Jonathan Israel Mendez
jonimend@espol.edu.ec
FICT

Angie Nicole Medina
angnmedi@espol.edu.ec
FICT

Priscila Estefanía Valverde
priesval@espol.edu.ec
FICT

Leonardo Antonio Gutiérrez
Leonardo.gutierrezgarces@ugent.be
Ghent University

Comparative Evaluation of Lime Softening vs. Electrocoagulation for the Removal of Ca^{2+}, SO_4^{2-}, and Mn Species in Groundwater

PROBLEMATIC

Groundwater treatment in San Cristóbal, Ecuador, **faces significant challenges due to the presence of hardness, sulfates, and manganese**. These substances negatively impact community health, leading to severe health problems.

CHALLENGES OF THE WATER TREATMENT PLANT IN SAN CRISTOBAL

Inadequate Treatment Train | **Untrained Operators** | **Limited Economic Resources**

OBJECTIVE

Evaluate the electrocoagulation process compared to lime precipitation method to improve water treatment in San Cristóbal, Ecuador, aiming to provide clean water by reducing chemical use and energy requirement.

METHODOLOGY

(1) Field Inspection.

- Water sampling.
- In-situ measurement of quality indicators.

SCAN ME

Fig. 1 Schematic diagram of the water treatment train

(2) Experimentation: Conventional chemical precipitation; using lime and alum, and the advanced electrocoagulation process.

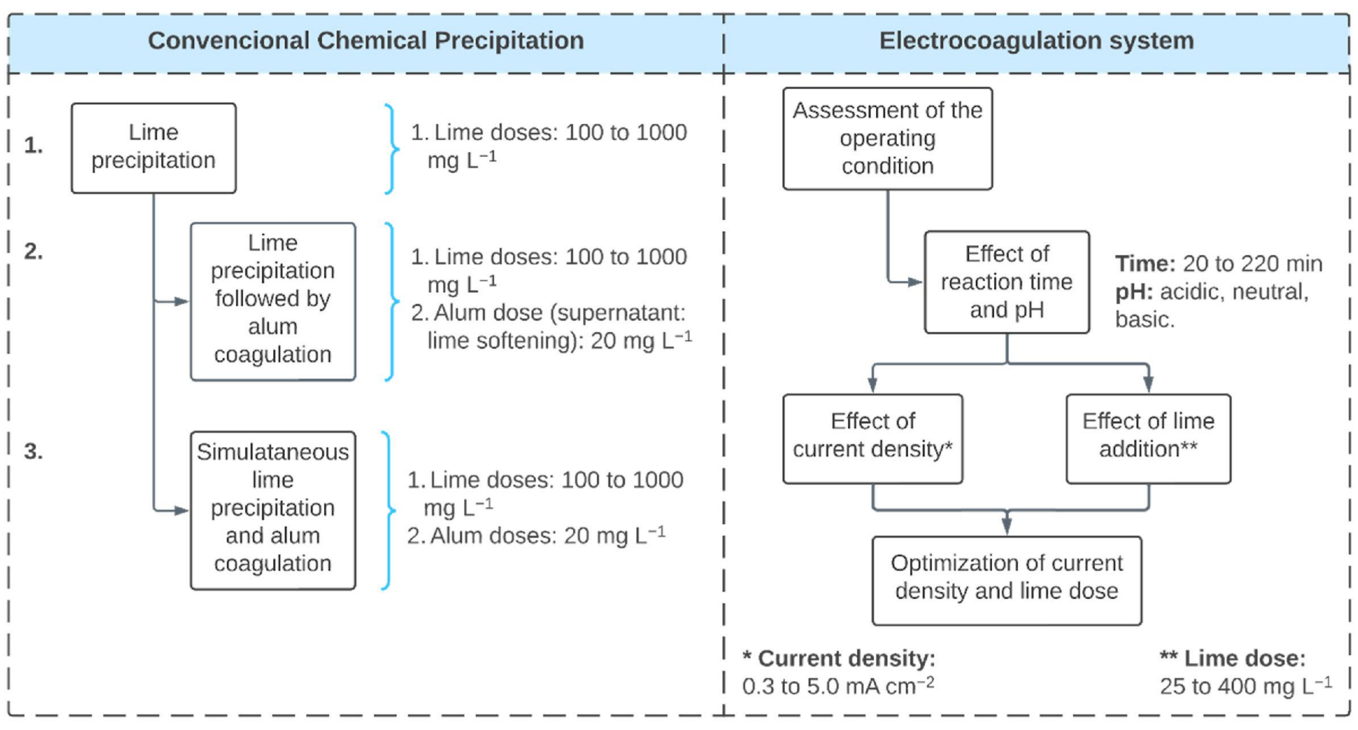

Fig. 2 Diagram of the experimental method.

RESULTS

CHEMICAL PRECIPITATION

Lime precipitation (LP)

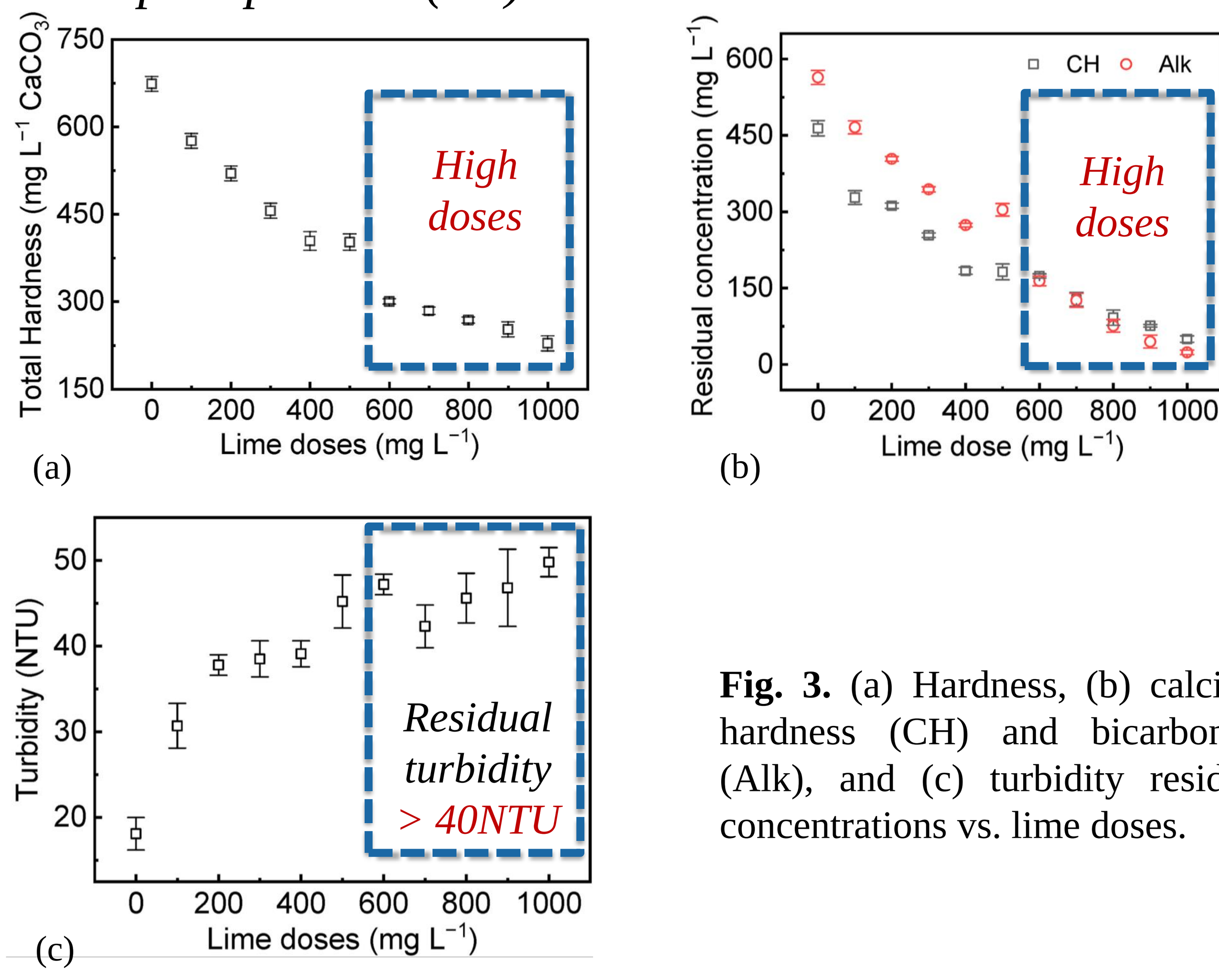

Fig. 3. (a) Hardness, (b) calcium hardness (CH) and bicarbonate (Alk), and (c) turbidity residual concentrations vs. lime doses.

High doses of lime (> 600 mg L^{-1}) needed for water softening **affect water turbidity**.

Lime precipitation followed by alum coagulation (LP-AC)

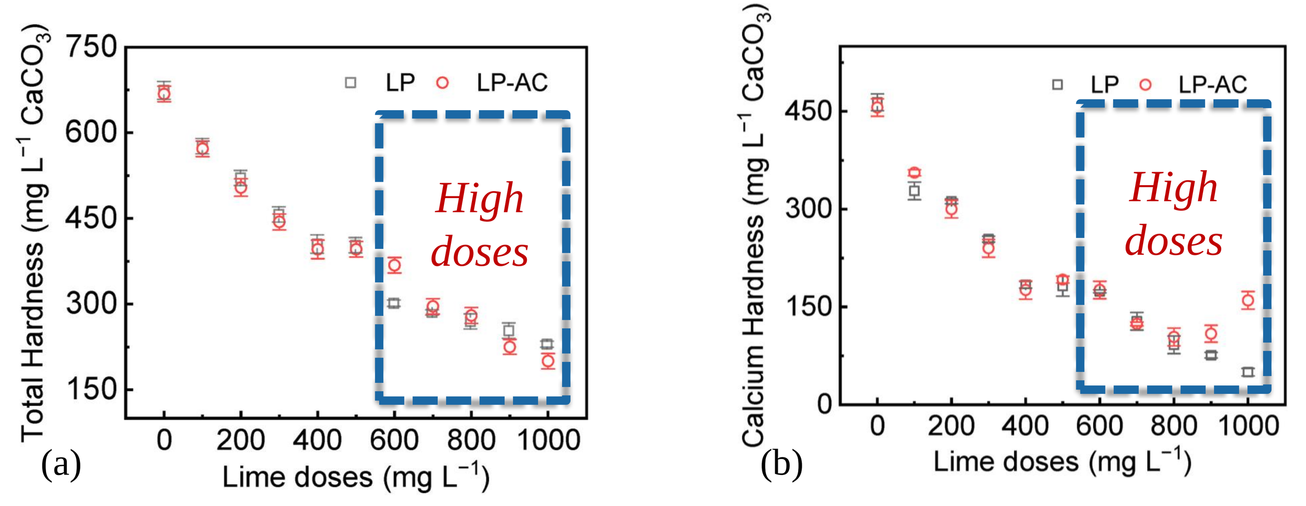

Fig. 4 (a) Hardness and (b) calcium hardness vs. lime doses and an alum dose of 20 mg L^{-1}.

Residual turbidity is ~5NTU, but **deployment requires significant space.**

Lime precipitation and alum coagulation (LP+AC)

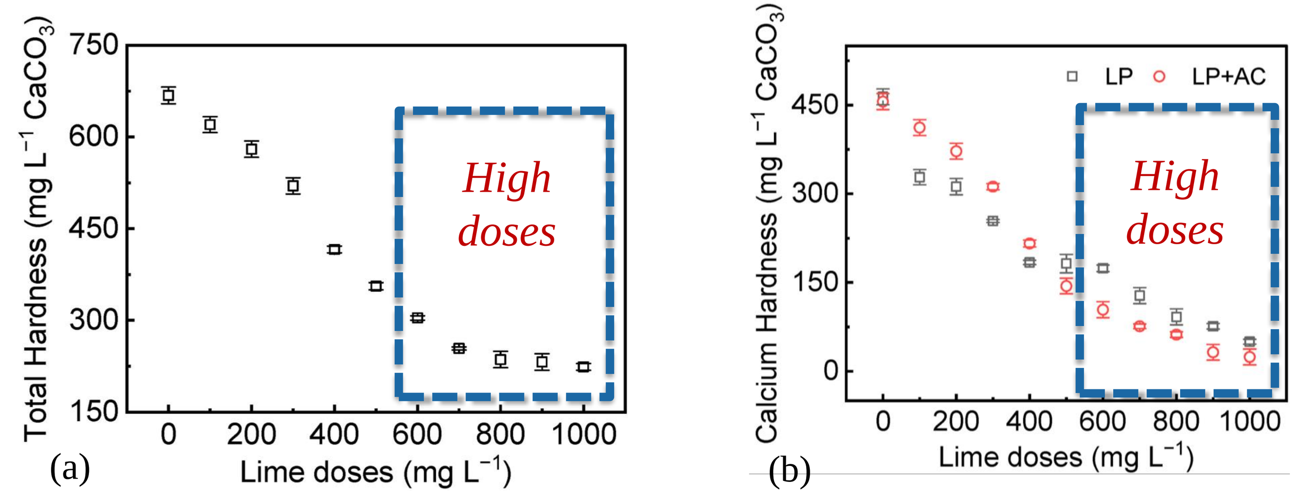

Fig. 5 (a) Hardness and (b) calcium hardness vs. simultaneous lime doses and 20 mg L^{-1} of alum.

Large lime doses achieve hardness < 300 mg L^{-1}.

ELECTROCOAGULATION

Effect of the operating time and pH

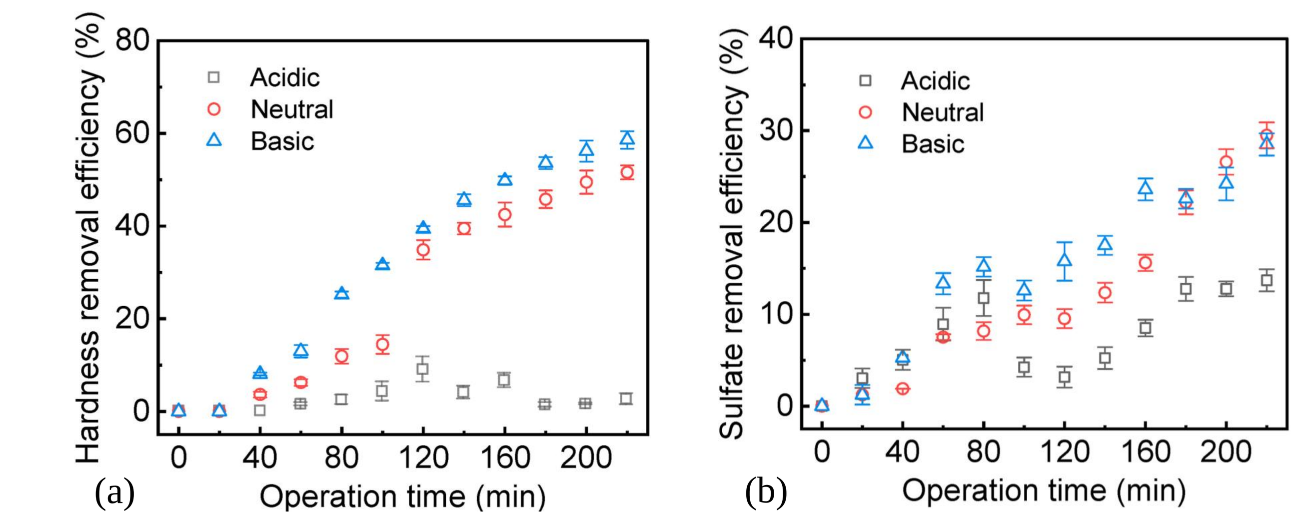

Fig. 6 (a) Hardness and (b) SO_4^{2-} removal efficiencies vs. electrocoagulation operating time in different pH media.

Extended operating time in basic media removes most hardness and sulfate ions. **Optimal:** 80 min in basic media.

Effect of the current density and lime addition

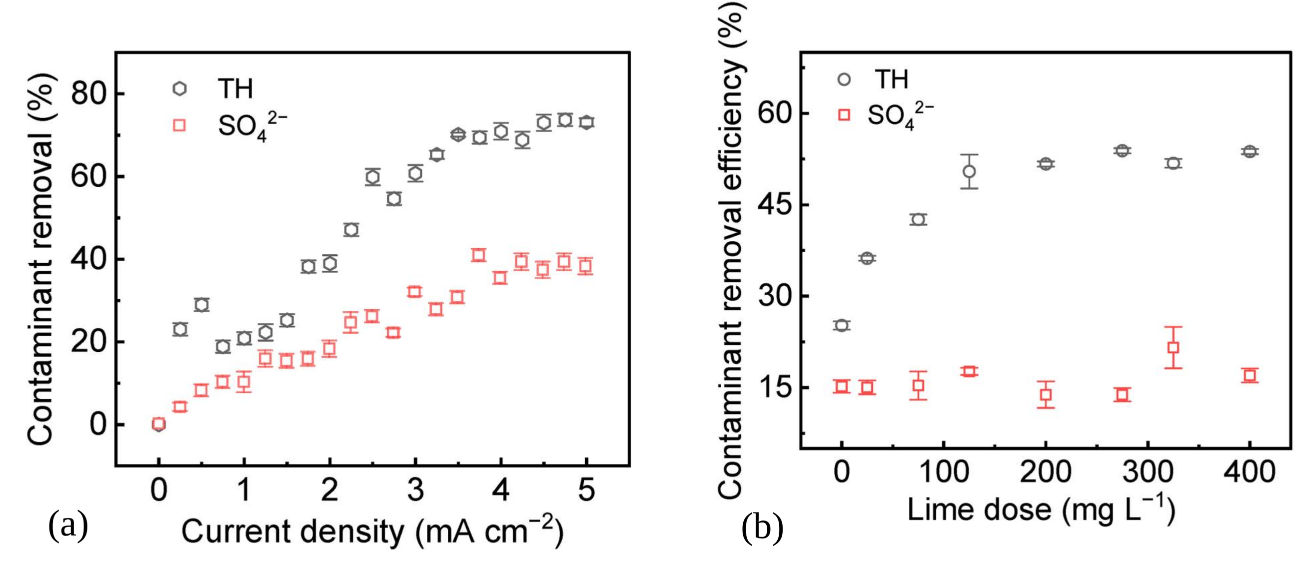

Fig. 7 (a) Hardness (TH) and SO_4^{2-} removal efficiencies vs. current density and (b) vs. lime dose during electrocoagulation.

Prolonged current density and high lime doses remove most hardness and sulfate ions.

Optimization of the current density and lime dose

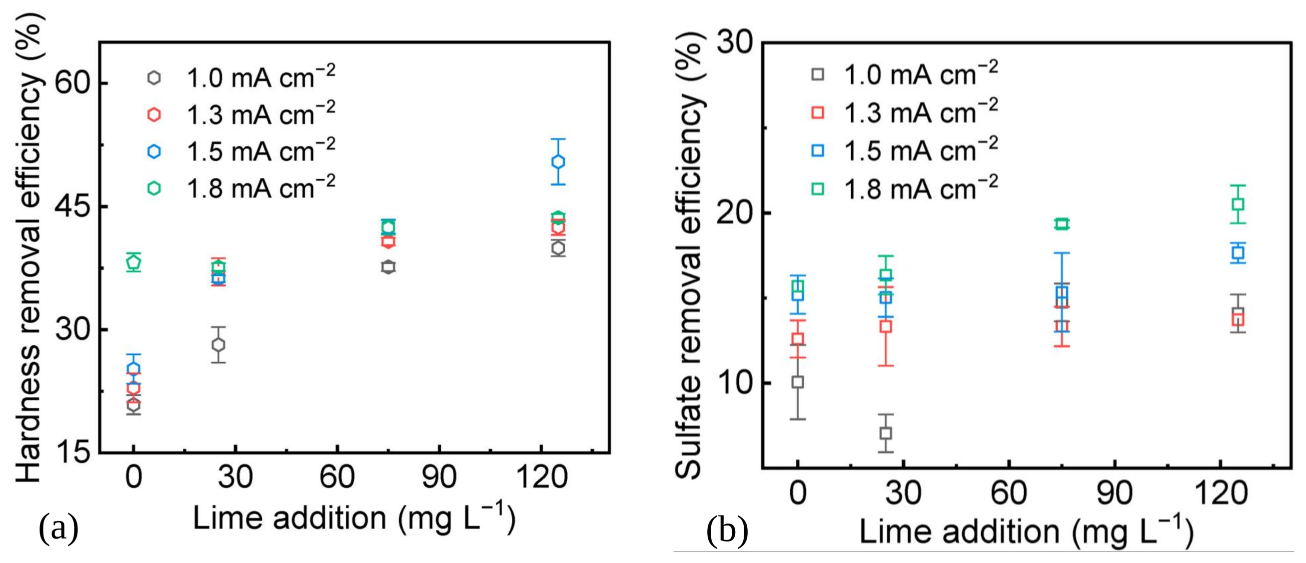

Fig. 8 (a) Hardness (TH) and SO_4^{2-} removal efficiencies vs. lime dose at various current densities.

Optimal conditions are 80 min in basic media, 1.0 mA cm^{-1} current density, and 75 mg L^{-1} lime dose. This removes 38% of Ca^{2+}, 15% SO_4^{2-}, and 65% Mn.

CONCLUSION

This investigation showcases the potential of advanced electrocoagulation for a chemical-minimized, energy-efficient, and sustainable water treatment method.

ACKNOWLEDGEMENT

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