Proposed List of MELiSSA PhD Topics

Topic Title: MELiSSA C3: Modelling and predictive control of C3

Keywords: Nitrification, heterotrophy, Mathematical modelling, metabolome

Abstract

MELiSSA stands for "Micro-Ecological Life Support System Alternative". The nature of the MELiSSA project is characterized by a biological and chemical/physical approach based on first principles modelling and implementation of a suitable deterministic engineering approach with the goal of developing a closed life-support system**.** The MELiSSA loop as a regenerative life support system has to maximize the recovery of the main consumables (e.g. Water, Oxygen Food), as a key to develop a closed and self-sustainable process. Circularity of chemical elements is by nature the key challenge of closed life support systems, and so far, no project has yet demonstrated such a circularity over a full loop, a long period of time and multiple cycles.

Within the MELiSSA processes nitrification is in charge to transform the nitrogen content of urine in the nominal nitrogen source for plants and microalgae (e.g nitrates). In fully autotrophic mode, efficiency of the nitrification rate has been demonstrated to be very high, and is only slightly reduced by high salinity. Unfortunately, these excellent results drop to much lower values when autotrophy enter in competition with heterotrophic mode.

Over years and experience many hypotheses have been established and partially validated, however so far, the possibility to predict and pilot the nitrification process in heterotrophic conditions and high N transformation rates have not been demonstrated. Several reasons can be established: competition for oxygen availability, high content of organic carbon, preferred metabolic pathways, ...

Within this PhD, it is proposed to revisit the existing deterministic models of autotrophy and heterotrophy, complement the missing pathways of operating strains in the framework of well-defined microbial consortia, kinetics and limitations, with the key control objectives to reach a high nitrogen transformation rate.

This work is supposed to be performed and validated with the MELiSSA nitrifying consortium in axenic conditions.

Impact on MELiSSA Project:

Nitrogen circularity, ALiSSE criteria,

Potential MELiSSA Partners:

U Anvers, EAWAG, UCA, UAB

References:

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- Faust V, van Alen T.A, Op den Camp H.J.M., Vlaeminck S.E., Guanigué R., Boon N., Udert K.M. C3 Ammonia oxidation by novel "Candidatus Nitrosacidococcus urinae" is sensitive to process disturbances at low pH and to iron limitation at neutral pH Water Research X October 2022, 100157 17,1

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- Ilgrande C, Leroy B, Wattiez R, Vlaeminck S E, Boon N, Clauwaert P C3 Metabolic and Proteomic Responses to Salinity in Synthetic Nitrifying Communities of Nitrosomonas spp. and Nitrobacter spp. Frontiers in Microbiology

- MELiSSAfoundation.org

-ALISSE criteria presentation. Version 1, issue 0, 18th November 2009.

- ESA Technical Note 137.4 Appendix. Applicable document for using Oscar Methodology System Engineering applied to the MELiSSA data management system: requirements

Candidate's background requirements:

Candidates preferably possess a degree in biology, chemistry, biotechnology or bioengineering. They have to be familiar with metabolic pathways analysis, process modelling and simulation tools.