# HYBRID ELECTRO-CHEMICAL COAGULATION PROCESS FOR WASTEWATER TREATMENT

***Project Reference No.:*** *48s_Be_0403*

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**Keywords:**

Electrocoagulation, wastewater treatment, Contaminant removal, chemical coagulants, Industrial applications, Energy-efficient, Sustainable technology.

**Introduction**:

Water pollution is a growing concern due to rapid industrialization and urbanization, leading to the discharge of complex and hazardous wastewater. Traditional treatment methods often fall short in effectively removing all contaminants. The Hybrid Electro-Chemical Coagulation (HECC) process has emerged as an innovative solution, combining the advantages of electrocoagulation and chemical coagulation.

In this process, an electric current is passed through aluminium electrodes in the wastewater, generating coagulants through electric current. Before the process, chemical coagulants are added to enhance the current conductivity and contaminant removal efficiency. This dual mechanism improves the destabilization and aggregation of suspended particles, making it highly efficient in treating a wide range of pollutants including heavy metals, dyes, and organic compounds.

HECC is known for its high removal efficiency, reduced chemical usage, and minimal sludge generation. It is particularly suitable for treating industrial wastewater and can be adapted for both large and small-scale operations. Additionally, its potential for automation and precise control makes it a sustainable and cost-effective alternative to conventional methods.

Overall, the Hybrid Electro-Chemical Coagulation process offers a robust, efficient, and eco-friendly approach to modern wastewater treatment challenges.

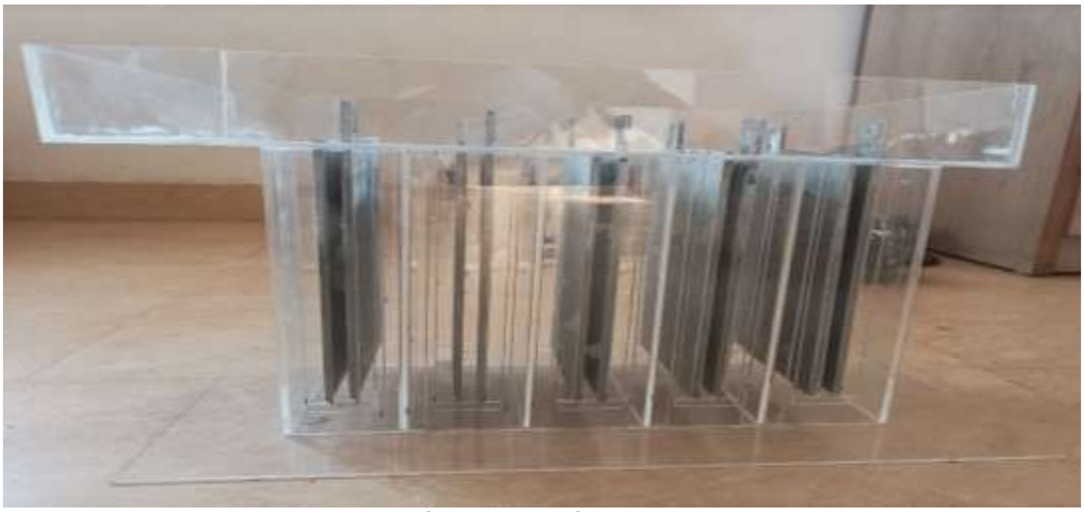
**Objectives:**

1. To fabricate a working model for Hybrid Electro-Chemical Coagulation in Continuous pattern.
2. To optimizes the process parameters for the treatment of Industrial waste water.
3. Aiming to scale up for the pilot plant design.
4. To develop a Hybrid Electro-Chemical Coagulation process and apply AI modelling to optimize treatment parameters for efficient and cost-effective wastewater purification.

**Methodology:**

1. Design: The tank has been fabricated by Perspex material in the department of chemical engineering, SDMCET, Dharwad.
2. Pre-treatment: Filter wastewater to remove large suspended particles and adjust pH if needed.
3. Electrocoagulation Setup: Place aluminium or iron electrodes in a tank, connected to regulating power supply.
4. Chemical Coagulation: pre-determined dosage of chemical coagulants was added before sending to the tank (e.g., Sodium hexa meta phosphate, Poly aluminium chloride, DK Set)
5. Reaction: Operate the system for a defined time (15–60 minutes), allowing pollutant removal through floc formation.
6. Post-treatment: Treat the effluent further, if necessary, for reuse or discharge.

Optimize process parameters (pH, coagulant dose, and residence time) based on wastewater characteristics



Figno.1 front view of process tank

Fig no.2 Top view of process tank

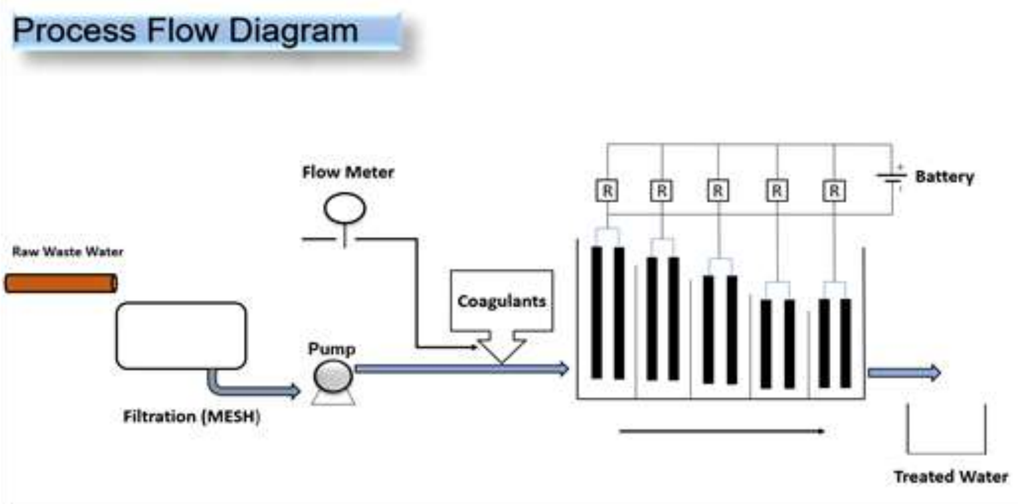



Fig no.3

**Result and Conclusion:**

**Series Connection:**

In a series connection of electrodes, current flows through each electrode consecutively, with the total voltage divided among them. This setup ensures uniform current distribution and minimizes power losses, making it suitable for large-scale systems like wastewater treatment and electroplating. However, careful design is required to maintain efficiency and balance across all electrodes.

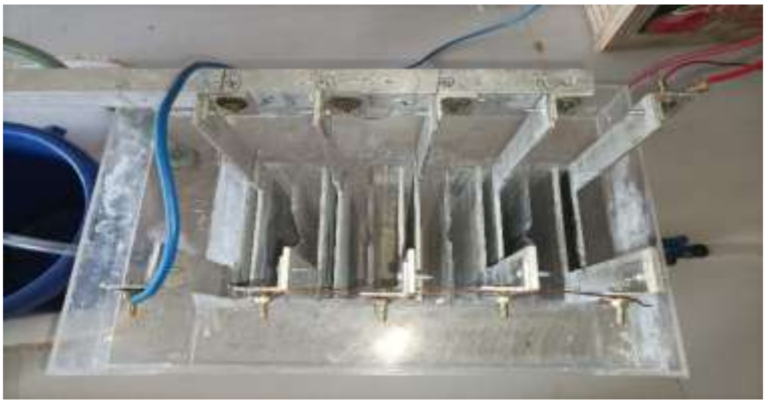


**Fig no.4 series connection of electrode**

**Parallel Connection:**

In a parallel connection of electrodes, each electrode is connected across the same voltage source, allowing current to flow through multiple paths simultaneously. This configuration ensures that the voltage across each electrode is the same, while the total current is the sum of the currents through each path. Parallel connections are beneficial for increasing the overall surface area for reactions and improving efficiency in electrochemical processes.

**Fig no. 5 parallel connection of electrode**

Conclusion: A series connection is not feasible for our setup because, for efficient current flow, the water must pass through all the chambers at once, ensuring uniform exposure to the electrodes. In a series configuration, the current would have to flow sequentially through each chamber, which would not allow for simultaneous treatment of the water, compromising the overall effectiveness of the process.

**Table no.1 Characterization of Laundry wastewater**

| SR .NO | PARAMETER | UNIT | RESULTS |
|---|---|---|---|
| 1 | pH | - | 10.00 |
| 2 | COD | mg/L | 420.6 |
| 3 | Turbidity | NTU | 131.4 |
| 4 | TDS | Mg/L | 290.0 |
| 5 | Nitrate | Mg/L | BDL |

**The Waste Water is treated in every chamber of the tank: [ 25V =10A]**

**Table no.2 Characterization of Treated Water from chamber 1**

| **SR .NO** | **PARAMETER** | **UNIT** | **RESULTS** |
|---|---|---|---|
| 1 | pH | - | 10.00 |
| 2 | COD | mg/L | 415.8 |

| | | | |
|---|---|---|---|
| 3 | Turbidity | NTU | 123.87 |
| 4 | TDS | Mg/L | 282.67 |
| 5 | Nitrate | Mg/L | BDL |

**Table no.3 Characterization of Treated Water from chamber 2**

| SR .NO | PARAMETER | UNIT | RESULTS |
|---|---|---|---|
| 1 | pH | -- | 10.00 |
| 2 | COD | mg/L | 411.6 |
| 3 | Turbidity | NTU | 116.98 |
| 4 | TDS | mg/L | 275.36 |
| 5 | Nitrate | mg/L | BDL |

**Table no.4 Characterization of Treated Water from chamber 3**

| SR .NO | PARAMETER | UNIT | RESULTS |
|---|---|---|---|
| 1 | pH | - | 10.00 |
| 2 | COD | mg/L | 408.7 |
| 3 | Turbidity | NTU | 109.54 |

| | | | |
|---|---|---|---|
| 4 | TDS | Mg/L | 267.54 |
| 5 | Nitrate | Mg/L | BDL |

**Table no.5 Characterization of Treated Water from chamber 4**

| SR .NO | PARAMETER | UNIT | RESULTS |
|---|---|---|---|
| 1 | pH | - | 10.00 |
| 2 | COD | mg/L | 406.12 |
| 3 | Turbidity | NTU | 101.78 |
| 4 | TDS | Mg/L | 259.78 |
| 5 | Nitrate | Mg/L | BDL |

**Table no.6 Characterization of Treated Water from chamber 5**

| SR .NO | PARAMETER | UNIT | RESULTS |
|---|---|---|---|
| 1 | pH | - | 10.00 |
| 2 | COD | mg/L | 405.6 |
| 3 | Turbidity | NTU | 95.12 |
| 4 | TDS | Mg/L | 251.23 |

| | | | |
|---|---|---|---|
| 5 | Nitrate | Mg/L | BDL |

**GRAPHS:**

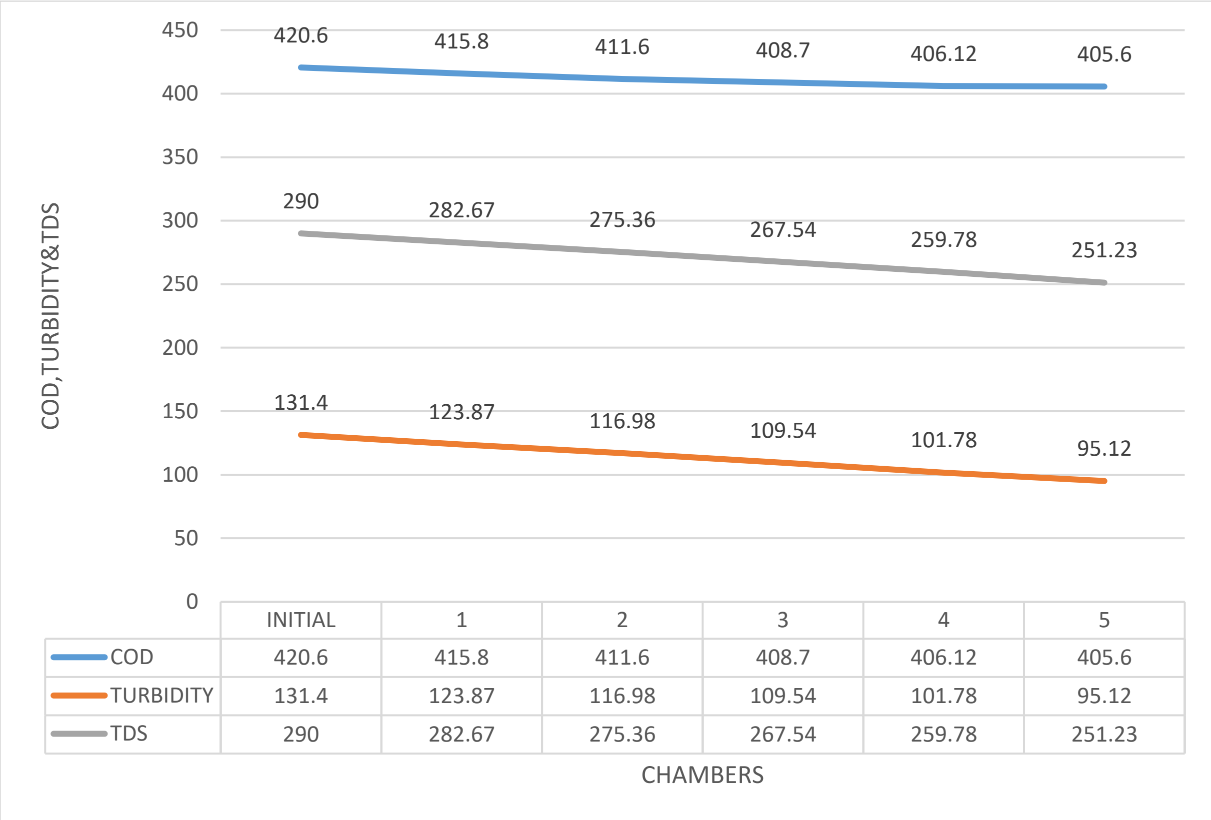



**Fig no.6 characteristics of treated water v/s chambers of tank**

The graph demonstrates that during the 1-hour operation, parameters such as COD, TDS, and turbidity have decreased slightly, showing a marginal improvement in water quality. This indicates that the process is effective but operates at a slower rate of reduction. The analysis suggests that batch-wise operation is more feasible than continuous processing for achieving better control and optimization of treatment conditions. To further enhance the efficiency of the process, it is crucial to increase the residential time, allowing more extended interaction between the treatment agents and the contaminants.

Calculation of optimum dosage test:

- Quantity of sample taken in a beaker = 800 ml
- Time of rotation for floc = 20 min
- Quantity of Coagulant added in each 100 ml beaker ( for dilution )= 0.6 g, 0.9 g, 1.2 g, 1.5 g
- Maximum flocs obtained in a beaker for a detention time of 20 min = 0.9 g/100ml
- Optimum dosage of coagulants = (900*20)/100 = 180 mg/800 ml
- For 1000ml = (180*1000)/800= 225 mg/ ltr

Total Suspended Solids

Initial TSS: 190 ppm
Final TSS (after chemical coagulant test): 74 ppm

Calculation: ((Final wt – Initial wt) *1000000)/ sample volume (ml)

Initial Laundry waste before treatment:

Sample volume= 100ml
Initial wt: 0.643
Final wt: 0.662

((0.662-0.643) *1000000)/100
=190ppm

Laundry waste after chemical coagulant test:

Sample volume: 100ml

Initial wt: 0.6606

Final wt: 0.668

((0.668-0.6606) *1000000)/100

=74ppm

Percentage reduced is 61%

**Project Outcomes & Industry Relevance:**

The project aims to improve wastewater treatment efficiency using the Hybrid Electro-Chemical Coagulation (HECC) process. It will effectively remove contaminants like heavy metals, dyes, and organic pollutants. The process will reduce chemical consumption and minimize sludge generation. Overall, it will enhance treatment performance, making it cost-effective and sustainable. The project will contribute to developing an eco-friendly, scalable wastewater treatment method for industrial applications.

The Hybrid Electro-Chemical Coagulation (HECC) process has significant relevance across various industries, including textiles, pharmaceuticals, chemicals, and food processing, where effective wastewater treatment is crucial. By offering a sustainable and cost-efficient solution, the process helps industries reduce environmental impact, comply with stringent wastewater disposal regulations, and lower operational costs. The ability to treat complex wastewater, minimize chemical usage, and generate less sludge aligns with industry goals for cleaner production and improved resource management, making the HECC process an ideal choice for modern industrial wastewater treatment needs.

**Working Model vs. Simulation/Study:**

The project involved the development of a physical working model of the Hybrid Electro-Chemical Coagulation (HECC) process. The model was used to study and optimize key process parameters such as current density, pH, coagulant dosage, and residence time. The focus was on observing real-world treatment performance and understanding the practical behaviour of the system, alongside theoretical studies and simulations to predict outcomes and guide optimization.

**Project Outcomes and Learnings:**

1. Effective treatment: The HECC process efficiently removed contaminants like heavy metals, dyes, and organic pollutants.
2. Parameter optimization: Key parameters (current density, pH, coagulant dosage, reaction time) were optimized, improving contaminant removal.
3. Cost-effective solution: The process reduced chemical use and sludge generation, offering an eco-friendly and cost-effective treatment method.
4. Scalability: The working model showed that the process is scalable for industrial applications.

The project offered valuable hands-on experience in applying theoretical concepts to build and operate a physical working model, effectively bridging the gap between classroom learning and real-world application. Through continuous experimentation, we developed skills in optimizing complex processes by adjusting key variables and analyzing their impact on treatment efficiency. We also learned to troubleshoot challenges during model operation, such as maintaining consistent performance under varying conditions. Additionally, the project strengthened our abilities in teamwork, communication, and overall project management—from initial design to final execution.

**Future Scope:**

1. Apply HECC to wastewater from other industries like textiles, pharmaceuticals, and automobile industry.
2. Implement automation and real-time monitoring for improved process control and efficiency.
3. Optimize energy consumption to make the process more sustainable and eco-friendlier.
4. Optimize and study the process parameters like residence time, dosage and current density with the AI modelling.