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Electrocoagulation of Hotel Wastewater using Different Electrodes

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Abstract – Among the different wastewater treatment technologies, electrocoagulation is an innovative technology. In this study, electrocoagulation of hotel wastewater was done using different electrode materials. Aluminum, mild steel, stainless steel and hybrid combinations were used as electrodes. Experiments aimed in determining the efficiency of electrocoagulation to remove wastewater parameters. Treatment and settling time used were 1.5 and 1 hours respectively. DC volt of 12 V was supplied using switched mode power supply circuit. From the study, aluminum and aluminum-mild steel were determined as best electrode materials for the treatment of hotel wastewater. Aluminum is more recommendable. Turbidity, TSS, COD and BOD removal efficiencies observed were 94.14, 99.55, 89.36 and 85.04 % respectively with aluminum. Electrocoagulation process can be recommended as an efficient wastewater treatment technology due to its high parameter removal efficiency and advantages over conventional methods.

Key Words: **Electrocoagulation, hotel wastewater, aluminium, mild steel, stainless steel, hybrid electrodes.**

1. INTRODUCTION

Water is a transparent, tasteless, odorless and nearly colorless chemical substance. 71% of earth's surface is covered with water in the form of sea and oceans, small portion of 1.7% occur as groundwater. Most of the water bodies are getting polluted because of the discharge of pollutants into the water body without proper treatment. Sewage, garbage and liquid wastes from households, agricultural land and factories are discharged into water bodies with or without providing the required treatment. Dumping of solid waste and litters into water bodies also degrade the water quality.

Water pollution problems moved to a more serious phase since the beginning of industrial revolution. Major industries include integrated iron & steel industry, sugar industry, pulp & paper industry, fermentation industries like maltry, brewery, distillery, textile industry, tanneries, dairy industry, rubber processing industry, fertilizer industries, battery manufacturing industries, chemical industries, food industry, electric power plants, mines & quarries, nuclear industries, petroleum refining and petrochemicals etc.

Different water and wastewater treatment technologies are developed and researches being made on the development of advanced technologies all over the world. Some of the treatment technologies include activated sludge process, advanced oxidation, aerated lagoons, anaerobic digesters, chemical coagulation, dissolved air flotation, desalination, electrocoagulation, forward osmosis, ion exchange methods, membrane bio reactors, moving bed biofilm reactors, reverse osmosis, rotating biological contactor, sand filter, screen filter, trickling filter, ultraviolet disinfection etc.

Electrocoagulation is a technique in which coagulating metal ions are introduced electrolytically from the sacrificial electrodes. EC is an advanced wastewater treatment technology. It effectively removes suspended solids, breaks emulsions, and oxidize heavy metals from wastewater.

Literature studies reveal that electrocoagulation mechanism can be used to treat a variety of contaminants from different wastewaters. These include heavy metals, food waste contaminants, edible or non-edible oils, dyes from textile industries, landfill leachates that may contain organic contaminants, chemical and mechanical polishing wastes, polymeric wastes, nitrate, fluorine, arsenic, phenolic waste, lignin, suspended and ultrafine particles in aqueous media, etc.

1.1 OBJECTIVE

a. To identify the electrode that has maximum efficiency in removing parameters of wastewater.

b. To determine the efficiency of the process to treat hotel wastewater.

1.2 LITERATURE REVIEW

a. Aswathi Mithran *et al* (2018)

Conducted a study on electrocoagulation of canteen wastewater using aluminum & stainless steel electrodes. DC supply was used for the study. Electrodes were connected in mono polar mode. The percentage removal of BOD & turbidity with time & nature of change of pH with volt and time were the factors studied. The treatment using Aluminum electrode shows that up to 94 % BOD can be removed with electrocoagulation operated at 30 V for 25 minutes. Approximately 99 % turbidity were removed at 30 V & 25 minutes operation. With voltage & time, the pH shows an increasing trend due to the formation of hydroxyl ions for both electrode materials.

b. Habibe Elif Gulsen Akbay *et al* (2018)

Studied the treatment of fruit juice concentrate wastewater by electrocoagulation. Study was aimed to optimize the condition for best COD removal. The electrode material used were iron, aluminum & steel of dimension 60 x 90 mm. An inter electrode distance of 2 cm was maintained. Electrode combinations including Fe-Al, Fe-St, Al-Al, Al-St, Fe-Fe and Al-Fe were used as anode & cathode. Best COD removal was observed with original pH of 5.5, current 0.8 A and in 10 minutes time.

c. P. Santhosh *et al* (2015)

Conducted a study on treatment of sullage wastewater by electrocoagulation using stainless steel electrodes of dimension 70 x 50 x 3 mm. The experiment was carried out in a reactor of 500 ml capacity. Electrodes were connected in bi polar mode. The inter electrode distance were maintained at 40 mm. Variables used are time, voltage, current density and initial pH. From the analysis it was observed that maximum removal efficiency of parameters were obtained at pH 6.8, 8V & 30 minutes time. Maximum COD removal percentage obtained was 92.71 % and that of BOD & SS are 88.76 % & 93.1 % respectively at pH 6.8, voltage 8 V & 30 minutes treatment time.

2. METHODOLOGY

2.1 Materials

Wastewater treatment using electrocoagulation process involve the use of different materials and arrangements. The materials used are different sets of electrodes, electrolytic reactor, switched mode power supply device and wastewater. Laboratory instruments and various chemicals are also required.

Different electrode materials are used in the treatment of wastewater in this study. They are aluminum, mild steel, stainless steel, aluminum-mild steel combination, aluminum-stainless steel combination and mild steel-stainless steel combination. Materials in the form of sheets are cut into dimension of 22 cm x 9.5 cm. Material thickness is 2 mm. The number of plates in one set are 14.

2.2 Experimental setup and method

The experimental setup include 6 sets of electrodes, an electrolytic reactor and a switched mode power supply. The electrolytic reactor volume is chosen such that it can hold the volume of wastewater, the electrode and the sludge produced during the treatment. A tap provided towards the bottom of the reactor helps to collect water after treatment and settling in the reactor. Electrodes are arranged in mono polar configuration.

In this study, electrodes are placed vertically in the reactor and wastewater is poured after the removal of coarse substance, if any. Parameter analysis should be done before and after treatment. Electrodes are connected to the switched mode power supply unit and is powered. DC supply of 12 V is used in this treatment. Contact time used is 1.5 hours. Polarity reversal is done in every half hour to keep depositions on cathode minimum. Treated water is collected via pipe and analyzed.

Fig-1: Experimental set up

3. RESULTS AND DISCUSSIONS

The following are the results for electrocoagulation of hotel wastewater using different electrodes.

3.1 Using Aluminum electrodes

Table-1: Parameter analysis (Hotel- Aluminum)

PARAMETERS	BEFORE TREATMENT	AFTER TREATMENT
pH	3.833	9.293
Turbidity (NTU)	91	5.33
TSS (mg/L)	2824	12.67
COD (mg/L)	3760	400

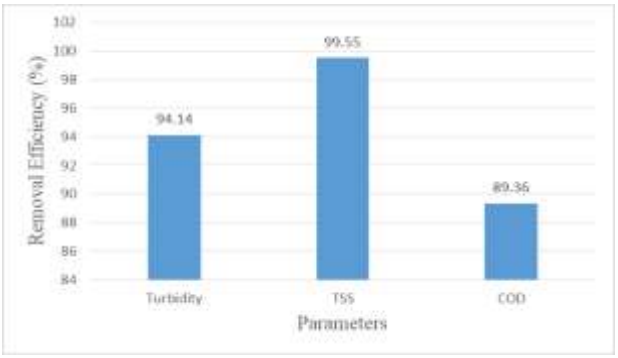

Chart-1: Parameter removal efficiency (Hotel – Aluminum)

For hotel wastewater, aluminum electrodes removes turbidity, TSS and COD up to 94.14, 99.55 and 89.36 % respectively.

3.2 Using Aluminum – Stainless steel hybrid electrodes

Table-2: Parameter analysis (Hotel- Aluminum-Stainless steel)

PARAMETERS	BEFORE TREATMENT	AFTER TREATMENT
pH	4.23	9.356
Turbidity (NTU)	93	2.33
TSS (mg/L)	1386	104
COD (mg/L)	1920	240

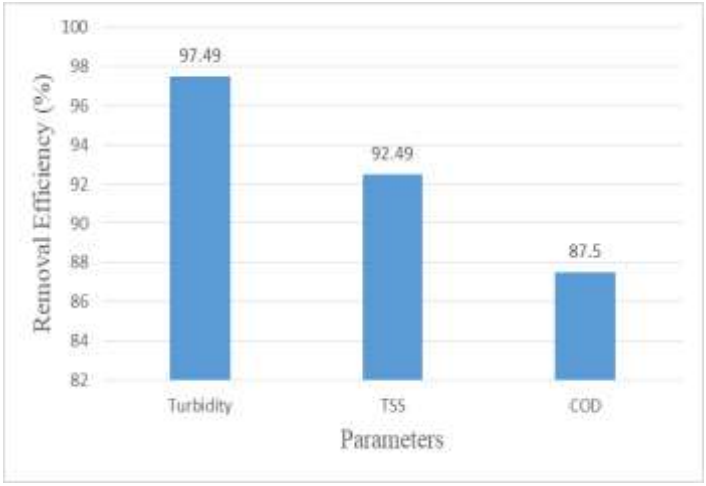

Chart-2: Parameter removal efficiency (Hotel- Aluminum-Stainless steel)

For hotel wastewater, aluminum-stainless steel hybrid electrodes shows a removal efficiency of 97.49, 92.49 and 87.5 % respectively for turbidity, TSS and COD.

3.3 Using Stainless steel electrodes

Table-3: Parameter analysis (Hotel- Stainless steel)

PARAMETERS	BEFORE TREATMENT	AFTER TREATMENT
pH	3.99	10.523
Turbidity (NTU)	84.33	13.33
TSS (mg/L)	2182.67	113.33
COD (mg/L)	2320	400

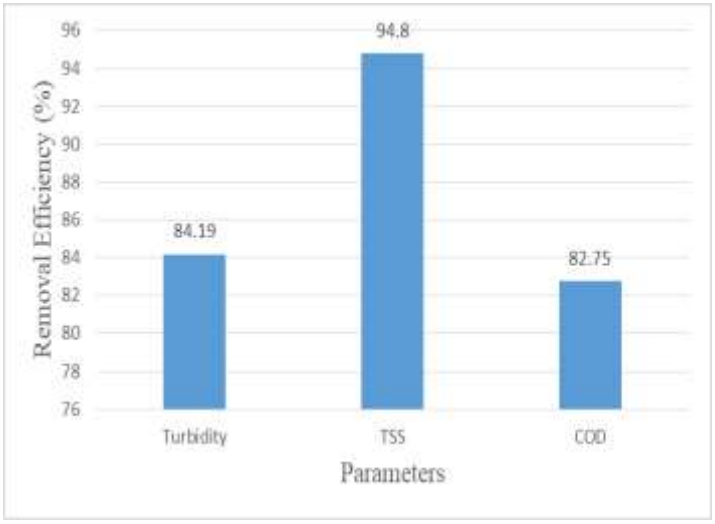

Chart-3: Parameter removal efficiency (Hotel- Stainless steel)

For stainless steel electrodes, turbidity, TSS and COD are removed up to 84.19, 94.8 and 82.75 % respectively.

3.4 Using Aluminum – Mild steel hybrid electrodes

Table-4: Parameter analysis (Hotel- Aluminum-Mild steel)

PARAMETERS	BEFORE TREATMENT	AFTER TREATMENT
pH	4.76	10.313
Turbidity (NTU)	93	4.55
TSS (mg/L)	1679.33	65.33
COD (mg/L)	960	80

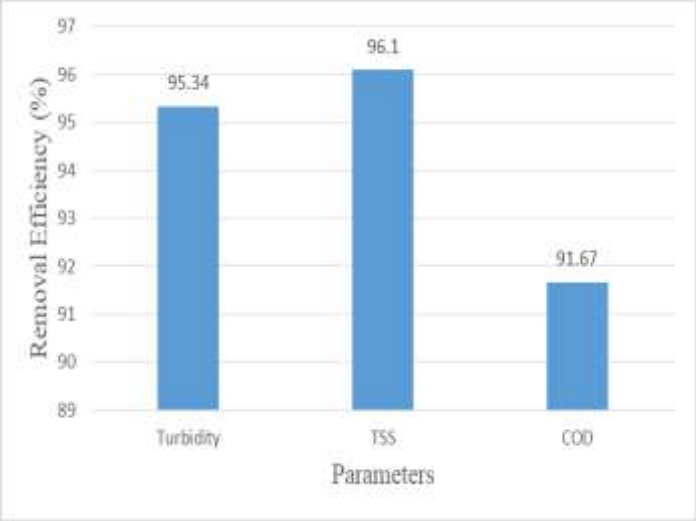

Chart-4: Parameter removal efficiency (Hotel- Aluminum-Mild steel)

For aluminum-mild steel hybrid electrodes, the removal efficiency of turbidity, TSS and COD are 95.34, 96.1 and 91.67 % respectively.

3.5 Using Mild steel electrodes

Table-5: Parameter analysis (Hotel-Mild steel)

PARAMETERS	BEFORE TREATMENT	AFTER TREATMENT
pH	4.02	10.063
Turbidity (NTU)	85	39
TSS (mg/L)	3908	107.33
COD (mg/L)	1680	80

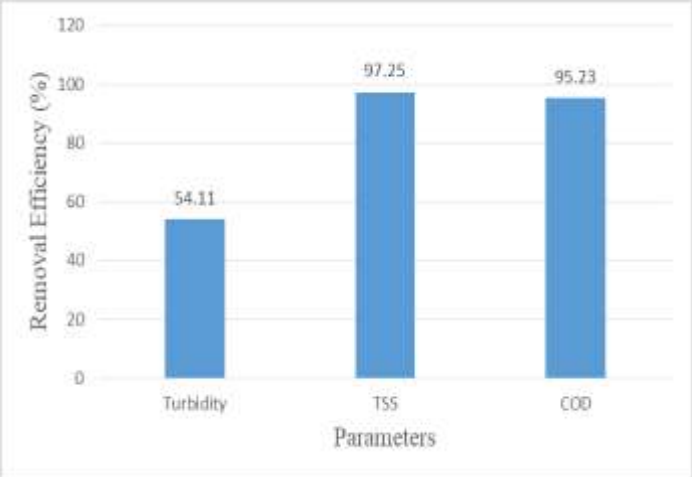

Chart-5: Parameter removal efficiency (Hotel-Mild steel)

Parameter removal efficiency of mild steel electrode with hotel wastewater are 54.11, 97.25 and 95.23 % respectively for turbidity, TSS and COD.

3.6 Using Mild steel – Stainless steel electrodes

Table-6: Parameter analysis (Hotel-Mild steel-Stainless steel)

PARAMETERS	BEFORE TREATMENT	AFTER TREATMENT
pH	3.9	9.44
Turbidity (NTU)	85	29.67
TSS (mg/L)	2260	424
COD (mg/L)	4080	640

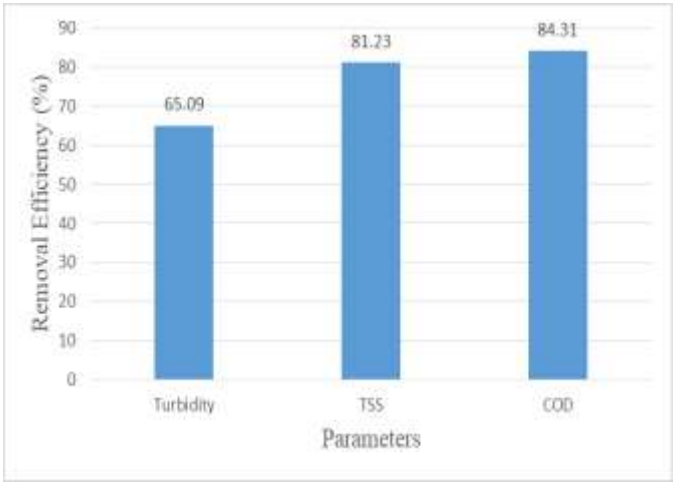

Chart-6: Parameter removal efficiency (Hotel-Mild steel-Stainless steel)

For mild steel – stainless steel hybrid electrodes, removal efficiencies of turbidity, TSS and COD are 65.09, 81.23 and 84.31 % respectively. It was observed during experiment that the flocs formed were of very small size compared to others. And settlement were even slower such that a settlement time of 1 hour could reduce turbidity only up to 65%. To understand better, the treated water were kept aside for settlement overnight. This resulted in a parameter removal up to 89.8% and 96.93% respectively for turbidity and TSS.

3.7 Comparison of electrodes for hotel waste water by removal efficiency

Table-7: Comparison of electrodes for hotel waste

ELECTRODES	TURBIDITY (%)	TSS (%)	COD (%)
Aluminum	94.14	99.55	89.36
Aluminum-Stainless steel	97.49	92.49	87.5
Stainless steel	84.19	94.80	82.75
Aluminum-Mild steel	95.34	96.1	91.67
Mild steel	54.11	97.25	95.23
Mild steel-Stainless steel	65.09	81.23	84.31

For hotel wastewater, Aluminum-mild steel hybrid electrodes and aluminum electrodes are showing best removal efficiencies. Among the two, aluminum is more recommendable. BOD of hotel wastewater treated with aluminum electrodes are reduced from 575 to 86 mg/L. Hence BOD removal efficiency is 85.04%.

4. CONCLUSIONS

A study of wastewater treatment with electrocoagulation process was carried out using different materials of electrodes and hotel wastewater. Electrodes used in the study were Aluminum, Stainless steel, mild steel and hybrid combinations of all the three. A treatment time of 1.5 hours and settlement of 1 hour is used.

For hotel waste, aluminum-mild steel hybrid and aluminum electrodes shows best performance. Among the two, aluminum is more recommendable. Mild steel and stainless steel materials impart a yellow color to the treated water, which is not desirable. It can be observed that the efficiency of mild steel-stainless steel hybrid electrodes are reduced in the case of hotel waste. This might be due to the low value of initial pH. When initial pH is less than 4, during electrolysis, Fe^{3+} ions will be produced for iron or its alloys. This leads to soluble complexes and the flocs formed may show greater tendency to dissolve back than to settle. But with aluminum electrodes, even at low initial pH values, the removal efficiencies are maintained at its best.

It can be recommended that aluminum electrodes will be best to use for a commercial scale treatment of wastewater using electrocoagulation. Aluminum is cheaper in terms of material and maintenance cost compared to steel.

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