

# Study of Dairy Wastewater Treatment Using Monopolar Parallel System of Electrocoagulation Process with Aluminium Electrodes

C. B. Jagadal<sup>1</sup>, C. B. Shivayogimath<sup>2</sup>P.G. Student, Department of Civil Engineering, Basaveshwar Engineering College, Bagalkot, Karnataka, India<sup>1</sup>Professor, Department of Civil Engineering, Basaveshwar Engineering College, Bagalkot, Karnataka, India<sup>2</sup>

**ABSTRACT:** Environmental pollution has grown to the global proportions and pollution is slipping away from the environmentalist think-tanks. Sustainable development is the need of the hour to face the challenges of depletion of precious environmental resources namely water, air and also to avoid environmental disasters. Among the food processing industries dairy industry is considered as the undisputed origin causing water pollution. Dairy industry generates 5000 liters to 90,000 liters waste effluent on daily basis containing predominantly organic contents. The waste effluent is characterized by high COD, BOD, nutrients and other pollutants. Along with this high volume of waste water, pungent odour adds further woes to the surrounding environment causing health hazards. If this wastewater is discharged to the water bodies and land, serious health hazards and ground pollution is inevitable. Quite a lot of research scholars have contributed in achieving the desired outcomes but only few have achieved with practical feasibility. Electrocoagulation technique is emerging as a promising technique for wastewater treatment. Hence the study was carried out to investigate the feasibility of the Electrocoagulation process for dairy wastewater treatment. Batch experiment were conducted in a 1L capacity Electrocoagulation cell (EC) having monopolar connection with aluminium electrodes arranged in parallel connection. Maximum COD, BOD, total solids and turbidity removals of 95.5%, 96.18%, 75%, & 95.4 % were obtained in parallel monopolar connection. From the experimental investigation it can be concluded that Electrocoagulation process with parallel electrode configuration could be an attractive alternative for cost effective treatment of dairy effluent.

**KEYWORDS:** Electrocoagulation, Electrolysis duration, Electrodes, COD, BOD.

## I. INTRODUCTION

Dairy industries produce different varieties of milk based products like: ice cream, liquid milk, butter, butter milk, cheese, flavoured milk, powdered milk, condensed milk, yogurt and other products. Effluent produced from the dairy industry contains organic matters and suspended solids from the raw materials (milk, fruit, etc.), and also have a high concentrations of carbohydrates, proteins and fats [1]. The organic substances present in wastes come directly in same form or in degraded form. The dairy wastewater is generated at receiving stations, sanitization, boiling plant, cheese plant, butter and dried milk plant as well as can washing plant etc [2]. The quantity of effluent generated in manufacturing unit ranges between 0.2 L to 10 L per litre of processed milk. The treatment of dairy wastewater is of critical importance both for the environmental point of view, also for recycling water for the use in industry purpose [1]. In the dairy wastewaters biochemical oxygen demand (BOD), chemical oxygen demand (COD) and nutrients are high than disposal standards. Discharging of wastewater without any treatment affect the whole environment system. Therefore the treatment of dairy wastewater is very important to protect environment for future generation and avoid the scarcity of water to the dairy and other industries requirements [3].

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Vol. 6, Issue 7, July 2017

The various biological methods used for dairy effluent treatment includes activated sludge process, aerated lagoons, trickling filters, sequencing batch reactor, up flow anaerobic sludge blanket reactor, anaerobic filters. Aerobic biological methods require more energy, on the other hand the effluent treated by anaerobic biological processes requires further treatment. These physical methods or chemical methods for dairy effluent treatment are coagulation or flocculation and adsorption. The Electrocoagulation (EC) process is a simple and compact reactor, with minimum operations and maintenance that gives maximum removal for varieties of wastewaters [3]. Hence in the present study an investigation is made to find suitability of EC process in parallel connection using aluminium electrodes for dairy wastewater treatment.

## II. LITERATURE REVIEW

**Jai Prakash Kushwaha et al. (2010) [4]** In this study research, the dairy wastewater is treated with electrocoagulation process, the investigation can be carried out for to know the removal efficiency of COD with using different variable parameters. In this batch reactor setup the experiments are conducted with operating parameter such as current density 61.73 to 308.64 A/m<sup>2</sup>, dosage of NaCl 0 to 2g/L, electrolysis time 10 to 90 min and pH varied 5 to 11. For these optimum values the COD removal efficiency was found 70%.

**Reza Davarnejad, Mehrzad Nikseresht (2016) [5]** By using electro Fenton process with iron electrode the dairy wastewater can be treated with electrocoagulation technology. In this study the evaluation can be done for the effect of five important parameters such as current density, reaction time, pH, molar ratio H<sub>2</sub>O<sub>2</sub>/Fe<sub>2</sub>, and volumetric ratio H<sub>2</sub>O<sub>2</sub>/Dairy wastewater. Initially they worked out optimum variable parameters values like current density-56mA/cm<sup>2</sup>, pH-7.52, molar ratio-3.965, volumetric ratio-0.898ml/l and COD removal were found 93.93%. For optimum condition where reaction time 86min, current density-55.1mA/cm<sup>2</sup>, pH-7.48, molar ratio-3.987, volumetric ratio-0.907ml/l the colour removal was found 97.32%.

**Edris Bazrafshan, et al. (2012) [6]** In this paper effect of different operational parameters like applied voltage, number of electrodes and reaction time can be studied. In the batch reactor they used aluminium electrodes and potassium chloride as electrolysis. For the experimental results with optimum voltage and time, the removal efficiency can be calculated. Finally the results were found at optimum voltage 60V and duration of 60 min the removal efficiencies are COD-98.84%, BOD-97.95%, TSS-97.75%, and bacterial indicators-99.9%. So using electrocoagulation process the maximum efficiency is achieved, for that EC is reliable technique to remove pollutants in dairy wastewater.

**Deepak Sharma, (2014) [7]** Using electrocoagulation process the percentage removal efficiency of COD, oil and grease can be calculated in this study. The experimental study with different parameters such as pH, duration of electrolysis, COD initial concentration of and current densities are examined. In batch reactor setup by using aluminium electrode the overall removal efficiency were observed, COD removal up to 87%, to optimum current density 3A, pH-9, and electrolysis time 75min. The mean energy consumption was calculated 112.9 kWh/Kg

**Shivayogimath.C.B and Vijayalaxmi R Naik, (2014) [8]** In this paper the feasibility of electrocoagulation technology for dairy wastewater were studied using 1.5 litre capacity of reactor with aluminium electrodes in monopolar parallel connection. For this the experiments were conducted and the analysis to calculate removal efficiency of COD and turbidity. Considering the maximum voltage of experimental calculation 7V and pH of 6 the reduction in COD and turbidity were observed 98.75%, 98.72% respectively. The total specific energy consumption can be calculated 0.00011 kWh/kg COD. So the EC process should be feasible alternative method to dairy wastewater treatment process.

## III. THEORY OF ELECTROCOAGULATION

In Electrocoagulation process, destabilization of suspended, dissolved and emulsified particles present in the waste while inducing the direct current through aqueous media. For this process the reactor can be used to conduct the experiments. The reactor consists of electrolytic cell and electrodes; electrodes are generally used to act one anode and other cathode. This process basically involves the operation of inducing direct current in the cell to electrodes via aqueous medium [9].

In electrocoagulation process three processes take place, which bring about purification of wastewater. First one electro-floatation, in this process buoyant gas bubbles were generated during electrolysis, these gas bubbles takes

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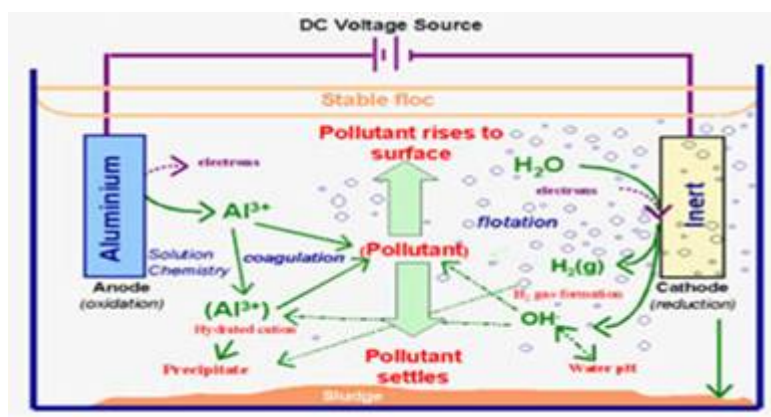
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Vol. 6, Issue 7, July 2017

the pollutants to the top surface of the reactor. It is generally called foam, which can be removed manually or mechanically. Second is electro oxidation, in this the organic materials present in the effluents are oxidizes and produce carbon dioxide and water. This oxidation process can takes place in two ways, direct anodic oxidation and indirect oxidation. Third one is electrocoagulation in which the destabilization of colloidal particles present in the effluent can takes place with two ways, first increase in ionic concentration and secondly sweeps flocculation. During EC process in reactor various reactions take place. The anode materials were goes into oxidation and cathodes into reduction [10].

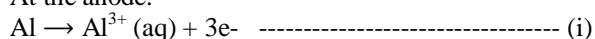
**Figure 1:**Explains all the three processes that take place in an EC reactor during wastewater treatment.



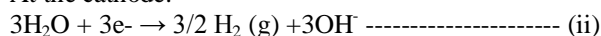
**Figure 1.0 EC reactor**

In EC process with Aluminium as electrode material, the following reactions were takes place:[10]

At the anode:



At the cathode:



In the solution:



## IV. MATERIALS AND METHODS

A batch electrocoagulation (EC) reactor was designed and fabricated to treat the dairy effluent. The batch reactor was made up of acrylic material with thickness of 6mm, a total working volume of 1.5 L capacity and with the dimensions of 15cmx10cmx10cm. The DC source of 30V and 0-2A was used as a power supply to the system. The EC units having a pair of four electrodes were connected in bipolar parallel system. The aluminium electrodes having dimensions of 10cmx9cmx0.1cm were immersed to a depth of 5cm in the reactor, the surface area covered is 45 cm<sup>2</sup> each electrode. The space between the electrodes was maintained at 1cm. A magnetic stirrer was used for mixing to form homogeneous solution at 200rpm.

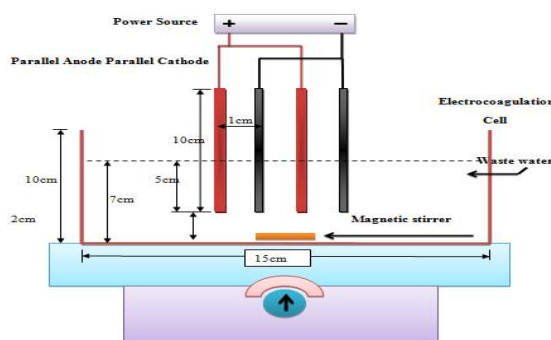
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Vol. 6, Issue 7, July 2017

**Figure 2:** .gives the schematic representation of experimental set up of EC reactor.



**Figure 2 Schematic experimental set up of EC reactor**

A sufficient quantity of wastewater was collected from nearby dairy industry wastewater (KMF, Belgaum) discharge point and characterization of sample was carried out according to standard methods gives.

**Table 1.**The various parameters of dairy wastewater.

**Table 1: Characteristics of dairy industry Wastewater**

Sl.No	Parameters	Values
1	COD	4500 mg/l
2	BOD	967 mg/l
3	Total solids	1950 mg/l
4	Turbidity	385 NTU

## V. EXPERIMENTAL RESULTS AND DISCUSSIONS

In the present study, the investigation was undertaken to study the effect of pH, applied voltage and electrolysis time on EC process of dairy effluent treatment.

The electrocoagulation experiments were carried out at wastewater pH(4.83) with four aluminium electrodes (two anode and two cathodes), In this set up of experiment varying pH of 4, 4.83, 8.0, 9.0 with 50 minutes electrolysis time duration with different voltages 5, 10, 15, 20V. The electrode distance is fixed to 1cm. For this experimental setup the percentage removal of different parameters such as COD, BOD, turbidity, and total solids can be studied.

**Figure 3:** Initially the optimization of different varying parameters carried out at constant effluent pH of 4.83. For this purpose experiments were conducted for different voltages such as 5V, 10V, 15V, and 20V. The electrolysis time was upto 50 minutes with 10 minutes interval. The COD values were measured and the efficiency of COD removal was observed 47.3%, 64%, 72%, and 88.8% respectively for different voltages. Below figure shows that the optimum voltage was 20 and optimum electrolysis time is 40 min.

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Vol. 6, Issue 7, July 2017

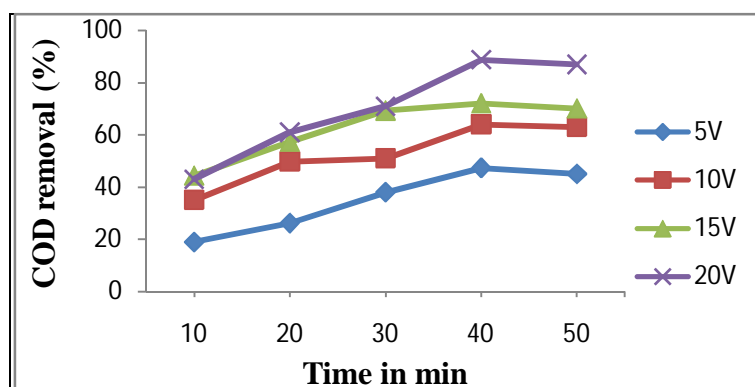


Figure 3: COD removal with different voltage and time at pH 4.83

**Figure 4:** In the next set of experiment the optimization of pH was carried out at optimum voltage and optimum electrolysis time. The COD values were measured for different pH 4.0, 4.83, 8.0, and 9.0. The corresponding efficiency of COD removals obtained were 82%, 88.8%, 95.5% and 77% respectively. The following figure shows that optimum pH was 8.0 and maximum COD removal.

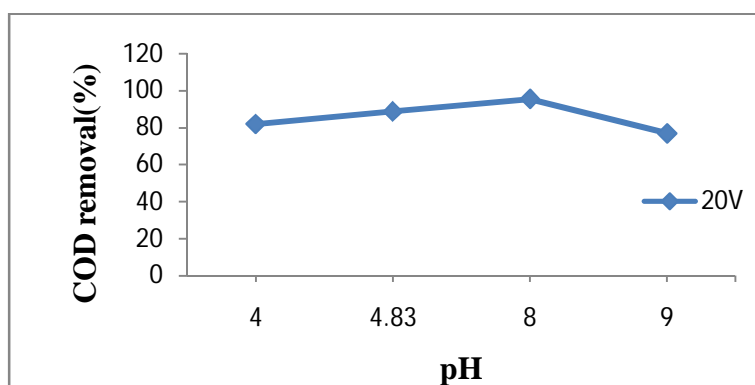


Figure 4: COD removal with different pH for fix voltage (20V) and time (40 min).

Thus the optimum operating parameters obtained by conducting series of experiments were pH = 8.0, Electrolysis time (ET) = 40 minutes and voltage = 20V. Further the experiments were conducted to find maximum removal of COD, BOD, total solids and turbidity at the optimum operating parameters which are discussed following sections.

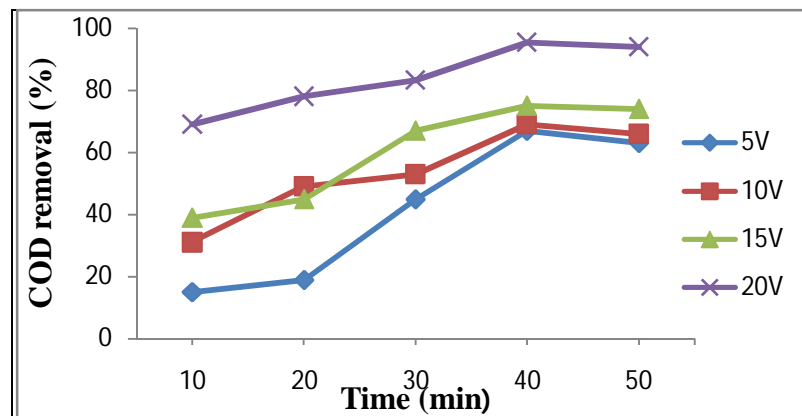
**Figure 5:** COD removal of different voltage and time: The experiments were carried out with different voltages with variable time of 10 min interval up to 50 min. The COD was reduced to 67%, 69%, 75% and 95.5% respectively during this process. Following figure shows the COD removal efficiencies of different voltage and electrolysis time with pH 8.0.

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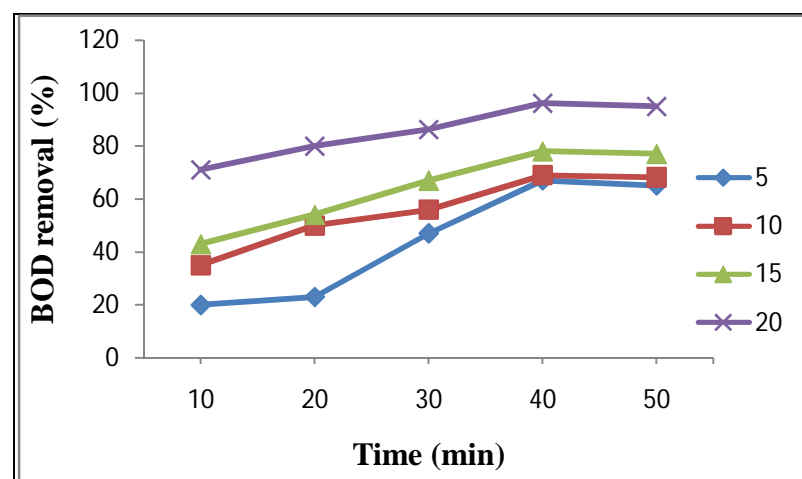
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Vol. 6, Issue 7, July 2017



**Figure 5: COD removal with different voltage and time at pH 8.0**

**Figure 6:** BOD removal of different voltage and time: For same set of experiments Electrocoagulation were conducted with different voltage and variable time of 10 min interval up to 50 min. The BOD was reduced to 67%, 69%, 78% and 96.18% respectively during this process. The belowfigure shows BOD removal efficiencies for same set of experiments for different voltages and ET at optimum pH of 8.0. The maximum BOD removal of 96.18% was obtained at pH 8.0 and voltage 20V.



**Figure 6: BOD removal with different voltage and time at pH 8.0**

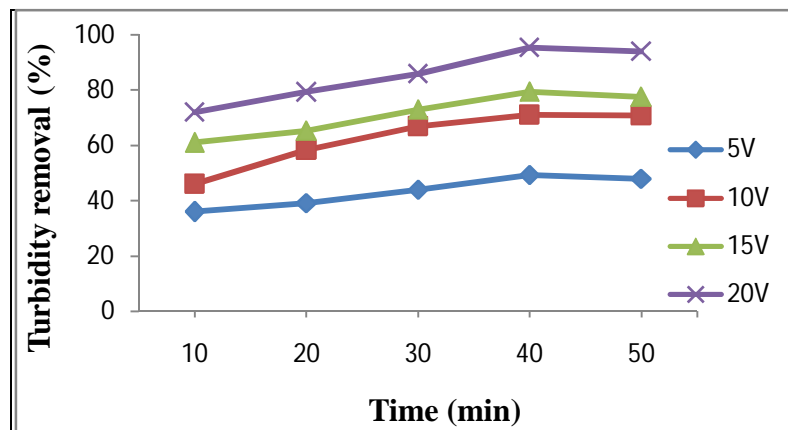
**Figure 7:** Turbidity removal of different voltage and time: Similarly the turbidity removals at different voltage and ET were measured at pH 8.0. The turbidity was measured. The turbidity reduction for different voltage of 5, 10, 15, and 20 are obtained 49.4%, 71.1%, 79.4% and 95.4% respectively. Below figure gives results of turbidity removal. The maximum turbidity removal was 95.4%.

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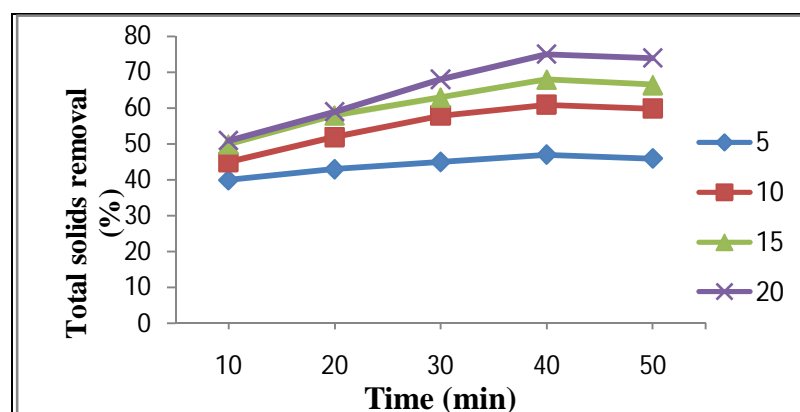
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Vol. 6, Issue 7, July 2017



**Figure 7: Turbidity removal with different voltage and time at pH 8.0**

**Figure 8:** Total solids removal of different voltage and time :Another important parameter namely total solid was measured during these experiments. Electrocoagulation experiments were conducted with different voltage and variable time of 10 min interval up to 50 min. The total solids were reduced to 47%, 61%, 68%, and 75% respectively during this process, following figure gives total solids removal at different voltage and ET at constant pH 8.0.the maximum total solids removal was 75%.



**Figure8: Total solids removal with different voltage and time at pH 8.0**

## Summary of mono polar parallel connection

**Table 2:** Gives the summary of the treatment of dairy effluent using EC process with aluminium electrodes in monopolar parallel connection.



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Vol. 6, Issue 7, July 2017

**Table 2: Summary of monopolar parallel connection**

Sl.No	Parameters	Untreated Effluent	Treated Effluent	Removal efficiency %
1	COD	4500 mg/L	202.5 mg/L	95.5
2	BOD	967 mg/L	36.939 mg/L	96.18
3	Turbidity	385 NTU	17.71 NTU	95.4
4	Total solids	1950 mg/L	487.5 mg/L	75.0

## VI. CONCLUSION

Based on the experimental results obtained the following conclusions were drawn for dairy wastewater treatment using electrocoagulation process with Aluminium as electrodes in monopolar parallel connection.

1. The optimum operating parameters for dairy wastewater are pH = 8.0, Electrolysis time = 40 min and Voltage = 20V
2. In the monopolar parallel connection system maximum COD,BOD,total solids and turbidity removals were 95.5%, 96.18%, 75% and 95.4% respectively. Colour removal was 100% and treated effluent looked like water.
3. The various parameters of treated dairy effluent meet the disposal standards.
4. When the results of monopolar parallel electrode connection gave higher removal efficiencies.

Hence from the project study it can be concluded that for EC technology with aluminium electrodes in monopolar parallel system is efficient and economical for dairy waste water treatment.

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