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SUSTAINABLE NITROGEN CYCLE FOR MARS SETTLEMENT: OPERATIONS ANALYSIS, AGRICULTURE, AND SOIL ECOSYSTEM

Abstract

As a component of atmospheric air, DNA, and proteins, nitrogen is a vital to sustain plant and animal life as we know it on Earth. Knowledge of the nitrogen cycle in space and how it passes through a living ecosystem is critical to evaluate the potential habitability of regions on Mars and other celestial bodies. The 21st century Martian atmosphere and regolith lacks plant available nitrogen compounds, which is one of the most limited resources on Mars and a key element missing in paraterraforming or terraforming.

Providing sufficient quantities of nitrogen for crop growth and air supply is essential for life support and human survival. A lack of research and knowledge on the payload analysis and nitrogen life cycle in greenhouses and habitats creates planning challenges for colony operations and expansion. As the largest supply of nitrogen for most crop plants is fertiliser via the Haber-Bosch process, direct atmospheric fixation is the primary source in natural environments.

Because cyanobacteria in the soil or root nodules of legumes have difficulty fixing atmospheric nitrogen to convert N2 to ammonium (NH4) in hydroponic systems on Earth, it is theorised that plants would have similar challenges in fixing nitrogen to produce nutrient dense food in situ to sustain plant and human life on Mars.

Researchers at Mars University and The University of Sheffield investigate the minimal and optimal nitrogen settlement supply levels to balance food mass, ratios, and logistics. A settlement-wide analysis is conducted to evaluate nitrogen sources from atmosphere, plants, storage tanks, urine, and manure to design a bioregenerative ecosystem with waste treatment plants, compressors, greenhouses, and habitats.

Research evaluates the development and integration of technologies and materials involved in food production, biomass soil quantities, nitrogen-converting cyanobacteria, autonomous portable nitrogen gas compressor units, cyanobacteria and N-Fix bacteria seed coats to improve nitrogen fixation, cryogenic nitrogen storage, and nitrogen supply chain pre-arrival, during, and following the first crewed human missions to Mars.

Understanding the nitrogen life cycle in settlements and greenhouses is important to better understand the needs and development of infrastructure, in situ resource utilisation, and technology roadmaps to enable industrial-scale production and expansion on Earth, Mars, Moon, and other celestial bodies.