Electrochemical Treatment for Indigo Dye Wastewater Resulting from Blue Denim Manufacturing

Pavankumar Rajendrakumar Sharma[1] Prof. Usman Shaikh[2]
[1]M. Tech Student [2]Assistant Professor
[1]Department of Environmental Engineering
[1,2]Aadishwar College of Technology, Gandhinagar, Gujarat, India

Abstract— The textile production industry uses highly water intensive chemical operations. This industry produces massive levels of wastewater and therefore presents great environmental and economic challenges. In the past, the process of electrochemical (EC) has attracted much attention. It has been a cost-effective and an environmentally friendly process implemented to remove different types of pollutants, including dyes, heavy metals , and organic substances . This process is known for its simple equipment and process and for producing relatively low amounts of sludge. Study has been made to replace the chemical treatment of wastewater containing residual indigo dye from the blue denim manufacturing by electrochemical process with consideration to achieve desired water quality. Present study was conducted to investigate the applicability of the electro-coagulation technique for the treatment of indigo dye wastewater. In this study lab-scale electro-coagulation was carried out for the treatment of indigo dye wastewater at different operating time i.e 15min, 20min, 25min, 30min using Aluminum as Cathode and Mild steel as a Anode, with 15mm and 10 mm electrode spacing, supplying 24v and 10amp. It is observed that the batch which is operated at 10Amp for 30 min has maximum removal efficiency of COD &Color i.e. 95% & 86% respectively at optimum pH 8.3.

Keywords: Indigo Dye, Electro-Coagulation, COD Removal

I. INTRODUCTION

With presence of some of the largest and prestigious denim manufacturing mills in India, composite textile mills comprising, spinning, weaving and processing of the denim fabric, popularly also known as integrated textile mills abroad, occupy a preeminent position in the Indian Textile Sector. This is evident from the fact, that the largest denim mill in Asia and the second largest in the world is located in India.

The Environmental pollution Control issue, Legal, Social, Industrial and Economical became increasingly important and general awareness about the environmental aspects in the society, the government and the judiciary grew enormously in the last 2-3 decades. The statutory norms for compliance stipulated by various regulatory authorities, such as State Pollution Control Boards, Central Pollution Control Board, Ministry of Environment and Forests, Local Municipal Corporations and so on for discharge of waste water, gaseous emission, hazardous solid waste by the industry became increasingly stringent and their sustained compliance legally and socially mandatory.

In spite of variations in the finished products, actual operational practices followed, the raw, untreated effluent from a composite denim textile mill almost universally depicts blue color and high alkanity in terms of pH. As mentioned above, the typical blue colour of the effluent is because of the indigo blue dye, one of the wet group of dyes, most commonly used in dying of the denim at warp stage and not at woven fabric stage has poor fixation (70-85 %) on the cotton subtract. Therefore, large part of the dye comes out in the effluent imparting blue colour, and raising its Chemical Oxygen Demand (C.O.D.).

Nowadays, many treatment plants use the chemical treatment but there are also disadvantages for that process. To enhance the removal efficiency of Color and COD in conventional treatment, chemical coagulant such as alum, ferric chloride, ferric sulfate and lime are usually used resulting in color removal efficiency ranging between 60% to 80%. The major disadvantages of chemical precipitation process for the removal of color and COD are that it involves the addition of chemicals which can be costly and result in the increase of Total Dissolve solids (TDS). Research in the past few decades, have shown that the Electro-Coagulation is a promising treatment method and have potential to treat variety type of wastewater including sewage.

Electro-coagulation treatment offers an alternative to the use of chemical coagulant such as metal salts or polymer for breaking the pollutants because during the Electro-coagulation process, the electrode can generate the metal hydroxides that destabilized and aggregate the suspended particles and precipitates. It is a complex process involving chemical and physical mechanism operating simultaneously to remove the color and COD. It involves 3 successive stages

1) Formation of coagulants by Electrolytic oxidation of the sacrificial electrode such as mild steel.
2) Destabilization of contaminants, particulate suspension and breaking of emulsion.
3) Aggregation of destabilized phase to floc formation. (Mollah et al., 2014)

Main aim of the study is to investigate the potential of Electro-Coagulation process using Mild Steel electrodes in the removal of COD and Color from indigo dye wastewater. The effect of electrolysis time, inter electrode distance for the removal of parameters are discussed.

II. MATERIALS AND METHODS

A. Waste Water Samples

Raw wastewater samples were collected from the blue denim manufacturing industry. The composition of wastewater then characterized to identify the pH, COD and Color.

B. Experimental Set-up

The batch experimental set-up shown in Fig. 1. The Electrochemical unit consists of an Electrocoagulation cell, a DC power supply and the electrodes (4 Aluminum as cathode and 3 Mild Steel as anode). A Monopolar electrode having same dimensions (230mm X 170 mm X 3mm) as an anode

and cathode which spacing of 10mm and 15 mm (depending on the experiment) between each other. The total effective area of electrode was 78200 mm^2. All the electrodes were washed with dilute HCl before every experiment conducted.

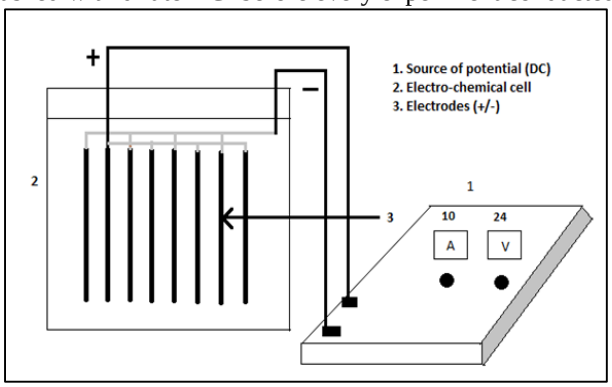

Fig. 1: Schematic diagram of experimental set-up

C. Specifications of Lab-scale Set-up

Sr No	Physical Features	Dimensions
1	Reactor Dimensions	380 X 235 X 255 mm^3
2	Liquid Depth	210mm
3	Width of Baffle	50mm
4	Volume of Reactor	22L
5	No of Electrode	4 Al + 3 MS
6	Electrode Dimensions	230mm x 170mm
7	Electrode Area	78200mm^2
8	Thickness of Electrode	3mm
9	Distance between Electrode	15 mm & 10mm

Table 1: Specification of Lab-scale reactor

D. Electrodes for Lab-scale Model

In the present work Aluminium used as Cathode and Mild steel used as Anode. Electrode design is one of the most important factor that affects the Electro-coagulation process. Electrode design affects the release of coagulants in the solution and the bubble type.

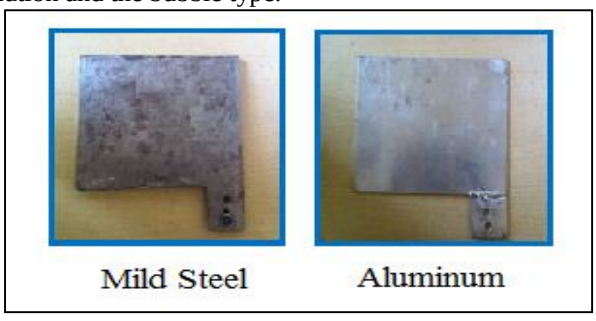

Fig. 2: Electrode Material

E. Experimental Procedure

The experiments were carried out in a batch mode. Monopolar electrodes used with electrode distance 15mm and 10 mm. 10 Ampere and 24 volt are fixed in power supply unit. Each run was carried out at time interval of 15min, 20min, 25 min, and 30 min, once the DC power supply was started. Experiments were carried out to determine the effect of electrode material, Electrocoagulation time, interelectrode distance and initial pH. After the experiment 500ml treated sample was taken from each plate and then kept undistributed for 60 min in order to allow the flocs to settle. Subsequently after settling the sample of supernatant was collected to perform the analysis of Color and COD.

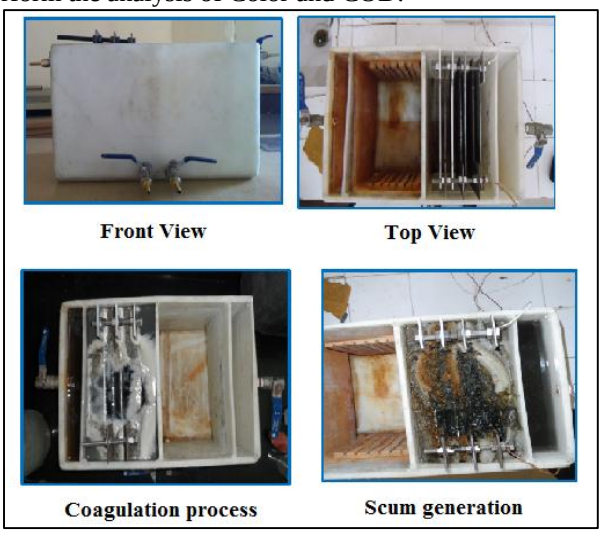

Fig. 3: Electrocoagulation Process

III. Result and Discussion

A. Characteristics of Wastewater:

Parameter	Range
COD(mg/L)	1100 - 1400
BOD(mg/L)	500 - 700
SS(mg/L)	800 - 1200
Color (pt-Co)	1000 - 2000
pH	7.0 – 7.8

Table 2: Wastewater characteristics is as follow:

B. Effect of Electrolysis Time

As shown in fig 4 as the time of electrolysis increase comparable changes in the removal efficiency of COD, color and pH are observed. Reactive time also influence the treatment efficiency of Electrocoagulation

Process because the more time consume the more production rate of hydroxyle and metal ions are produced on the electrodes.

Parameter	Raw	15 min	20 min	25 min	30 min
COD (mg/l)	1196	143.5	83.7	71.8	59.8
% Removal		88	93	94	95
SS (mg/l)	913	255.6	255.6	127.8	127.8
% Removal		72	72	86	86
Color (Pt-Co))	1216	243.2	182.4	158.1	145.9
% Removal		80	85	87	88
pH	7.2	7.6	7.8	8.1	8.3
Energy Consumption (KWH/m3)		6.31	8.42	10.52	12.6

Table 3: Effect of electrolysis time on organics removal

C. Effect of interelectrode distance

The effect of interelectrode distance shows a significant result in this experiment. As shown in fig 4, when interelectrode

distance increases the efficiency of COD and Color removal decreases slightly because the rate of electron transfer is become slower. Variations of the percentage removal with inter electrode distance is shown in figure below:

Electrolysis time(min)	COD(% removal)		Color (%removal)	
	15mm	10mm	15mm	10mm
15	23	88	35	72
20	30	93	50	72
25	32	94	60	86
30	50	95	77	86

Table 4: Effect of electrolysis time on COD and Color removal

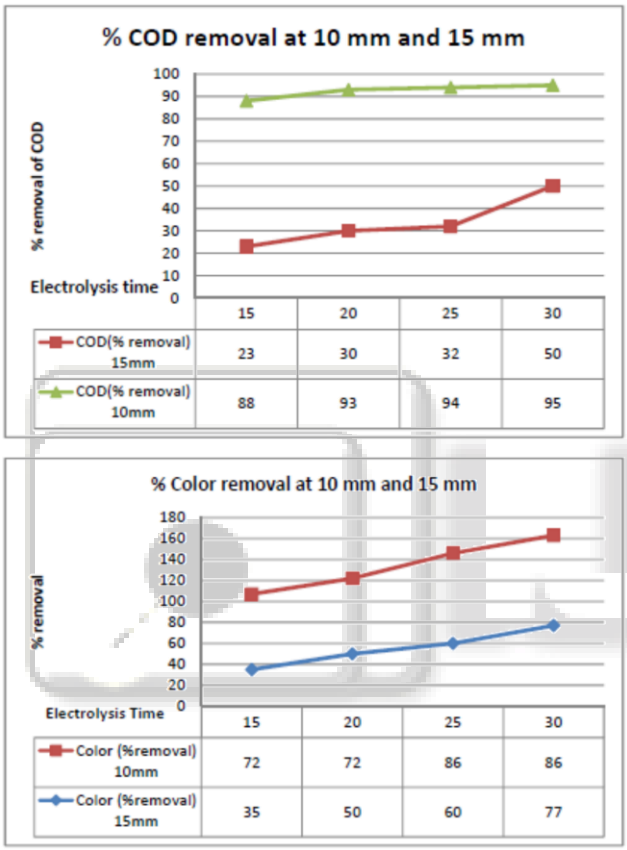

Fig. 4: Effect of inter electrode distance on COD and SS removal using MS and Al electrode, current density 42A/m^2 and for 15 min, 20min, 25min, 30min Ec time.

IV. Conclusion

In this study the EC process was found to be an effective method for the treatment of indigo dye wastewater. The effect of operational conditions such as electrolysis time, pH and inter electrode distance on removal of COD and Color was examined. The result showed that the removal of COD and Color increase with increase electrolysis time except for pH and inter electrode distance. The highest removal efficiency of COD by 95%, Color by 86% occurred at 42A/m^2 current density, 10mm electrode distance and pH 8.3 in 30min of operating time by Mild Steel electrode.

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