Detailed combustion analysis of fecal matter to optimize thermal processing technologies

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Outline

▶ Introduction
▶ Motivation and ISO/PC 318
▶ Analytical framework and methods
▶ Results
▶ Utility of results and adequacy of simulant
▶ Future work
Introduction

Thermal treatment and the Biogenic Refinery

- Why thermal treatment?
- Pyrolysis, gasification, and combustion
- The Biogenic Refinery
Motivation

Optimize thermal treatment with ISO/PC 318

Goals:
- Pathogen treatment
- Volume reduction
- Energy independence
- Value added products

How does feedstock influence system design?
How can we represent a feedstock undergoing thermal treatment?

**Volatiles**
- Driven off in pyrolysis (no $O_2$)
- Contain some energy

**Char**
- Consumed in combustion ($O_2$)
- Contains some energy

**Inorganics (Ash)**
- Remain after combustion
- Contain no accessible energy
Analytical Framework

How can we quantify the process?

**Volatile**
- Mass fraction
- Energy content
- Volatilization profile

**Char**
- Mass fraction
- Energy content

**Inorganics (Ash)**
- Mass fraction
Methods | Measurement

Micro-combustion calorimetry, bomb calorimetry and muffle furnace

- Micro-combustion calorimeter for volatiles
- Bomb calorimeter for total energy
- Muffle furnace for ash fraction
Methods | Sampling

What samples were used?

**Feces**
- India (A)
- United States (B)

**Pit latrine**
- Kenya (C)

**NASA Simulant**
- Onabanjo, 2016

Results | Mass Fraction and Energy Content

What was the composition of our samples?
Results | Volatile Heat Release Profiles

How are volatiles released during pyrolysis?
How may these results be used in system design?

- Accurate energy balance and thermal profiling improves the design process
- Optimal energy liberation for ISO 30500 and ISO/PC318
- Facilitate optimal sample drying techniques and biochar production
How effective is NASA simulant in capturing pyrolysis/combustion?

**Combustion: Very good**
- Similar total energy content
- Similar ash fraction

**Pyrolysis: Not so much**
- Different char fractions
- Different volatilization profiles

“Results from this study suggest that NASA synthetic feces may not be ideal as a model for the energy content of human fecal char.”

WARD, 2014

What gaps are suggested?

Additional fuel characterization
- Thermogravimetric analysis
- Differential scanning calorimeter
- Mass spectrometry

Simulant more suited for thermal treatment?
Thank you!

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