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Pyrolysis of human waste for a biochar based space agriculture

Preparing the production of edible plants from faecal biochar and urine fertilizer

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Introduction

Manned space missions will require highly sophisticated life support systems. Astronauts on planetary bases or on long space flights will have to be provided with everything needed for their survival, health, safety and well-being during a significant time span. Working hypothesis: pyrolysis of human solid waste can be a valuable (pre)treatment step in life support systems degrading fibres, sanitizing wastes and creating a carbon and nutrient storage in form of biochar, that can be reused as a substrate or fertilizer in hydroponic food production. The pyrolysis process itself does not require oxygen and CO_2 for plant uptake can be produced demand-driven by incinerating the stably stored biochar.

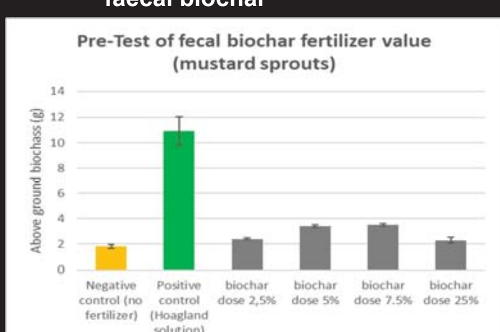
1 Production and characteristics of pyrolysed human waste
2 Fertilizer value of pyrolysed human waste
3 Prerequisites for food production from faecal biochar
4 Lab scale hydroponic experiments
5 Fecal biochar and inert substrate recycling

1 Pyrolysis Experiments & biochar Analysis

- Collection of feces from voluntary donors
- Pyrolysis of dried feces at 300°C with a hold time of 20 min
- Drying and pyrolysis → total volume reduction of 80%
- pH of biochar is high (9.1) → monitor the effect on hydroponic
- nutrient solution!
- Biochar water extract has an electrical conductivity of 2.0 mS/cm → no salt induced plant stress to be expected
- 53.4 wt% carbon in fecal biochar → makes it suitable for demand driven CO2- production
- Fecal biochar contain 5.2wt% total nitrogen & 0.62 wt% plant
- available phosphorous → fertilizer value

Dried feces, fecal biochar and microgreen plant tests

2 Microgreen production with faecal biochar

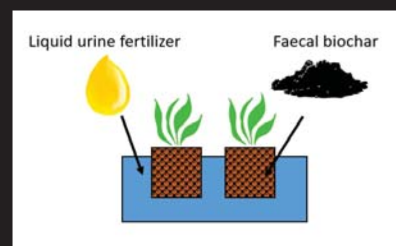


Results of fecal biochar fertilization pre-test including (means of 3 replicates, error bars represent standard error of the mean)

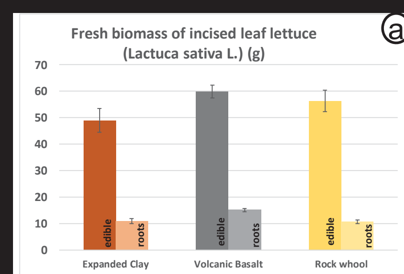
- Some fertilizer value but not in the range of standard fertilizer solution → nitrogen is present in biochar, but not plant available
- Negative impact at high doses → high pH?
- Best biochar dosage 5 -7 vol%

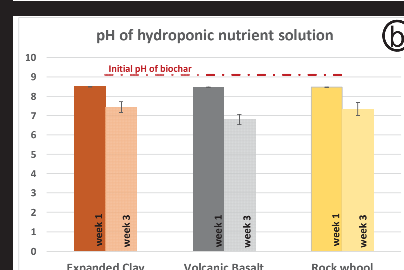
3 Suitable, recyclable inert substrate, pH and EC for hydroponics

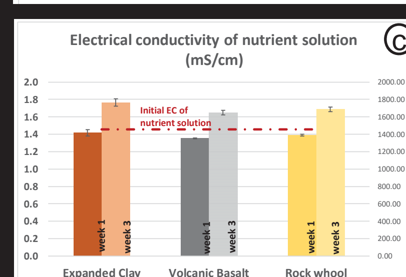
Incised lettuce hydroculture with 3 different inert/mineral substrates + faecal biochar + nitrified urine fertilizer (Aurin by Vuna GmbH).



Hydroponic pre-tests with incised lettuce grown in urine fertilizer solution, faecal biochar and three inert mineral substrates







a) volcanic basalt seems most suitable as an inert substrate combined with biochar

b) High pH of biochar only increases nutrient solution pH temporarily

c) Over time biochar leaches ions that contribute to EC → additional fertilizer value or NaCl ?

4 5 The next steps and questions

- Development of lab scale recirculating hydroponics fertilized with faecal biochar and nitrified urine
- Investigation of pre-processing steps to make bound N in biochar plant available
- Investigation of nutrient and carbon uptake, recycling efficiencies, substrate and biochar reuse, recycling techniques.