OF DAIRY WASTEWATER

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Abstract

The study focused on treatment of dairy wastewater with help of Electrocoagulation. The batch experiments were conducted in an electrocoagulation (EC) reactor of 1500ml capacity, using aluminum electrodes as anode and cathode in a parallel connection. The process performance was analyzed in terms turbidity and other parameters as a function of pH, cell voltage and electrolysis time (ET). The maximum Turbidity removal efficiencies of 84.7% (60 min) were obtained with optimum operating conditions: cell voltage, 30 V. The study proved that EC process is an efficient method to remove the pollutants from the dairy wastewater.

Keywords: Electrocoagulation, aluminium electrodes, Turbidity and dairy industry wastewater.

1 INTRODUCTION

Water use in food processing generates large amounts of wastewater, which need to be treated before its release in receiving water bodies. Among the food industries, the contribution of dairy pollution of water bodies is very significant, since the processing of milk causes considerable pollution load, due to the presence of large amounts of organic matter in wastewater [1]. Most of the wastewater generated in the dairy industry results from cleaning of transport lines and equipment between production cycles, cleaning of tank trucks, washing of milk silos [2]. The dairy plant includes conversion of fresh milk into different products viz, milk for consumption, Yogurt, Cheese, Butter and Ice cream .Utilizing the techniques namely chilling, pasteurization and homogenization. The efforts are made by public and private sector by improving cattle genetics, qualitative and quantitative fodder availability are increasing milk productions capacity in manifold. Gujarat, Karnataka, UP, Haryana, Punjab, Maharashtra, Rajasthan, Andrapradesh and Tamil Nadu state is a milk excess state accounting for 79% of milk produced [3]. The Dairy Industry is one of the most widely spread of all the industries. These vary from small receiving stations to large plants where most of the products made from milk are manufactured. Wastes from milk product manufacture contain milk solids in a more or less dilute condition, but in varying concentration [4]. The review of literature on the electrocoagulation process are, treatment of sugar wastewater [5], textile wastewater [6], fluoride water [7], sewage water [8], marble processing water [9] etc.

Electro coagulation (EC) has been suggested as an advanced technique in pollutant removal from raw waters and wastewaters. In this technology, metal cations are released into water through dissolving metal electrodes. During EC, coagulants are obtained in situ by the dissolution of the anode [10]. Response-surface methodology comprises a body of methods for exploring for optimum operating conditions through experimental methods. Typically, this involves doing several experiments, using the results of one experiment to provide direction for what to do next. This next action could be to focus the experiment around a different set of conditions, or to collect more data in the current experimental region in order to fit a higher order model or confirm what we seem to have found [11].

2 MATERIALS AND METHODS

The average characteristics are given in the Table I.

Sl.No	Characteristics	Value
1	pH	12
2	BOD (mg/L)	967.68
3	COD (mg/L)	3000
4	Conductivity (µS/cm)	786
5	Color	Whitish
6	Turbidity (NTU)	255
7	Total Fixed Solids (mg/L)	584
8	Nitrogen	18.85
9	Phosphorous	7.86
10	Chloride (Mg/L)	380

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The batch experiments were performed in EC reactor of 1500mL capacity (1000 ML actual volume for analysis) with four aluminum electrodes in monopolar parallel connection with DC power supply. The electrodes were of size 90 mm x 90 mm x 1mm with 10 mm spacing between them. To maintain homogeneous conditions, the EC reactor was equipped with the magnetic stirrer and rotating speed 180 rpm. A schematic diagram of the experimental setup is shown in Figure. 1.

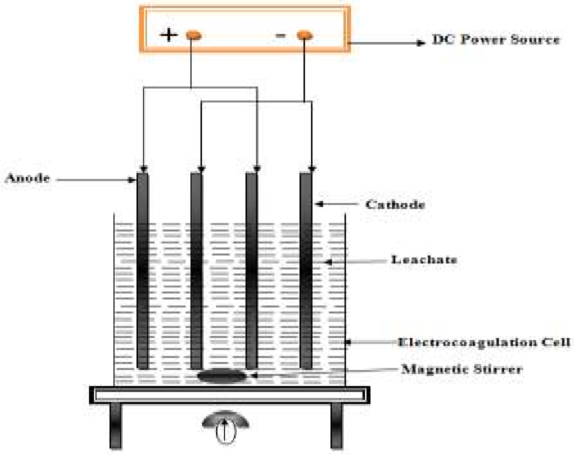

Fig.1. Schematic view of Experimental setup of EC process for dairy wastewater treatment.

The reaction time of EC process was up to 60 min and the sample were collected at different intervals for analysis. The investigation was carried out at three different voltages from 10-30V.

Fig2. Photo view of Experimental setup of EC process for dairy industry wastewater treatment.

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3 RESULTS AND DISCUSSION

The effects of initial pH, applied cell voltage and electrolysis time (ET) on the Turbidity removal efficiencies were focused.

3.1 RSM METHODOLOGY

RSM is a statistical technique was useful for the optimization of chemical reactions and/or industrial processes and commonly used for experimental design.

Table 3.1. Experimental range and levels of Time, Voltage and pH in composite design

Variable	Parameter	Level			
		-1	+1	-α	+α
X1	Time (min)	16	60	1.00056	74.9994
X2	Voltage (V)	10	30	3.18207	36.8179
X3	pH	04	08	2.63641	9.36359

Both response surface and isoresponse contour plots are of data presentation from RSM. The response and isoresponse contour plots are represented as three and two dimensional diagrams respectively. Both the plots are presented using design expert software. The parameter choosen for the study are Electrolysis Time, Voltage and pH.

A 2^3 – factorial central-composite-experimental-design was employed and experiment were conducted, leading to 20 set of experiments, were used to optimized wastewater removal. Experimental plan employed for the optimization of Time, Voltage, and pH (obtained using Expert software, Version 7.1.6, stat-Ease, U.S.A) is given in Table 3.

Table 3.2 Experimental plan employed for the optimization of Electrolysis Time, Voltage and pH

Run no.	Time (min) (X_1)	Voltage (V) (X_2)	pH (X_3)
1	16	10	04
2	60	10	04
3	16	30	04
4	60	30	04
5	16	10	08
6	60	10	08

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7	16	30	08
8	60	30	08
9	01	20	06
10	75	20	06
11	38	3.18	06
12	38	36.82	06
13	38	20	2.64
14	38	20	9.36
15	38	20	06
16	38	20	06
17	38	20	06
18	38	20	06
19	38	20	06
20	38	20	06

Where X_1, X_2 and X_3 are the coded values of the independent variables viz. time , voltage and pH respectively. The values in the parenthesis are corresponding to decoded values .

The design expert (Stat-ease Inc., U.S.A) statistical program package was used for regression analysis of the data obtained and to estimate the coefficients of the regression equation (analysis of variance, (ANOVA) table). The goodness of fit of the regression model obtained was given by the coefficient of correlation R and by the coefficient of determination R^2.The statistical signification of the model was determined by the application of Fischer's Test.

Table 3.3 Experimental data obtained for turbidity removal

Run	Time (min)	Voltage	pH	% of Turbidity Removal
1	16	10	04	35
2	60	10	04	58
3	16	30	04	65
4	60	30	04	84.7
5	16	10	08	43.8
6	60	10	08	85.8
7	16	30	08	65
8	60	30	08	89

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9	1	20	06	19
10	75	20	06	68
11	38	3.18	06	67.3
12	38	36.82	06	82
13	38	20	2.64	85
14	38	20	9.36	51.8
15	38	20	06	75
16	38	20	06	68
17	38	20	06	67
18	38	20	06	67
19	38	20	06	68
20	38	20	06	67

The application of RSM offers in the basics of parameters estimate an empirical relationship between the response variable and test variable under consideration. Multiple regression analysis of experimental data (using design expert software) gives the fallowing second order polynomial equation in terms of turbidity removal.

% of Turbidity Removal = +8.36975 + 1.74567*Time + 1.26241*Voltage - 1.27248*pH - 0.012102*time*Voltage + 0.066193*Time*pH - 0.20187*Voltage*pH - 0.016641*Time^2 + 0.029590*Voltage^2 + 0.18732*pH^2

3.2 Effect of different voltage, pH and time on turbidity removal

During the EC process focused parameters are COD, Color and turbidity. In this study we focused on turbidity removal only. The experiments were carried out using design expert software for parameters optimization to know the different time, voltage and pH for Turbidity removal. The Turbidity were measured at different parameters pH range 4 to 8, Time 16 to 60 min, and Voltage 10 to 30V respectively. For these experimental conditions turbidity removals were evaluated and results are shown in the Fig. 3 & 4.

From the results it was observed that at pH 4, voltage 30V and time 60 min the maximum Turbidity reduced from 255 to 39.015 NTU during this process. The experiment was carried out at pH 8 at 10V the maximum turbidity reduced was 255 to 38.25 NTU at 60 min of operation.

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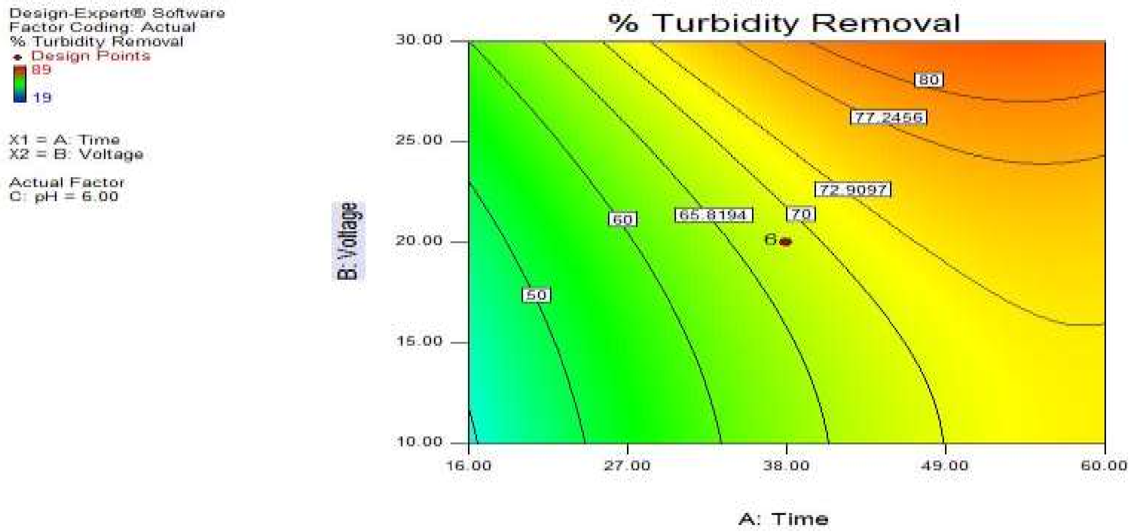

Fig. 3 Isoresponse contour plots showing the effect of voltage and time and their % of Turbidity removal.

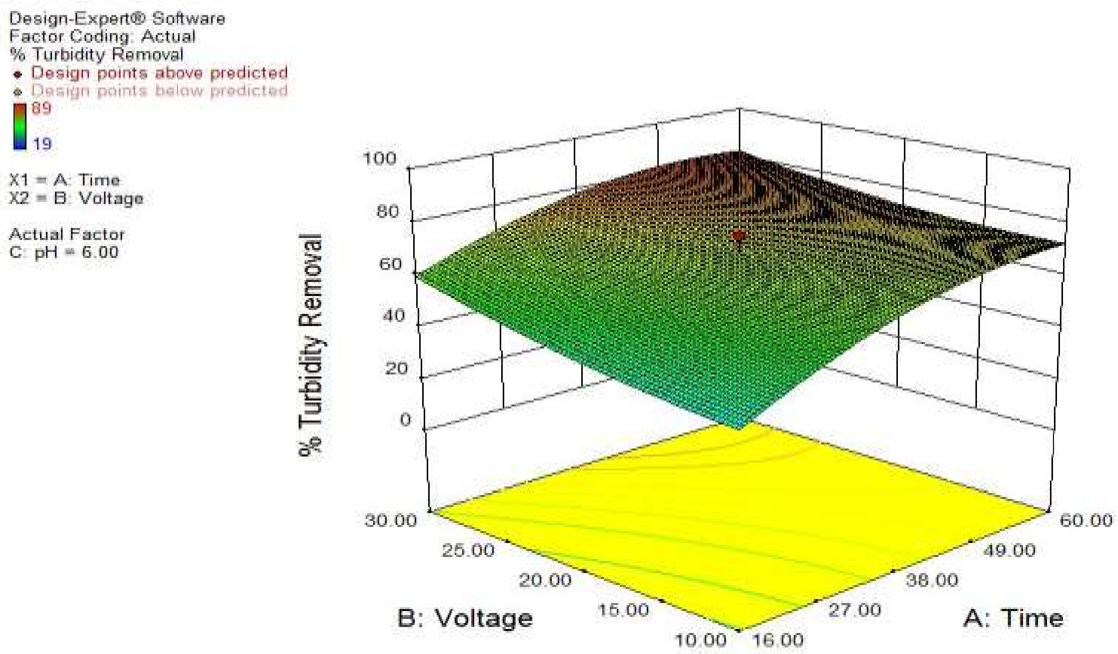

Fig. 4 Response surface plots showing the effect of voltage and time and their % of Turbidity removal.

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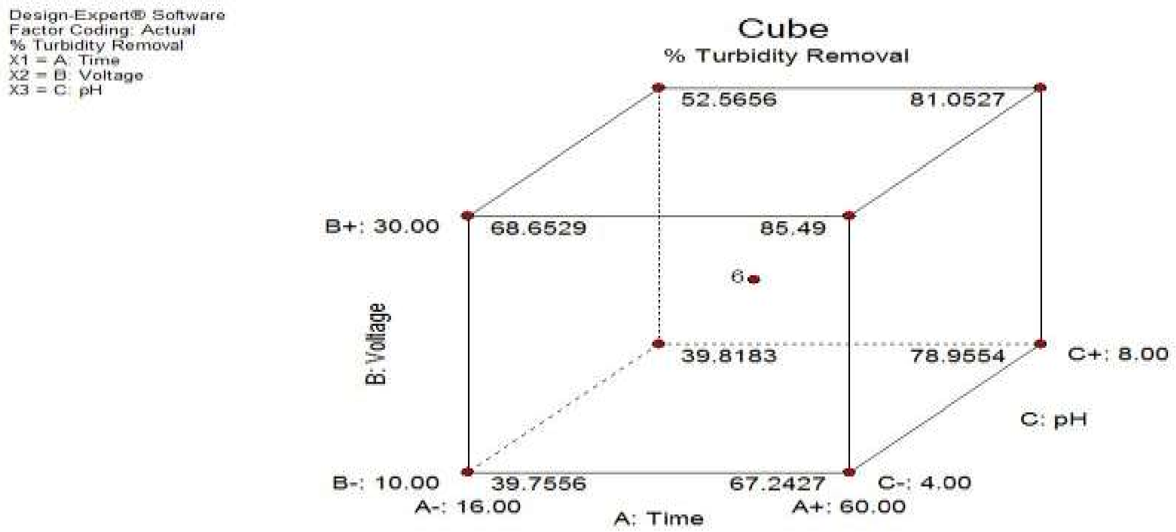

Fig. 5 Representation of experimental ranges and predicted results of Turbidity removal in %.

3.3 Comparision of experimental and predicted design values

In order to confirm the accuracy of the predicted models, an electrocoagulation was carried out as per the obtained optimum conditions as given by the software. There is very good agreement between experimental optimum data and predicted data of turbidity are shown in the fig. 6.

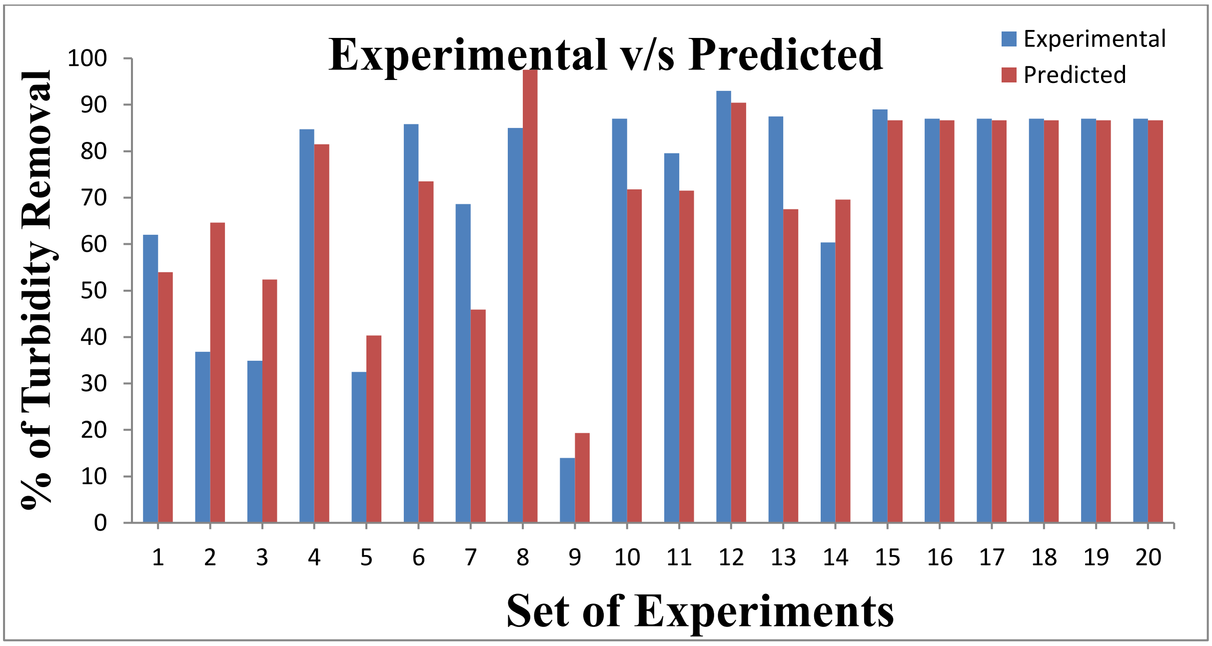

Fig. 6 Representation of Experimental v/s Predicted results of Turbidity removal in %.

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4 CONCLUSIONS

A lab-scale EC unit with aluminum electrodes in monopolar parallel connection was used to study its performance for the treatment of dairy wastewater. The maximum turbidity removals were obtained at the optimum operating parameters. From the results it was observed that at pH 4, voltage 10V and time 60 min the maximum turbidity removal is 84.7% during process. The results showed that at pH 4, voltage 30V and time 60 min the maximum turbidity removal 84.7% during process. The experiment was carried out in acidic i.e. pH 6 at 36.82V the maximum turbidity removal is 82% at 38 min of operation. The experiment was also carried out at pH 8 at 30V the maximum turbidity removal is 83% at 60 min of operation.

Hence from the study it can be concluded that the obtained % removal not much differ in turbidity removal but obliviously it must effect on other parameters of electrocoagulation process with aluminum electrodes. At this stage we seen the wastewater almost clear asearlier and EC process proved to efficient in removal of turbidity from wastewater.

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