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Domestic Wastewater Treatment by Electrocoagulation Using Copper and Aluminum Electrodes

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ABSTRACT: The study was focused on treating domestic wastewater by electrocoagulation using copper and aluminum electrodes was investigated sample is made up to run at different interval of time i.e., 10, 20 and 30minutes and different volts (7V, 14V, 20V).The combination effects of Volts, pH, and treatment time to the efficiency of the electrocoagulation process for the removal of Chemical Oxygen Demand, Nitrates was considered to evaluate the treatment efficiencies. The results were obtained in the removal of considered parameter with four no of electrodes, for four electrodes configuration with 30 min contact period removal efficiency of COD, Nitrates, were 63.2%, 62%.

KEYWORDS: Aluminum, COD, Nitrates, Contact time, Domestic, Electrode, Copper, Voltage, wastewater.

I.INTRODUCTION

Wastewater is the main cause for irreversible damages to the environment and also contributes to the reduction of fresh water reserves, creating threats to the next generation. Many industries consume fresh water and exhaust as a wastewater. It should be treated properly to reduce or eradicate the pollutants and achieve the permissible limit for its reutilization in the industrial/agriculture process to promote sustainability [2]. There is a need of more cost-effective methods to purify a wide range of polluted water on-site, and with minimal additives that are required for sustainable water management. Electrolytic treatment of wastewater presents an innovative technology in which a sacrificial metal anode and cathode produce electrically active coagulants and tiny bubbles of hydrogen and oxygen in water. [3]. One of the challenging tasks faced by scientists and engineers today is to provide safe water to support healthy human life. But human activities always generate wastewaters which contain various pollutants that create problems to aquatic life and contaminate water resources [4]. Highly developed countries, such as the US, are also experiencing a critical need for wastewater cleaning because of an ever-increasing population, urbanization and climatic changes [7]. Recently, there has been considerable interest in identifying new technologies that are capable of meeting more stringent treatment standards [8].Various electrochemical treatments are available for effluent treatment however; these processes were basically developed for the treatment of either organic impurities or desalination of waters for human consumption. Moreover the cost of these electrochemical treatments was a major factor of concern due to Degeneration [9]. Many water and wastewater treatment technologies have been developed in last few decades for the removal of diverse aquatic pollutants. During the last years, the electrochemical methods have been developed and used as alternative options for the remediation of water and wastewaters mainly due to their advantages, e.g., environmental compatibility, versatility, high energy efficiency,

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amenability of automation and safety, and cost effectiveness. [11].

II. RELATED WORK

Recently there has been growing interest towards electrochemical techniques for the treatment of wastewater containing organic pollutants. Two important features of the electrochemical process are converting non-biocompatible Organics in to biocompatible compounds and oxidation of organics into carbon dioxide and water. A typical electrochemical treatment process consists of electrolytic cell, which uses electrical energy to affect a chemical change. In simplest forms, we can say that, an electrolytic cell consists of two electrodes, anode and cathode, immersed in an electrical conducting solution (the electrolyte), and are connected together, external to the solution, via an electrical circuit which includes a current source and control device[10]. In India EC technology has been successfully adopted for the treatment of the textile dye wastewater [10], purification of wastewater [3], Heavy metals [9] and domestic wastewater [4]. This method is characterized by simple equipment and easy operation. The EC processes have lesser amount of sludge and the EC process have been successfully used in removal of COD and Nitrates as high as 98% and 86%, from Domestic Wastewater using iron electrodes[12], 98.07%, from Domestic wastewater using iron, aluminum electrodes and stainless steel electrodes, [13].

III. ELECTROCOAGULATION MECHANISM

Electrocoagulation in combination with other treatment methods is a safe and effective way for the removal of pollutants
[6].Generally, three main processes occurs serially during Electrocoagulation: (a) Electrolytic reactions at electrode surfaces,
(b) Formation of coagulants in aqueous phase,
(c) Adsorption of soluble or colloidal pollutants on Coagulants, and removal by sedimentation or floatation.
The advantages of electrocoagulation as compared to chemical coagulation are as follows: EC requires no addition of chemicals and provides better removal capabilities for the same species than chemical Coagulation, removes many species that chemical coagulation cannot remove, It produces less sludge, thus lowering the sludge disposal cost sludge is more readily filterable and can be utilized as a soil additive. EC sludge contains metal oxides that pass the leach ability test. This technique needs minimal startup time; the process can be started by turning on the switch [6]. Electro coagulation is the technique to create conglomerates of the suspended, dissolved or emulsified particles in aqueous medium using electrical current causing production of metal ions at the expense of sacrificing electrodes and hydroxyl ions as a result of water splitting. Metal hydroxides are produced as a result of EC and act as coagulant/flocculent for the suspended solids to convert them into flocs of enough density to be sediment under gravity. Destabilization of the contaminants, particulate suspension, breaking of emulsions, and aggregation of the destabilized phases to form flocs. The reactions occurring in an EC process using aluminum anode and cathode is represented below [5].

Anode:

$$Al\text{-}3e \longrightarrow Al^{3+} \quad (1)$$

$$Al^{3+} + 3OH^{-} \longrightarrow (OH)_3 \quad (2)$$

$$Al^{3+} + 3H_2O \longrightarrow Al(OH)_3 + 3H^{+} \quad (3)$$

$$2H_2O\text{-}4e \longrightarrow O_2 + 4H^{+} \quad (4)$$

Cathode:

$$2H_2O + 2e \longrightarrow H_2 + OH \quad (5)$$

Dissociation of water by Electrocoagulation generates hydroxide ions, which of the most reactive species which oxidize

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The organic compounds, Polyhydroxides or Hydroxide have strong bond attraction, further dispersed particles as well as counter ions to cause coagulation. Suspended solids will takes place in upward direction due to gas evolved at the electrodes. [5]

IV. MATERIALS AND METHODS

Materials

The electrochemical cell consists of a borosil glass beaker of 5 lit capacity to hold a sample, commercially available Aluminum/Copper plate were cut into required sizes [150×50×3mm] and provisions for electrical connections were made by making holes at the top of plates. Polarity of current was reversed at regular intervals in order to minimize the deposition on electrodes; Provisions were made in the reactor for the change of electrodes. 3cm gap will be maintained between the bottom of the electrodes and the bottom of the cell is allowed for easy stirring. The electrolytic cell was equipped with a magnetic stirrer in order to keep the electrolyte well mixed. In this study, an individual effect of Cell Voltage and applied pH and Electrolysis time was quantified. The electrolysis was carried out under galvanostatic conditions covering a wide range of operating conditions.

Methodology

The efficiency of the electrolytic cell was studied with Different Voltages, and Electrolysis Time. Each experiment was of batch operation for every 10, 20, 30 minutes samples were drawn and Operating Parameters such as COD, Nitrates, were measured. Before each run, the impurities in the surfaces of electrodes will be removed by dipping in HCl solution (15% W/V) for 1–2 min and then washed with distilled water. At the end of each experimental (i.e. after electrocoagulation) run, the sample will be transferred into another and it will be kept undisturbed for 20 minutes in order to allow the flocs that formed during electrocoagulation to settle down. When too large current is used, there is a high chance of wasting electrical energy in heating up the water. More importantly, a too large current density would result in a significant decrease in current efficiency. Table1. Shows that Methods adopted and Equipment used for the Analysis of the Parameter. Table 1: Laboratory analytical methods [1]

Parameter	**Methods Adopted**	**Equipment Used**
pH	Electrometric	pH Meter
Nitrate	Spectrophotometer	Spectrophotometer
COD	Open Reflux	Volumetric glassware

Analysis of Sample

The current study area is Nittuvalli HKR Circle Area, is located at Davanagere district of Karnataka State, India. All the reagents used were of analytical grade and solutions were made of distilled water. Parameters such as COD, Nitrates, etc., were determined using standard analytical methods and procedures. The instruments used were calibrated before use for observing readings. The repeated measurements were made to ensure precision and accuracy of result. In order to examine its effect, the sewage water was adjusted to the desired pH by using Sodium hydroxide (NAOH) and sulphuric acid (H_2SO_4).

V.RESULTS AND DISSCUSSIONS

The Characteristics of the Domestic Wastewater are presented in Table 2.In the Present Study the Electrochemical degradation for the wastewater is conducted with pH adjustments, In the present study Sodium hydroxide (NAOH) and sulphuric acid (H_2SO_4) was used to maintain the pH. During this investigation the operating parameter such as

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Volts, Electrolysis time was varied to explore the effect on COD and Nitrate removal. Results showed that higher removal of COD and Nitrate takes place at Alkaline Range.

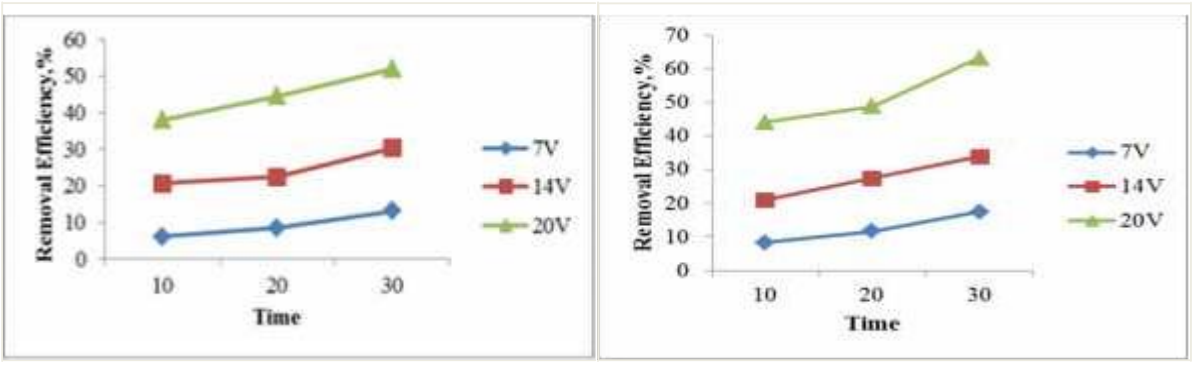
Table 2: Characteristics of Raw Wastewater

Parameter	**Sample**	**Threshold Value#**
COD, mg/L	458	250
Nitrates, mg/L	4.5	10

#Standard for Discharge of Effluent to Surface water, The Environment (Protection) Rules, 1986, India

Effect of Cell Voltage and pH on COD Removal

It has been established that pH is an operating Parameter influencing the performance of electrocoagulation process. The influent raw wastewater was maintained for all ranges; hydrogen evolution at cathodes takes place at acidic condition when pH increases, formation of OH^- ions near the anode would release H^+ leading to decrease of pH [10].The variation of COD removal efficiency with electrolysis time is shown in Fig 1.When pH was in Acidic Range i.e. (3-5), COD removal increases with Electrolysis time, However maximum COD removal efficiency of 52% was obtained at Electrolysis time of 30min at cell voltage 20V, during this period COD reduced from 458mg/L to 220mg/When pH was in Neutral Range i.e.(7-8), COD removal increases with electrolysis time, However maximum COD removal efficiency of was obtained at Electrolysis time of 30min at cell Voltage 20V, COD reduced from 430mg/L to 158mg/L. The pH was increased moving towards alkaline condition at pH (12-14), Maximum COD removal efficiency of 61% was obtained at Electrolysis time of 30mint cell voltage 20V, during this period COD was reduced from 340mg/L to 130mg/L. is shown in Fig 1.



(a) (b)

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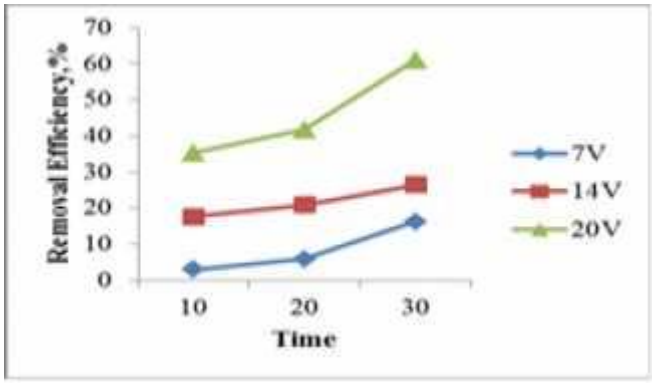
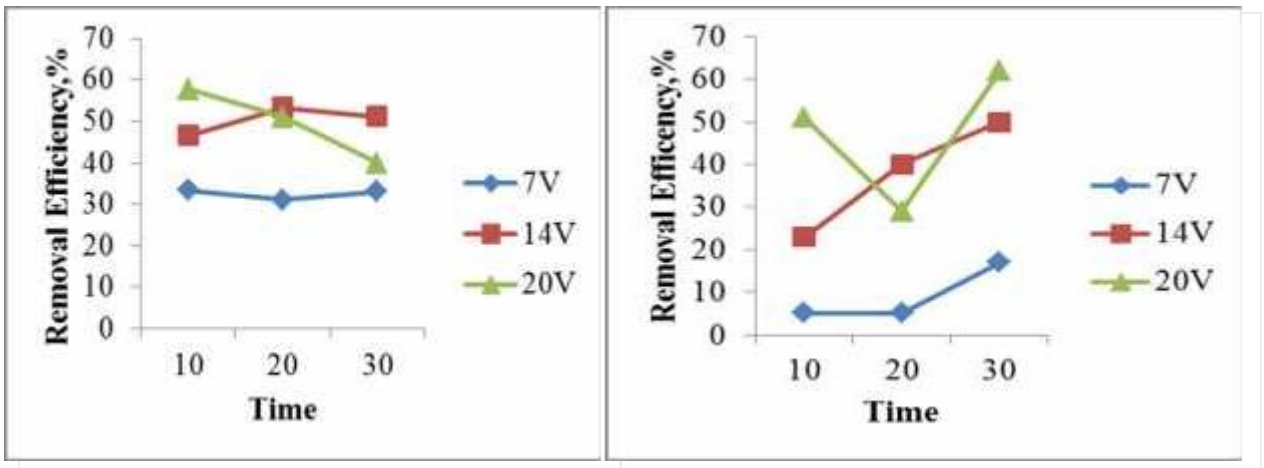


(c)

Fig.1 Effect of pH on the Removal Efficiency of COD (a) COD removal efficiency at pH (3-5) at Electrolysis duration of 30min (b) COD removal efficiency at pH (7-8) at Electrolysis duration of 30min (c) COD removal efficiency at pH (12-14) at Electrolysis duration of 30min and cell voltage 7,14, 20V

Effect of Cell Voltage and pH on Nitrate Removal

The variation of Nitrates with electrolysis time for different Volts is presented in Fig 2. From figure we know that Nitrates decreases with increasing electrolysis time in Neutral range, the trend of Nitrate reduction with electrolysis time at different volts is adopted in the present investigation. Also rate of nitrate reduction increases with increasing Volts is shown in fig.2 when pH was in Acidic Range i.e. (3-5), Nitrates removal increases with Electrolysis time, However maximum Nitrate removal efficiency of 58% was obtained at Electrolysis time of 30min at cell voltage 20V, during this period Nitrates reduced from 4.5mg/L to 1.92mg/L. When pH was in Neutral Range i.e.(7-8), Nitrates removal increases with electrolysis time, However maximum Nitrates removal efficiency of 62% was obtained at Electrolysis time of 30min at cell Voltage 20V, Nitrates reduced from 2.0mg/L to 0.76mg/L. Final pH was increased moving towards alkaline condition at pH (12-14) Maximum Nitrates removal efficiency of 50% was obtained at Electrolysis time of 30mint at cell voltage 20V,during this period Nitrates was reduced from 4.0mg/L to 2.0mg/L. is shown in Fig 2.



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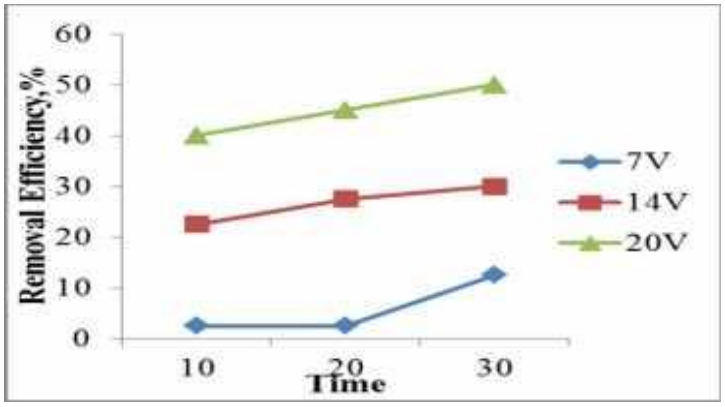

(c)

Fig.2 Effect of pH on the Removal Efficiency on nitrates (a) Nitrate removal efficiency at pH (3-5) at Electrolysis duration of 30min (b) Nitrate removal efficiency at pH (7-8) at Electrolysis duration of 30min (c) Nitrate removal efficiency at pH (12-14) at Electrolysis duration of 30min at cell voltage 7, 14, 20

VI. CONCLUSION

The study investigated the removal of COD, Nitrates, from Domestic Waste water. It was found that operating parameters such as electrolysis time, pH, and voltage significantly affected the treatment of Domestic Wastewater, The Optimum COD, Nitrate removal of 63.2%, and 62% respectively were obtained at a Electrolysis Time of 30 minutes cell voltage of 20V with Domestic Wastewater pH as 7-8, the study concludes that the applied Potential increases the rate dissolution of sacrificial electrodes and also increases at the Distance of 3cm. The results also showed that COD & Nitrates removal efficiency is directly proportional to input voltage and contact duration. Finally the results of study showed that, EC technology could be applied for the cost effective treatment of Domestic Waste water.

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