From Waste to Taste; Closing the MELiSSA Loops for escaping and sustaining the Earth habitat (Poster Flash Talk)

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1. Introduction

MELiSSA (Micro-Ecological Life Support Alternative) has been initiated by ESA with the ambitious goal of developing "autonomous habitats in deep space, supplying astronauts with fresh air, water and food through continuous microbial recycling of human wastes" [1]. The now popular MELiSSA Diagram (Figure 1) that showed little change since it was first outlined by Mergeay et al [2] is the foundation for the consortium's research objectives. It describes the flows and interaction of the crew with 4 different compartments colonized from anoxygenic thermophilic up to photo-autrophic organisms (plants) [3].

This paper discusses the outcomes of the latest MELiSSA endeavors and their potential for Earth applications. The SEMiLLA Sanitation Hubs project is described by analyzing the feasibility of scaling the MELiSSA loop to a 40 feet container and closing the gaps by recovering water and nutrients and producing food for extreme Earth habitats.

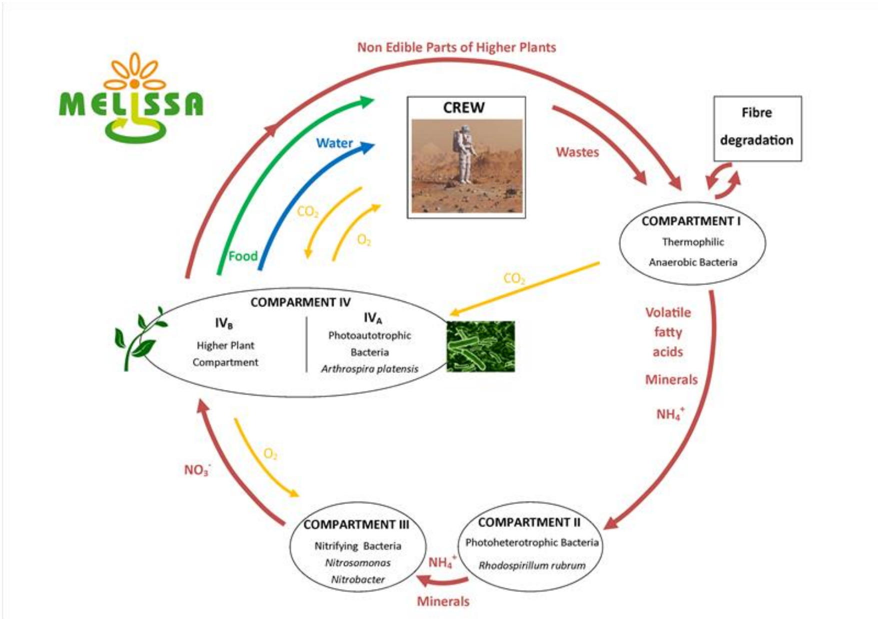

Figure 1: MELiSSA Diagram

2. MELiSSA Application for Space and Earth

The scientific knowledge unfolding in the framework of MELiSSA is paving the way to achieving the artificial environment that can assure the crew with food, oxygen, and water in the confined habitats designed for space exploration. Equally important, this know-how can be applied on Earth to improving the life of the people in terrestrial closed ecosystems (eg desert), smart cities of the future and even remote or disaster areas.

2.1 SEMiLLA Sanitation Hubs

The project is a cooperation between IP Star, University Ghent and HAS University and aims to establish the feasibility of using advanced space technology from MELiSSA program for urine, gray and black water treatment. The compartments described before are scaled down to a **40 feet container** which is modular and can be rapidly transported by air, land or water to the targeted area. The goal is to have deployable containers that have the hardware that allows the recovery of nutrients and water.

3. From waste to taste

3.1 Waste Water Treatment Unit (WWTU)

The objective of this work is to manage the flows and stock of the MELiSSA loop through mathematical models. The existing ones will be adapted to the unit scale (40 feet container) which will enclose the first three compartments from the loop. Next, the input-output balance will be addressed with case studies and further experiments on the prototype. For the case studies, it is considered that a "dietary protein intake of 0.8-1.5 g protein kg^{-1} body weight for a crew member with a body weight between 65 and 85 kg is expected to result in a urinary excretion of between 7 and 16 g N d^{-1}. Fecal nitrogen excretion is typically in the order of 1-2 g N d^{-1}" [4] (Figure2). The project aims to assess the feasibility of the unit through mathematical modeling with a high degree of prediction regarding the water and nutrient flows. By the end of 2017, the sanitation container will be ready to be deployed in remote areas.

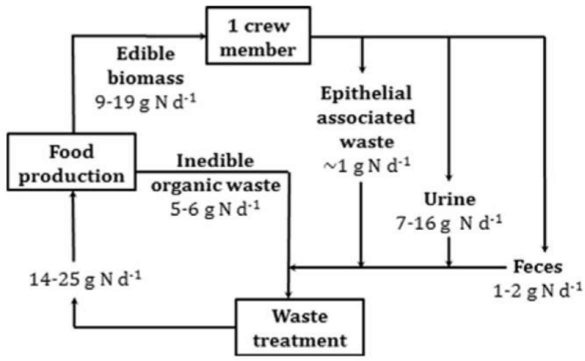

Figure 2: Theoretically calculated Nitrogen balances [4]

3.2 Food Production Unit (FPU)

Based on the results obtained from the mathematical model and the experiments regarding the WWTU, a second container will be designed that will use the water and fertilizers recovered, for producing food in the controlled environment. The container allows vertical stacked growing beds that can assure a surface of approximately 150 sqm for the plants which suffice for an intake of 3040 kcal $person^{-1}$ day^{-1} for about 3 crew members. These models aim to match the complexity of the compartments interaction and then be validated by experiments on the prototypes. Using the technology developed for compartment C4 (Figure1) the linkage of the two units will correspond with closing the MELiSSA loop at unit scale for terrestrial extreme habitats.

4. Life support systems outer and inner Earth feedback loop

The results of the various, multiple, ongoing research projects conducted by the partners from the MELiSSA consortium are pushing the scientific knowledge and help to reach the goal of developing reliable life support systems for long term space missions. The know-how can be transferred and adapted to the extreme habitats on Earth. Nonetheless, the application tested and validated on Earth is a certification of the efforts directed to interplanetary objectives. This creates a feedback loop that is accelerating the progress in the energy, waste, water, air and food nexus.

References

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Short Summary

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