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Treatment of Dairy Wastewater Using Electrocoagulation Technique

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Abstract: Main objectives of the present paper to evaluate the removal of COD, TSS,TDS and oil and grease from the dairy industry wastewater by Electrocoagulation using iron as Monopolar configuration at different voltages and electrolysis time. To study the effect of inter electrode spacing and effect of different initial pH for the removal of COD, TSS, TDS, oil and grease at constant voltage for the iron electrode. Electrocoagulation (EC) is one of the commonly used processes for the treatment of wastewater, it involves the generation of coagulants in situ by dissolving the ions from the electrode.

Key words: Atmospheric Boundary Layers, vehicular emission dispersion, array of building Obstacles, downwind distances, Wind tunnel study.

Introduction

Electrocoagulation (EC) is one of the commonly used processes for the treatment of wastewater, it involves the generation of coagulants in situ by dissolving the ions from the electrode. It is defined as Electro means applying an electrical charge to water and coagulation means the process of reducing the colloidal particle surface charge and allowing suspended matter to form agglomeration. The various electrodes such as iron, aluminium, stainless steel and graphite are used in this technology.

There has been renewed interest in the use of electrocoagulation owing to the increase in environmental restrictions on wastewater. In the past decade, this technology has been increasingly used in developed countries for the treatment of industrial wastewaters, by allowing the particles to react with an ion having an opposite charge or floc of metallic hydroxides generated within the effluent [7].EC method not only applied for the treatment of slaughterhouse wastewater, wastewater containing heavy metals, pesticides and phenol compounds, but also for the treatment of drinking water for fluoride removal.

The currently available conventional treatment technologies for the treatment of dairy wastewater consist of a series of physical, chemical and biological methods. But some soluble organic compound goes untreated in these treatment steps, resulting in increased levels of pollutants in the treatment plant effluents. However, there is no single technology that can meet all requirements according to the variable nature of the wastewater. Electro coagulation process is playing a more prominent role in the treatment of dairy industry wastewater by virtue of various benefits including environmental compatibility, versatility, energy efficiency, safety, selectivity, amenability to automation and cost effectiveness.

Ghahremani.Het.al.[2] has carried out the investigation on "Treatment of Dairy Industry Wastewater was using an Electrocoagulation Process "In this study, the treatment of dairy industry wastewater using an electro-coagulation process has been investigated. The COD removal percentage was considered as the efficiency index of the procedure.

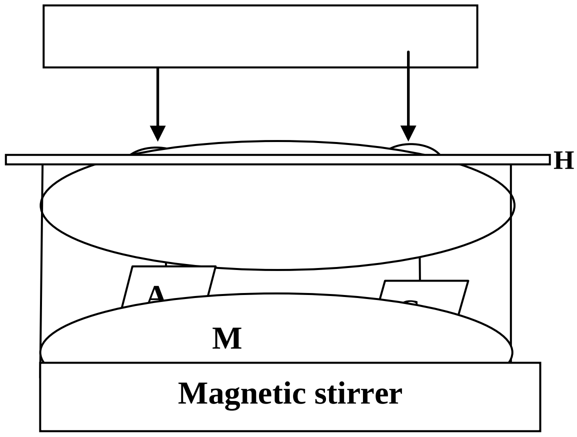
This study has been conducted with the aim of optimizing the factors affecting the process of COD reduction or removal which include contact time (0 - 120 min), voltages (20, 10 and 30v), electrode gaps (2, 4 and 6 cm) and electrode materials (iron, aluminum and stainless steel). It was observed that the removal efficiency is directly proportional to the electrode material, contact time and voltage and inversely proportional to electrode gaps. An optimal COD removal was achieved with the iron electrode and a time, gap and voltage of 120 min, 2 cm and 30V, respectively. Sekman et.al.,[18] has carried out the investigation on **.,**" Treatment of Oily Wastewater From Port Waste Reception Facilities by Electrocoagulation "The present study investigated oil/water demulsification and treatment of oily wastewater originated from port waste reception facilities by electro coagulation using aluminum electrodes in a batch reactor.

Main objectives of the present paper to evaluate the removal of COD, TSS,TDS and oil and grease from the dairy industry wastewater by Electrocoagulation using iron as Monopolar configuration at different voltages and electrolysis time. To study the effect of inter electrode spacing and effect of different initial pH for the removal of COD, TSS, TDS, oil and grease at constant voltage for the iron electrode.

Materials and Methodology

Experimental Setup

Experiments were carried out as batch mode in 1 liter capacity circular borosil glass beaker, for Monopolar configuration of electrocoagulation technique. Fig1 shows the schematic diagram of experimental set up. The iron electrode with dimension 5cm X 5cm and 1mm thickness were used in this present study. Experiments were carried with different voltages, varying inter electrode spacing and pH.For each voltage at every 15minutes intervals samples are taken and analyzed for COD, TSS, TDS, oil and grease and efficiency is studied for iron electrode. The electric power required during the electrolysis was provided by a laboratory Dual DC power supply unit (0-30V, 2A).Copper wires were connected to the electrodes to supply the DC current to the system. The electrolytic cell was equipped with a magnetic stirrer mixing the sample. The wastewater for this study is collected from Manmull product dairy, Gejjelgere, Mandya ,Karnataka, the collected wastewater was analyzed as per standard methods.



A= Anode H= Head plate
M= Magnetic bit
C= Cathode

Fig.1. Schematic diagram of electrocoagulation unit

2.2 Methodology for different electrical potential, electrolysis time and pH

Monopolar configuration of two iron plate electrodes was used for electrocoagulation. Iron electrodes are placed at inter electrode gap of 1.5 cm up to 3cm at an interval of 0.5 cm, on the fiber electrode holding stand fixed to the mouth of the reactor and connected to the 30V dual DC power supply. The reactor was placed on the magnetic stirrer and magnetic beads are placed for continues and uniform mixing of the wastewater. The batch experiment was conducted at varying voltage of 10V, 20V and 30Vwith selected time intervals of 15, 30 up to 120 minutes at room temperature. In each run, approximately one liter of dairy wastewater sample were placed in reactor after adjusting the pH to 4, 6, 7 and 9 by adding H_2SO_4 and 1N NaOH respectively.

Results and discussion

Performance evaluation of Electro coagulation process with the iron electrodes was carried out for different voltages of 10V, 20V, 30V with selected times of 0 to 120 minutes at time intervals 15 minutes. Different electrode spacing of 1.5 cm up to 3cm at an interval of 0.5cm and varying pH of 4, 6, 7 and 9 was discussed. Removal efficiency for all the operating parameters was discussed and presented.

Characteristics of Dairy Wastewater

In the present study collected wastewater from product dairy was analyzed as per standard methods and presented in Table 1.

Table 1 Characteristics of dairy wastewater

Parameter	Values
ECμS/cm	2240
pH	7.65
COD mg/L	2150
TSS mg/L	1790
TDS mg/L	1344
Oil and grease mg/L	750

Effect of electrical potential and electrolysis time

Fig.2. depicts the COD removal efficiency at different voltages, time intervals and selected pH 7.5 for iron electrodes. A COD removal of 69.4%, 78.9% and 80.4% was obtained at 10, 20, 30V respectively and optimum removal of COD is achieved at 30V for contact time of 90 min.COD removal efficiency increases as the electrical potential and electrolysis time increases. This was due to the release of metal ions increases with increase in electrical potential. Therefore, there was an increase in floc formation and hence an enhancement in the COD removal efficiency.

The decrease of TSS with increase in the voltage and current time is shown in the Fig. 3. From the figure it can be ascertained that 77.4%, 82% and 85.1% of TSS is removed at 10 V, 20 V and 30 V respectively. The maximum removal is at 90 minutes after that increasing electrolysis time did not affect the removal rate significantly and an optimum removal of 85.1% was achieved at 30V.Electrical potential affected the efficiency of total suspended solids removal significantly. This is due to the influence of the increased hydroxides with the increase in the voltage and electrolysis time.

Fig.4. illustrates TDS removal efficiency at different voltages and time intervals for iron electrodes. About 79%, 81.5% and 83.6% was achieved at 10, 20,30V respectively and an optimum removal of 83.6% was achieved at 30V for contact time of 90 min and after that it remains constant up to 120 minutes. The hydrogen gas liberated at the cathode helps to float the contaminants this influences the removal of TDS. The TDS removal efficiency increases with increase in electrical potential and electrolysis time.

The effect of voltage and electrolysis time on oil and grease removal is shown in the Fig.5.from the figure it was observed that for the first 15 minutes, oil and grease removal reached to a higher than 80% for all voltages. Optimum removal of 91.4% was observed at 30V and contact time of 30 minutes after that increasing electrolysis time did not affect the removal rate significantly. Increase in voltage enhances the generation of hydrogen and oxygen gases formed at electrode surfaces. This leads to an increase in the number of gas bubbles inside the EC unit Consequently the attachment step between gas bubbles and oil drop is enhanced and more oil drops are carried by gas bubbles to the surface and oil removal was increased.

From the figures it was concluded that increase in voltage and contact time increases the removal efficiency and optimum removal efficiency with the iron electrode is achieved at 30V and contact time of 90 minutes for COD, TSS, TDS and 30V, 30minutes for oil and grease removal. Hence the optimum voltage is 30V and 90 minutes contact time.

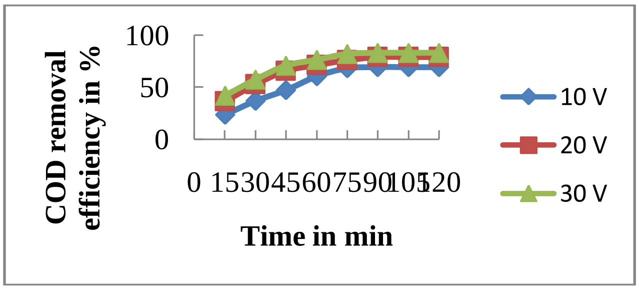


Fig.2.Variation in removal efficiency of COD

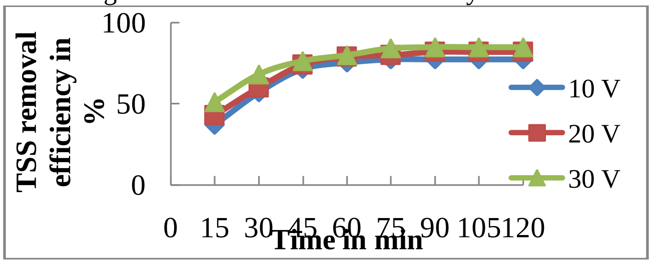


Fig.3.Variation in removal efficiency of TSS

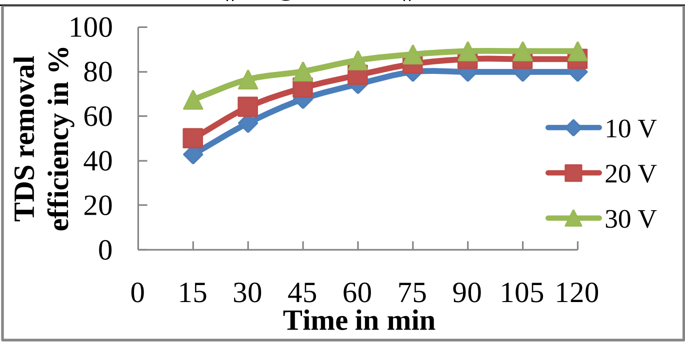


Fig. 4.Variation in removal efficiency of TDS

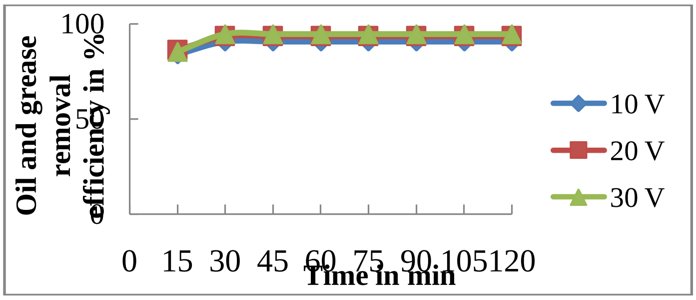


Fig.5.Variation in removal efficiency of Oil and grease

Effect of inter electrode spacing with iron electrode

The EC process was conducted for electrodes spacing of 1.5cm, 2cm, 2.5cm and 3cm at optimized voltage of 30V and selected pH of 7.5.

Fig.6. illustrates the removal COD is about 83.8%, 80.4%, 76.4% and 72.3% at 1.5cm, 2.cm, 2.5cm and 3cm respectively, removal efficiency was more at 1.5 cm of electrode gap than the other electrode gaps.Fig.7. shows the removal efficiency of TSS. About 87.1%, 85.1%, 82% ,and 78.8% of removal observed at 1.5cm, 2cm, 2.5cm and 3cm of electrode spacing respectively. The optimum removal efficiency was observed at 90 minutes

Fig.8.depicts the removal efficiency of TDS about 85.9%, 83.8%, 81.5 and 80.4% were observed at 1.5cm, 2cm, 2.5cm and 3cm of electrode spacing respectively. The optimal removal efficiency was observed at 90 minutes. Fig.9. demonstrate the removal efficiency of oil and grease about 95%, 94.6%, 92.8% and 91% were observed at 1.5cm, 2cm, 2.5cm and 3cm of electrode spacing respectively. The maximum removal was observed at 15 minutes and slight increase at 30 minutes. From the figures it was concluded that increase in the electrode spacing decreases the removal efficiency

Gharemani et al.,[1] and Belmont et al., [26] stated that increase in the electrode spacing decreases the removal efficiency due to the fact that increase in the electrode spacing increases the solution resistivity and reduce the concentration of ions and a consequence decrease in the electrostatic attraction. The shorter gap favor the minimization of the potential drop which leads to a higher current density and after an optimum spacing the removal efficiency is suppressed.

The higher removal efficiency of the pollutants was observed at electrode gap of 1.5cm this optimized electrode gap was maintained in this study for further operational condition with the iron electrode.

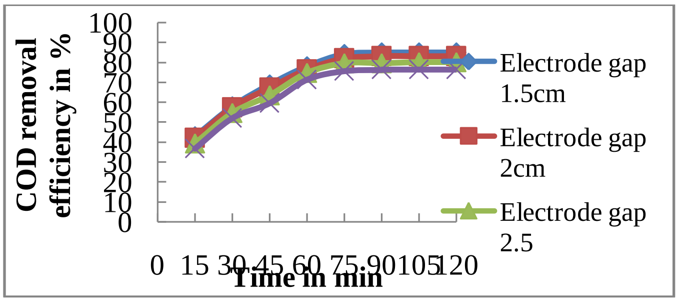


Fig .6.Variation in removal efficiency of COD

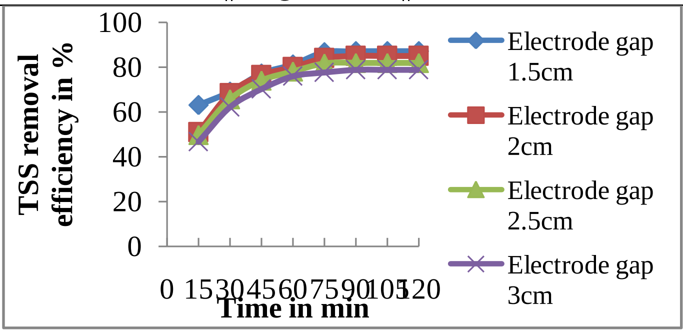


Fig .7.Variation in removal efficiency ofTSS

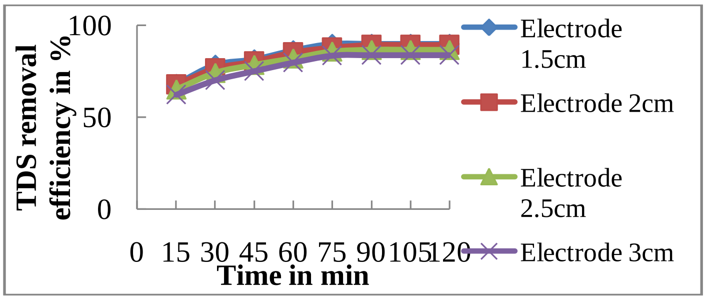


Fig.8.Variation in removal efficiency of TDS

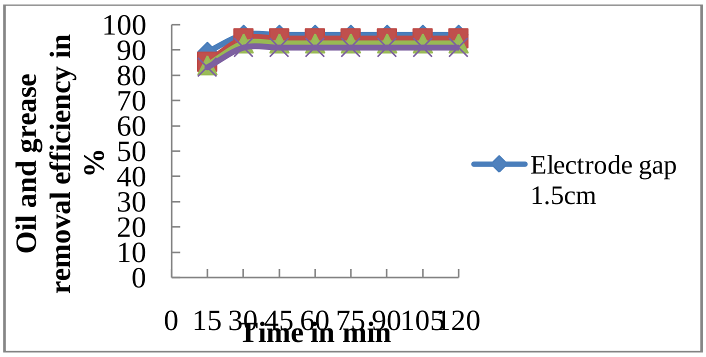


Fig.9.Variation in removal efficiency of Oil and grease

Effect of initial pH with iron electrode

In this mode of operation, evaluation of Electro coagulation process with the iron electrodes was carried out for optimized voltage of 30V and 1.5cm of electrode gap with selected time of 0 to 120 minutes at time intervals 15 minutes with varying pH of 4, 6, 7 and 9. The obtained results and percentage removal efficiency for pH of 4, 6, 7 and 9 were presented in the Fig.10 to 13.

Fig.10 illustrates the effect of initial pH on the reduction of COD. About 79.3%, 84%, 86.5% and 75.3% of COD was removed at pH of 4, 6, 7 and 9respectively. At all selected pH COD was removed efficiently but removal efficiency was maximum at pH range of 6 to 7 and decreases at pH 9. The optimum removal of COD was at pH 7.Fig.11 illustrate the effect of initial pH on the reduction of TSS about 80.2%, 87.1%, 88% and 76.8% of TSS was removed at pH of 4, 6, 7 and 9 respectively. At all selected pH TSS was removed efficiently but removal efficiency was maximum at pH rang of 6 to 7 and decreases at pH 9. The optimum removal of TSS was at pH 7.

Fig.12 represents the effect of pH on the reduction of TDS. About 75.9%, 87.4%, 90.2% and 70.9% of TDS was removed at initial pH of 4, 6, 7 and 9 respectively. At all selected pH TDS was removed efficiently but removal efficiency was maximum at pH range of 6 to 7 and decreases at pH 9. The optimum removal of TDS was at pH 7. Fig.13 exemplifies the effect of pH on the reduction of Oil and grease. About 89%, 93%, 94.5% and 93.3% of oil and grease was removed at pH of 4, 6, 7 and 9 respectively. At all selected pH oil and grease was removed efficiently but removal efficiency was maximum at pH rang of 6 to 7 and decreases at pH 9. The optimum removal of oil and grease was at pH 7.

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From the Fig it was concluded that COD, TSS, TDS and oil and grease removal efficiency was more successful at pH range of 6 to 7. The higher removal efficiency is observed at pH 7 and the efficiency decreases at pH 9. Masoumeh moayerikashani et al., [5] and Kashefialas M. et al., [15]stated that at pH7, the formed Fe ions in the sample could possibly result in the formation of $Fe(OH)^{2+}$, $Fe(OH)^{4-}$, $Fe(OH)^{4-}$, $Fe(H_2O)_5OH^{2+}$which were finally transformed in to $Fe(OH)_3$. When pH less than 4is in soluble formFe^{3+} and when pH higher than pH 7, Fe $(OH)_3$is in soluble formof $Fe(OH)^{4-}$ and thus the removal efficiency declines.

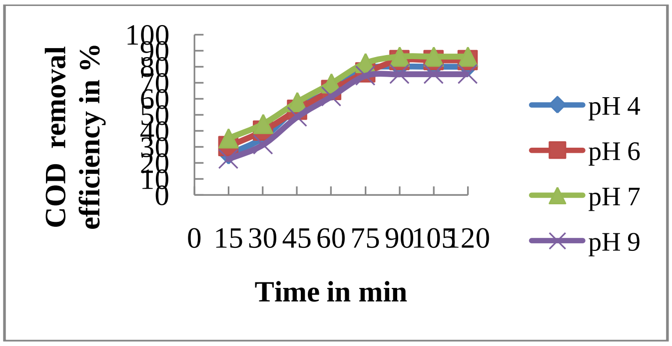

Fig .10 Variation in removal efficiency of COD

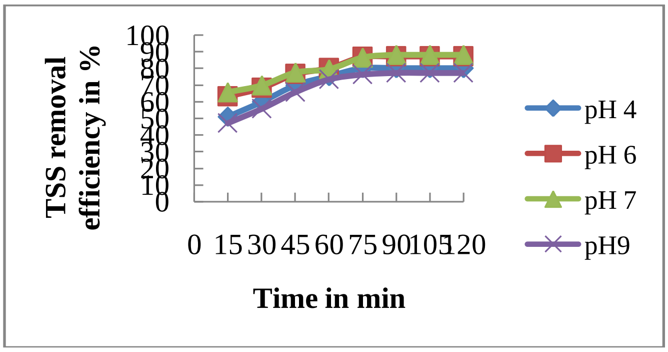

Fig.11 Variation in removal efficiency of TSS

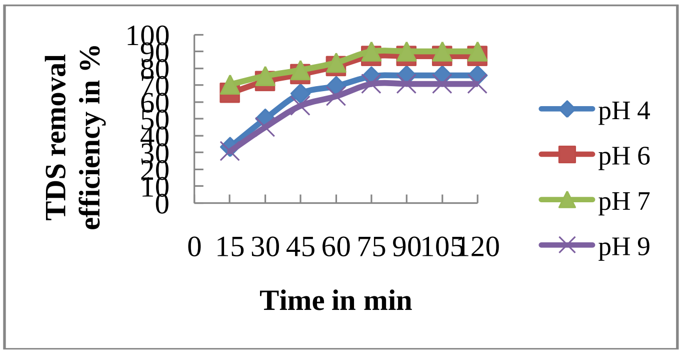

Fig.12. Variation in removal efficiency of TDS.

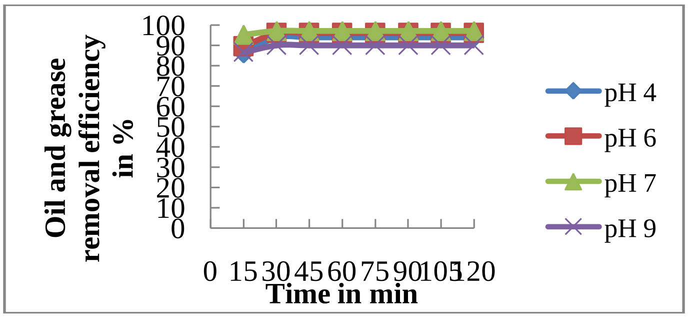

Fig.13. Variation in removal efficiency of Oil and grease

Conclusions

The increase in voltage and electrolysis time increases the removal efficiency. For the removal of COD, TSS, TDS the optimum voltage and electrolysis time was 30V and 90 minutes for iron electrode. The percentage removal efficiency of 80.4%, 85.1%, 83.4% and obtained for the 30V. For oil and grease the removal efficiency of 91.4% was achieved at an optimum voltage and contact time of 30 V and 30 min.

At the pH range of 4 to 7 the optimum removal efficiency of 86.5% of COD, 88% of TSS, 90.2 % of TDS and 94.5% of oil and grease was achieved with iron electrode. The removal efficiency decreases with increase in electrode spacing. 83.8% of COD, 87.1% of TSS, 85.9 % of TDS and 95% of oil and grease was achieved with iron electrode. The electrode consumption and production of sludge increases with increase in voltage.

Study recommended conducting experiment using other electrodes such as mild steel, stainless steel and graphite for the treatment of wastewater. In addition, bipolar configuration and hybrid Monopolar configuration can be used for the electrocoagulation treatment method.

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