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DOMESTIC WASTEWATERTREATMENT BY ELECTROCOAGULATION TECHNIQUE USING IRON ELECTRODES

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ABSTRACT

Ever increases domestic and rapid urbanization have considerably increased the rate of water pollution. Specially, water bodies nearer to domestic area have been extremely affected from the disposal of water. So, domestic waste is the most common source of water pollution in the present day. Therefore it is desirable for the environmental benefits to treat the domestic wastewater to prevent any pollution from domestic operation. Here, a number of batch experiments were carried out in a laboratory scale for the treatment of domestic waste with iron electrodes and the removal efficiency of these electrodes were studied under similar operation conditions. It was found that all operational conditions influence on the COD,TSS and TDS efficiency.At an electrolysis time of 90min, electrical potential of 20V, inter-electrode spacing of 3cm iron shows maximum removal efficiency of 79.87%, 92% and 85.71% was obtained for COD, TSS and TDS respectively.From the study it was clear that, the removal efficiency is directly proportional to the electrode material, electrolysis time, electrical potential and inversely proportional to the inter-electrode spacing.

Keywords—Waste water treatment, COD, TSS, TDS, Electrocoagulation.

I. INTRODUCTION

The major challenge for 21^{st} century is water and energy. Due to increased Pollution from point and non-point sources quality of the water become crucial problem. Wash water is not only one of the main causes of irreversible damages to the environmental balance but also contributing to the depletion of the fresh water reserve at the planet. Wastewater generally consist of biochemical oxygen demand (BOD), chemical oxygen demand (COD),Total suspended solids (TSS), heavy metals, food stuff, oil wastes, textile and dyes, organic matter and suspended particles.

Domestic wastewater is one of the important pollution sources in the pollution of the waste environment. During the last century a huge amount of domestic wastewater was discharged into the rivers. Lakes and coastal areas. This resultant is serious pollution problems in the water environment and caused negative effect to the eco system and human’s life.

Coagulation and flocculation are traditional methods for the treatment of polluted water. In these processes, coagulating agents (e.g. alum or ferric chloride) and other additives (e.g. poly electrolytes) are dosed to produce larger aggregates, which can be separated physically. This is a multi-stage process that requires considerable land area and a conventional supply of chemicals. A more cost effective method to clean a wide range of polluted water, on site, and with minimal additives, is required for sustainable water management. Electrocoagulation treatment of water may fit this description. Due to high BOD, COD, TSS, TDS, oil and grease removal and sludge production expenses, as well as high costs, the electrochemical treatment of domestic wastewater has grown in importance.

Electrocoagulation involves the generation of coagulation in situ by dissolving electrically either aluminum or iron ions from aluminum or iron electrodes, respectively. The metal ions generation takes place at the anode; the hydrogen gas is released from the cathode. The electrodes can be arranged in a monopolar or bipolar mode. The materials can be aluminum or iron in plate from or packed form of scraps turning and milling

II. OBJECTIVES OF THE STUDY

This study is focused on

1. Study the applicability of electrocoagulation process.

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2. Evaluate the removal efficiency of TSS, TDS and COD using iron electrodes in monopolar configuration.
3. Scrutinize the optimum value of operational variables such as electrical potential, inter electrode spacing and electrolysis time using iron electrodes.

III. MATERIALS AND METHODOLOGY

The details of the different materials and experimental set up developed in the presentstudy have been Presentedherein. In addition, a brief outline of the batch experimental procedures, mode of operation has also been described. All physicochemical parameters were analyzed as per standard methods.

i) Wastewater Source

The raw wastewater for this study was collected from SJCIT BOYS HOSTEL and was analyzed for BOD, COD, TDS, TSS and pH and was analyzed as per standard methods.

ii) Electrode details

Iron (Fe) electrodes were used as sacrificial electrodes in parallel mode.

iii) Initial characteristics

The raw domestic wastewater was collected from SJCIT BOYS HOSTEL, Chickballapur and wastewater was analyzed as per the standards and the values are shown in Table1

Table1: Initial characteristics of domestic wastewater

Characteristics	Values
pH	9.96
Turbidity	480NTU
COD mg/L	800
Total suspended solids,mg/L	5000
Total dissolved solids, mg/L	5600

iv) Experimental setup and design

The batch experiments were carried out in the plastic beaker of 1lt capacity equipped with cathode and anode. The iron electrodes were used in this study. The domestic wastewater was used for each experiment. Electrodes were placed in the domestic wastewater and connected to the terminal of DC power supply. The voltage and current flowing through the cell were measured with multimeter. The electrodes used are placed parallel with the dimension of 5cm X 5cm and thickness of 1mm. These dimensions were chosen in a manner so that required electrical current for meeting the design treatment efficiency was achievable. The electrolytic cell was equipped with a magnetic stirrer in order to keep the electrolyte well mixed. The efficiency of the EC method was studied at different voltages and time intervals for every 15 min - 90 min samples were taken from the cell and analyzed for the each parameter and the efficiency of each electrode is calculated as per the standard methods. [3] proposed a principle in which another NN yield input control law was created for an under incited quad rotor UAV which uses the regular limitations of the under incited framework to create virtual control contributions to ensure the UAV tracks a craved direction. Utilizing the versatile back venturing method, every one of the six DOF are effectively followed utilizing just four control inputs while within the sight of un demonstrated flow and limited unsettling influences. Elements and speed vectors were thought to be inaccessible, along these lines a NN eyewitness was intended to recoup the limitless states. At that point, a novel NN virtual control structure which permitted the craved translational speeds to be controlled utilizing the pitch and the move of the UAV. At long last, a NN was used in the figuring of the real control inputs for the UAV dynamic framework. Utilizing Lyapunov systems, it was demonstrated that the estimation blunders of each NN, the spectator, Virtual controller, and the position, introduction, and speed following mistakes were all SGUUB while unwinding the partition Principle.

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Fig 1: Electrocoagulator and Electrodes used in EC technique

1. Methodology of electrolysis time and electrical potential

In this mode of operation, two monopolar iron plate electrodes with dimensions of 5cm X 5cm and 1mm thickness used as both anode and cathode and the domestic wastewater of 1lt was used for each experiment. Before each run electrodes were cleaned with 15% of HCL solution. The spacing between electrodes was measured and kept. The efficiency of EC method was carried out for different voltages of 10V to 30V with different time intervals 15 min, 30 min up to 90 minutes. Each experiment was of batch operation and for every 15 min samples were taken from the cell using a pipette tube to avoid passivation of the electrodes and analyzed for COD, TSS, TDS and pH. All experiments were carried out at a room temperature near 30^{o}c. The electrochemical cell and electrodes were entirely cleaned after each experiment with detergent. Removal Efficiency is calculated.

Removal efficiency is calculated using the formula,

Removal efficiency %= $\{(C_o-C)/C_o\}*100$

Where C_o= concentration of the sample before electrolysis.

C= concentration of the sample after electrolysis.

Iron upon oxidation in an electrolytic system produces iron hydroxides, $Fe(OH)_n$ where n = 2 or 3. Two mechanisms have been proposed for the production of $Fe(OH)_n$.

- Anode:
  $4Fe_{(s)} \rightarrow 4 Fe^{2+}{}_{(aq)} + 8e^-$
  $4Fe^{2+}{}_{(aq)} + 10 H_2O_{(l)} + O_{2(g)} \rightarrow 4Fe (OH)_{3(s)} + 8H_{(aq)}$
- Cathode: $8H^+{}_{(aq)} + 8e^- \rightarrow 4 H_{2(g)}$
- Overall:
  $4Fe_{(s)} + 10 H_2O_{(l)} + O_{2(g)} \rightarrow 4Fe (OH)_{3(S)} + 4H_{2(g)}$

2. Methodology for different inter-electrode spacing

In the mode of operation the two monopolar iron plate electrodes with dimension of 5 cm X 5 cm and 1mm thickness used as both anode and cathode and domestic wastewater of 1litre was used for each experiment. Before each run electrodes were cleaned with 15% of HCL solution. The electrodes were kept at 1 cm, 2 cm and 3 cm distance, the pH of the wastewater was adjusted to above 9, efficiency of EC method was carried out for different voltages 10V to 30V with different time intervals of 15 min, 30 min up to 90 min for all inter-electrode spacing respectively. Each experiment was of batch operation and for every 15 min samples were taken from the cell using a pipette tube to avoid the passivation of the electrodes and allow to settling, then the supernatant was analyzed for COD, TDS, TSS, oil and grease at all pH. All experiments were carried out at room temperature near 30^{0}C. The electochemical cell and electrodes were entirely cleaned after each experiment with detergent. Removal Efficiency is calculated.

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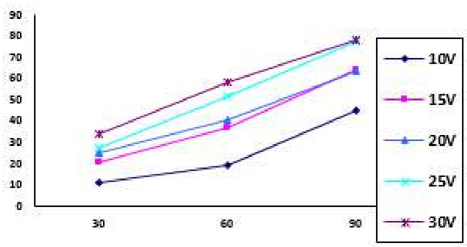
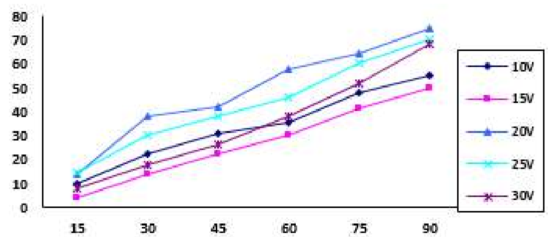
Fig2.Formation of floc during EC process

Fig3.Water after EC process

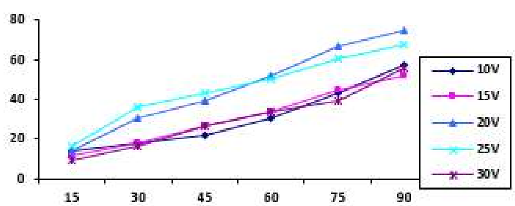
IV. RESULTS AND DISCUSSIONS



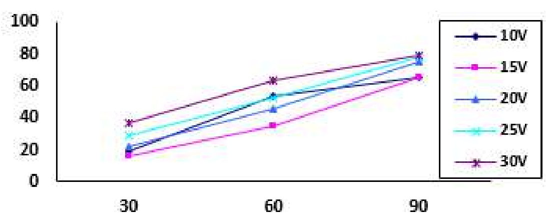
Graph 1: COD Removal efficiency at different voltage and time interval for iron electrodes having 1cm gap between electrodes (x – axis:- Time in min, y- axis:- Efficiency in %)



Graph 2: TSS removal efficiency at different voltage and time interval for iron electrodes having 1cm gap between electrodes (x – axis:- Time in min, y- axis:- Efficiency in %)



Graph 3: TDS removal efficiency at different voltages and time intervals for iron electrodes having 1cm gap between electrodes (x – axis:- Time in min, y- axis:- Efficiency in %)



Graph 4: COD removal efficiency at different voltage and time intervals for iron electrode having 2cm gap between electrodes (x – axis:- Time in min, y- axis:- Efficiency in %)

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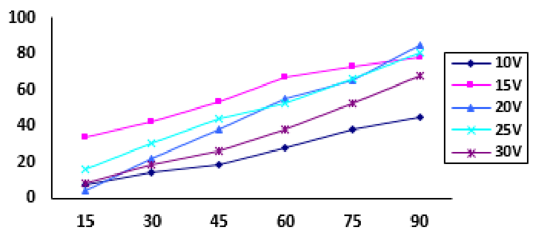
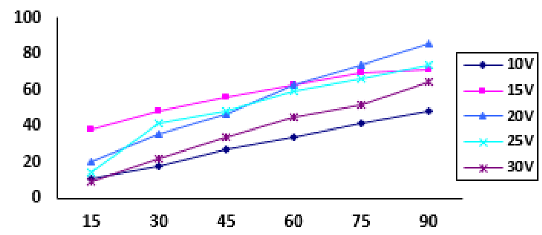
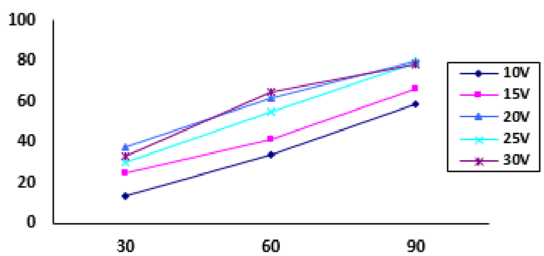


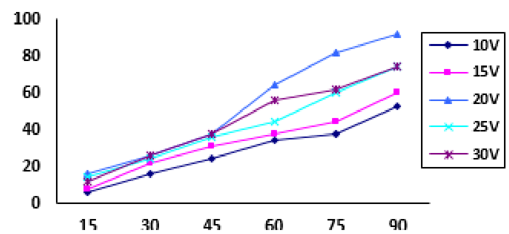
Graph 5: TSS removal efficiency at different voltage and time intervals for iron electrodes having 2cm gap between electrodes (x – axis:- Time in min, y-axis:- Efficiency in %)



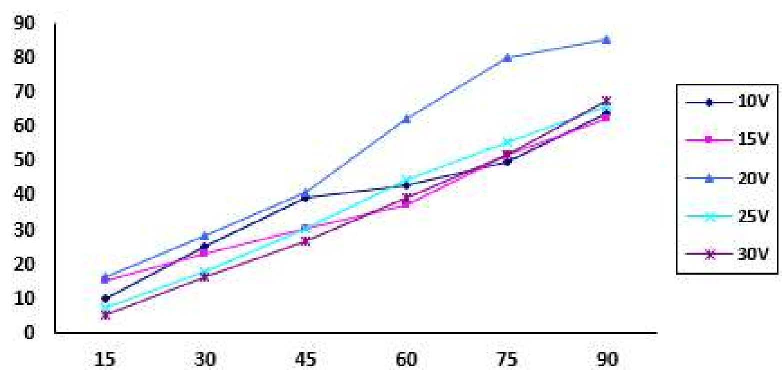
Graph 6: TDS removal efficiency at different voltage and time intervals for iron electrodes having 2cm gap between electrodes (x – axis:- Time in min, y-axis:- Efficiency in %)



Graph 7: COD removal efficiency at different voltages and time intervals for iron electrode having 3cm gap between electrodes (x – axis:- Time in min, y- axis:- Efficiency in %)



Graph 8: TSS removal efficiency at different voltages and time intervals for iron electrodes having 3cm gap between electrodes (x – axis:- Time in min, y- axis:- Efficiency in %)



Graph 9: TDS removal efficiency at different voltages and time intervals for iron electrodes having 3cm gap between electrodes (x – axis:- Time in min, y- axis:- Efficiency in %)

Results and discussion of treated domestic wastewater for different voltages and time intervals using iron electrode at 3cm electrode spacing:

Here the performance of evaluation of EC process with the iron electrodes was carried out for different voltages of 10V, 15V, 20V up to 30V with different time intervals of 15min, 30min, up to 90 minutes at 1cm of electrode gap the obtained results and percentage removal efficiency are presented in graph7 to 9 respectively.

Graph 7 depicts the COD removal efficiency at different voltages and time intervals for iron electrodes. The COD removal efficiency increases as the electrical potential and electrolysis time increases. This may be explained by the release of metal ions increases with electrical potential. Therefore, there is an increase in floc production and hence an improvement in the COD removal of 59%, 66.5%, 79.87%, 79% and 78% was obtained at 10V, 15V, 20V, 25V, 30V respectively and an optimum removal of COD is achieved at 20V for contact time of 90min.

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Graph 8 demonstrates the TSS removal efficiency at different voltages and time intervals for iron electrodes. Electrical potential affected the efficiency of total suspended solids removal significantly. The TSS removal efficiency increases as the total electrical potential and electrolysis time increases. About 16% of TSS was removed at 20V for contact time of 15min. The TSS removal rate increases up to 90minutes contact time for all the 10V, 15V, 20V, 25V, and 30V to about 52.6%, 60%, 92%, 74% and 74% respectively. After that increasing electrolysis time did not affect removal rate significantly and an optimum removal of 92% was achieved at 20V for contact time of 90 minutes.

Graph 9 illustrates the TDS removal efficiency at different voltages and time intervals for iron electrode. The TDS removal efficiency increases as the electrical potential and electrolysis time increases. The iron electrodes at 20V and 15 minutes of electrolysis time could dispose of 16.07% of TDS from reactive wastewater.

From the figures it was observed that the optimal removal efficiency of COD, TSS and TDS with the iron electrode is achieved at 20V and contact time of 90minutes and for electric conductivity 20V and 90 minutes contact time.

V. CONCLUSION

The present study investigated the treatability of domestic wastewater by EC process using iron electrode and at different operating conditions. On the basis of obtained results the following conclusions can be drawn.

- The increase in voltage and electrolysis time increases the removal efficiency. The optimum electrical potential and electrolysis time for COD, TSS and TDS was 20V and 90 min were 79.87 %, 92%, 86% efficiency was achieved with iron electrode.
- At 3 cm inter-electrode spacing, the optimum removal was observed with iron electrodes for all analyzed parameters.
- Overall it was concluded that, at 20V electrical potential, 90 min contact time, 3 cm inter-electrode spacing at 100rpm.

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