BIOCHAR FROM HUMAN WASTE BY DIRECT PYROLYSIS

STEPS TOWARDS A NEW SANITATION APPROACH

Zurich University of Applied Sciences

Life Sciences and Facility Management

Institute of Natural Resource Sciences

Andreas Schoenborn[1], Nicola Bulant[2] and Mira Bleuler[1]

1: Zurich University of Applied Science, PO Box, CH-8820 Waedenswil, Contact: andreas.schoenborn@zhaw.ch
2: Stammerstrasse 20, CH-8260 Stein am Rhein, Switzerland

Introduction and objectives

Human waste

- source of 80-90% of the nutrients found in domestic wastewater
- major path of pathogen transmission
- difficult to reclaim nutrients after mixing with water

Working hypothesis

Human waste should be…

- caught and treated as close to the source as possible
- converted into biochar (by direct pyrolysis)…
- … which can then be safely reused as soil amendment

Objectives of this study

Development of an experimental pyrolysis batch reactor for direct conversion of human feces into biochar:

a) Reactor development and proof-of-concept
b) Full control of and first data on process parameters
c) Elemental composition of biochar (N,P,K,Mg,Ca,trace metals)

Material and methods

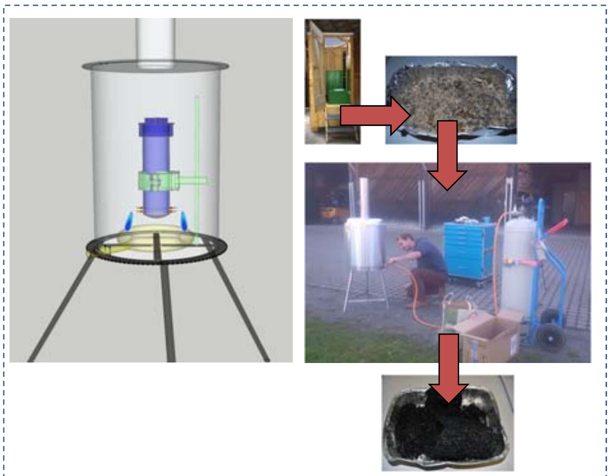

Fig. 1: Batch pyrolysis reactor and workflow (Sketch and photos from [1])

Sample provenience:

- Human waste (HW) from a private composting toilet
- Substrate HW contains: feces, urine, pine wood shavings
- HW-biochars from 9 test runs:
    - o 4 x pine wood shavings
    - o 5 x human waste (mixed with additional pine wood shavings)
- 2 x biochars from sewage sludge (Austria) and wood (Switzerland)

Methods:

- Reactor process parameters:
    - Heat-up rate: 10-50 °C/min (slow pyrolysis)
    - Temperature range: 450-450°C
    - Holding time: between 10 and 15 minutes
- Water content of substrate and biochar
- Temperature (continuously)
- Elemental composition of biochar (with XRF, ICP, CHN-analyzer)

References

[1] N. Bulant (2015), Pyrolyse von Fäzes zur Anwendung als Bodenhilfsstoff in Terra preta Erde, Bachelorarbeit IUNR
[2] M. Bleuler (unpublished), Elementaranalyse von Pyrolysekohlen aus menschlichen Fäzes und weiteren Ausgangsmaterialien, Master tutorial, Zurich University of Applied Sciences

Results

1 Water content is major factor for energy demand

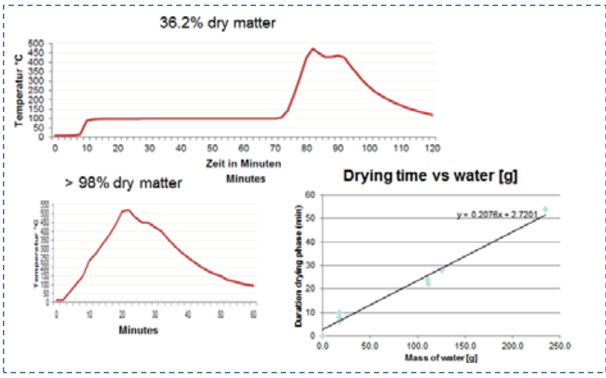

Fig. 2: Correlation of water content and length of drying time during pyrolysis

2 High nutrient content, sometimes low solubility

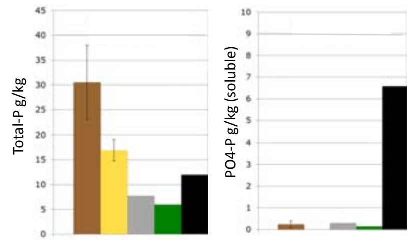

Fig. 3: Mean P-content in pyrolytic biochar and fecal matter (from [2])

3 Some C-H-N lost during process

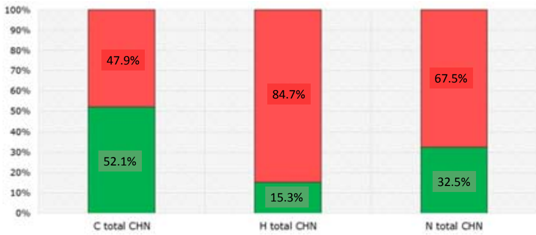

Fig. 4: CHN losses in the pyrolytic process (from [2])

Conclusions & Outlook

Pyrolysis is an interesting way to reclaim nutrients from human waste and convert them to a hygienically safe product!

- Pyrolytic process, next steps:
    - Better process control of pyrolysis needed
    - Energy balance needs to be improved
    - Stable source of fecal matter needed
    - Water content < 46% recommended, can be reached by pre-drying or by mixing HW with dry organic material
- Composition: Compared to char from chippings, biochar from HW has…
    - higher pH: HW 8.74, wood 7.47
    - higher conductivity (salt content): HW 2'849, wood 841 µS/cm
    - Much higher P, K and N, as well as Cu and Zn
    - Much lower Pb
- Lab:
    - The results generated by ICP and XRF were not always consistent
    - New protocols needed for elemental analysis of biochar
- To be investigated:
    - Potential toxicity of exhaust gases and biochar
    - Plant availability of nutrients