

Proposed List of MELiSSA PhD Topics

Topic Title: MELiSSA C1 inoculum and consortium characterization and standardization

Keywords: MELiSSA loop, Microbial community, metabolic pathways, metagenome, mathematical modelling

Abstract

MELiSSA stands for “Micro-Ecological Life Support System Alternative”. MELiSSA is the European project for circular life support systems and is characterized by a biological and chemical/physical approach based on first principles modelling and implementation of a suitable deterministic engineering approach. Within the MELiSSA loop, the waste compartment, (i.e. C1), is responsible of the primary degradation of the waste material generated by the crew, to shorter molecules, such as CO₂, Volatile Fatty Acids, NH₄⁺.

A deep knowledge of each sub-system (e.g. composition, behaviour, metabolism, kinetics, limitation, inhibition, etc..) is crucial for their control and integration in the entire MELiSSA loop. The C1 community metabolic model shall be further studied to allow to link any change in reactor performance and community/functional composition to changes in the C1 metabolome and hence in microbial metabolic pathways. A validated C1 community metabolic model, which indicates the metabolic interactions between species and/or functional groups, will be defined in a view of the future development of the C1 mechanistic model.

The proposed PhD project shall use meta-omics approaches to

- validate this preliminary microbial network,
- expand this preliminary microbial network to address the degradation of additional macromolecules (i.e., lipids and proteins),
- identify key species/functions/biomarkers of C1.

In addition, C1 inoculum preparation and maintenance protocol and storage protocols are missing. The candidate will also address the characterization of the C1 inoculum microbial community and its function, how to store C1 inoculum and for how long to ensure minimum loss of activity and functionality.

Impact on MELiSSA Project:

Definition of C1 microbial networks, corresponding metabolic pathways to elaborate and validate metabolic model(s) describing the interaction in complex communities in anaerobic fermentation.

Standardization of C1 inoculum elaboration, stability and preservation.

Potential MELiSSA Partners:

University of Gent (B), VITO (B), University Clermont-Auvergne (F)

References:

Identification of the microbial core community in the MELiSSA C1 compartment presentation to MELiSSA Workshop, ESTEC Contract 4000113144/14/NL/PA

Van Tinh Nguyen, 2023, Characterization of a thermophilic acidogenic microbial community treating organic waste and producing the high commodity chemical n-caproate using a combination of culturomics and meta-omics. KU Leuven. PhD thesis

Ramirez I, Volcke EIP, Rajinikanth R, Steyer J-P. 2009. Modeling microbial diversity in anaerobic digestion through an extended ADM1 model. Water Research 43:2787–2800

Regueira López A. 2020. Mechanistic understanding of mixed-culture fermentations by metabolic modelling. Universidade de Santiago de Compostela. PhD tesis

Regueira López A. 2022. Bioenergetic modelling for predicting and steering VFA production in carbohydrates anaerobic fermentation. Presentation to workshop. ESA Contract no: 4000118924/15/NL/AT

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, microbiology, biotechnology or bioengineering. They must be familiar with metabolic pathways analysis, anaerobic microbiology and metabolic pathways, bioinformatic and process engineering.