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AN ALGAE MEMBRANE PHOTOBIOREACTOR FOR RESILIENT WATER MANAGEMENT

Abstract

Resilient water management is a challenge both terrestrially, and for long-term space travel. Though a great challenge, reliable water systems must be in place for humans to survive extra-terrestrially. The purpose of this work is to develop enabling technology for the recovery of water, energy, and nutrients for proposed Lunar or Martian colonies. To do this, an algae membrane photobioreactor (mPBR) has been designed and tested to TRL5. In this design, algae, well-known to grow on wastewater (ww) sources, are cultivated within a reactor using (ww) as a growth medium. The ww diffuses through a membrane as a source of water, nutrients, and gases. Incorporating a membrane allows for physical separation from the algae crop and background contaminants. Algae provide the additional benefit of consuming CO2, generating oxygen, a source of biofuel, and potentially a source of human and animal nutrition.

A new prototype (2.5L volume reactors, connected in series to scale) has been designed and is undergoing testing in relevant environments. It has been tested in the lab and outdoors (with outdoor air temperature extremes ranging 6-42C). Terrestrially, this prototype operates at TRL5, with plans to move to TRL6 testing in the municipal ww treatment plant setting. For extra-terrestrial applications, this prototype is at TRL5, with low-gravity being the major environmental factor yet to be tested and optimized for.

Preliminary results indicate high algal crop density culturing capabilities (1g/L in outdoor raceway, and 10g/L in municipal ww with previous prototype iterations). Cultures remain contaminant-free throughout 21 day experiments, including outdoor settings. Cultures within this mPBR maintained more stable temperatures and pH than controls without membrane diffusion. The membrane initiates filtration for dewatering the biomass at the time of harvest. All of these features are greatly beneficial for extraterrestrial application.

Future work on this project must investigate the resulting effect of low/micro-gravity environments (i.e., Mars, Moon). It is predicted that with lower gravity, algae will settle slower, resulting in better mixed systems for longer periods of enhanced growth; however, low settlability will also minimize the enhanced harvesting. The intent of this design is to provide a low energy, reliable platform for the cultivation of algae utilizing waste streams of water for the purpose of better water cycling. Even more so than on earth, an extra-terrestrial colony requires highly sustainable technologies, generating as little waste as possible. This is of particular importance with regard to nonrenewable resources, such as water.