

A Study on the Effectiveness of Electrochemical Treatment of Wastewater Collected from Sugar Industry in Western Maharashtra Region of India Using Iron and Aluminum Electrodes

Ankush Rameshwar Bhangе¹, Dr. Abhijit Kundu²

¹Ankush Bhangе, Student G.H.Raisoni University, Amravati Maharashtra, India

²Prof, Dept. Of Civil Engineering, GH Raisoni University, Amravati Maharashtra, India

Abstract - This study investigates the effectiveness of electrochemical treatment for wastewater collected from sugar industries in the Western Maharashtra region of India, utilizing iron and aluminum electrodes. The sugar industry, a significant contributor to wastewater pollution in the region, generates effluents with high organic load, suspended solids, and chemical contaminants. Traditional treatment methods often fail to meet the required standards due to high treatment costs and complexity. Electrochemical treatment, known for its efficiency and relatively low environmental impact, offers a promising alternative for wastewater management. The research explores the performance of iron and aluminum electrodes in removing contaminants from the wastewater, analyzing parameters such as chemical oxygen demand (COD), biochemical oxygen demand (BOD), total suspended solids (TSS), and color removal. Various operational factors, including current density, electrode material, and treatment duration, were optimized to assess the maximum pollutant removal efficiency. Experimental results will be analyzed for parameters such as turbidity, chemical oxygen demand (COD), and concentrations of specific contaminants before and after treatment. Additionally, the comparative performance of iron and aluminum electrodes will be assessed based on removal rates, energy efficiency, and operational stability. The findings of this study are expected to provide valuable insights into the practical application of electrochemical treatment for wastewater, offering an effective and sustainable solution for water purification. The project will contribute to the development of optimized electrochemical treatment systems that could potentially be applied at various industrial scales to address the growing concerns of wastewater contamination.

Key Words: Electrochemical treatment, Electrocoagulation (EC), Electro flotation (EF), Iron electrodes, Aluminium electrodes, Contaminant removal efficiency.

1.INTRODUCTION

Electrochemical treatment of industrial wastewater has garnered attention as an effective method for removing pollutants, especially in regions with high industrial activity. The sugar industry in Western Maharashtra, India, generates large volumes of wastewater, which contains high

concentrations of organic matter, suspended solids, and various chemicals. Traditional treatment methods, such as biological treatment and chemical coagulation, often struggle to meet stringent effluent standards while also being cost-effective and energy efficient. The sugar industry in Western Maharashtra plays a pivotal role in the region's economy, contributing significantly to agricultural production and rural employment. However, the industry also generates large volumes of wastewater containing high levels of organic matter, suspended solids, and various chemical pollutants, which pose severe environmental and health risks. The untreated or inadequately treated effluent from sugar mills can lead to contamination of water bodies, degradation of aquatic ecosystems, and adverse effects on public health, especially in water-scarce regions like Maharashtra.

1.1 METHODOLOGY

The wastewater samples were collected from the effluent discharge point of Agasti Sugar Industry, situated in Akole district, Ahilyanagar, Maharashtra. This location was chosen due to its direct discharge of untreated or partially treated wastewater, which is representative of the effluent generated by the sugar industry in this region. Along with the raw sample from effluent discharge point, I have collected sample from the treatment plant of sugar industry after pretreatment processes in PST (like sedimentation) and after the complete treatment.

Below are some photographs from site visit,





Table 1.1- Effluent chemical characteristics

| Sr No | Parameters | Values |
|-------|------------------------|-----------------|
| 1 | pH | 5.0 |
| 2 | Colour | Greenish Yellow |
| 3 | Total Dissolved Solids | 1440mg/lit |
| 4 | BOD5 | 1850mg/lit |
| 5 | COD | 5400mg/lit |

1.2 Materials & Methods

Iron Electrodes: Iron electrodes are effective in generating Fe^{3+} ions, which are strong coagulants. They are also relatively inexpensive and widely available.

Aluminum Electrodes: Aluminum electrodes generate Al^{3+} ions, which are also effective coagulants. They are particularly useful in removing organic pollutants and colour from wastewater.

Laboratory Setup: The reactor made up of plastic material with the dimensions of 14cm x 9cm x 15cm was used. The working volume of the reactor was 1L. The EC unit consisted of four iron electrodes connected as bipolar system in the reactor and DC power supply. The dimensions of the electrodes were 5cm x 5cm x 1mm.

1.3. Experimental Procedure: 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 four electrodes was maintained 1cm in all the experiments. In each run the voltage was varied to a desired value of 8, 10 and 12V. To maintain homogenous mixing of the reactor content, magnetic stirring unit 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.

2. RESULTS & DISCUSSION

Wastewater sample was collected from the Agasti sugar industry and was characterized by quality parameters. To maintain secrecy & not to have any conflict of interest the officials from sugar industry shared the results of raw wastewater effluent orally for study purpose. The various parameters of wastewater are shown in Table 1.1,

In order to have lesser load on electrochemical treatment & for cost effectiveness, effluent wastewater is first treated with pretreatment methods such as sedimentation. After allowing the wastewater in PST for 5 hours of detention time. Collective sample from PST is also tasted. In pretreatment methods some impurities are removed and parameters reduced are shown in table 1.2,

Table 1.2- Wastewater chemical characteristics after pretreatment methods

| Sr No | Parameters | Effluent Values | After pretreatment methods | % Removal |
|-------|------------------------|-----------------|----------------------------|-----------|
| 1 | pH | 5.0 | - | |
| 2 | Colour | Greenish Yellow | - | |
| 3 | Total Dissolved Solids | 1440mg/lit | 775 | 46.2 |
| 4 | BOD5 | 1850mg/lit | 1155 | 37.6 |
| 5 | COD | 5400mg/lit | 3440 | 36.3 |

The wastewater sample is then taken to lab for electrochemical treatment.

The study was mainly focused on the electrocoagulation of the sugar industry wastewater with high concentration of COD for determining effects of operating parameters such as pH, voltage and electrolysis time on COD, BOD and TDS removal.

Initially, the experiment was carried out without adjusting pH of raw wastewater at pH 5 with varying voltages. The COD reduced from 3440mg/L to 740 and 550 mg/L thereby giving 78.5% and 84% COD removal efficiencies respectively for 10V and 12V at 4 hours, almost same results are obtained for BOD5 as well (Table 1.3). However, the COD removal efficiencies remained nearly same for 5 hours of electrolysis time. The TDS reduced from 775mg/lit to 380 and 290 mg/lit thereby being 73.6%, 79.8% efficient in removing TDS from wastewater respectively for 10V and 12V at 4 hours (Table 1.3). The TDS removal efficiencies also did not change further for 5 hours of electrolysis duration. Next the experiment was

carried out by increasing pH to 6.0 with different voltages 10V and 12V and maximum COD removal efficiencies of 80.4% and 90.3% respectively were obtained for 4 hours (Table 1.5) which remained constant for 5 hours of electrolysis time. Similarly, maximum TDS removal efficiencies of 77.1% and 81.9% for 4 hours (Table 1.5) were obtained. Similarly, tests were conducted using aluminum electrodes with variation in parameters as mentioned above for iron electrodes. Test results is as follows,

Table 1.3 – Summary of test results at operating pH 5

| Parameter | Raw Effluent | PST | | Electrical Coagulation-Iron Electrodes (4Hours) | | | |
|------------|--------------|------|------|---|------|---------|------|
| | | 3h | R% | 10 Volt | | 12 Volt | |
| | | | | 4 hr | R% | 4 hr | R% |
| COD (mg/L) | 5400 | 3440 | 36.3 | 740 | 78.5 | 550 | 84.0 |
| BOD (mg/L) | 1850 | 1155 | 37.6 | 280 | 75.8 | 180 | 84.4 |
| TDS (mg/L) | 1440 | 775 | 46.2 | 380 | 73.6 | 290 | 79.9 |

Table 1.4 – Summary of test results at operating pH 5

| Parameter | Raw Effluent | PST | | Electrical Coagulation-Aluminium Electrodes (4Hours) | | | |
|------------|--------------|------|------|--|------|---------|------|
| | | 3h | R% | 10 Volt | | 12 Volt | |
| | | | | 4 hr | R% | 4 hr | R% |
| COD (mg/L) | 5400 | 3440 | 36.3 | 970 | 71.8 | 695 | 79.8 |
| BOD (mg/L) | 1850 | 1155 | 37.6 | 380 | 67.1 | 270 | 76.6 |
| TDS (mg/L) | 1440 | 775 | 46.2 | 470 | 67.4 | 360 | 75.0 |

Table 1.5 – Summary of test results at operating pH 6

| Parameter | Raw Effluent | PST | | Electrical Coagulation-Iron Electrodes (4Hours) | | | |
|------------|--------------|------|------|---|------|---------|------|
| | | 3h | R% | 10 Volt | | 12 Volt | |
| | | | | 4 hr | R% | 4 hr | R% |
| COD (mg/L) | 5400 | 3483 | 35.5 | 680 | 80.5 | 300 | 91.4 |
| BOD (mg/L) | 1850 | 1156 | 37.5 | 240 | 79.2 | 100 | 91.4 |
| TDS (mg/L) | 1440 | 772 | 46.4 | 330 | 77.1 | 260 | 81.9 |

Table 1.6 – Summary of test results at operating pH 6

| Parameter | Raw Effluent | PST | | Electrical Coagulation-Aluminium Electrodes (4Hours) | | | |
|------------|--------------|------|------|--|------|---------|------|
| | | 3h | R% | 10 Volt | | 12 Volt | |
| | | | | 4 hr | R% | 4 hr | R% |
| COD (mg/L) | 5400 | 3483 | 35.5 | 890 | 74.4 | 630 | 81.9 |
| BOD (mg/L) | 1850 | 1156 | 37.5 | 290 | 74.9 | 220 | 81.0 |
| TDS (mg/L) | 1440 | 772 | 46.4 | 420 | 70.8 | 320 | 77.8 |

3. CONCLUSIONS

Based on the experimental findings, the electrolysis duration of 4 hours, pH 6.0 and 12V were found to be the critical operating parameters for the treatment of wastewater using iron as electrode material. Maximum COD removal of 91.4% and TDS removal of 81.9% were obtained at these optimum operating conditions. Hence, it can be concluded that the electrochemical technology using iron electrodes appears to be a feasible alternative for the treatment of sugar industry wastewater. Thus electrochemical treatment along with pretreatment methods is an efficient process for treatment of sugar industry wastewater which is fast and easy and can be operated using less equipment and limited space.

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