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PYROLYSIS OF PIT LATRINE CONTENTS IN DEVELOPING COUNTRIES

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INTRODUCTION

In most developing countries, pit latrines are the predominant form of excreta disposal. However, the management of pit emptying and treatment of pit latrine content has proven to be difficult due to its varied nature. The main global challenge is to provide a safe, sustainable and technically feasible solution to faecal sludge management. The main purpose of this research is to evaluate the feasibility of the pyrolysis of pit latrine content in developing countries as an alternative solution to faecal sludge management, with a focus on biochar production.

METHDOLOGY

Step 1:
Literature review
Pit latrine content
Biochar production

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Step 2:
Feasibility study
Energy analysis

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Step 3:
Predict characteristics of biochar produced
Identify areas for further research

PIT LATRINE CONTENT

The physicochemical properties of pit latrine contents are affected by the initial characteristic (1), storage time and emptying method. Common indicators of pit latrine content characteristics are water content (2), organic content in the form of volatile solids (3), and inorganic content in the form of ash (4).

	Over time and over depth	Pit content compared with sewage sludge	Impact on pyrolysis process	Impact on biochar production
(1)	Heterogeneous	More varied, less biochemically stable	Result in different reaction pathways	Varied yield and quality
(2)	Decreases due to leaching, lead to higher sludge concentration	More varied	Must be high enough to facilitate removal, large energy consumption for sludge drying	High water content reduces biochar yield, promotes bio-oil yield
(3)	Decreases due to different degradation processes	Pit latrine content ~58% Sewage sludge ~34%	Affect the heat capacity of sludge	High volatile solids reduces biochar yield, promotes bio-oil and syngas yield
(4)	Accumulate at pit bottom in the form of ash fraction of sludge	More non-biodegradable material	Affect the heat capacity of sludge	Ash content remains within biochar. High content increases biochar pH, reduces highest heating value (HHV)

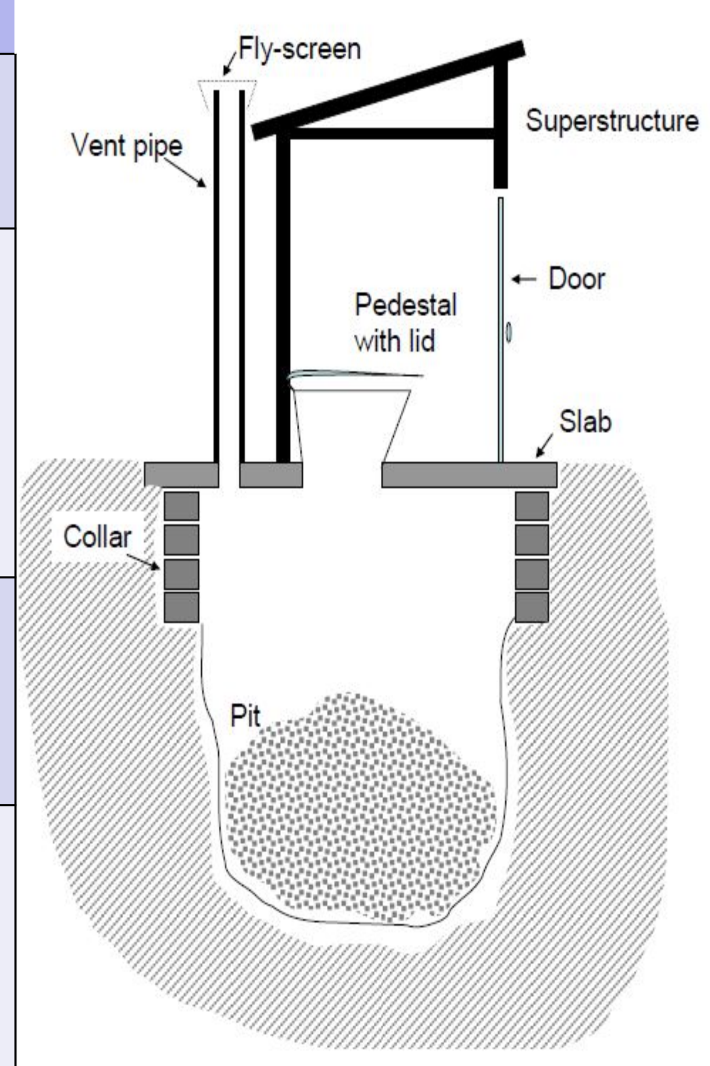

Figure 1. Diagram of pit latrine (Bakare et al., 2012)

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BIOCHAR

Biochar is produced through pyrolysis of biomass, a thermochemical process in the absence of oxygen. It is defined with specific application to soil for agronomic use or environmental management (Lehmann & Joseph, 2015). The benefits of biochar production are:

- By-products, bio-oil and syngas, can be harnessed as biofuels
- Increase in nutrient and water retention capacity of soil through increase in Braunaer-Emmet-Teller (BET) surface area and cation exchange capacity
- Heavy metal immobilisation
- Act as long-term carbon sink and mitigate climate change

Figure 2. Biochar-soil mixture (Pacific Biochar, 2016)

FEASIBILITY STUDY

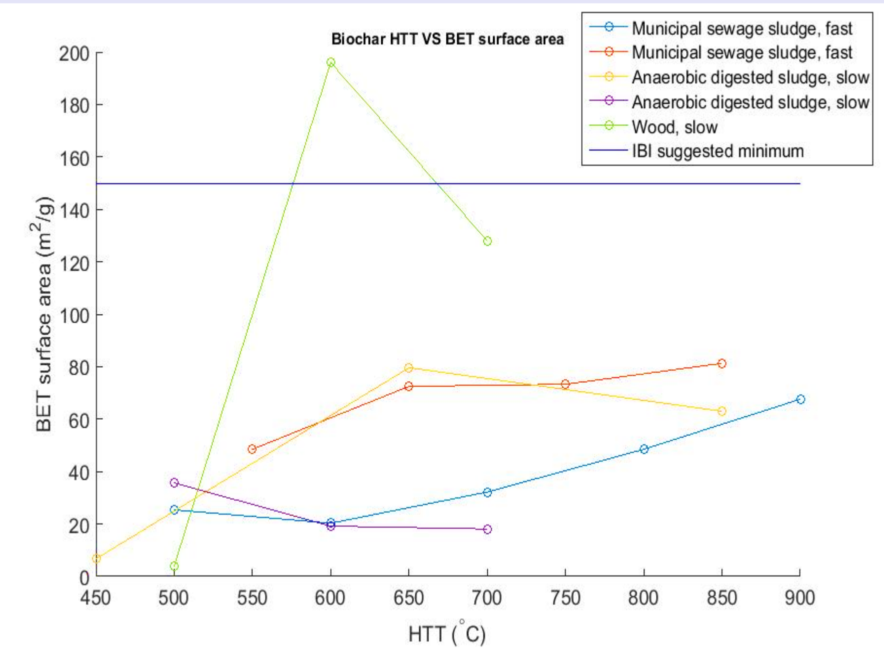
Experimental data from 19 sewage sludge pyrolysis studies were used to calculate the total energy consumption Q_{total} and the net energy requirement of biochar production using the following equations:

$$Q_{total} = Q_{drying} + Q_{target} + Q_{pyrolysis}$$

$$Net\ energy\ requirement = Q_{total} - \sum HHV_{product} \times Yield_{product}$$

Results

- Q_{drying} accounted for 80% of Q_{total}
- Water content has greater impact on Q_{total} than volatile solids content
- A negative net energy requirement, where biochar production was considered feasible, was only found in the case where pit latrine content was air dried, pyrolysed at low highest treatment temperature (HTT), bio-oil or both bio-oil and syngas was harnessed for energy
- Lower HTT resulted in higher biochar yield, lower net energy requirement but lower BET surface area
- BET surface area of sewage sludge-based biochar was lower than the suggested value of 150 m^2/g from the International Biochar Initiative, which indicate poor biochar performance in soil
- High biochar pH is derived from feedstock
- Varied nutrient retention and heavy metal immobilisation response, specific to feedstock and soil type



CONCLUSIONS

Biochar produced from pit latrine content is predicted to have high pH and low HHV due to high ash content and low BET surface area. The use of drying methods that require minimal energy prior to pyrolysis to reduce the water content will make biochar production a more attractive treatment process.

REFERENCES

Lehmann, J. & Joseph, S. (2015) *Biochar for Environmental Management: Science, Technology and Implementation.* Second Edition.
Bakare, B., Foxon, K., Brouckaert, C. & Buckley, C. (2012) Variation in VIP latrine sludge contents. *Water SA.* 38 (4), 479-486.
Pacific Biochar (2016) Dense mix biochar. [Online] Available from https://pacificbiochar.com