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Assessing electrocoagulation (Al and Fe electrodes) and the electro-Fenton for landfill leachate membrane concentrate treatment

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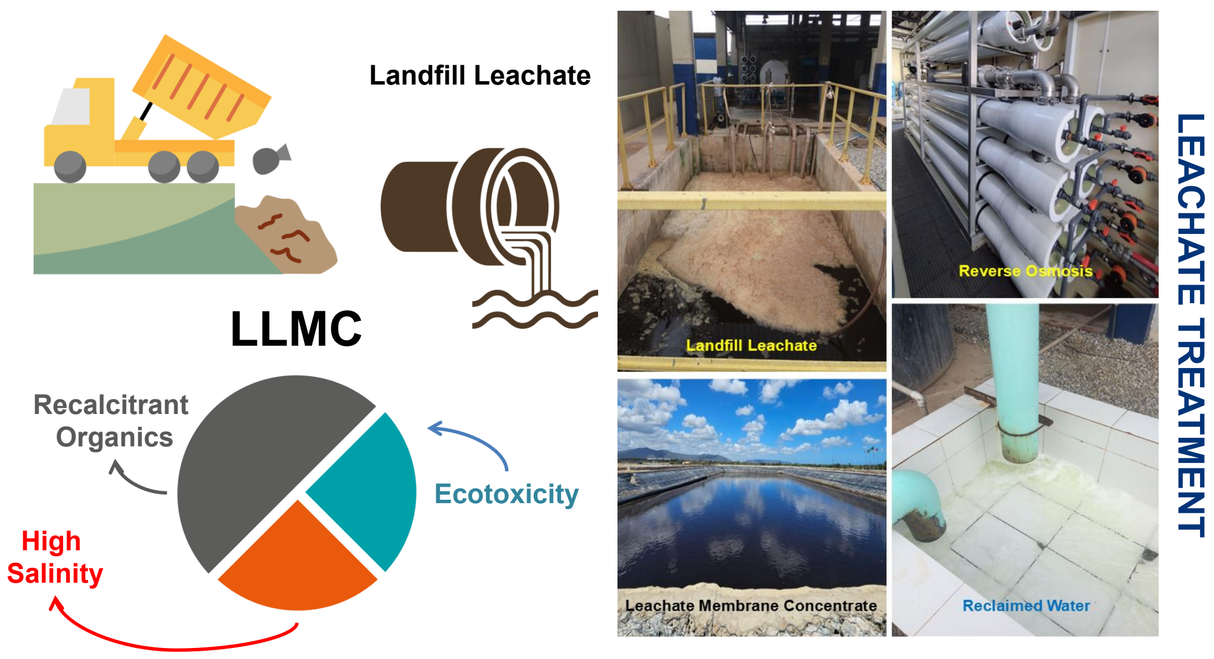
INTRODUCTION & AIM

Landfill Leachate Membrane Concentrate Management (LLMC)



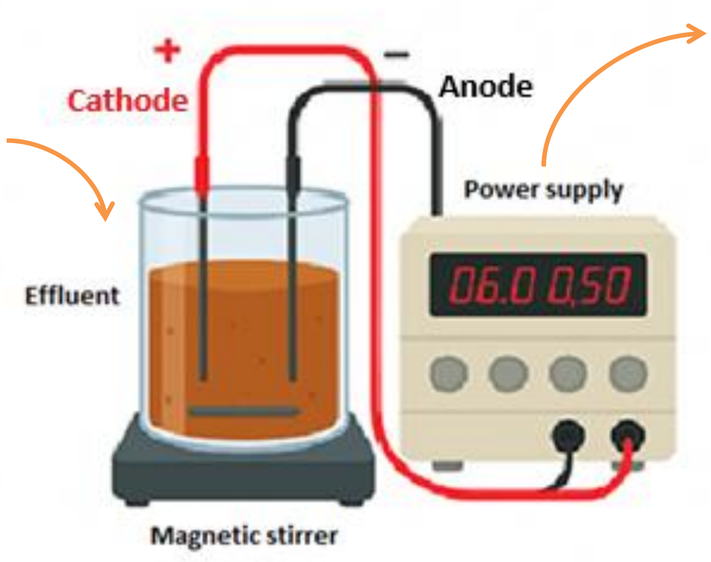
This study investigates the application of electrocoagulation (EC), using aluminum (Al) and iron (Fe) electrodes, as well as the electro-Fenton (EF) process for ultrafiltration (UF)-treated membrane concentrate from landfill leachate treatment.

METHOD

EC and EF tests were conducted using a laboratory-scale apparatus. In each trial, Al and Fe plate electrodes (15 × 3 × 2 cm) were connected in parallel, with a fixed inter-electrode distance of 30 mm. Treatment performance was assessed based on true color, dissolved organic carbon (DOC), and absorbance at 254 nm (Abs254) [1].

Samples were subjected to electrolysis times of 10, 20, 30, and 40 minutes for EC, and up to 60 minutes for EF.

The pH of the samples was adjusted to pH 3 – 5 with H_2SO_4 98% prior to Fe EC and EF tests.



EF: 3.6 Volts, 500 – 550 mA, up to 60 minutes.

Al and Fe EC

Al and Fe plate electrodes (15 × 3 × 2 cm);
6.0 Volts, 400 – 800 mA, up to 40 minutes.

Electro-Fenton (EF)

H_2O_2 (30%), H_2O_2/Fe(II) ratio of 4;
50 mmol H_2O_2 L^{-1};
$Na_2S_2O_3 \cdot 5H_2O$ 32 mmol L^{-1} was added to stop the oxidation reactions.

Figure 1. Electrocoagulation and Electro-Fenton apparatus used in the experimental tests. EC = electrocoagulation. EF = electro-Fenton.

RESULTS & DISCUSSION

UF permeate, i.e., the LLMC-treated sample used in EC and EF oxidation experiments, was characterized as pH = 9.0 – 9.5, conductivity = 17 – 22 mS cm^{-1}, true color = 7825 – 8100 Pt-Co L^{-1}, and Abs254 = 20.2 – 28.1.

Removal of true color and Abs254 in Al and Fe EC and EF:

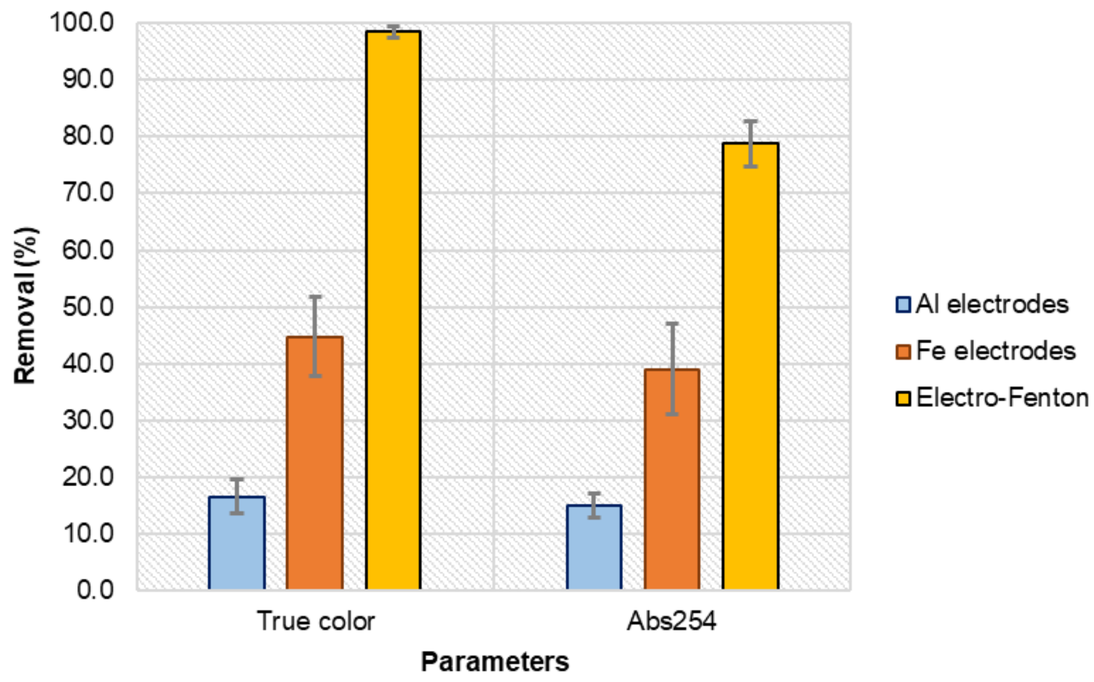


Figure 2. Results of true color and Abs254 removal of Al and Fe EC and electro-Fenton for UF-treated membrane concentrate treatment. Al (pH = 9, 30 minutes, 6.0 volts, and 400 – 800 mA), Fe (pH = 3 – 5, 40 minutes, 6.0 volts, and 400 – 800 mA). Electro-Fenton (pH = 3, 30 minutes, 3.6 volts, and 500 – 550 mA).

Al electrodes, operating at a pH of 9, 400 – 800 mA, and 30 min, demonstrated a promising 18.1±2.8% color and 14.6±1.9% Abs254 removal efficiencies in EC. Furthermore, Al EC facilitated a 24.3±6.7% reduction in DOC. However, it's worth noting that the specific ultraviolet absorbance ($SUVA_{254}$) increased from 0.65±0.09 to 0.80±0.16 L mg^{-1}, indicating an enrichment of recalcitrant organics.

Fe electrodes, while not reaching the treatability performance of previous studies [2, 3], still provided improved outcomes, instilling confidence in the progress of our research. The electro-Fenton technique demonstrated promising treatability results: 98.5±1.0% true color and 78.8±4.0% Abs254.

CONCLUSION

Electrocoagulation and electro-Fenton seem promising for the management of high-salinity streams, like leachate membrane concentrate. Still, practical application drawbacks should be overcome in the laboratory to enable the possible scale-up of the technology, including proper pH control, chemical and energy demands, reactor geometry, and operational conditions.

FUTURE WORK / REFERENCES

Future research will focus on the reactor design and process optimization of EC and electrochemical oxidation methods, considering factors such as reactor geometry/configuration, voltage/current intensity, and operating conditions.

[1] Standard methods for the examination of water and wastewater. 24th ed. Washington, DC: APHA, AWWA, WEF, 2017.
[2] Electrochemical activation of peroxides for treatment of contaminated water with landfill leachate: Efficacy, toxicity and biodegradability evaluation, Chemosphere 279 (2021) 130610. https://doi.org/10.1016/j.chemosphere.2021.130610.
[3] Characterization and electrocoagulative treatment of nanofiltration concentrate of a full-scale landfill leachate treatment plant, Desalination 268 (2011) 158–162. https://doi.org/10.1016/j.desal.2010.10.012.

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