

Treatment of Secondary Treated Sewage by Electrolytic Method

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ABSTRACT: The treated sewage from secondary treatment plants has residual suspended matter and fine particulates and contains some amount of turbidity (TD), biological oxygen demand (BOD), chemical oxygen demand (COD) and phosphate which should be removed in the tertiary treatment. Tertiary treatment process is used to improve the quality of the effluent which has resulted from primary and secondary treatment processes. After the tertiary treatment, the water can be safely discharged into the environment (water bodies like rivers and lakes etc.) and used for agricultural, industrial and, in many cases, domestic purposes. There are several methods of tertiary treatment such as sand filter, activated charcoal, oxidation ponds, membrane process etc.,

In the present study, treatment of secondary treated sewage using electrolytic method was studied. A preliminary study was conducted for the treatment of secondary treated sewage (STS) water through the electrolytic batch mode experiments with DC power supply (24 V) by varying time up to 30 min and using a novel concept of electrode combinations of Aluminium and Stainless steel. The effect of different electrode combination and different time of concentration on the electrolysis of STS water was studied. The maximum removal of COD (66.67%), TD (100%) and phosphate (85.84%) was recorded with Al-SS electrode system, while the maximum removal of BOD (89%) was recorded with SS-Al electrode combination.

KEYWORDS: Electrolytic process - Removal efficiency - Tertiary treatment - Electrode combinations - Secondary treated sewage

I.INTRODUCTION

Water is an essential substance for living system as it allows the transport of nutrients as well as waste products in the living systems. However, sustainable water supply is becoming more challenging by the day due to ever increasing demand of growing population as well as increasing contamination of water resources. At the same time, huge quantities of wastewater generated by industries of every hue and kind and also by exponential growth in the number of households are becoming a serious concern for society.

The role of electrochemistry in water and effluent treatment is relatively small, since conventional electrode materials achieve only low current efficiencies due to the water electrolysis side reactions. However, the use of sacrificial electrodes of metals which can give rise to multiple charged ions and their corresponding salts in the electrolytic systems results in coagulation and flocculation of dissolved and undissolved water impurities. This helps in the removal of contaminants from wastewater. The generation rate of flocks can be controlled by applying varying amount of current. The electrochemically generated metallic ions can be hydrolyzed next to the anode and generate a series of metal hydroxides that are able to destabilize the dispersed particles present in the wastewater. The destabilized particles are believed to be responsible for the aggregation and precipitation of the suspended particles and for the adsorption of the dissolved and/or colloidal pollutants which are subsequently removed by sedimentation and/or flotation

A.ELECTROLYTIC MECHANISM

The electrolytic process involves the generation of coagulants in situ by electrolytic oxidation of the sacrificial electrode material. Metal cations are generated by the dissolution of sacrificial anodes upon the application of direct current. The metal ions generated are hydrolyzed in the electrochemical cell to produce metal hydroxide ions.

Generation of metal hydroxide is followed by an electrophoretic concentration of colloids (usually negatively charged), which are then swept by the electric field in the region close to the anode. The particles

subsequently interact with the metal hydroxide and can be removed by the electrostatic attraction. In region the close to the anode, the high concentration of local metal hydroxide increases probability of coagulation of colloids.

B.ELECTROCOAGULATION

Electrocoagulation (EC) is a feasible alternative prior to RO membranes, for the pre-treatment of different types of water, including brackish water, plant feed water, firefighting water, seawater, textile wastewater, and groundwater. In recent years, researchers have started to focus on electrocoagulation owing to its short reaction time, compact size, simple operation, and low capital and operating costs. In particular, addition of excessive chemicals and production of unnecessary sludge can be avoided, due to the in situ generation of coagulants by electro-oxidation of the sacrificial anode.

II.LITERATURE SURVEY

For the post-treatment of anaerobically-treated municipal wastewater, Indian effluent disposal standards for COD, BOD, phosphates, pH and suspended solids can be achieved using Continuous electrocoagulation process with aluminium electrodes. The confirmatory tests under optimum conditions predicted by response surface methodology models gave 90 mg/L effluent COD, 0.57 mg/L effluent phosphate and 15.2 NTU effluent turbidity. Further, >99.8% reduction of total and faecal coliforms were also observed. **Makwana A.R et al. (2016)**

Electrocoagulation is capable of having high removal efficiencies of colour, chemical oxygen demand (COD), biochemical oxygen demand (BOD5) and achieving a more efficient treatment processes quicker than traditional Scoagulation and inexpensive than other methods of treatment such as ultraviolet (UV) and ozone. Unlike biological treatment which requires specific conditions, therefore limiting the ability to treat many waste ultraviolet (UV) and ozone. Unlike biological treatment which requires specific conditions, therefore limiting the ability to treat many wastewaters with high toxicity, xenobiotic compounds, and pH, electrocoagulation can be used to treat multifaceted wastewaters, including industrial, agricultural, and domestic waters with high toxicity, xenobiotic compounds, and pH, electrocoagulation can be used to treat multifaceted wastewaters, including industrial, agricultural, and domestic. **Edris Bazrafshan et al. (2015)**

MP-P mode is the most cost effective among monopolar-parallel (MP-P), monopolar-serial (MP-S), and bipolar-parallel (BP-P) connection types. All connection types show similar results in reducing color and turbidity, MP-P is preferred as a low cost treatment. In addition, iron and aluminum electrode materials have been investigated in the MP-P EC reactor. The results show that, according to electrical and sacrificial electrode costs, iron is superior to aluminum but aluminum electrode leads to high turbidity, color and COD removal efficiencies in the treatment of a real textile wastewater by electrocoagulation (EC). **Yavuz Demirci et al. (2015)**

A pilot-scale electrocoagulation process was developed for simultaneous removal of hardness, COD, and turbidity, with the related experimental design being supported by the RSM. This was critical for mitigating membrane scaling and fouling. A preliminary research was employed to obtain desired operating conditions: initial pH 7, current density 5.56 mA/cm² and electrolysis time 30 min. RSM with an eighteen-run CCD design was performed and second-order regression models were generated. ANOVA was conducted to validate the significant consistency between experimental values and predicted ones. The pH and current density had the most significant effects on pollutant recovery, while reaction time was least significant. The models derived from the EC process provided optimum operating conditions with the initial pH of 7.36, the current density of 5.90 mA/cm², and the reaction time of 30.94 min. The maximized hardness, COD, and turbidity removal efficiencies were 85.81, 66.64, and 93.80%, respectively. The operating refinement of EC processes by RSM was a promising alternative for the pre-treatment of produced water prior to RO membranes. The product water from the batch EC-RO system was suitable for reinjection or beneficial reuse. **Shan Zhao et al. (2014)**.

III.METHODOLOGY

COLLECTION OF WASTE WATER SAMPLE

The secondary treated sewage is collected from GPURE WATER SOLUTIONS treatment plant at Medavakkam, Chennai. The secondary treated sewage contains some amount of BOD, COD, and phosphate and it requires tertiary treatment.

TESTING OF SAMPLE

The sewage collected from secondary treatment plant was tested to determine the initial pH, Turbidity, BOD, COD and Phosphate concentration. For this purpose the following tests were carried out.

TESTING FOR pH

The electrodes are calibrated with two standard buffer solution of pH 4 and 7 buffer solution. It is a solution offering resistances. The sample temperature is determined at the same time and is entered into the meter to allow for a temperature correction. The electrodes are rinsed thoroughly with ionized distilled water and carefully wiped with a tissue paper. Then the electrode is dipped into the sample solution wait upto 1 min for steady reading. The reading is taken when indicator value remains constant for about 9 minutes.

TESTING FOR BOD

Distilled water is aerated for 4 hours to attain saturated Dissolved Oxygen (DO) level. In distilled water 1 ml of each nutrients (Phosphate buffer, Magnesium Sulphate, calcium Chloride and Ferric Chloride) and 1 ml of pre acclimatized seed per 1 liter of distilled water is added. Two BOD bottles are taken. The wastewater sample 10 ml is taken in the BOD bottles and then 290ml of aerated water is filled. DO test is conducted for the one BOD bottle sample by the following steps and initial DO is noted. 1 ml Manganese Sulphate solution is added, followed by 1 ml of Alkali – Iodide–Azide reagent. Then the bottle is mixed twice and allowed to precipitate settle for 5 minutes. 1ml of conc. Sulphuric Acid is added slowly and mixed twice. 203 ml of sample is taken and titrated against Sodium thio Sulphate solution with starch indicator. Disappearance of blue colour is taken as end point. Volume of Sodium thio Sulphate consumed is noted. Another bottle is placed in incubator at 20^o C. After 5 days DO test is conducted and final DO is noted.

DO CALCULATION

DO in (mg/l) = $(V_2 \times N \times 8 \times 1000) / V_1$ Where,

V₁ = Volume of water sample in ml.

V₂ = Volume of Sodium thiosulphate consumed in ml. N = Normality of sodium thiosulphate.

BOD CALCULATION

BOD₅ (mg/L) = [(Initial DO – Final DO) x dilution factor] Where,

Dilution factor = Volume of diluted sample/ Volume of waste water sample added.

TESTING FOR COD

0.4g of HgSO₄ is placed in the reflux flask. 20ml of sample is added to the flask. Then 10ml of more concentrated dichromate solution are placed into flask together with glass beads. 30ml of H₂SO₄ containing Ag₂SO₄ is added slowly and mixed thoroughly. Now the flask is connected to the condenser and the contents are mixed thoroughly before heating. Improper mixing results in bumping and the sample may be blown out. The mixture is refluxed for a minimum period of 2 hours. Then the condenser is cooled down and washed with distilled water. After cooled, the sample is diluted to make up 150ml and cooled again. Excess K₂Cr₂O₇ is titrated with 0.1N Fe(NH₄)₂SO₄ using Ferron indicator. Sharp colour change from blue green to wine red indicates the end point. At last, the blank is refluxed the in the same manner using distilled water instead of sample. COD of the sample is calculated from the volume of ferrous ammonium sulphate consumed.

COD CALCULATION

Total Chemical Oxygen Demand (mg/l) = $(A - B) \times N \times 8000 / V$ Where, A – Volume of ferrous ammonium sulphate used for blank solution

B – Volume of ferrous ammonium sulphate used for sample titration N – Normality of ferrous ammonium sulphate solution

V – Volume of wastewater sample taken

TESTING FOR PHOSPATE

The phosphate content in the sample is determined using spectrophotometer. Initially the spectrophotometer was set to 690nm and calibrated. Prepared standard solutions is filled in the cuvette holders and place in the compartment. The colour developed and the peak value is noted for different concentrations. 25 ml of filtered and clear sample is taken in a bottle and 1 ml of ammonium molybdate solution and 2 drops of stannous chloride is added to that. The blue color developed at 690 nm on a spectrophotometer and the readings are noted after 5 minutes but before 12 minutes. The concentration of the phosphate is determined with the help of the standard curve. The standard curve is plotted by

finding the absorbance values at known concentration of phosphate at 690 nm using Spectrophotometer.

TESTING FOR TURBIDITY

Turbidity meter is switched on and allowed to warm for 15-20 minutes. The cell with distilled water is inserted into the cell holder and it is covered with light shield. The range [1-100 NTU] is selected as yield by range on panel meter with the help of “Set Zero” control knobs. The instrument is calibrated for 100 NTU. Then the sample solution is inserted and the reading is noted.

SELECTION OF ELECTRODES

The electrodes selected for this project are Aluminium (AL) and Stainless steel (SS). The wastewater from secondary treatment plant is treated using the AL and SS electrodes as Anode / Cathode and as Cathode/ Anode. And by varying the time of concentration.

TREATING OF SAMPLES USING ELECTRODES

The schematic arrangement of the experimental setup is shown in Fig. 3.2 The experiments were carried out in a cylindrical reactor having a capacity of 2 L. The electrodes were connected to the respective anode and cathode leading to the DC rectifier and energized for a required duration of time at a fixed voltage (24 V). The time of concentration was varied between 10 to 30 mins. All the experiments were performed at room temperature (30 ± 2 C) and at a constant stirring speed (100 rpm) to maintain the uniform mixing of effluent during the electrolytic procedure. Before conducting an experiment, the electrodes were washed with water, dipped in dilute hydrochloric acid (HCl, 5 % v/v) for 5 min, thoroughly washed with water and finally rinsed twice with distilled water. After electrolytic treatment, the effluent was allowed to stand for 2 h and then sampled for analysis. When a DC electric field is applied, the following electrolysis reactions are expected in the vicinity of the electrodes. At anode:

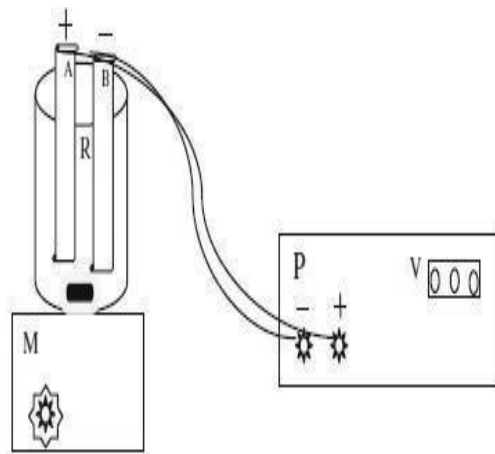
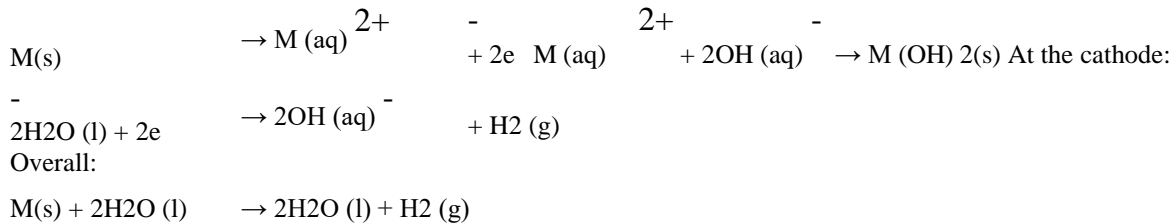


Figure 1 A Schematic diagram of experimental setup A - Anode, B – Cathode, R – Reactor, P – DC power supply

Table 3.1 Operating conditions for electrolytic treatment of STS

Parameters	Conditions
Electrode material (anode/cathode)	Al/SS and SS/Al
Applied voltage	24 V
Shape of voltage	Circular
Inter-electrode distance(cm)	3 cm
Time of operation (min)	10, 20 and 30
Volume of sample	2L

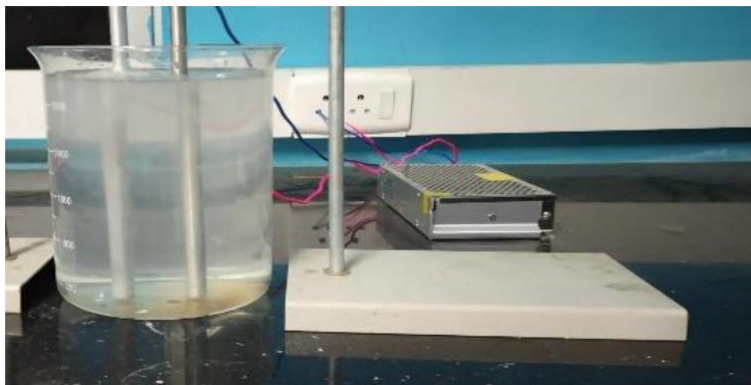


Figure 2 Experimental setup & Figure 3 Coagulation of floc after treatment



Figure 4 Sample before and after treatment

3.5 TESTING OF SAMPLES AFTER TREATMENT

The samples after treated by electrolytic method is tested again to determine the final pH, Turbidity, BOD, COD and Phosphate concentration. The same tests which are carried out before treatment is done again

IV.RESULT AND DISCUSSION

RESULTS FROM THE TREATMENT OF STS

The STS treated by electrolytic method was characterized and compared with initial characteristics and permissible limits. The results are tabulated in the Table 4.1 to 4.5.

Table 4.1 Comparison of Influent and Effluent pH with permissible limit

Time	Influent mg/l	Effluent SS/AL mg/l	Effluent AL/SS mg/l	Permissible limit mg/l
10 mins	7.58	7.41	7.5	5.5 – 9
20 mins	8.47	8.22	8.3	5.5 – 9
30 mins	7.97	7.91	8.09	5.5 - 9

Table 4.2 Comparison of Influent and Effluent BOD with permissible limit

Time	Influent mg/l	Effluent SS/AL mg/l	Effluent AL/SS mg/l	Permissible Limit mg/l
10mins	97.56	35.49	55.89	20
20mins	35.49	9.15	12.15	20
30mins	56.85	6.15	15.15	20

Table 4.3 Comparison of Influent and Effluent COD with permissible limit

Time	Influent mg/l	Effluent SS/AL mg/l	Effluent AL/SS mg/l	Permissible limit mg/l
10mins	304	160	144	250
20mins	248	120	104	250
30mins	192	80	64	250

Table 4.4 Comparison of Influent and Effluent Phosphate with permissible limit

Time	Influent mg/l	Effluent SS/AL mg/l	Effluent AL/SS mg/l	Permissible limit mg/l
10mins	18.25	12.75	4.75	5
20mins	18.4	7	3.25	5
30mins	10.6	1.5	1.5	5

Table 4.5 Comparison of Influent and Effluent Turbidity with permissible limit

Time	Influent mg/l	Effluent SS/AL NTU	Effluent AL/SS NTU	Permissible limit NTU
10mins	6.4	2.3	0.6	5
20mins	5.45	1.4	0.35	5
30mins	6.4	0.2	0	5

EFFECT OF ELECTRODE COMBINATION

The wastewater sample is treated for different electrode combination to study the effect of electrode combination on removal efficiency. The results are plotted in the form of graph as shown in Fig. 4.1 to 4.6



Figure 4.1 % removal graph of AL/SS & SS/AL at 10 mins

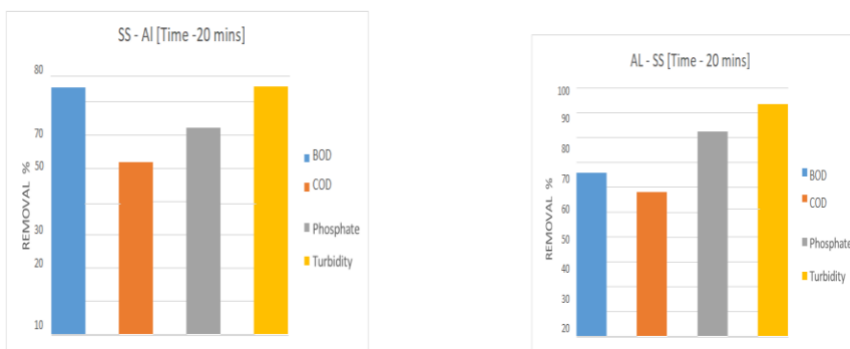


Figure 4.2 Percentage removal graph of SS/AL & AL/SS at 20 mins

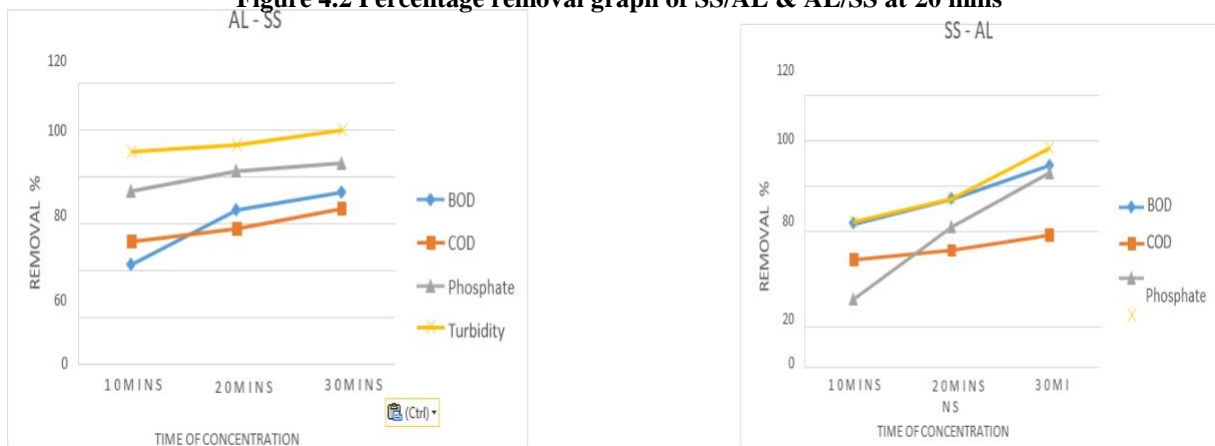


Figure 4.3 Effect of time of concentration on SS/AL combination

EFFECT OF TIME OF CONCENTRATION

The wastewater sample is treated for different time of concentration to study the effect of time of concentration on the treatment efficiency. The results are plotted in the form of graph as shown in Fig. 4.7 and 4.8

V.CONCLUSION

The SS/AL combination removed 89 % of BOD, 58.33 % of COD, 85.84 % of Phosphate, 96.88 % Turbidity at 30 mins and the corresponding effluent parameters were 6.15 mg/l, 80 mg/l, 1.5 mg/l, 0.2 NTU respectively. The AL/SS combination removed 73.33 % of BOD, 66.67 % of COD, 85.84 % of Phosphate, 100 % Turbidity at 30 mins and the corresponding effluent parameters were 15.15 mg/l, 64 mg/l, 1.5 mg/l, 0 NTU respectively. The overall removal efficiency of AL/SS combination is better than SS/AL combination. This revealed the superiority

of aluminium as a sacrificial electrode over that of stainless steel which can probably be attributed to better flocculation capabilities of aluminium than that of stainless steel. Thus Al–SS electrode combination proved more effective in comparison to SS–Al electrode combination for the treatment of STS water.

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