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Wastewater Treatment on Paper & Pulp Industry by Electro-Coagulation

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ABSTRACT –

The study analysed how operating parameters like initial pH, TDS, EC, BOD, COD, and electrolyte concentration affect colour removal and energy use. Findings showed that colour removal improved with longer electrolysis time, higher current density, increased sodium chloride concentration, and the use of multiple electrodes. The best results were achieved at an initial pH of 6.5–8.5, 120 minutes of operation, a current density of 61.8, and specific anode-cathode arrangements. The results confirmed that electrocoagulation is more effective than adsorption for treating paper and pulp wastewater, as evidenced by the significant colour change after treatment.

Key Words: Electrocoagulation, wastewater treatment, effluent, BOD reduction

1.INTRODUCTION

Electrocoagulation (EC), a process involving the application of electric current through water, has been shown to effectively remove contaminants. Also referred to as short-wave electrolysis, this method is widely used for treating water, wastewater, industrial process water, and hospital effluents. It is particularly effective for removing organic pollutants that are resistant to biodegradation. In this study, wastewater from the paper and pulp industry was treated using the electrocoagulation process with monopolar aluminum electrodes as both anode and cathode. The experiments were conducted in a 2.5 L electrochemical cell with monopolar aluminum electrodes arranged in parallel. The research investigated how factors such as initial pH, TDS, EC, BOD, COD, and electrolyte concentration influence removal efficiency and energy consumption.

2. Problem Statement

2.1 Problem identified:

1. Wastewater often contains significant quantities of chemicals, which can cause serious environmental issues, including elevated chemical oxygen demand (COD).
2. Removal of solid particles from water.

2.2 Justifications:

1. Electrocoagulation (EC) treatment produces water that is clear, colourless, and free of odour.
2. EC is more effective compared to traditional water treatment methods.
3. Treating wastewater helps minimize risks to human health.
4. It aids in preventing the transmission of waterborne diseases.
5. EC is versatile and can purify various contaminants present in wastewater.

3. OBJECTIVES OF THE STUDY

Primary Objectives of Wastewater Treatment:

1. Explore different methods of wastewater treatment.
2. Investigate the electrocoagulation process.
3. Develop and design an experimental setup.
4. Analyze waste generated by the paper and pulp industry.
5. Treat industrial wastewater and evaluate its treatment efficiency.

4. LITERATURE REVIEW

The extensive literature survey has been carried out through various sources. The comprehensive review of literature is presented below:

A) Doaa Bassyouni, Safaa Ali, Abdel-Aziz, and Elsayed Elashtoukhy: This research focuses on treating black liquor effluent from the Rakta Paper and Paper Company mill, which utilizes rice straw as a raw material for paper fiber production. The treatment was conducted using the electrocoagulation method with monopolar aluminum electrodes. Experiments were performed in a 2.5 L electrochemical cell, equipped with monopolar aluminum electrodes arranged in parallel. The study analyzed the effects of operating parameters, including initial pH, current density, number of plates, and electrolyte concentration, on removal efficiency and power consumption.

B) K.S. Parama Kalyani: The pulp and paper industry are a highly water-intensive chemical process sector and a significant source of environmental pollutants, such as black liquor. Effluent from this industry is rich in organic matter, suspended solids, intense color, Biological Oxygen Demand (BOD), and Chemical Oxygen Demand (COD). Limitations of conventional treatment methods have driven industries and researchers to seek more effective approaches for the complete degradation of pollutants.

C) Ravi Shankar and Lovjeet Singh: This study examines the treatment of pulp and paper industry wastewater using electrocoagulation in a batch reactor, with aluminum as the sacrificial electrode. The research investigates the influence of parameters such as pH, treatment duration, current density, and the distance between electrodes on the removal of Chemical Oxygen Demand (COD), Total Organic Carbon (TOC), and color. Optimum process conditions were determined based on the findings.

D) Zakaria Al-Qodah & Mohammad Al-Shannag: This detailed review explores the fundamental principles of electrocoagulation (EC), including its mechanisms, kinetic models, and isotherm models as studied by various researchers. The review also examines the effects of key design and operational parameters on removal efficiency. The authors provide valuable conclusions and perspectives to guide future research in this area.

5. METHODOLOGY

5.1 Collection of Original Wastewater Sample

The original wastewater sample was obtained from the paper industry from nearby areas in Nagpur region. The wastewater sample was dark in colour containing large number of organic solids.

5.2 Chemical Analysis of Wastewater

The collected wastewater sample underwent analysis for various parameters, including colour, pH, Total Dissolved Solids (TDS), Electrical Conductivity (EC), and Biological Oxygen Demand (BOD). The results of the chemical and physical analyses of the wastewater sample are summarized in Table.1

4.2 **PARAMETER**	**VALUES**
Ph	9.24
TDS	810ppm
EC	1490 mg/l
COLOR	COKE

5.3 Design and Fabrication of Electrocoagulation Unit

An electrocoagulation (EC) reactor, in its basic design, consists of an electrolytic cell with two sacrificial electrodes measuring 13 mm x 80 mm. The electrodes are spaced 1.5 cm apart, and each has a total surface area of 1.04×10^{-3} m². These electrodes are mounted on a wooden strip, allowing movement via an external power source. A DC power supply provides 12V (0.12A) to the system. The rotation of the electrodes can be adjusted through a mechanism on the wooden strip. The setup includes a schematic representation of the EC cell with mobile electrodes and a circuit diagram illustrating the power supply to the electrodes using a 12V DC motor

5.4 Electrocoagulation route for treatment of wastewater

A wastewater sample of approximately 1.5 liters was treated using the electrocoagulation (EC) process. The treatment was conducted over time intervals ranging from 0 to 2 hours, while keeping parameters such as current density, pH, and rotational speed constant. Aluminum and iron were chosen as suitable electrodes, arranged in parallel, for the EC process. These materials acted as sacrificial anodes in electrolytic oxidation experiments, while stainless steel served as the cathode in both setups. When connected to an external power supply, the anodes underwent electrochemical corrosion due to oxidation, while the cathode experienced passivation. The study also aimed to compare the performance of aluminum (Al) and iron (Fe) electrodes in reducing pollution from paper mill effluent and simultaneously producing hydrogen during the EC process. Chemicals utilized in the process:

1. Manganese sulphate
2. Alkali-iodide azide
3. Sodium thiosulfate
4. Sulfuric acid
5. Starch solution

5. RESULTS

5.1 Testing of Sample 1

Sr. No.	Property	Influent Characteristics	Effluent Characteristics	% Removal
1.	pH	9.01	7.60	18.55%
2.	TDS	750ppm	495ppm	51.52%
3.	EC	1498mg/l	985mg/l	52.15%
4.	BOD	2.08mg/l	1.12mg/l	85.71%

5.2 Testing of Sample 2

Sr. No.	Property	Influent Characteristics	Effluent Characteristics	% Removal
1.	pH	9.75	7.71	26.46%
2.	TDS	848ppm	552ppm	53.63%
3.	EC	1562mg/l	994mg/l	57.15%
4.	BOD	3.15mg/l	1.75mg/l	80.12%

5.3 Testing of Sample 3

Sr. No.	Property	Influent Characteristics	Effluent Characteristics	% Removal
1.	pH	8.95	7.55	18.54%
2.	TDS	830ppm	512ppm	62.10%
3.	EC	1410mg/l	895mg/l	57.55%
4.	BOD	2.76mg/l	1.45mg/l	89.94%

5.4 Average Result

SR. NO.	PROPERTY	%REMOVAL
1.	pH	21.26%
2.	TDS	55.77%
3.	EC	55.54%
4.	BOD	85.42%

The expected result is that the successful treatment of paper & pulp industry with all the parameters within permissible standards.

1. Wastewater of the industry is now permissible to get disposed as it is safe.
2. As per APHA, CPCB & SPCB, the disposal standard of wastewater is in permissible standard.
3. BOD should be less than 10mg/l & pH is in between7.5-8.5 as per APHA.
4. Under optimum operating conditions, the removal percentage of pH, TDS, EC & BOD is 21.26%, 55.77%, 55.54% & 85.42%

6. CONCLUSIONS

In this case study, the electrocoagulation treatment for paper industry effluent achieved an efficiency of 80%. The effluent was treated using iron and aluminum as sacrificial anodes. The mobile electrode setup used in the electrocoagulation process made the batch model more innovative. Agitation was found to

enhance the contact between the electrodes and the pollutant ions in the wastewater, leading to improved coagulation without the need for electrolyte salts. The results were highly promising, with the aluminum electrode showing better removal efficiency than the iron electrode. However, these findings are based on the electrode dimensions mentioned earlier, and the results could differ with different electrode sizes. The process steps are simple, efficient, and effective for treating paper and pulp industry effluent.

7. PHOTOGRAPHS OF THE STUDY

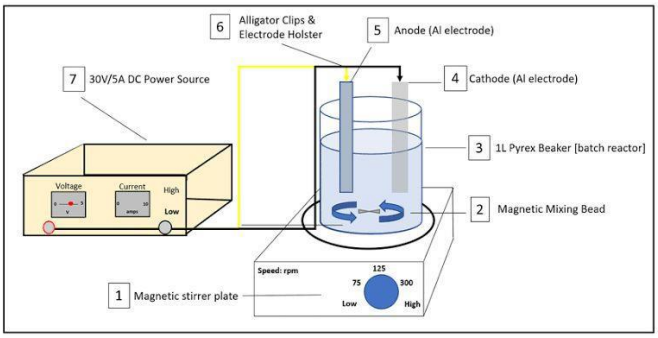

Fig -1 Implementation of Electrocoagulation Set-up

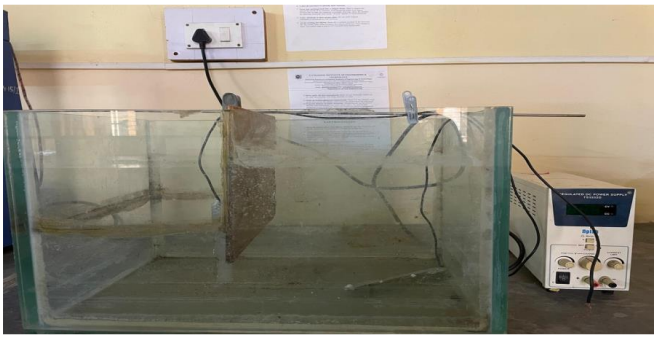

Fig -2 Lab Set-up of Electrocoagulation

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