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

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OUTLINE

A. INTRODUCTION

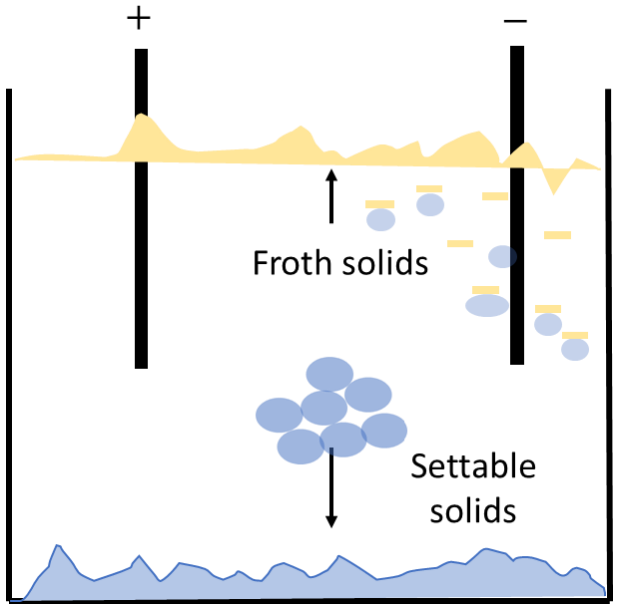
B. EXPERIMENTAL

C. RESULTS AND DISCUSION

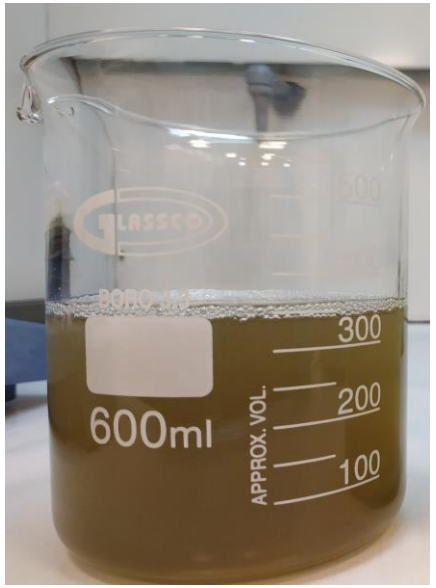
D. CONCLUDING REMARKS

A. INTRODUCTION

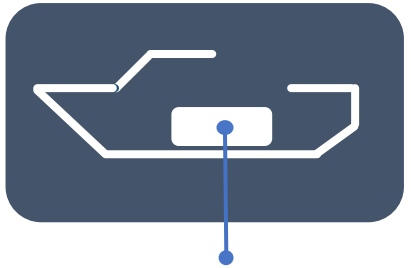
- Bilge wastewater treated with electrocoagulation is the subject matter of this study.



Electrocoagulation



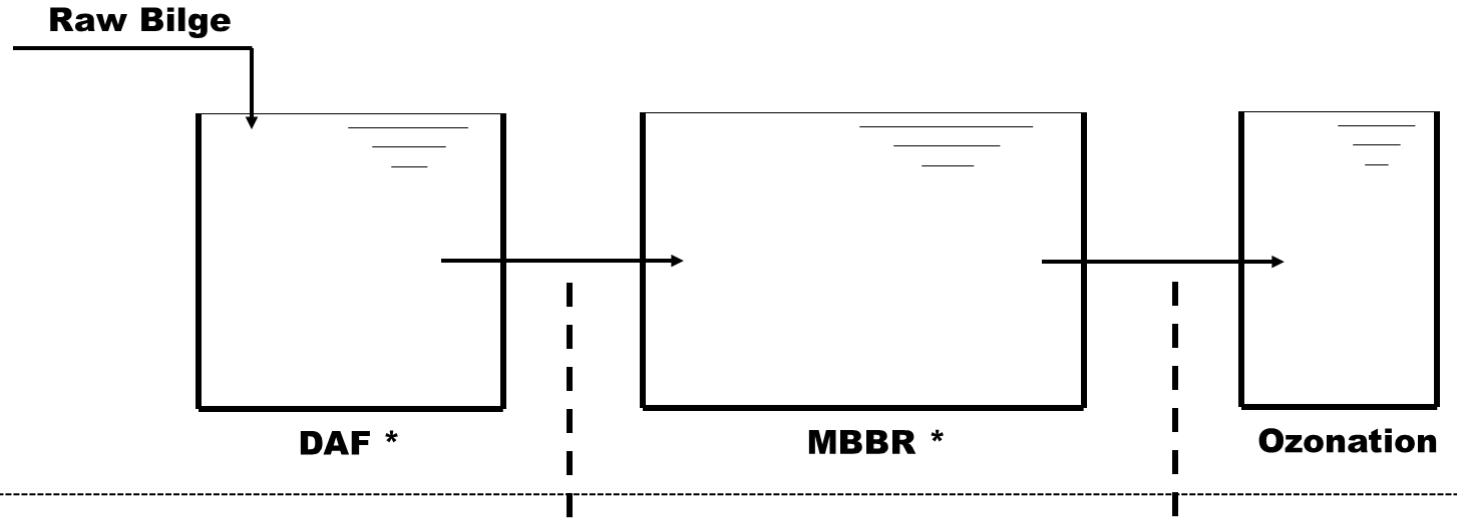
Real Bilge Wastewater



Bilge water is any oil and water leakage from the ship machinery room

B. EXPERIMENTAL: Collected Bilge effluent

Treatment process diagram **- Ecofuel (Cyprus) ltd**



Collected Effluent after DAF

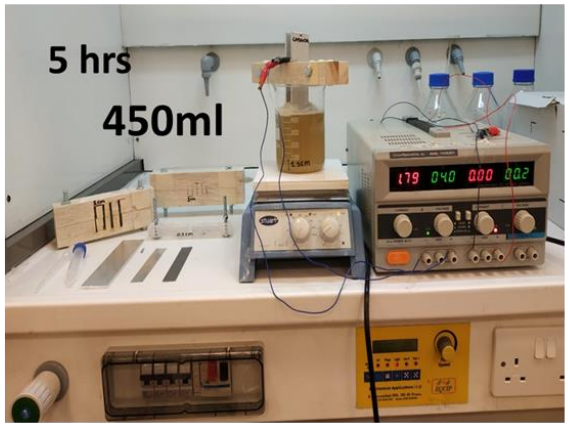
Collected Effluent after MBBR

*

DAF Dissolved Air Flotation

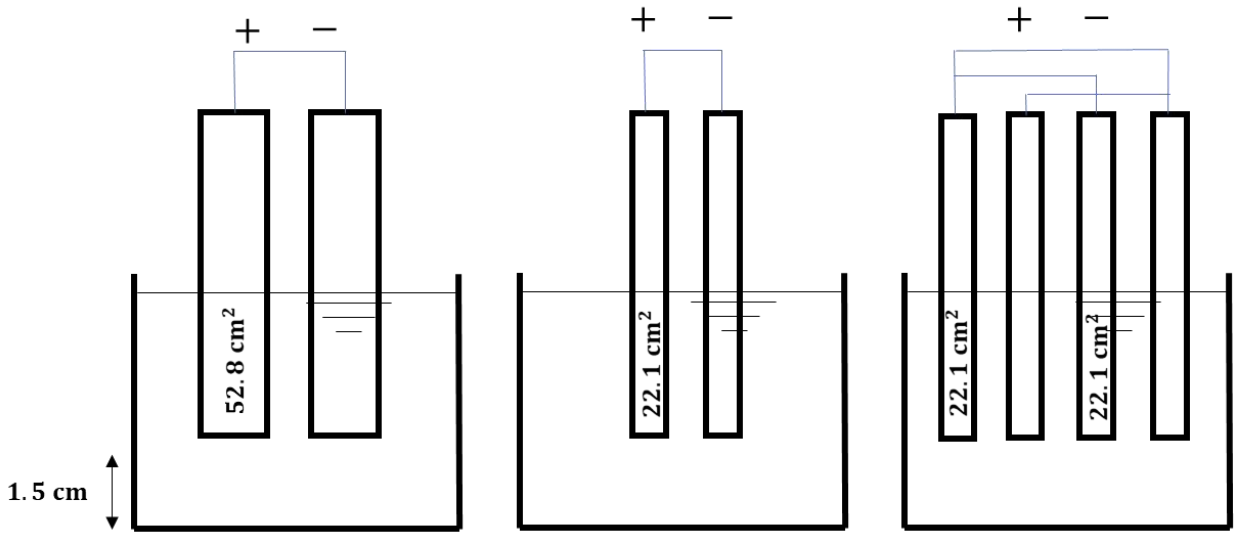
MBBR aerobic 200 m^3 moving bed biofilm reactor

B. EXPERIMENTAL: Electrocoagulation (**Al**)



Controlling parameters

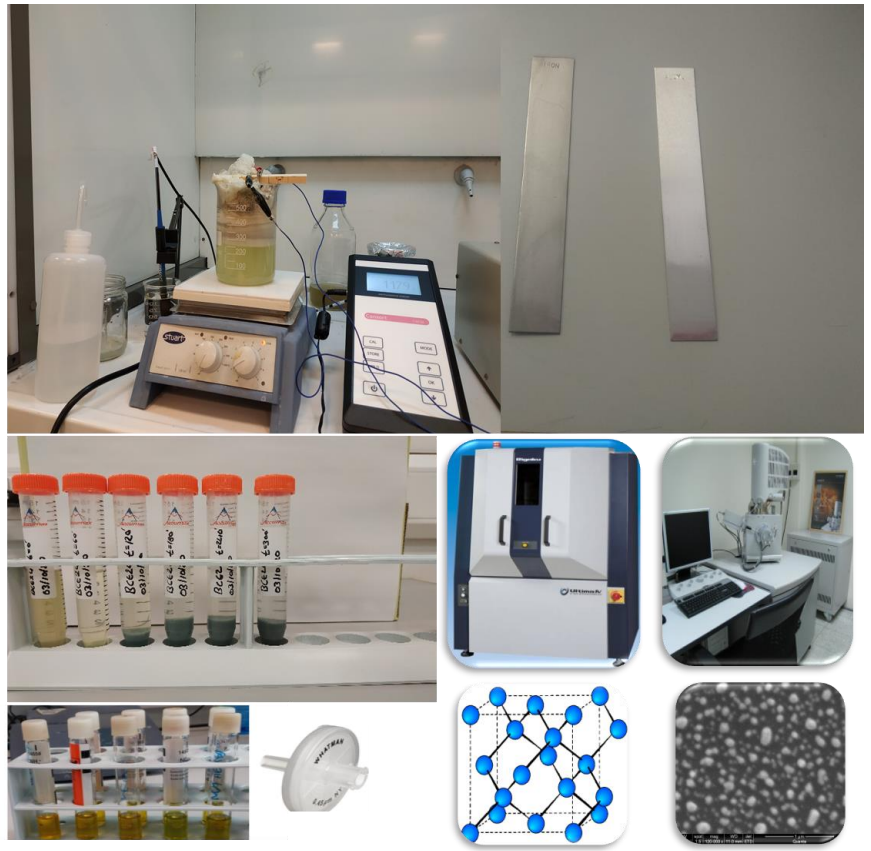
- spacing (0.5 cm – 3.0 cm)
- voltage (2.0 V – 5.5V)
- Nature of effluent
- Electrode surface



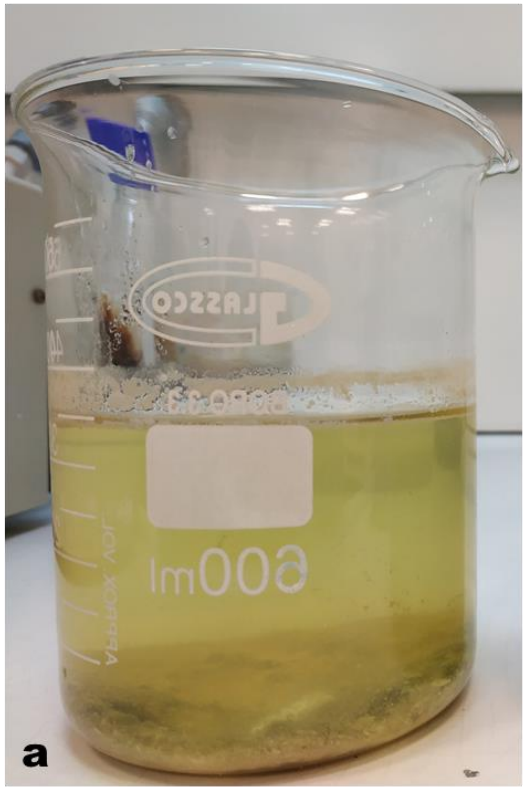
B. EXPERIMENTAL: Characterization

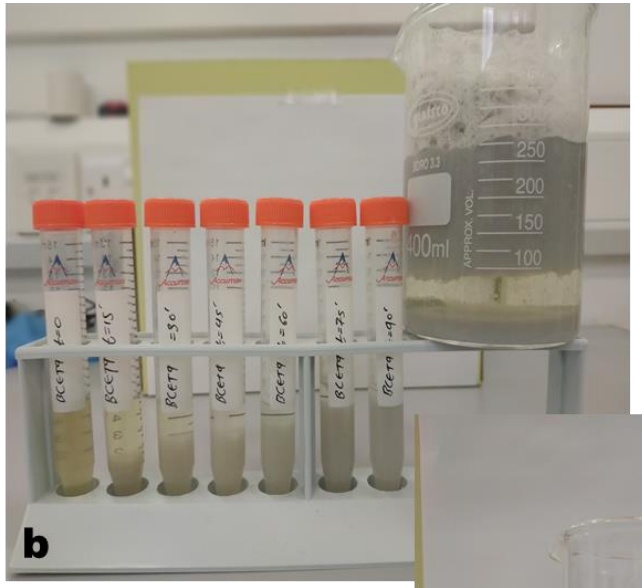
- Chemical:
  - **COD**
- Physical:
  - **pH**
  - **Conductivity**
  - **Turbidity (Qualitatively)**
  - **Solids (XRD, SEM/EDX)**

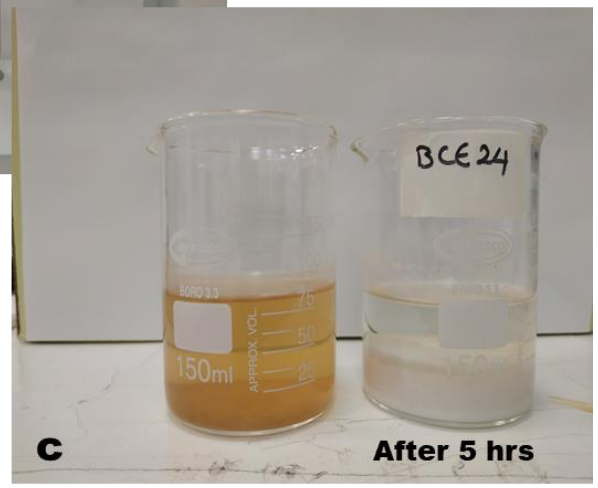
- **Coagulation dose**: Weighting Anode mass loss, $W_{initial}(g) - W_{final}(g)$



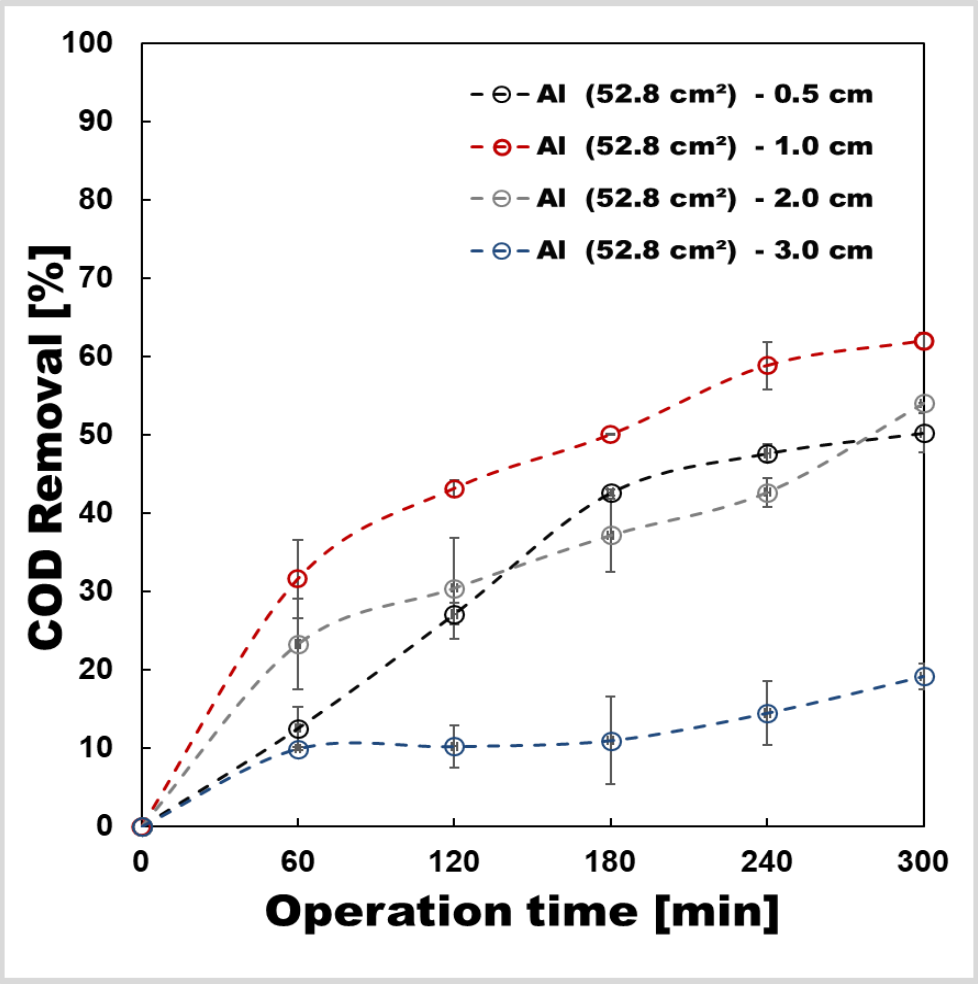
C. RESULTS: Effect of electrocoagulation (**Al**) on the removal of turbidity



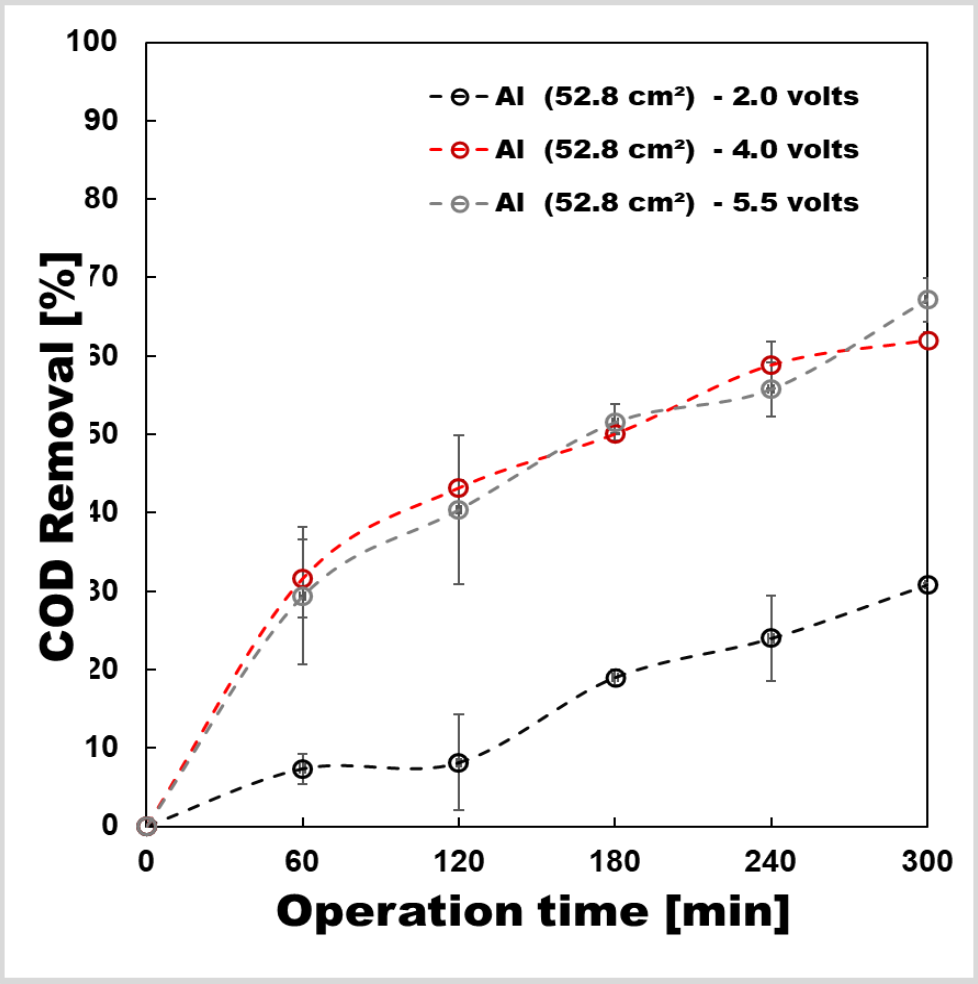




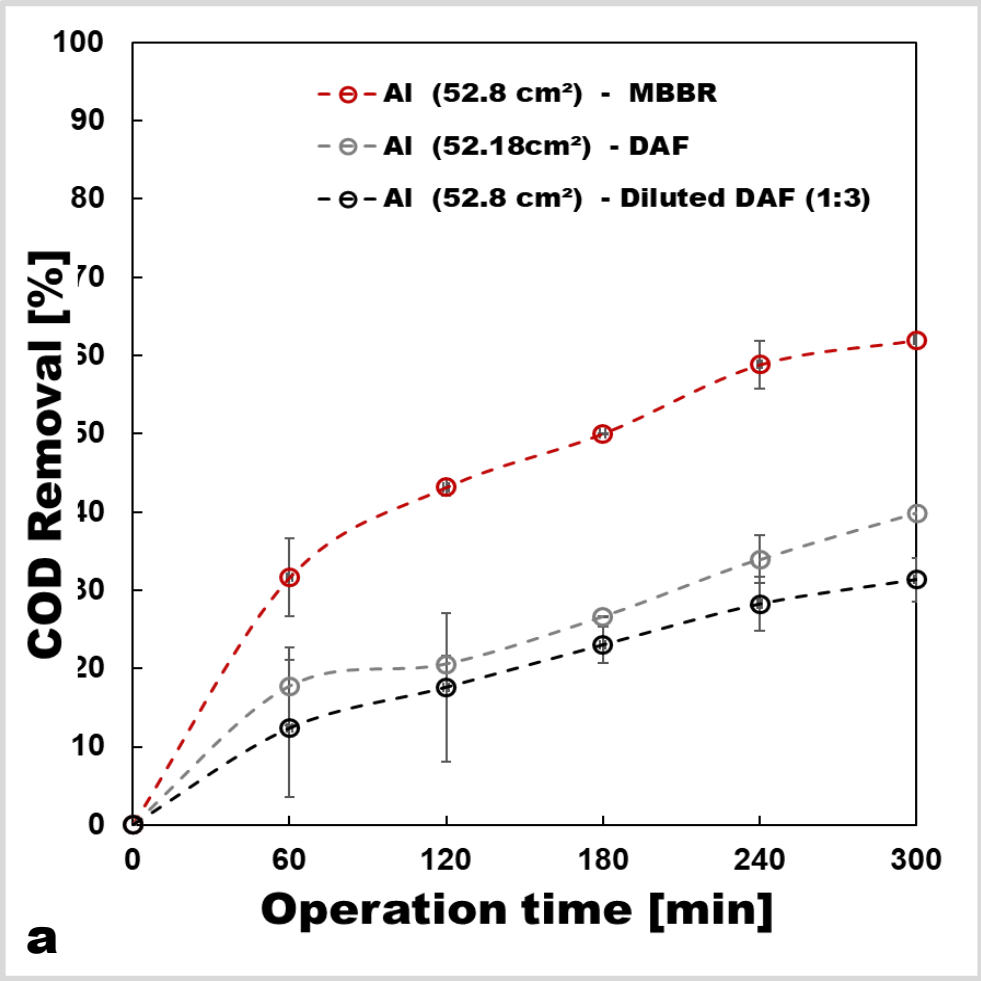
C. RESULTS: Efficiency of electrocoagulation (**Al**) on the removal of COD - **Spacing**

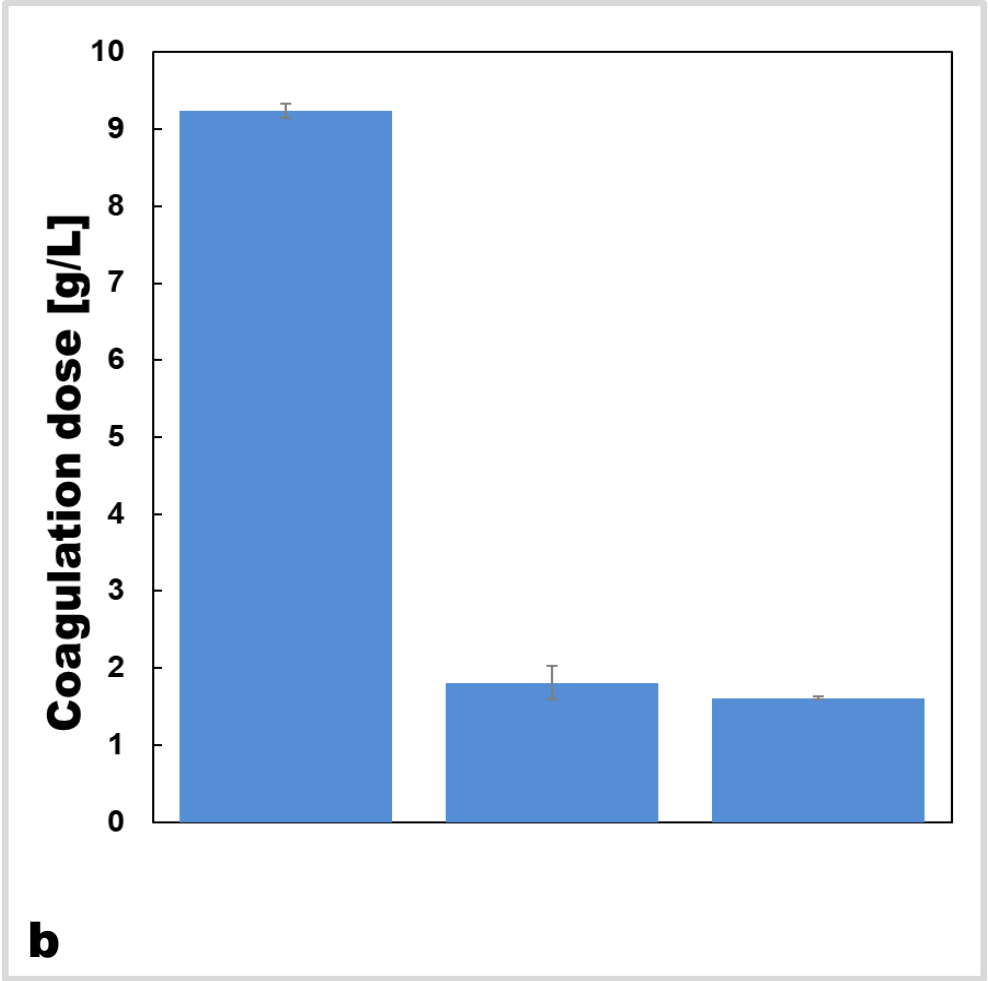


C. RESULTS: Efficiency of electrocoagulation (**Al**) on the removal of COD - **Voltage**

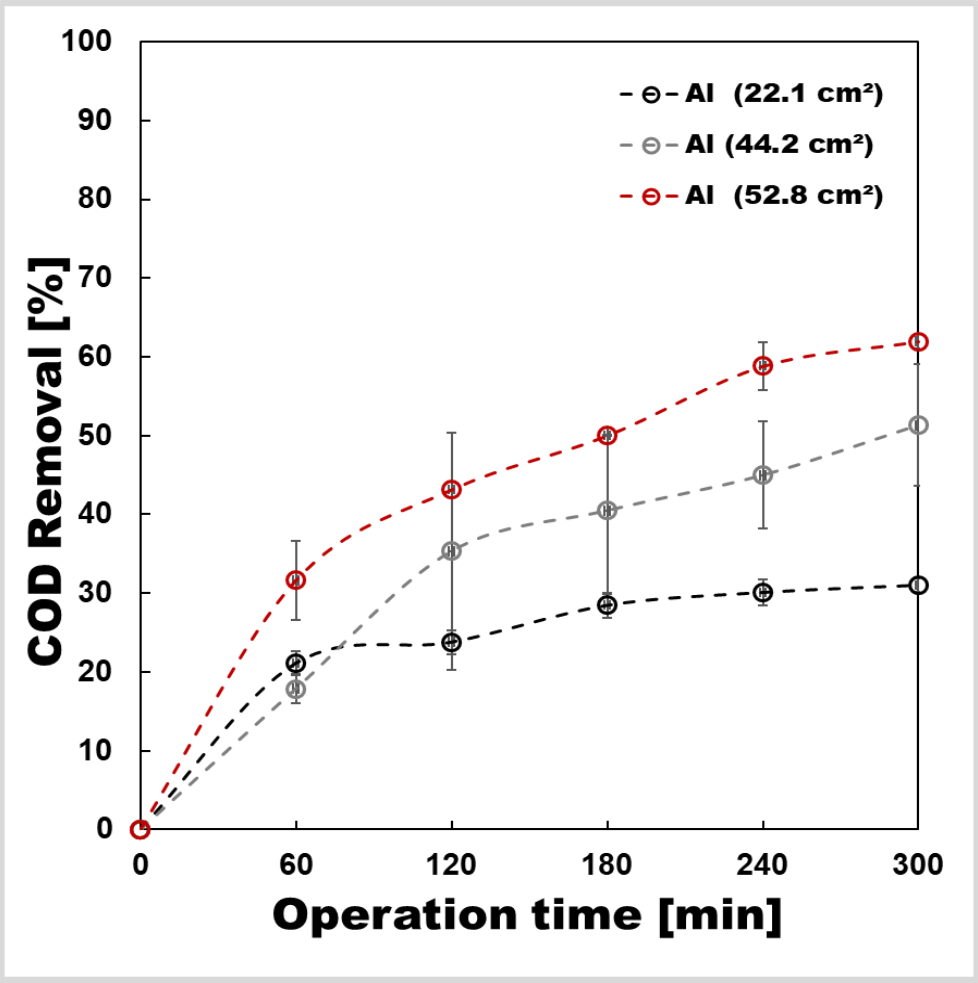


C. RESULTS: Efficiency of electrocoagulation (**Al**) on the removal of COD – **Nature of effluent**

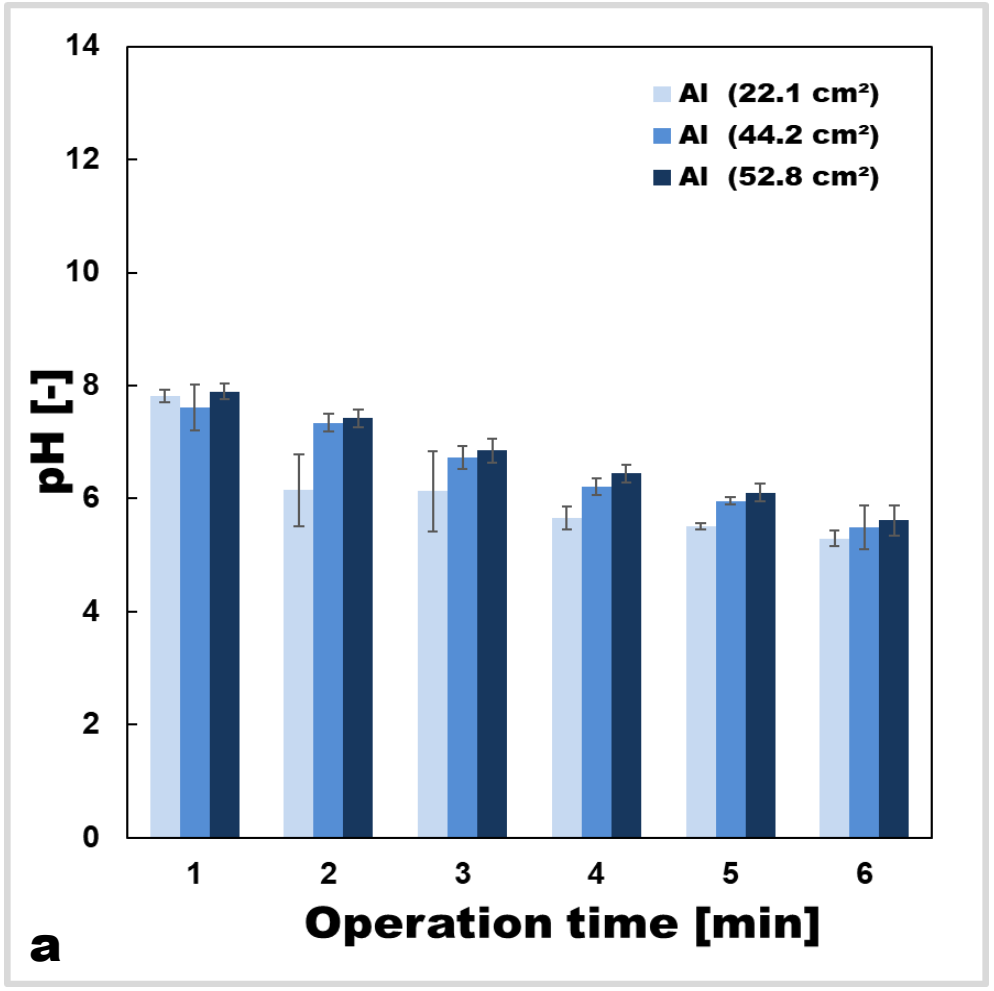


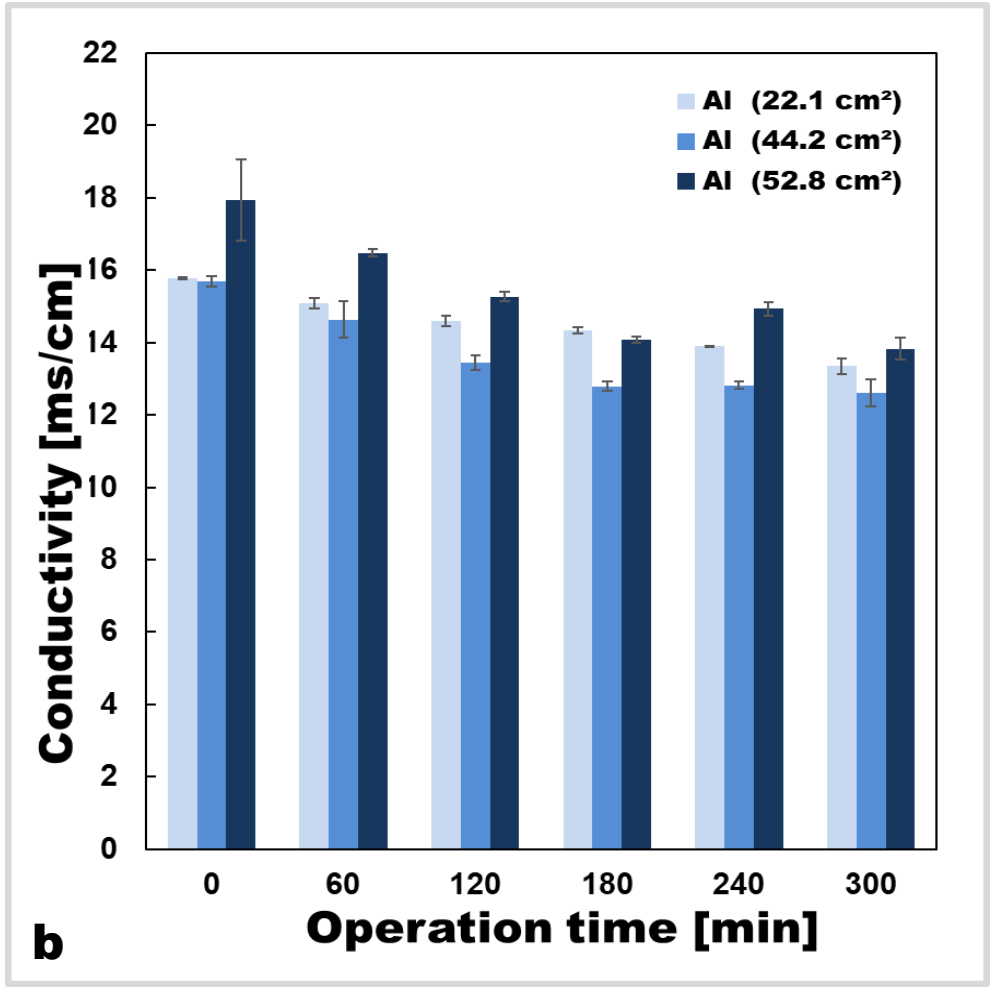


C. RESULTS: Efficiency of electrocoagulation (**Al**) on the removal of COD – **Immersed electrode surface**



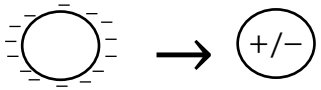
C. RESULTS: Effect of electrocoagulation (**Al**) on pH and conductivity





C. RESULTS: Electrocoagulation (**Al**) mechanism

$$Al^0 \rightarrow Al^{3+} + 3e^- \quad \text{Eq. 1}$$

a) $Al^{3+} +$  Eq 2

b)
$$Al^{3+} + 3H_2O \rightarrow Al(OH)_3 + 3H^+ \quad \text{Eq 3}$$
$$Al^{3+} + 3OH^- \rightarrow Al(OH)_3 \quad \text{Eq. 4}$$
$$Al^{3+} + 3OH^- \rightarrow AlO(OH) + H_2O \quad \text{Eq 5}$$

c) Eq 6

Cathode (reduction)

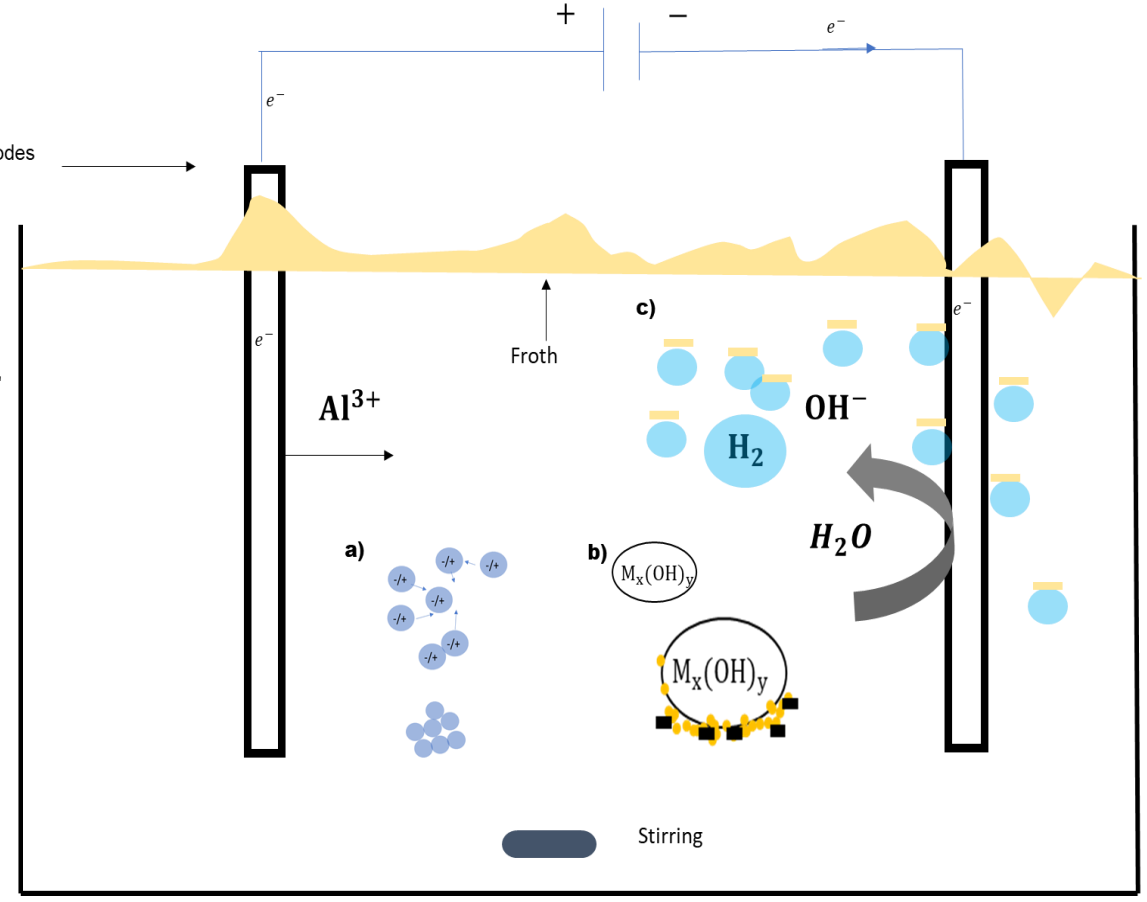
$2H_2O + 2e^- \rightarrow H_2 + 2OH^-$

Anode (oxidation)

$4OH^- \rightarrow O_2 + 4e^- + 2H_2O$

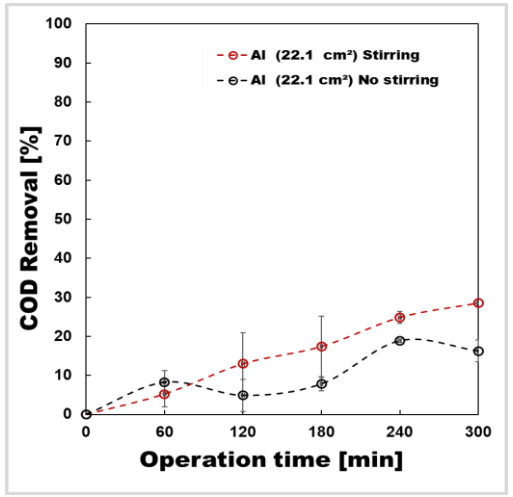
Overall reaction

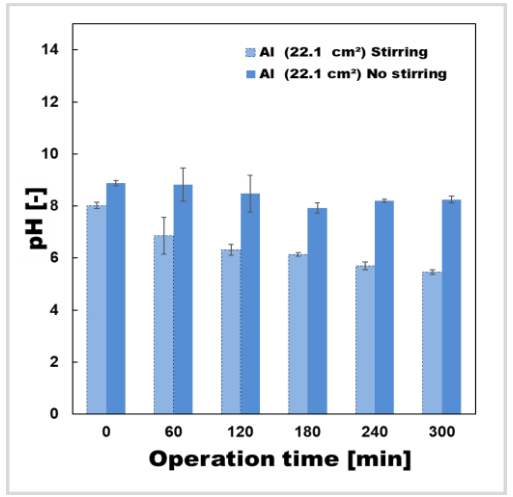
$H_2O \leftrightarrow H_2 + {}^1/_2\, O_2$

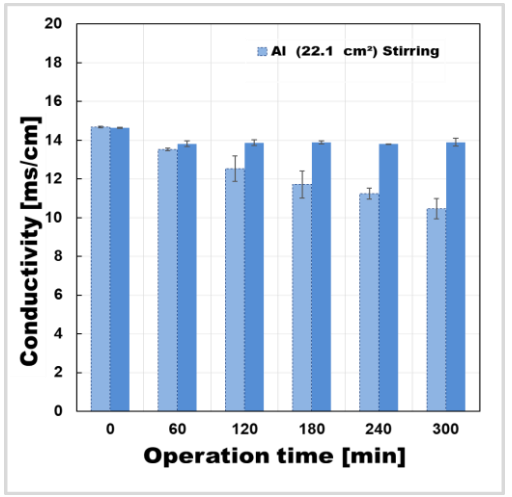


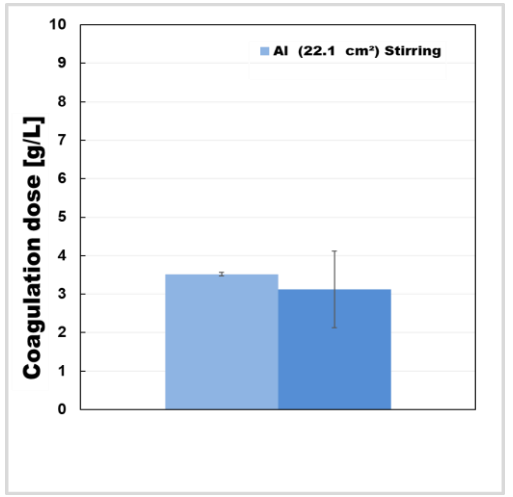
a) Adsorption and Charged Neutralization, b) Sweep Coagulation, c) Froth Flotation

C. RESULTS: Electrocoagulation (**Al**) mechanism – Adsorption and Charged Neutralization

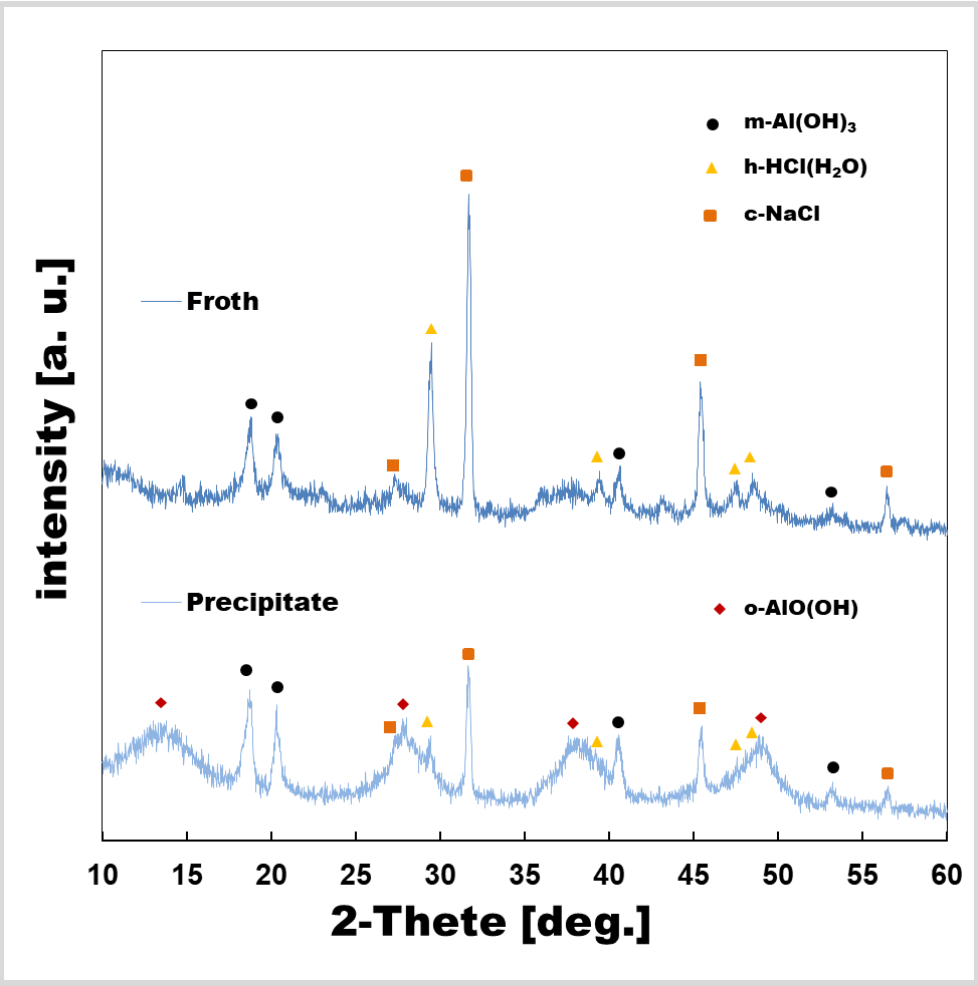




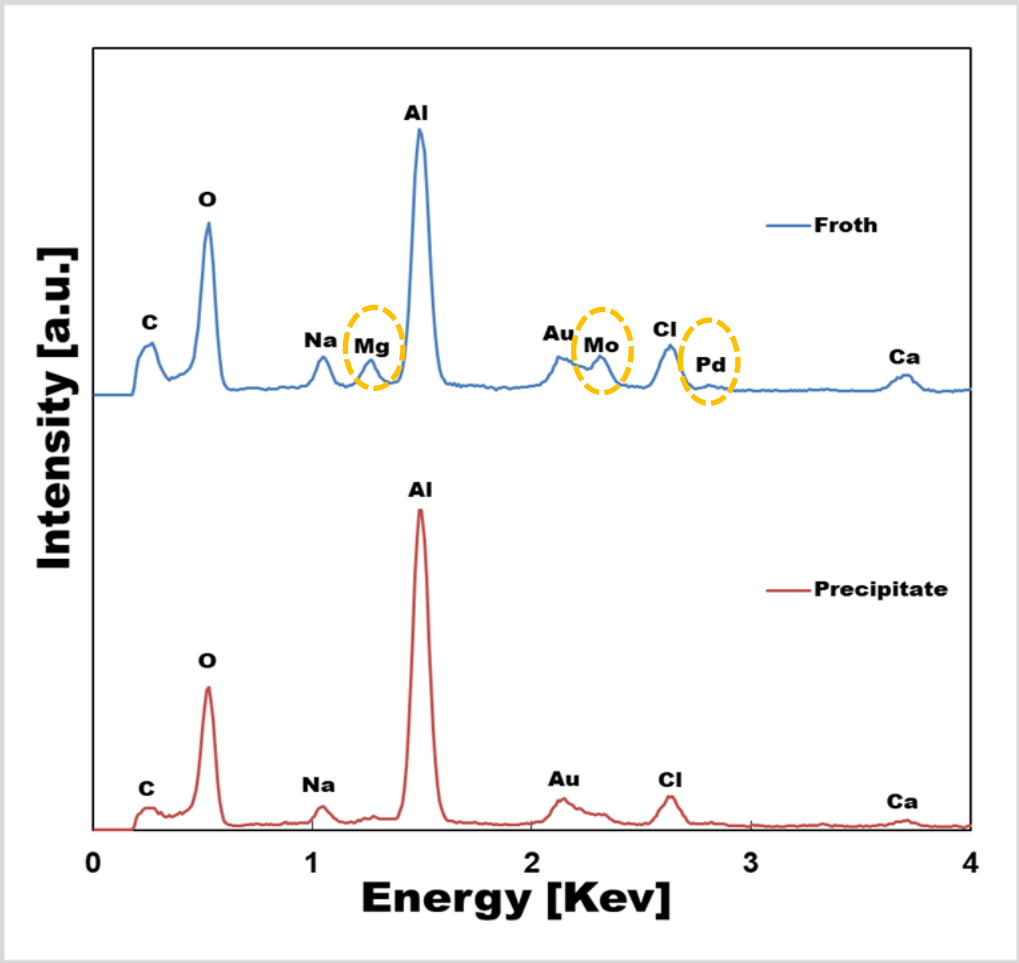




C. RESULTS: Electrocoagulation (**Al**) mechanism – Sweep Coagulation, XRD

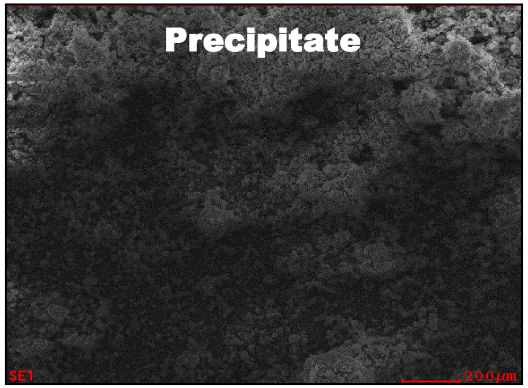


C. RESULTS: Electrocoagulation (**Al**) mechanism – Froth Flotation, SEM/EDX



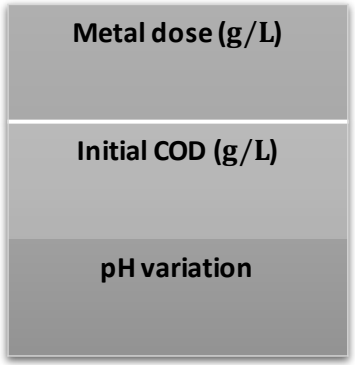
NB: Gold (Au) used as the sputter coating for SEM – EDX

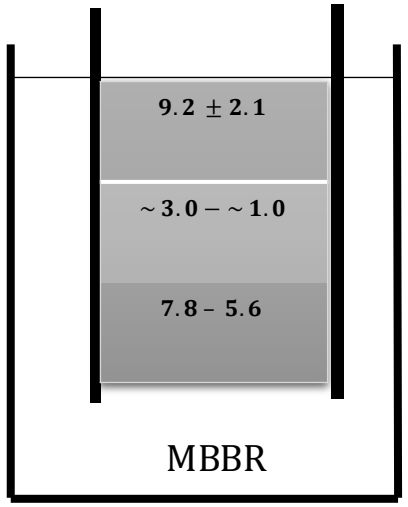
Element	Composition wt. %
C	18.99
O	36.34
Na	2.12
Mg	----
Al	27.27
Mo	----
Cl	3.72
Pd	----
Ca	1.07
Total	100.0



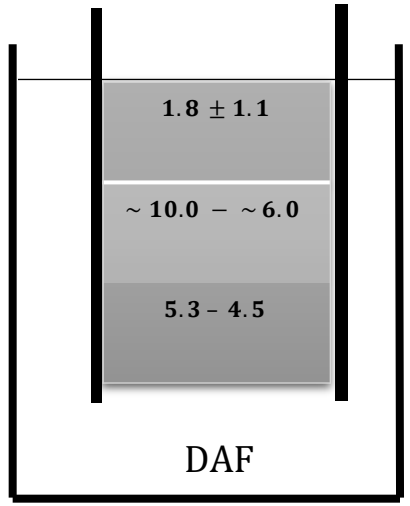
Element	Composition wt. %
C	26.64
O	34.41
Na	2.60
Mg	1.76
Al	16.00
Mo	4.78
Cl	3.70
Pd	0.12
Ca	1.89
Total	100.0

C. RESULTS: **MBBR** vs.**DAF** vs.**Diluted DAF**

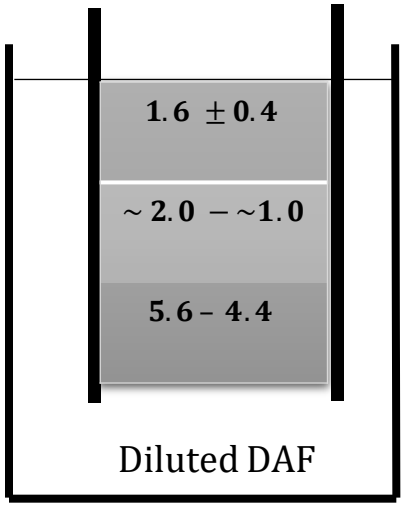




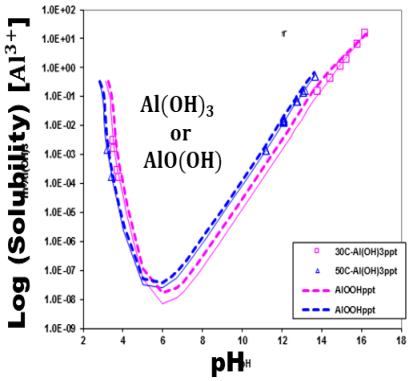
22.2 % > COD Removal



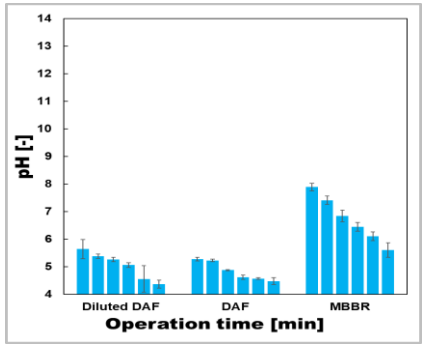
8.4 % > COD Removal



Solubility diagrams for boehmite and gibbsite at 30°C and 50°C.



Lister, T.E. and Glazoff, M.V., 2019. Chemistry and Reactivity of Oxide Films on Aluminum Clad Test Reactor Fuels (No. INL/CON-18-52107-Rev000). Idaho National Lab.(INL), Idaho Falls, ID (United States).



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 ($< 1.0\ \mathrm{cm}$) 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

D. CONCLUDING REMARKS

The Electrocoagulation (Al) removal mechanism is based on three categories:

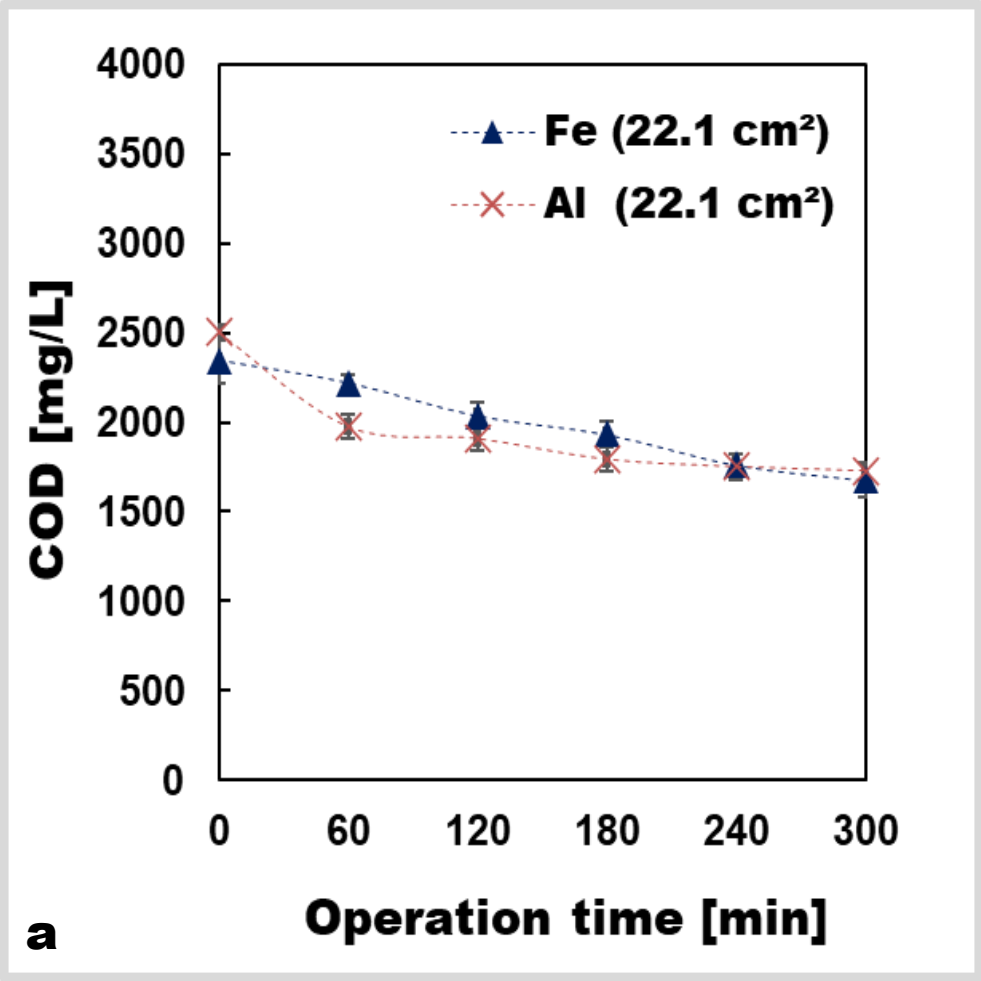
i) **Adsorption and charged neutralization,**

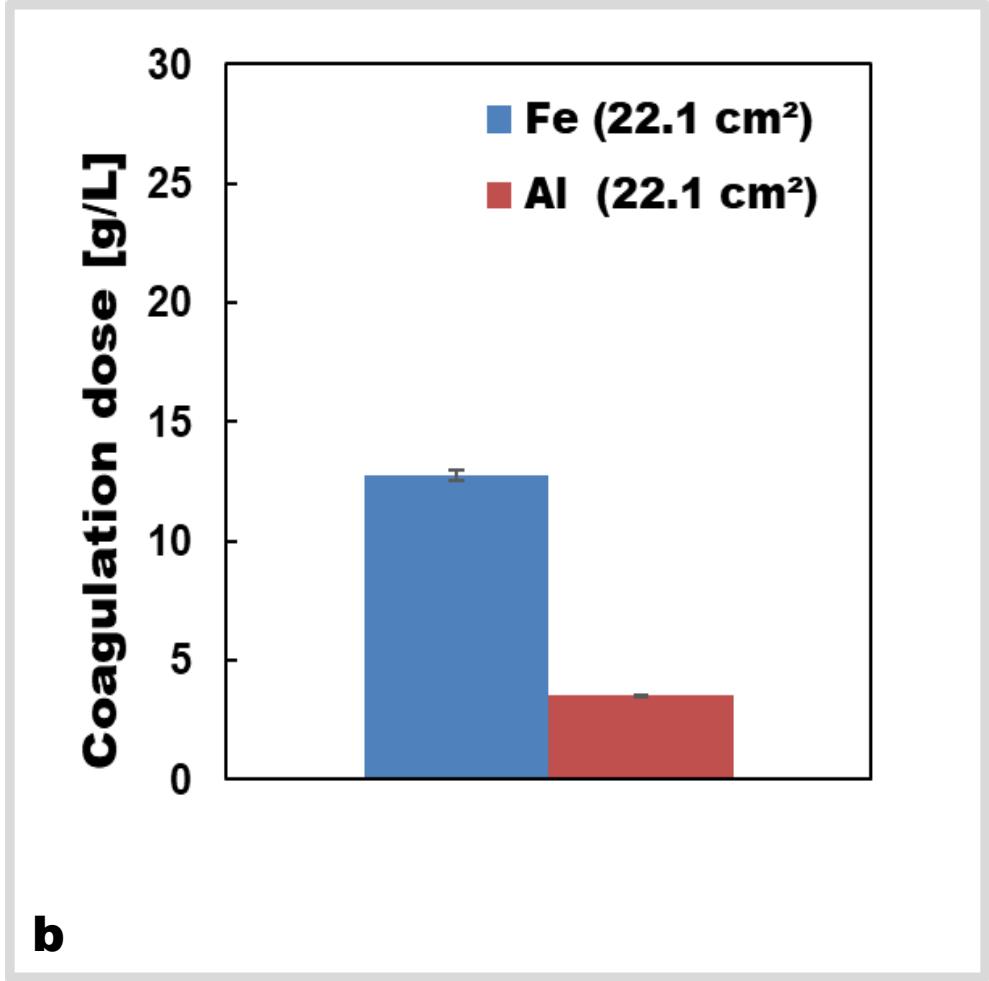
ii) **sweep coagulation**

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**





ACKNOWLEDGMENTS

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Thank you for your attention