

ELECTROCHEMICAL REDUCTION OF NITRATES FOR ALGAL GROWTH



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INTRODUCTION

Nitrate contamination in greywater from household sources degrades water quality and promotes harmful algal blooms posing a threat to freshwater sources across the globe. Electrochemical nitrate reduction offers a solution by converting nitrates into more bioavailable ammonia, which can be used to cultivate *Chlorella vulgaris* for biofertilizer applications. This microalga is rich in amino acids, growth hormones, microelements and essential vitamins that can enhance plant growth with a reduced need of chemical fertilizers.¹

RESEARCH OBJECTIVE

This study explores the influence of nitrogen species produced through electrochemical treatment on algal growth and nitrogen uptake.

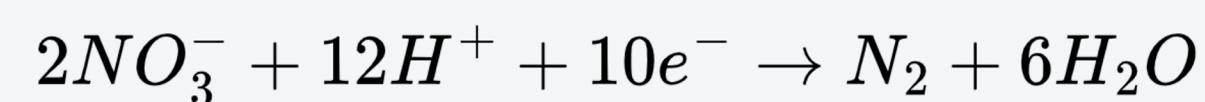
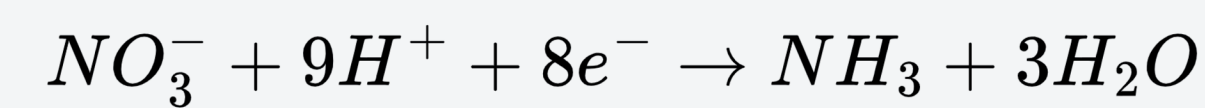
METHODOLOGY: GREYWATER NITRATE REDUCTION

- The electrochemical experiments were performed in a batch reactor equipped with a copper foam cathode (dimensions: 1.5 cm × 1.5 cm, surface area: 2.25 cm²) and a dimensionally stable anode. Electrodes were spaced 1 cm apart in a 250 mL of artificial greywater solution.

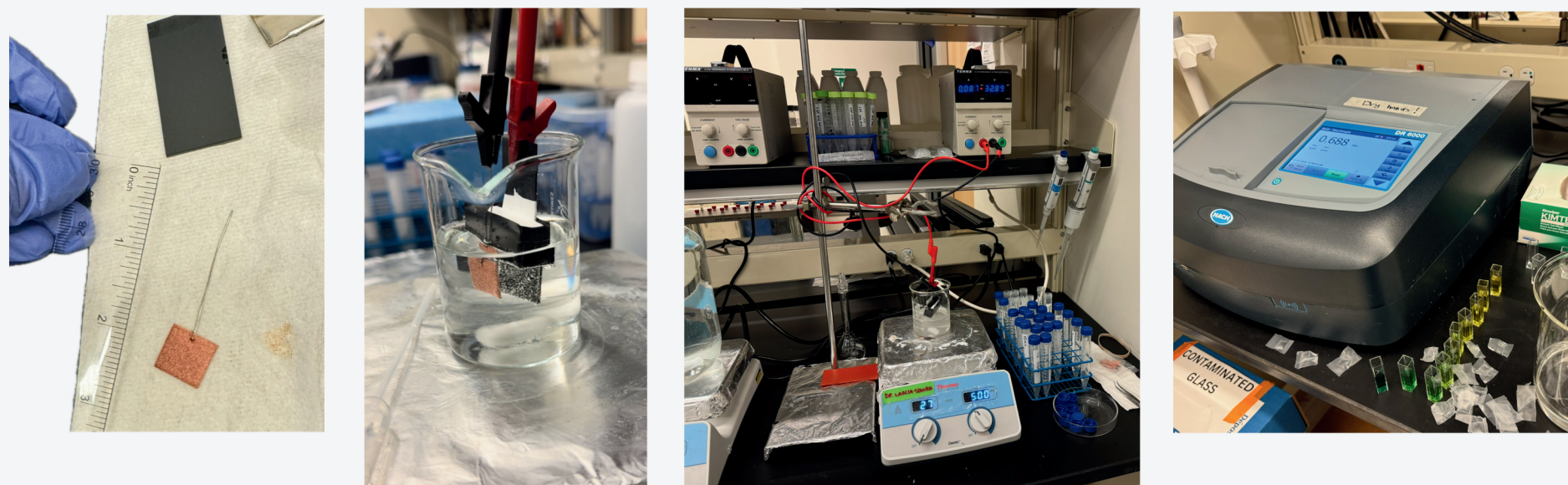
- Experiments were run under galvanostatic conditions of 0.8 A for 120 minutes, with continuous stirring (500 rpm) to mitigate concentration polarization and improve mass transport to the cathode surface.

- Samples collected every 30 minutes for analysis. Nitrate, nitrite, and ammonia concentrations were measured using uv-vis spectroscopy. Nitrate conversion efficiency and ammonia selectivity were calculated to evaluate electrode performance.

The major overall reactions include:



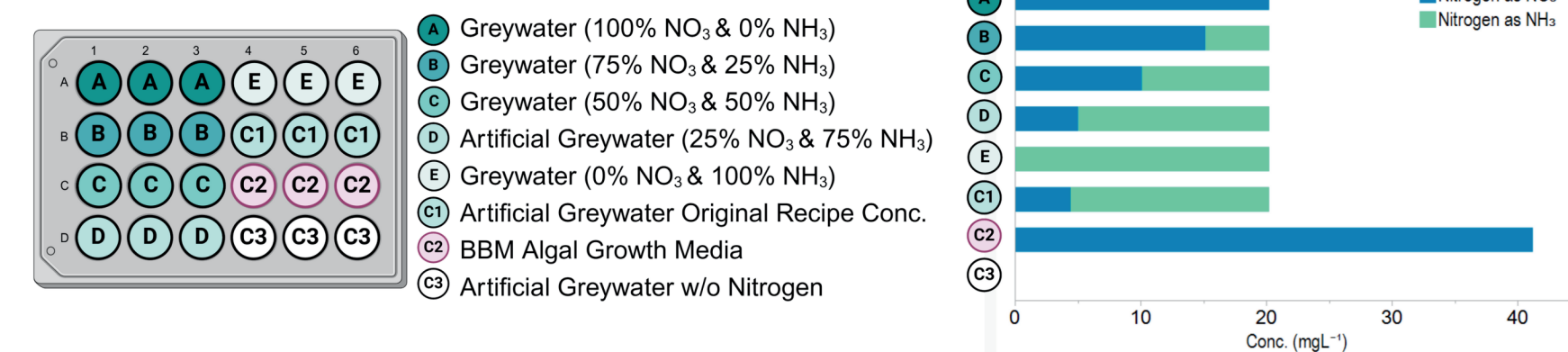
- Copper foam electrode is cut, sonicated in acetone, & cleaned with HCl
- Cu & DSA electrodes are placed in the artificial greywater solution
- Experiment run at 0.09 A, samples taken at T= 0, 15, 30, 60, 90, & 120 min
- Color reagents are used to detect NO₃⁻, NO₂⁻, & NH₃ using UV-vis



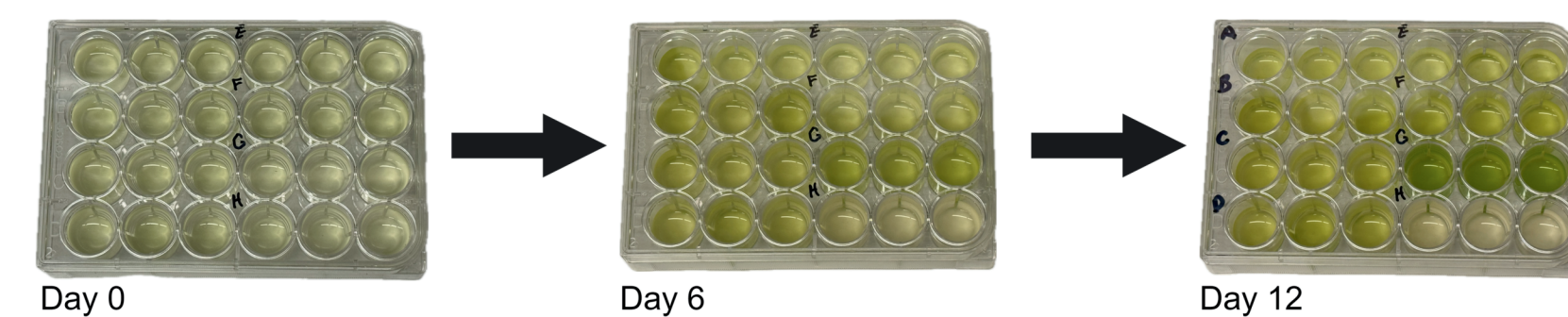
METHODOLOGY: C. VULGARIS GROWTH & QUANTIFICATION

WELL PLATE LAYOUT

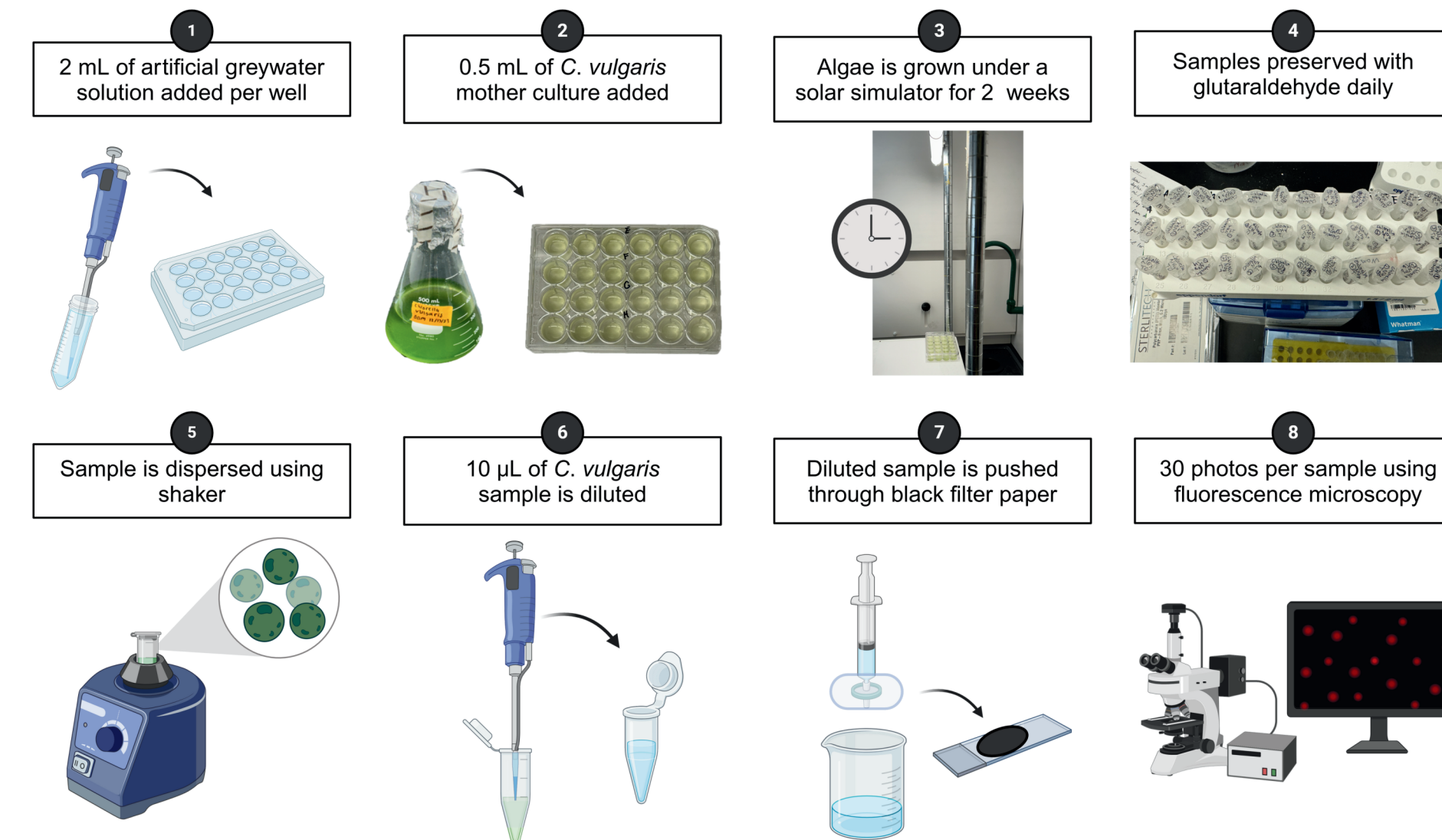
Experiments used manually added ammonia and nitrates in the greywater solution to assess algal growth at specific N- ratios.



Growth of *C. vulgaris*

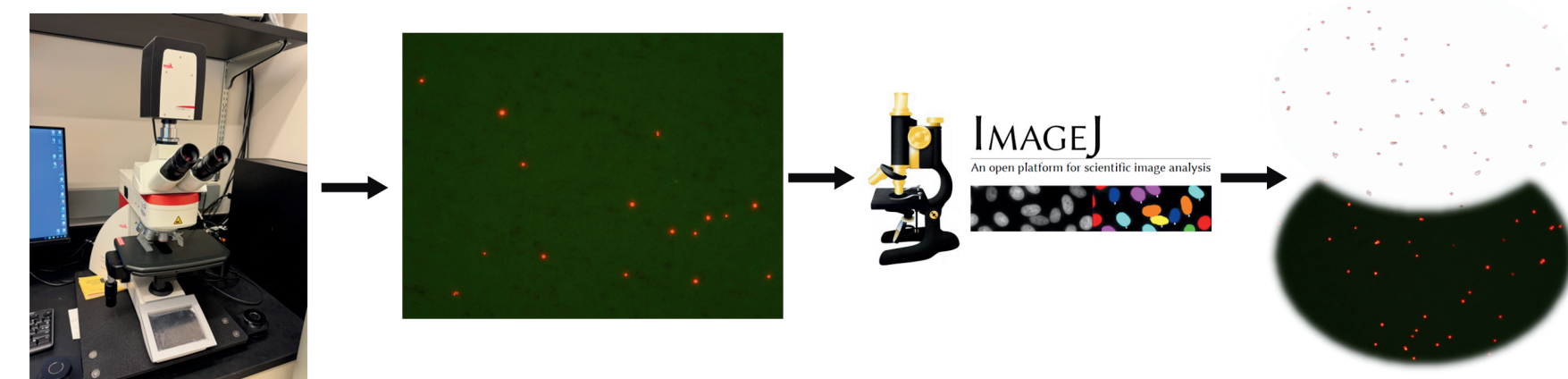


CELL COUNTING



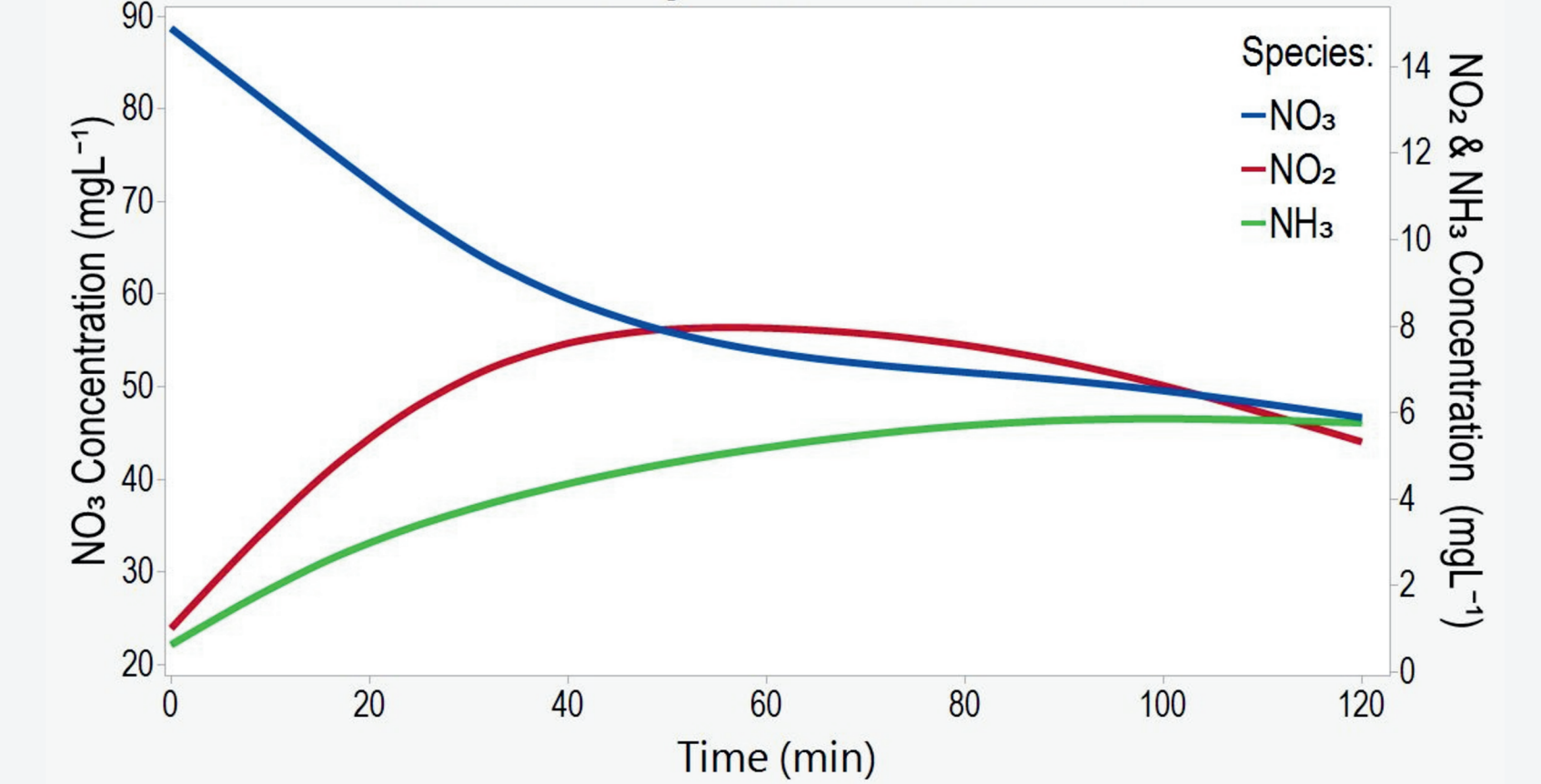
FLUORESCENCE MICROSCOPY

Images were processed & counted using imageJ software.



NITRATE REDUCTION

Artificial Greywater NO₃ Reduction



KEY METRICS

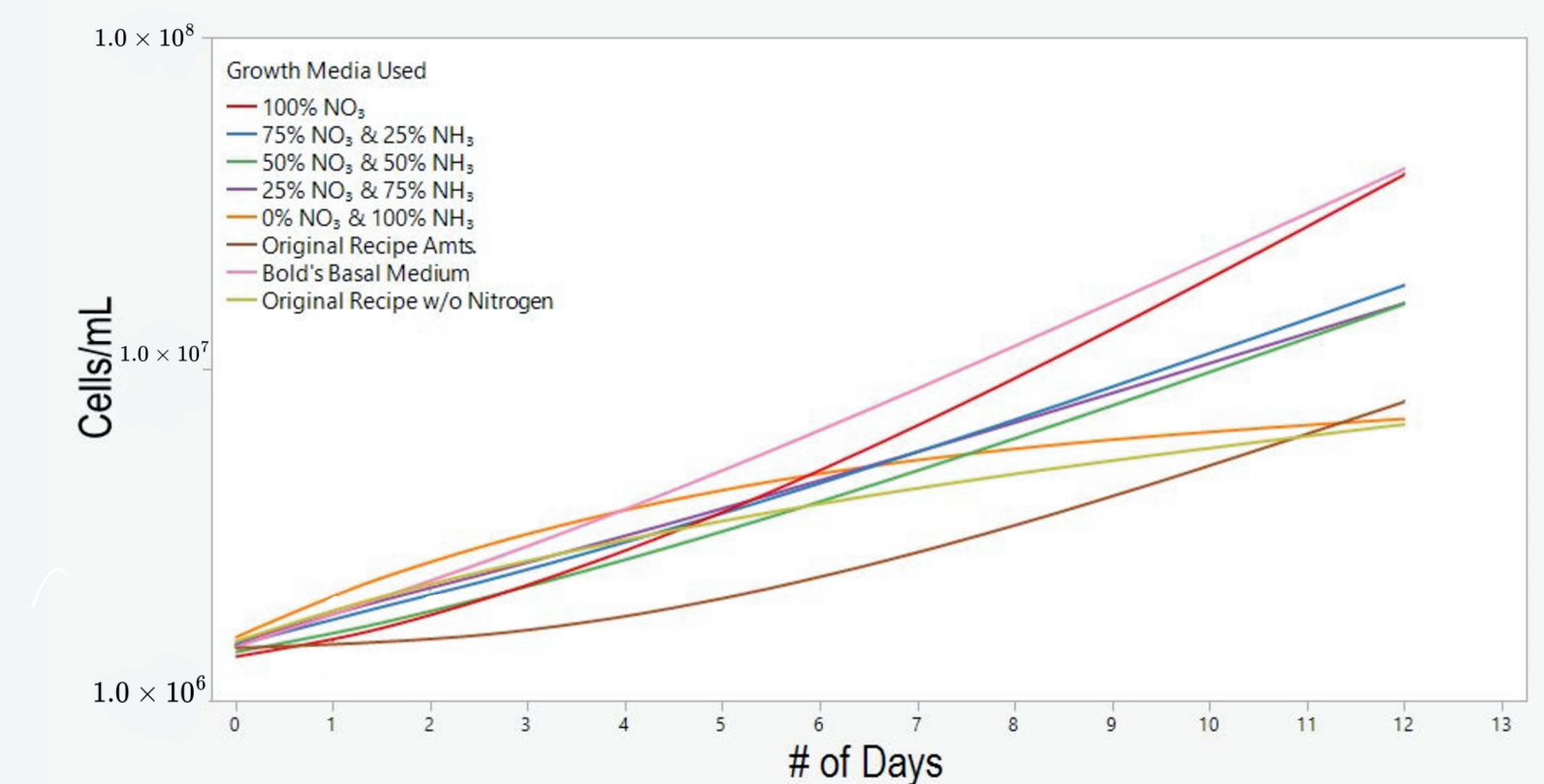
Nitrate conversion (%) = 47.9%

Selectivity towards ammonia (%) = 48.5%

OUTCOMES

The presence of organic matter and other contaminants can lead to fouling of the copper foam cathode, blocking active sites on the electrode and lowering overall efficiency of the nitrate reduction process.²

CELL COUNTING DATA



OUTCOMES

- C. vulgaris* experienced ammonia toxicity in greywater with 75% and 100% ammonia concentrations, showing growth curves similar to nitrogen-free conditions.

- Despite ammonia being energetically favorable for uptake, biomass production did not improve compared to nitrates in this study.¹

REFERENCES

- Lachmann, S. C., Mettler-Altmann, T., Wacker, A., & Spijkerman, E. (2019). Nitrate or ammonium: Influences of nitrogen source on the physiology of a green alga. *Ecology and Evolution*, 9(3), 1070–1082. <https://doi.org/10.1002/ece3.4790>
- Cerrón-Calle, G. A., Fajardo, A. S., Sánchez-Sánchez, C. M., & García-Segura, S. (2022). Highly reactive Cu-Pt bimetallic 3D-electrocatalyst for selective nitrate reduction to ammonia. *Applied Catalysis B: Environmental*, 302, 120844. <https://doi.org/10.1016/j.apcatb.2021.120844>