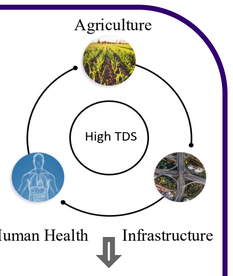
Estimation of Total Dissolved Solids From Solution Conductivity

Rhea Kulkarni, Hunter Alvis, Daven Rikhof, Sophie Sinnett, & Dijia Bao

University of Washington & Membrion, Inc. Seattle, WA

Motivation

This project investigates the relationship between Total Dissolved Solids (TDS) and Electrical Conductivity (EC) in industrial wastewater streams, focusing on:



Semiconductor Wastewater

[1]

Acid Mine Drainage (AMD)

[2]

Battery Manufacturing

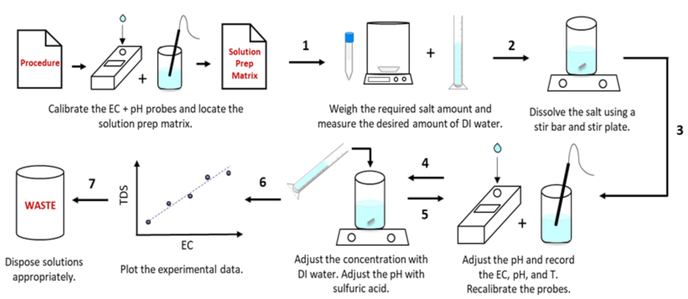
[3]

High TDS levels pose significant risks to human health, agriculture, and infrastructure, meaning efficient measurement and removal methods are crucial.

[4-6]

Methods

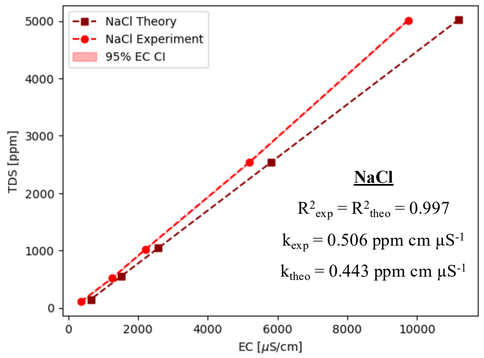
- Tested the electrical conductivity of industrially applicable acidic wastewater streams across concentrations from 100 to 5000 ppm
- Phase 1 experiments
  - NaCl, $CaCl_2$, $MgCl_2$, Na_2SO_4, $CaSO_4$, $MgSO_4$
- Phase 2i experiments combined the phase 1 salts
  - NaCl+$MgSO_4$, $CaCl_2$+Na_2SO_4, and $MgCl_2$+$CaSO_4$
- Phase 2ii experiments added 8 metal salts in isolation to each of the combination salt solutions
  - $FeSO_4$, $CuSO_4$, $ZnSO_4$, LiCl, $FeCl_2$, $CuCl_2$, $ZnCl_2$, Li_2SO_4

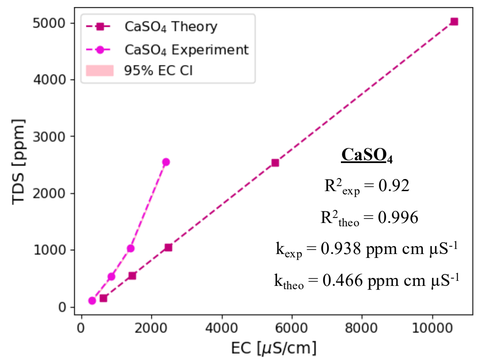


- Assumed linear fit between total dissolved solids and solution conductivity, negligible conductivity contribution from sulfuric acid concentration, and ambient/standard conditions

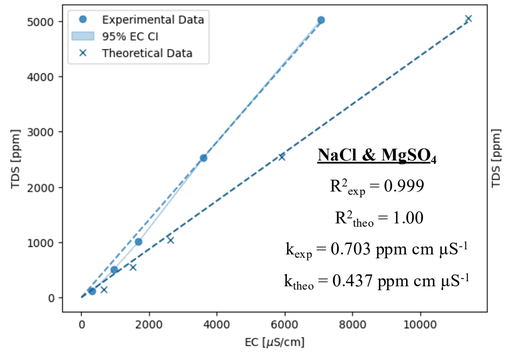
Comparing Theoretical & Experimental Models

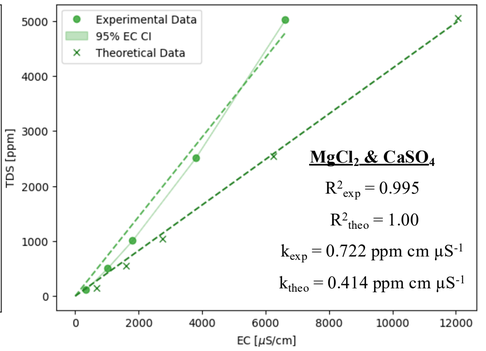
Phase 1: Single Salt Solutions



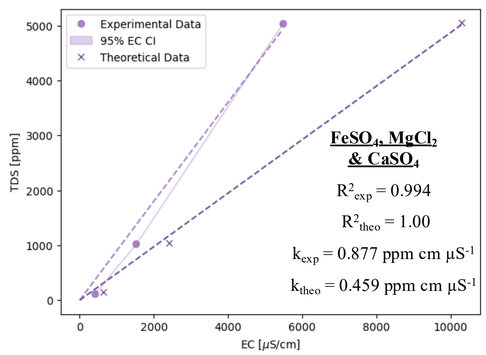


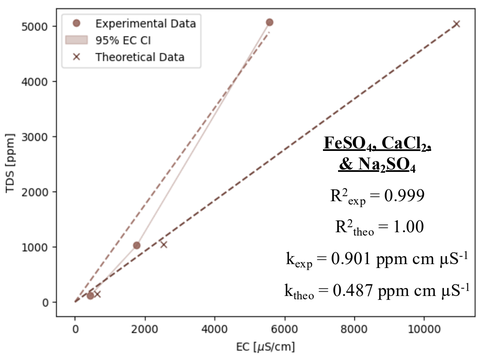
Phase 2i: Two-Salt Solutions





Phase 2ii: Three-Salt Solutions

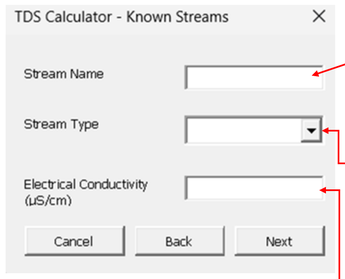




Phase	R^2	MAE range (µS cm^{-1})	k-value range (ppm cm µS^{-1})	
			Theoretical	Experimental
1	> 0.9	[333 – 1750]	[0.36 – 0.52]	[0.47 – 0.94]
2i	> 0.99	[37 – 111]	[0.41 - 0.45]	[0.703 - 0.77]
2ii	> 0.99	[72 – 154]	[0.41 - 0.50]	[0.65 - 0.99]

AquaKlear

- Built-in macros, allowing intuitive user operation
- Multiple stream type selection
- Automatic EC to TDS conversion
- User can input custom molar compositions



User can input custom names, making information easily identifiable

Several preprogrammed stream types are available to users

Based on stream type and EC, AquaKlear is then able to calculate the TDS

Future Work

- Additional data collection in a humidity-controlled environment for redundancy
- Implementing new equipment to minimize effects of random error and instrument bias
- Incorporating equipment with lower measurement uncertainty
- Preparing separate solutions for each concentration to maintain constant volume
- Expanding testing to include the full range of salts seen in industry applications

Citation & Acknowledgements

Thank you to all at both Membrion and UW who helped guide us in developing this software

Thank you Dr. Unnati Rao, Ryan Flores, and Dr. David Beck

[1] *Shulman, M. PFAS in Semiconductor Wastewater: Rising Risks and the Role of Reverse Osmosis. Water Technology Online, May 20, 2025. https://www.watertechonline.com/wastewater/article/55290926/ide-technologies-pfas-in-semiconductor-wastewater-rising-risks-and-the-role-of-reverse-osmosis*
[2] *Earthworks. Acid Mine Drainage. Earthworks, https://earthworks.org/issues/acid-mine-drainage/*
[3] Weinberger, H. The Complicated Process of Recycling Batteries in Washington State. Cascade PBS, September 23, 2022. https://www.cascadepbs.org/environment/2022/09/complicated-process-recycling-batteries-washington-state
[4] *Leichman, A. K. Israeli Agricultural Innovations Will Keep the World Fed. ISRAEL21c, April 24, 2022. https://www.israel21c.org/israeli-agricultural-innovations-will-keep-the-world-fed/*
[5] *Kuehn, G. New Health Sciences Frontiers in Metagenomics and the Human Microbiome. Metabiomics, June 15, 2011. https://www.metabiomics.com/new-health-sciences-frontiers-in-metagenomics-and-the-human-microbiome/*
[6] *Aldrich, A. Z. Addressing America's Failing Infrastructure through Education. UConn Today, February 12, 2019. https://today.uconn.edu/2019/02/gaann/*