Electrocoagulation of Canteen Waste Water Using Aluminium and Steel Electrodes

Aswathi Mithran#, Gana VB*, Anjali S*

Assistant Professor, Dept. Of Civil Engineering, *Student M TECH (Environmental Engineering), M DIT Ulliyeri, India

***Abstract*-Treatment of canteen wastewaters by electrocoagulation using aluminium and steel electrode plate has been investigated in this project. A sample of 600 cubic centimeters is taken in the electrolytic cell and is made up to run at different interval of time i.e,10, 15,20,25 minutes and different volts (20V, 25V, 30V). The combination effects of Volts and treatment time to the efficiency of the electrocoagulation process for the removal of Biochemical Oxygen Demand, Turbidity was considered to evaluate the treatment efficiencies. The results showed that effluent waste water was very clear, and the quality exceeded the general effluent standards. Aluminium is the suitable plate for the removal of waste as it removes 94.4% of BOD when compared to steel plate which only removes 83% at 30 volts in 25 minutes. Turbidity reduced to 98.59 % by using aluminium plate at 30 volt for 25 minute treatment time on the other hand by using steel it only reduced to 97.79% at 30 V for a treatment time of 10 minute.pH level can be brought to a neutral range of 7 by using steel plate when compared to aluminium plate.**

Keywords*-Electrocoagulation, BOD, COD, pH, Turbidi*ty

I. INTRODUCTION

Electrocoagulation (EC) has been suggested as an advanced alternative to chemical coagulation in pollutant removal from raw waters and wastewaters. In this technology, metal cations are released into water through dissolving metal electrodes. Simultaneously, beneficial side reactions can remove flocculated material from the water. However, there are also adverse side reactions, such as deposition of salts on the electrode surface, which may cause deterioration of removal efficiency after long operation. As in the case of chemical coagulation with metal salts, aluminium or iron cations and hydroxides are the active compounds in EC. A host of very promising techniques based on electrochemical technology are being developed and existing ones improved that do not require chemical additions

II. METHODOLOGY

A. Sample Collection

Waste water is collected in jar from the canteen. Water passed through a sieve that remove coarse material from water, but concentrations of colloidal and dissolved material are not affected.

B. Materials Used

Electrolytic Cellis made of plexiglass having dimension 10x7x15 cm. An outlet is provided at the bottom. The top cover has grooves provided for the insertion of plates having dimension 3x0.3 cm.Steel plate having dimension of 12x2.5 cm is used, and plate is having thickness of 0.3 cm. They are separated by means of plexiglass to avoid contact between them. Aluminium plate having dimension of 12x2.5 cm is used, and plate is having thickness of 0.3 cm. They are also separated by means of plexiglass to avoid contact between them. Electric current is applied on the plates which are projected on the top of the electrolytic cell. Holes were provided on the plates for connecting wires. The top cover was fixed by using glue

C. Equipments Used

DC SupplyDC power supply is used to provide sufficient voltage for the electrocoagulation. Initial and final turbidity of waste water were found out by using turbidimeter. Initial and final turbidity of waste water were found out by using pH meter Magnetic stirrer was used for stirring the sample during operation BOD incubator was used to find out BOD_5 during the testing of samples.

D. Experimental Set Up

Schematic diagram of electrocoagulation and laboratory experimental setup are shown below

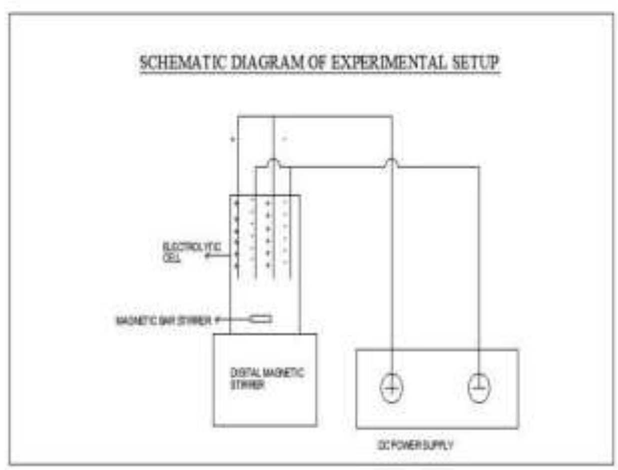

Fig 1. Schematic diagram of experimental setup

The thermostatic electro coagulator was made of Plexiglas as shown in fig 3.11 with the dimensions 15cm × 10cm × 7cmat constant stirring speed (200 rpm). There are four monopolar electrodes, two anodes and two cathodes of the same dimensions. Both Aluminium or steel cathodes and anodes are made from plates with dimensions of 12cm × 2.5cm × 0.3 cm.The total effective electrode area was 78 cm.sq and the spacing between electrodes was 10 mm. The electrodes were connected to a digital dc power supply (20V, 25V, 30V)

E. Procedure

In each run, 600 cubic centimeters of the waste water solutions was placed into the electrolytic cell. The voltage was adjusted to a desired value and the connection were done in monopolar mode and the coagulation was started. The sample was collected at time 10 minutes, 15 minutes, 20 minutes 25 minutes for each Voltage of 20V, 25V and 30V for Aluminum and Steel plates respectively. Before each run, electrodes were washed with water to remove surface grease. At the end of the run, the electrodes were washed thoroughly with water to remove any solid residues on the surfaces.BOD test and turbidity test are carried out according to the Standard Methods for Examination of Wastewater. The turbidity (NTU) is determined from turbidimeter BOD of samples are tested by BOD test. The pH was measurement by a pH meter

III. RESULT AND DISCUSSION

Raw water characteristics are shown below in table

TABLE I

RAW WATER CHARACTERISTICS

Initial characteristics	Unit	Value
BOD	Mg/l	1800
Turbidity	NTU	999
pH		4.80

A. Electrocoagulation using Aluminum Plate

Percentage removal of BOD in raw water at 20V, 25V, 30V are shown below.

TABLE II
PERCENTAGE REMOVAL IN BOD AT 20 V, 25V, 30V

	At 20 V		At 25 V		At 30 V	
Time min	BOD mg/l	Removal %	BOD mg/l	Removal %	BOD mg/l	Removal %
10	1800	0	1400	22.22	400	77.77
15	1700	5.55	1000	44.44	300	83.33
20	1500	16.66	600	66.66	200	88.88
25	1300	27.77	500	72.22	100	94.44

Percentage removal Vs Time at different voltage was plotted in a graph.

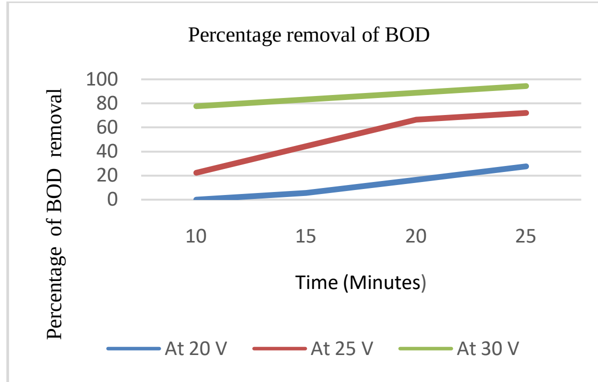

Fig2. Percentage removal of BOD V/s Time

At 20 Volts, there was a steep increase in percentage removal of BOD took place at 10 minute 15 minutes 20 minutes and 25-minute time interval from 0 to 27.7 percentage. But in the initial stage was no reaction ie. A lag was shown in the initial phase. At 25 volts, there was a leap increase in the removal of BOD from 22.22 to 66.66 took place for a treatment time of 20 minutes and a slight increase to 72.22 for a treatment time of 25 minutes. At 30 volts, the graph shows variation from 77.7 to 94.4 percentage removal of BOD. At 15 minutes and 20 minutes there was no sudden changes in the values but for 25 minutes treatment a sudden variation shown from 88 to 94 percentage removal of BOD.

Percentage removal in turbidity at 20 V ,25V, 30Vare shown below.

TABLE III

PERCENTAGE REMOVAL IN TURBIDITY AT 20 V, 25V, 30V

	At 20 V		At 25 V		At 30 V	
Time min	Turbidity mg/l	Removal %	Turbidity mg/l	Removal %	Turbidity mg/l	Removal %
10	974	24.99	442	55.7	32	90.7
15	630	36.9	334	66.5	26	97.39
20	532	46.7	226	77.3	19	98.09
25	523	7.6	120	87.9	14	98.59

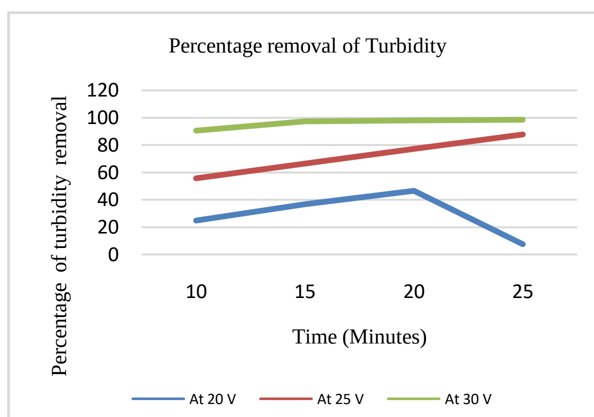

Fig 3. Percentage removal of turbidity Vs Time

In case of turbidity, at 20 volts starting from 24.99 percent for operating time of 10 minutes, turbidity has removed to 47.65 percentage at 25 minutes. In case of 25 volts, sudden change in the turbidity removal occurred from 55.7 to 98.59. At 30 volts in the 10 minutes itself 96.7 percent turbidity has already removed, and it reached to 98.59 percentage.

Change in pH by using aluminum plate at 20 V ,25V, 30V is shown below.

TABLE IV

CHANGE IN pH AT 20V, 25V, 30V

	20V	25V	30V
Time	pH	pH	pH
10	5.45	5.46	5.39
15	5.38	5.49	5.45
20	5.47	5.51	5.53
25	5.5	5.54	5.6

pH vs Time at different voltage was plotted in a graph.

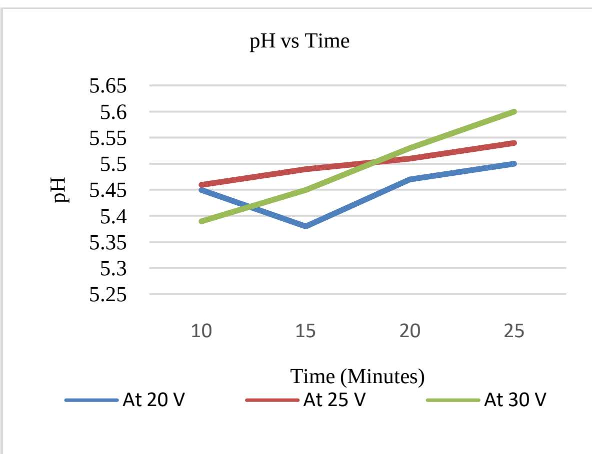

Fig.4 pH vs Time

pH was increased from 4.8 to a range of 5 due to the formation of hydroxyl ions.

B. Electrocoagulation using Steel Plate

Percentage removal of BOD in raw water at 20 V, 25V, 30V is shown below.

TABLE V

PERCENTAGE REMOVAL IN BOD AT 20 V, 25V, 30V

	At 20 V		At 25 V		At 30 V	
Time min	BOD mg/l	remova l %	BOD mg/l	remov al %	BOD mg/l	remova l %
10	1700	5.55	1500	16.66	800	55.55
15	1500	16.66	1100	38.88	500	72.22
20	1200	33.33	800	55.55	400	77.77
25	1000	44.44	600	66.66	300	83.33

Percentage removal Vs Time at different voltage was plotted in a graph

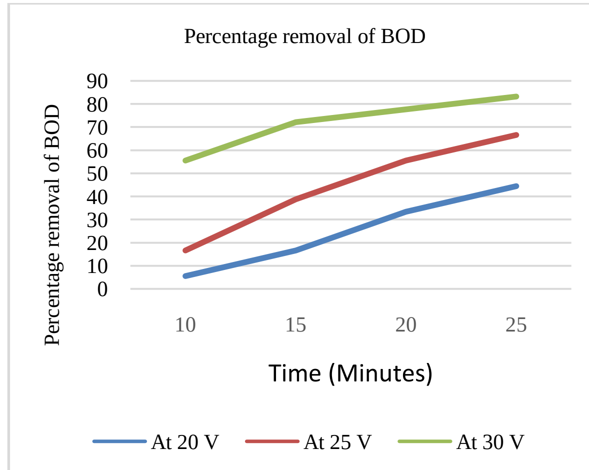

Fig.5 Percentage removal of BOD vs Time

At 20V there was a steep increase in percentage removal of BOD took place at 10 minutes, 15minutes, 20 minutes, 25 minutes time interval from 5.55 to 44.44 percentages. There was a sudden reaction were shown at the initial stage. At 25V the percentage removal of BOD increases linearly with time from 16.66 to 66.66 percentages. At 30V there is a gradual increase in percentage removal of BOD from 55.55 to 83.33 at 10 minutes to 25 minutes. In the initial phase itself 55.55 % BOD is removed.

Percentage removal in turbidity at 20 V ,25V, 30V is shown below

TABLE VI

PERCENTAGE REMOVAL IN TURBIDITY AT 20 V, 25V, 30V

	At 20 V		At 25 V		At 30 V	
Time min	Turbi dity mg/l	remov al %	Turbi dity mg/l	remova l %	Turbi dity mg/l	remov al %
10	440	56.18	463	53.7	22	97.79
15	408	59.18	353	64.69	24	97.59
20	389	61.99	327	67.29	35	96.49
25	523	47.6	120	88.09	53	94.69

Percentage removal of turbidity Vs Time at different voltage was plotted in a graph.

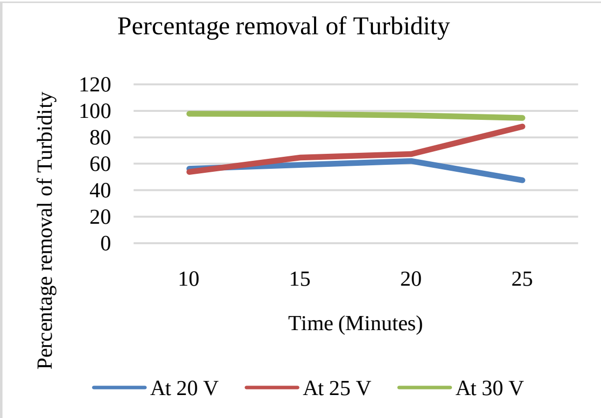

Fig 6.Percentage removal of turbidity Vs Time

At 20V there is a leap increase in the removal of turbidity at initial stage and thereafter from 15minutes to 25 minutes there is a gradual change in the removal of turbidity from 59.18 to 73.99.

At 25V the percentage removal of turbidity varies from 53.70 to 88.09 from 10 minutes to 25 minutes. At 30V the percentage removal of turbidity at 10 minutes and 15 minutes are almost same. But at 20 minutes and 25 minutes the percentage removal of turbidity decreases due to the formation of some iron complexes.

Change in pH by using steel plate at 20 V, 25V, 30V is shown below.

TABLE VII

CHANGE IN PH AT 20V, 25V, 30V

	20V	25V	30V
Time	pH	pH	pH
10	6.4	6.39	6.7
15	6.4	6.24	6.57
20	5.9	6.15	6.7
25	6.67	6.23	6.75

pH vs Time at different voltage was plotted in a graph

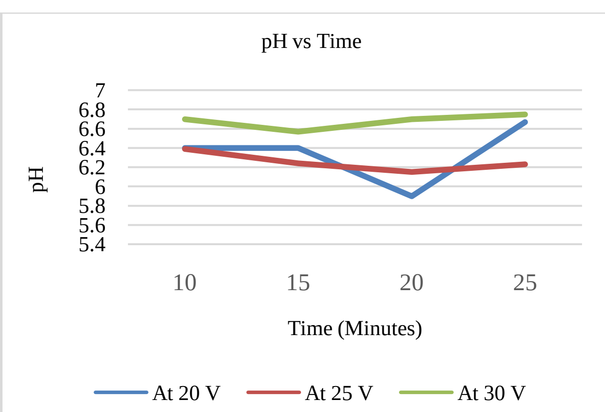

Fig 7. pH vs Time

The initial pH of waste water was 4.8 (acidic region). But after treatment at 20V, 25V, 30V the pH can be brought to a 6.75 due to the formation of hydroxyl ions, that is almost neutral range.

C. *Comparison Between Aluminium and Steel*

Aluminium is the suitable plate for the removal of waste as it removes 94.4% of BOD when compared to steel plate which only removes 83% at 30 volts in 25 minutes. Turbidity reduced to 98.59 % by using aluminium plate on the other hand by using steel it only reduced to 97.79% at 0 v by using steel plate .When it comes to removal of turbidity, by using steel it increases by increasing voltage above 25 volt due to the formation of excess iron complexes for steel plate and therefore aluminium is also the suitable material for removal of turbidity .pH level can be brought to a neutral range of 7 by using steel plate when compared to aluminium plate But sudden reactions were shown by steel in the initial stage rather than Aluminum plate for BOD removal. The use of steel and aluminium as sacrificial electrode materials in the treatment of canteen wastewater by electrocoagulation has been found to be pH dependent. According to the results, in acidic medium, pH<6, BOD and turbidity removal efficiencies of aluminium are higher than those of steel.

D. Specifications

As per IS 2296-1982 for drinking water source without conventional treatment followed by disinfections, the max. Permissible limit for BOD (3 days at 27°C) is 3mg/l.As per IS 2296-1982 for drinking water source with conventional treatment but after disinfections, the max. Permissible limit for BOD (3 days at 27°C) is 2mg/l.

E. General Effluent Standards

The BOD (3 days at 28°C) of effluent should be less than 30 mg/l if it is to be discharged to the inland surface water [As per E (P) rules, schedule VI part A].

The BOD (3 days at 28°C) of effluent should be less than 100 mg/l, if it is to be used for land irrigation [As per E (P) rules, schedule VI part A].

F. Discussion

Thus, the waste water after electrocoagulation by treating with aluminum at 30 Volt for 25 minutes can be used for land irrigation [As per E (P) rules, schedule VI part A].

IV. CONCLUSION

Electrocoagulation is suitable for the removal of various pollutants from surface water and wastewaters. It can produce high quality fresh water from highly coloured surface water having high concentrations of organic matter. Produced fresh water could be used as potable water or industrial fresh water. Optimum BOD removal and low residual aluminium can be obtained simultaneously with EC, which could be of significant benefit to EC in surface water treatment compared to chemical coagulation. Organic matter removal from wastewaters with iron electrodes was poor. Aluminium seems to be a more suitable electrode material for EC applications because it produces Al(III) species. Metal ions and hydroxides produced by iron electrodes are less effective in the destabilisation of pollutants because iron electrodes produce more soluble and less charged Fe(II) species.

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