ELECTROCOAGULATION OF REAL BILGE WASTEWATER:
EFFECT OF ELECTRODE TYPE (Al, Fe), SPACING AND VOLTAGE

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OUTLINE

A. INTRODUCTION
B. EXPERIMENTAL
C. RESULTS AND DISCUSSION
D. CONCLUDING REMARKS
A. INTRODUCTION

- Bilge wastewater treated with electrocoagulation is the subject matter of this study.
B. EXPERIMENTAL: Collected Bilge effluent

Treatment process diagram - Ecofuel (Cyprus) Ltd

* DAF Dissolved Air Flotation
* MBBR aerobic 200 m³ moving bed biofilm reactor

Collected Effluent after DAF
Collected Effluent after MBBR
B. EXPERIMENTAL: Electrocoagulation (Al)

Controlling parameters

- spacing (0.5 cm – 3.0 cm)
- voltage (2.0 V – 5.5V)
- Nature of effluent
- Electrode surface
B. EXPERIMENTAL: Characterization

- Chemical:
  - COD
- Physical:
  - pH
  - Conductivity
  - Turbidity (Qualitatively)
  - Solids (XRD, SEM/EDX)

- **Coagulation dose**: Weighting Anode mass loss, $W_{\text{initial}}(g) - W_{\text{final}}(g)$
C. RESULTS: Effect of electrocoagulation (AI) on the removal of turbidity
C. RESULTS: Efficiency of electrocoagulation (Al) on the removal of COD - Spacing
C. RESULTS: Efficiency of electrocoagulation (Al) on the removal of COD - Voltage

![Graph showing COD removal vs. operation time for different voltages.]

- Al (52.8 cm³) - 2.0 volts
- Al (52.8 cm³) - 4.0 volts
- Al (52.8 cm³) - 5.5 volts

The graph demonstrates the increasing COD removal percentage as the voltage increases from 2.0 to 5.5 volts over the operation time of 300 minutes.
C. RESULTS: Efficiency of electrocoagulation (Al) on the removal of COD – Nature of effluent

![Graph showing COD removal vs. operation time for different effluents with error bars for each data point.](image-a)

![Bar graph showing coagulation dose in g/L for two different treatments.](image-b)
C. RESULTS: Efficiency of electrocoagulation (Al) on the removal of COD – Immersed electrode surface
C. RESULTS: Effect of electrocoagulation (Al) on pH and conductivity
C. RESULTS: Electrocoagulation (Al) mechanism

\[
\begin{align*}
\text{Al}^0 & \rightarrow \text{Al}^{3+} + 3e^- \quad \text{Eq. 1} \\
\text{a)} \quad \text{Al}^{3+} + \text{Q} & \rightarrow \text{+/-} \quad \text{Eq 2} \\
\text{b)} \quad \text{Al}^{3+} + 3\text{H}_2\text{O} & \rightarrow \text{Al(OH)}_3 + 3\text{H}^+ \quad \text{Eq 3} \\
\text{Al}^{3+} + 3\text{OH}^- & \rightarrow \text{Al(OH)}_3 \quad \text{Eq 4} \\
\text{Al}^{3+} + 3\text{OH}^- & \rightarrow \text{AlO(OH)} + \text{H}_2\text{O} \quad \text{Eq 5}
\end{align*}
\]

\[\text{Cathode (reduction)} \quad 2\text{H}_2\text{O} + 2e^- \rightarrow \text{H}_2 + 2\text{OH}^- \quad \text{Eq 6}\]

\[\text{Anode (oxidation)} \quad 4\text{OH}^- \rightarrow \text{O}_2 + 4e^- + 2\text{H}_2\text{O}\]

Overall reaction

\[\text{H}_2\text{O} \leftrightarrow \text{H}_2 + \frac{1}{2} \text{O}_2\]

\[a) \text{ Adsorption and Charged Neutralization, \hspace{1cm} b) \text{ Sweep Coagulation, \hspace{1cm} c) Froth Flotation}\]
C. RESULTS: Electrocoagulation (Al) mechanism – Adsorption and Charged Neutralization
C. RESULTS: Electrocoagulation (Al) mechanism – Sweep Coagulation, XRD
C. RESULTS: Electrocoagulation (Al) mechanism – Froth Flotation, SEM/EDX

NB: Gold (Au) used as the sputter coating for SEM – EDX
C. RESULTS: MBBR vs. DAF vs. Diluted DAF

Results from this study

D. CONCLUDING REMARKS

The parameters that affect the efficiency of EC on real bilge are as follows:

a) The distance between the electrodes. The two electrodes cannot be very close (< 1.0 cm) as some of the electrons would flow directly from reducing agent to oxidized agent. The optimum distance is recorded at 1.0 cm.

b) As one applies a high potential difference then definitely the rate of movement of the charged particles will very fast, so definitely the efficiency will be high.

c) The higher the immersed electrode surface the greater the EC efficiency. This result is also irrespective of the electrode configuration. Here using single and monopolar electrodes in parallel series configuration.

d) The nature of effluent affects the processibility of EC treatment
The Electrocoagulation (Al) removal mechanism is based on three categories:

i) Adsorption and charged neutralization,

ii) sweep coagulation

iii) froth flotation

• Sweep coagulation is the predominate mechanism that removes turbid matter from MBBR bilge, as it is affected from both coagulant dose, initial colloidal concentration and pH value.
C. PRIMARY RESULTS: **Al** vs. **Fe**

![Graph a](image1)

**Graph a:**
- **COD [mg/L]**
- **Operation time [min]**
- Lines for **Fe (22.1 cm²)** and **Al (22.1 cm²)**

![Graph b](image2)

**Graph b:**
- **Coagulation dose [g/L]**
- Bars for **Fe (22.1 cm²)** and **Al (22.1 cm²)**
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