World Academy of Science, Engineering and Technology
International Journal of Environmental and Ecological Engineering
Vol:17, No:05, 2023

Assessing the Recycling Potential of Cupriavidus Necator for Space Travel: Production of Single Cell Proteins and Polyhydroxyalkanoates From Organic Waste

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Abstract : Today, on the international space station, multiple supplies are needed per year to supply food and spare parts and to take out waste. But as it is planned to go longer and further into space these supplies will no longer be possible. The astronaut life support system must be able of continuously transform waste into valuable compounds. Two types of production were identified as critical and could be be supplemented by microorganisms. On the one hand, since microgravity causes rapid muscle loss, single cell proteins (SCPs) could be used as protein rich feed or food. On the other hand, having enough building materials to build an advanced habitat will not be possible only by transporting space goods from earth to mars for example. The bacterium Cupriavidus. necator is well known for its ability to produce a large amount of proteins or of polyhydroxyalkanoate biopolymers (PHAs) depending on its implementation. By coupling the life support system to a 3D-printer, astronauts could be supplied with an unlimited amount of building materials. Additionally, based on the design of the life support system, waste streams have been identified: urea from the crew urine and volatile fatty acids (VFAs) from a first stage of organic waste (excrement and food waste) treatment through anaerobic digestion. Thus, the objective of this, within the Spaceship.Fr project, was to demonstrate the feasibility of producing SCPs and PHAs from VFAs and urea in bioreactor. Because life support systems operate continuously as loops, continuous culture experiments were chosen and the effect of the bioreactor dilution rate on biomass composition was investigated. Total transformation of the carbon source into biomass with high SCP or PHA content was achieved in all cases. We will present the transformation performances of VFAs and urea by the bacteria in bioreactor in terms of titers, yields and productivities but also in terms of the quality of SCP and PHA produced, nucleic acid content. We will further discuss the envisioned integration of our process within life support systems.

Keywords : life support system, space travel, waste treatment, single cell proteins, polyhydroxyalkanoates, bioreactor
Conference Title : ICES 2023 : International Conference on Environmental Systems
Conference Location : Barcelona, Spain
Conference Dates : May 22-23, 2023