ELECTROFLOCCULATION ON TEXTILE DYE WASTEWATER

Thesis submitted in partial fulfillment for the requirement of degree of

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In
Environmental Science and Technology

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DECLARATION

I hereby declare that the thesis entitled **"Electroflocculation on textile dye wastewater"**, is an authentic record of my own work carried out as requirements for the award of degree of Master of Technology in Environmental Science & Technology from Thapar University, Patiala, under the guidance of Dr. A.S.Reddy (Associate Professor, Department of Biotechnology and Environmental Sciences) & Mr. Harpreet Singh (Assistant Research Scientist, TCIRD) during January to July 2012.

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ABSTRACT

Textile dye bath dumps are very rich in dyes and chemicals (sodium sulfate or chloride, hydroxides, and carbonates). Mixing of this wastewater with other textile processing wastewaters makes the wastewater treatment very difficult and costly, and compliance with the applicable effluent standards (while conserving water or wastewater minimization) almost impossible. Further, this reduces the recycling and reuses potential of the treated effluents. Segregation and handling of the dye bath dumps separated from the other wastewaters has been considered as an appropriate solution to the problem. The dye bath dump wastewaters can be decolourized and chemical recovery can be tried on the decolourized wastewater.

In the present study, decolourization of the dye bath dump wastewaters (sulfate rich and chloride rich wastewaters), collected from the cotton fabric dyeing process, by electro-flocculation have been tried. Of the iron and aluminum electrodes used, iron electrodes were found more effective than aluminum electrodes. 98% colour removal and 84% COD removal were observed at 4, 10 and 9.6 volts potential and when treated for 15, 6 and12.6 minutes for sulphate rich wastewater respectively. However, combination electrodes of iron and aluminium (iron as anode and aluminum as cathode) gave still better results. colour removal and COD removal were observed 97 % and 73 % at 8 and 10 volts potential and when treated for 9 and 6 minutes respectively.

For chloride rich waste water iron and steel electrodes gave the better results. 91 % COD and 99.4 % color was removed at 12 volts potential and when treated for 15 minutes with steel electrodes respectively. 80 % COD and 99 % color was removed at 5.8 and 12 volts potential and when treated for 5.7 and 15 minutes with iron electrodes respectively.

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Chapter 1

Introduction

The major problem faced by Human race today is how to provide clean water to the vast population of the world. As fresh water sources like rivers, canals etc are limited and those available are polluted by industries by indiscrimate discharge of their pollutants make water a cherished commodity now a days. Thus emphasis is on 3R which are reduction, recycle and reuse of natural resources like fresh water. Further there are several difficult wastewaters for which feasible techniques are not available and conventional treatments are not effective on them. Thus for recycle and reuse, there is an urgent need to develop an innovative, more effective and inexpensive technique.

The components generally present in a textile dye bath and in the textile industry are dye stuff, solubilising chemicals, electrolytes, specially dying assistants – leveling agents, lubricant, defoamer and water. Water is used in many processes which mainly dilutes the pollutants concentration. This makes recovery of pollutants impossible.

Electrochemical treatment plays an important role in waste water treatment. It has a wide range of applications including the treatment of toxic wastes, effluent treatment to control pollution and clean and cheap synthesis of organic and inorganic chemicals.

Electrochemical treatment can also be used as pretreatment scheme to improve the treat ability of the overall wastewater of the industrial unit.

In the present thesis work, on the basis of experimental results for textile dye wastewater (chloride and sulphate rich) on a lab scale, attempts are made to find out which electrode are better and optimum conditions like voltage and time to get the effective treatment of waste water in a cost effective manner.

1.1: Objective of work

To search the better electrodes from wide range of electrodes (Al, Fe, SS, hybrid) for treatment of wastewater and to optimize the treatment conditions (voltage and time) on lab scale, the result of which can be used to scale up to a pilot scale treatment unit for textile dye wastewater.

1.2: Scope of work

1. Literature had been reviewed from peer journals (textile treatment related), manuals and internet sources.

2. Original wastewater was used (from textile industry) which was provided by Dr.A.S.Reddy, Associate Professor, Thapar University for electroflocculation.

- Sulphate rich textile dye waste water
- Chloride rich textile dye waste water

3. Main emphasis was on electro flocculation of wastewater and to obtain results under different set of experimental conditions.

1.3: Significance of work

1. On two types of waste water work has been done, so this report has strong importance for us to know the treat ability of these wastewaters and if any person wants to do any further work then this report will immensely help him.
2. Most of the abstract related to electro flocculation, available online, were go through. Relevant research papers related to electroflocculation treatment of textile waste water were also studied.

1.4: Limitations

Following limitations were faced while working on present thesis.

1. The electrodes were sacrificial as they dissolute in solution so consumption of electrodes is an important factor.
2. The interference of chloride by chloride rich sample makes the sample analysis difficult especially for COD.

Chapter-2

Theory of Electro flocculation

Electro flocculation provides an alternative technique for the removal of pollutants from wastewater. The process involves the application of an electric current to sacrificial electrodes, usually Al/Fe, inside a processing tank/reactor.

The anode and cathode reactions are as follows:

$2H_20 + 2e- \rightarrow H_2 (g) + 2 OH- (cathode)$

$2H_2O \rightarrow O_2 (g) + 4H+ + 4e- (anode)$

$Al(s) \rightarrow Al^{3+} +3e- (anode)$

$2Al+6H_20 \rightarrow 3H_2 (g) + 6OH- + 2A1^{3+} (Total)$

For iron

$Fe\rightarrow Fe^{2+} + 2e- (anode)$

$2 H_2O + 2e- \rightarrow H_2 +2OH^- (cathode)$

$Fe^{2+} + 2OH \rightarrow Fe (OH)_2$

Hydrogen gas will evolve on the cathode, and oxygen gas will evolve on the anode; oxygen gas will only evolve at high current densities. It is an advantage that hydroxyl ions are developed at the cathode, because they maintain the pH in the electrolyte. To create the correct aluminium complexes, the pH must be close to 7.

The well known properties of the aluminium ions as a coagulating agent cause them to combine with the pollutants. The gas bubbles generated can capture the coagulated agglomerates, resulting in most of the pollutant being floated to the surface.

This electro flocculation process can be used, with the added advantage that there are no chemicals to be added. In addition to the use of Aluminum, other metals also have coagulating properties and can be used in place of Aluminum like Fe. The use of these in conjunction with or independently of the use of aluminum, offers several potential advantages associated with the electroflocculation process. Not the least of these is that the aluminum/metal coagulating cation is added without the addition of an anion. This means that the whole process is carried out without any substantial effect upon the salinity of the water.

Additionally, the sludge produced by electrocoagulation is reduced by a factor of 2 or 3 over the use of chemical coagulants (Musquere et al., 1983).

Also, experiments suggested that electrolytically added aluminium ions were much more active than chemically added aluminium ions (Donini et al., 1994), meaning that less aluminium was required and that this process could be used to treat a number of different pollutants which could not be handled by chemical flocculants such as alum (aluminium sulphate).

2.1 Factors affecting electroflocculation

The design of the electro-coagulation unit greatly affects the operation and its efficiency. The main issues generally considered are (1) Geometry of unit (2) Electrode material (3) Current density (4) Distance between electrodes (5) Voltage (6) pH (7) Conductivity (8) TDS (9) Temperature (10) Consumption of electrodes.

1. Geometry: geometry of the reactor affects the operational parameters including bubble path, flotation effectiveness, floc formation, mixing and settling characteristics.

2. Electrode material: In any electrochemical process, the electrode material has significant effect on effluent treatment. For drinking water treatment, the electrode material should be nontoxic for human health. Iron and Aluminum are usually preferred because of their low cost and easy availability. However, iron electrode has a disadvantage as it turns the effluent color into green or hard yellow. This coloration comes from the Fe^{2+} ions (green) and Fe^{3+} ions (yellow) generated during electrolytic treatment. With the Aluminum electrode, the effluent becomes clear and stable, with no change in color. Plate types of Electrodes are generally used for the treatment. Either bipolar type or mono polar type electrodes are generally used by keeping one side of electrodes insulated by applying some coating.

3. Current density

The current not only determines the coagulant dosage rate but also the bubble production rate and fluid regime (mixing) with in the reactor. Low current produces low bubble density leading to a low upward momentum flux and thus poor mixing. As the current increase, the bubble density and the amount of mixing increase. Hence the operational current has a strong influence on the dominant pollutant removal path.

4. Distance between electrodes

At a constant electric current increasing the electrode gap results in enlarged ohmic drops and higher energy consumption, which leads to a significant temperature increase, that can affect the interfacial properties of the multiple medium, and alter treatment efficiency.

COD removal is a decreasing function of the electrode gap.

5. Voltage

Voltage influences the electro-flocculation process very much. Voltage can be related to current density, effluent's conductivity, electrodes spacing and its surface state (Chen et al., 2002) by the following equation:

$$U=\delta*d/k$$

Where

U = applied tension, V

δ = current density, A/m^2

d = distance between electrodes, m

k = electrolyte conductivity, S/m.

6. pH

pH plays a very important role in treatment process. It is found that low pH is generally favorable for maximum pollutants removal. The basic reason behind this is, in low pH metal electrode become more unstable and more reactive, so they release more ions in the solution and hence enhance dissolution of metals in the solution. But very less pH is not favorable because at very low pH the flocs will not aggregate or they become dissolve in the solution and hence the settling will not be proper. As the pH increases the efficiency for color removal, COD and turbidity decreases. For electro oxidation pH is generally maintained around 2-3, and for Electro-flocculation pH is generally maintained in between 4-6.

7. Conductivity: Conductivity also plays a significant role as usually higher the conductivity higher will be the removal efficiency. It also determines the voltage and energy consumptions. Increasing conductivity increases power consumption. The optimum value of conductivity was found to be in between 300-500 µ S/cm**.**

8. TDS: Total Dissolved Solids (TDS) are indirectly related to the conductivity of the solution

9. Temperature: According to (Daneshwar et al., 2004) increase in temperature of solution provides an increment of removal efficiency because of the increase in the ion movements that facilitate collision of ions with coagulated material. However if the temperature is >300K, the removal efficiency decreases because breakage of flocs from the increased movement of the ions. Also very high temperature increases the solubility of precipitates.

10. Consumption of electrodes:

First Faraday's law is directly linked to electro-flocculation, the consumed mass of electrodes is directly linked to the electric current applied and is mathematically defined by the following equation:

$$M_{el} = i.t.M / F.z$$

Where:

M el= maximum amount of electrodes mass consumed (grams)

i = electrical current (Ampere)

t = total time of current application (s)

M = molar mass of the main electrode element (g/mol)

z = number of electrons involved in oxidation reaction of anode's element

F = Faraday constant, 96500C/mol

Considering this as a theoretical calculated value which is usually near the result of experimentally determined value, however mistakes can be detected if the electrode’s set geometry is not properly determined and if the reactor is not operating in optimal conditions.

Chapter-3

Literature Review

Electro coagulation is one of the most effective techniques to remove colour and organic pollutants from wastewater, which reduces the sludge generation. Electro-coagulation has been used for the removal of colour from solutions containing dyes by ***Daneshvar*** *et al (2005)*. The effect of operational parameters such as Current density, initial pH of solution and time of electrolysis, initial dye concentration and solution conductivity were studied to reach higher removal efficiency. The findings in this study shows that an increase in the current density upto 60-80 A/m^2 enhance the colour removal efficiency, the electrolysis time was 5 min. and the range of pH was determined between 5.5 and 8.5 for two mentioned dye solutions. It was found that for, the initial concentration of dye in solutions should not be higher than 80 mg/L in order to achieve higher removal efficiency. The optimum conductivity was found to be 8 mS/cm, which was adjusted using proper amount of NaCl with the dye concentration of 50 mg/l. Electrical energy consumption in the above conditions for the decolourization of both the dye solutions containing were 4.70 kWh/(kg dye removed) and 7.57 kWh/(kg dye removed) respectively. Also, during the EC process under the optimized conditions, the cod decreased by more than 75% and 99% in dye solutions containing BB3 and BR46, respectively.

Poultry slaughterhouse wastewater (PSW) by electro-coagulation(EC) batch wise was investigated by ***Kobya Mehmet et al(2005)***. Effects of the process variables such as medium pH, electrode material, current density, and operating time are investigated on COD and oil-grease removal efficiencies, electrical energy consumption and sacrificial electrode consumption. The highest COD removal efficiency is reached with aluminum as 93%. Combined use of both electrode materials in the EC unit may yield high process performances w.r.t. both COD and oil-grease removals.

Textile wastewater was treated by electrocoagulation using iron and of aluminum electrode materials by ***Kobya mehmet et al (2003)***. The effect of relevant wastewater characteristics such as conductivity and pH and important process variables such as current density and operating time on the COD and turbidity removal efficiencies have been explored. The highest removal efficiencies have been obtained with aluminum in acidic medium with pH<6, while iron is more efficient in neutral and alkaline medium especially between 6<pH<9. High conductivity favors high process performances. Iron requires a current density of 80-100 A/m^2, while aluminum requires 150 A/m^2 for a operating time of 10 min. for the same turbidity or COD removal efficiencies. It is also observed that the energy consumption kWh per kg COD removed is lower with iron, while the electrode consumption per kg COD removed is lower generally with aluminum. The results show that iron is superior to aluminum as sacrificial electrode material, from COD removal efficiency and energy consumption points.

The decolorization of the levafix orange textile dye in aqueous solution by electrocoagulation using aluminum sacrificial electrode was investigated by ***Kobya mehmet et al (2005)***. The process performance is analyzed in terms of decolorization efficiency and the important cost related parameters such as electrode and energy consumptions as a function of initial ph, conductivity, current density, initial dye concentration and electrolysis time. Almost complete removal of pollutants nearly 99% with typical operating conditions; 100A/m^2 current density, 15 min operating time and initial pH 3. On the other hand, 95% decolorization efficiency may be obtained for the same current density in 12 min and at a pH 6.4.

Reclaimed water system was designed by ***Lin et al. (2005)*** which provides an economically and environmentally favorable method for disposing of waste water. However, some critical influences on site reclaimed water systems, such as limited building area, often limit the effectiveness of conventional treatment methods. The author also observed the effect of aluminum release dosage on pollutants removal. When the dosage of aluminum increased to 25 mg/L, 60% COD removal is obtained. Raising the dosage to 50 mg/L did not increase cod removal efficiency. COD removal efficiency was determined by the dosage of aluminum released and is generally restricted by the presence of soluble contaminants in the influent. Furthermore this pilot scale process reclaimed domestic greywater at 28 m3/day, meeting the general guidelines for water in human non contact usage. The cost was US \$0.27/m^3, and the treatment facility required an area of 8m^2. The experimental results supports the feasibility of the on site reuse of greywater in high rise buildings.

The feasibility of the removal of nitrate from water by applying electrochemical methods such as electro reduction and electrocoagulation was investigated by ***Koparal et al (2001)***. In electro reduction, removal of nitrate to an allowable concentration has been accomplished at the ph range of 5-7 with energy consumption value of 1*10 -3kWh/g. In electrocoagulation ,an allowable concentration of nitrate has been achieved at the ph range of 9-11 with energy consumption value of 0.5 x 10 -4kWh/g. Full removal of nitrate was also possible but with higher energy consumptions for these two methods.

The ability of system viz. Electrofloc plus to treat municipal wastewater was investigated by ***Nielson et al (2004)***. The results of an extensive experimental program showed that the technique was effective in reduction of certain water quality parameters including TSS, TP. The removals of COD and BOD5 were inadequate. It was concluded that the system was alone insufficient to treat municipal wastewater to levels required by the regulatory standards. It was also determined that the system requires large power inputs to achieve the treatment obtained in the event that the conductivity of the waste water was not increased to >4500 mS/cm by the addition of salt. The study further found that ozone addition as a coagulant aid did improve process performance.

The treatment of phenolic compounds containing wastewater generated from phenol-formaldehyde resin manufacturing, oil refinery and bulk drug manufacturing industries by electrochemical method was done by ***Rajkumar et al (2004)***. Experiments were conducted at a fixed current density of 5.4 A/dm^2 using Ti/tiO_2-RuO_2-IrO_2 electrode and an undivided reactor. For phenol resin manufacturing ww the COD removal was 61% for the effluent as such and 82.4% for chloride added effluent after 24Ah/l charge input with energy consumption of 161.2 and 102.1 kWh/kg of COD removal respectively. For oil refinery ww the COD/TOC value of 83 mg/l. ECT with addition of chloride is effective for refinery waste water. For bulk drug manufacturing industry waste water the COD and TOC removals were 73.1 and 53.3 % after the passage of 12 Ah/l charge. Among the three effluents examined here, bulk drug manufacturing unit of the pharmaceutical industry showed much higher current efficiency on the removal of cod than the other effluents. Although all the effluents show a significant increase in the AOX concentration during the initial periods of treatment, extended electrolysis led to decrease in the concentration. Hence, at the end of the ECT, it is recommended that the treated water be given an activated carbon polishing treatment to remove chlorinated organic compounds before the discharge.

The overview of processes most commonly used and the state of the development of recent electrochemical innovations was suggested by ***Roessler et al (2003)***. In recent attempts, various electrochemical reducing methods have been investigated, such as the indirect electrochemical reduction employing a redox mediator, the direct electrochemical reduction of indigo via the indigo radical, the electro catalytic hydrogenation route and the direct electrochemical reduction on graphite. All these methods offer tremendous environmental and economic benefits, since they minimize the consumption of chemicals as well as the effluent load. From the point of stability, availability and costs, the latest development concerning direct electrochemical reduction on graphite granules seems to be the most attractive process and the results are obviously a promising basis for further development.

The onshore testing of produced water by electroflocculation was investigated by ***Rubach et al (1997)***. He presentedThe activities and results of work done at the Elf Aquitaine Production Research Centre in Pau, France was presented by. The research objective were to test and to determine the optimal running conditions for a 1 m^3/h electroflocculation pilot plant with produced water and drainage water. In addition, the limits for acceptable performance were investigated. The following results were obtained. With North Sea condensate, the separation efficiency for saturated hydrocarbons was 98.8 %, aromatics 97.8 %, and polar components 95.8 %. The total separation was 98.4 %. The energy consumption was decreased from 9-1.5 kWh/m^3 when the conductivity increased from 60 to 4800 mS/m. the outlet oil concentration was not influenced by the change in conductivity. The addition of deemulsifier, corrosion inhibitor and scale inhibitor did not have any influence on the efficiency.

The stability of DSA electrodes for use in oily waste water remediation was assessed by ***Santos et al (2005)***. It has been established that DSA electrodes can be very active in reducing the content of organic components presented in oily waste water samples. Voltammetric and chronoamperometric experiments revealed that the reduction of organic material occurred at the same potential as the OER. At potentials higher than 1.100V the anodic displacement of the OER revealed a breakdown in acid base equilibrium at the metal oxide layer. The removal of COD was influenced by temperature, increases in which mainly favored electro chemical process. At a current density of 100 mA/cm^2, the most efficient COD reduction was achieved at 50’C reaching 40% after 12 h, and 57% after 70h. The result substantiates the importance of the use of DSA and electrochemical processes in the treatment of waste water from the petroleum industry.

The rate of pollutant removal was significantly influenced by the type of anode material and electrochemical parameters showed by ***Szpyrkowicz et al (2005)***. These factors govern the type of electrode reactions including an eventual direct discharge of pollutants and the relative contributed of direct and mediated electro oxidation. Two anode materials Ti/Pt-Ir and Ti/PdO-Co_3O_4 can be indicated as appropriate for the electrochemical treatment of tannery wastewater, when the chlorine evolution reaction produces a mediator for indirect bulk oxidation. A two fold increase of the current density resulted in a more than a double increment of the observed rates of pollutants depletion, indicating the precipitation of other mediators, apart from active chlorine, such as hydrogen peroxide or hydroxyl radicals.

The depletion of pollutants was well described by pseudo-first order kinetics with the highest rate of removal achieved for ammonia present in biologically pre treated wastewater. In the case where the organic load is efficiently removed by a conventional biological process, electro chemical oxidation can be applied as a post treatment to remove residual ammonia with 0.4 kWh/m^3 energy consumption, offering a valid alternative to biological nitrification/denitrification.

The feasibility of oxidizing the principle components: ammonium ions, sulfide, tannins and other organics of tannery waste water demonstrated by ***Szpyrkowicz et al (2001)*** by electrochemically generated active chlorine, formed by chloride oxidation in an undivided electrochemical batch reactor with parallel plates electrodes. The results of the treatment showed that selectivity of the removal of different pollutants was affected by current density to a small extent. By contrast hydrodynamic conditions strongly influenced the rates and the differential selectivity ratio of depletion of pollutants, with the exception of tannins. The kinetics of elimination of ammonium ions, removes only via oxidation by active chlorine, was diminished by agitation, contrary to its effect in enhancing the removal of the other pollutants, for which direct anodic oxidation was an additional process for their destruction.

Simplified operating cost analysis for the treatment of a textile waster by EC using iron and aluminum electrode materials was done by ***Bayramoglu et al (2003)***. The effects of various for two electrode materials was measured separately.

Cigarette industry waste water using cast iron electrode and treatment efficiency was measured in terms of COD, BOD and suspended solids concentration by ***Bejankiwar et al (2002)***. About 56% of COD and 84% of BOD removal was observed at 3.5 A current for 5 h of electrolysis.

Comparative cost analysis of chemical coagulant was done by ***Can et al (2006)*** in both chemical and electro chemical.

A process was developed by ***Chen et al (2000)*** which is the combination of both Electro coagulation and electro flotation and applied to restaurant wastewater treatment. Advantage is that this process is shorter retention time and low water content in sludge produced.

The electro-coagulation process was applied to restaurant wastewater by ***Chen et al (2000)*** which has high oil and grease content. The electrode use was Aluminum and 94 % oil and grease was removed.

The influence of electrolysis concentration, initial concentration and current density was studied by ***Fernandes et al (2003)*** on the degradation rates using two electrolytes- KCL and Na_2SO_4 with boron dipped electrode on C.I acid orange(AO7). Results for color and COD removal are 90%.

The results reported in the literature were summaries by ***Francesco et al (2002)*** and on the basis of that proposed a model for the evaluation of the feasibility of industrial-scale reactors. Considerable results have been achieved in terms of detailed scientific knowledge of the reaction mechanisms, but very few data are available on the behavior-scale reactors; furthermore, the energetic balance of the overall process has rarely been analyzed. Owing to this fact, he discussed a proposal for a suitable reactor design.

The electrochemical oxidation of olive oil mill wastewaters by ***Gotsi et al (2005)*** using titanium- tantalum-iridium anode. In most cases, nearly complete degradation of phenols and decolonization were achieved at short treatment times up to 60 min with 40 % COD removal. As voltage increase, the conversion of total phenols and COD as well as the extent of decolorization generally increase.

Electro coagulation for the decolorization of strong colored solutions used by ***Gurses et al (2001)*** containing the reactive textile dyes. The variables chosen for this work are mixing rate, cell voltage, electrolysis time and current density. Results showed that the effective variables on decolorization process are cell voltage, electrolysis time and current density. MINITAB software was used for obtaining non linear regression of data.

Electro coagulation that focuses on the interactions between electrochemistry, coagulation and flotation was reviewed by ***Holt et al (2004)*** and also focuses on the fact that why electro coagulation has never become accepted as a mainstream water treatment technology. The reason for this is the lack of systematic approach to electrocoagulation reactor design/operation and the issue of electrode reliability has limited its implementation. However recent technical improvements combined with a growing need for small-scale decentralized water treatment facilities have led to a reevaluation of electrocoagulation

.

Chapter 4

Materials and Methodology

Based upon above mentioned advantages and properties of Electroflocculation development work will undertake with the following objectives:

1. Collection of wastewater from textile industry
2. Analyzing the Characteristics (pH, colour, COD, turbidity, conductivity) of that textile wastewater.
3. Electrolytic treatment of wastewater at varying voltage and time.
4. Analyzing the treated wastewater for above said parameters after treatment.

4.1 Waste water studied

Two types of waste water (sulphate rich and chloride rich) from textile dye industry were studied and analyzed.

S.No.	Parameter	Untreated value
1	Color	1000 Pt Co units
2	COD	1243 mg/l
3	Turbidity	217 FTU
4	Conductivity	51.2 mS/cm
5	pH	10.8

Table 4.1. Characteristics of sulphate rich textile wastewater

S.No	Parameter	Untreated value
1	Color	2135 Pt Co units
2	COD	756 mg/l
3	Turbidity	385 FTU
4	Conductivity	32 mS/cm
5	pH	9.53

Table 4.2. Characteristics of chloride rich textile dye wastewater

4.2 Experimental setup

The experimental system used for the treatment of wastewater, includes a Reactor, a DC power supply. Please see fig.4.2.1 for details.

Reactor (fabricated using 6mm acrylic sheet) of 6.1 cm length, 4.7 cm width and 33.3 cm height was used for electro flocculation treatment. Working volume of this reactor is 415 ml. Two electrodes (anode and cathode) each of 4.9 cm width, 20 cm length (without stick) and 3mm thickness were put inside the reactor as shown in fig.4.2.1. Four different pairs of electrode namely Al-Al, Fe-Fe, SS-SS and also a hybrid of Fe-Al were used in the present study. With the help of grooves in the reactor wall, the electrodes were maintained at 10mm distance apart. For mixing, a 2.3cm long stirring bead was used and over the magnetic stirrer, reactor was placed. The DC power supply system used was capable of supplying of DC power in the range of 0-30V and 0-30 Amperes. The system also has the facility of supply of DC power at desired constant voltage (0-30V) or desired ampere (0-30Amp.) and it can also give the regulated and metered supply of DC power of both voltage and ampere.

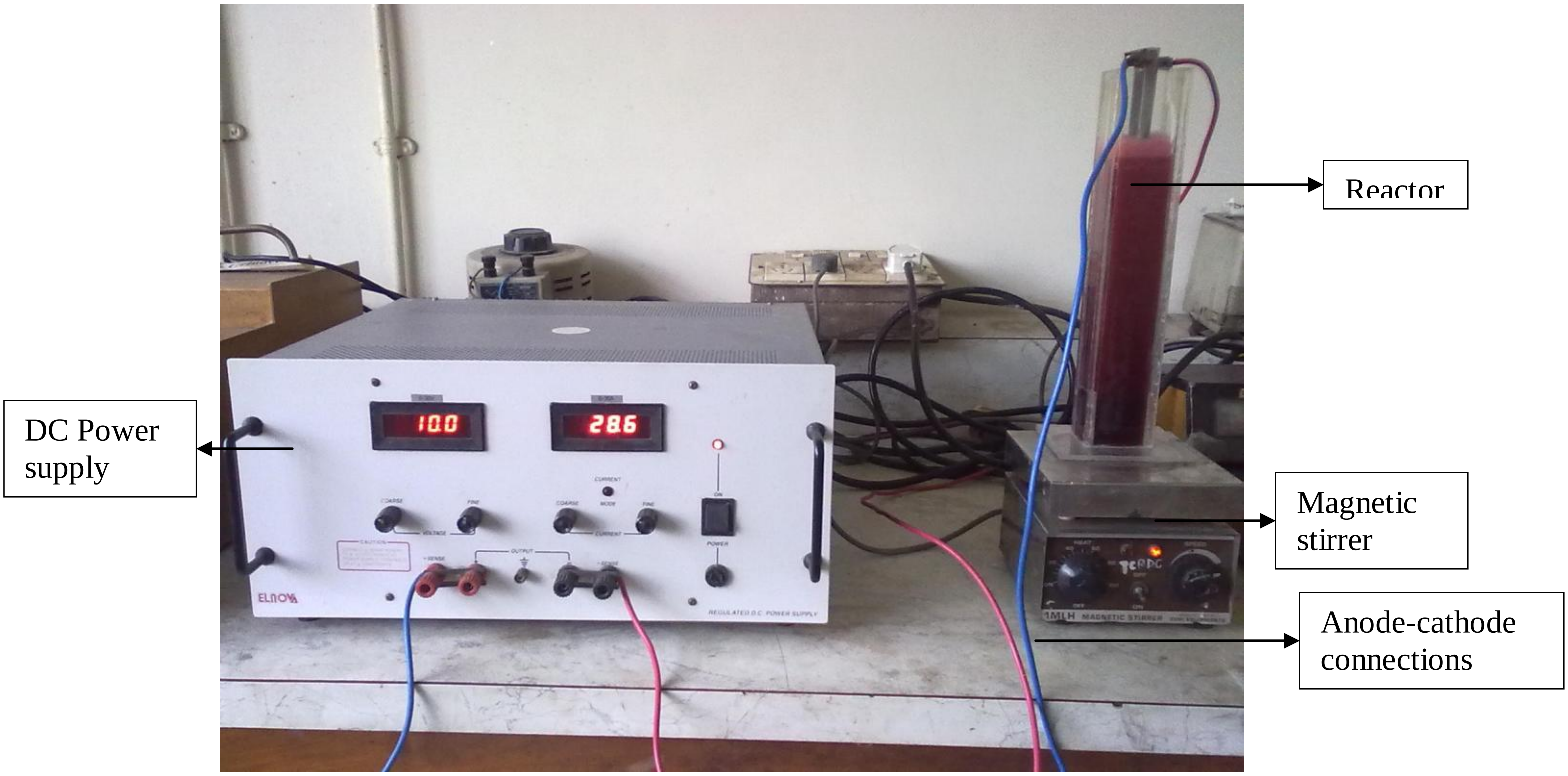

Fig.4.2.1. Experimental setup of electro flocculation

4.3 Approach followed

Electro flocculation treatment of textile dye waste water of both sulphate rich and chloride rich was studied using different pairs of electrode namely Al-Al, Fe-Fe, SS-SS and Fe-Al and focused on the optimization of parameters like colour, COD, turbidity, conductivity and sludge generation rate. COD removal and colour removal were used as a measure of treatment.

A set of design of experiments was used to carry out the specific parameters and responses were recorded.

In case of sulphate and chloride rich textile dye waste water, the set of experiments were carried out at specific parameters condition. The set of experiments were run by 4 different pairs of electrode, first set with Al-Al, second set with Fe-Fe, third set with SS-SS and fourth set with Fe-Al.

Waste water was taken into reactor, different types of electrodes were placed, voltage was fixed at desired level and current was pass through for specific time and noted for that specific period of time. After treatment, the treated wastewater was allowed to settle and then filter. After that sample was taken for analysis of different parameters like COD, color, turbidity, conductivity, pH and sludge generation rate.

4.4 Analytical techniques

pH was measured with electronic pH meter (LI 127) by elico India instruments. Conductivity was measured by digital conductivity meter (model 555A) made by thermo Orion.

Chemical oxygen demand (COD) was determined by open reflux (titrimetric) method (method number 5220 B of standard method, 1989).

Turbidity and colour of sample was measured by Hach DR/2000 direct reading spectrophotometer at 450nm and 455nm respectively.

Sludge generation rate was determined by filtering the samples through whattman filter paper No. 1 and then taking its oven dried weight.

4.5 Methods

Procedure for COD (Open reflux titrimetric method)

Take 20 mL sample in COD tubes. Add pinch of $HgSO_4$. Add 10 mlL of potassium dichromate. Now add 5mL COD reagent. Mix all well.

After that Add 25 ml COD reagent and mix. Put it in COD digestor for 2 hrs at 150º C.

After 2 hrs wash it with 80 ml distilled water and allow cooling. Titrate it with FAS after adding 4-5 drops of indicator.

Procedure for COD for chloride sample

The sample which contain high amount of chloride in it. Measuring COD for that has a difficult task. The method generally used for that is the spiking method which is done with the help of KHP standard. In this method 10 mL KHP has taken along with 10 mL sample for reducing the chloride interference. The procedure is same as open reflux titrimetric method beside in this sample is taken with standard solution. After that pinch of HgSO4, 10 mL potassium Dichromate and 5mL COD reagent is added and after mixing, 25 mL COD reagent is again added. After mixing digest it for 2 hrs at 150ºC then wash it with 80 mL distilled water and after cooling titrate it with FAS solution and note the burette reading when color becomes reddish brown.

Calculation

COD (mg/ L) = {(blank – sample)* 1000* 8* normality of FAS)}/ Vo;ume of sample taken

Color is measured by setting the wavelength at 455 nm and by selecting the method number 120 in hach spectrophotometer. After that first of all instrument is set to zero by blank sample and then reading of samples are taken.

Conductivity reading is taking directly from the digital conductivity meter (model 555A) made by thermo Orion by dipping the rod in samples in mS/cm.

For sludge generation initial weight of filter paper is taken then after filtration final weight is taken then by difference of initial and final sludge generation is measured.

Chapter 5

Results and Discussion

Both waste water (sulphate rich and chloride rich) dye from textile industry are investigated in the following study. The experimental design which is used is shown in table5.1. Both the sulphate rich and chloride rich dye waste water from textile industry was used and the experiments were conducted as per experimental design using different pair of electrodes (Al-Al, Fe-Fe, SS-SS, Fe-Al). Colour, turbidity, pH, COD and sludge generation rate was analyzed.

Firstly the experiments was conducted at 3, 6, 9 and 12 volts at 10, 20, 30 minutes respectively with all electrodes and then experimental design was set after setting the desired results from above experiments with help of Design-Expert Software with two factors Voltage and Time and the respective responses..

Different pair of electrodes is used. There are total 19 experiments as per the experimental design at different voltage and different time intervals as shown in Table 5.1.

Table 5.1 Set of experimental design

S.No	Factor 1: voltage	Factor2: Treatment time (min)
1	12	15
2	4	15
3	12	15
4	4	15
5	4	3
6	12	3
7	12	3
8	10	6
9	6.6	12.9
10	5.8	5.7
11	9.6	12.6
12	8	9
13	8	9
14	8	9
15	12	9.6
16	7.6	3
17	4	8.4
18	4	8.4
19	7.6	3

The experiments were carried in a following way as shown in table 5.1.1. showing the voltage and current variation at a particular time period for different voltages and time.

Voltage-12 V

Time- 15 minutes

minutes	Volt(V)	Current(A)
0	12	1.3
1	12	1.9
2	12	.8
3	12	1.8
4	12	3.7
5	12	4.7
6	12	5.2
7	12	5.5
8	12	6.1
9	12	6.5
10	12	6.9
11	12	8.0
12	12	8.9
13	12	10.2
14	12	11.4
15	12	12.5

Table 5.1.1 voltage and time variation

This table is obtained by running the sample in a reactor for a desired period of time (here 15 min.) and at definite voltage (here 12 V), on the basis of this table the current density and power consumption is calculated.

The data also shows the current variation and efficiency is calculated on the basis that whether current variation is high or low.

5.1 Treatment of sulphate rich textile dye waste water

Different pairs of electrodes are used. There are total 19 experiments as per the experimental design at different voltage and different time intervals.

First set- Aluminium

Result:

S.No	Volt	Time (min)	Current density (A/m^2)	Colour (pt Co Units)	COD (mg/L)	Conductivity (mS/cm)	pH	Power consumption (kWh/m^3)	Sludge generation rate (g/L)
1	12	15	7224	227	549	51.5	11.1	48.32	.0053455
2	4	15	1204	364	575	50.5	11.23	14.59	.0049136
3	12	15	9673	184	484	50.8	11.4	64.05	.0050498
4	4	15	1061	870	609	51.8	10.6	7.05	.0047654
5	4	3	4244	1200	924	52.6	10.1	.562	.0034783
6	12	3	3404	1120	851	50.8	10.36	4.37	.0038631
7	12	3	3967	720	786	50.7	10.4	5.25	.0038325
8	10	6	1438	930	931	50.7	10.20	3.78	.0029231
9	6.6	12.9	1104	880	857	51.9	10.16	6.28	.0027973
10	5.8	5.7	562	970	948	50.6	10.6	1.41	.0027807
11	9.6	12.6	4163	550	783	51.6	10.2	23.1	.0031594
12	8	9	9722	566	743	50.2	10.3	38.6	.0030558
13	8	9	3338	730	873	51.9	10.20	13.26	.0045785
14	8	9	1257	750	865	51.8	10.14	4.99	.0035987
15	12	9.6	7518	640	750	51.6	10.25	31.8	.003924
16	7.6	3	1085	970	989	51.2	10.6	1.43	.0028284
17	4	8.4	2143	760	923	50.5	10.07	7.94	.0027404
18	4	8.4	351	880	956	51.5	10.3	1.30	.0022103
19	7.6	3	10624	740	914	50.2	9.7	14.08	.0029

Table 5.1.2 showing results by Aluminum electrodes

This experimental design consists of 19 experiments. Electrodes used are Al-Al. and the volume of 370 mL.

Best result of COD comes to be 549 mg/L as compared to 1243mg/L of original sulphate rich waste water at 12 V 15 minutes with power consumption of 64.05 kWh/m^3. Hence removal efficiency is 61 % with sludge generation rate of .005 g/L

Color comes to be 184 Pt Co units as compared to 1000 Pt Co units. Hence removal efficiency is 82 %.

Second set- Fe-Al

Result:

S.No	Volt	Time (min)	Current density (A/m^2)	Colour (pt Co Units)	COD (mg/L)	Conductivity (mS/cm)	pH	Power consumption (kWh/m^3)	Sludge generation rate (g/L)
1	12	15	25812	90	449	54.6	11.6	163	.0191902
2	4	15	1306	507	606	52.4	10.88	1.68	.003912
3	12	15	28230	100	412	54.3	11.26	174	.0189833
4	4	15	367	680	864	53.3	11.0	2.39	.0037352
5	4	3	122	970	1220	53.4	10.75	1.3	.001223
6	12	3	29755	73	379	51.2	10.9	38.3	.0066108
7	12	3	35142	65	362	51.8	11.11	45.3	.0068647
8	10	6	23877	50	326	53.2	11.8	61.4	.0098090
9	6.6	12.9	7004	33	339	52.9	11.83	38.8	.0083835
10	5.8	5.7	2071	500	714	52.5	10.23	5.14	.0033902
11	9.6	12.6	17339	60	367	54.8	10.9	96.13	.0124999
12	8	9	11346	36	343	53.7	10.9	41.3	.0089761
13	8	9	11102	33	360	53.4	10.88	43.01	.0082612
14	8	9	11592	30	387	53.9	11.4	44.8	.0080011
15	12	9.6	28663	104	444	52.3	10.8	118.5	.0159671
16	7.6	3	5568	522	680	53.2	10.3	7.18	.0027161
17	4	8.4	612	900	1200	53.4	10.9	2.21	.0034554
18	4	8.4	939	553	920	52.7	10.64	3.47	.0031950
19	7.6	3	4761	465	680	53.7	10.7	6.14	.0023994

Table 5.1.3 showing results by Fe-Al electrodes

This experimental design consists of 19 experiments. Electrodes used are Fe-Al. and the volume of 380 mL.

Best result of COD comes to be 326 mg/L as compared to 1243mg/L of original sulphate rich waste water at 10 V 6 minutes with power consumption of 61.4 kWh/m^3. Hence removal efficiency is 73 % with sludge generation rate of .009 g/L

Color comes to be 30 Pt Co units as compared to 1000 Pt Co units at 8 V 9 minutes with power consumption of 45 kwh/m^3. Hence removal efficiency is 82 % with sludge generation of .0082 g/L

Third set- Iron

S.No	Volt	Time (min)	Current density (A/m^2)	Colour (pt Co Units)	COD (mg/L)	Conductivity (mS/cm)	pH	Power consumption (kWh/m^3)	Sludge generation rate (g/L)
1	12	15	24750	43	324	54.7	10.98	155.4	.0095878
2	4	15	1795	23	562	53.2	11.9	12.56	.0032084
3	12	15	24974	50	335	54.9	10.56	168.14	.0109847
4	4	15	2102	27	554	51.9	10.05	13.20	.0031598
5	4	3	1935	497	752	51.8	9.24	2.430	.001458
6	12	3	33578	90	407	51.8	9.23	41.7	.0043868
7	12	3	34138	80	403	50.8	10.7	40.04	.0040787
8	10	6	27561	23	353	52	10.8	65.17	.0049454
9	6.6	12.9	9051	25	404	52.6	11.2	48.9	.0045512
10	5.8	5.7	6001	43	746	51.9	11.4	14.32	.0025441
11	9.6	12.6	24772	23	506	52.7	11.8	130.72	.0081258
12	8	9	17281	36	590	51.7	11.73	66.76	.0058499
13	8	9	14840	25	618	51.7	11.3	55.9	.0057045
14	8	9	16555		612	51.7	11.2	62.4	.0058903
15	12	9.6	28189	23	561	52.2	11.5	112.14	.0093690
16	7.6	3	9228	149	652	50.9	11.8	11.5	.0031545
17	4	8.4	1873	66	659	52.2	11.3	6.59	.003481
18	4	8.4	1820	100	713	52.3	11.7	6.40	.0034926
19	7.6	3	11097	146	576	50.7	11.6	13.9	.0031226

Table 5.1.4: showing results by iron electrodes

This experimental design consists of 19 experiments. Electrodes used are Fe-Fe. and the volume of 390 mL.

Best result – COD comes to be 324 mg/L as compared to 1243mg/L of original sulphate rich waste water at 12 V 15 minutes with power consumption of 155 kWh/m^3. Hence removal efficiency is 73 % with sludge generation rate of .00095 g/l

Color comes to be 23 Pt Co units as compared to 1000 Pt Co units at 4 v 15 minutes, 10 V 6 minutes and 9.6V 12.6 minutes with power consumption of 13, 65.17 and 131 kwh/m^3 respectively. Hence removal efficiency is 82 % with sludge generation of .003, .004 and .008 g/L respectively.

Fourth set- steel

Results:

S.No	Volt	Time (min)	Current density (A/m^2)	Colour (pt Co Units)	COD (mg/L)	Conductivity (mS/cm)	pH	Power consumption (kWh/m^3)	Sludge generation rate (g/L)
1	12	15	34016	2120	796	53.8	10.5	204.6	.0022190
2	4	15	1489	1170	894	50.7	10.63	1	.0013128
3	12	15	34959	2210	718	54.5	10.55	223.2	.0021589
4	4	15	1592	1030	906	51.0	10.78	10.8	.0011073
5	4	3	134	1070	918	51.5	10.6	1.5	.0011297
6	12	3	33142	1560	808	52.7	10.60	47.8	.0017945
7	12	3	38082	1560	828	51.8	10.69	50.45	.0019580
8	10	6	25959	1600	800	52.1	10.64	70.6	.0016643
9	6.6	12.9	8216	1410	783	51.5	10.66	48.08	.0015829
10	5.8	5.7	5332	1300	972	51.1	10.61	13.7	.0015879
11	9.6	12.6	25861	1580	799	51.8	10.19	147.84	.0025414
12	8	9	12228	1400	873	51.0	10.79	49.9	.0025312
13	8	9	12693	1390	849	52.3	10.62	51.8	.0022564
14	8	9	12081	1500	865	51.5	10.59	49.3	.0028658
15	12	9.6	34665	1560	824	50.6	10.42	150.9	.0024997
16	7.6	3	7677	1050	1030	50.1	10.5	10.45	.0021620
17	4	8.4	865	990	1071	50.6	10.76	3.29	.0011750
18	4	8.4	775	910	939	50.2	10.66	2.95	.0013671
19	7.6	3	9461	1210	1013.52	51.0	10.43	12.87	.0025814

Table 5.1.5: showing results by steel electrodes

This experimental design consists of 19 experiments. Electrodes used are steel. and the volume of 360 mL.

Best result of COD comes to be 718 mg/L as compared to 1243mg/L of original sulphate rich waste water at 12 V 15 minutes with power consumption of 223 kWh/m^3. Hence removal efficiency is 42 % with sludge generation rate of .002 g/L

Color comes to be 910 Pt Co units as compared to 1000 Pt Co units at 4 V and 8.4 minutes with power consumption of 3 kwh/m^3. Hence, removal efficiency is 9 % with sludge generation of .0013 g/L.

5.2 Treatment of chloride rich textile dye wastewater

Different pairs of electrodes are used. There are total 19 experiments as per the experimental design at different voltage and different time intervals.

First set- Aluminium

Result:

S.No	Volt	Time (min)	Current density (A/m^2)	Colour (pt Co Units)	COD (mg/L)	Conductivity (mS/cm)	pH	Power consumption (kWh/m^3)	Sludge generation rate (g/L)
1	12	15	24502	451	303	33.8	9.42	162.2	.012650
2	4	15	1510	2110	735	32.4	9.38	10.2	.0026650
3	12	15	26987	461	307	33.7	9.55	174	.0137665
4	4	15	1755	2260	726	32.5	9.34	11.8	.0053030
5	4	3	1975	2750	466	31.6	9.48	2.6	.0013255
6	12	3	29632	1130	449	31.7	9.70	39.2	.0029368
7	12	3	30979	1150	642	32.7	9.85	41.0	.0035911
8	10	6	23265	800	693	32.3	9.66	61.6	.0047454
9	6.6	12.9	7731	910	346	32.2	9.52	44.02	.0058338
10	5.8	5.7	4497	1300	111	32.8	9.7	11.4	.0031878
11	9.6	12.6	18710	830	228	33.5	9.43	104	.0097032
12	8	9	6930	1260	553	30.8	9.55	27.5	.0037922
13	8	9	9853	1000	537	31.3	9.65	39.1	.0029834
14	8	9	12244	910	569	31.2	9.6	48.6	.0058584
15	12	9.6	28236	390	268	33.3	9.5	116.47	.0066545
16	7.6	3	10779	2130	651	39.5	9.34	14.2	.0030244
17	4	8.4	1551	2560	594	31.4	9.3	5.75	.0028710
18	4	8.4	1775	2060	570	30.8	9.32	6.58	.0026989
19	7.6	3	9538	2320	668	30.8	9.55	12.6	.0034668

Table 5.2.1: results by Aluminum electrodes

This experimental design consists of 19 experiments. Electrodes used are Al-Al and the volume of 370 mL.

Best result of COD comes to be 111 mg/L as compared to 756mg/L of original chloride rich waste water at 5.8 V 5.7 minutes with power consumption of 11.4 kWh/m^3. Hence removal efficiency is 85 % with sludge generation rate of .003 g/L

Color comes to be 390 Pt Co units as compared to 2135 Pt Co units at 12 v 9.6 minutes with power consumption of 116 kwh/m^3 . Hence removal efficiency is 81 % with sludge generation of .0066 g/L.

Second set-Fe-Al

Results:

S.No	Volt	Time (min)	Current density (A/m^2)	Colour (pt Co Units)	COD (mg/L)	Conductivity (mS/cm)	pH	Power consumption (kWh/m^3)	Sludge generation rate (g/L)
1	12	15	24122	94	866	33.4	11.1	155.52	.0110724
2	4	15	1685	72	874	33.1	11.5	10.86	.0030453
3	12	15	22468	98	850	33.2	11.4	144.4	.0091413
4	4	15	1510	198	819	32	10.9	9.73	.0032526
5	4	3	1869	278	820	32.1	9.94	1.203	.0012620
6	12	3	24244	32	529	32	11.15	31.2	.0036621
7	12	3	32448	32	498	31.3	10.07	41.8	.0044587
8	10	6	16326	76	717	34.1	10.3	42.10	.0047552
9	6.6	12.9	5111	141	702	31.3	11.88	28.3	.0039276
10	5.8	5.7	3497	280	717	33.2	10.3	8.56	.0023894
11	9.6	12.6	13087	86	717	33.9	11.3	70.8	.0059774
12	8	9	9265	73	411	33.1	10.8	35.8	.0052374
13	8	9	11355	49	378	32.9	11.2	43.9	.0054116
14	8	9	8506	142	396	31.7	10.4	32.9	.0041588
15	12	9.6	27428	58	835	31.8	10.5	113.17	.0059774
16	7.6	3	9771	55	655	31.3	10.4	12.6	.0027250
17	4	8.4	1542	57	906	31.8	10.5	5.57	.0020639
18	4	8.4	1424	69	976	31.4	10.19	5.14	.0017517
19	7.6	3	10678	38	702	32.3	10.6	13.77	.0024371

Table 5.2.2: showing results by Fe-Al electrodes

This experimental design consists of 19 experiments. Electrodes used are Fe-Al and the volume of 380 mL.

Best result of COD comes to be 378 mg/L as compared to 756mg/L of original chloride rich waste water at 8 V 9 minutes with power consumption of 44 kWh/m^3. Hence removal efficiency is 50 % with sludge generation rate of .004 g/L

Color comes to be 32 Pt Co units as compared to 2135 Pt Co units at 12 V 3 minutes with power consumption of 31.2 kwh/m^3. Hence removal efficiency is 99 % with sludge generation of .003 g/L

Third set-Iron

S.No	volt	Time (min)	Current density (A/m^2)	Colour (pt Co Units)	COD (mg/L)	Conductivity (mS/cm)	pH	Power consumption (kWh/m^3)	Sludge generation rate (g/L)
1	12	15	30367	32	552	35.3	11.55	187.11	.0067354
2	4	15	1918	63	242	33.3	12.11	12.11	.0036434
3	12	15	31193	26	405	34.9	11.45	189.39	.0088631
4	4	15	2408	43	230	31.9	11.52	15.12	.003817
5	4	3	1959	375	441	31.9	10.1	2.46	.001245
6	12	3	30244	87	331	31.9	10.45	38	.0033868
7	12	3	22775	89	405	31.7	10.42	28.6	.0030787
8	10	6	18622	84	204	32.2	10.32	46.7	.0039391
9	6.6	12.9	6175	92	242	31.9	10.6	33.36	.0035540
10	5.8	5.7	4598	133	149	31.7	10.3	10.9	.0022254
11	9.6	12.6	19180	42	767	32.	11.1	101.2	.0074139
12	8	9	10457	46	613	31.2	11.2	39.4	.0048499
13	8	9	10579	53	407	31.7	11.0	39.8	.0047037
14	8	9	12987	45	516	31.5	11.01	48.9	.0052674
15	12	9.6	33918	43	527	33.3	11.16	136.6	.0086390
16	7.6	3	8181	130	510	31.8	10.55	10.2	.0022660
17	4	8.4	2298	98	553	32.1	10.5	8.08	.0024882
18	4	8.4	2322	99	467	31.5	10.8	8.17	.0024742
19	7.6	3	9003	138	406	31.3	10.55	11.3	.0023714

Table 5.2.3: showing results by iron electrodes

This experimental design consists of 19 experiments. Electrodes used are Fe-Fe and the volume of 390 mL.

Best result of COD comes to be 149 mg/L as compared to 756mg/L of original chloride rich waste water at 5.8 V 5.7 minutes with power consumption of 11 kWh/m^3. Hence removal efficiency is 80 % with sludge generation rate of .002 g/L

Color comes to be 32 Pt Co units as compared to 2135 Pt Co units at 12 V 15 minutes with power consumption of 189 kwh/m^3 . Hence removal efficiency is 99 % with sludge generation of .008 g/L

Fourth set-steel

Results:

S.No	volt	Time (min)	Current density (A/m^2)	Colour (pt Co Units)	COD (mg/L)	Conductivity (mS/cm)	pH	Power consumption (kWh/m^3)	Sludge generation rate (g/L)
1	12	15	30342	12	63	35.9	11.90	196	.0087802
2	4	15	2163	30	674	32.1	10.88	14.9	.0034831
3	12	15	30000	10	72	36.4	11.63	198.04	.0089852
4	4	15	1575	47	690	33.2	10.5	10.7	.0030080
5	4	3	902	1950	771	31.8	10.24	1.22	.001312
6	12	3	31346	80	656	32.1	10.2	42.75	.003326
7	12	3	31102	83	567	31.8	10.21	42.33	.0037091
8	10	6	20102	38	616	32.5	10.98	54.7	.0046246
9	6.6	12.9	5785	44	412	32.1	10.90	33.8	.0045755
10	5.8	5.7	3042	274	728	31.9	10.0	7.86	.0018423
11	9.6	12.6	18710	41	132	32.6	11.6	106.96	.0076892
12	8	9	10302	44	150	33.3	11.17	40.8	.0054141
13	8	9	10293	57	228	31.7	10.27	42.0	.0049925
14	8	9	12612	53	268	32.1	11.07	51.5	.0050699
15	12	9.6	31345	11	268	33.2	11.37	136.5	.008385
16	7.6	3	6080	650	190	31.1	9.67	8.27	.0014403
17	4	8.4	702	970	632	31.4	9.58	2.67	.0015229
18	4	8.4	677	1160	672	31.6	9.68	2.58	.0017894
19	7.6	3	6987	478	133	31.7	9.52	9.25	.0016594

Table 5.2.4: showing results by steel electrodes

This experimental design consists of 19 experiments. Electrodes used are steel and the volume of 360 mL.

Best result of COD comes to be 63 mg/L as compared to 756mg/L of original chloride rich waste water at 12V 15 minutes with power consumption of 196 kWh/m^3. Hence removal efficiency is 91 % with sludge generation rate of .008 g/L

Color comes to be 10 Pt Co units as compared to 2135 Pt Co units at 12 V 15 minutes with power consumption of 198 kwh/m^3. Hence removal efficiency is 99.4 % with sludge generation of .008 g/L.

Chapter 6

Conclusion

Electro flocculation treatment process was used to treat textile dye wastewater for both sulphate and chloride rich from textile dye industry. For both waste waters a set of experimental design was made which is based on different voltage and time intervals and the treatment efficiency was accessed on the basis of color and COD removal efficiency. 4 different pair of electrodes was used – Fe-Fe, Al-Al, S-S, Fe-Al.

In case of sulphate rich waste water 4 different pair of electrodes was used. Voltage and time were fixed for each experiment and the results were accessed on the basis of COD and colour removal efficiencies. In this iron electrodes give the best results as COD removal efficiency was 84% and colour removal was 98%.

In case of chloride rich waste water 4 different pair of electrodes was used. Voltage and time were fixed for each experiment and the results were accessed on the basis of COD and colour removal efficiencies. In this iron and steel electrodes gave the better results as COD removal is about 80-90% and colour removal is above 95 %.

Thus both sulphate and chloride rich waste water from textile dye industry gave encouraging results with electro flocculation treatment process, so after pilot scale testing the process can be used on the industrial scale.

The sludge generation rate is less than treatment done chemically.

Chapter 7

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