# THE EFFECTIVENESS OF THE ELECTROCOAGULATION PROCESS IN REDUCING TDS CONCENTRATION IN BRACKISH WATER IN SUBANG REGENCY

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## Abstract

Brackish water is a water resource that has the potential to be used as raw water, but has limitations due to high levels of total dissolved solids (TDS) This study aims to analyze the effectiveness of the electrocoagulation method in reducing these pollutant parameters in brackish water samples from Subang Regency. The groundwater samples were taken in the area of the Diniyah Takmiliyah Awaliyah Islamic Madrasa School. The research was conducted using a prototype electrocoagulation device with a pair of aluminum plates, varying voltages (10, 12, 14, and 15 volts), varying flow rates (0.06 L/second and 0.08 L/second), and conditions with and without a plate settler in the sedimentation unit. The results showed that increasing the voltage significantly reduced TDS levels. The highest efficiency was achieved at 10 volts with a flow rate of 0.06 L/second, reducing TDS from 3,400 mg/L to 3,110 mg/L (8.5%). Meanwhile, the lowest efficiency was achieved at 12 volts with a flow rate of 0.08 L/second, at 2.1%. Overall, this study confirms that electrocoagulation can be an alternative brackish water treatment technology in coastal areas. Although the TDS reduction efficiency is still limited, this method can be further developed as part of an integrated system to support sustainable clean water availability.

**Keywords**: *aluminum electrode, electrocoagulation, brackish water, TDS*

## Introduction

The availability of clean water in Indonesia's coastal areas remains a serious challenge. One major issue is the limited freshwater resources due to seawater intrusion, which has caused many community wells to become brackish. Brackish water is characterized by high TDS, salinity, and hardness levels that do not meet quality standards for domestic and industrial use (SNI 01-3553-2006; Minister of Health Regulation No. 492 of 2010). Efforts to treat brackish water have been widely developed, such as distillation, reverse osmosis, and membrane filtration, but these methods are relatively expensive and require intensive maintenance. Previous research has shown that water shortages have become more severe on small islands, such as the Spermonde Archipelago in South Sulawesi, since the 1960s, with both natural conditions and human activities contributing to the problem (Mânez et al., 2012). In eastern Indonesia, regions such as Lembata Regency continue to experience prolonged seasonal shortages, where drought can limit water availability for up to seven months each year, highlighting the urgent need for effective water storage and management solutions (Masduqi et al., 2020).

Saltwater intrusion poses a significant challenge to freshwater availability in coastal regions, as demonstrated in West Sumatra, where river systems have been contaminated, reducing

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access to clean water (Raharini et al., 2025). While adoption has been limited, recent innovations—such as brackish water treatment technologies in East Java that utilize locally available materials—indicate promising pathways for improving potable water access (Hermawan et al., 2023). At the same time, vulnerability assessments emphasize that small islands remain particularly at risk due to their sensitivity to environmental changes and their limited adaptive capacity (Kusumartono & Rizal, 2019).

Although Indonesia possesses abundant water resources, coastal regions often face chronic scarcity due to seasonal variability, saltwater intrusion, and limited water management capacity. Addressing these challenges requires not only strong national policy frameworks but also the integration of local community-based initiatives to ensure long-term water security and sustainability.

One major issue is the limited freshwater resources due to saltwater intrusion, which has caused many community wells to become brackish. Brackish water is characterized by high TDS (water soluble solids), salinity, and hardness, which do not meet quality standards for domestic and industrial use (SNI 01-3553-2006; Minister of Health Regulation No. 492 of 2010). Many brackish water treatment methods, such as distillation, reverse osmosis, and membrane filtration, have been developed, but these methods are relatively expensive and require intensive maintenance (Tayeh, 2024).

Electrocoagulation is an alternative technology that utilizes an electric current to dissolve metal electrodes, forming flocs capable of binding dissolved particles. This technology has proven effective in reducing organic and inorganic pollutants in various types of wastewaters (Mollah et al., 2001; Vik et al., 1984). Electrocoagulation has a few benefits, such as being easy to design, cheap to run, and not needing many extra chemicals. Electrocoagulation (EC) is a new way to treat water and wastewater that uses an electric current to dissolve sacrificial metal electrodes, usually aluminum or iron, and release metal cations. These cations hydrolyze to create hydroxides that work as coagulants. This makes colloidal particles less stable and causes dissolved organic and inorganic contaminants to come together in flocs that can be separated from the water matrix (Mollah et al., 2001; Vik et al., 1984). Compared to traditional chemical coagulation, EC has benefits like simple system design, low chemical needs, low operational costs, and the ability to make coagulant species on-site without needing to store and handle chemicals (Afiatun et al., 2019; Pradiko et al., 2018; Golder et al., 2007; Emamjomeh & Sivakumar, 2009).

Numerous studies have examined EC for the remediation of various wastewater types, including textile effluents, oily wastewater, food industry effluents, and groundwater with elevated salinity or hardness. Its effectiveness has been demonstrated in reducing turbidity, chemical oxygen demand (COD), total dissolved solids (TDS), heavy metals, salinity, and hardness (Holt et al., 2002; Kobya et al., 2003; Kobya et al., 2006; Un et al., 2013).

In coastal and semi-arid regions, brackish water often presents elevated TDS concentration that poses challenges for potable water use. Electrocoagulation has been shown to effectively mitigate these parameters, making it a promising alternative for decentralized water treatment in coastal communities. Thus, the present research, focused on brackish water in Subang Regency, aims to provide both scientific insight into EC's mechanism of pollutant reduction and practical solutions for improving water quality in coastal environments.

The coastal area of Subang is experiencing difficulties in obtaining clean water due to severe seawater intrusion and erosion on its northern coast. One area affected by the impact is the Diniyah Takmiliyah Awaliyah Islamic Madrasa School, including the adjacent Al Furqon mosque. The need for clean water for school and worship is crucial, necessitating the treatment of saltwater into usable water. This research was conducted to investigate the effectiveness of the electrocoagulation method in reducing TDS levels in brackish water in Subang Regency.

## Research Methodology

The research conducted as an experimental research category. This method aims to investigate the possibility of a cause-and-effect relationship by implementing controls. Experimental research is a research method used to determine the effect of certain treatments on other things under controlled conditions. This research aims to determine the optimal efficiency of the electrocoagulation process in a continuous reactor using aluminum plate electrodes in reducing TDS parameter in raw water.

*Research Location*

Legonkulon District is located in the northern part of Subang Regency, West Java, Indonesia. It has a flat topography with an average elevation of 2 meters above sea level. Most of the area consists of lowlands stretched along the coast. Communities in this coastal area still use groundwater for daily needs such as bathing and washing, while they rely on bottled water for clean drinking water. Groundwater in Legonkulon District, Subang Regency, West Java, is experiencing a problem of seawater intrusion. Currently, residents find it difficult to obtain clean water for drinking purposes. Therefore, the problem in Legonkulon District is complex and requires further attention.

Sampling of groundwater was taken place in the Diniyah Takmiliyah Awaliyah Islamic Madrasa School area which is located in Mayangan Street, Legon Kulon District, Subang Regency, West Java, Indonesia. Meanwhile, the experiment and water characteristic analysis process were conducted at the Universitas Pasundan Water Laboratory, Campus IV, Bandung City, West Java, Indonesia.

*Reactor Setting*

Electrocoagulation complete reactor consists of the main electrocoagulation unit, flocculation unit, sedimentation unit, clear tank unit and feeder tank as a raw water reservoir. Figure 1 and 2 show the reactor used in this study. Tools and materials of the main unit are 5-liter capacity acrylic electrocoagulation reactor, aluminum electrodes (anode-cathode) with DC power supply (6–12 V).

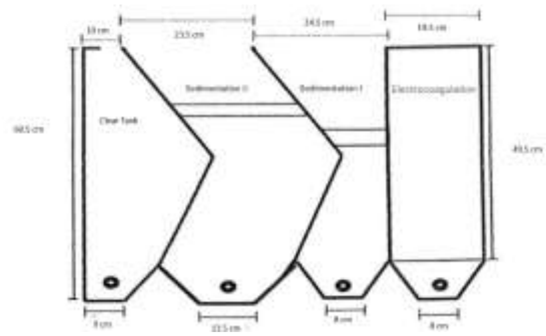

**Figure 1**. Reactor Complete Scheme

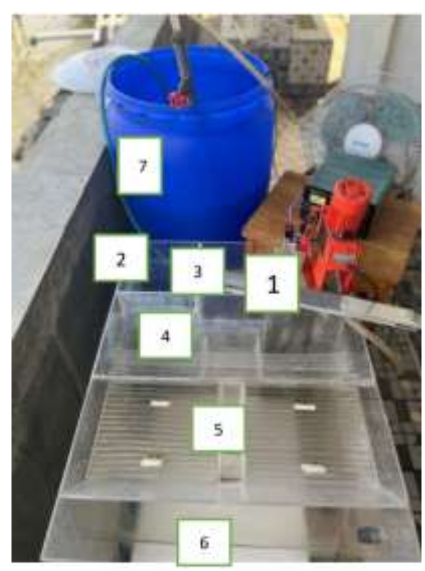


**Figure 2.** Reactor Configuration: (1 & 2) electrocoagulation unit, (3) flocculation unit, (4 & 5) sedimentation unit, (6) clear tank unit, (7) feeder tank

*Experiment Variations*
There are 2 kinds of variation in this experiment, i.e. flowrate and voltage. For flowrate variation used were 0.06 L/s and 0.08 L/s, while for voltage variations applied were 10, 12, 14, and 15 volts each of which produces a different current density, resulting in different removal efficiencies. The plates used are 1 pair of aluminum. Stirring is performed at a speed of 100 RPM.

*Parameter Analyses*
The parameters examined in this experiment was TDS (Total Dissolved Solids). This parameter was analyzed using procedures based on SNI (Indonesian National Standard) and Standard Methods (APHA, 2017).

*Data Analysis*
The research conducted shows that the data obtained is quantitative. This quantitative data was obtained from measuring water sample parameters in each unit of the continuous electrocoagulation reactor system. Quantitative data was obtained by recording each parameter measurement result in the preliminary and main research for each unit. The recorded data was then processed and presented in graphical form.

The results of the TDS measurements of the samples in the continuous electrocoagulation reactor system are then compared with the initial salinity and TDS values before treatment in the reactor. The performance of the electrocoagulation reactor and settler in the sedimentation unit can be determined by their efficiency in reducing the salinity and TDS levels of the treated water. Pollutant removal efficiency (R%) can be calculated using the formula (1).

$$R\% = \frac{initial\ concentration - treated\ concentration}{initial\ concentration} \times 100\% \quad (1)$$

## Results and Discussion

Samples taken from the field shows the concentration of TDS was 3400 mg/L. The results of the study showed that increasing voltage and contact duration were directly proportional to the efficiency of reducing the three water quality parameters.

*Variation 1*
Table 1 and Fig. 3 show the results obtained from voltage variations of 10, 12, 14, and 15 volts with flowrate of 0.06 L/s and the final sampling point was at the Clear Tank unit.

**Table 1.** TDS Removal Efficiency of Flow Rate of 0.06 L/s Variation

| Initial TDS Conc (mg/L) | Voltage (Volt) | Current Voltage (A) | Plate Area (m2) | Current Density (A/m2) | Treated TDS Conc (mg/L) | Removal Efficiency (%) |
|---|---|---|---|---|---|---|
| 3400 | 10 | 13 | 0.0213 | 611.76 | 3110 | 8.5 |
| | 12 | 15 | | 705.88 | 3320 | 2.4 |
| | 14 | 16.5 | | 776.47 | 3290 | 3.2 |
| | 15 | 19 | | 894.12 | 3290 | 3.2 |

Figures 3 shows a relationship between TDS (Total Dissolved Solids) and electrical voltage. The higher the voltage, the greater the TDS (Total Dissolved Solids) removal, indicating more optimal processing. However, this study found that the TDS (Total Dissolved Solids) removal was unstable due to significant erosion of the $Al^{3+}$ removal on the electrode plate. This is due to brackish water's high salt content, which can accelerate the wear and tear of the aluminum plate, making it less than optimal for use. Brackish water typically contains elevated levels of dissolved salts such as chloride, sulfate, and bicarbonate ions. These salts, especially chloride ions, are highly corrosive to aluminum electrodes when used in electrocoagulation systems.

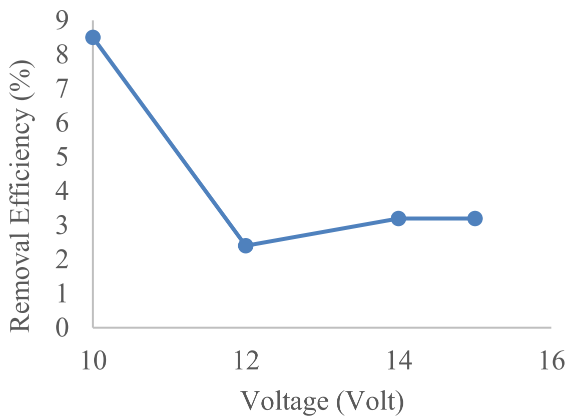


**Figure** 3. TDS removal at a flowrate of 0.06 L/s

The presence of high salinity accelerates electrochemical reactions, leading to pitting and localized corrosion of the aluminum plates, which reduces electrode lifespan and increases maintenance requirements (Brinda et al., 2025; Vasudevan et al., 2011). This accelerated wear and tear not only compromises treatment efficiency over time but also raises operational costs due to more frequent electrode replacement. Due to the lack of floc formation in the electrocoagulation and flocculation tanks, which is influenced by the low voltage and electrode plate pairing, the removal efficiency obtained at a flow rate of 0.06 L/second was 8.5% at the highest and 2.1% at the lowest.

*Variation 2*

Table 2 and Fig. 4 show the results obtained from voltage variations of 10, 12, 14, and 15 volts with 0.08 L/s flowrate and the final sampling point was at the Clear Tank unit.

**Table 1**. TDS Removal Efficiency of Flow Rate of 0.08 L/s Variation

| Initial TDS Conc (mg/L) | Voltage (Volt) | Current Voltage (A) | Plate Area (m2) | Current Density (A/m2) | Treated TDS Conc (mg/L) | Removal Efficiency (%) |
|---|---|---|---|---|---|---|
| 3400 | 10 | 11.5 | 0.0213 | 541.18 | 3300 | 2.9 |
| | 12 | 16.5 | | 776.47 | 3290 | 3.2 |
| | 14 | 19 | | 894.12 | 3310 | 2.6 |
| | 15 | 19 | | 894.12 | 3290 | 3.2 |

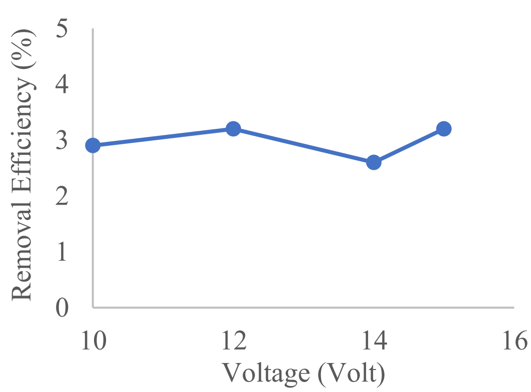


**Figure 4.** TDS removal at a flow rate of 0.08 L/s

Based on Table 2 and Fig. 4, it is known that the efficiency of reducing the Total Dissolved Solids (TDS) parameter is unstable as the electrical voltage flowing through the aluminum plate increases. At voltage variations of 10, 12, 14, and 15 volts, the TDS value decreases by 2.9%, 3.2%, 2.6%, and 3.2%, respectively.

The current density value will increase with increasing voltage because the higher the voltage used, the higher the current produced. However, the effect of removal on the Total Dissolved Solids (TDS) parameter is also influenced by the electrode plate usage, as the longer the electrode plate is used, the less optimal its performance becomes. The current density value will increase with increasing voltage because the higher the voltage used, the higher the current produced. It aligns with previous studies by Rusdiana et al. (2020) and Mustapha (2025), which reported the high effectiveness of electrocoagulation in reducing dissolved ions in industrial wastewater. The advantages of this method are that it does not require additional coagulant chemicals and can be operated at low electricity costs.

A comparison between 0.06 L/s and 0.08 L/s discharges shows that the lower discharge yields a relatively higher TDS removal rate. Optimal discharge rates vary for each reactor with specific pollutants removed. Previous research that removed Fe, Ca, and Mg found an optimum discharge of 1 mL/s (Salam et al., 2022).

However, the results also showed that despite the significant reduction, the final TDS level was still above drinking water thresholds. Therefore, electrocoagulation is more appropriate as a pretreatment before further processes such as membrane filtration or desalination. Filtration unit may support as a further treatment of brackish water after electrocoagulation unit up to 80% improvement on TDS concentration (Danial et al., 2024). Electrocoagulation shows strong potential as a pretreatment method for mitigating key reverse osmosis (RO) membrane scaling agents, including silica (Si) and divalent cations such as magnesium ($Mg^{2+}$), calcium ($Ca^{2+}$), and barium ($Ba^{2+}$) (Jebur et al., 2024).

## Conclusions

With raw water at 3400 mg/L, the highest removal efficiency was 3110 mg/L (8.5%) at a flow rate of 0.06 L/s, with a voltage of 10 volts producing a current of 13 amperes; and the lowest removal efficiency was 3330 mg/L (2.1%) at a flow rate of 0.08 L/second, with a voltage of 12 volts producing a current of 15 amperes. Based on the overall results analyzed, several changes are needed to achieve better removal results, including increasing the electrical voltage, reducing the flow rate, and adding a filtration unit before entering the clear tank. This technology has great potential for preliminary application in coastal areas as a simple, inexpensive, and environmentally friendly water treatment solution. Further research is recommended to examine the integration of electrocoagulation with advanced treatment methods to meet drinking water standards.

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