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Available online at: www.jrrset.com
ISSN (Print) : 2347-6729
ISSN (Online) : 2348-3105
JIR IF : 2.54
SJIF IF : 4.334
Cosmos: 5.395
Volume 5, Issue 7 - January 2017 - Pages 144-153

TREATMENT OF DAIRY WASTEWATER BY ELECTROCOAGULATION TECHNOLOGY

[1]Chandrakant S. Watawati1, [2]C.B. Shivayogimath, Charles Ruskin[1]
Kumar.S[1]Assistant Department of Civil Engineering, Rural Engineering College, Hulkoti, Gadag, Karnataka, India, cswatawati@gmail.com
[2]Principal, Basaveshwar Engineering College, Bagalkot, Karnataka, India

Abstract

The study focused on electrocoagulation process for the treatment of dairy wastewater. The batch study were conducted in an electrocoagulation (EC) reactor of 1 litre volume, using aluminum electrodes as anode and cathode. The process performance was analyzed in terms color and other parameters as a function of pH, cell voltage and electrolysis time (ET). The maximum Color removal efficiencies of 87% (60 min) were obtained with optimum operating conditions: cell voltage, 30 V.

Keywords: Electrocoagulation, aluminium electrodes, Colr and dairy wastewater.

1 INTRODUCTION

Milk and milk products such as curd, butter, yogurt etc are the basic and primary needs of nutrition in our day today life. India has emerged as highest milk producer in all over the world. The present level of annual milk production estimated as 94.5 million tons. The increased production of milk has improved per capita milk availability to 250 gm/ day. The demand of milk and milk products in India is projected to increase up to 191.3 million tons in 2020. Milk production plays important role in Indian Economy and hence dairy industries are expected to increase further in coming decades.

The present problem with dairy industry is that it generates significant quantity of wastewater which contains large quantity of fat, casein and inorganic salts. These contribute high BOD, COD, oil and grease which are more than discharge limits as per CPCB standards. When discharged on land wastewater will affect the soil quality and soil structure and part of

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wastewater can also leach to underlying groundwater and affects its quality. The problem is more serious, when it concerns wastewater discharge without treatment from dairy or milk processing industry. Dairy wastewater are generally treated using biological methods such as activated sludge process [1]. Different types of operations in the dairy industries are bottling, pasteurization, preparation of flavoured milk, butter, paneer, ice cream, cheese, milk powder etc. thereafter it generates about 0.2 to 10 liters effluents per liter of processed milk which also release strong foul odours [2]. The Dairy Industry involves processing raw milk into products such as consumer milk, butter, cheese, yogurt, condensed milk, dried milk (milk powder) and ice-cream using processes such as pasteurization, bottling, filling in cans etc. Electrocoagulation (EC) is an electrochemical technique for treating polluted water using electricity instead of expensive chemical reagents. It has been successfully applied for treatment of soluble or colloidal pollutants in various industrial effluents including, effluent issues from food industries, tanneries, mechanical workshop (soluble oil) polymerization manufacture, and wastewater textile industries that containing heavy metals, suspensions solids, emulsified organics and many other contaminants [3].

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. These metal ions and hydroxides remove organics from wastewater by agglomeration with the colloidal particles present in the wastewater to form bigger size flocs which are ultimately removed by settling. During EC, coagulants are obtained in situ by the dissolution of the anode [4]. 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 [5].

2 MATERIALS AND METHODS

The actual dairy wastewater collected from well established industry.

The average characteristics are given in the Table I.

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Sl.No	Characteristics	Value
1	pH	10
2	BOD (mg/L)	967.68
3	COD (mg/L)	3000
4	Conductivity (µS/cm)	750
5	Color	Whitish
6	Turbidity (NTU)	240
7	Total Fixed Solids (mg/L)	584
8	Nitrogen	20
9	Oil and grease	ND

The batch experiments were performed in EC reactor of 1.5 litre capacity (1 litre 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. A schematic diagram of the experimental setup is shown in Figure. 1.

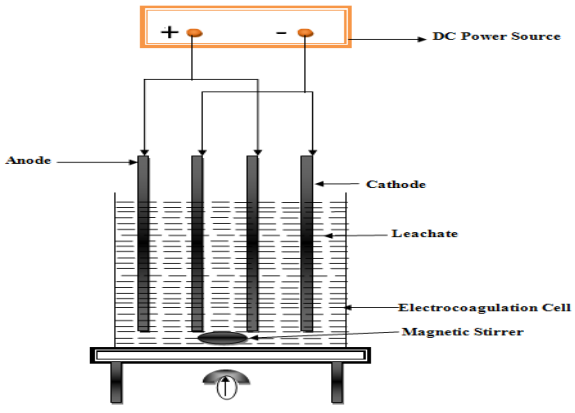

Figure 1. Schematic view of Experimental setup of EC process for dairy wastewater treatment.

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.

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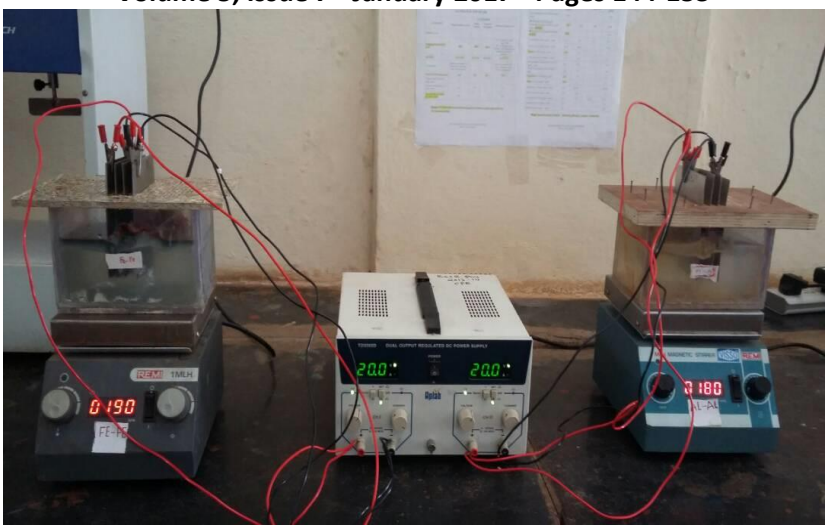

Figure 2. Photo view of Experimental setup of EC process for dairy wastewater treatment.

3 RESULTS AND DISCUSSION

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

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. Nowadays, RSM has been widely and effectively applied for optimization of water and wastewater treatment processes in order to obtain the maximum benefit from the process.

Table 2. Experimental range and levels of Time, Voltage and pH in composite design

Variable	Parameter	Level			
		-1	+1	-α	+α
X1	Time	16	60	1.00056	74.9994
X2	Voltage	10	30	3.18207	36.8179
X3	pH	4	8	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

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respectively. Both the plots are presented using design expert software. The parameter choosen for the study are 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 2.

Table 3 Experimental plan employed for the optimization of Time, Voltage and pH

Run no	Time (X_1)	Voltage (X_2)	pH (X_3)
1	16	10	4
2	60	10	4
3	16	30	4
4	60	30	4
5	16	10	8
6	60	10	8
7	16	30	8
8	60	30	8
9	1	20	6
10	75	20	6
11	38	3.18	6
12	38	36.82	6
13	38	20	2.64
14	38	20	9.36
15	38	20	6
16	38	20	6
17	38	20	6
18	38	20	6
19	38	20	6

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20	38	20	6

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 4 Experimental data obtained for Color removal

Run	Time	Voltage	pH	% of Color Removal
1	16	10	04	51
2	60	10	04	68
3	16	30	04	42
4	60	30	04	87
5	16	10	08	74
6	60	10	08	85
7	16	30	08	59
8	60	30	08	84
9	1	20	06	14
10	75	20	06	68
11	38	3.18	06	48
12	38	36.82	06	48
13	38	20	2.64	71
14	38	20	9.36	83
15	38	20	06	79
16	38	20	06	72
17	38	20	06	72
18	38	20	06	71
19	38	20	06	73
20	38	20	06	72

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

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of experimental data (using design expert software) give the fallowing second order polynomial equation in terms of Color removal.

% of Color Removal = +6.77468 + 1.89972*Time + 2.35954*Voltage - 4.47170*pH + 0.023864*Time*Voltage - 0.073864*Time*pH - 0.16250*Voltage*pH - 0.017176*Time^2 - 0.058382*Voltage^2 + 1.10370*pH^2

3.2 Effect of different voltage and time on Color removal

During the EC process focused parameter is Color. The experiments were carried out using design expert software for parameters optimization to know the different time, voltage and pH for Color removal. The Color was measured at different parameters pH range 4 to 8, Time 16 to 60 min, and Voltage 10 to 30V respectively. For these experimental conditions Color removals were calculated and results are shown in the Fig. 3 & 4.

The experiment was continued with color removal, the results revealed that at pH 4 with 30V the maximum color removal 84% at time 60 min EC process. As we increases time percentage of color removal also increases and was noticed in fig. 5.5 & 5.6. It was also noticed that, at this stage dairy wastewater almost colourless.

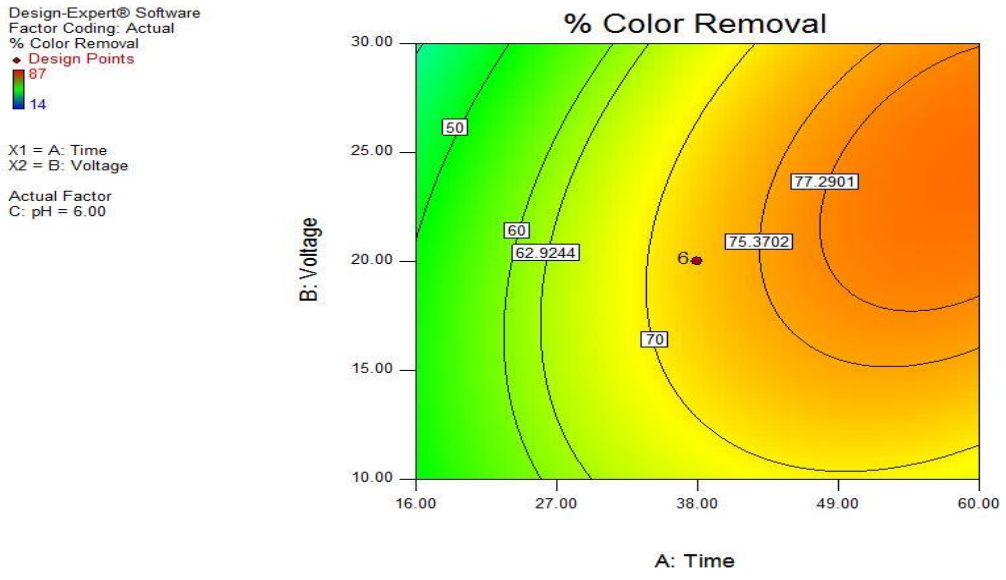

Fig. 3 Isoresponse contour plots showing the effect of voltage and time and their % of Color removal.

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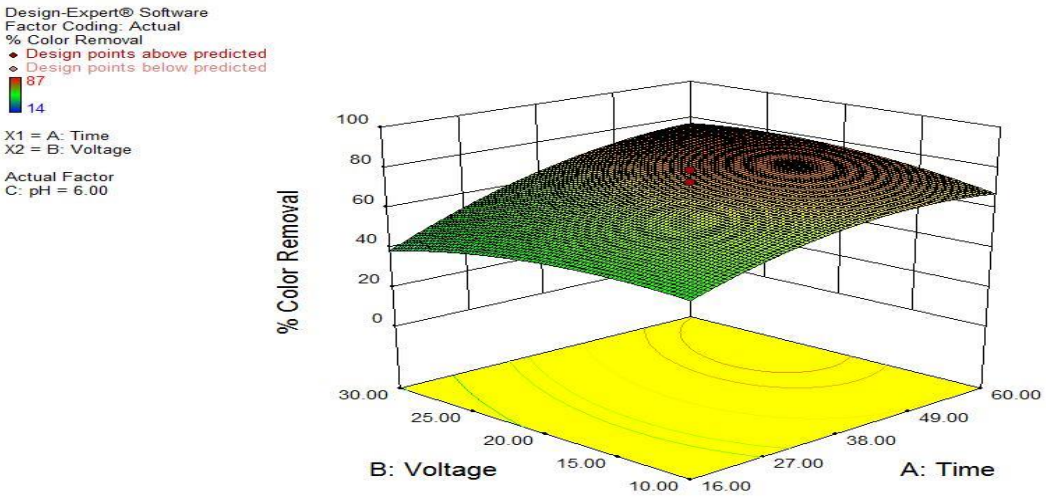

Fig. 4 Response surface plots showing the effect of voltage and time and their % of Color removal.

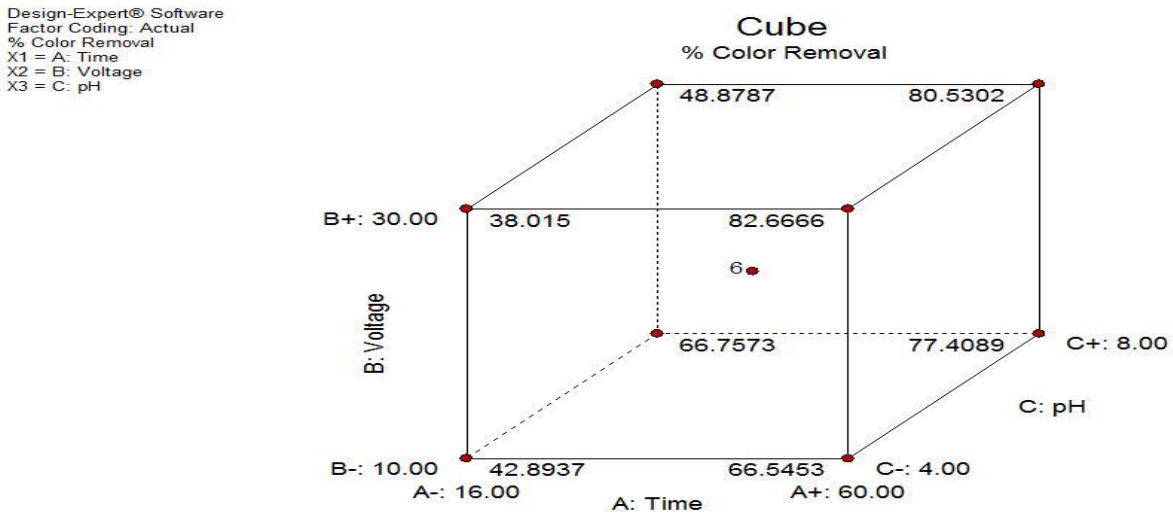

Fig. 5 Representation of experimental ranges and predicted results of Color removal in %.

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 are shown in the fig. 6.

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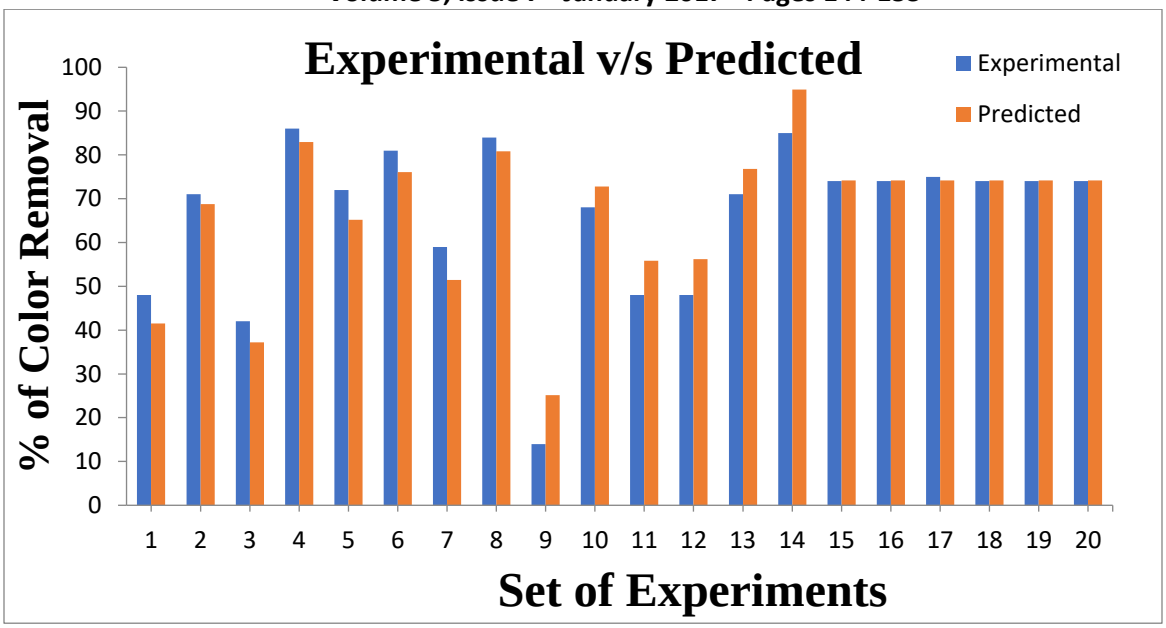

Fig. 6 Representation of Experimental v/s Predicted results of Color removal in %.

4 CONCLUSIONS

A lab-scale EC unit with aluminum electrodes was used to study its performance for the treatment of dairy wastewater. The maximum color 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 Color removal is 84% during process. Hence from the study it can be concluded that EC removes maximum color to meet the standards.

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