COLLEGE OF ENGINEERING

Chemical, Biological, and Environmental Engineering

SUSTAINABLE NUTRIENT-WATER RECOVERY FROM LIQUID ANAEROBIC DIGESTATE VIA A HYBRID ELECTRODIALYSIS (ED) - FORWARD OSMOSIS PROCESS

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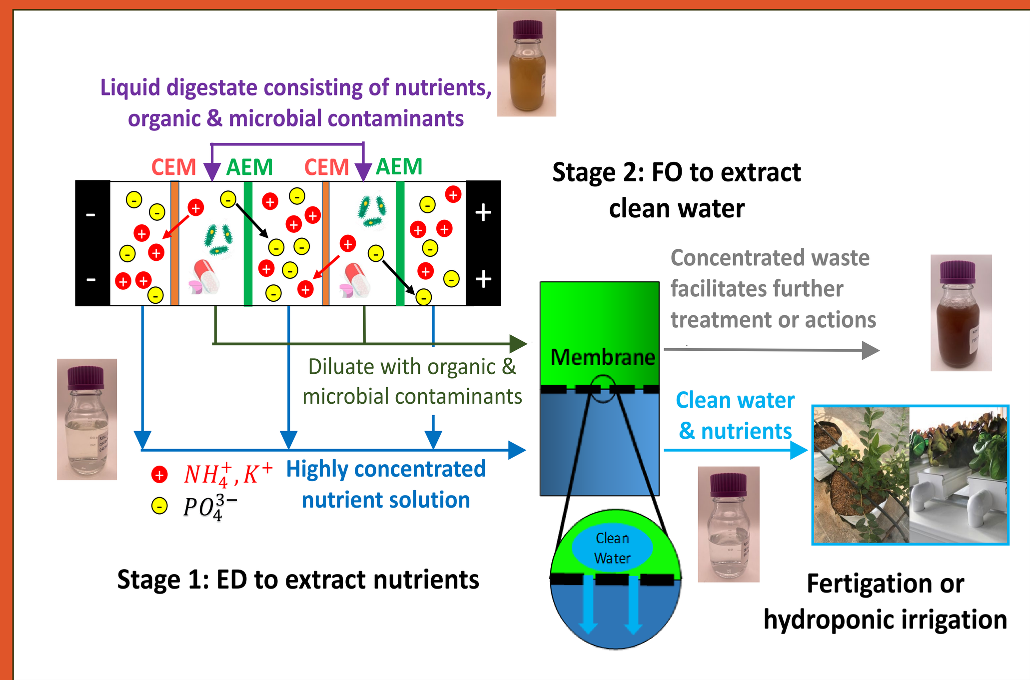
RATIONALE

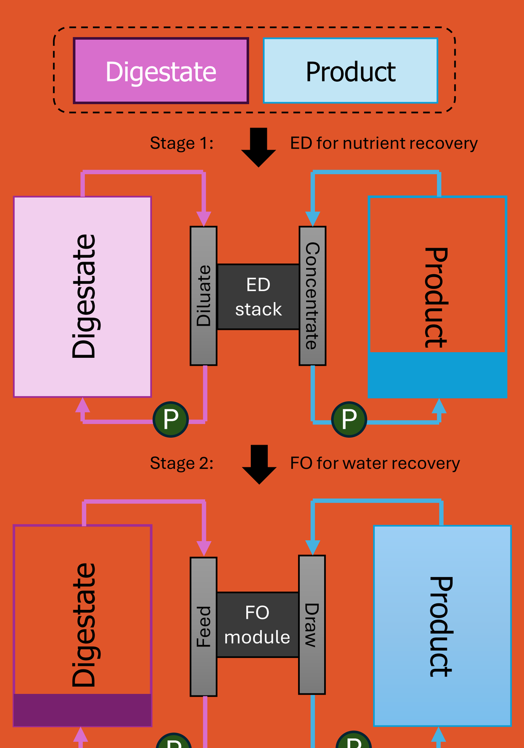


❖ **Water Scarcity and Sustainable Agriculture**: The increasing prevalence of water shortages in agriculture due to climate change and droughts necessitates innovative solutions to secure water resources.

❖ **Nutrient Recovery and Environmental Protection**: Synthetic fertilizers, essential for crop growth, pose significant environmental and economic challenges, including energy-intensive production processes, finite resource availability, and pollution risks.

❖ **Removal of Contaminants and Health Risks**: Direct application of untreated liquid digestate carries risks due to the presence of heavy metals, pathogens, and emerging contaminants.

ADVANTAGES



- **Simultaneous recovery** of clean water and nutrient ions from liquid waste.
- Do not require significant **consumables** (i.e., chemical addition) other than electricity.
- Much **less susceptible** to membrane fouling

PUBLISHED WORK

Sustainable Nutrient Water Recovery by a Hybrid Electrodialysis (ED) - Forward Osmosis (FO) Process for Agricultural Application. Journal of Environmental Chemical Engineering 2024, 12 (2), 112091.

ACKNOWLEDGMENT

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Oregon State University

NOWRA USDA

EXPERIMENTAL DESIGN

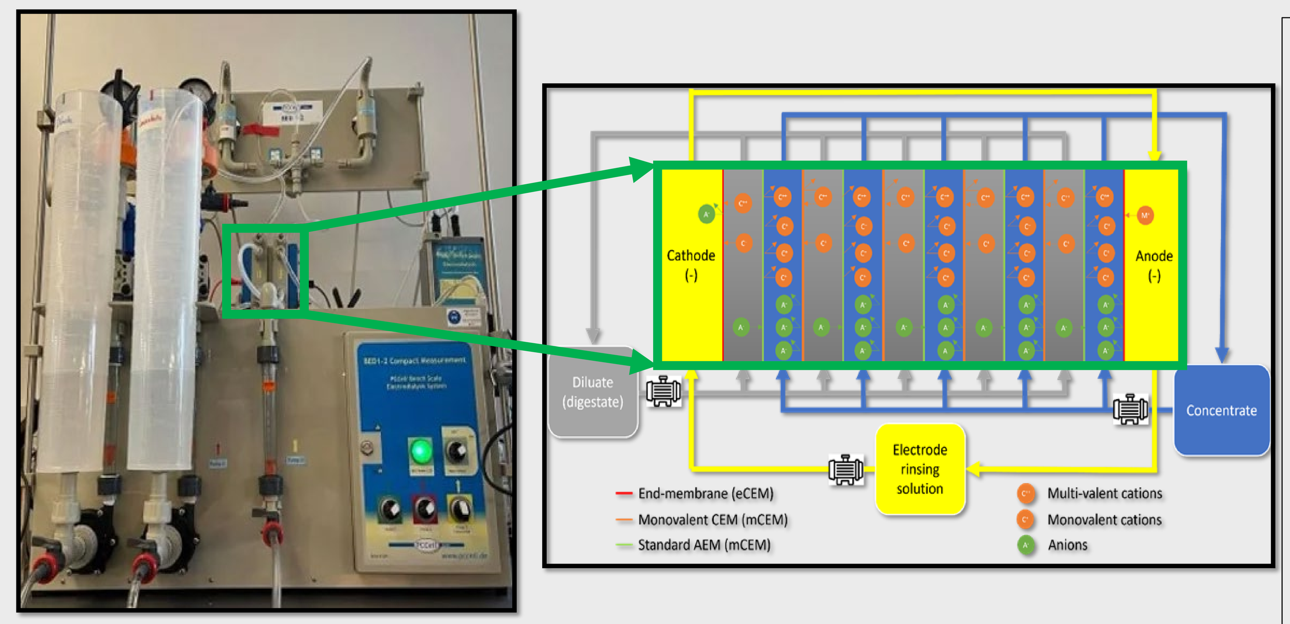


Figure 1. Bench-scale ED testing system

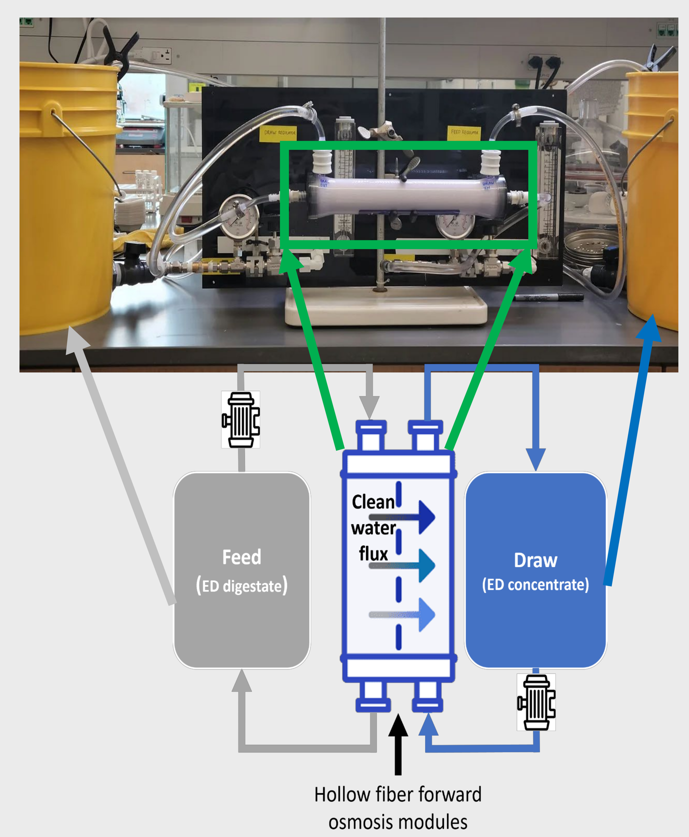
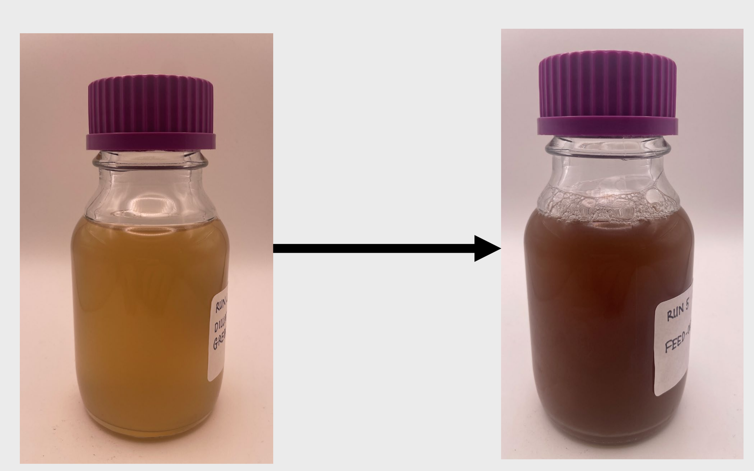
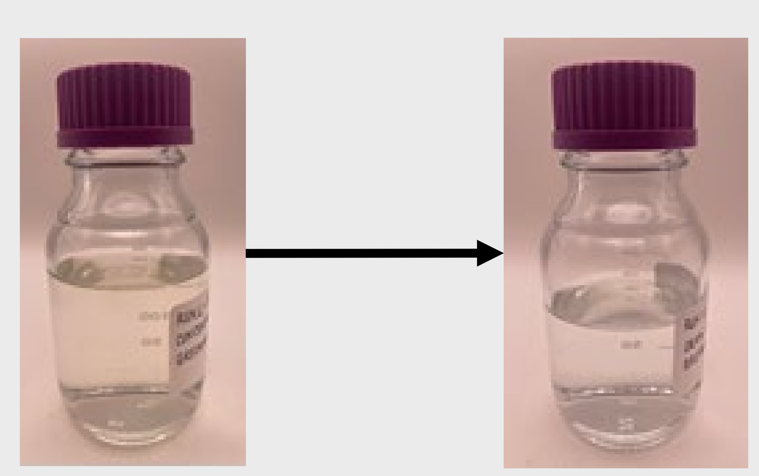


Figure 4. Bench-scale ED testing system



Liquid digestate (6 liters → 1 liters of concentrate)



Recovered product (1 liters primer → 6 liters)

PERFORMANCE EVALUATION

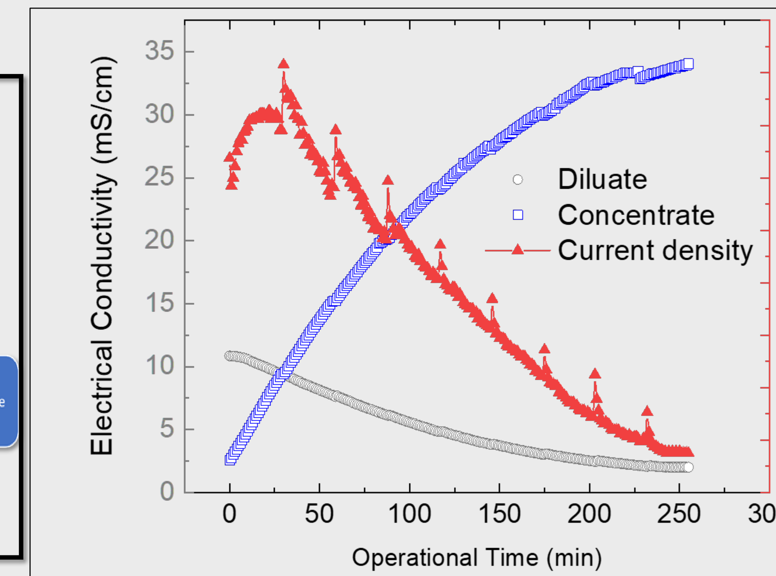


Figure 2. Electrical conductivity and current density of the diluate and concentrate streams over time.

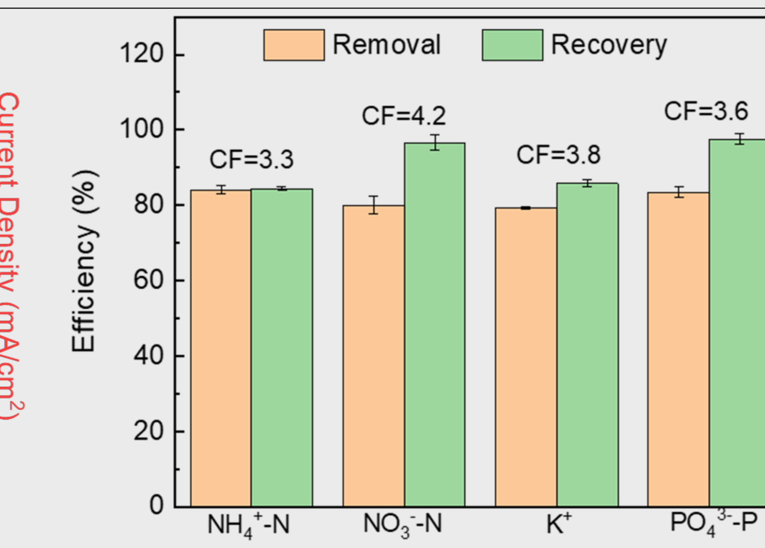


Figure 3. Removal and recovery efficiency and concentration factor (CF) of the ED treatment

- **Charged constituents**, mostly inorganic salts, **migrated from the diluate to concentrate compartment.**
- **Current density (red line) decreased gradually overtime**, mostly attributed to membrane fouling and bulk conductivity decline of the diluate compartment.
- **Majority of the migrated ions** was recovered in the concentrate compartment at the end of the ED process, with recovery efficiency ranging above 90%.

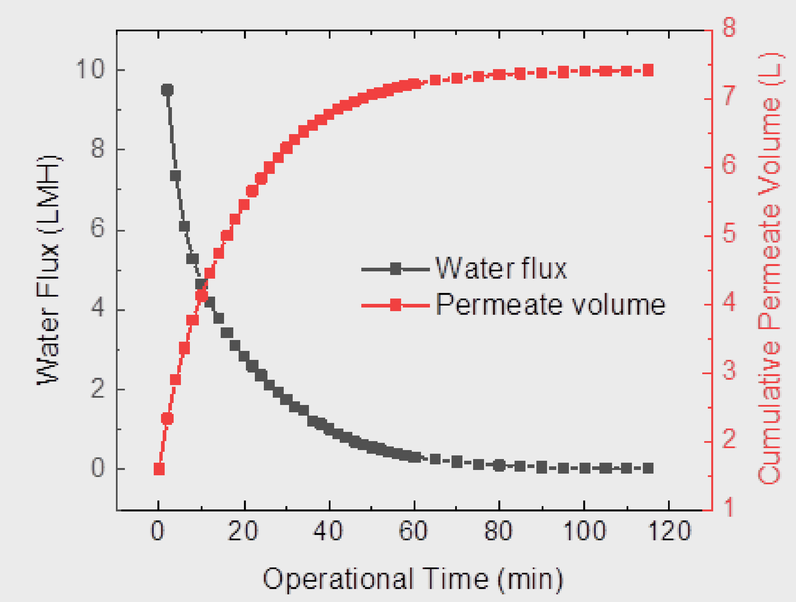


Figure 5. Water flux and accumulated permeate volume over time during FO operation

- **Ion accumulation** in the concentrate compartment creates **osmotic pressure difference** between the two solution → water is drawn from the feed to draw compartment.

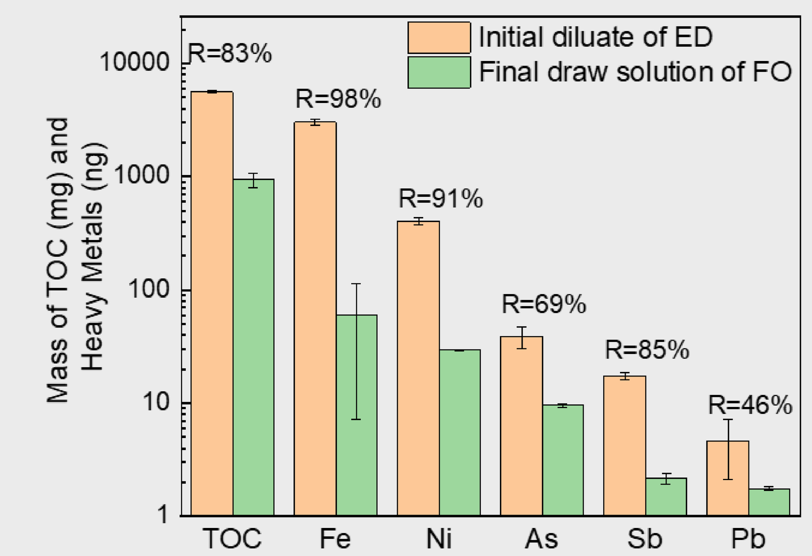


Figure 6. Average mass of TOC and heavy metals in the initial diluate before ED and final draw solution after FO

- ED membrane stack utilized **monovalent cation exchange membrane**, thus only extracting nutrients (ammonium and potassium ions) along with sodium and **rejecting metal ions**.
- Majority of **dissolved organic matter was retained (83%)** in the concentrated digestate at the end of the process.

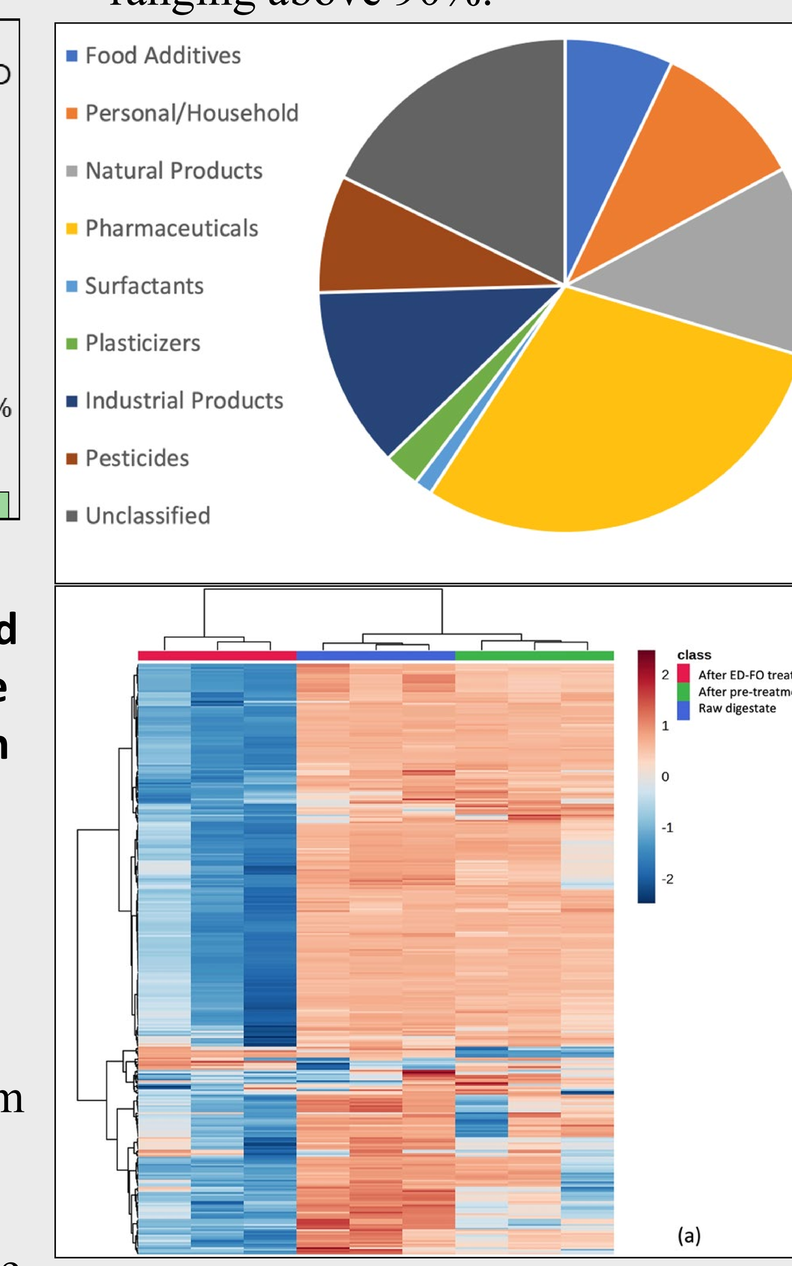


Figure 7. Occurrence and intensity of 333 annotated compounds in raw, pretreated and ED-FO treated water samples

→ **RETAINED EMERGING CONTAMINANTS**

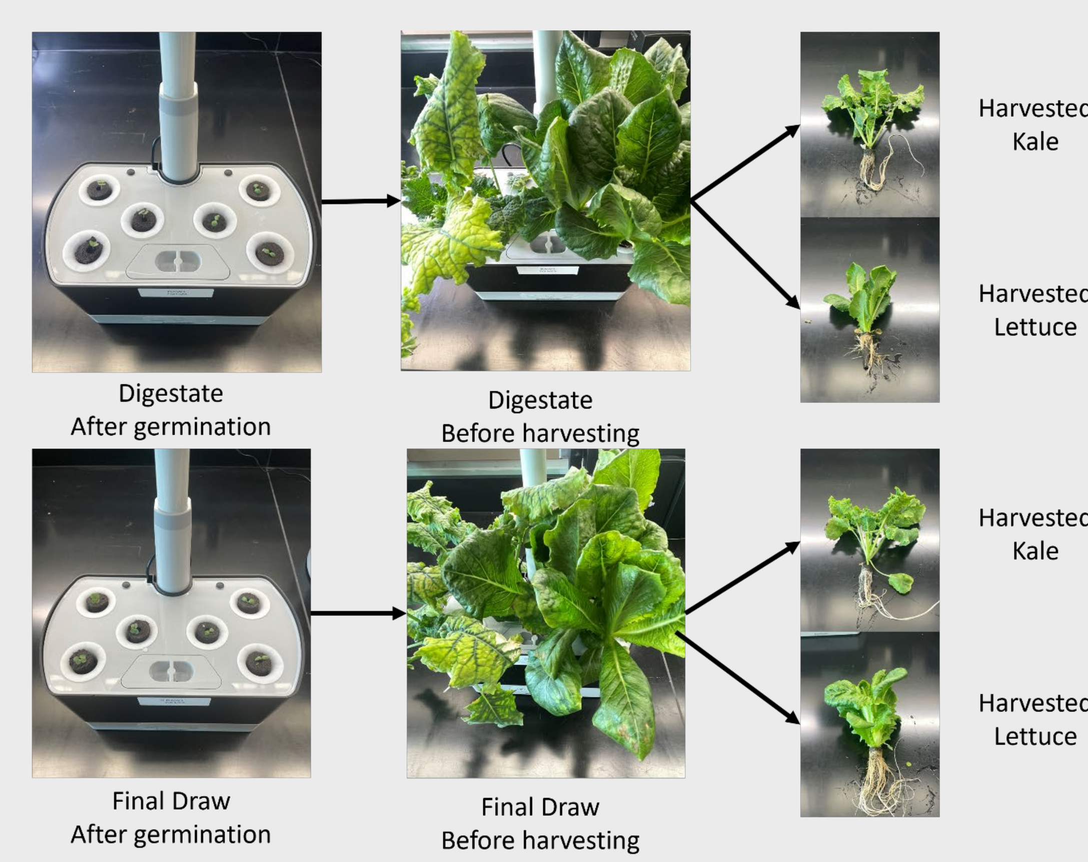
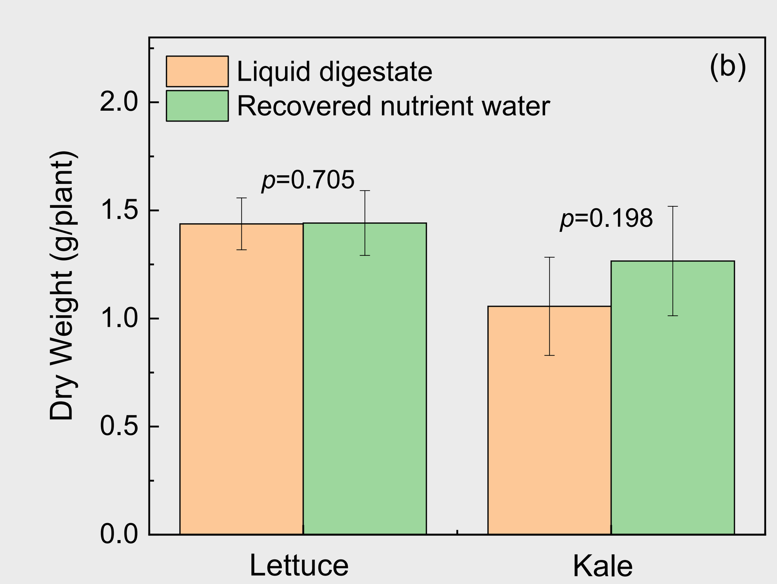


Figure 8. Hydroponic Growth of Lettuce and Kale



- No difference in the fresh or dry weights of plants grown with liquid digestate or nutrient water recovered via ED-FO treatment, suggesting feasibility as **substitute for synthetic fertilizers**