Does gravity affect biogeochemical cycles? The Eu:CROPIS: Euglena: Combined Regenerative Organic-food Production In Space, satellite mission as an example. Rocco L. Mancinelli[1], Jens Hauslage[2], Peter Richter[3], Sebastian Strauch[3], and Michael Lebert[3] [1]BAER Institute, NASA Ames Research Center, Moffett Field, CA USA, Rocco .L.Mancinelli@nasa.gov, [2]DLR Cologne, Germany, Jens.Hauslage@dlr.de, [3]University of Erlangen, Erlangen, Germany, peter.richter@fau.de, sebastian.m.strauch@fau.de michael.lebert@fau.de.
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Introduction: The DLR's Eu:CROPIS (Euglena with Combined Regenerative Organic-food Production In Space) mission's goal is to determine if gravity has an affect on a simple ecosystem. Its core element is a microbiological trickling filter of lava rock – the habitat of a multitude of microbes that purify and decontaminate water. An important objective is to determine if gravity affects Eu:CROPIS's nitrogen cycle. Nitrogen is an essential element for life and is present in all living systems. Without nitrogen life as we know it could not exist. Because only Earth has a 1 x g environment, understanding how the nitrogen cycle operates as a function of gravity is key to sustaining and understanding life off Earth. To change the gravity levels the spacecraft will be spun to produce three different gravity regimes for 6 months each during the mission. The three gravity regimes will be 0.01 x g - 0.1xg (microgravity), 0.16 x g (Moon gravity) and 0.38 x g (Mars gravity). Modeling the nitrogen cycle of the system is essential to understanding how the system functions. It will be the first time nitrogen-transformation reactions will be measured as a function of gravity.

Objective: 1) Compare the rates of reactions of the N-cycle transformation reactions at each g level and at 1 x g in the ground control. 2) Develop a model of the N-cycle as a function of gravity.

Hyptothesis: The rates of N-transformation reactions change due to physiological effects of changes in the organisms performing these reactions and due to physical changes in the environment caused by gravity changes.

Rationale: 1) Gene regulation changes occur in altered gravity [1]. 2) Mixing due to convection decreases as gravity level decreases changing the concentration of N-species immediately surrounding the cell.

Methods/Results: A laboratory breadboard system was constructed to mimic the flight system and physically linked the euglena growth chamber with the trickling filter and the tomato greenhouse. Ion chromatography was used to measure the N species in the system. When running the system there is an initial increase in NH_4^+ (breakdown of urea) and a slow increase in NO_2^- (the first step of nitrification), followed by a decrease in NO_2^- and a slow rise in the level of NO_3^- (from the second step of nitrification). There is a slow decrease in NO_3^- (due to denitrification). When the system is drained and fresh synthetic urine is added. The production of NO_3^- occurs immediately. If the system is replenished ~ every 10 days thereafter NO_3^- increases rapidly with little NO_2^- detected. One explanation is that the system is primed with all microbes at a higher population density in the trickling filter to readily begin metabolism, so as soon as NH_4^+ is produced it is transformed to NO_2^- that is immediately oxidized to NO_3^-. The rate of nitrification is faster if the pH is not controlled, but the total yield of NO_3^- is less, whereas if the system is buffered the rate of nitrification is slower, but the total amount of nitrate produced is greater. If the system is allowed to become anaerobic denitrification occurs and the system ceases to function properly.

The results of additional experiments and a mathematical model of the nitrogen cycle will be presented.

References:

[1] Horneck, G, Klaus D. & Mancinelli, R 2010.Microbiol. Molec. Biol. Rev. 74:121-156