

# Domestic Wastewater Treatment by Electrocoagulation with Fe-Fe Electrodes

C. Sarala

Centre for Water Resources, IST, Jawaharlal Nehru Technological University  
Hyderabad, Kukatpally, Hyderabad-500085, Andhra Pradesh, India.

**Abstract** — The treatment of wastewater has become an absolute necessity. An innovative cheap and effective method of purifying and cleaning wastewater before discharging into any other water systems is needed. A wide range of wastewater treatment techniques are known which include biological processes and physicochemical processes. A host of promising techniques based on electrochemical technology are being developed and existing techniques are improved to reduce less chemical additions.

The present study was conducted to investigate the applicability of the electrocoagulation technique for the treatment of domestic wastewater at JNTU Hyderabad. Electrocoagulation is a surface reaction. Electrocoagulation is the process of passing electric current through a liquid, using anode and cathode. In this experiment iron electrodes are used and the sample is made up to run at different intervals of time i.e., 5, 10, 15 and 20 minutes and different amperes of current is passed in the sample (0.12 A, 0.25A, 0.36A). The combination effects of current, pH and treatment time to the efficiency of the electrocoagulation process for the removal of Chemical Oxygen Demand, Total Dissolved Solids, pH, Color, chlorides etc, from the domestic wastewater showed that only current (C) and treatment time (t) have correlation with each other. It observed that the batch which is operated at 0.25A for 20 minutes has maximum removal efficiency of Chemical Oxygen Demand, Total Dissolved Solids, pH, Color, chlorides etc.

**Key words**— Domestic waste water, Electro coagulation, iron electrodes, time intervals, Chemical oxygen demand.

## I. INTRODUCTION

Municipal wastewater is the mixture of domestic wastewater, (the basic component), small amounts of industrial and storm water, drain water, surface infiltration, and ground water. It usually consists of a number of contaminants, such as suspended solids, biodegradable organics, pathogens, nutrients, refractory

organics, heavy metals and dissolved inorganics. Direct discharge of untreated wastewater into the natural water bodies is not desirable, as the decomposition of the organic waste would seriously deteriorate the water quality [1]. In addition, communicable diseases can be transmitted by the pathogenic microorganisms. Nutrients such as nitrogen and phosphorous, along with organic material when discharged to the aquatic environment can also lead to excessive growth of undesirable aquatic life when discharged in excessive amounts on land can also lead to the pollution of groundwater. It was estimated that nearly half a million organic compounds have been synthesized and some 10,000 new compounds are added each year. As a result, many of these compounds are now found in the wastewater from municipalities and communities. For these reasons, treatment of wastewater has become necessary for the protection of the environment keeping in view public health, economic, social and political concerns.

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. Although wastewaters may come from various sources, it mostly consists of domestic wastewaters (DWWs). Currently, domestic wastewater is mostly is normally treated by aerated biological methods. For example, the activated sludge, being the most famous biological method of wastewater treatment, produces high quality effluent, i.e. 90% biological oxygen demand (BOD) and suspended solids (SS) removal as in [3]. There are some disadvantages of applying the biological method for wastewater treatment, such as requiring continuous air supply, high operating costs (skilled labor, energy, etc), sensitivity against shock toxic loads, longer treatment time and necessary sludge disposal.

From an environmental point of view, the sewage treatment process is still far from being environmentally sustainable. There is an urgent need for the development of a more sustainable treatment process. Some of the possibilities include electrochemical treatment,

improvement of the mitigation of toxic pollutants, high temperature sludge treatment processes, and membrane separation processes. Electrochemical process is a promising treatment method due to its high effectiveness. Its lower maintenance cost, less need for labour and rapid achievement of results [5], [6]. Other alternative solutions to wastewater treatment problems are still needed.

Using electricity to treat water was first proposed in United Kingdom in 1889 [10], [12]. The electrocoagulation of drinking water was first applied on a large scale in the United states in 1946 [2], [13]. Because of the relatively large capital investment and the expensive electricity supply, electrochemical treatment of water or wastewater technologies did not find application worldwide [11], [14]. However, due to extensive research in United States and USSR Russia during the following half century, the process has gained large amount of knowledge. With the ever-increasing stringent environmental regulations regarding the wastewater discharge, electrochemical technologies have regained their importance worldwide during the past two decades [4], [7]. Now a days, electrochemical technologies have reached a state that they are not only comparable with other technologies in terms of cost but also potentially more efficient and for some situations electrochemical technologies may be the indispensable step in treating wastewaters containing refractory pollutants [3], [9].

The electrocoagulation –flotation method for domestic wastewater treatment has a greater ability for the removal of chemical oxygen demand (COD) and suspended solids (SS) from effluents in comparison with treatment by conventional coagulation and so the present laboratory scale studies have been carried out to treat domestic waste water using electrocoagulation.

## II. MATERIALS AND METHOD

### A. Study area

The college is located at Kukatpally, Rangareddy district, a 100 acres site, about 20km from the heart of the city, on Bombay National Highway (NH-9). The territorial jurisdiction of the university covers the areas of Hyderabad, Ranga Reddy, Medak, Nizamabad, Adilabad, Karimnagar, Warangal, Khammam, Nalgonda and Mahboobnagar districts of Andhrapradesh state.

Hyderabad lies between 17° 20' North latitude and 78° 30' East longitude. The climate of Hyderabad is very hot in summer and generally dry except during the southwest monsoon season. The average annual rainfall is 8500mm. Granites, sand stones and red soils are observed in university area.

### B. Electro coagulation Process

All the experiments were conducted in batches. In each experimental run, a wastewater sample of 1.2 litres was collected and placed in an electrolytic cell. The sample was rigorously stirred by a stirrer. Iron electrodes were dipped into the solution upto an active surface area of 72cm<sup>2</sup> and the following currents of 0.12, 0.25 and 0.36 amp (0.36 amp-15V, 0.25) were passed for a contact time of 5, 10, 15 and 20 minutes. After passing each current for each time period (i.e., after each batch experiment), the sample was transferred into another beaker, and measured for pH. The measured sample was then taken to the jar test equipment, where it was rapidly mixed for 1 minute at 100 rpm. After a rapid mix for 1minute, the sample was kept for flocculation by setting the speed of the paddles at 30 rpm for 20 minutes. Subsequently, the flocculated sample was kept undisturbed for 20 minutes, in order to allow the flocs that formed during the flocculation to settle down. After a settling time of 20 minutes, 250 ml supernatant sample was collected to perform the physical and chemical analysis according to APHA standards. Similar analysis was done with the influent raw municipal wastewater samples before starting the experiment.

After each batch experiment, samples were again filtered with 0.45µm filter paper, to remove the electricity produced sludge, chlorides, alkalinity and a 20ml sample was collected to perform the Total suspended solids analysis with APHA standard experiments.

## III. RESULTS AND DISCUSSION

The treated wastewater samples are collected from the experimental setup for the analysis. From the treatment of the wastewater by electrocoagulation process, it is observed that the color of the water sample had changed to colourless after the treatment and for different currents the Electrical conductivity decreased with increase in the time. From the Fig.1 a slight increase in the pH was observed with time during the process which was within the regulatory drinking water standards. Chlorides and alkalinity also decreased with reaction time for different current amperes.

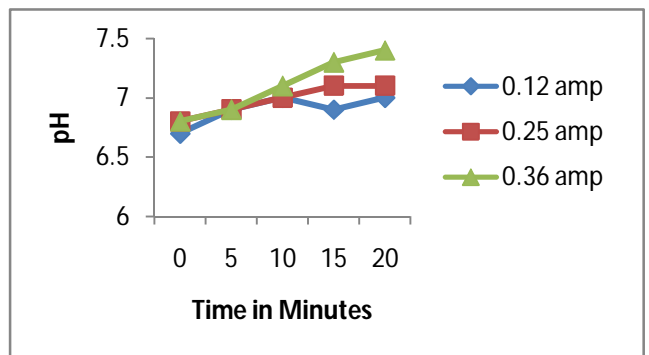


Fig. 1 Change in pH with Time for Different Currents

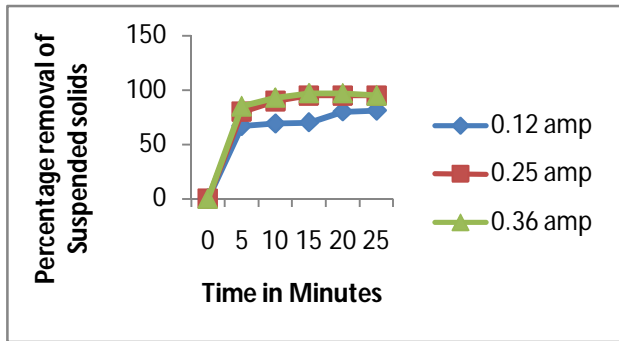


Fig. 2 Percentage removal of suspended solids with Time for Different Currents

From the Fig. 2 it is predicted that the suspended solids removal will increase with the increase of operating time and remain constant after 20 minutes of observation. With increase of current the removal efficiency of suspended solids also increased. The Fig. 3 depicts the relationship between the percent removals of total dissolved solids and the current at various contact times. Total dissolved solids concentration is found to be decreasing with the increase in current and detention time in the settled samples. This is due to the presence of flocculent that is produced with increase in current and detention time that contributes to high removal of suspended solids. Up to 0.25 amp, total dissolved solids are found to be continuously decreasing with detention time. However at 0.36 amp, a sharp decrease in the concentration of total suspended solids at a contact time of 5 minutes is observed. A gradual increase is observed later. It is due to the re-stabilization phenomenon that took place because of excess coagulant dose that made particles re-stabilize and brought them back in suspension.

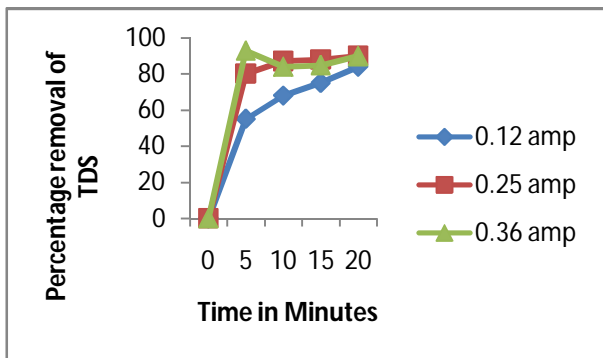


Fig. 3 Percentage removal of Total dissolved solids with Time for Different currents

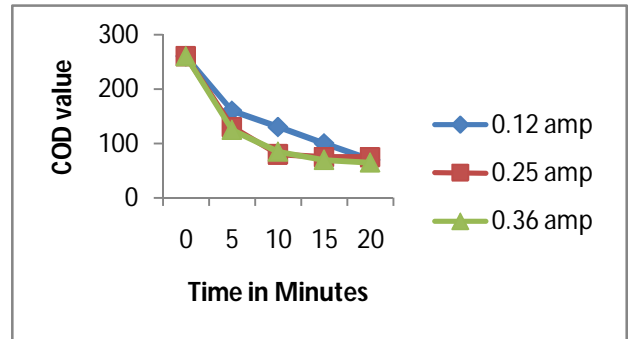


Fig. 4 Decrease in Chemical Oxygen Demand value with Time for Different Currents

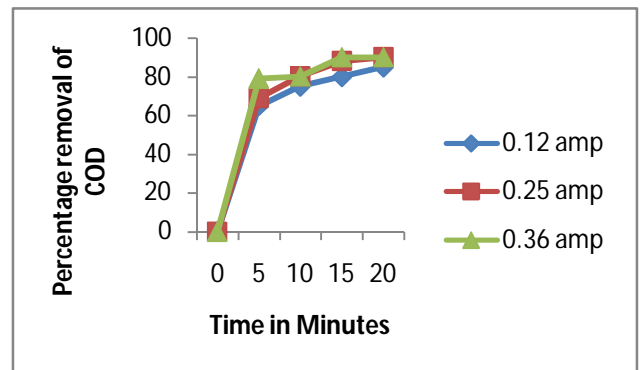


Fig. 5 Removal percentage of Chemical Oxygen Demand with Time for Different Currents

The variation of COD with electrolysis time is shown in Fig. 4. COD decreases with increasing electrolysis time and reaches to a constant value. There is a sharp decrease in COD at the first 5 minutes of the process and after that there is a gradual decrease in the level. With the electrode combination Fe-Fe for different currents at different time intervals used and percentage removal of Chemical oxygen demand values are depicted in Fig. 5. From the graph initially the percentage removal of chemical oxygen demand had increased and gradually the percentage removal decreases.

From the results, it was obtained that the maximum reduction in the parameters is obtained at 20 minutes time

interval with a variation of current ampere at 0.25 amp. The variation in parameters is presented in the Table 1.

TABLE I

REDUCTION IN VARIOUS PARAMETERS BEFORE AND AFTER THE ELECTROCOAGULATION TREATMENT

S.NO	Name of the Parameter	Units	Before treatment	After treatment
1	Color	----	Blackish brown	Colourless
2	pH	----	6.7	7.1
3	COD	Mg/l	260.4	60
4	Total Dissolved Solids	Mg/l	672	60.48
5	Chlorides	Mg/l	111.2	68.56
6	Suspended solids	Mg/l	160	20
7	Electrical Conductivity	μs/cm	128	123.78
8	Alkalinity	Mg/l	420	Nil

#### IV. CONCLUSIONS

From the present study, it was concluded that the treatment process had shown feasible activity in removing the impurities present in the wastewater. In this process without using any chemicals and the chemicals which are present in the sample can be removed, it does not leave any additional chemicals in the sample. In this process, suspended solids formed after electrocoagulation process removed by filtration and Chemical oxygen demand decreased to 90% with increase of contact time for different currents, maximum reduction of Chemical oxygen demand is observed at 20 minutes for 0.25 amp, 0.36 amp. The maximum reduction of total dissolved solids is 90% at 20 minutes for 0.25 amp, 0.36 amp. A successful application of electrocoagulation (EC) technique for the removal of suspended solids from wastewater would address the environmental needs of reduction in the operational costs and potential saving in processing unit. A host of very promising techniques based on electrochemical technology are being developed but are not yet to the commercial stage. Among different physical and chemical methods of water and waste water treatments, electrocoagulation method offers a special attraction due to its ecologically friendly, safety, simplicity and lower operating costs.

Based on the results, it was suggested that for successful industrial application of electrocoagulation, quantitative parameters must be identified to ensure dimensional consistency between small and large scale processes. Development of advanced materials and application of different electrode types brings a new dimension to electrocoagulation. Different electrode material can be used to assess different coagulant types for specific pollutants. For example the use of iron will produce ferric ions that are readily used in the water industry. Electrodes operation, such as periodic polarity reversal, controls passivation formation in situ. Development of sophisticated electrode arrangements and associated operation programs lead to significant developments for passivation control. Further this technique will continue to make inroads into the water treatment area because of numerous advantages and the nature of the changing strategic water need in the world.

#### REFERENCES

- [1] N. Blasubramaniam and K. Madhava, *Arsenic removal from industrial effluent through electrocoagulation*. Chem. Eng. Technol, 2001, 24.
- [2] C. F. Bonilla, *Possibilities of electronic coagulator for water treatment, water sewage*, 1947, 85, pp. 21-22, 44-45.
- [3] Chen Guohua, *Electrochemical technologies in wastewater treatment" separation and Purification technology*, 2003, 31.
- [4] G. Chen and X. Chen, P.L. Yue, "Electrocoagulation and electroflotation of restaurant wastewater," *J. Environ. Eng.*, vol.126, pp. 858- 863, 2000.
- [5] C. Feng, N. Sugiura , S. Shimada , T. Maekawa , "Development of a high performance electrochemical wastewater treatment system," *J. Hazard. Mate*, vol.103, pp. 65-78, 2003.
- [6] J. Iniesta, E. Expósito, J. González-Garcia, V. Montiel and A. Aldaz, "Electrochemical Treatment of Industrial Wastewater Containing Phenols," *Journal of Electrochemical Society*, vol. 149, pp. 57- 62, 2002.
- [7] S.H. Lin, C.F. Peng, "Treatment of textile wastewater by electrochemical method," *Water Res*, vol. 28, pp. 277-282, 1998.
- [8] Metcalf & Eddy, *Wastewater Engineering, Treatment and Reuse*. Fourth Edn, McGraw Hill Education, 2003, pp. 1329.
- [9] M.J. Mattenson, L. Regina Dobson, W. Robert, Jr. Glenn, Nagesh S. Kukunoor, H. William, Waits III and Eric J. Clayfield, "Electrocoagulation and separation of aqueous suspensions of ultra fine particles," *Coll. Surf:Physicochemical. Eng. Aspects*; vol.104, pp.101-109, 1995.
- [10] M.Y.A. Mollah, R. Schennach, J.R. Parga and D.L. Cocco "Electrocoagulation (EC)- science and application," *Journal of Hazardous Materials*, vol.84, pp. 29-41, 2001.
- [11] M.F. Pouet, A. Grasmick, "Urban wastewater treatment electrocoagulation and flotation," *Water Sci. Technol*, vol.31, pp. 275-283,1995.
- [12] P.P. Strokach, *Electrochem*, Ind. Process. Bio., 1975, 55: 375.
- [13] E.E. Stuart, *Electronic water purification progress report on electronic coagulator. A new device which gives promise of unusually speedy and effective results*, *Water sewage*, 1946, 84: 24-26.
- [14] Mehmet Kobya, Orhan Taner Can and Mahmut Bayramoglu, "Treatment of textile wastewaters by electrocoagulation using iron and aluminum electrodes," *Journal of Hazardous Material*, vol. 100, pp. 163-178, 2003.