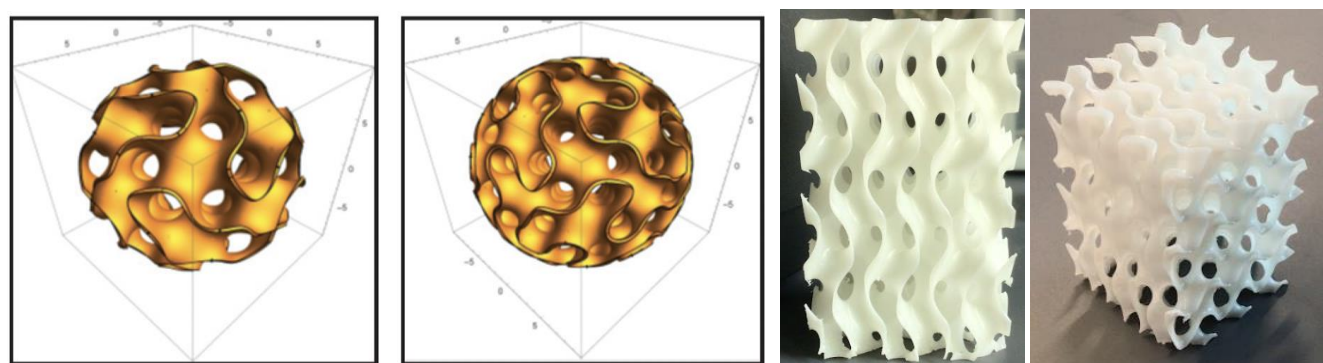


Background

- Nutrients from nonpoint source (NPS) pollution is one of the main drivers of freshwater eutrophication nationally and globally.
- Both rural and urban stormwater discharge high concentrations of nutrients (i.e., Nitrogen and Phosphorus) to freshwaters
- Best Management Practices (BMPs) like bioreactors have proven effective at removing these nutrients but require constant monitoring and maintenance.
- Project goal: Manufacture and test a Bioreactor module that utilizes a novel 3D-printed media for nutrient removal.
- The media was designed to have relatively high surface area to volume ratio (SSA) promoting sustained algae growth for nutrient consumption.

Methods



SSA= 863 m²/m³ SSA= 1168 m²/m³

Fig. 1: Original media gyroidal pattern (left) and resulting media (right).

- Media was printed on a resin SLA printer (Elegoo Saturn 2)
- 63 media blocks were printed to run three experimental bioreactors
- 3 tanks were tested: Control (no media), media, and media with illumination.



Fig. 2: Resin SLA Printer

Experimental Design

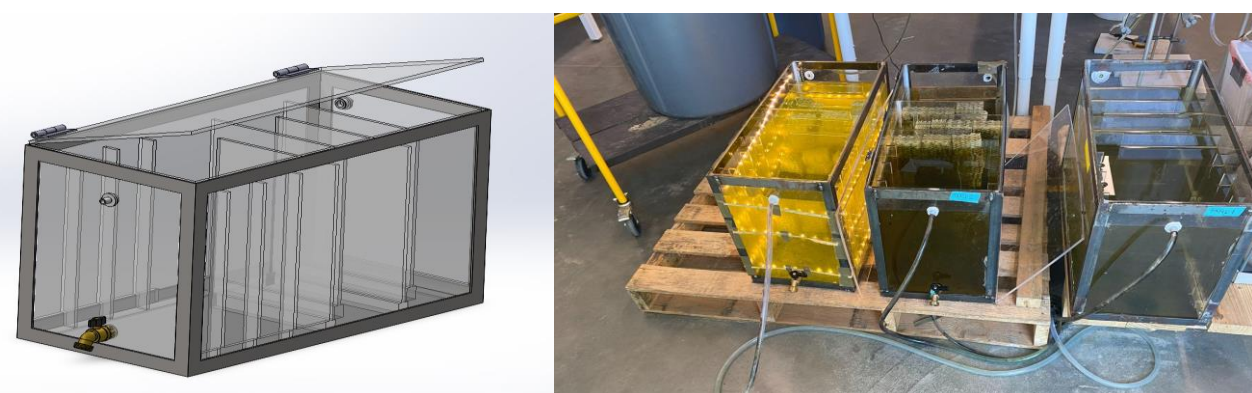
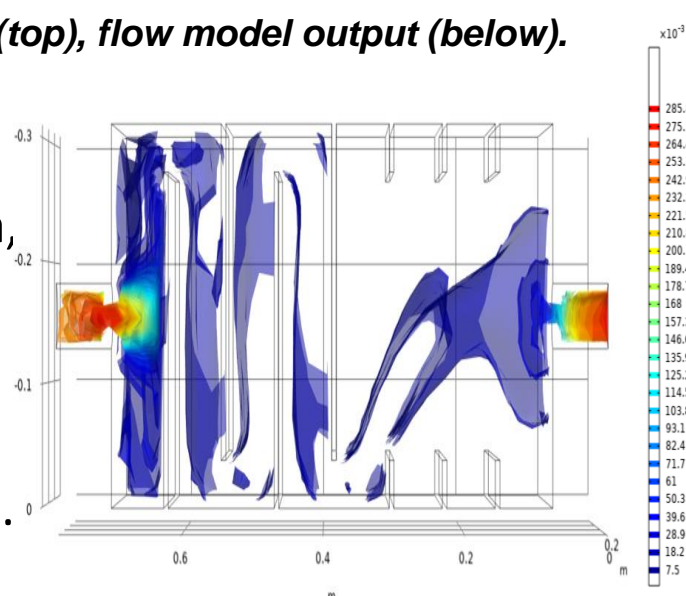
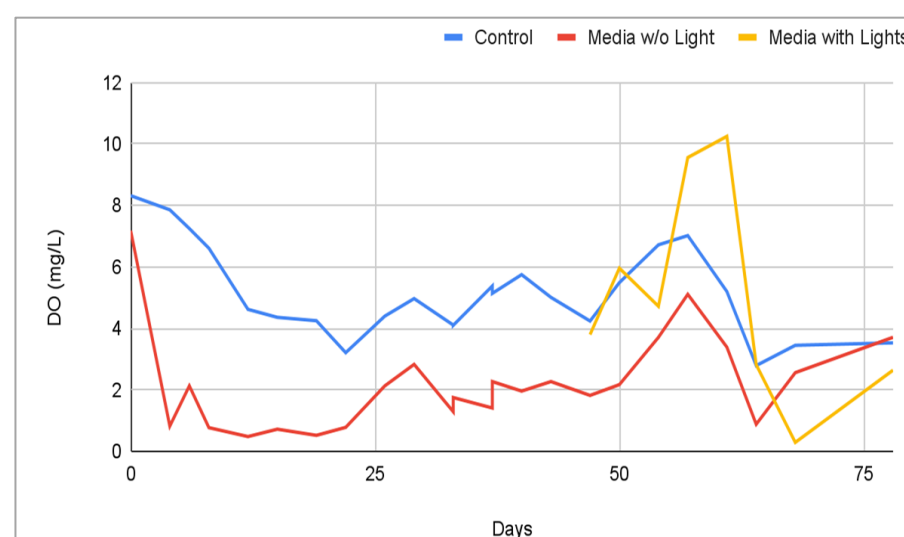


Fig. 3: Reactor design and setup (top), flow model output (below).

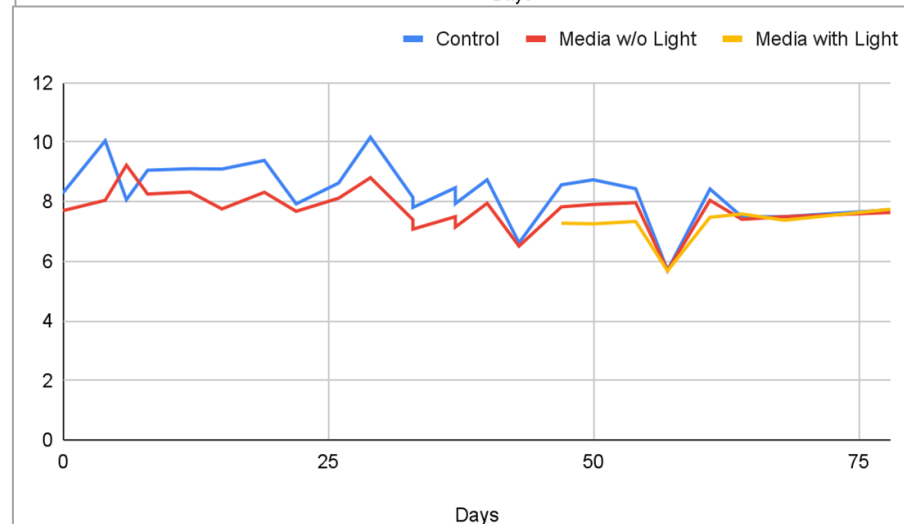
- Reactor's Initial part to promote flow through media, final part promotes a more quiescent environment.
- Flow was modeled to assure mixing along the vertical axis.



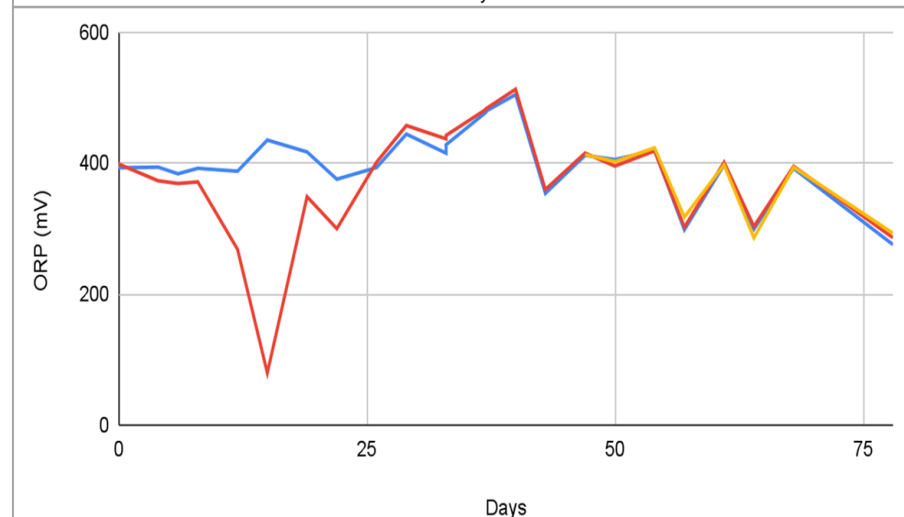
Environmental Conditions



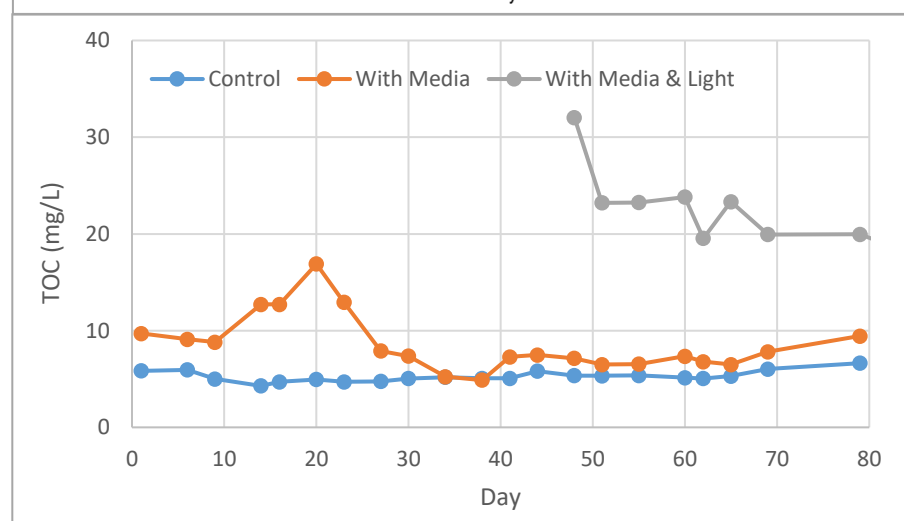
a) Dissolved Oxygen to identify aerobic vs. anaerobic environments



b) pH to assess algae's impact



c) ORP to differentiate between oxidized and reduced environments



d) Dissolved organic carbon to measure excessive algae growth

Fig. 4: a) DO, b) pH, c) ORP, d) DOC

Results

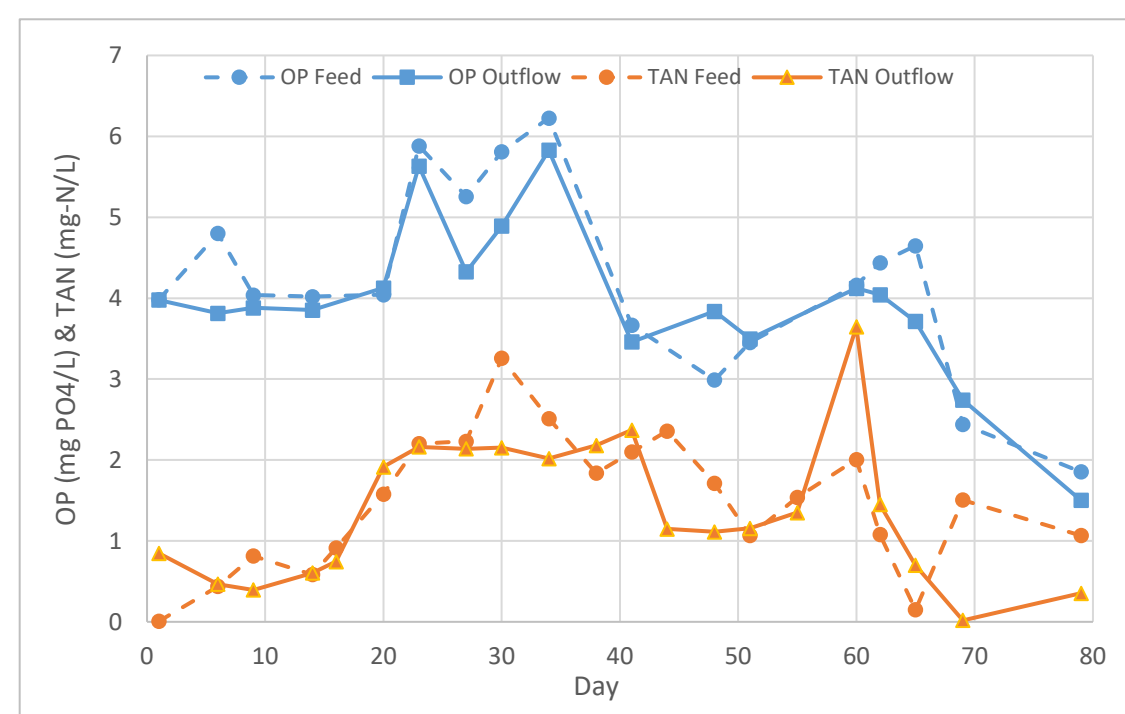


Fig. 5: Time series for OP and ammonia in control tank

- Control: OP, ammonia, and nitrate Cout/Cin was 0.95, 0.89, and 0.86 respectively. TN = 0.91.

Results Continued

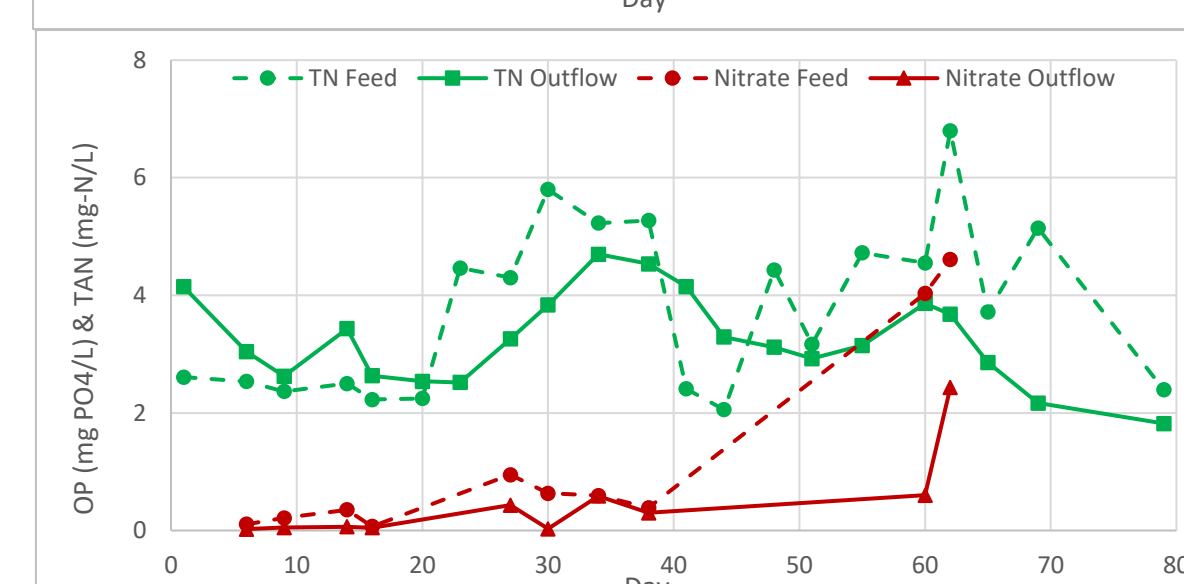
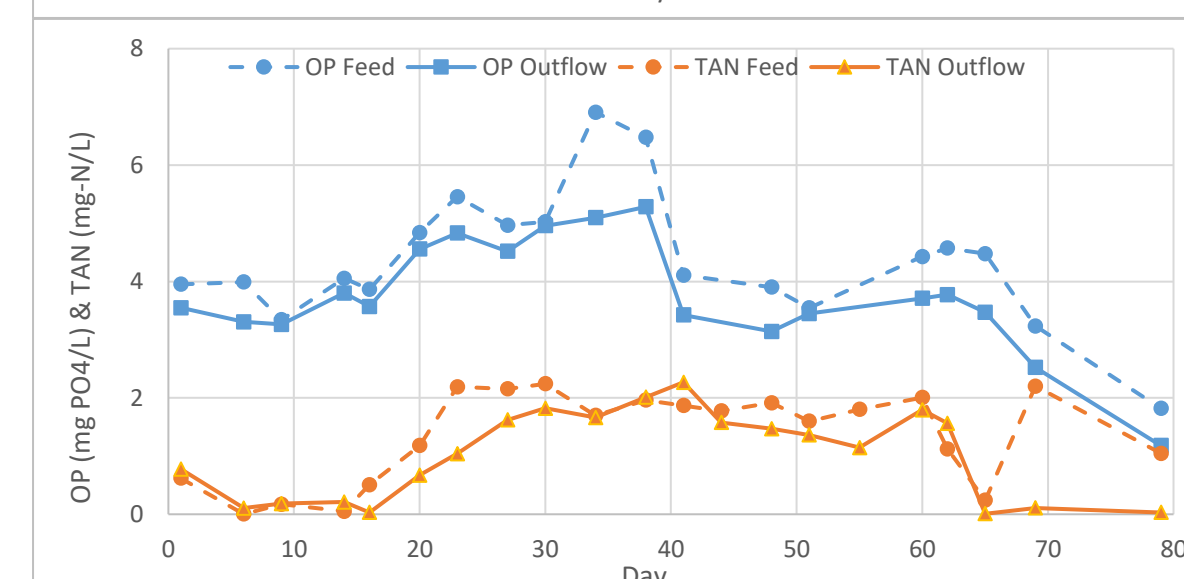
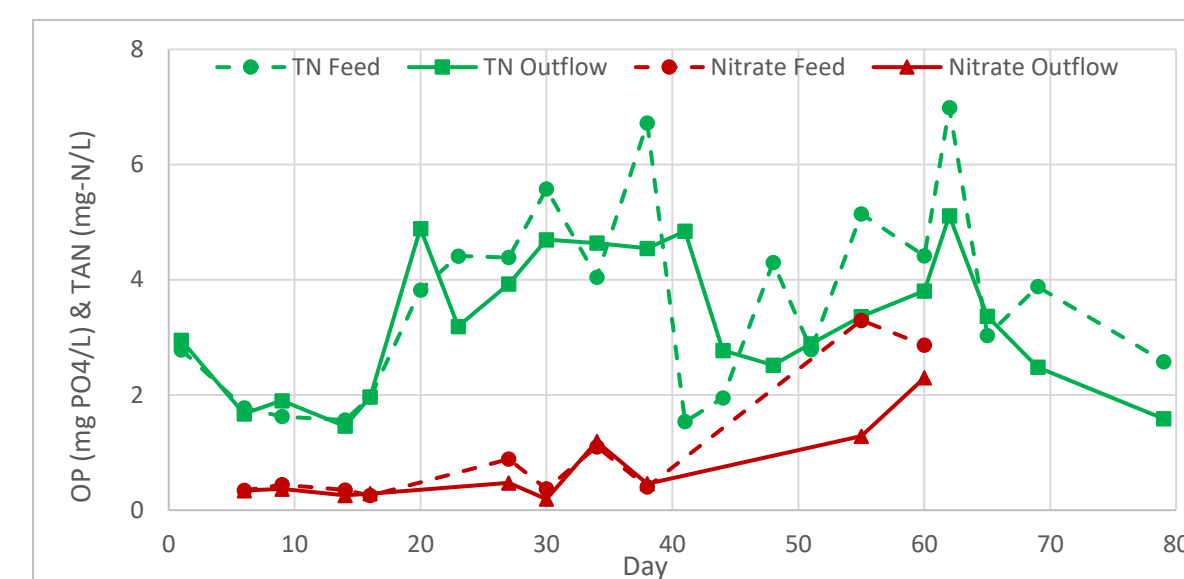


Fig. 6: Time series for: Nitrate & TN control (top), OP & ammonia media tank (middle), and nitrate and TN media tank (bottom)

Discussion & Conclusions

- With a retention time of 5 days (40 mL/min), the tank with media was able to achieve higher removal for all nutrients measured.
- Cout/Cin for OP, ammonia, and nitrate was 0.85, 0.69, and 0.43 respectively. TN removal = 0.9.
- Tank with media and lighting achieved higher removal in shorter time. Cout/Cin for OP, ammonia, and nitrate was 0.75, 0.69, and 0.4 respectively.
- Algae synergy with biofilm organisms was the mechanism for nutrient depletion.

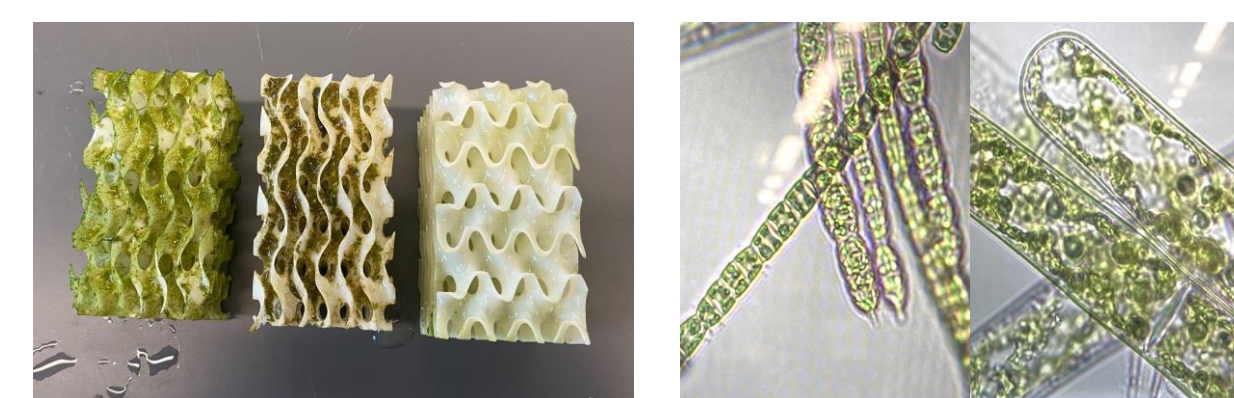


Fig. 7: Algae growth in media at day 75 (left). Cleanest media is after harvesting the algae. Filamentous algae in media (right).