

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



Optimize thermal treatment with ISO/PC 318

Goals:

- ▶ Pathogen treatment
- ▶ Volume reduction
- ▶ Energy independence
- ▶ Value added products

How does feedstock influence system design?

Analytical Framework

How can we represent a feedstock undergoing thermal treatment?

Volatiles

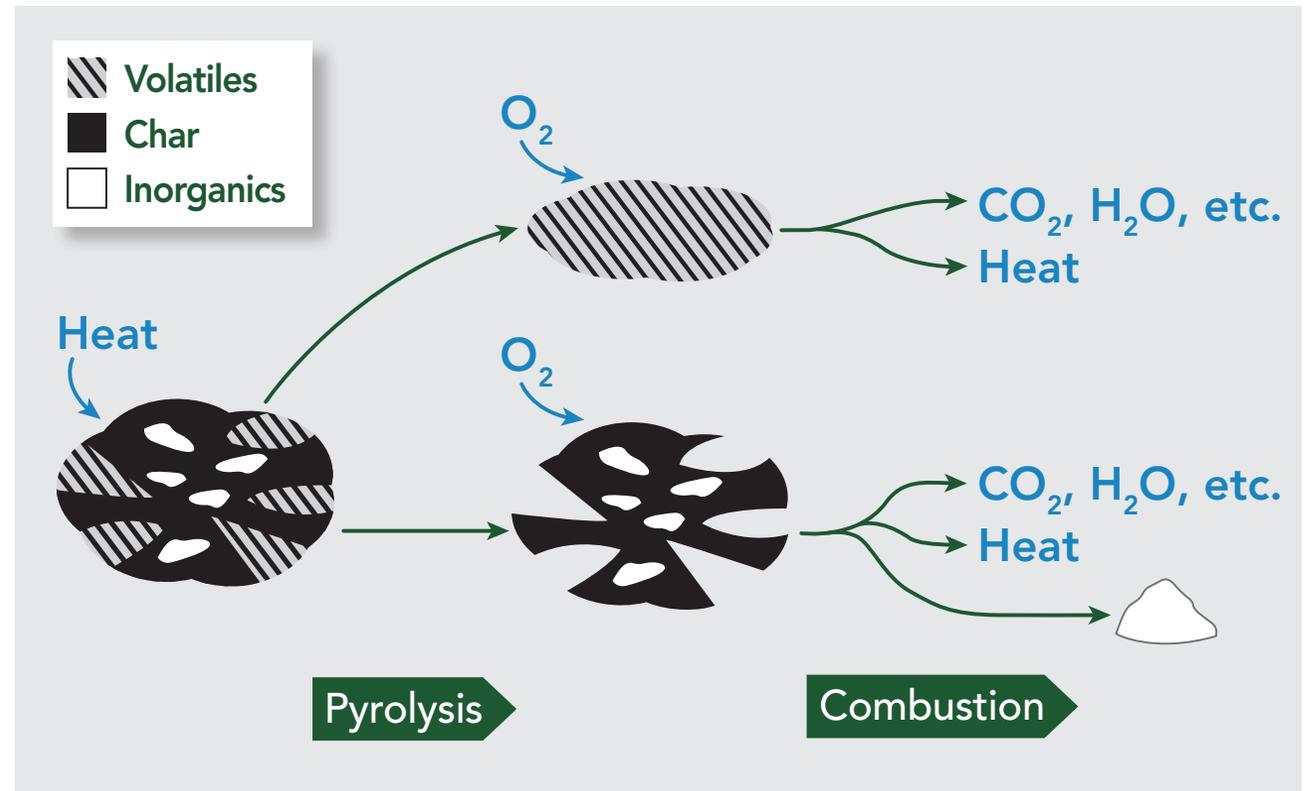
- ▶ Driven off in pyrolysis (no O_2)
- ▶ Contain some energy

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?

Volatiles

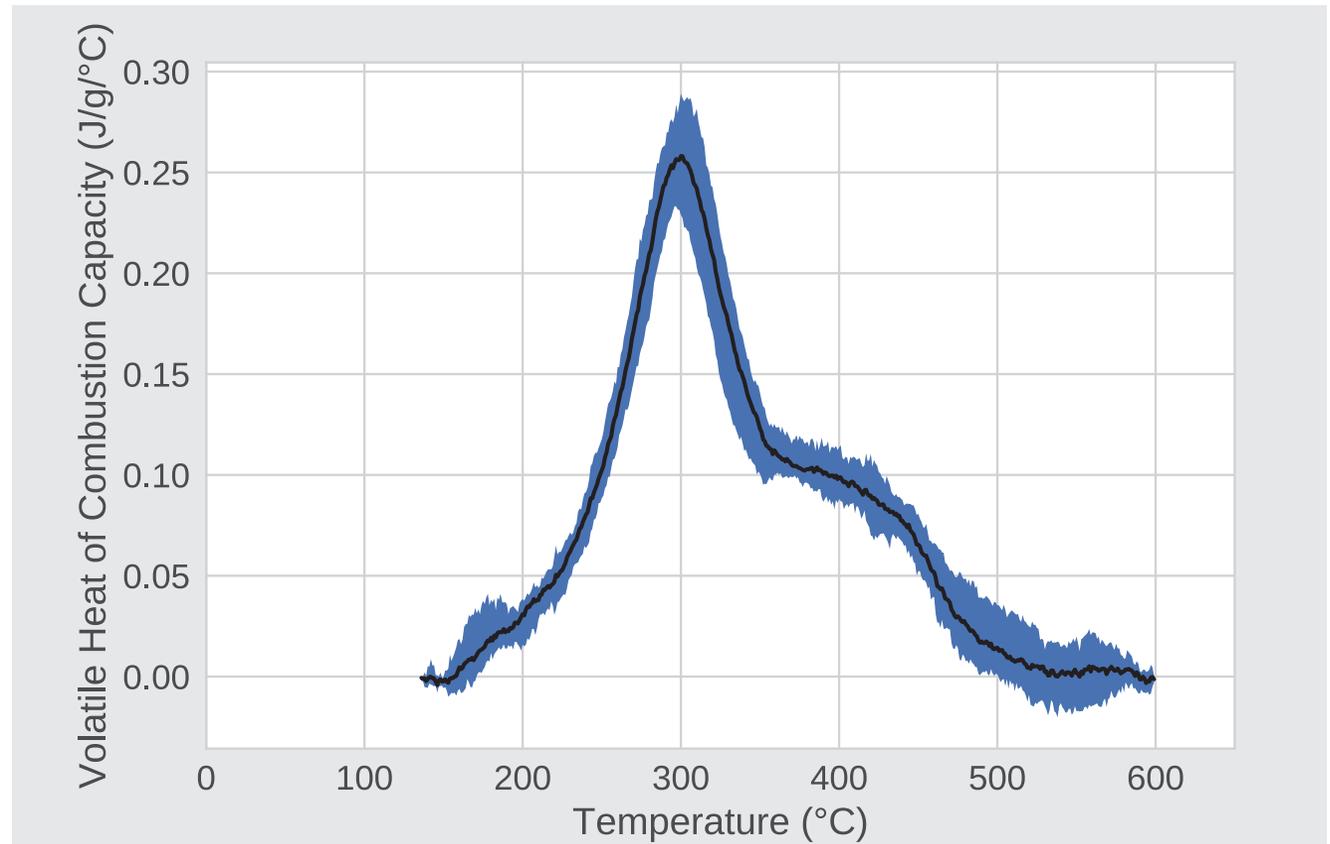
- ▶ Mass fraction
- ▶ Energy content
- ▶ Volatilization profile

Char

- ▶ Mass fraction
- ▶ Energy content

Inorganics (Ash)

- ▶ Mass fraction



Micro-combustion calorimetry, bomb calorimetry and muffle furnace

- ▶ Micro-combustion calorimeter for volatiles
- ▶ Bomb calorimeter for total energy
- ▶ Muffle furnace for ash fraction



What samples were used?

Feces

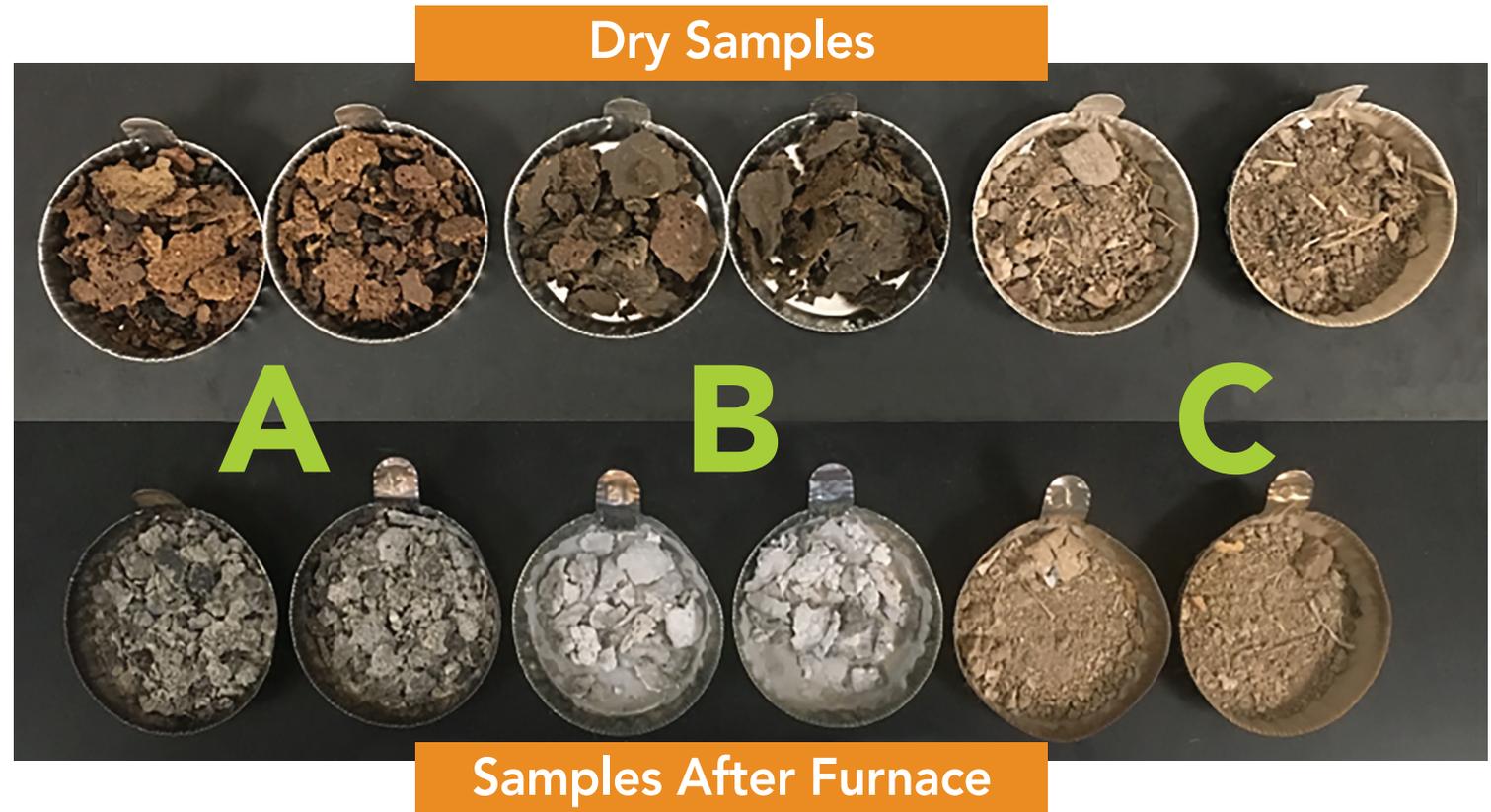
- ▶ India (A)
- ▶ United States (B)

Pit latrine

- ▶ Kenya (C)

NASA Simulant

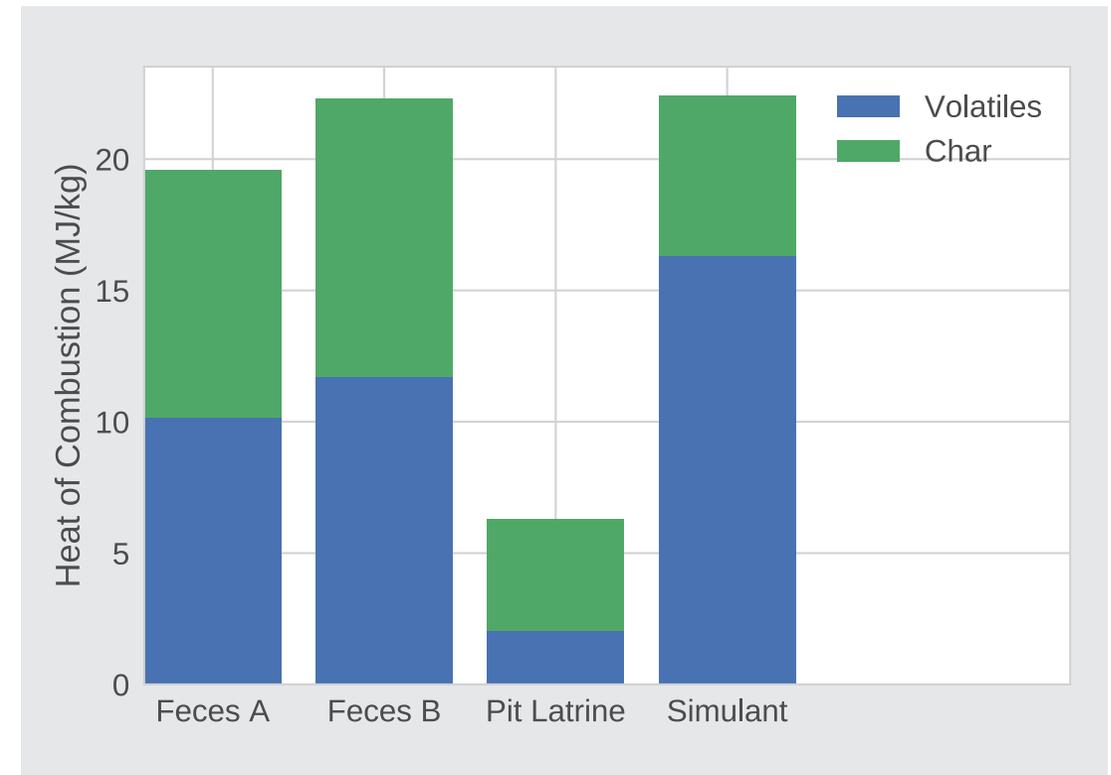
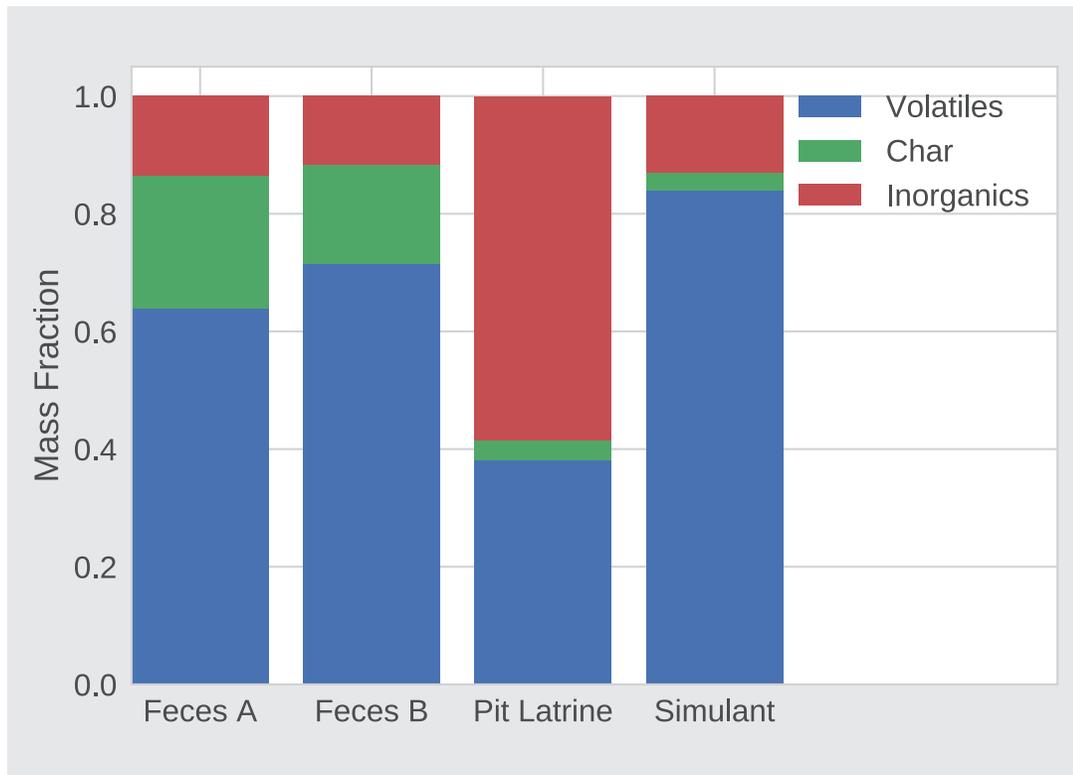
- ▶ Onabanjo, 2016



Onabanjo, T., Kolios, A. J., Patchigolla, K., Wagland, S. T., Fidalgo, B., Jurado, N., ... Cartmell, E. (2016). An experimental investigation of the combustion performance of human faeces. *Fuel*, 184, 780–791.

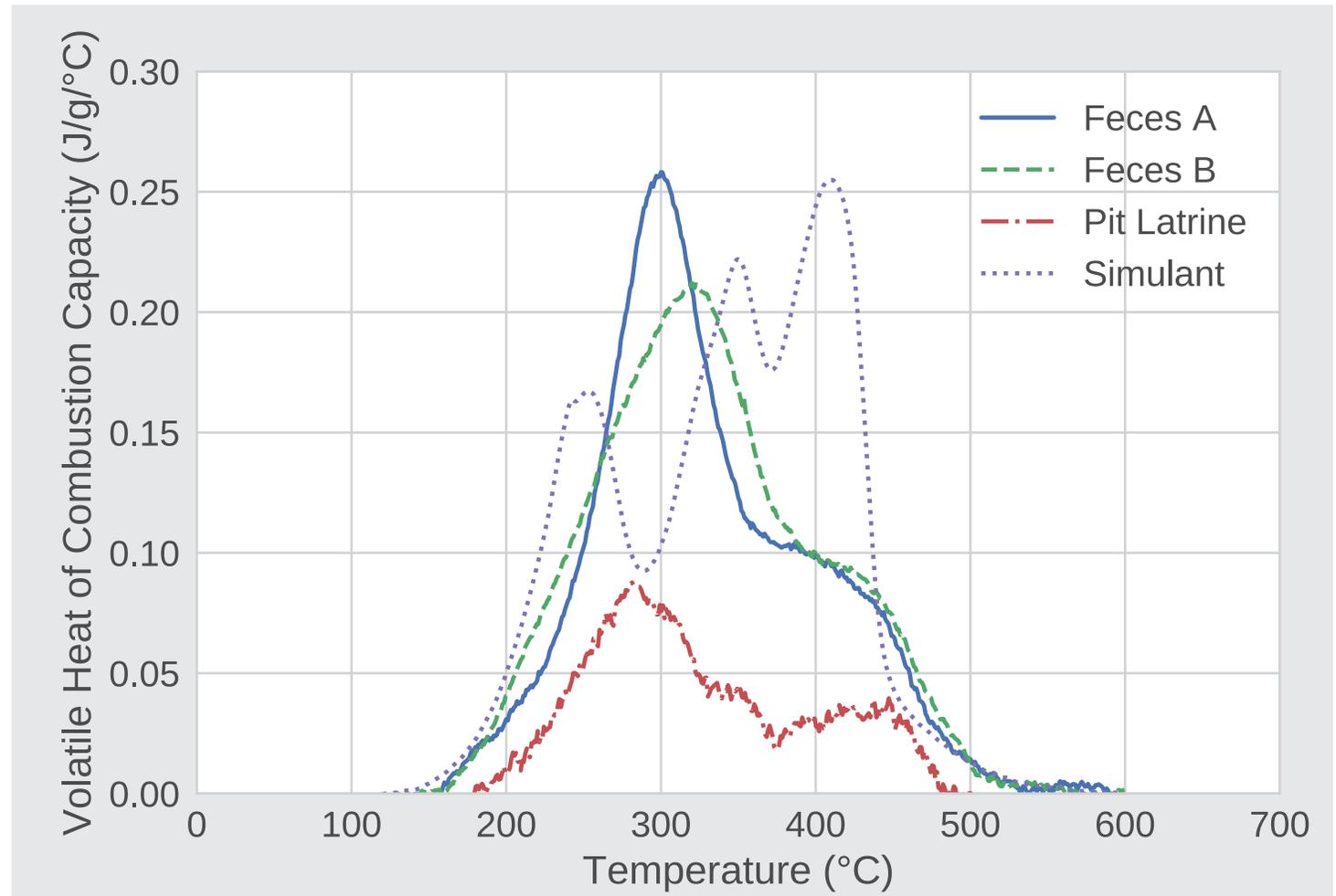
Results | Mass Fraction and Energy Content

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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ACKNOWLEDGEMENTS

Fernando Montoya, University of Maryland | Graham Miller, Duke University

Brian Stoner, Duke University | Brian Hawkins, Duke University | Santiago Septien, UKZN

