Bioreactors as the Solution to Extraterrestrial Sustainable Human Habitation

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Long term human habitation in space is dependent on the ability to recycle wastewater at recoveries that exceed 95%. NASA and NASA funded researchers have been operating and evaluating technologies that are capable of producing potable water from urine and other habitation waste streams (e.g. laundry, hygiene, humidity condensate) with a goal of operating closed loop systems. Space habitation wastewaters are very concentrated (600-2000 mg/l DOC and 800-3000 mg/l organic N) compared to terrestrial municipal wastewater and recycling systems must minimize volume, energy demand, and maintenance as well as minimize consumables and waste production. While some attributes (micro-gravity dependent) of space based water recycling systems are not pertinent to terrestrial systems, future decentralized treatment systems and/or source separated wastewater treatment combined with the need for remote and rural recycling systems can share many of the same requirements as space based systems. One significant issue for any water recycling system treating high strength wastewater is the need to stabilize the water to prevent biofouling, scaling, and volatilization of NH_3 during desalination regardless of the process (e.g. RO, FO/RO, distillation, etc.) utilized. We have been developing membrane aerated bioreactors (MABR) to stabilize space-based wastewaters as a means of reducing the reliance on consumables and decreasing the required human capitol maintenance requirements. We have demonstrated that MABRs can be operated for long periods (>4 years) with limited consumption of consumables, need for maintenance, and simple controls. These MABRs can be used to perform carbon oxidation, nitrification/nitritation as well as be coupled to anoxic/anaerobic bioreactors for additional N removal using denitrification or anammox. Our results support their use as part of an integrated wastewater recycling system to enable potable reuse of diverse wastewaters under dynamic loading typical of small occupancy systems. Our presentation will focus on summarizing NASA's ongoing water recycling efforts and our efforts to develop integrated water recycling systems in support of closed loop habitations and decentralized and remote water recycling systems.