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

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Abstract - *Among the food processing industries dairy industry is considered as the undisputed origin causing water pollution. 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. Hence, the cost effective treatment of dairy effluents for environmental protection is a challenging task. The removal of pollutants from dairy was experimentally investigated using direct current electrocoagulation (EC).Electrocoagulation technique is emerging as a promising technique for wastewater treatment. In this batch experiment were conducted with a 1L capacity Electrocoagulation cell (EC) having monopolar connection with aluminium electrodes arranged in series connection. Maximum COD, BOD, total solids and turbidity removals of 88%, 88.98%, 63.5%, & 93.1 % were obtained in monopolar series connection. From the experimental investigation it can be concluded that Electrocoagulation process with series electrode configuration could be an attractive alternative for cost effective treatment of dairy effluent.*

***Key Words*: Electrocoagulation, Electrolysis duration, Electrodes, COD, BOD.**

1. INTRODUCTION

The dairy industry is considered to be the largest source of wastewater in many countries among the food processing Industries[1]. In India, dairy industry is one of the major industries causing water pollution. Dairy wastewater is enriched in organic matter & also contains biodegradable carbohydrates [2].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 [3]. 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 [4]. In the dairy wastewaters biochemical oxygen demand (BOD), chemical oxygen demand (COD) and nutrients are higher 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 [5].

Dairy effluents are generally treated with physico-chemical and biological processes. The physico-chemical processes suffer the disadvantage that reagent costs are high and soluble COD removal is low. Further, chemical treatment could induce a secondary pollution due to the addition of chemical coagulants which may contaminate the treated water. The biological treatment process require more spaces and long time for treatment along with generation of high amount of sludge as well as high energy costs [6].The electrocoagulation (EC) process could be other alternative process for treating the dairy effluent. Recently, electrocoagulation process is emerging as a cost effective treatment method for the treatment of varieties of wastewater [7] The Electrocoagulation (EC) process is a simple and compact reactor, with minimum operations and maintenance that gives maximum removal for varieties of wastewaters [8].Hence in the present study an investigation is made to find suitability of EC process in monopolar series connection using aluminium electrodes for dairy wastewater treatment.

2. THEORY OF ELECTROCOAGULATION

Before you begin to format your paper, first write and save the content as a separate text file. Keep your text and graphic files separate until after the text has been formatted and styled. Do not use hard tabs, and limit use of hard returns to only one return at the end of a paragraph. Do not add any kind of pagination anywhere in the paper. Do not number text heads-the template will do that for you.

Finally, complete content and organizational editing before formatting. Please take note of the following items when proofreading spelling and grammar: The EC is a process in which the anode material undergoes oxidation whereas the cathode subjected to reduction and hence, various monomeric and polymeric metal hydrolyzed species are formed at the electrode surface. These metal hydroxides

remove organics from wastewater by sweep coagulation and by aggregating with colloidal particles present in the wastewater to form bigger size flocs and ultimately get removed by settling. The metal ions generation takes place at the anode and hydrogen gas is released from the cathode. This hydrogen gas would also help to float the flocculated particles out of the water by process called electro flotation [9].When aluminum is used as electrode materials, the electrochemical reactions are as follows [10]. All the three process that take place in an EC reactor during at waste water treatment as shown in Fig

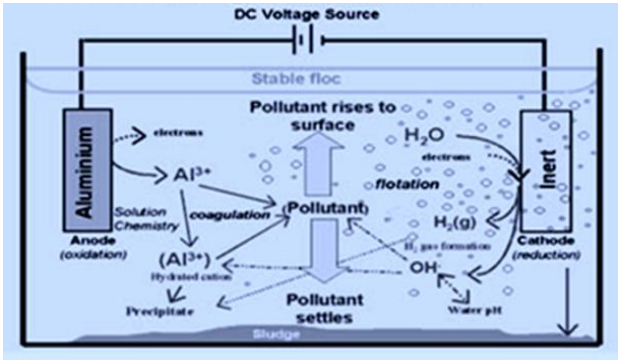

Fig-1: EC reactor

In EC process with Aluminium as electrode material, the following reactions were takes place:[11]

At the anode:

$$Al \longrightarrow Al^{3+}(aq) + 3e^- \quad \text{---------- (i)}$$

At the cathode:

$$3H_2O + 3e^- \rightarrow 3/2\ H_2(g) + 3OH^- \quad \text{---------- (ii)}$$

In the solution:

$$Al^{3+}(aq) + 3H_2O \rightarrow Al(OH)_3 + 3H^+(aq) \quad \text{------- (iii)}$$

3. 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 15cm x10cm x 10cm. 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 10cm x9cm x0.1cm were immersed to a depth of 5cm in the reactor, the surface area covered is 45 cm^2 each electrode. The space between the electrodes was maintained at 1cm. A magnetic stirrer was used for mixing to form homogeneous solution at 200rpm. Figure 2: gives the schematic representation of experimental set up of EC reactor.

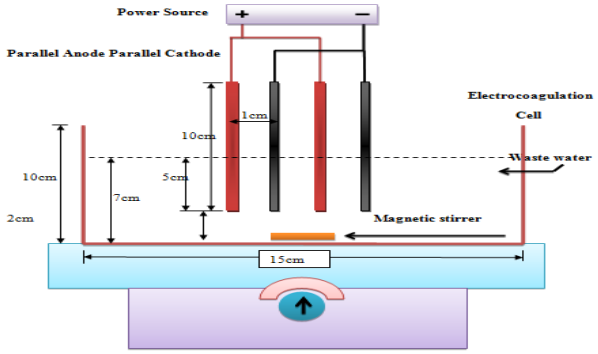

Fig-2: Schematic experimental set up of EC reactor

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. The various parameter of dairy wastewater was given in table 1

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
5	pH	4.83

4. EXPERIMENTAL RESULTS AND DISCUSSIONS

The investigations were 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.

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 the optimum voltage was 20 and optimum electrolysis time is 40 min.

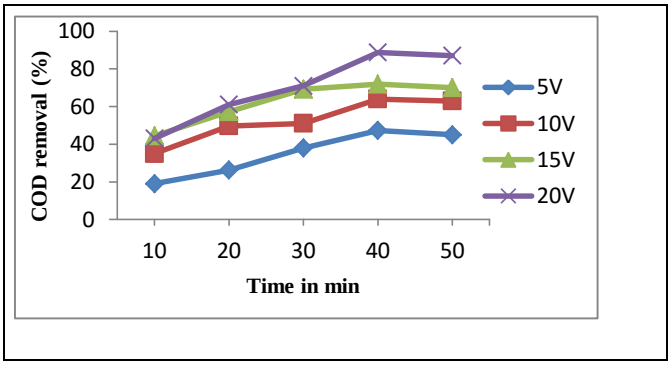

Fig-3: COD removal with different voltage and time at pH 4.83

In the next step, by using same 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.

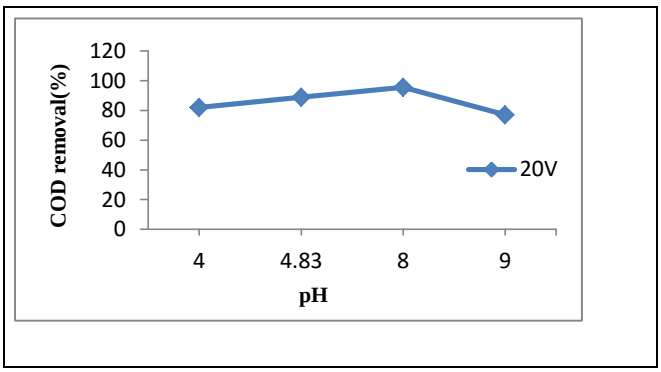

Fig-4: COD removal with different pH for fix voltage (20V) and time (40 min).

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.

The experiments were carried out with different voltages with variable time of 10 min interval up to 50 min. The COD was reduced to 77.43%, 82.26%, 87.4% and 88% respectively during this process; the results are shown in the Figure. Following figure shows the COD removal efficiencies of different voltage and electrolysis time with pH 8.0.

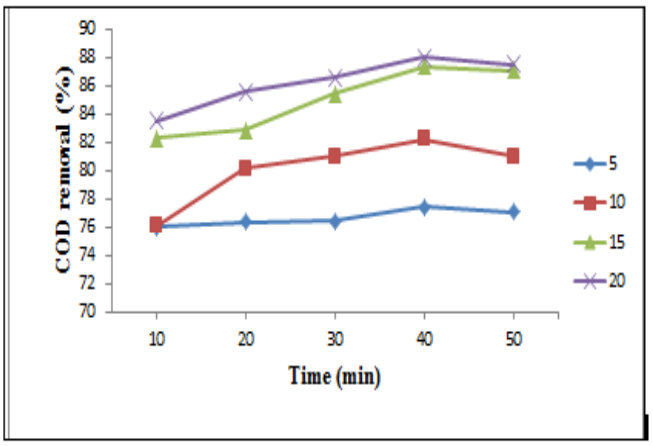

Fig-5: COD removal with different voltage and time at pH 8.0

For same set of experiments Electrocoagulation were conducted with different voltage and variable time of 10 min interval up to 50 min. The BOD were reduced to 80.58%, 84.6, 87% and 88.98% respectively during this process, the results are shown in the Figure 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 88.98% was obtained at pH 8.0 and voltage 20V.

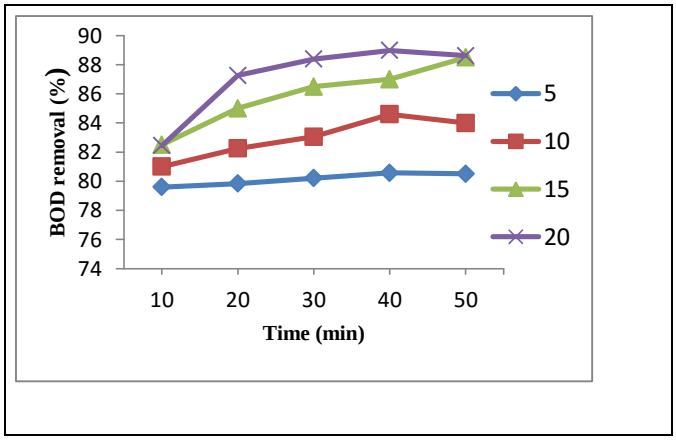

Fig-6: BOD removal with different voltage and time at pH 8.0

Similarly the turbidity removals at different voltage and ET were measured at pH 8.0. The turbidity were measured, the reduction in turbidity for different voltages of 5, 10, 15, and 20 are obtained as fallows 50%, 72.2%, 82%.and 93.1% respectively Below figure gives results of turbidity removal. The maximum turbidity removal was 93.1%.

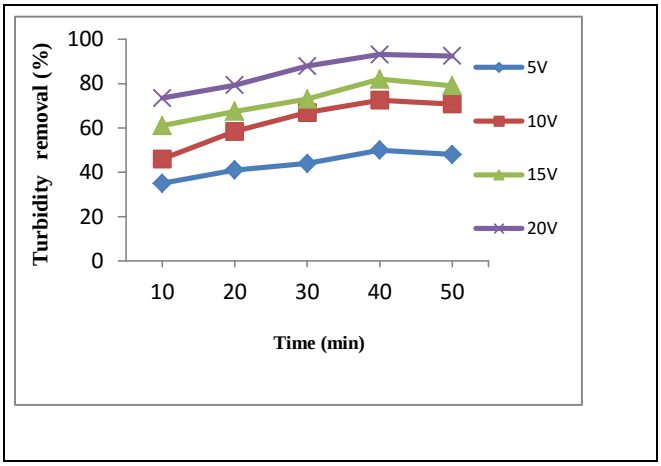

Fig-7: Turbidity removal with different voltage and time at pH 8.0

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 44.18%, 54.23%, 58.08% and 63.5% respectively during this process, the results are shown in the Figure, following figure gives total solids removal at different voltage and ET at constant pH 8.0.the maximum total solids removal was 63.5%.

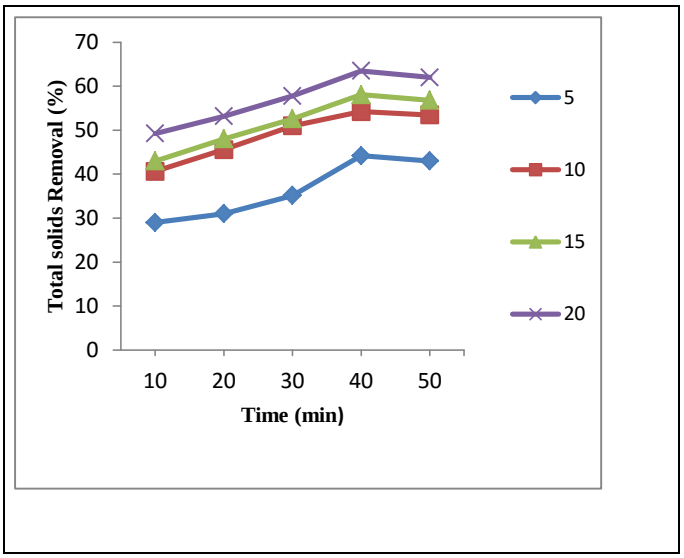

Fig-8: Total solids removal with different voltage and time at pH 8.0

Summary of mono polar parallel connection

The summary of the treatment of dairy effluent using EC process with aluminium electrodes in monopolar parallel connection shown in Table 2.

Table-2: Summary of monopolar parallel connection

Sl.No	Parameters	Untreated Effluent	Treated Effluent	Removal efficiency %
1	COD	4500 mg/L	540 mg/L	88
2	BOD	967 mg/L	106.56 mg/L	88.98
3	Turbidity	385 NTU	140.525 NTU	93.1
4	Total solids	1950 mg/L	134.55 mg/L	63.5

5. CONCLUSIONS

Based on the experimental results obtained the following conclusions were drawn for dairy wastewater treatment using electrocoagulation process with Aluminium as electrodes in monopolar series 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 88%, 88.98%, 63.5% and 93.1% respectively. Colour removal was 100% and treated effluent looked like water.

3. The various parameters of treated diary 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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