Optimizing nutrient recovery from urine for space missions

Valentin Faust^{1,2,*}, Kai M. Udert^{1,2}, Peter Clauwaert³, Siegfried E. Vlaeminck^{3,4}, Nico Boon³

¹ Eawag – Swiss Federal Institute of Aquatic Science and Technology, Überlandstrasse 133, 8600 Dübendorf, Switzerland

² Institute of Environmental Engineering, ETH Zürich, 8093 Zürich, Switzerland

³ Center for Microbial Ecology and Technology (CMET), Ghent University, Coupure Links 653, 9000 Gent, Belgium

⁴ Research Group of Sustainable Energy, Air and Water Technology, Department of Bioscience Engineering, University of Antwerp, Groenenborgerlaan 171, 2020 Antwerpen, Belgium

* E-mail address: valentin.faust@eawag.ch



Fig. 1: Proposed urine treatment chain for space application combining urine treatment technology of Eawag with MELiSSA Input: human urine. Output: chemically stable fertilizer free of micropollutants and pathogens for the photoautotrophic compartment (Comp. IV) of the MELiSSA loop. No base is added, therefore only half of the ammonia is nitrified. Stable nitrification reactor performance is possible if the pH is controlled with the inflow rate.



Fig. 2: Small stable operation range

Stable nitrate production requires that the nitrite oxidizing bacteria (NOB) Nitrobacter sp. grow faster than the ammonia oxidizing bacteria (AOB) Nitrosomonas sp. and Nitrosococcus sp. High inflow rates will result in the accumulation of nitrite and the washout of NOB, while low inflow rates foster the growth of the acid-tolerant AOB Nitrosococcus sp. and the production of harmful nitrogen oxide gases. Figure by courtesy of A. Fumasoli.

Picture references: VUNA Ltd., OxyMem Ltd., WAGO Ltd., Dynamita Ltd.





How to increase process reliability?

1. Model of the biological processes

- Treatment units: degradation of organics and nitrification
- Calibrate and validate mechanistic model



2. Control strategies

- Model all treatment units and their inter-connections
- Determine optimal parameters for process control
- Try out different control strategies

3. Axenic cultures

- Identify dominant nitrifying and heterotrophic bacteria in the system and reproduce axenic cultures of identified bacteria
- Compare performance of synthetic and natural consortia .
- Integrate results in the mechanistic model





