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Identifying The Best Pair of Electrode For Industrial Wastewater Treatment by Electrocoagulation

B.Sc. Engineering (Civil & Environmental Engineering) Thesis

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APPROVAL

This is to certify that the thesis submitted by Alvy Hasan (180051127), Tamzid Kamal Nahian (180051143) and Rafiul Hasan Antar (180051146) have been found as satisfactory and accepted as partial fulfillment of the requirement for the Degree Bachelor of Science in Civil & Environmental Engineering has been approved forthe Bachelor of Science Degree in Civil and Environmental Engineering.

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DECLARATION

We hereby declare that the thesis under the supervision of Dr. Amimul Ahsan entitled '**Identifying The Best Pair of Electrode For Industrial Wastewater Treatment by Electrocoagulation'**, has been performed by us and this work has not been submitted elsewherefor reward of any degree or diploma (except for publication).

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DEDICATION

We dedicate this thesis work to our loving parents. We also express our heartfelt gratitude to our respected supervisor Dr. Amimul Ahsan.

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ABSTRACT

Each year, a large number of businesses release a substantial quantity of wastewater into the environment. To treat this wastewater and lower the level of contaminants, many techniques are used. Sediment and light suspensions that float are two different types of contaminants that are removed from the wastewater during the electrochemical process of emulsification. By electrochemically dissolving sacrificial anodes, usually made of iron or aluminum, the electrocoagulation (EC) procedure disturbs pollutants that are suspended, dissolved, or emulsified. This method has the potential to remove both organic and inorganic pollutants that can be present in different types of wastewater. The pH, electrode type, operation time, and current density are some of the factors that affect how effective the EC process is. Examining the most pertinent recently released studies on this subject is the goal of this study. Electrode passivation and energy consumption are the two main issues with the EC technique. Using 36 different variations of electrode pair, the treated sample is tested different parameter. The best value for additional efficiency of E.C & Salinity for Al(+) and Zn(-) pair is 147.376 & 143.75 respectively. No other electrode pair have more than one higher parameter value. Compared to other conventional technologies, EC has benefits including lower operating costs and energy consumption. The following variables are controlled in this study: pH, BOD, COD, TSS, TDS and Salinity.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1 INTRODUCTION

1.1 Background of the study

Water is a scarce natural resource, and there are frequently insufficient supplies of water of sufficient quality for industrial and home usage. Numerous contaminants found in water streams have been shown to be hazardous and damaging to both the environment and people. Development of new or better industrial processes that have no or little environmental impact as well as procedures for the handling of inevitable waste are common ecological conservation strategies.

Electrocoagulation (EC) is a hopeful method for treating industrial wastewater that has become popular due to various benefits it has over traditional methods. Electrocogulation utilizes an electrical flow to treat sewage, which aids in getting rid of contaminant particles by grouping them together for settling or floating to the surface. This is a chemical procedure that encourages the breakup and merging of substances that are suspended, mixed in a solution or dissolved, ultimatelyleading to the creation of bigger, collectible clumps.

paper sets out to examine and assess the capability of using electrocoagulation as a via ble and environmentally friendly technique for dealing with industrial wastewater. This research aims to uncover how electrical components, materials used in electrodes and wastewater qualities interact to impact the efficiency of the EC process. It will explore the basic principles and mechanisms of this process. By conducting experiments and studying data, we will analyze how effective electrocoagulation is at removing contaminants, using energy, and being cost-effective.

addition, this study will focus on improving the settings for operation and developing electrocoagulation devices that are customized for certain types of industrial wastewater. The impact of factors like the amount of electric current, how the electrod es are set up, how acidic or basic the solution is, how long the reaction goes on, and what is in the wastewater will be analyzed to find the best possible circumstances for

getting the most efficient treatment while using the least amountof energy and the fewest expenses.

Research will evaluate the environmental consequences and durability of electrocoagu lation in contrast to conventional ways of treating wastewater, besides analyzing its te chnological components. We will assess the creation and handling of waste material, the possibility of utilizing it for other purposes, and analyze the entire process of EC systems to gain a thorough comprehension of their Environmental impact.

There is a pressing need to create more efficient, cutting-edge, and affordable methods for the treatment of wastewater since rivers, lakes, and other waterbodies are constantly being contaminated and there is often not enough drinkable water available. Long-established methods of destabilizing the colloidal materials in wastewater including organic and inorganic components include coagulation and flocculation. For sustainable water management, there is a need for more affordable ways to filter a variety of contaminated water on-site with the fewest possible additions. The production of electrically active coagulants and tiny bubbles of hydrogen and oxygen in water by a sacrificial metal anode and cathode during the electrolytic treatment of wastewater is a significant technological advancement [1].

The primary variables that determine the EC process are electrode type, electrode spacing, applied current density, starting pH, electrolyte conductivity, and treatment time. Therefore, in every EC research, the operational factors must be optimized. Iron (Fe) and aluminum (Al) plates are frequently employed as electrodes because they are accessible, affordable, and very effective in removing waste. As the current is applied, these sacrificial metal electrodes release metal hydroxides into the electrolyte, which have a strong propensity to interact with the contaminants in the electrolytic cell [2].

1.2 Objectives of the study

- Evaluate the performance of different electrode materials in electrocoagulation for industrial wastewater treatment.
- Compare the removal efficiencies of different electrode pairs in electrocoagulation processes.
- Optimize the electrode selection and configuration parameters to achieve the highest treatment efficiency and cost-effectiveness in electrocoagulation for industrial wastewater treatment.
- Provide recommendations and guidelines for selecting the best pair of electrodes for specific industrial wastewater treatment applications based on performance, efficiency, and economic considerations.

1.3 Scope of the study

The scope of the study "Identifying the Best Pair of Electrodes for Industrial Wastewater Treatment by Electrocoagulation" encompasses several key aspects related to the use of electrocoagulation for treating industrial wastewater. The study aims to evaluate different electrode materials and optimize process parameters to determine the most effective electrode pair for efficient wastewater treatment.

- Investigating a range of electrode materials commonly used in electrocoagulation processes, such as aluminum, iron, stainless steel, graphite, or other suitable materials.
- Assessing the performance of these electrode materials in terms of their removal efficiency, energy consumption, electrode lifespan, and cost.

1.4 Organization of the thesis

Chapter I: Introduction

Chapter II: Literature Review

Chapter III: Methodology of Study

Chapter IV: Results and Discussion

Chapter V: Conclusions and Recommendations

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

This chapter will discuss and expand upon the efficiency of electrolytic systems in the treatment of wastewater, as well as the processes, functions and conditions which result in such efficiency. It will elaborate on electrolysis as a significant wastewater treatment process and its implementations on an industrial scale. The efficiency of electrolysis on the parameters of wastewater will also be discussed

2.2 Electrolysis in Water Treatment

Utilizing electrical energy to remove all solid pollutants from wastewater is known as electrolytic treatment. This is accomplished through an electrochemical reaction, the nature of which is influenced by the types of pollutants that are present in the wastewater as well as the electrodes that are employed in the procedure. Different electrolytic processes are carried out using a variety of tools and equipment. The fact that electrolysis therapy uses no expensive equipment, specific chemicals, or reagents is a big advantage. If renewable energy sources are employed, there is extremely little environmental effect[3]. Additionally, very little sludge is produced, and it disappears quickly [4].

Iron, steel, aluminum, and other materials have all been used as electrodes in several experiments on electrolysis. This research has concentrated on extracting heavy metals, chemical pollutants, and other solid wastes from various wastewater samples that were collected from various sites. It has been demonstrated that electrolysis works well on several forms of dirty water, including poultry effluent[4], laundry wastewater and industrial wastewater[5]. The electrodes best suited for electrochemical wastewater treatment are generally Aluminum (Al), Iron (Fe), steel and graphite [6]. Fly ash leachate has been successfully treated using electrolysis[7]. The use of electrocoagulation to remove contaminants from wastewater was studied by researcher

Kabuk. Another study conducted by researcher Fernandes combined anodic oxidation (AO) and the electrocoagulation process (ECP). This combination was chosen in order to improve the leachate from landfills' capacity for biodegradation. Another cutting-edge technique being researched to extract phosphorus (P) from manure and runoff is electrolysis[6].

2.2.1 Efficiency of Electrolytic Treatment

Electrochemical treatment has yielded promising results in treating wastewater due to its high effectiveness, lower costs and labor requirements and faster output of results [8]. Treatment of wastewater through different electrolytic processes has been very effective. Multiple varied methods of electrolytic treatments have been adopted to remove different types of solid wastes from different types of wastewaters. Electrocoagulation is a process where destabilized agents (Al, Fe etc.) are produced electrochemically to neutralize electric charge to remove pollutants. This process has proved to be highly effective in removing contaminants from water, has produced less sludge, requires no chemical use and is easy to operate [9]. Aluminium plates can be used as electrodes to produce Al^{3+} ions by connecting the plates to a low power supply, which will produce Al^{3+} ions, which will attract all the negatively charged particles, therefore causing their coagulation and sedimentation [10]; [11]. Electro-flotation (EF) is another method used for separating substances. Here, electrically generated minuscule gas bubbles of hydrogen and oxygen interact with pollutant particles causing them to coagulate and float on the surface of the water body [12].

An investigation was undertaken by [13], where the wastewater was cleaned of contaminants by the electrocoagulation method. Removal efficiencies thus achieved were 60.5%, 92.4%, 60.8%, 28.3% and 28.9% for COD, total suspended solids (TSS), total organic carbon (TOC), total Kjeldahl nitrogen (TKN) and ammonia nitrogen, respectively. To improve the biodegradability of landfill leachate, which researcher Fernandes combined the method of electrocoagulation (ECP) and anodic oxidization (AO) techniques. Through ECP, the full removal of chromium and partial removal of zinc were accomplished. The leftover zinc was likewise removed during the subsequent

AO process. Researcher Zailani looked at the effectiveness of an electrocoagulation method that uses an electrode made of aluminum for pollution removal. Pollutants from wastewater were removed using this method. The elimination of 60% of COD, 37% of ammonia, 94% of color, 88% of turbidity, and 89% of suspended particles was reported to occur with a current density application of 200 A/m2 under ideal circumstances and a pH value of 4.0 over a period of 20 minutes. A low-cost process, investigated by Ahsan et al. (2014), utilized electrolysis and activated carbon filtration to remediate leachate. BOD, COD, TDS, and TSS removal efficiencies from the procedure were 75.6%, 57%, 72%, and 83.1%, respectively. The total procedure had a current of 7 V and a retention duration of 4 hours. However, after filtering with activated carbon was used following electrolysis, the removal efficiency rose for all the contaminants stated at once. In contrast, under the same conditions, BOD removal efficiency improved from 54.6% to 61.5% at 3 V and from 66.4% to 70.5% at 5 V, while COD removal efficiency increased from 7.5% to 38.5% at 3 V and from 31.1% to 49.5% at 5 V. The effects of pH, NaCl and electrode distance on the efficiency of electrolysis in treating BOD, COD, TDS, TSS, turbidity, salinity, zinc (Zn) and manganese (Mn) have been investigated by Erabee [14]. An electric potential of 60 V, a retention duration of 120 minutes, and a 5% NaCl solution with aluminum (Al) as the anode and iron (Fe) as the cathode kept 3 cm apart were described as the most effective conditions. 94% COD elimination and 93% Mn removal were attained under ideal circumstances. To test how well electrolysis and photo-assisted electrolysis in the presence of chloride removed TOC, COD, BOD, pH, chlorides, color, conductivity, and turbidity from dairy waste, researcher Sousa conducted his research. Only electrolysis (with chloride) was able to remove more than 90% of TOC and COD, and photo-assisted electrolysis (with chloride) was able to remove more than 95% of TOC AND COD. Mansur and Chalbi looked at how the performance of the EF cell was affected by the current density, coagulant concentration, oil concentration, flotation time, and other operating parameters (Ben Mansur et al., 2006). With a flotation period of 40 minutes, an initial oil concentration of 1000 mg dm3, a current density of 120 A/m2, 3.5% NaCl by weight with an extra 30 mg dm3 coagulant, and 3.5% NaCl by weight, a maximum change in the percentage of oil removal was recorded.

CHAPTER 3 METHODOLOGY

3.1 Introduction

A summary of the research's trial processes will be given in this section. The scope of this will include collecting and readying wastewater, traits of the wastewater and the tools used in the trial, assembling the apparatus, readying the samples, and using the electrolysis method.

3.2 Wastewater Proportions and Case Study

The wastewater was collected from Textile mills, and the volume was 20L. During the experiment, four beakers were used. One beaker was used to test the water parameters of our Raw sample water which is dyeing water. Its volume was 1000 ml. The other three beakers were used for electrolysis treatment for 1 hour retention time. Each beaker had nearly 1000 ml of wastewater.

3.3 Preparation of Materials and Apparatus

In accordance with how the case study was to be done, the equipment and materials were prepared. This entails using laboratory equipment in accordance with accepted procedures. For this experiment, the standard electrolysis apparatus, comprising beakers, electrodes, and a dependable power source, was required. The necessary wastewater was acquired and safely kept in advance of the experiment. The electrodes are made of a variety of materials. The beakers must be large enough to accommodate the necessary volume of effluent. As a power source, a lab's DC power supply was used. The power supply, as well as the electrodes of the close-by beakers, are wired to the electrodes.

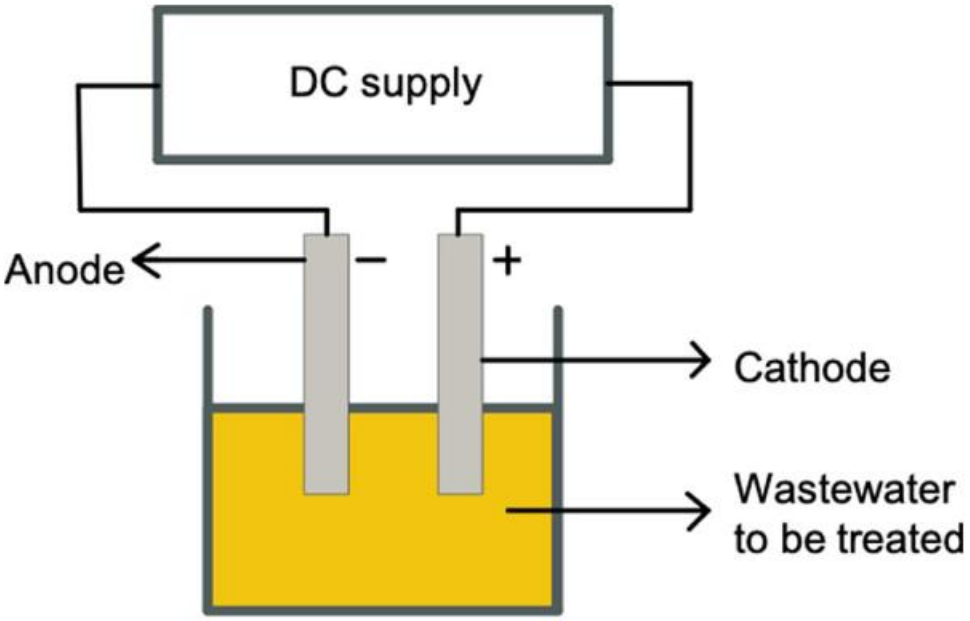


Figure 3.3.1 Schematic of the fundamental electrocoagulation experiment setup

3.4 Laboratory DC Power Supply

A laboratory DC power supply is a device that produces a direct current (DC) output voltage that is adjustable and stabilized within a given range (for example, 0 and 30 V DC). It has a variable current limiter that is used to reduce the output voltage in order to set a maximum output current limit. This is significant because, in the event that the output current exceeds the preset limit, it can protect the electric circuit from being destroyed.

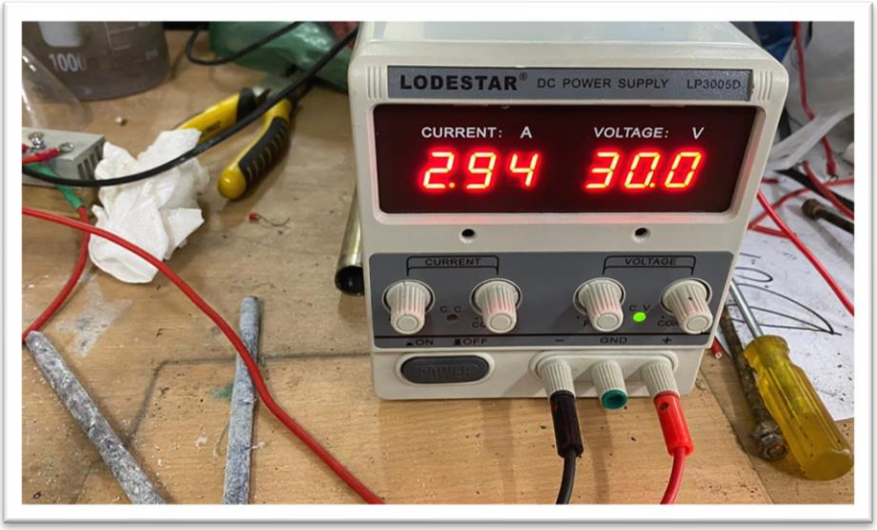


Figure 3.2 DC power supply

3.4.1 Multiparameter Meter

A multiparameter meter may be used to measure a variety of electrochemical parameters, including pH, conductivity, dissolved oxygen, salinity, temperature, and turbidity. A multiparameter meter is a crucial part of any electrochemical measurement. Researchers from all around the world use these instruments to precisely measure a number of different compounds at the same time.

Before using the equipment, it must first be prepared. First, the meter has to be properly calibrated. The calibration order is temperature, specific electrical conductance, dissolved oxygen, pH, oxidation-reduction potential, turbidity, and ion-selective

electrodes before chlorophyll-fluorescence and other sensors. After the sample has been prepared, the multiparameter meter is used to record measurements for each parameter.

Figure 3.3 Multiparameter Meter

3.4.2 Spectrophotometer

A spectrophotometer is a device used to assess the power of light beams at various wavelengths. The analytical spectrum is produced using a spectrophotometer using a monochromator and diffraction grating, which can be either fixed or movable. The sample and control solutions are illuminated by a light source that is shone into the monochromator of a spectrophotometer, diffracted into a rainbow, divided into two beams, and then scanned across them. Both the sample and the reference either transmit or reflect a portion of the incident wavelengths. The photodetector gadget subsequently receives the generated light beam and compares the relative intensities. Electronic

circuits transform relative currents into linear transmission percentages, concentration, and absorbance measurements.

Figure 3.4 Spectrophotometer

3.4.3 Turbidity Meter

The cloudiness or turbidity of a liquid brought on by suspended particles in the sample is measured using a turbidity meter. Turbidity, which is often referred to as water clarity, is frequently used to gauge the water's hygienic condition and frequently shows when filters are malfunctioning.

Figure 3.5 Turbidity Meter

3.5 Wastewater

The wastewater was collected from an industrial dyeing plant in CHANDORA, KALIAKOIR, GAZIPUR, BANGLADESH. The wastewater is untreated effluent from the plant. After collecting, both were kept in a secure place to prevent any unwanted reactions.

3.6 Properties of Wastewater

There are some distinctive qualities of wastewater. Wastewater comes in several varieties with various characteristics. Some varieties contain a greater proportion of inorganic stuff, whereas others contain a greater proportion of organic content. The effluent from a dyeing plant was used in this experiment's wastewater. Such effluent includes colors in varied amounts along with other contaminants. This effluent is often treated before being released into the closest aquatic body. The wastewater has been collected for the experiment without going through any treatment steps, preserving its current state.

3.7 Experimental Setup

The required equipment was prepared, and the experiment was then set up appropriately. At one time, three beakers were utilized. The beakers were filled with the effluent. 6 different types of electrodes were used. Each beaker has 2 electrodes, being the anode and cathode respectively. The three beakers will be connected in a series connection.

3.8 Sample Preparation

Each beaker is properly cleaned with distilled water (and other cleaning agents if necessary) to prevent the wastewater from reacting negatively to any impurities. 1000 ml or so of wastewater are placed in each of the beakers. Each beaker's two edges have rulers attached to them that are partially buried in the wastewater. Next, the wires from the first beaker's electrodes are attached to the DC power source. The electrodes of the next two beakers are then joined in series to those of the first beaker's electrodes.

Figure 3.6 Experimental Setup (a)

Figure 3.7 Experimental Setup (b)

3.9 Scum and Cathode-Anode

After the water had been treated, the amount of scum was measured, and it was discovered that the electrolysis process had caused the cathode to deteriorate more quickly than the anode. Electrolysis caused the cathode to develop a scum layer.

A

B

Figure 3.8 Deposition of Scum (A) Side View and (B) Top View

3.10 Testing

The power supply is switched on to start the electrolysis. The machine will be running continuously for 1 hour. Readings on each of the beakers are taken after intervals of 1 hour. At each interval, the following tests are run on the wastewater to record the changes:

- Turbidity
- pH test
- DO (Dissolved Oxygen)
- COD (Chemical Oxygen Demand)
- TDS (Total Dissolved Solids)
- TSS (Total Suspended Solids)
- TOC (Total Organic Carbon)
- EC (Electroconductivity)
- Salinity test

Figure 3.9 Chemical Testing of Samples

CHAPTER 4 RESULTS AND DISCUSSION

4.1 General

The findings of the study are discussed and summarized in this chapter. Examined and explored are the effects of differing voltages on wastewater. Different electrode types provide various parameter values. We'll talk about the parameter outcomes. There has also been discussion of the relationship between EC, Total Dissolved Solids (TSS), and Turbidity. A mathematical model for the electrocoagulation therapy procedure has also been built using equations.

4.2 Effects of different electrode pair

The effects of different electrode pairs are discussed here. It is well established that the removal efficiency (RE) also increases with the increase of voltages. Different types of electrodes give different parameter value. MS & Carbon pair has 4 good parameter value whereas Zn & Copper has other good parameter values.

4.2.1 Removal Efficiency of pH

Anode(+R) Cathode(-B)	**Initial pH (mg/l)**	**Final pH (mg/l)**	**R.E (pH) (%)**
Carbon Carbon	8.5	7.21	15.17647
Copper Copper	8.5	11.46	-34.8235
Zinc Zinc	8.5	11.2	-31.7647
Zinc Carbon	8.5	10.9	-28.2353
Carbon Copper	8.5	6.8	20
Copper Carbon	8.5	11.34	-33.4118
Aluminium Aluminium	8.62	9.68	-12.297
Copper Zinc	8.62	11.13	-29.1183

Aluminium Carbon	8.62	9.32	-8.12065
Aluminium Copper	8.37	9.07	-8.3632
Aluminium Zinc	8.37	8.96	-7.04898
Zinc Aluminium	8.37	10.34	-23.5364
Copper Aluminium	7.93	10.71	-35.0567
Carbon Aluminium	7.93	7.25	8.575032
Carbon Zinc	7.93	7.42	6.431274
Zinc Copper	7.93	10.26	-29.3821
SS SS	7.93	10.51	-32.5347
SS MS	7.93	10.01	-26.2295
MS SS	7.78	11.23	-44.3445
Carbon MS	7.78	7.99	-2.69923
Carbon SS	7.78	7.74	0.514139
Copper MS	7.78	11.4	-46.5296
Copper SS	7.78	11.34	-45.7584
Zinc MS	7.78	10.98	-41.1311
Zinc SS	7.78	9.76	-25.4499
Aluminium MS	7.78	9.23	-18.6375
Aluminium SS	7.78	9.27	-19.1517
MS Carbon	7.66	11.39	-48.6945
SS Carbon	7.66	10.48	-43.0809
MS Copper	7.66	10.96	4.046997
SS Copper	8	7.35	8.125
MS Zinc	8	11.02	-37.75
SS Zinc	8	9.19	-14.875
MS Aluminium	8	10.13	-26.625
SS Aluminium	8	9.61	-20.125

Table 1 Removal Efficiency of pH Of Different Electrode Pair

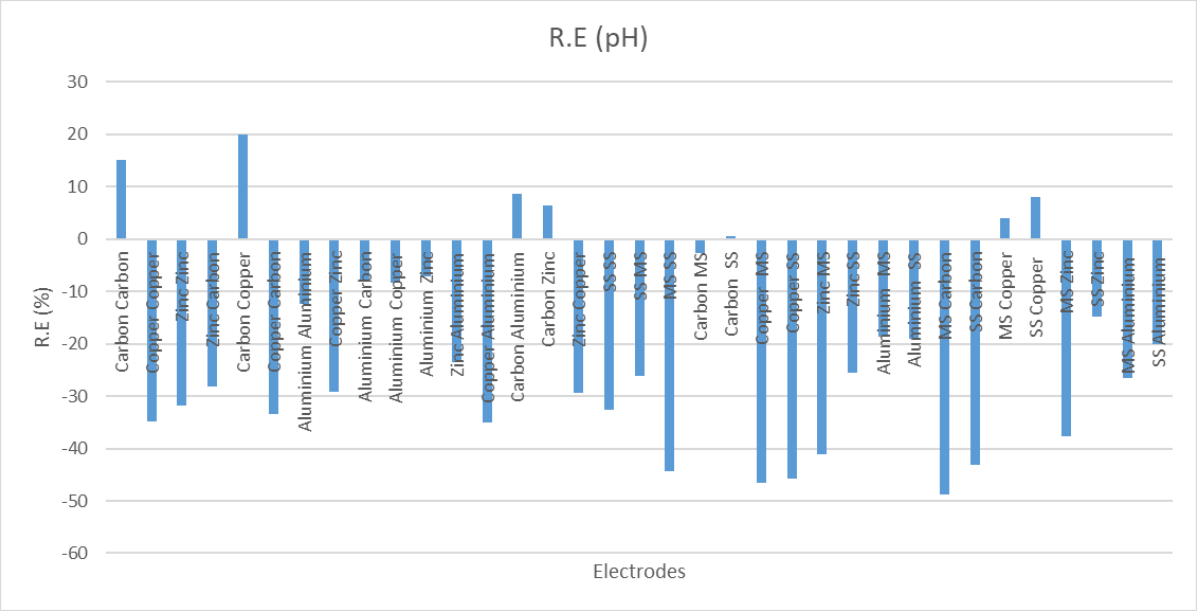


Figure 4.1 Graph of Removal efficiency of pH

4.2.2 Removal Efficiency of TDS

Anode(+R) Cathode(-B)	Initial TDS (mg/l)	Final TDS (mg/l)	R.E (TDS) (%)
Carbon Carbon	570	1548	-171.579
Copper Copper	570	1797	-215.263
Zinc Zinc	570	1740	-205.263
Zinc Carbon	570	1660	-191.228
Carbon Copper	570	1578	-176.842
Copper Carbon	570	1750	-207.018
Aluminium Aluminium	570	1825	-207.018
Copper Zinc	572	1831	-220.105
Aluminium Carbon	572	1760	-207.692
Aluminium Copper	636	1749	-175
Aluminium Zinc	636	1639	-157.704
Zinc Aluminium	636	1652	-159.748
Copper Aluminium	639	1664	-160.407
Carbon Aluminium	639	1746	-173.239
Carbon Zinc	639	1708	-167.293
Zinc Copper	639	1717	-168.701
SS SS	639	1809	-183.099
SS MS	639	1766	-176.369
MS SS	547	1616	-195.43
Carbon MS	547	1581	-189.031

Carbon SS	547	1642	-200.183
Copper MS	547	2116	-286.837
Copper SS	547	1797	-228.519
Zinc MS	547	1706	-211.883
Zinc SS	547	1634	-198.72
Aluminium MS	547	1653	-202.194
Aluminium SS	547	1693	-209.506
MS Carbon	553	2115	-282.459
SS Carbon	553	1808	-226.944
MS Copper	553	1424	-157.505
SS Copper	558	1661	-197.67
MS Zinc	558	1862	-233.692
SS Zinc	558	1680	-201.075
MS Aluminium	558	1594	-185.663
SS Aluminium	558	1580	-183.154

Table 2 Removal Efficiency of TDS of Different electrode pair

Copper and MS has the highest removal of TDS. The removal percentage is 74.15%.

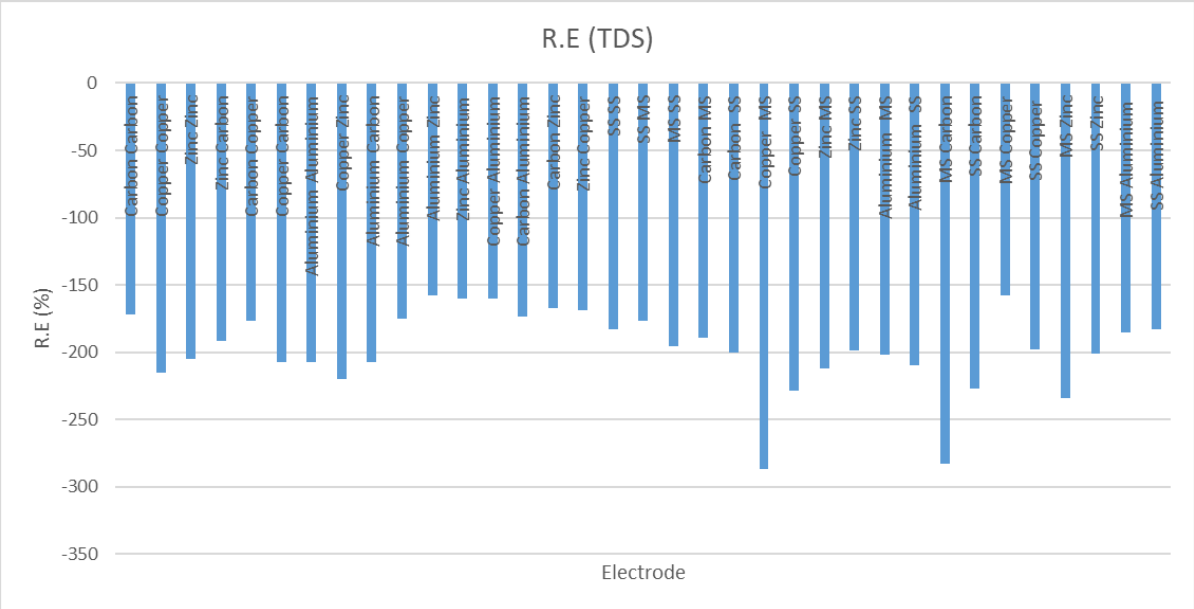


Figure 4.2 Graph of Removal efficiency of TDS

4.2.3 Removal Efficiency of TSS

Anode(+R) Cathode(-B)	Initial TSS (mg/l)	Final TSS (mg/l)	R.E (TSS) (%)
Carbon Carbon	91	103	-13.1868
Copper Copper	91	139	-52.7473
Zinc Zinc	91	95	-4.3956
Zinc Carbon	91	288	-216.484
Carbon Copper	91	217	-138.462
Copper Carbon	91	154	-69.2308
Aluminium Aluminium	21	4	80.95238
Copper Zinc	21	29	-38.0952
Aluminium Carbon	21	13	38.09524
Aluminium Copper	156	0	100
Aluminium Zinc	156	2	98.71795
Zinc Aluminium	156	3	98.07692
Copper Aluminium	64	39	39.0625
Carbon Aluminium	64	67	-4.6875
Carbon Zinc	64	58	9.375
Zinc Copper	64	21	67.1875
SS SS	64	6	90.625
SS MS	64	4	93.75
MS SS	262	16	93.89313
Carbon MS	262	269	-2.67176
Carbon SS	262	372	-41.9847
Copper MS	262	231	11.83206
Copper SS	262	256	2.290076
Zinc MS	262	416	-58.7786
Zinc SS	262	4	98.47328
Aluminium MS	73	1	99.61832
Aluminium SS	73	2	99.23664
MS Carbon	73	20	72.60274
SS Carbon	73	40	45.20548
MS Copper	73	29	60.27397
SS Copper	82	65	20.73171
MS Zinc	82	17	79.26829
SS Zinc	82	18	78.04878
MS Aluminium	82	8	90.2439
SS Aluminium	82	4	95.12195

Table 3 Removal Efficiency of TSS of Different electrode pair

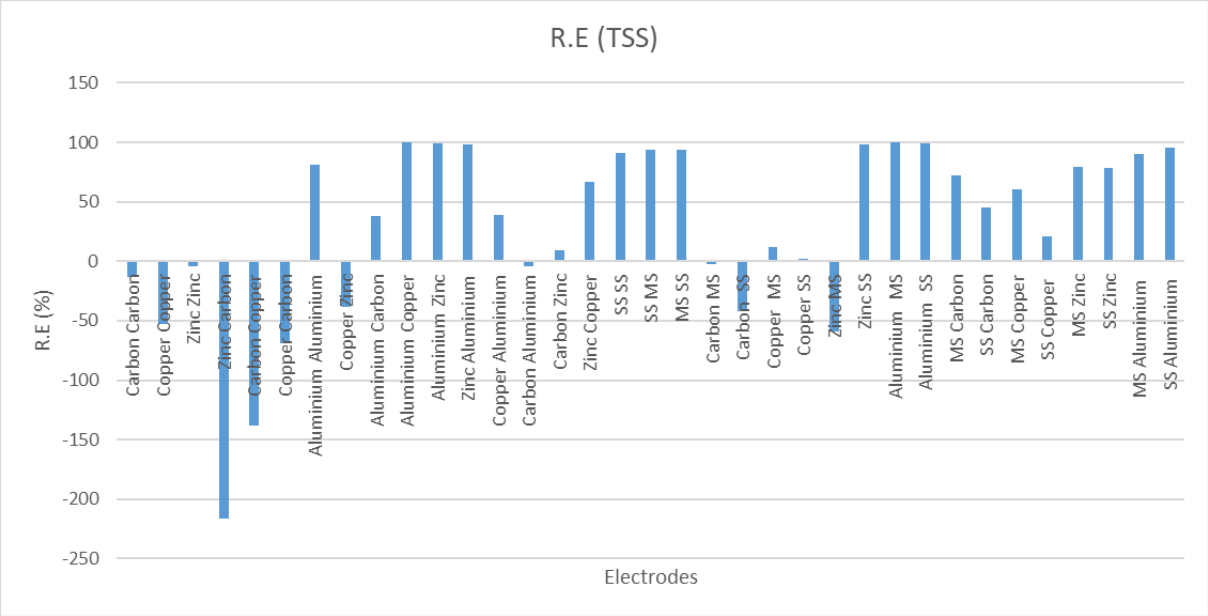


Figure 4.3 Graph of Removal efficiency of TSS

4.2.4 Removal Efficiency of TS

Anode(+R) Cathode(-B)	**Initial TS (mg/l)**	**Final TS (mg/l)**	**R.E (TS) (%)**
Carbon Carbon	661	1651	-149.773
Copper Copper	661	1936	-192.89
Zinc Zinc	661	1835	-177.61
Zinc Carbon	661	1948	-194.705
Carbon Copper	661	1795	-171.558
Copper Carbon	661	1904	-188.048
Aluminium Aluminium	593	1829	-208.432
Copper Zinc	593	1860	-213.659
Aluminium Carbon	593	1773	-198.988
Aluminium Copper	792	1749	-120.833
Aluminium Zinc	792	1641	-107.197
Zinc Aluminium	792	1655	-108.965
Copper Aluminium	703	1703	-142.248
Carbon Aluminium	703	1813	-157.895
Carbon Zinc	703	1766	-151.209

Zinc Copper	703	1738	-147.226
SS SS	703	1815	-158.179
SS MS	703	1770	-151.778
MS SS	809	1632	-101.731
Carbon MS	809	1850	-128.677
Carbon SS	809	2014	-148.949
Copper MS	809	2347	-190.111
Copper SS	809	2053	-153.77
Zinc MS	809	2122	-162.299
Zinc SS	809	1638	-102.472
Aluminium MS	809	1654	-104.45
Aluminium SS	809	1695	-109.518
MS Carbon	626	2135	-241.054
SS Carbon	626	1848	-195.208
MS Copper	626	1453	-132.109
SS Copper	640	1726	-169.688
MS Zinc	640	1879	-193.594
SS Zinc	640	1698	-165.313
MS Aluminium	640	1602	-150.313
SS Aluminium	640	1584	-147.5

Table 4 Removal Efficiency of TS of Different electrode pair

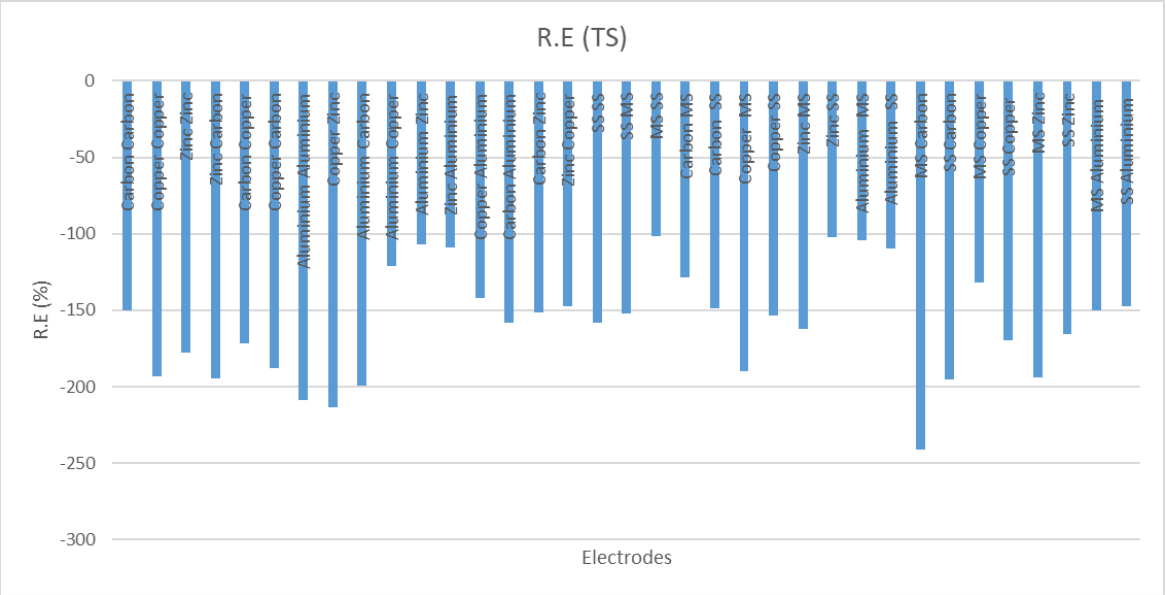


Figure 4.4 Graph of Removal efficiency of TS

4.2.5 Removal Efficiency of E.C

Anode(+R) Cathode(-B)	Initial E.C (mS/cm)	Final E.C (mS/cm)	R.E (E.C) (%)
Carbon Carbon	1.14	3.01	-164.035
Copper Copper	1.14	3.47	-204.386
Zinc Zinc	1.14	3.38	-196.491
Zinc Carbon	1.14	3.42	-200
Carbon Copper	1.14	3.3	-189.474
Copper Carbon	1.14	3.5	-207.018
Aluminium Aluminium	1.2	3.69	-207.5
Copper Zinc	1.2	3.74	-211.667
Aluminium Carbon	1.2	3.56	-196.667
Aluminium Copper	1.334	3.51	-163.118
Aluminium Zinc	1.334	3.3	-147.376
Zinc Aluminium	1.334	3.32	-148.876
Copper Aluminium	1.286	3.37	-162.053
Carbon Aluminium	1.286	3.57	-177.605
Carbon Zinc	1.286	3.47	-169.829
Zinc Copper	1.286	3.43	-166.719
SS SS	1.286	3.59	-179.16
SS MS	1.286	3.51	-172.939
MS SS	1.126	3.2	-184.192
Carbon MS	1.126	3.12	-177.087
Carbon SS	1.126	3.25	-188.632
Copper MS	1.126	4.25	-277.442
Copper SS	1.126	3.68	-226.821
Zinc MS	1.126	3.6	-219.716
Zinc SS	1.126	3.22	-185.968
Aluminium MS	1.126	3.27	-190.409
Aluminium SS	1.126	3.34	-196.625
MS Carbon	1.14	4.24	-271.93
SS Carbon	1.14	3.7	-224.561
MS Copper	1.14	2.9	-154.386
SS Copper	1.14	3.42	-197.391
MS Zinc	1.15	3.84	-233.913

SS Zinc	1.15	3.49	-203.478
MS Aluminium	1.15	3.3	-186.957
SS Aluminium	1.15	3.36	-192.174

Table 5 Removal Efficiency of E.C of Different electrode pair

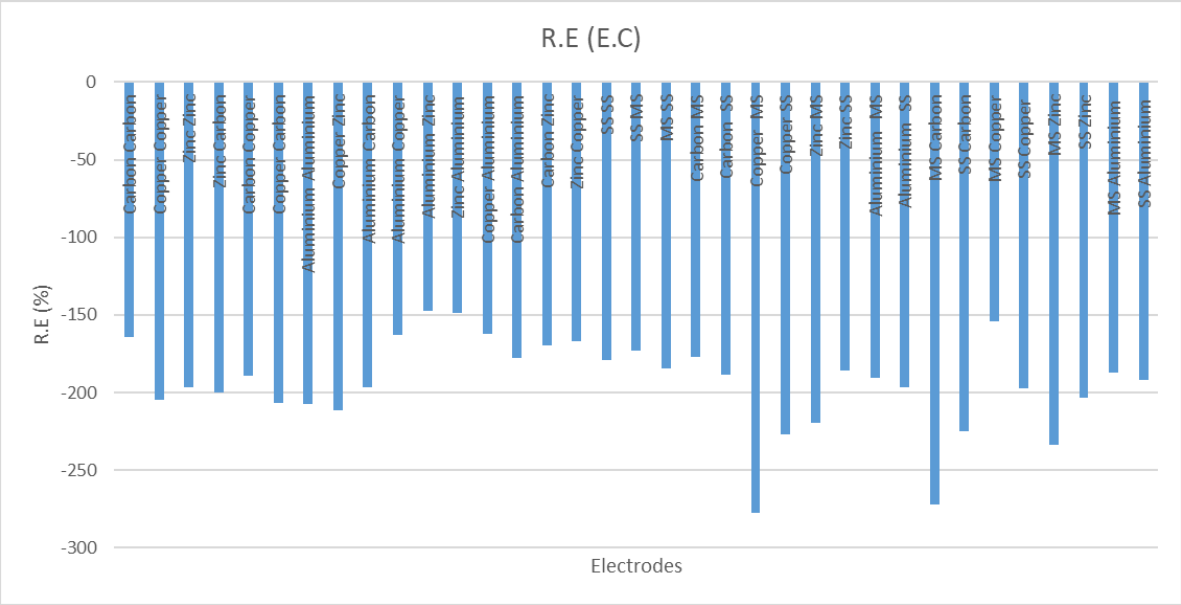


Figure 4.5 Graph of Removal efficiency of EC

4.2.6 Removal Efficiency of Salinity

Anode(+R) Cathode(-B)	**Initial Salinity (%)**	**Final Salinity (%)**	**R.E (Salinity) (%)**
Carbon Carbon	0.57	1.57	-175.439
Copper Copper	0.57	1.83	-221.053
Zinc Zinc	0.57	1.77	-210.526
Zinc Carbon	0.57	1.68	-194.737
Carbon Copper	0.57	1.6	-180.702
Copper Carbon	0.57	1.78	-212.281
Aluminium Aluminium	0.57	1.85	-224.561
Copper Zinc	0.57	1.86	-226.316

Aluminium Carbon	0.57	1.84	-222.807
Aluminium Copper	0.64	1.78	-178.125
Aluminium Zinc	0.64	1.56	-143.75
Zinc Aluminium	0.64	1.68	-162.5
Copper Aluminium	0.64	1.69	-164.063
Carbon Aluminium	0.64	1.77	-176.563
Carbon Zinc	0.64	1.73	-170.313
Zinc Copper	0.64	1.74	-171.875
SS SS	0.64	1.84	-187.5
SS MS	0.64	1.79	-179.688
MS SS	0.55	1.64	-198.182
Carbon MS	0.55	1.6	-190.909
Carbon SS	0.55	1.67	-203.636
Copper MS	0.55	2.15	-290.909
Copper SS	0.55	1.83	-232.727
Zinc MS	0.55	1.73	-214.545
Zinc SS	0.55	1.66	-201.818
Aluminium MS	0.55	1.68	-205.455
Aluminium SS	0.55	1.72	-212.727
MS Carbon	0.55	2.15	-290.909
SS Carbon	0.55	1.84	-234.545
MS Copper	0.55	1.44	-161.818
SS Copper	0.56	1.69	-201.786
MS Zinc	0.56	1.89	-237.5
SS Zinc	0.56	1.71	-205.357
MS Aluminium	0.56	1.62	-189.286
SS Aluminium	0.56	1.6	-185.714

Table 6 Removal Efficiency of Salinity of Different electrode pair

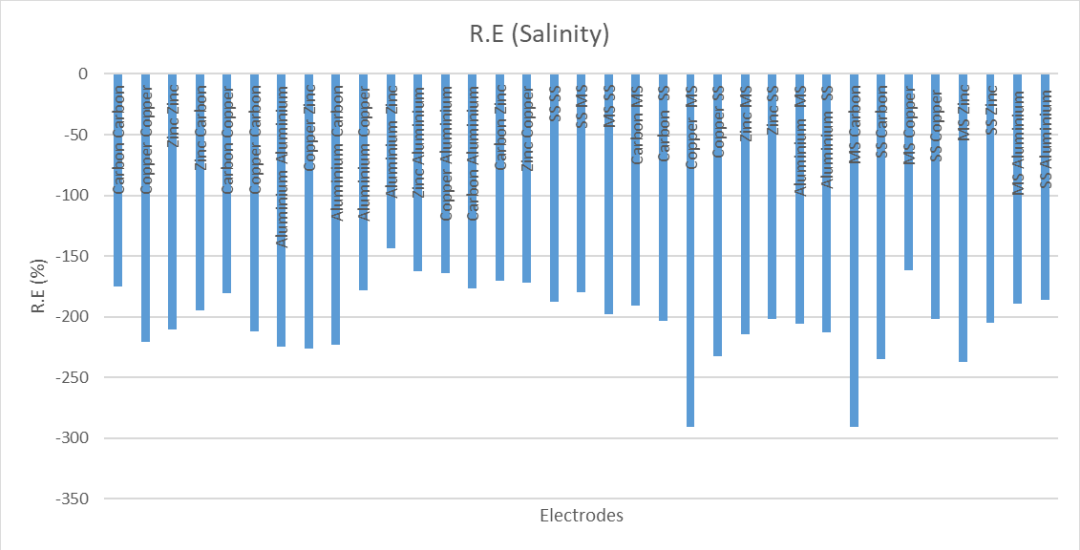


Figure 4.6 Graph of Removal efficiency of Salinity

4.2.7 Removal Efficiency of DO

Anode(+R) Cathode(-B)	Initial DO (mg/l)	Final DO (mg/l)	A.E(DO) (%)
Carbon Carbon	1.42	4.26	-200
Copper Copper	1.42	2.92	-105.634
Zinc Zinc	1.42	2.57	-80.9859
Zinc Carbon	1.42	2.44	-71.831
Carbon Copper	1.42	3.18	-123.944
Copper Carbon	1.42	2.54	-78.8732
Aluminium Aluminium	5.87	7.64	-30.1533
Copper Zinc	5.87	7.73	-31.6865
Aluminium Carbon	5.87	7.11	-21.1244
Aluminium Copper	0.13	7.05	-5323.08
Aluminium Zinc	0.13	6.69	-5046.15
Zinc Aluminium	0.13	7.44	-5623.08
Copper Aluminium	3.72	3.13	15.86022
Carbon Aluminium	3.72	4.06	-9.13978
Carbon Zinc	3.72	4.75	-27.6882
Zinc Copper	3.72	7.84	-110.753
SS SS	3.72	6.36	-70.9677
SS MS	3.72	6.36	-70.9677
MS SS	0.15	6.04	-3926.67
Carbon MS	0.15	5.36	-3473.33
Carbon SS	0.15	0.21	-40
Copper MS	0.15	2.92	-1846.67
Copper SS	0.15	2.36	-1473.33
Zinc MS	0.15	2.7	-1700
Zinc SS	0.15	7.62	-4980
Aluminium MS	0.15	5.39	-3493.33
Aluminium SS	0.15	4.68	-3020
MS Carbon	0.35	0.46	-31.4286
SS Carbon	0.35	0.66	-88.5714
MS Copper	0.35	0.51	-45.7143
SS Copper	0.67	0.75	-11.9403
MS Zinc	0.67	0.79	-17.9104
SS Zinc	0.67	1.61	-140.299
MS Aluminium	0.67	0.64	4.477612
SS Aluminium	0.67	1.06	-58.209

Table 7 Removal Efficiency of DO of Different electrode pair

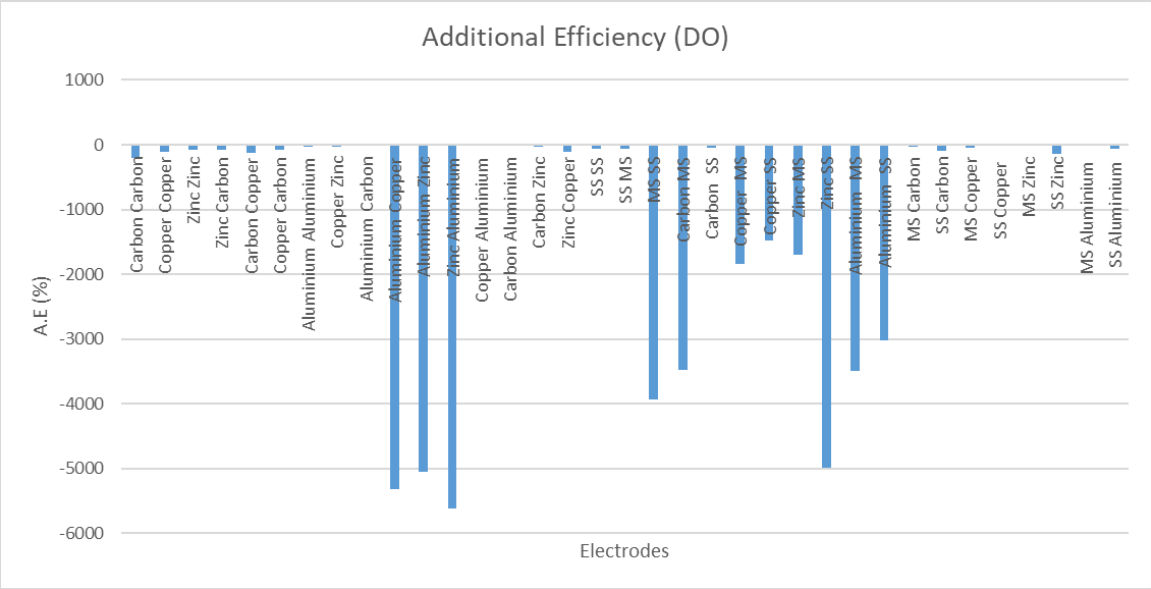


Figure 4.7 Graph of additional efficiency of DO

4.2.8 Removal Efficiency of Turbidity

Anode(+R) Cathode(-B)	**Initial Turbidity (NTU)**	**Final Turbidity (NTU)**	**R.E (Turbidity) (%)**
Carbon Carbon	53.9	39.7	26.34508
Copper Copper	53.9	127	-135.622
Zinc Zinc	53.9	107	-98.5158
Zinc Carbon	53.9	371	-588.312
Carbon Copper	53.9	94.5	-75.3247
Copper Carbon	53.9	139	-157.885
Aluminium Aluminium	9.29	11.3	-21.6362
Copper Zinc	9.29	34.8	-274.596
Aluminium Carbon	9.29	3.23	65.23143
Aluminium Copper	180	2.35	98.69444
Aluminium Zinc	180	2.16	98.8
Zinc Aluminium	180	3.63	97.98333
Copper Aluminium	67	54.5	18.65672
Carbon Aluminium	67	96.7	-44.3284
Carbon Zinc	67	72.5	-8.20896

Zinc Copper	67	32.8	51.04478
SS SS	67	6.1	90.89552
SS MS	67	5.26	92.14925
MS SS	359	3.66	98.9805
Carbon MS	359	338	5.849582
Carbon SS	359	333	7.24234
Copper MS	359	268	25.34819
Copper SS	359	294	18.10585
Zinc MS	359	659	-83.5655
Zinc SS	359	9.25	97.4234
Aluminium MS	359	2.95	99.17827
Aluminium SS	359	3.99	98.88858
MS Carbon	94.7	24.3	74.34002
SS Carbon	94.7	35.6	62.4076
MS Copper	94.7	30.3	68.00422
SS Copper	95.5	82.6	13.50785
MS Zinc	95.5	20	79.05759
SS Zinc	95.5	20.7	78.32461
MS Aluminium	95.5	26.4	72.35602
SS Aluminium	95.5	17.4	81.7801

Table 8 Removal Efficiency of Turbidity of Different electrode pair

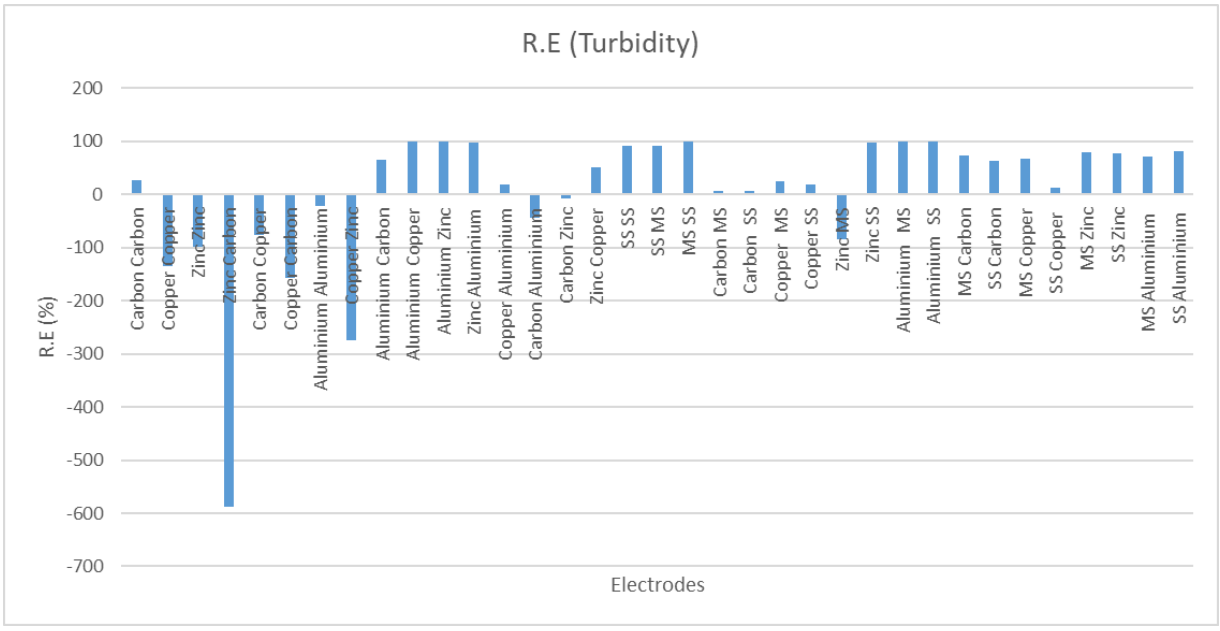


Figure 4.8 Graph of Removal efficiency of Turbidity

4.2.9 Removal Efficiency of COD

Anode(+R) Cathode(-B)	Initial COD (mg/l)	Final COD (mg/l)	R.E (COD) (%)
Carbon Carbon	180	208	-15.5556
Copper Copper	180	192	-6.66667
Zinc Zinc	180	110	38.88889
Zinc Carbon	180	120	33.33333
Carbon Copper	180	340	-88.8889
Copper Carbon	180	210	-16.6667
Aluminium Aluminium	41	10	75.60976
Copper Zinc	41	7	82.92683
Aluminium Carbon	41	3	92.68293
Aluminium Copper	341	103	69.79472
Aluminium Zinc	341	107	68.6217
Zinc Aluminium	341	104	69.50147
Copper Aluminium	320	82	74.375
Carbon Aluminium	320	110	65.625
Carbon Zinc	320	258	19.375
Zinc Copper	320	226	29.375
SS SS	320	238	25.625
SS MS	310	243	24.0625
MS SS	310	55	82.25806
Carbon MS	310	254	18.06452
Carbon SS	310	284	8.387097
Copper MS	310	112	63.87097
Copper SS	310	110	64.51613
Zinc MS	310	52	83.22581
Zinc SS	0	0	0
Aluminium MS	0	0	0
Aluminium SS	0	0	0
MS Carbon	0	0	0
SS Carbon	0	0	0
MS Copper	0	0	0
SS Copper	0	0	0
MS Zinc	0	0	0
SS Zinc	0	0	0
MS Aluminium	0	0	0
SS Aluminium	0	0	0

Table 9 Removal Efficiency of COD of Different electrode pair

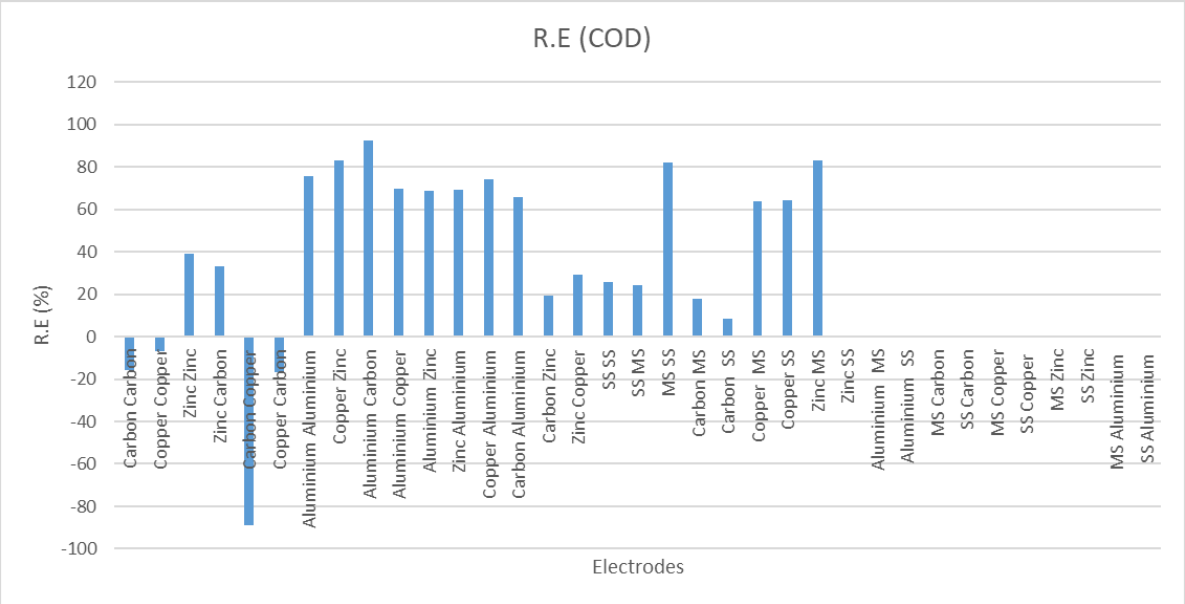
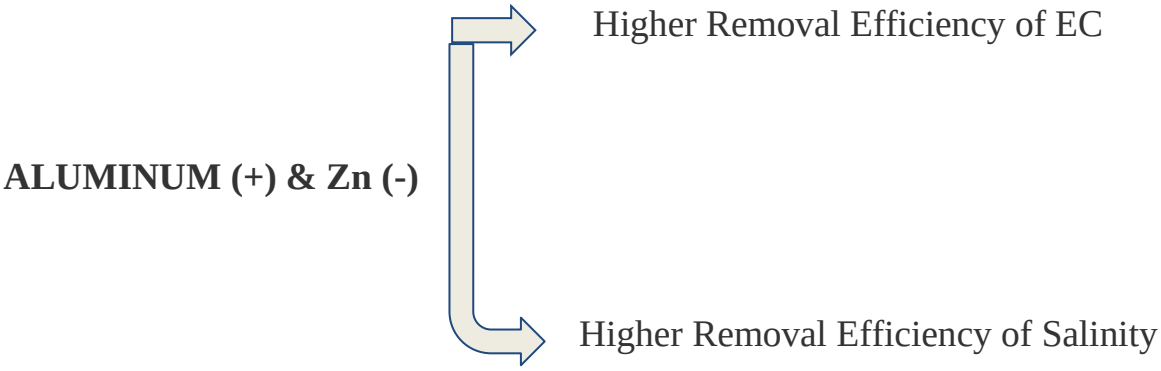


Figure 4.9 Graph of Removal efficiency of COD



After testing all the parameters of 36 combinations of electrodes we got the best results from Aluminum and Zinc pair because it has higher removal efficiency in most of the cases.

CHAPTER 5 CONCLUSIONS AND RECOMMENDATIONS

5.1 General

This chapter summarizes the results and discussions of our study and suggests recommendations, as well as proposes future works related to the research.

5.2 Conclusions

The results of this study have been obtained through multiple experiments. Based on these results, the following conclusions can be drawn:

1. MS & Carbon electrode pair have higher removal of pH, TS, EC, Salinity. The TDS cannot be reduced to a tolerable level.
2. Higher voltage results higher scum height.
3. Increase in TDS is proportional to the increase in conductivity.
4. Zn & Aluminum pair have higher removal of DO.

5.3 Recommendations

Finding a way to lower the TDS is vital, the study has indicated. This is strongly advised because the study's findings won't mean much if the final product still has unbearable TDS levels in it.

Additionally, it is advised to utilize a reliable power supply for all parameter testing and the electrolysis procedure. This is to guarantee that the experiment can continue operating normally even if the laboratory loses electricity owing to load shedding or for any other cause.

The water samples used for the tests should also be stored in a location where others cannot tamper with them and alter the composition in an unnecessary or undesirable way.

5.4 Limitations

One of the major limitations of our investigation has been the removal of TDS from the dye house effluent. This is a significant issue since excessive TDS levels render the water unfit for human consumption or usage. Another negative is the lack of time, since the project's deadline prevented two-parameter tests (BOD and E. coli) from being completed.

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APPENDIX A

Experimental Setup

The experimental setup used in this study consisted of the following components:

Wastewater Source: Wastewater collected from

APEX HOLDINGS LIMITED
FACTORY: CHANDORA, KALIAKOIR, GAZIPUR, BANGLADESH
TEL # 880-06-822-51204-6 EXT. 4123
FAX # 880-06-822-51187
E-mail: water-monitoring@apexholdings.com

Power Supply: A laboratory DC power supply is an apparatus that generates a direct current (DC) output voltage that is controllable and stable within a predetermined range (for instance, 0 and 30 V DC).

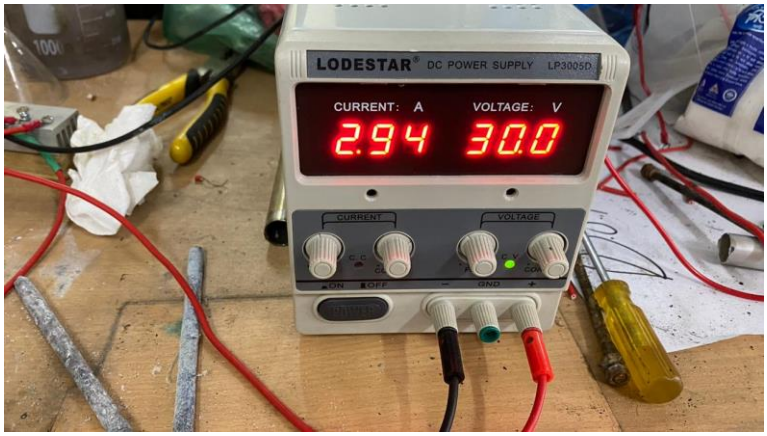

Figure 0.1 DC Power Supply

Electrodes: Used different types of electrodes like Carbon, Copper, Aluminium, Zinc, Stainless Steel, Mild Steel etc.

Figure 0.2 Different types of electrodes

Experimental Setup:

Figure 0.3 Setup, Sludge & Scum production

Experimental Parameters: pH, TS, TSS, TDS, Electric Conductivity, Salinity, DO, Turbidity, COD.