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REDUCTION OF POLLUTANTS IN BRINE EFFLUENT USING ELECTROCOAGULATION

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ABSTRACT

Brine effluent generated from industrial processes contains high levels of suspended solids, organic pollutants, and heavy metals, posing significant environmental and health risks if discharged untreated. Conventional treatment methods are often costly and ineffective in handling high salinity content. This study aims to evaluate the effectiveness of electrocoagulation using aluminium electrodes in removing key pollutants such as suspended solids (turbidity), organic load (COD), pH, and heavy metals (aluminium and zinc) from brine effluent. The electrocoagulation process was conducted in a batch setup with varying treatment durations (30 to 150 minutes). Water quality parameters were measured before and after treatment, and the results were analyzed using one-way ANOVA to determine statistical significance. The results showed a significant improvement in water quality: pH increased from 5.11 to 7.41, COD decreased from 26 mg/L to 2 mg/L, and turbidity increased initially due to floc formation but was managed through settling. Aluminium concentration dropped from 0.380 mg/L to 0.019 mg/L, while zinc reduced from 0.33 mg/L to 0.26 mg/L. The ANOVA analysis verified that all parameters show statistically significant differences ($p < 0.05$) throughout treatment durations. These results suggest that electrocoagulation is environmentally friendly, cost-effective, and efficient for treating brine wastewater. This innovation outcome is to promote sustainable wastewater management practices and offer a practical solution for industries that attempt to comply with environmental discharge standards.

Keywords: Brine effluent, Pollutants, Electrocoagulation, Aluminium

INTRODUCTION

The global increase in water shortage as a result of climate change, urbanization, and population growth has reinforced the reliance on alternative water sources, such as aquaculture and desalination. However, these processes produce a significant amount of brine effluent, a highly concentrated discharge that contains a complex mixture of contaminants and a high salinity. The direct discharge of untreated brine into the environment has the potential to severely damage aquatic ecosystems, reduce dissolved oxygen levels, and increase salinity in the recipient waters.

Brine effluent frequently contains contaminants with suspended particulates, turbidity, elevated COD, and heavy metals, all of which cause serious dangers to the ecosystem and water quality. Current treatment technologies, including membrane filtration, chemical coagulation, and biological treatment, have limitations. Chemical methods require costly chemicals and generate significant amounts of sediment, while biological processes involve extended retention periods and are susceptible to salinity (Nishat et al., 2023).

Electrocoagulation (EC) has been recognized as a promising method within alternative technologies due to its simple operation, high degree of removal efficiency, and minimal chemical input. The in-situ generation of coagulants through the dissolution of sacrificial electrodes, typically aluminium, under an applied electric field is the process of electrochemical coagulation (Das et al., 2022).

However, there is a limitation of research that has specifically evaluated the utilization of aluminium electrodes and does not investigate the impact of alternative materials, such as iron or hybrid configurations. Other parameters that are significant in electrocoagulation, including electrode spacing, current density, applied voltage, and conductivity, are maintained consistently and not thoroughly assessed as the study is in short duration. This creates a gap in the literature, especially if the treatment time is limited. Therefore, the objective of this investigation is to determine characteristics of brine effluent in terms of several pollutants before and after electrocoagulation treatment, as well as to evaluate the effectiveness of electrocoagulation in reducing pollutants in brine effluent.

METHODS

Materials and Sample Preparation

The brine effluent was collected from seawater desalination plant at Kota Bharu, Kelantan.

Experimental Setup

The electrocoagulation procedure (Figure 1) was conducted in a 10 liter acrylic batch reactor that was equipped with 10 aluminium plate electrodes. The electrodes were connected to a DC power supply. In order to assess the efficiency of removal that varies depending on time, treatment durations were adjusted from 30 to 150 minutes.



Figure 1.: Experimental Setup

Analytical Parameters

Post-treatment, the effluent was analyzed for the following parameters:

- pH – measured using a calibrated digital pH meter.
- COD – determined via the closed reflux colorimetric method (APHA 5220D).
- Turbidity – assessed with a nephelometric turbidity meter (APHA 2130B).
- Aluminium– analyzed using a spectrophotometer.

RESULTS AND DISCUSSION

Table 1 summarizes the removal efficiency for all parameters. COD and aluminium showed the highest reductions (>90%), while pH was successfully neutralized. However, turbidity increased due to lack of sedimentation.

Table 1.: Removal efficiency of pollutants after 150 min of electrocoagulation

Parameter	Initial Value	Final Value	Change / Removal (%)
COD	26.00 mg/L	2.00 mg/L	92.31% (↓)
Aluminium	0.380 mg/L	0.019 mg/L	95.00% (↓)
Turbidity	0.43 NTU	5.95 NTU	+1283.72% (↑)
pH	5.11	7.41	+2.30 units

CONCLUSION

The purpose of this study was to evaluate the effectiveness of electrocoagulation (EC) as a treatment method and to determine the characteristics of brine effluent in terms of several pollutants before and after electrocoagulation treatment. These results confirm the effectiveness of EC in the treatment of organic and metallic contaminants in brine effluent. The importance of improving operational conditions and incorporating post-treatment filtration to improve turbidity control is emphasized by the study. Future research should focus on the improvement of heavy metal removal efficiency, the investigation of alternative electrode materials, and verification of results at the experimental scale in order to facilitate industrial-scale applications.

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