

Treatment of Dairy Effluent by Electrocoagulation-Fenton Oxidation

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ABSTRACT: Environmental pollution has grown to the global proportions and pollution control is slipping away from the environmentalist think-tanks day by day. Among the food processing industries dairy industry is considered as the undisputed origin causing water pollution. The effluent is characterized by high COD, BOD₅, nutrients and other pollution loads. Because of harmless nature of reagents and leaving no traces, increased research has been dedicated to Electrocoagulation coupled with Fenton oxidation of treating dairy waste effluent which is a novel technique with maximum treatment efficiency, cost effective, lesser production of sludge and very less space for operation. The experiments conducted with aluminium electrodes at 1cm gap with Fenton's reagent for COD, BOD, TDS, Colour, removal at an electrode interval of 1cm showed the efficiency of 98%,99%,84.6% & 99.4%,respectively.

KEYWORDS: Fenton Oxidation, electrocoagulation, Bipolar Parallel Connection, Hydrogen Peroxide, COD, BOD, TDS, Turbidity.

I. INTRODUCTION

In India, expeditious rapid growth of industrialization and urbanization with simultaneous population boom has caused an irreversible damage To the nature and caused depletion of fresh water pools, generating threat to the future generation. Hence, sustainability is important factor to confront the obstacles of fresh water pools & meet the ever increasing clean water demand. Whilst, waste water technology are trustworthy, still there is need for novel, economical treatment process that can substitute large and high prized traditional systems for third world countries like India.

The reuse of wastewater has become a dire necessity. Every day huge quantity water is wasted as industrial discharge. The untreated and partially treated effluent discharge to water body are polluting the fresh water sources. The discharged norm have become strict to counter the water body pollution. All types of industrial effluent need specific treatment in order to comply with national permissible standard to reduce water pollution and protect environment [1].

Milk is nourishing for man. For human it the primary sources of nutrition. Emulsion such has cream, margarine and colloidal such as whey are the physical and chemical properties of milk that contained dissolved carbohydrates . Thus milk is crucial trade commodity and day-to-day food supplements [2]. The dairy plant includes conversion of fresh milk into different products viz, milk for consumption, Yogurt, Cheese, Butter, Ice cream. Utilizing the techniques namely chilling, pasteurization and homogenization. Particular by products are butter milk and their derivatives [3]. Thus, Milk processing is quality intended business of manufacturing, packing of dairy products. It emphasis on physical, biological, chemical and microbiological features of source and the technological features of conversion of milk into variety of consumer products, inclusive of beverages, fermented products, concentrated and dried products [4].Among the 3000 million people involved in farming, three fourth are partially or completely dependent on livestock farming. Until many countries have considered milk too bulky and perishable to make long distance trade feasible. For these most dairying nations have complex mechanism to regulate their dairy industries through interventions, financial support and physical controls [5]. Asia-Pacific region consistently been a milk importer and is predicted that imports will surge year after year. The import includes milk powder and partial imports of condensed milk and evaporated milk. To contradiction, the developed nation imports almost all the cheese produced from the developing countries like Japan and USA [6]. Presently the annual dairy growth rate is 7%. Regardless growth in milk production, the wide gap of the

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needed quantity and produced quantity has turned to be much anticipated approach caused by vigorous population growth, altered eating habits and fast urbanization activity. Thus there is an immediate requirement in dairy sector boom to balance expeditious growth of Indian economy [7]. Notion of milk production is that it will rise due to revamped management practices adopted by the Indian Dairy Industries. Also efforts made by public and private sector by improving cattle genetics, qualitative and quantitative fodder availability are increasing milk productions capacity in manifold. Gujarat, Karnataka, UP, Haryana, Punjab, Maharashtra, Rajasthan, Andrapradesh and Tamil Nadu state is a milk excess state accounting for 79% of milk produced [8]. The essence and blend of the waste too vary. The mixture consists of considerable amount of composition of fat, protein, lactose, lactic acid, minerals, and detergents[9].

The process involving generation and usage of powerful, Yet non selective Hydroxyl radicals in paramount quantity which readily oxidizes almost all of the complex chemicals present in the effluent are known as advanced Oxidation Process (AOP's). Among the highest oxidation potential (Eo), OH⁻ Hydroxyl stands first compared with that of normal hydrogen electrode (Fluorine).

The process involves production of hydroxyls OH⁻, which are highly powerful non selective chemicals oxidants. From this rationale the AOP's are garnering much notice from the scientists and technocrats. Mechanism of AOP's can be elaborated by (a) creation of hydroxyl (OH) radicals, (b) oxidation. The final conversion of dissolved organic pollutants is converted to CO₂ and H₂O. Highly effective hydroxyl radicals is possible by ultraviolet, ozone, hydrogen peroxide, Titanium oxide & other procedures [10].

The electro coagulation (EC) technology includes coagulation followed by precipitation of contaminants through a DC electrolytic operation which is trailed by the separation of flocculants, in the presence or absence of coagulation. The EC reactor is made up of electrode pairs, arranged in pairs of anode & cathode either of iron or aluminium make. The conductive plates are called sacrificial electrodes which may or may not be of same metal which acts as cathode & anode [11]. A direct current is applied to the plates which induce electrochemical reaction necessary to achieve coagulation. Processed water is released from the system for reuse or disposal. Electrocoagulation is a process in which anode plate experiences the oxidation and consequently leading to formation of monomeric and polymeric metal hydrolysed species. These metal species separate organics from effluent by sweep coagulation are by clustering with colloidal particles to form larger size flocs to be eventually removed by settling [12]. The production of the metal ions occurs on anode side and hydrogen gas gets released from the cathode. Hydrogen gas is also responsible for floatation of flocs particles out of water.

II. MATERIALS AND METHODS

Experimental Set Up:

A batch electrocoagulation (EC) reactor was designed and fabricated for the treatment of dairy effluents. The reactor was made up of acrylic material with a total working volume of 1 L 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 six electrodes were connected in bipolar parallel system.

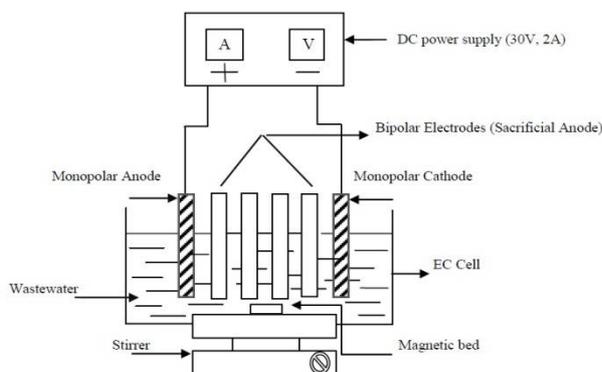


Fig 1-Experimental Set Up.

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Methodology :-

The experimental electrocoagulation technique was used for the batch treatment of dairy wastewater. The wastewater sample collected from the dairy industry was stored in a deep freezer at 4°C and was analyzed for various parameters as per standard analytical methods after bringing down to the room temperature. After the initial characterization of waste water batch experiments were conducted to regulate the various working conditions such as pH, Voltage and duration of electrolysis. The sample solution was prepared as required. The batch experiments were performed with six electrodes connected in bipolar parallel system to the DC power supply. Two different configurations of electrodes namely Al/Al with different spacing were alternately used in the present study. The total submerged surface area of individual electrode is 50cm².thus the space across the electrodes was maintained at 1.0 or 2.0 cm throughout the experiment, and 2cm gap was maintained from the base of the reactor. Electrode plates were weighed before and after each run. For each experiment conducted varied voltage of experiment conducted varied voltage of 10,15,20,25 volts and pH was regulated to by addition of either dilute HCl or NaOH as per need. The volume of solution in each batch experiment was 1L.Optimum dosage of 50ml of H₂O₂ of analytical grade and 50ml of FAS .1N solution was added to the 1L solution. The magnetic stirring unit was used to maintain homogenous mixing of the reactor content at 200rpm. About 2g/L of boric acid was added as electrolyte during the each process to increase the conductivity; and also it acted as buffer, so that there was no much change in pH. The concentration of dairy effluent was halved to its strength throughout the experiments to minimize current expending, duration and achieving better efficiency. At start of each experiment the electrodes were scraped with sand paper to detach the scales and were revised by 15 – 20 % HCl, followed by a detergent wash for the removal of impurities from the electrode surface before the start of every experiment. The EC experiments were performed for optimum electrolysis time of 60 minutes and in each run samples were collected at every 15 minutes interval for necessary analysis. Necessary investigation the samples after the treatment were enabled to get settled for minimum of an hour before any chemical analysis. The sludge produced was collected for further analysis.

The experiments were performed with electrodes connected to the DC power supply in following configuration and presented in fig1.

Al/Al bipolar electrode in parallel mode with spacing 1cm .

Table 1: Physio-chemical characteristics of dairy industry Wastewater

| Sl No. | Parameters | Values |
|--------|-------------------------------|---------|
| 1. | pH | 5.85 |
| 2. | Colour | Whitish |
| 3. | COD (mg/L) | 2150 |
| 4. | BOD5 (mg/L) | 950 |
| 5. | Conductivity (µS/cm) | 1569 |
| 6. | Turbidity (NTU) | 223 |
| 7. | Total Solids (mg/L) | 1200 |
| 8. | Total Dissolved Solids (mg/L) | 705 |
| 9. | Suspended Solids (mg/L) | 245 |
| 10. | TOC (mg/L) | 295.75 |
| 11. | Chlorides (mg/L) | 185.65 |
| 12. | Colour @ 410nm (ABS) | 0.575 |
| 13. | Nitrate Nitrogen (mg/L) | 7.65 |
| 14. | Phosphate (mg/L) | 16.89 |
| 15. | Sulphates (mg/L) | 96 |

III. RESULTS AND DISCUSSIONS

Effect of pH And Applied Voltage on COD Removal

pH parameter plays a pivotal role in influencing the performance of electrochemical process. The experiments were carried out in batch mode with six aluminium electrodes connected as bipolar placed at 1cm apart. The results obtained after the experiments with electrodes distance at 1cm gaps have been shown with their respective varied pH, voltages, and electrolysis duration. To enhance the conductivity of wastewater about 2g/L of Boric acid (H_3BO_3) was added as an electrolyte to each experiment. the trial was performed to pH 7.0 at 1cm electrode distance with different applied voltages of 10V, 15V, 20V and 25V; the COD reduced from 2150mg/L to 430, 322.5, 172 and 43mg/L thereby being COD removal efficiencies of 80%, 85%, 92 % and 98 % respectively. The results remain unchanged after 60 minutes of electrolysis time (ET) is shown in the Fig 2.

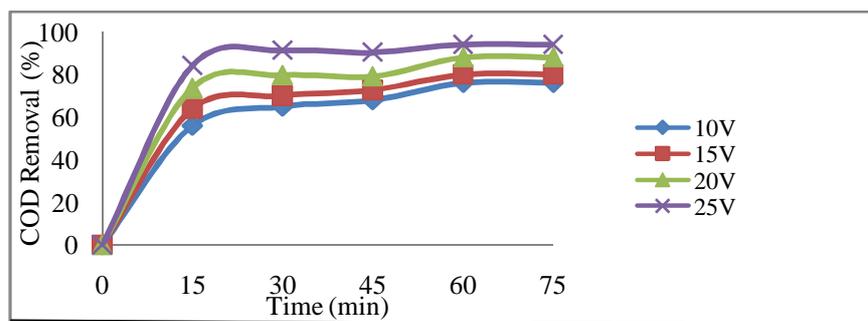


Fig. 2: COD removal with electrolysis time for different voltages at pH 7.0 (d=1cm)

The outcomes from the graphs showed that removal efficiency increased with increase in applied cell voltage (10V-25V) up to electrolysis time of 60 minutes. During EC process, the neutral pH and slightly acidic pH was found to be better for COD removal.

Effect Of pH and Applied Voltage On TDS Removal

Trial was conducted at pH 7.0 with different applied voltages 10V, 15V, 20V and 25V. The TDS reduced from 705 mg/L to 169.2,141, 119.85 and 108.57 mg/L thereby being 76%, 80%,83% and 84.6% efficient in removing TDS from wastewater respectively are shown in Fig. 3.

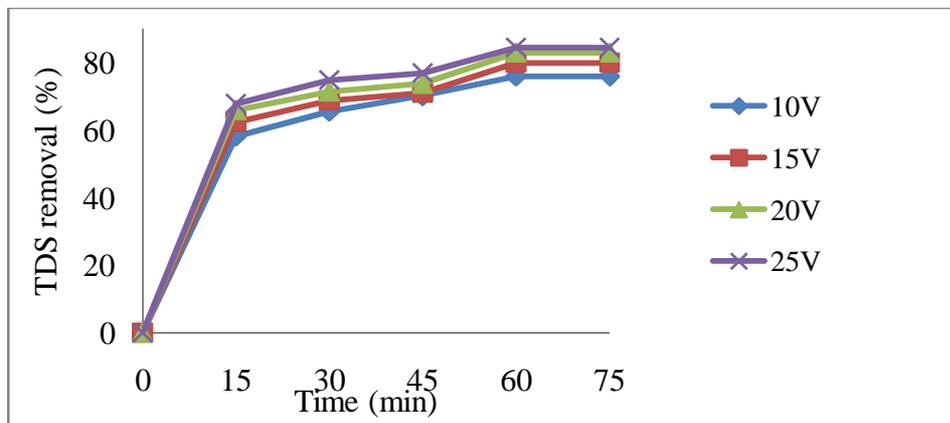


Fig. 3: TDS removal with ET for different voltages at pH 7.0 (1cm)

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From the study it was observed that, TDS removal efficiency was not much changed in the variation of pH. The changes occur with increasing the applied cell voltage and electrolysis duration. The EC experiment which is 25V and 60 minutes is capable of reducing the TDS of the wastewater more effectively.

Effect of pH And Applied Voltage On Colour Removal

Colour is an important parameter considered in any wastewater for analysis. It physically represents the extent of pollution of wastewater. Hence in the present study, removal of colour from dairy wastewater has been made using EC technique with aluminium electrodes shown in fig 4.

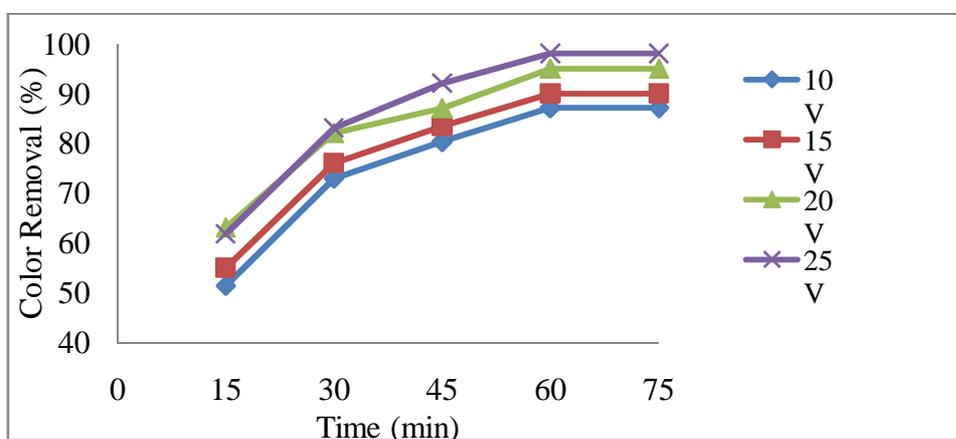


Fig. 4: Color removal with time for different voltages at pH 7.0 (1cm)

The same EC experiment were carried out at pH 7 (d=1cm) with different cell voltages 10V, 15V, 20V and 25V the colour reduced by 92.6%, 94.2%, 96.9%, and 99.4% respectively shown in Fig.4 In the present investigation, it was observed that maximum colour removal efficiency was obtained at pH 7.0(d=1cm), 25V and 60 minutes of ET. As the applied cell voltage increased, the removal efficiency was also increased.

Effect of pH And Applied Voltage on BOD Removal

The batch EC experiments were conducted with aluminium electrodes connected in bipolar mode to treat dairy wastewater. Initially, the experiment was carried out at pH 7.0 with different applied voltages 10V, 15V, 20V and 25V. The BOD reduced from 950mg/l to 152, 104.5, 57 and 9.5 mg/L thereby being 84%, 89%, 94% and 99% efficient in removing BOD from wastewater respectively are shown in Fig 5.

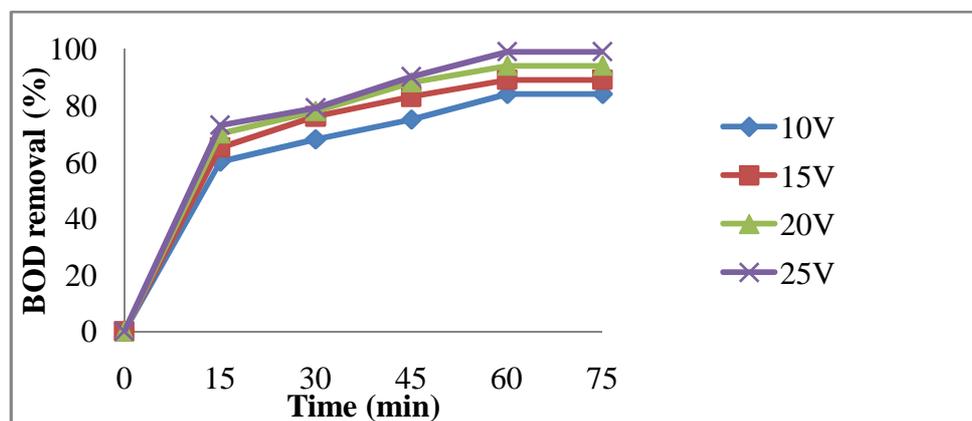


Fig. 5: BOD reduction with time for different voltages at pH 7.0 (1cm).

The maximum efficiency was observed at pH 7 and at 25V for 60mins electrolysis time.

IV. CONCLUSIONS

The batch experiments were carried out for the treatment of dairy effluent by EC process coupled with Fenton's oxidation technique. The operating parameters such as pH, applied voltage and electrolysis time were varied, its effects were studied on the treatment efficiency of the electrode materials with different electrode distance in terms of COD, BOD, turbidity and colour removal. For all the batch experiments, variations in pH and current density were noted. The removal efficiency at electrode distance 1cm gap is shown in table 2.

Table 2:-Removal Efficiency Table

| Sl.No. | Parameters | Removal efficiency Al/Al at 1cm |
|--------|------------|------------------------------------|
| 1 | COD | 98% |
| 2 | BOD | 99% |
| 3 | TDS | 84.6% |
| 4 | Colour | 99.4% |

Based on the experimental results, the following conclusions can be drawn:

1. As the batch experiments were conducted with aluminium electrodes at 1cm gap and Fenton's reagent, results obtained are 98%,99%,84.6%,99.4% as the maximum removal efficiency of COD, BOD, TDS, Colour, respectively at pH 7.0, 25V and 60 minutes duration.
2. Because of polymerization settling of sludge is faster compared to only electrocoagulation .
3. Thus the Bipolar Electrocoagulation–Fenton Oxidation was efficient in the treatment of dairy industry effluent.

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