



# Smoldering and catalytic conversion for fecal sludge

## Reinvent the toilet project

Samoil Vohra, Shadi Saberi, Kasra Samiei,  
Ewa Iwanek, Steven Le, Saad Ali and Yu-Ling Cheng

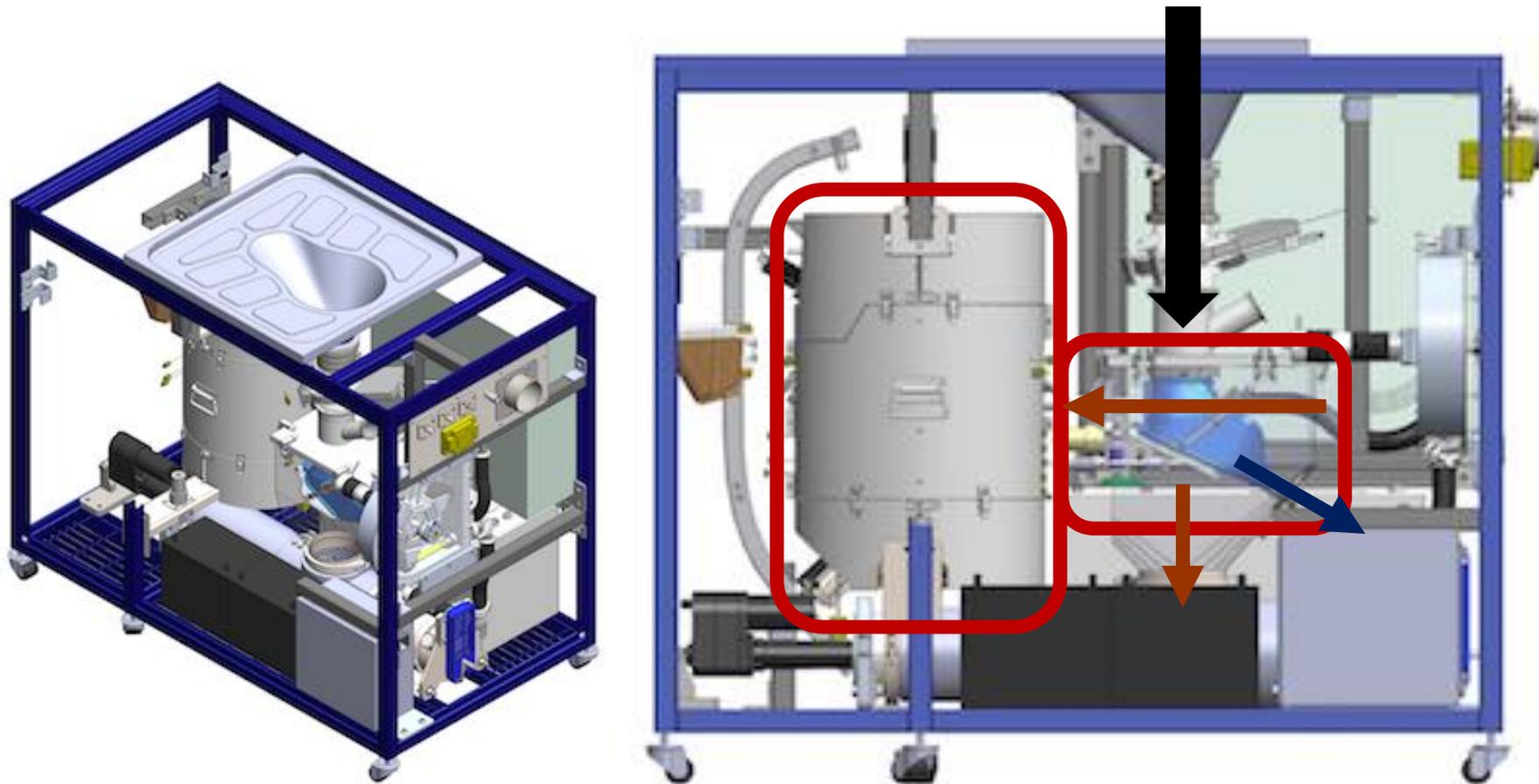
## University of Toronto



UNIVERSITY OF  
TORONTO

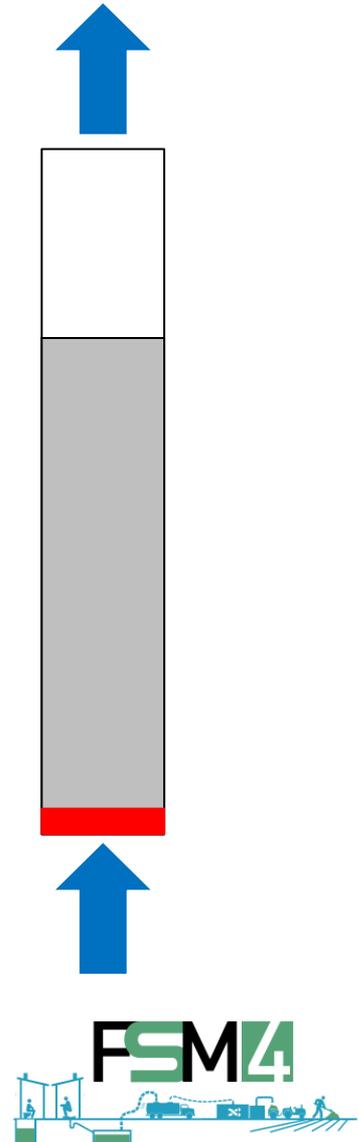


# Automated & integrated household processing unit



# Treatment processes

- ❑ Solid waste combusted by smoldering
  - ❑ Oxygen limited
  - ❑ Analogous to a burning cigarette
- ❑ Liquid waste is heated to over 75°C for 20 minutes for pasteurization
  - ❑ At 70°C, residence time in order of few minutes is sufficient to kill 6 logs of Helminth eggs

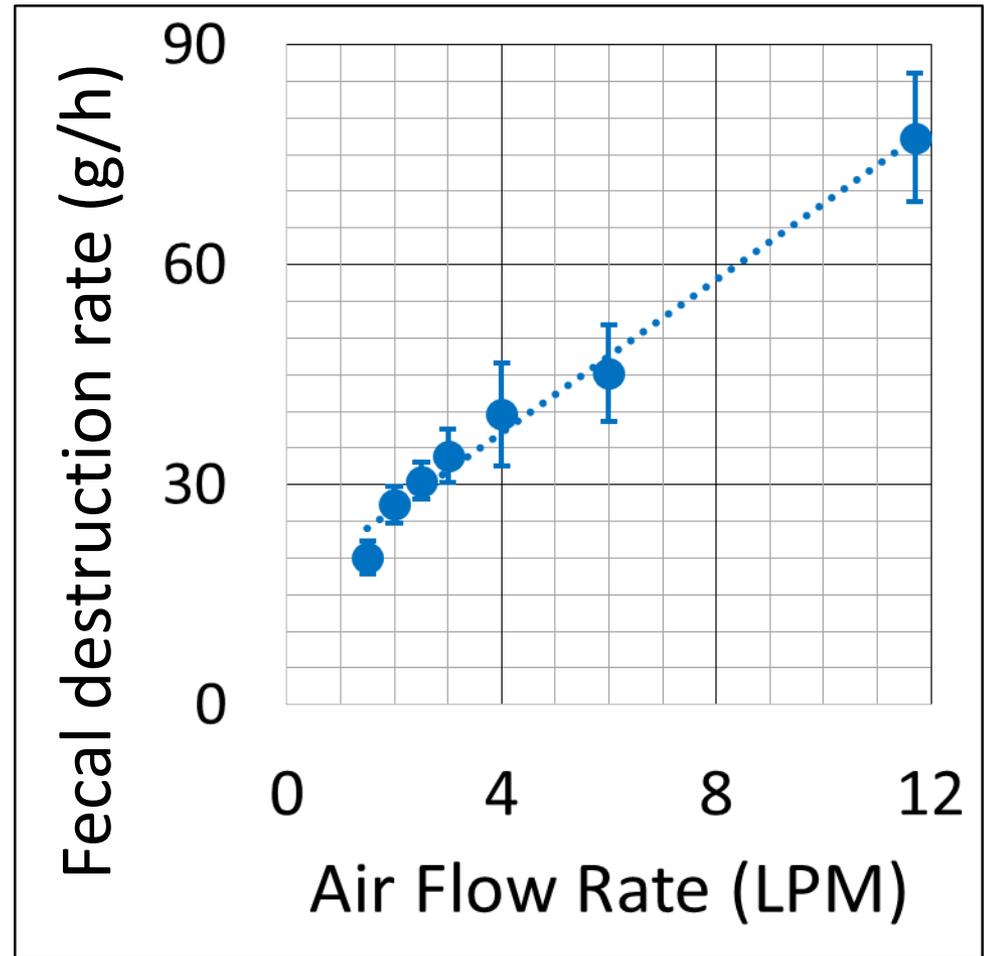


# Challenges of household scale solution

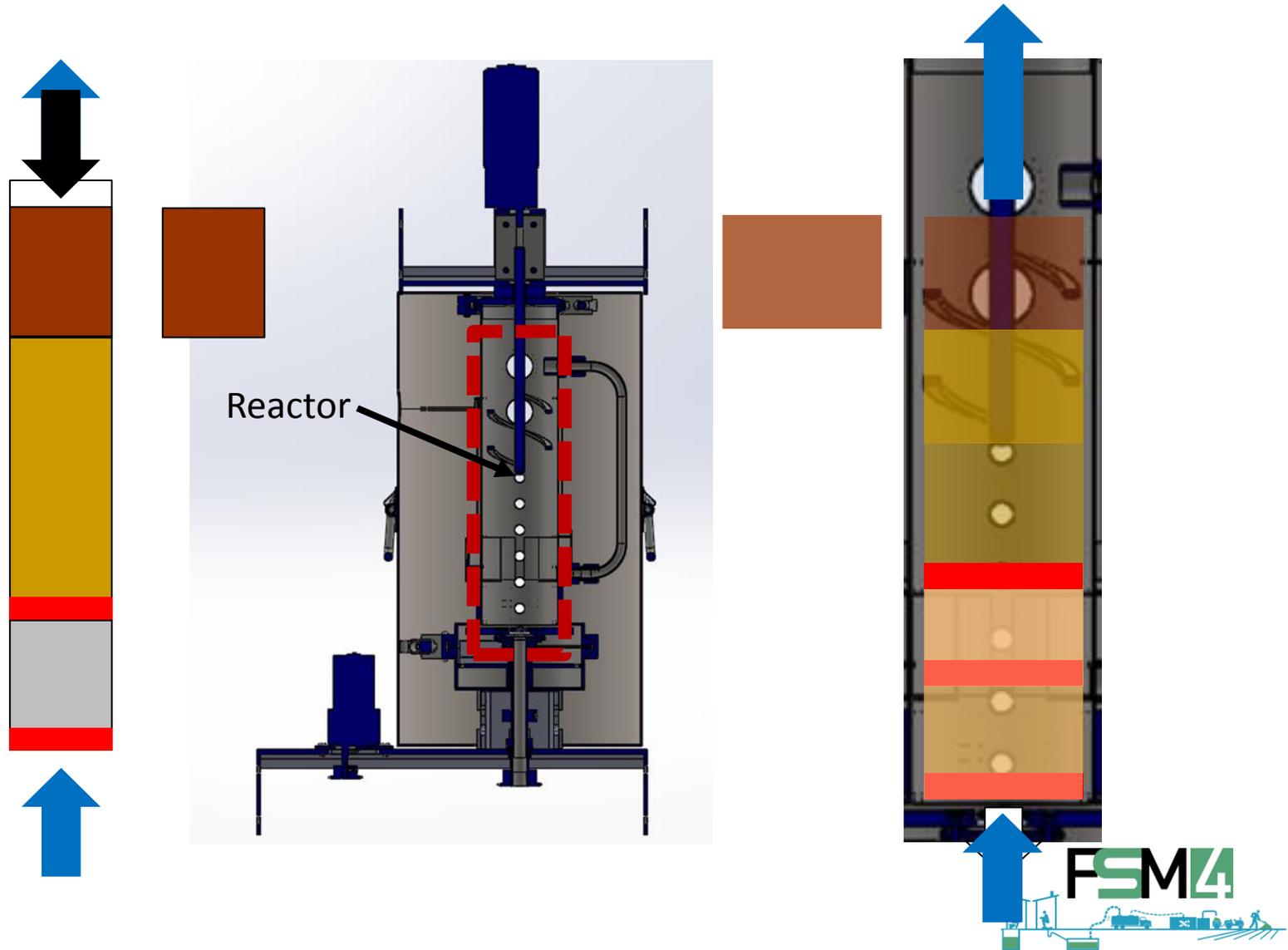
- ❑ Low processing rate
- ❑ Variability proportionately more pronounced at small scale
  - ❑ E.g. wedding scenario
- ❑ Energy efficiency
- ❑ Users, not operators or maintenance workers

# Self sustaining processing rates

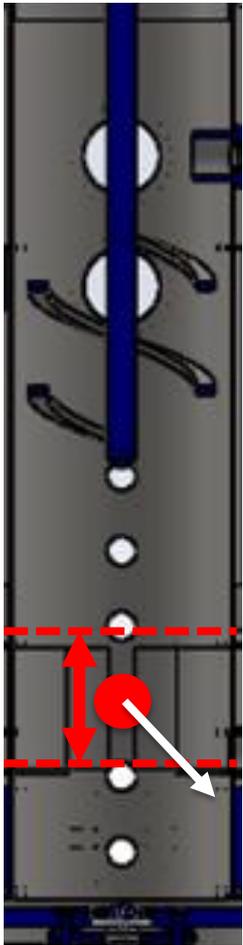
- ❑ Primary control parameter is airflow
- ❑ 10-200g/h processing rates demonstrated
  - ❑ Required rate of 3 g/h pp
- ❑ Accommodates variability in input rates



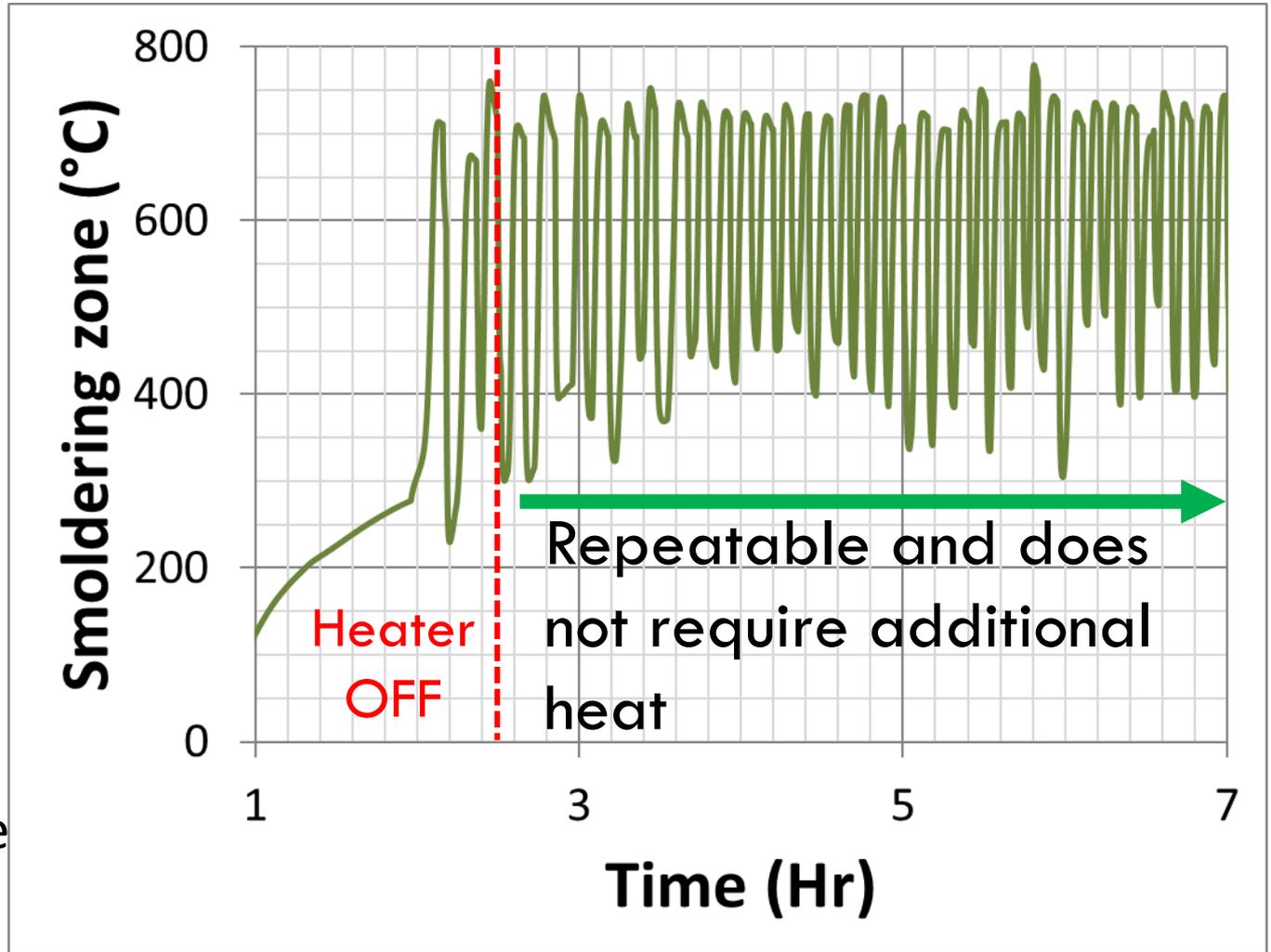
# Continuous smoldering



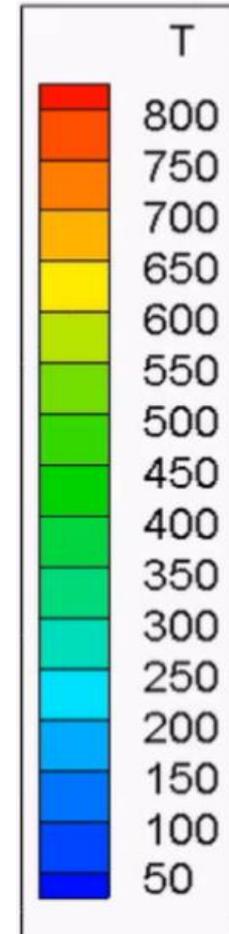
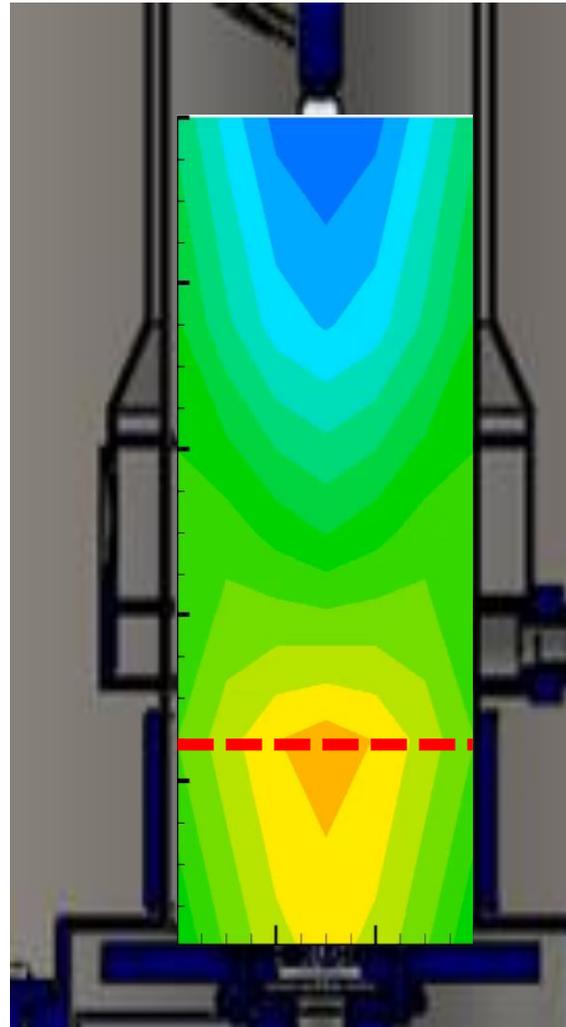
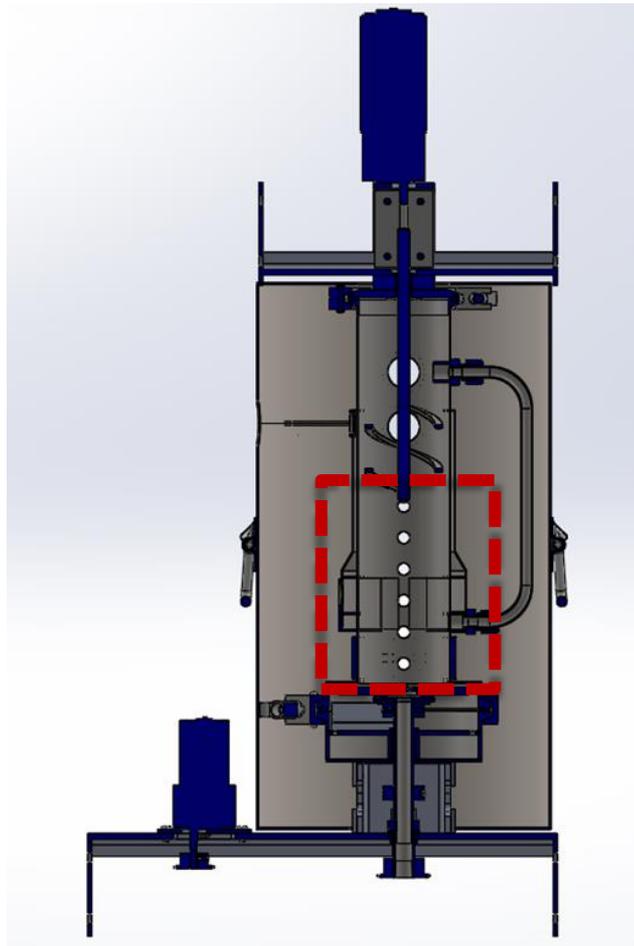
# Continuous cyclic operation



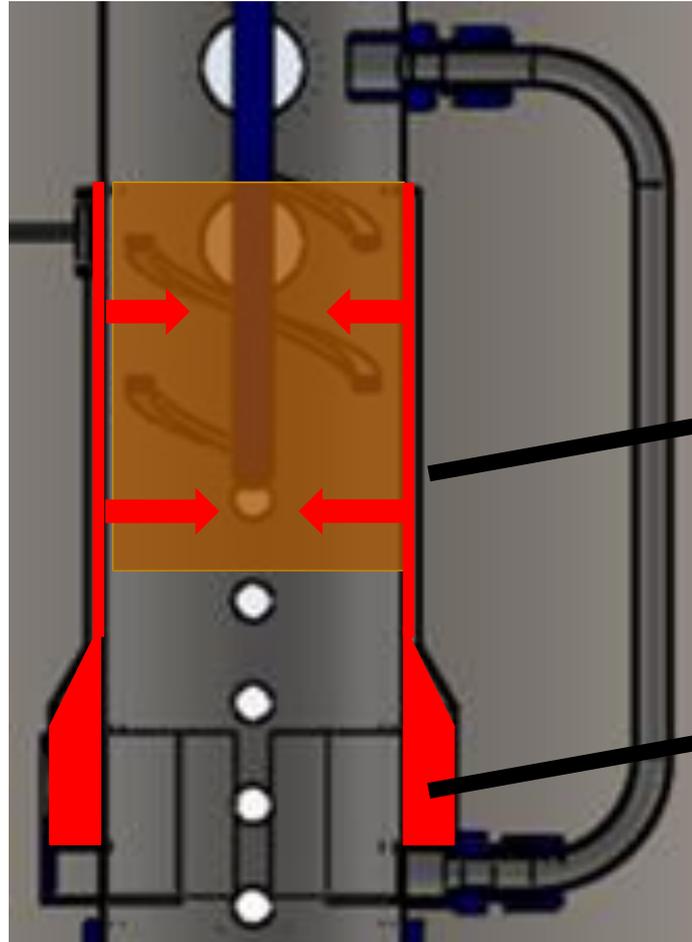
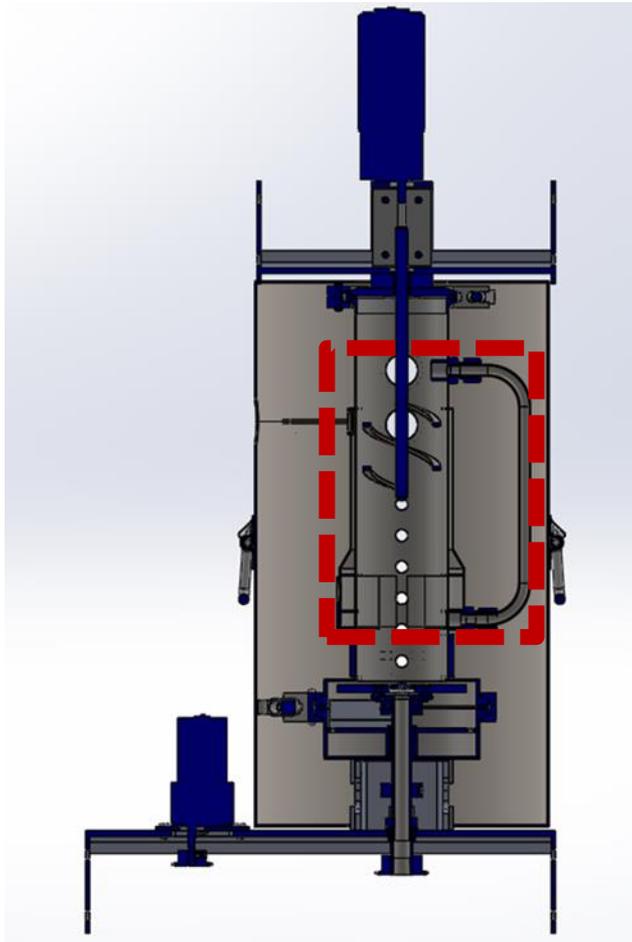
TC  
Probe



# Continuous cyclic operation



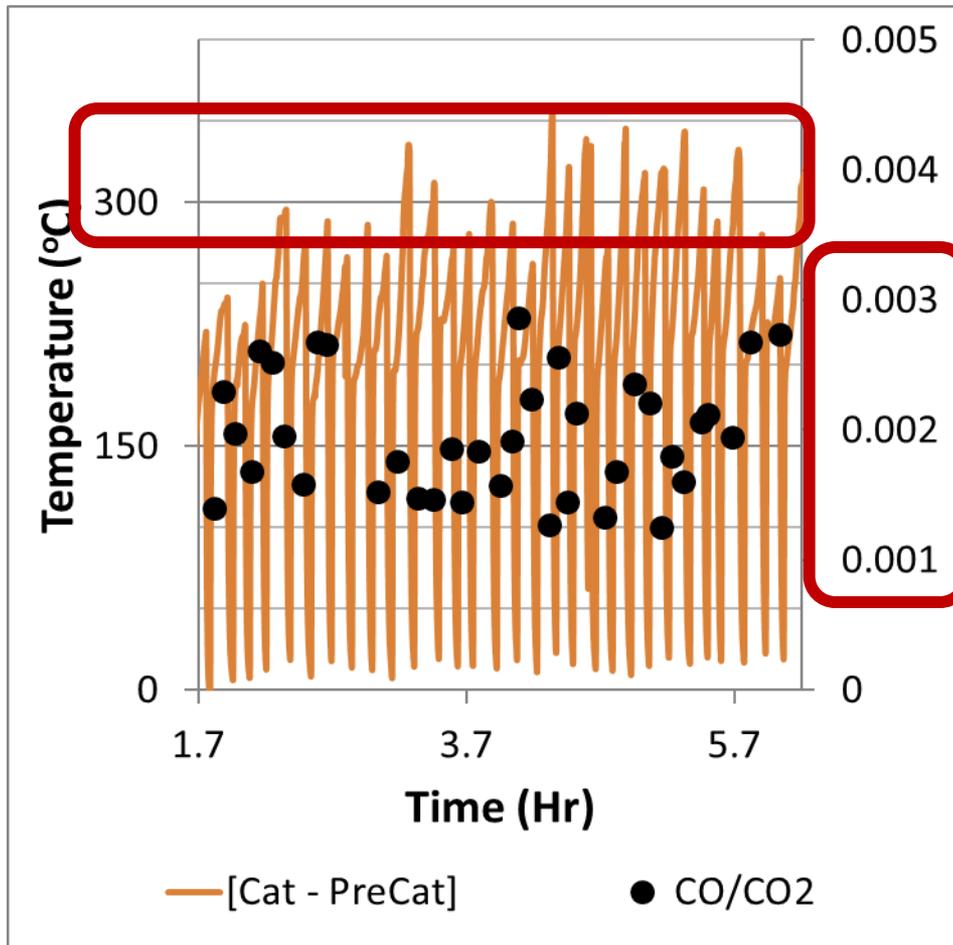
# Catalyst module



Heat exchanger

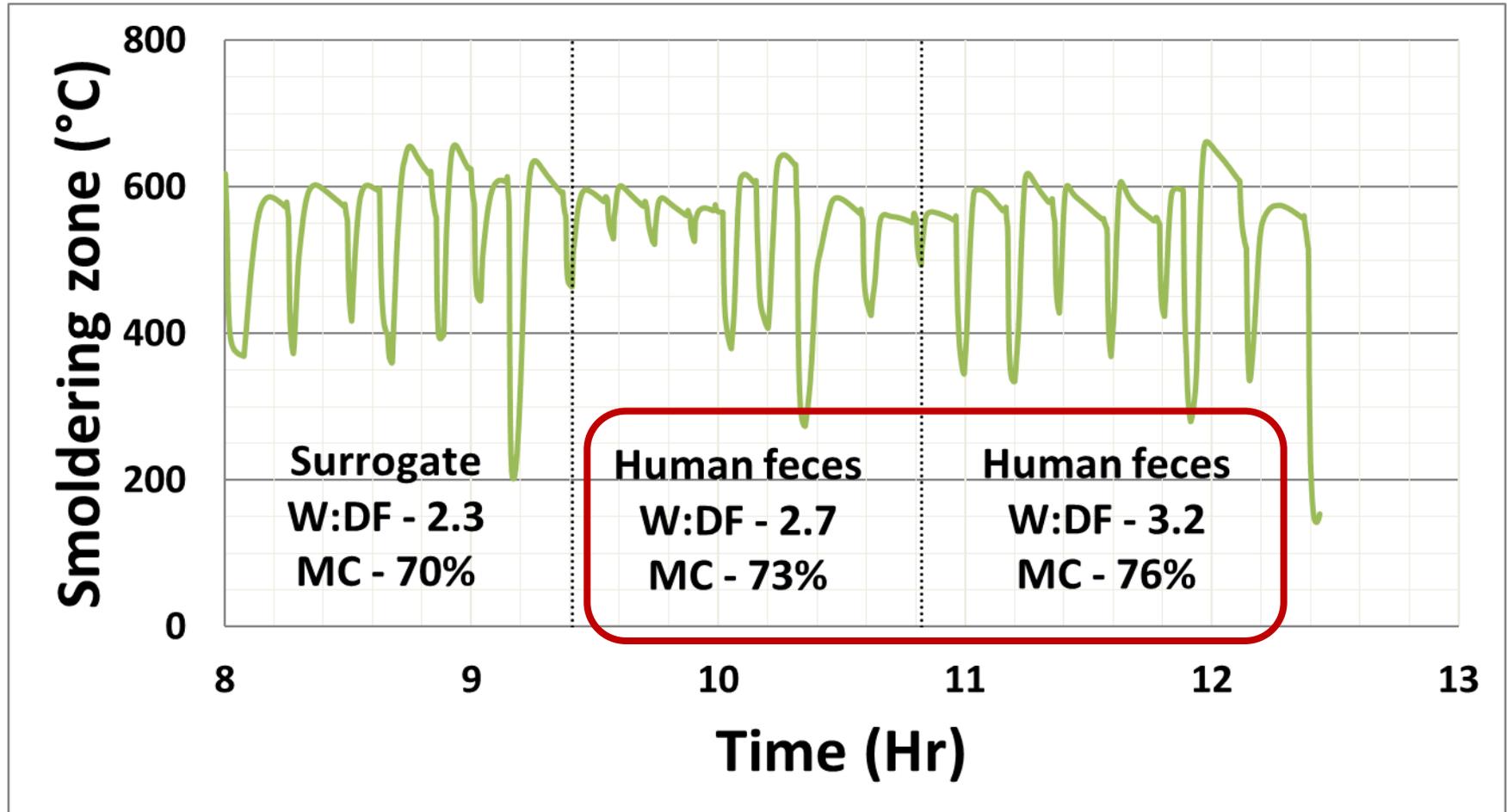
Catalyst module wrapped around reactor

# Catalytic oxidation of flue gases

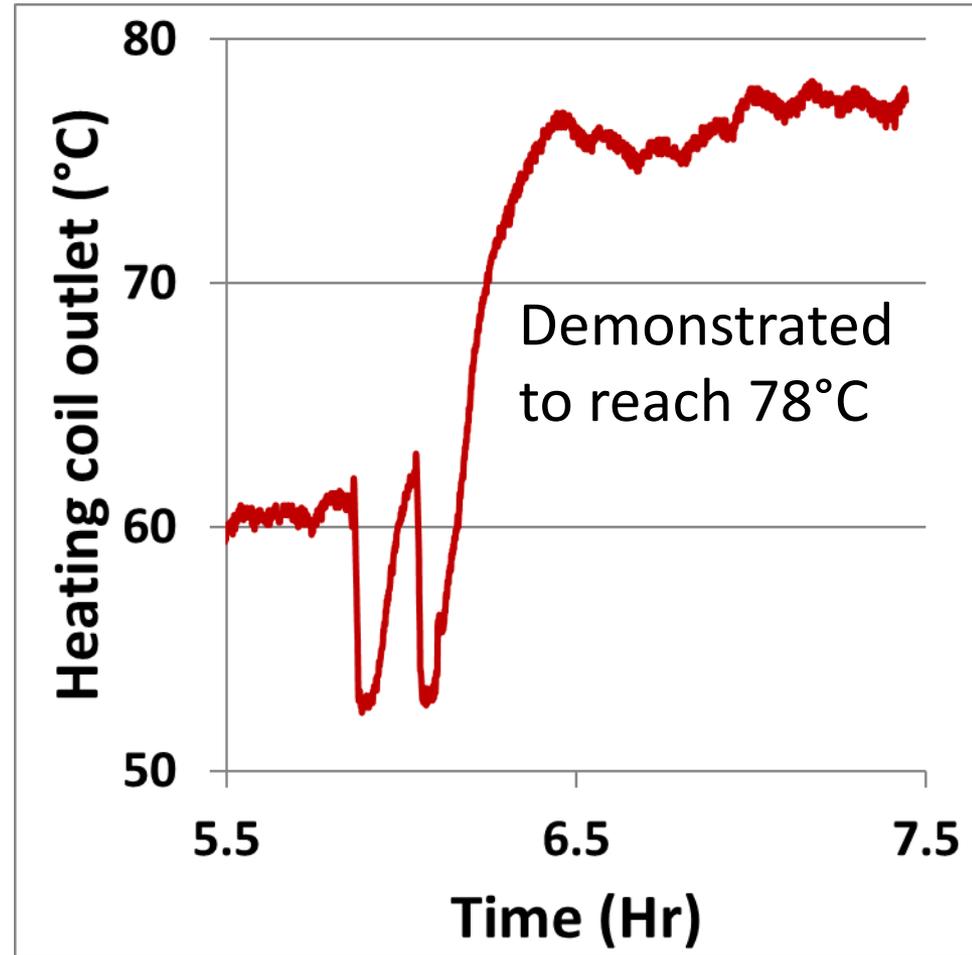
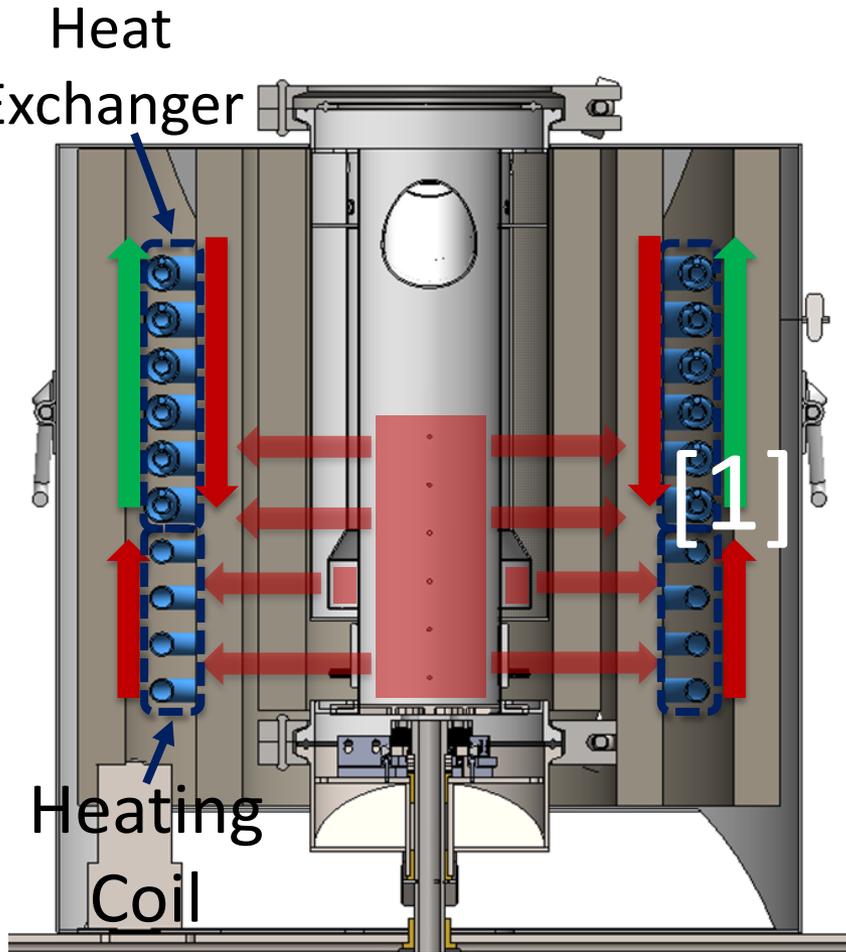


- $T \uparrow$  by up to 300°C across catalyst
- $CO/CO_2 < 0.003$
- $[CO]$  between 100 to 300 ppmv

# No pre-drying step for human feces processing



# Liquids treatment



# Challenges of household scale solution

- ❑ Low processing rate & variability in fuel input
  - ❑ Demonstrated 10-200g/h operating range with easy controllability
- ❑ Energy efficiency at smaller scale
  - ❑ Reduce energy consumption
  - ❑ Maximize heat generation and its effective use to process human feces without pre-drying
- ❑ Users, not operators or maintenance workers
  - ❑ Automated process control with one button startup and shutdown
  - ❑ Periodic ash removal





# Questions?



# Extra slides



# Energy efficiency summary

- ❑ Incineration of solids through continuous smoldering
- ❑ Catalytic oxidation of smoldering by-products
- ❑ In situ drying of untreated human feces
- ❑ Radial heat transfer used to treat Liquid waste

# Daily material flow per person

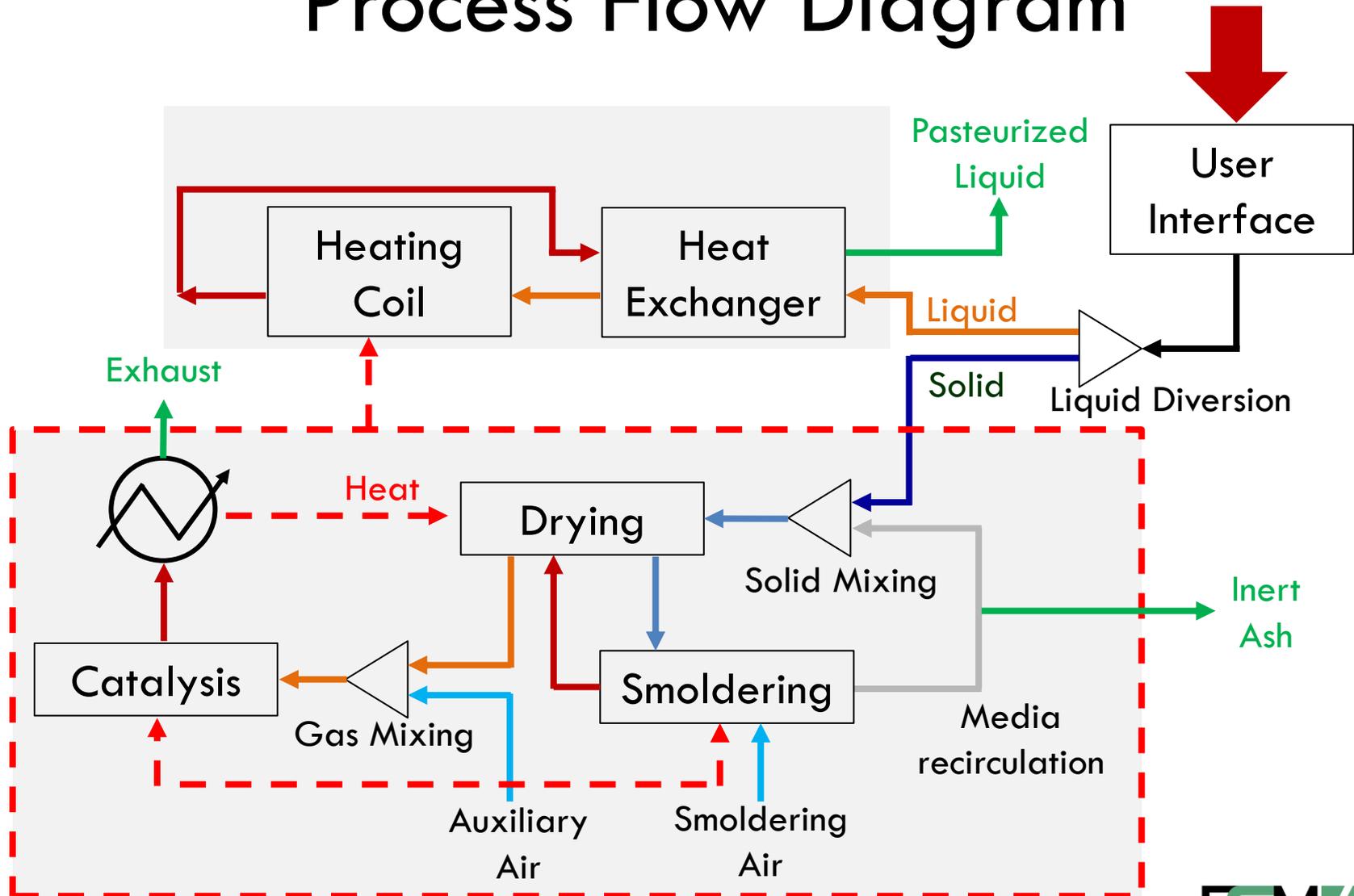
mass (g)

Feces		300
	Dry solids	75g
	Fecal water	225g
Urine		1500
Wash water		1000 to 3000
Total solids		75
Total liquid		2725 to 4725

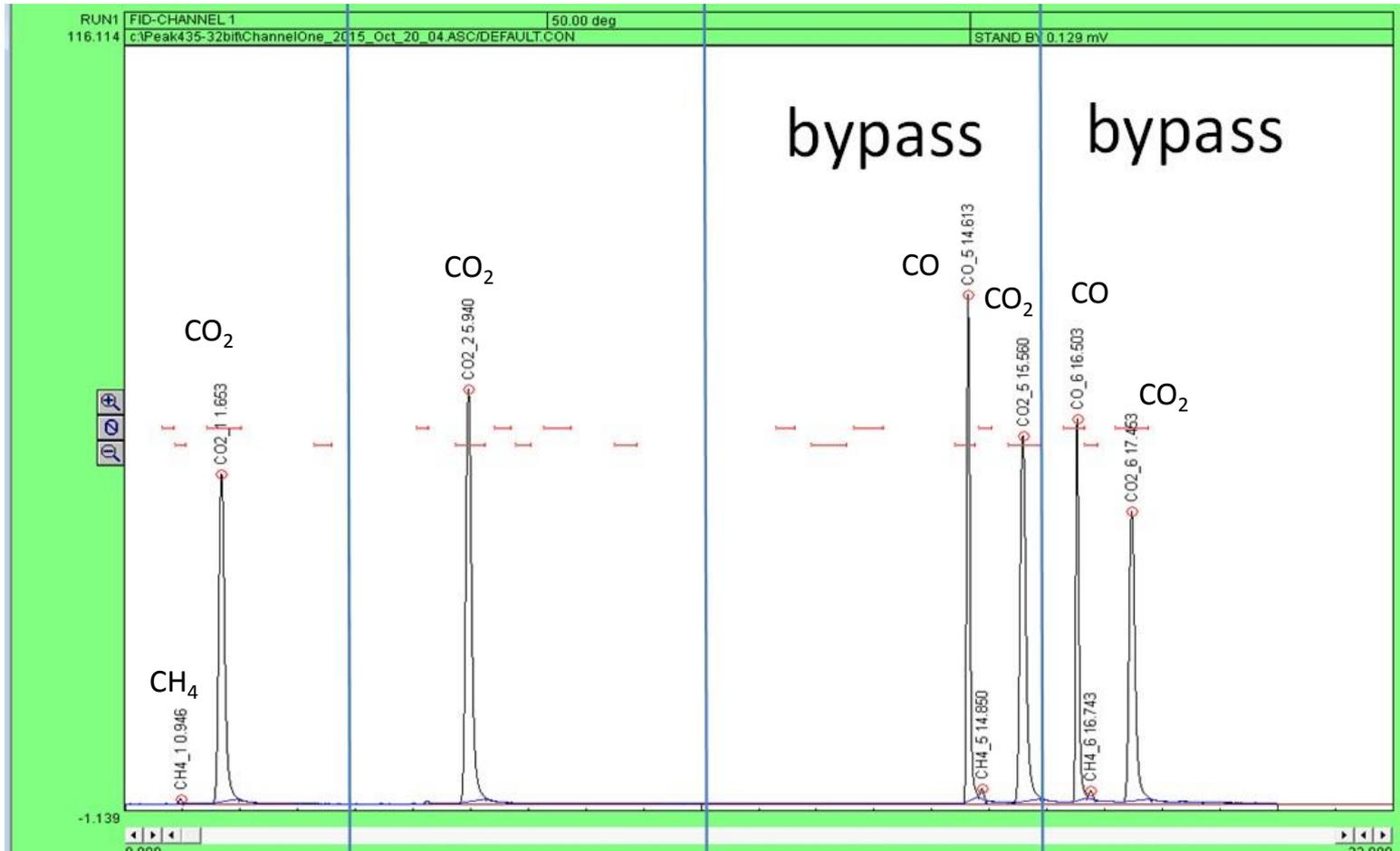
Working value for design



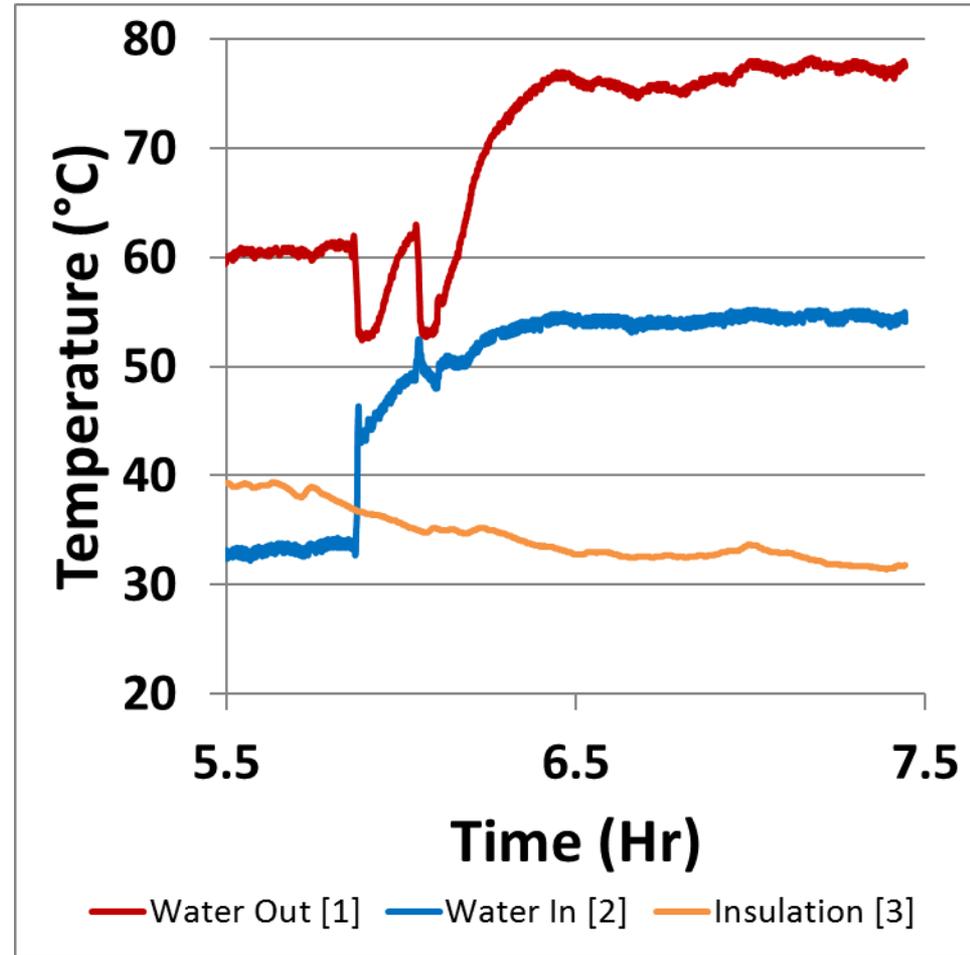
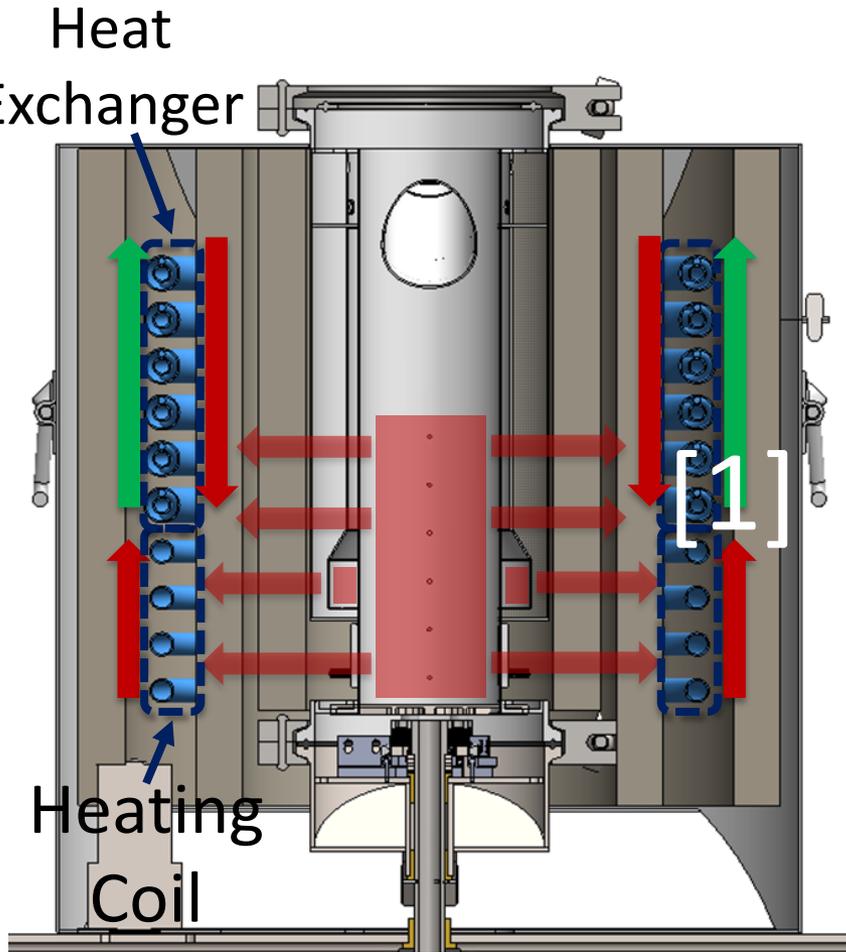
# Process Flow Diagram



# Emissions Before and After Catalyst



# Liquids treatment



# Liquids treatment

## □ Liquids treated through pasteurization

- At 70°C, residence time in order of few minutes is sufficient to kill 6 logs of Helminth eggs

