Removal Of Cod From Sugar Industry Wastewater By Electrocoagulation Method

Adwitiya Bhattacharya[1], Swetal Gandhi[2], Shreeketu Patel[3], Dipal Ravalji[4], Mr. Manoj Kumar[5]
[1, 2, 3, 4]Dept of Environmental Science and Technology
[5]Assistant Professor and Project Guide
[1, 2, 3, 4, 5] Shroff S.R. Rotary Institute of Chemical Technology Vataria.

Abstract- *Sugar industry plays an important role in the economy of India by way of farming and creation of employment. The by-products of sugar mills are also used as raw materials in different industry. The sugar industry generates strong waste water characterized by high Chemical Oxygen Demand (COD) and Turbidity. Furthermore, the sugar industry is one of the largest sources of industrial effluents. Hence, the cost effective treatment of sugar effluent for environmental protection is a challenging task. The removal of pollutants from sugar industries waste water will be experimentally investigated using direct current Electro coagulation (EC). EC technology with Aluminium electrode in bipolar parallel system could be an attractive alternative for the treatment of sugar effluents. In the present work, an attempt was made for the treatment of sugar industry wastewater using Electro coagulation technique with aluminium electrodes as sacrificial anode in bipolar connection system.*

According to our experimental work, within 4 hrs the COD reduced from 5200 mg/L to 532 mg/ L. At 12 V, the COD removal efficiency was maximum. Thus, the electrolysis duration of 4 hrs, pH 6 and 12 V were found to be the critical operating parameters for the treatment of sugar industry waste water using Aluminium electrode and DC power supply. Maximum COD removal of 89.75 % was obtained at these optimum operating conditions.

Keywords- Sugar effluents, Electro-coagulation treatment, iron electrodes, COD, Turbidity,

I. INTRODUCTION

Effluent discharge from agro industries like sugar are characterized by high COD(chemical oxygen demand) due to their level of organic contents and this effluent contain milk and milk products with wash water [1]. Rapid urbanization and industrialization in the developing country like India pose severe problems in collection, treatment and disposal of effluents. This situation leads to serious public health problems. Unmanaged organic waste fractions from industries, municipalities and agricultural sector decompose in the environment resulting in large scale contamination of land, water and air. These wastes not only represent a threat to the environmental quality but also possess a potential energy cane crushed. Because of high value which is not fully utilized despite the fact that they are cheap and abundant on most parts of the world [2]. Large quantity of waste water originates due to their different operations. The organic substance in the wastes comes either in the form in which they were present in milk, or in a degraded from due to their processing. The sugar industry wastes are very often discharged intermittently. The nature and composition of waste depends on the type of products produced and size of the plant [3].Demands of clean industrial waste water to avoid environmental pollution and especially contamination of fresh water resources have become national and international issues. The increase in the volume of waste water discharge in to the environment that pollutes freshwater resources is the result of modification in the manufacturing processes. The sugar industry utilize around 1500-2000L of water and produce about 1000L of waste water per ton of cane crushed. The sugar manufacturing processes produce waste water contain Chemical Oxygen Demand (COD) is from 2300-8000mg/L, Biochemical Oxygen Demand (BOD) is from 1700-6600mg/L and Total Suspended Solids are up to 5000mg/L [4].

Sugar industry effluent is conventionally treated by adopting various physic-chemical and biological methods. These conventional processes suffer the disadvantage that the reagent costs are high and the soluble COD removal is low. Moreover, chemical treatments could induce a secondary pollution due to the fact that chemical additives may contaminate the treated water. Coagulants in addition to increasing the amount of sludge production increase the total solids in the effluents, adsorption process necessitates back washing and use of membranes has the problem of scaling and frequent membrane fouling. Convectional biological treatment systems for sugar factory wastewater may not be feasible due to large land space requirement as well as high capital and operational cost. Hence electrochemical treatment of sugar industry waste water may be considered as an economical alternative process when convectional treatment methods fail to reduce pollution [5]. The EC technique has been successfully used for the treatment of various wastewater such as Textile wastewater [6], Pharmaceutical wastewater [7], Paper industry wastewater [8], Hospital wastewater [9], Petrochemical industry wastewater [10] etc. Hence in the present study on the evaluation of efficiency of the electrocoagulation process on treatment of sugar industry wastewater using Iron electrodes.

III. THEORY OF ELECTROCOAGULATION

3.1 Principle

Electrocoagulation (EC) is a method of treating polluted water where sacrificial anodes corrode to release active coagulant precursors (usually aluminium or iron cations) into solution.

3.2 Mechanism of EC Process :

The EC is a process in which the anode material undergoes oxidation whereas the cathode subjected to reduction and hence, various monomeric polymeric metal hydrolyzed species are formed at the electrode surface [1]. These metal hydroxides remove organics from wastewater by sweep coagulation and/or by aggregating with the colloidal particles present in the wastewater to form bigger size flocs which ultimately are removed by settling [5]. Electro-coagulation is the process of destabilizing suspended, emulsified, or dissolved contaminants in an aqueous medium by introducing an electric current into the medium. In its simplest form, an electro-coagulation reactor may be made up of an electrolytic cell with one anode and one cathode [8]. An iron are usually used as electrodes and their cations are generated by dissolution of sacrificial anodes upon the application of a direct current investigated EC technologies for the treatment of wastewaters using iron and electrode materials. The result shows that from COD removal efficiency and energy consumption points of view, iron is superior to aluminium as a sacrificial electrode material [11].

At the anode:

$M_{(S)} \rightarrow Mn^{+}_{(aq)} + ne^{-}$
$2H_2O_{(l)} \rightarrow 4H^{+}_{(aq)} + O_{2\,(g)} + 4e^{-}$

At the cathode:

$Mn^{+}_{(aq)} + ne^{-} \rightarrow M_{(S)}$
$2H_2O_{(l)} + 2e^{-} \rightarrow H_{2\,(g)} + 2OH^{-}$

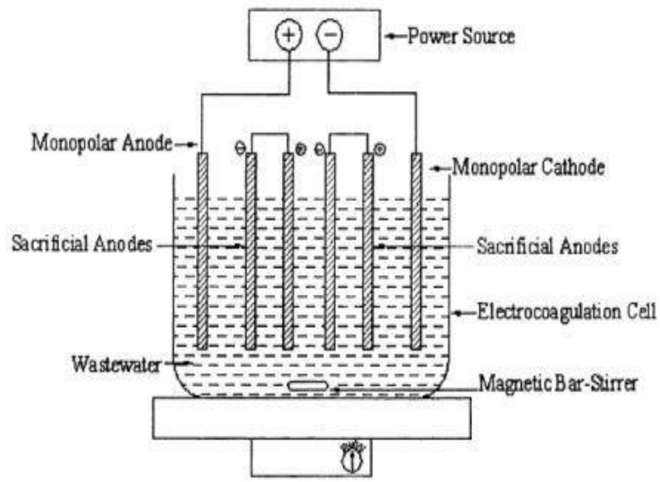


Figure 1 : Schematic Diagram of experimental set-up for Electrocoagulation Process

IV. MATERIALS AND METHOD

4.1 Sample and Materials :

The experimental work was done in our college named Shroff SR Rotary institute of Chemical Technology, Vataria, Valia, Bharuch, Gujrat,India. Aluminium sheet were purchased from local market. Measure dimension of the sheet was cut with a metal cutter and clean before used. Laboratory grade chemical was used according to advice from our guide and lab assistant. The waste water is carried out from the Sugar industry near to our college named Shree Ganesh Khand Udyog Sahkari Mandli Limited, located at Shri Harisinhji Mahida Bhavan, Vataria, Valia dist, Near Ankleshwar, Bharuch, Gujarat - 393001, India. Other materials and equipments used are COD digester, Ferroin Indicator, Potassium dichromate ($K_2Cr_2O_7$), Ferrous Aluminium Sulphate(FAS), H_2So_4 conc., Ag_2So_4, $HgSo_4$, Distilled water, Glass wares, Aluminium electrodes, Glass beaker, Magnetic stirrer, DC power supply, pH meter. These all chemicals, equipment and glass wares were available in our college laboratory.

4.2 Experimental Procedure:

First, for the electrocoagulation, the reactor made up of acrylic material with the dimensions of 30cm x 15cm x 12cm was used. The working volume of the reactor was 1L. The EC unit consisted of two Aluminium material electrodes connected with the DC power supply. The dimensions of the electrodes were 10cm x 5cm x 1mm.The representation of the experimental setup is shown in **Fig 3**. After the initial characterization of wastewater, experimental studies were conducted to optimize the various parameters such as pH, electrolysis time (ET), COD and voltage. Experiments were performed with two electrodes connected to the DC power supply to determine optimum conditions. In the bipolar connection of electrodes, there is no electrical connection between inner electrodes; only the outer electrodes are connected to the power supply. The space between the two electrodes was maintained 1cm in all the experiments. In each run, the voltage was varied to a desired value of 0, 2, 4, 8, 10 and 12V. To maintain homogenous mixing of the reactor content, magnetic stirrer is used. The wastewater concentration was reduced to half the strength throughout the study to reduce the time and current consumption and to obtain better efficiency. The EC experiments were performed for 4 hours and in each run samples were collected at every half an hour.

4.3 Experiment for analysing COD:

4.3.1 Objective

To determine the COD of given water or waste water sample.

4.3.2 Apparatus

Conical flask, Magnetic stirrer, Burette, Beaker, Pipette, Glass tube, COD digester.

4.3.3 Chemicals

0.1N Potassium dichromate solution
0.1N Ferrous ammonium sulphate solution (FAS)
$AgSO_4$ with concentrate H_2SO_4
$HgSO_4$ powder
Ferroin indicator.

4.3.4 Procedure

Take all glass wear and wash them with distilled water. Now take given waste water sample and dilute it with distilled water in ratio of 1:99 or 5:95. Make up it up to 100ml. Take conical flask or beaker and add 20ml diluted sample in it. Now add 10 ml of potassium dichromate ($K_2Cr_2O_7$) in it. Add 30ml of concentrated H_2SO_4 mixed with 0.4mg of $HgSO_4$. Mix it with magnetic stirrer. Now take blank solution as per the same procedure. Pour this solution of sample & blank in glass tube & put these glass tubes in COD digester with reflux condenser on it. Now allow for digestion up to 2 to 2.5 hrs at 150° C. After that take out and cooled it down for some time. Add this solution in beaker then add 6 to 8 drops of ferroin indicator and titrate this solution again ferrous ammonium sulphate solution till red wine colour appear from blue green. Note down this result for sample as well as blank solution.

4.3.5 Calculation formula

COD (mg/L) = (A-B) x N x 8 x 1000 / ml of sample taken

Where, A = ml of Ferrous ammonium sulphate used for blank
B = ml of Ferrous ammonium sulphate used for sample
N = normality of Ferrous ammonium sulphate
8 = mill equivalent weight of oxygen

4.3.6 Observation and Calculation :

Sample/Week	Blank Reading	Titration reading
Initial (Before treatment)	25.5	24.2
(After treatment) 1st	24	23.4
2nd	23.1	22.4

Table 1 : Observation Table

4.3.7 Calculation of COD:

- **Initial (befrore treatment) :**

$$COD = \frac{(25.5 - 24.2)\ x\ 0.1\ x\ 8000}{20\ x\ \frac{1}{100}}$$

= 5200 mg / l

- **Aftre Treatment : 1st reading**

$$COD = \frac{(24 - 23.4)\ x\ 0.1\ x\ 8000}{20\ x\ \frac{5}{100}}$$

= 532.015 mg/ l

- **2nd reading :**

$$COD = \frac{(23.1 - 22.4)\ x\ 0.1\ x\ 8000}{20\ x\ \frac{5}{100}}$$

= 533.33 mg/ l

- **Result and Discussion**

4.4.1 Result Table

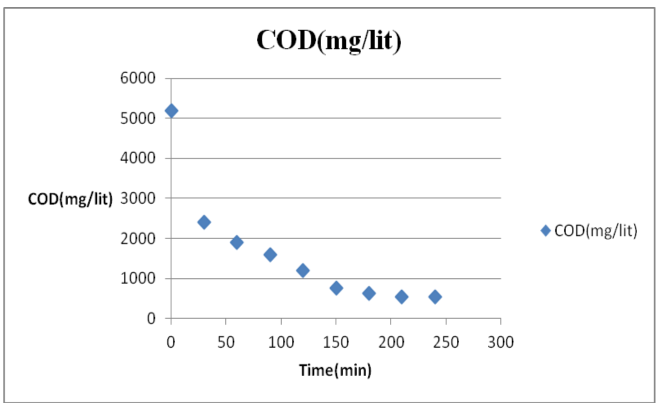
Sr NO.	Time interval (min)	COD removal (mg / l)
1	0	5200
2	30	2400
3	60	1900
4	90	1600
5	120	1200
6	150	750
7	180	620
8	210	533
9	240	532

Table 1: Readings of time interval and COD

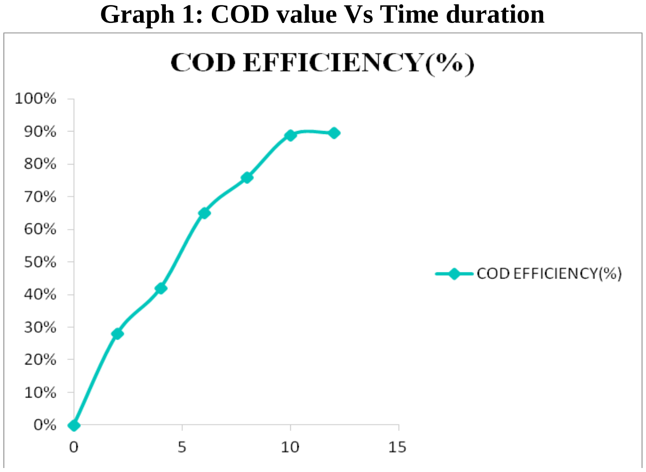
Sr No	Voltage (V)	COD Efficiency (%)
1	0	0
2	2	28
3	4	42
4	6	65
5	8	76
6	10	89
7	12	89.75

Table 2 : Readings of Voltage Difference and COD removal Efficiency

4.4.2 Graphical representation of removal efficiency of COD:



Graph 1: COD value Vs Time duration



Graph 2: COD efficiency Vs DC Voltage

The experiment is based on the electrocoagulation of the sugar industry wastewater with high concentration of COD for determining the effects of operating parameters such as pH, voltage and electrolysis time on COD removal. Initially the experiment was carried out by adjusting the pH 6 of the waste water with varying voltages. Within 4 hrs the COD reduced from 5200 mg/L to 2400 ,1900 , 1600 , 1200 , 750 , 620 , 532 and 532 mg/ L at time interval of 30 , 60 , 90 , 120 , 150 , 180 , 210 , 240 min respectively. With varying voltages the COD efficiency achieved was 72 %, 86 %, 89.75 % at 0V, 2V, 4V, 6V, 8V, 10V and 12V respectively. Thus the electrolysis duration of 4 hrs, pH 6 and 12 V were found to be the critical operating parameters for the treatment of sugar industry waste water using Aluminum electrode and DC power supply. Maximum COD removal of 89.75 % was obtained at these optimum operating conditions

V. ADVANTAGES

EC is a simple equipment and easy to work with adequate operational scope that can overcome most of the problems that may be encountered during the operation. The water after purification are palatable, clear, colorless, and without odor.The sludge produced during the process is ready to be set again and easy to be dried out, because they mostly contain metallic oxides and hydroxides. The flocs that are produced by EC are similar to the chemical flocs; however, it is expected to be larger and contain less bound water, be more stable and acide-resistant that can, consequently, be separated faster by filters.

In comparison with the chemical treatment, EC produces sewage that contains less total dissolved solids (TDS) contents. Consequently, if this water is going to be reused, the low TDS level requires lower recovery cost. The EC process removes the lower amount of colloidal elements, because the used electric field sets them in faster movement by which the coagulation is facilitated.

VI. DISADVANTAGES

'Coagulation' process is relatively time consuming process. 'Electrochemical' process is the saline (or acidic) electrolyte poses the risk of corrosion to tool, work piece and equipment. 'Coagulation' process is generate high sludge production The 'sacrificial electrodes' are dissolved into wastewater streams as a result of oxidation, and need to be regularly replaced. The use of electricity may be expensive in many places. An impermeable oxide film may be formed on the cathode leading to loss of efficiency of this unit. High conductivity of the wastewater suspension is required. Gelatinous hydroxide may tend to solubilize in some cases.

VII. COMPARISON

Electrocoagulation (EC) utilizes methods that precipitate out large quantities of contaminants in one operation, the technology is the distinct economical and environmental choice for industrial, commercial and municipal waste treatment. The capital and operating costs are usually significantly less than chemical coagulation.

Chemical precipitation in wastewater treatment involves the addition of chemicals to alter the physical state of dissolved and suspended solids and to facilitate their removal by sedimentation. The chemicals used in wastewater treatment include Alum, Ferric chloride, Ferric sulphate, ferroussulphate, and Lime. The inherent disadvantages associated with most chemical unit processes is that they are additive processes. This problem is eliminated in the Electrocoagulation process. These chemicals are not only expensive, but, more importantly, the net increase in the dissolved constituents in the wastewater render it impractical or impossible to reuse.

Electrocoagulation uses electricity to precipitate the dissolved and suspended solids. The total dissolved solids in the liquid usually decrease by 60 percent or more. This enables the water to be reused in many applications, such as water reuse in steam cleaning operations. Electrocoagulation produces a cleaner water than either chemical precipitation or sedimentation.

The total sludge generated by EC contains less than 0.5 percent added coagulant. Total sludge generated by Chemical precipitation contains 49 percent added coagulant. The added sludge generated by chemical precipitation effectively doubles the sludge disposal volume. Electrocoagulation can produce an environmentally friendly sludge in the 6 to 7 pH range. Chemical precipitation on the other hand, usually creates a sludge in the caustic pH range above 10.

VIII. CONCLUSION

As per our project experimental work, we can say that electrocoagulation is more efficient and cost reliable as compare to other process for the removal of COD from Sugar industry wastewater and for its treatment. Aluminum electrodes are found to be more efficient as compare to iron electrodes. Thus have performed the experiment by using Aluminum electrodes and by applying DC power supply.

REFERENCES

[1] ChethanMarol, DattatreyaNarale, RajeshwariNagaral, SiddalingTalwar, GurappagoudBirdar “Treatment of Sugar Industry Waste Water by Electro Coagulation (EC) Technique” IJSTE-International Journal of Science Technology & Engineering | Volume 2 | Issue 11 | May 2016.

[2] ChethanMarol, SiddalingTalwar, DattatreyaNarale, GurappagoudBirdar, RajeshwariNagaral “Removal of Cod and Turbidity by ElectroCoagulation (EC) Technique” IJSRD-International Journal of Scientific Research &Devlopment | vol 4, Issue 03, 2016.

[3] ChetanMarol, SiddalingTalwar, DattatreyaNarale, “Treatment of Sugar Industry Waste Water by Electro Coagulation (EC) Technique” International Journal of Advance Engineering And Research Devlopment | volume 3, Issue 5, May-2016.

[4] Prof.Shrti A Byadgi, Prof.MAnjunath S Sharanappanavar, Mr.BasavarajDhamoji, Mr. Asif Nadaf, Mr.SiddarameshMunennavar “Treatment of Sugar Industry Waste Water using Zinc Electrodes” IJETSR-International Journal of Engineering Technology Science and Research | Volume 4, Issue 6, June 2017.

[5] C. B. Shivayogimath, RashmiJahagirdar “Treatment of Sugar Industry WasteWater using ElectroCoagulation Technique” IJRET-International Journal of Research in Engineering and Technology.

[6] NehaTyagi, Sanjay Mathur, Dineshkumar“ Electrocoagulation Process for Textile Wastewater treatment in continuous upflow reactor” Journal of Scientific & Industrial Research, vol 73, March 2014.

[7] HadjiraKermet-Said, NadjiMoulai-Mostefa “Optimization of Turbidity and COD Removal from Phamaceutical Wastewater by Electrocoagulation. Isotherm Modeling and cost analysis” Pol. J. Environ. Stud. Vol.24, No 3(2015).

[8] Walid K. Lafi“ Electro-coagulation Treatment of wastewater from Paper Industry” ISBN. Recent Research in Energy, Environment, Devices Systems, Communication and Computers.

[9] MansoorehDehghani, SomeihShiebani, Hassan Hashemi “Treatment of hospital wastewater by electrocoagulation using aluminium and iron electrodes” International Journal of Environmental Health Engineering | volume 2 Issue 5 | September – October 2013.

[10] E.M. Nassef, Y.A.El-taweel, O.Abdelwahab “Treatment of Petrochemical wastewater containing phenolic compound by Electrocoagulation using a fixed bed Electrochemical reactor. International Journal of Electrochemical Science 2013.

[11] M.F. Ni'am*, F. Othman** , J. Sohaili** and Z. Fauzia** "Electrocoagulation technique in enhancing COD and suspended solids removal to improve wastewater quality" Water Science & Technology Vol 56 No 7 pp 47–53.

[12] Rumi Chaudhary, O.P. Sahu "Treatment of Sugar Waste Water by Electrocoagulation" Journal of Atmospheric Pollution, 2013, Vol. 1.

[13] Prof.Shruti A Byadgi, Prof.Manjunath S Sharanppanavar, Mr. Basavaraj Dhamoji, Mr. Asif Nadaf, Mr.Siddaramesh Munennavar "Treatment of Sugar Industry Waste Water using Zinc Electrodes" IJETSR-International Journal of Engineering Technology Science and Research Volume 4, Issue 6, June 2017.

[14] M.F. Ni'am, F.Othman, J.Sohaili, Z.Fauzia "Electrocoagulation technique in enhancing COD and suspended solids removal to improve wastewater quality" Water Science& Technology Vol.56 No.7 2007.