Domestic Wastewater Treatment Using Fe-Al Electrodes

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***Abstract*— This research study was focused on treating domestic wastewater by electrocoagulation using iron and aluminum electrodes. The routine Physico chemical characteristics viz., COD, BOD_5, Nitrate, Phosphate, Electrical conductivity, TDS and pH were considered to evaluate the treatment efficiencies. A glass reactor of capacity 1.3 L with a working volume of 1 L into which electrodes were immersed was used. Reactor operating conditions was contact period and potential applied across the electrode (5, 10, 15V). Two Electrode configurations with Fe-Al and four electrode configuration with Fe-Al-Fe-Al were considered. The promising results were obtained in removal of considered parameters with increase in number of electrodes. For 4 electrode configuration with 30min contact period, removal efficiency of PO_4, NO_3 and COD were 94%, 86% and 98% respectively. BOD_5 removal was higher than 80% for both 2 and 4 electrode configuration employed.**

***Index Terms*— Al, BOD, COD, Contact time, Domestic, Electrode, Fe, Voltage, Wastewater**

I. INTRODUCTION

Electrocoagulation is a electrochemical wastewater treatment technology, in which a electrolysis cell or reactor equipped with electrodes is employed. These electrodes are usually made of Iron or Aluminum, and the electrolyte used may be water or wastewater [1]. In electrocoagulation process, coagulants are generated inside the reactor due to the dissolution of anodic electrode and simultaneously hydroxyl ions and hydrogen gas are formed at the cathode. Hydroxides and/or poly hydroxide metal ions thus formed and gas generated imparts coagulation and flocculation effect which helps in removing the pollutants.

Electro coagulation has been employed in treating wastewaters from textile, catering, petroleum, tar sand, and oil shale. It is also used to treat the carpet and chemical fiber wastewater, oil–water emulsion, oily wastewater clay suspension, nitrite, and dye from wastewater. This method of treating wastewater is being practiced in industries such as pulp and paper [2], edible oil [3], textile [4], mining and metal-processing [5]. Advantages of electro coagulation over conventional treatment methods are: i) Reduces sludge production ii) capable of treating wide ranges of pollutants iii) treatment of wastewater without unnecessary increase in salinity of water [5].

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In practice, electrocoagulation is carried out by connecting two electrodes of same metal (i.e. either Fe or Al to both anode and cathode). However, an attempt is being made in this research study to check the feasibility of using two electrodes of two different metals and to carry out the performance evaluation of the reactor for varied applied voltage and contact time.

II. MATERIALS & METHODS

Wastewater samples were collected from a local sewage farm. Grab sampling method was adapted. The samples were kept undisturbed for 10mins to settle out heavy particles and the supernatant liquid was analyzed for its physico chemical characteristics and then fed to the glass reactor and the electrodes were immersed for a contact depth of 60mm. Specifications of the materials used are furnished in Table 1. The total capacity of the glass reactor was 1.3L and working volume was maintained constant of 1L.

Table 1 Specification of Materials used

Materials	Dimension, mm
Iron electrode	90× 40×2
Aluminum electrode	90 × 40 × 2
Rectangular glass reactor	250×70 × 100

Two different electrode configurations were considered in the study and the same is indicated in Figure 1 and 2. In the first configuration, Fe and Al electrodes was connected to anode and cathode respectively and in the second configuration, Fe and Al electrodes were placed alternately. Aplab make (TD3202D) dual output regulated DC power supply (0 - 32V; 0 - 2A) was used to apply potential across the electrodes.

The spacing between the electrodes was maintained at 50mm throughout the study for both the configurations. The removal efficiency was evaluated for different contact time and voltage. The wastewater was in contact with the electrodes for a period of 5, 10, 15, 20, 25 and 30min at the applied potential of 5, 10 and 15V. The treated wastewater was then analyzed for concerned physico-chemical parameters. At the end of each contact time treated wastewater was decanted and replaced with fresh wastewater and the electrodes were cleaned thoroughly using distilled water and dried.

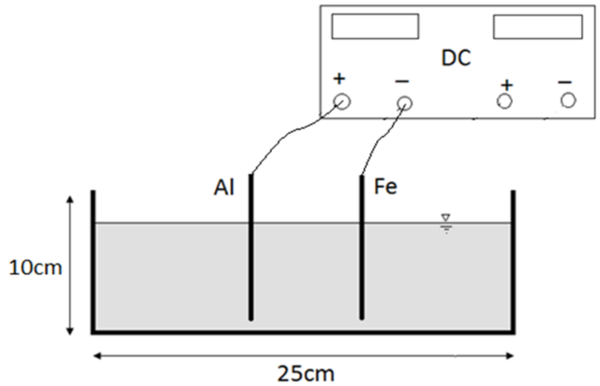

Figure 1. Two Electrode Configuration

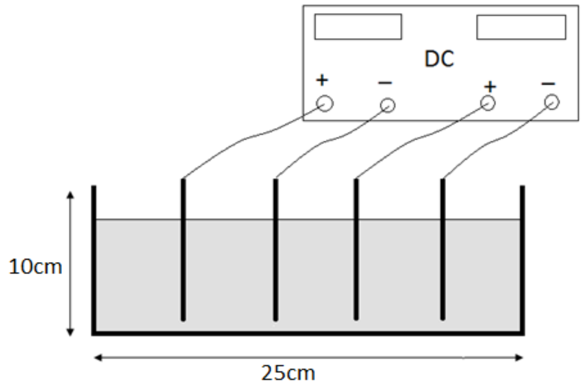

Figure 2. Four Electrode Configuration

III. RESULTS & DISCUSSION

The initial Physico-chemical characteristic of raw wastewater is indicated in Table 2. Based on the BOD and COD concentration, the wastewater can be classified as strong. It can be observed that excluding pH and nitrate, the obtained values for all the other parameters are exceeding the permissible values for discharge.

Table 2 Physico Chemical Characteristics of Raw Wastewater

Parameters	Sample	Threshold Value#
pH	7.5	6.5 – 8.5
TDS, mg/L	910	2000
Conductivity, m mho	2.1	-
BOD, mg/L	450	30
COD, mg/L	4240	250
Phosphate, mg/L	57.02	05
Nitrate, mg/L	30.2	10

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

From Figure 3 through 6, it can be observed that the trend in removal efficiency of concerned parameters is similar. With the increase in applied potential and electrode contact area, the removal efficiency of the pollutants has also increased. This is because, as the applied potential increases, the rate of dissolution of sacrificial anode increases leading to formation of Fe^{2+} ion and further combining with OH ions to form hydroxy complex such as $Fe(OH)_2$ and $Fe(OH)_3$.

It can be observed that for all the applied potential of 5, 10 and 15V, the nitrate and phosphate removal was below 30% for two electrode configuration (Fe-Al). However, the removal efficiency of the same parameters increased for 4 electrodes configuration (Fe-Al-Fe-Al). Further, from Figure 3, it is evident that phosphate concentration has been reduced from 57.02mg/L to 4mg/L for 20min contact time with 4 electrode configuration at applied potential of 15V. As per the BIS, the effluent discharge Standards on to surface water bodies for dissolved phosphate must be less than 5mg/L.

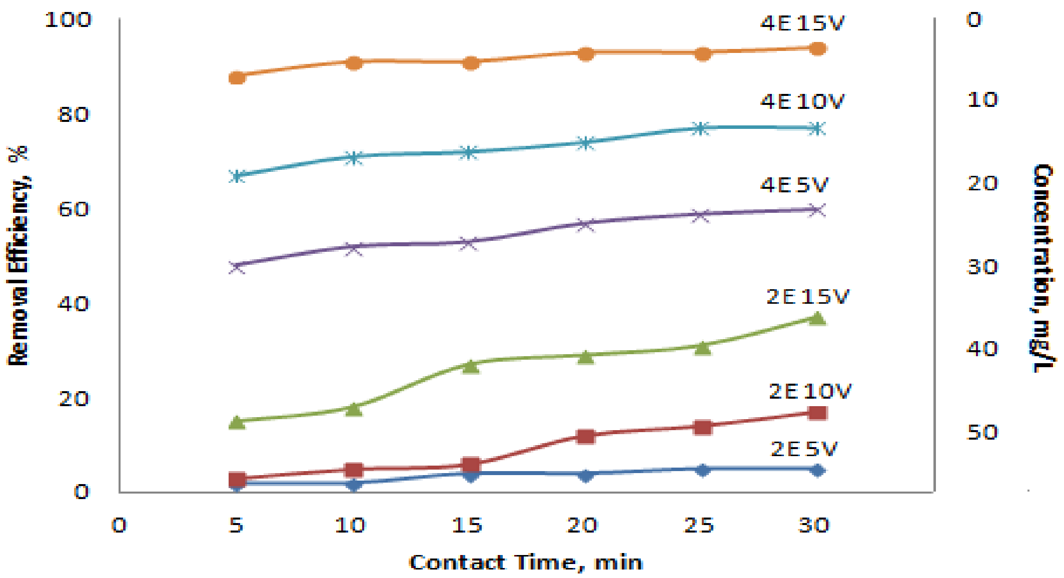

Figure 3 Removal efficiency of Phosphate for varying applied potential

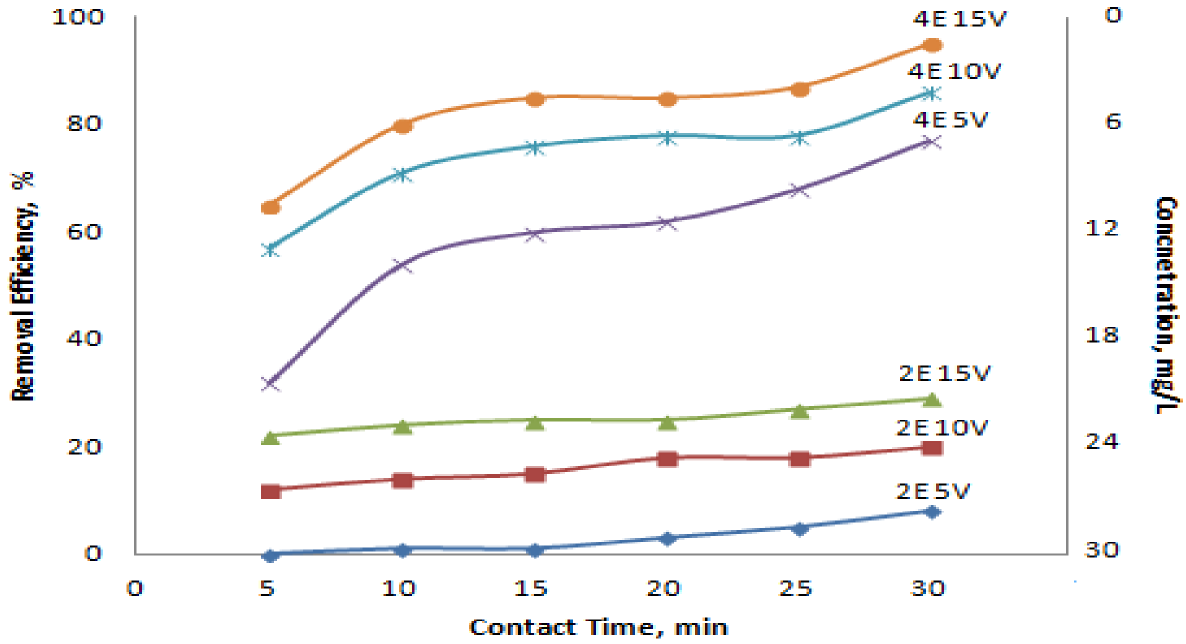

Figure 4 Removal efficiency of Nitrate for varying applied potential

As per the effluent discharge standard for nitrate is 10mg/L (Surface water body) and 20mg/L (coastal marines). The 2 Electrode configuration was able to reduce nitrate concentration from 30.2mg/L to 21.4mg/L. With 4 Electrode configuration, nitrate removal was significantly high. For applied potential of 5V, nitrate reduced from 30.2mg/L to 20.5mg/L (5min), 13.9mg/L (10min) and 9.7mg/L (25min). When the applied potential was doubled to 10V, it got reduced to 8.8mg/L within 10 min.

Figure 5 and 6 clearly illustrates that dissolved organics present in the wastewater are more readily oxidized compared to the oxidizable inorganic content. With 2 Electrode configuration and applied potential of 15V, the BOD concentration was reduced from 450mg/L to 72mg/L yielding 84% for a contact time of 30min. More than 90% removal was observed when the electrode contact area was increased from 102.4cm^2 (2E) to 204.8cm^2 (4E).

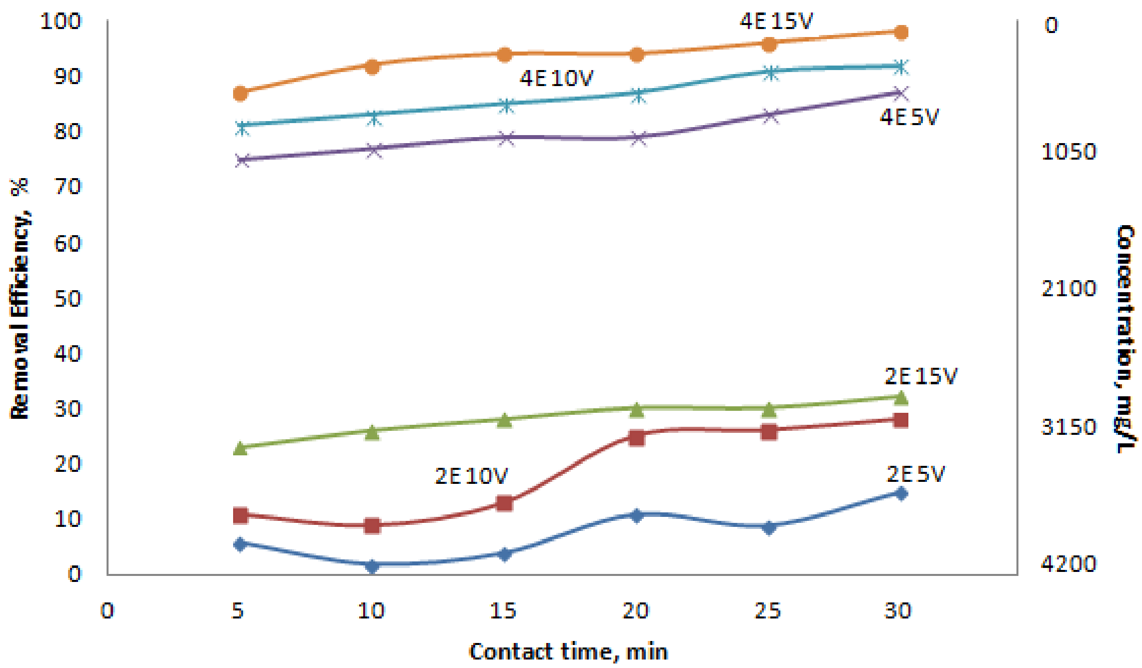

Figure 5 COD Removal efficiency for varying applied potential

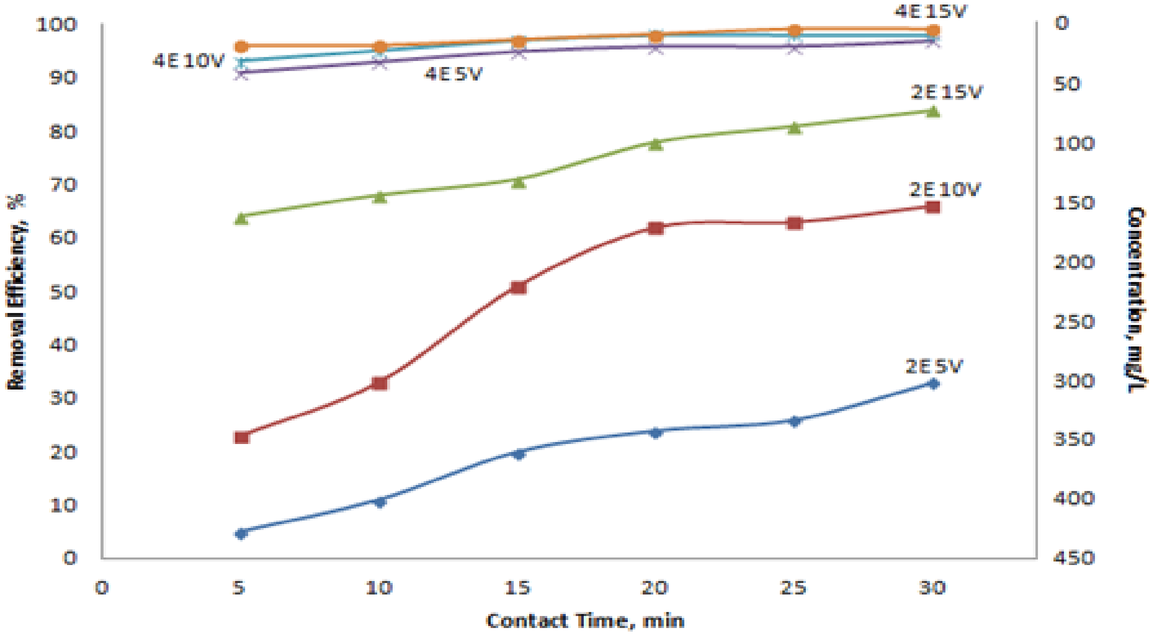

Figure 6 BOD Removal efficiency for varying applied potential

Oxidizable inorganic content present in the wastewater was reduced by more than 70% of the applied COD concentration when 4 Electrode configuration was used. The removal efficiency observed for both COD and BOD was significant with 4 Electrode configuration for all the three applied potentials and contact time. This attribution is due to oxygen released at anode oxidizes the oxygen demanding constituents present in wastewater. Hence, the removal of COD and BOD was significantly high.

IV. CONCLUSION

From the study it can be concluded that, as the applied potential increases rate of dissolution of sacrificial electrode also increases. The oxidizable organic content (BOD) was readily removed compared to the inorganic content (COD) of the wastewater. The removal of nitrate and phosphate was due to the coagulation effect caused by the formation of insoluble hydroxyl complexes of Iron. Further, when electrode contact area was increased the rate of removal of pollutants also increased. Four electrode configurations were highly effective in reducing the pollutant concentration compared to two electrode configuration. The batch study can be further extended to continuous flow of wastewater in the reactor and evaluate its performance in removing the pollutants.

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REFERENCES

[1] H. A. Moreno, D. L. Cocke, J. A. Gomes, P. Morkovsky, J. R. Parg, E. Peterson, C. Garcia. Electrochemistry behind Electrocoagulation using Iron Electrodes, *ECS Transactions*, 2007. 6 (9) 1-15.

[2] M. Vepsalainen, J. Selin, P. Rantala, M. Pulliainen, H. Sarkka, K. Kuhmonen, A. Bhatnagar, M. Sillanpaa. Precipitation of dissolved sulphide in pulp and paper mill wastewater by electrocoagulation. *Environ Technol*, 2011. 32(11-12): p. 1393-400.

[3] M. A. Nasution, Z. Yaakob, E. Ali, N. B. Lan, S. R. S. A. Abdullah. Comparitive Study Using Aluminum and Iron electrodes for the electro coagulation of palm oil mill effluent to reduce its polluting nature and hydrogen production simultaneously. *Pakistan J. Zool.*, 2013; 45(2): pp. 331-337.

[4] M. Kobya, M. Bayramoglu, and M. Eyvaz, Techno-economical evaluation of electrocoagulation for the textile wastewater using different electrode connections. *J Hazard Mater*, 2007; 148(1-2): p. 311-8.

[5] D. Kumarasinghe, L. Pettigrew, and L. D. Nghiem. Removal of heavy metals from mining impacted water by an electrocoagulation-ultrafiltration hybrid process. *Desalination and Water Treatment*, 2009; 11(1-3): p. 66-72.

[6] E. Ali, Z. Yaakob. Electrocoagualtion For Treatment of Industrial Effluents and Hydrogen Production, ED. Vladimir Linlov, 2012; http://dx.doi.org/10.5772/48633.