Fecal Sludge as a Solid Fuel: Exploring Byproducts of the Sol-Char Sanitation System

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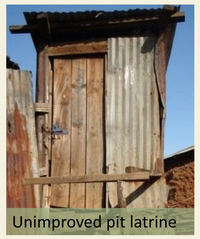
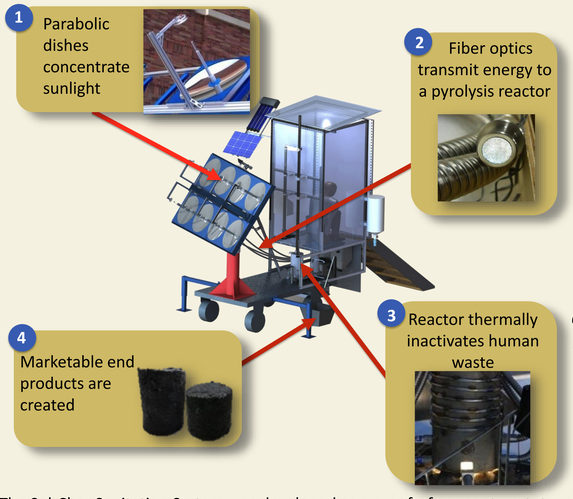
The Problems

- 2.5 billion people (40% of the global population) lack access to basic sanitation, and about 1.1 million still practice open defecation[1]
- Diarrhea kills more than 1.5 million people every year[1]
- 3 billion people, the great majority living in the least developed countries, are living in energy poverty with no access to affordable or healthy fuels[2]


Unimproved pit latrine


Rural women collecting firewood

The Sol-Char Sanitation Solution



The Sol-Char System creates usable products without grid energy, water, or sewage infrastructure by harnessing solar energy to power a high-temperature reactor that converts human waste to char.

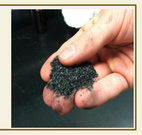
The Sol-Char Sanitation System was developed as a proof-of-concept prototype for the Bill & Melinda Gates Foundation Reinvent the Toilet Challenge. This prototype can process 2 kg of feces and 4 kg of urine with 4 hours of sunshine.

Marketable Byproducts of Sol-Char Waste Treatment

Soil Amendments

Dried Fecal Sludge
a safe-to-handle (disinfected) compostable material

Biochar
a soil amendment that increases yields in soils and improves poor, sandy, and acidic soils



Fertilizer

Nutrient Enriched Biochar
a fertilizer made by fortifying biochar with urine

Disinfected Urine
a ready-to-use fertilizer produced by thermally treating and disinfecting urine

Solid Fuels

Dried Fecal Sludge
an industrial fuel that requires less solar energy to produce and has a lower ash content

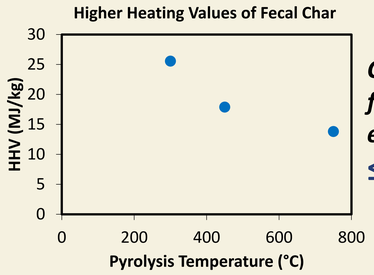
Charcoal Briquettes
a cooking fuel with an energy content comparable to traditional charcoals currently on the market

SOLID FUEL PRODUCTION is a lucrative way to offset the cost of sanitation systems in urban areas with an industry presence.

- Charcoal production for commercial and domestic cooking is a $10 billion industry in Sub Saharan Africa.[3]
- 45% of industry representatives interviewed in Kamapala would immediately adopt fecal sludge biomass providing it met their process requirements.[4]

Commercial/Domestic Fuels Evaluation:

Fecal Char Energy Content

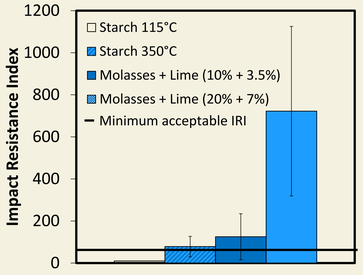


Char made from feces has an energy content **≤ 25.6 MJ/kg**

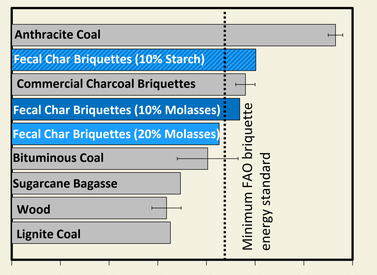

Char after a pyrolysis run

Fecal char produced at lowest pyrolysis temperature retains highest energy density

Fecal Char Briquettes



Impact Resistance Index (IRI) for human fecal char briquettes made from different binder configurations.



HHVs of common solid fuels and human fecal char briquettes manufactured in this study. Bars indicate range of reported values from literature.


Fecal char briquette

The strength and energy content of fecal char briquettes are competitive with commercial charcoal briquettes.

Next Steps: Briquette Cooking Emissions Study


Emissions testing facility at CU


Water boil test stove


Char briquettes

Finalizing updates to cookstoves emissions testing laboratory facility at CU Boulder

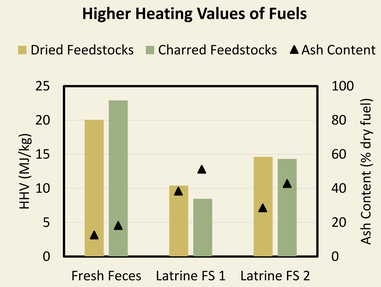
- Emissions testing underway to compare air pollution from burning fecal char briquettes to other solid fuels
  - CO, CO_2, PM (size distribution, heavy metals contents, ECOC)
- Water boiling testing in charcoal cookstove underway to compare fuel efficiency performance to other solid fuels
- Next, engineer briquette recipe to optimize durable, energy-dense, slow-burning fuel

Briquettes on an Indian cookstove

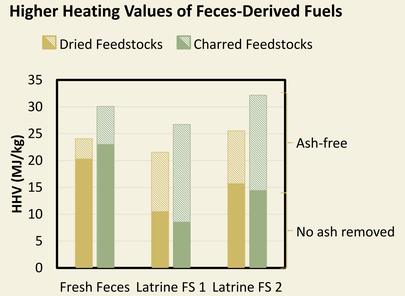
Industrial Fuels Evaluation:

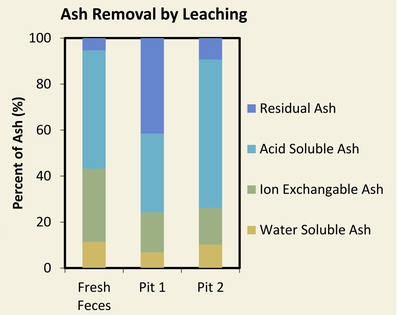
Dried Fecal Sludge vs. Fecal Char

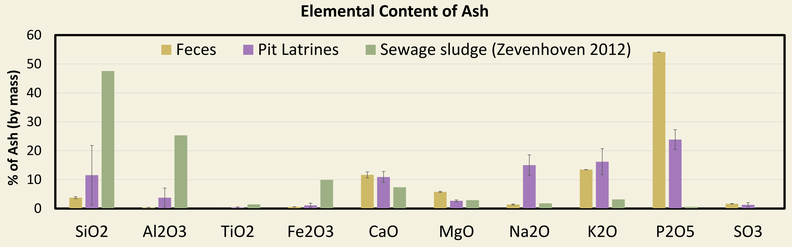
- "Fresh" feces has a higher energy content than pit latrine sludge
- Charring fresh feces improves energy content, but charring does not improve HHV of more degraded sludge
- Large variability in fecal sludge fuel characteristics



The Ash Content Issue







Next Steps: Kampala FS Study

- Repeat fuel analysis and ash speciation on fecal sludge samples collected from vacuum trucks in Kampala, Uganda
- Make recommendations for best pre-treatment methods to maximize fecal sludge fuel value

References

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2. WHO UNDP. *The Energy Access Situation in Developing Countries*, WHO: Geneva, Switzerland, 2009.
3. Schlag N, Zuzarte. *Market barriers to clean cooking fuels in Sub-Saharan Africa*, Working Paper Stockholm Environment Institute, 2008.
4. Gold M, Murray A, Niwagaba Ch, Niang S, Strande L. Faecal Sludge – From Waste to Solid Biofuel?, Sandec News 14, 2013.

Acknowledgements

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