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Study on Waste Water from Textile Industry

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Abstract: Water pollution poses serious threats to both the environment and the organisms that depend on their environment for survival. Due to the toxicity from dyes in textile wastewater, there is a dire need for the development of innovative and efficient treatment technologies. In this study treatability studies, using a electrochemical treatment (ECT) method followed by activated carbon (AC) based adsorption. ECT method was studied extensively for the treatment of reactive black dye. Moreover, to understand the practical applicability of ECTs, the findings were optimized for treatment of synthetic textile wastewater (STW).
Keywords: Textile, Industry, Waste Water, Treatment, Optimization

I. INTRODUCTION

Industrial development has introduced a large amount of waste materials into the water bodies. This activity has been going on since a long and continuous discharge of wastewater of industries has drastically affected the ecosystem. In the race of development, countries are lenient in setting the permissible limits and permitted discharge limits of the wastewater. Among the various industries, textile industries have been growing at a higher rate and the discharge of dyes from these industries highly alters the chemical composition of the water and water becomes unsuitable for drinking purposes. Therefore, removal of toxicants from the wastewaters of the textile industries has become a crucial issue in various nations. Among the various types of industries, dye and textile industries have a huge impact on human health. These industries comparatively generate a larger amount of wastewater. Dyeing and finishing operations in this industry uses a large amount of organic compounds which are not easily degraded and are dumped into the water bodies. Among the numerous organic dyes, azo dyes and its pigments are most used as they are easily bound to synthetic as well as natural textile fibers. For an instance, the major problem with these azo dyes is their complex chemical structure due to which they are not easily degraded by microorganisms and they get accumulated in different food chains (Pagga and Brown, 1986). Therefore, they finally enter into bodies of living beings and affect their body. These complex compounds if enter in human body could cause carcinogenic effects. Moreover, there are several other organic dyes such as: benzidine and other aromatic compounds, which have been reported to cause carcinogenic effects (Calrke and Anliker, 1980). In intestine of living beings these complex compounds are degraded into their monomers i.e. amines, which could cause serious health issues. Therefore, it is required to develop some new innovative technologies so as to the treat the wastewater containing dyes. Since last few decades, legislations have been made stricter for the pollution control and investments have been made, in research and development, to design some novel techniques for the treatment of effluent of textile industries. However, further research is still required to provide efficient solution for the emanating issues of treatment of effluent originating from textile industries.

II. OBJECTIVES

Broad objective of the study is to treat the effluent generated from a textile industry using a lab setup of electrochemical treatment. The other specific objectives that will be covered in this study are as follows:

A. To estimate the impacts of operational parameters such as, initial pH, density and electrolysis time on the response parameters. The response parameters chosen for this study are, COD, Dye removal and energy consumption during the treatment process.
B. In this way, central composite design of response surface methodology will be adopted to achieve maximum removal of COD and dye and simultaneously, the energy consumption of the treatment process will also be minimized.

III. EXPERIMENTAL DESIGN AND PROCEDURE

To develop a model emphasizing the relation between various factors was generated using a statistical approach. The operational parameters used for this analysis include, electric current passing through the electrodes, reaction time and initial pH of the reaction mixture.

There impacts on the response parameters were estimated. The response parameters chosen in the present study were percentage removal of COD and dye and amount of energy consumption.

The statistical approach adopted for this objective was a combination of a five-level central composite (CC) design and response surface methodology (RSM). Stat–Ease Design Expert (version 8.0.7.1) regression software was used for performing the statistical analysis. This approach is comparatively better than a time consuming and labor demanding one variable at a time (OVAT) approach. Also, this approach was used to design experiments and generate models based on linear or quadratic relations between the operating and response parameters (Banerji and Chaudhari, 2016). The relation developed between the operating and response parameters using this approach can be described using Eq. (3.1).

$$Y = c_o + c_1X_1 + c_2X_2 + c_3X_3 + c_{12}X_1X_2 + c_{13}X_1X_3 + c_{23}X_2X_3 + c_{11}X_1^2 + c_{22}X_2^2 + c_{33}X_3^2 \quad (3.1)$$

Where, $X_{1\text{-}3}$ depicts the operating parameters which were chosen as X_1 = electric current passing through the electrodes, mA/cm^2; X_2 = reaction time, min and X_3 = initial pH of the reaction mixture. Y presents the response parameters, which were designated as Y_1 = percentage removal of COD, %; Y_2 = percentage removal of dye, % and Y_3 = amount of energy consumption, KWh per litre of effluent treated; c_i = response function coefficients which were determined using Stat–Ease Design Expert (version 8.0.7.1) regression software.

Design Expert was further used to assess the adequacy of the generated models using analysis of variance (ANOVA). The various parameters calculated for the adequacy check were correlation regression coefficients, adjusted regression coefficients and goodness of fit. After all the statistical analysis, 3D plots of the results were also generated using RSM.

Coded representation of operating parameters for statistical analysis

S.No.	Operating parameters	Units	Coded values				
			-2	-1	0	+1	+2
1	Current (X_1)	mA/cm^2	14.17	17.72	21.26	24.8	28.34
2	Reaction time (X_2)	min	30	67.5	105	142.5	180
3	Initial pH (X_3)	pH	4	5.5	7	8.5	10

IV. STATISTICAL ANALYSIS

The quadratic equations presenting the relationship between the various input parameters, reduced snow albedo and enhanced snow melt were developed using BBD. The relationship between the input parameters and response parameters are described in Eq. (4.1) through Eq. (4.3).

$$Y_1 = 47.45 + 7.72X_2 - 3.18X_1^2 - 4.91X_2^2 + 5.71X_3^2 - 5.56X_1X_3 \quad (4.1)$$

Where, Y_1, X_1, X_2 and X_3, depicts the % removal of COD electric current passing through the electrodes, reaction time and initial pH of the reaction mixture, respectively. The quadratic equation, developed using CCD for % removal of dye, is mentioned in Eq. (4.2).

$$Y_2 = 88.16 - 2.91X_1 - 7.84 - 3.10X_2^2 - 3.84X_2X_3 \quad (4.2)$$

Where, Y_2 is percentage removal of dye. The quadratic equation, developed using CCD for amount of energy consumption, is mentioned in Eq. (4.3).

$$Y_3 = 0.00894 + 0.003171X_2 + 0.002659X_3 \quad (4.3)$$

Where, Y_3 is the amount of energy consumed during the treatment process and all the response function coefficients in these equations are mentioned without considering their statistical significance. In order to validate the results generated from these models/equations, the values of response parameters, predicted using these models/equations, are compared with the experimental results, as shown in Table 4.1.

Four different types of models were run to check the suitability for the experimental data. The four types of models identified were, linear, interactive, quadratic and cubic models. Among these four models, the most appropriate model was checked using sequential model sum of squares and model summary statistics. The results of this analysis are presented in Table 4.2, Table 4.3 and Table 4.4 for responses Y1, Y2 and Y3, respectively.

V. CONCLUSION

The findings of this study made it evident that electrochemical process may prove to be an prominent technology for the treatment of synthetic textile wastewater. Based on the findings of this study several conclusions were drawn, which are discussed as following:

A. RSM-based optimization of the treatment process proved that at optimum conditions of the response parameters, the values of operating parameters i.e., pH, current density and time were 6.25, 14.17 mA/cm^2 and 102 min, respectively.
B. At optimum conditions of the operating parameters, the values of response parameters i.e., % COD removal, % dye removal and consumption of energy during the treatment process, were observed to be 63.41%, 90.93% and 0.0035 KWh/per litre of the STW treated, respectively.
C. As value of pH was observed to be 6.25 at the optimum conditions, therefore, the species of aluminum hydroxide that were supposed to cause coagulation and adsorption would be $Al(OH)_3$, $Al(OH)_2^+$ and $Al(OH)^{2+}$.
D. Kinetic studies showed that EC based treatment of STW followed first order kinetics and the kinetic constants at 30°C for each response parameter i.e., % COD removal and % dye removal were 0.0205 min^{-1} and 0.0097 min^{-1}, respectively. Similarly, at 50°C the kinetic constants for % COD removal and % dye removal were 0.037 min^{-1} and 0.011 min^{-1}, respectively.
E. Amount of Al in the treated STW, sludge and scum was observed to be 25.16 mg/l, 0.50778g and 0.06006 g, respectively.

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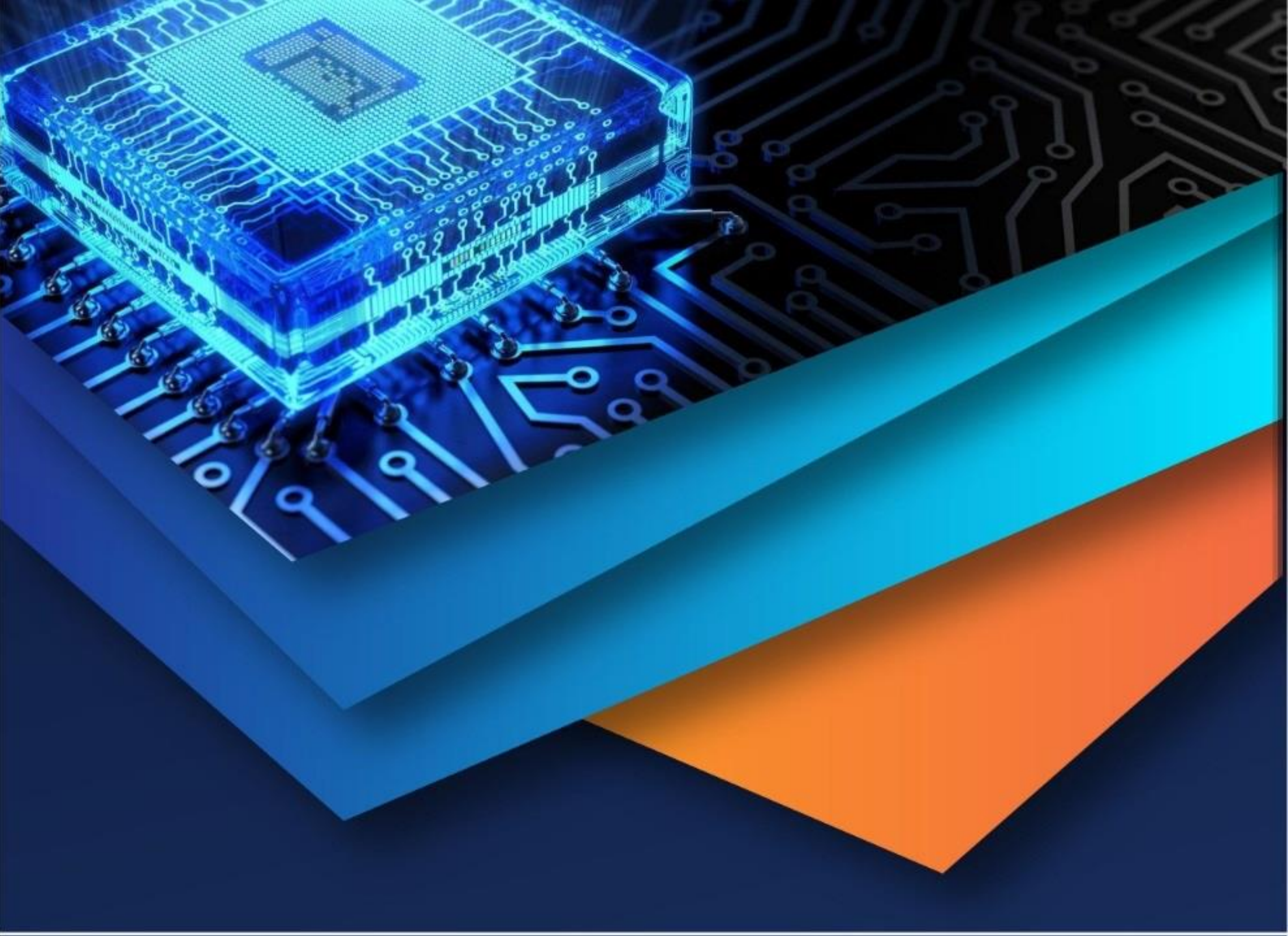

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