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Author: Ms. Angélique Verrecchia
International Space University (ISU), Portugal, angelique.verrecchia@community.isunet.edu

Dr. Thomas Murphy
NASA Ames Research Center, United States, tommurphyemail@gmail.com
Dr. Brad Bebout
NASA Ames Research Center, United States, Brad.M.Bebout@nasa.gov

BENEFITS OF MICROALGAE FOR HUMAN SPACE EXPLORATION

Abstract

Algae have long been known to offer a number of benefits to support long duration human space exploration. Algae contain proteins, essential amino acids, vitamins, and lipids needed for human consumption, and can be produced using waste streams, while consuming carbon dioxide, and producing oxygen. In comparison with higher plants, algae have higher growth rates, fewer environmental requirements, produce far less "waste" tissue, and are resistant to digestion and/or biodegradation. As an additional benefit, algae produce many components (fatty acids, H2, etc.) which are useful as biofuels.

On Earth, micro-algae survive in many harsh environments including low humidity, extremes in temperature, pH, and as well as high salinity and solar radiation. Algae have been shown to survive in microgravity, and can adapt to high and low light intensity while retaining their ability to perform nitrogen fixation and photosynthesis. Studies have demonstrated that some algae are resistant to the space radiation environment, including solar ultraviolet radiation. It remains to be experimentally demonstrated, however, that an algal-based system could fulfil the requirements for a space-based Bioregenerative Life Support System (BLSS) under comparable spaceflight power, mass, and environmental constraints.

Two specific challenges facing algae cultivation in space are that (i) conventional growth platforms require large masses of water, which in turn require a large amount of propulsion fuel, and (ii) most nutrient delivery mechanisms (predominantly bubbling) are dependent on gravity. To address these challenges, we have constructed a low water biofilm based bioreactor whose operation is enabled by capillary forces. Preliminary characterization of this Surface Adhering BioReactor (SABR) suggests that it can serve as a platform for cultivating algae in space which requires about 10 times less mass than conventional reactors without sacrificing growth rate.

Further work is necessary to compare the performance of microalgae-based systems, including SABR, with systems based on higher plants, as well as conventional physicochemical-based systems. Ongoing and future work in our laboratory is therefore directed determining the feasibility of using algae as a component of a BLSS in space.