Odors and FSM: Impacts and How to Deal with the Stench

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Is Odor the Elephant in the Room?

Outline

- Odor measurement and control
- Our survey of odor issues in FSM
- Fecal odor control using biofilters
- Bioaerosols in FSM… should we worry?
- Conclusions

Odor Measurement

Odor can be quantified by **Dilution-to-Threshold** (D/T) method
D/T = number of dilutions required to reach the detection level
(Other methods are used to describe sensory aspects)

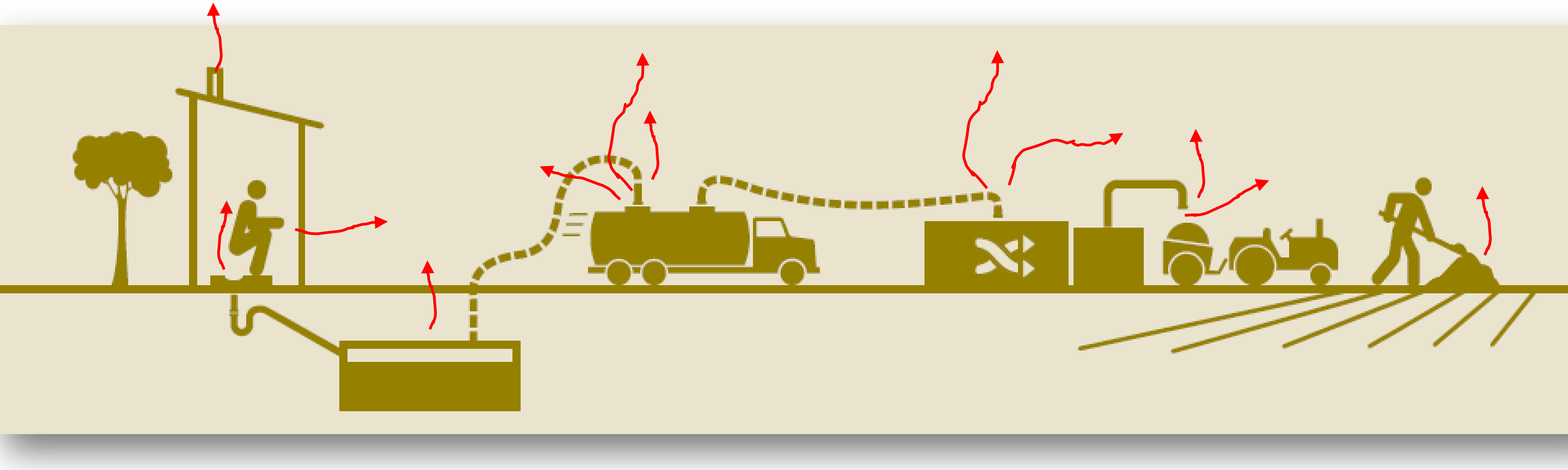
Field and lab olfactometry

Around sewage treatment plant: 100-300 D/T
Process air sewage treatment: 1000-5000 D/T
Very bad public toilet: 200-5000 D/T
Rendering plant process air: >1,000,000 D/T

A few odor thresholds:

Skatole: 0.002 - 50 ppb_v
Indole: 0.5 - 2 ppb_v
H_2S: 0.5 - 3 ppb_v
Butyric acid: 0.1 - 20 ppb_v
Methylamine: 1 - 50 ppb_v
NH_3: 5000 - 20,000 ppb_v

Odor Emissions – Odor Control Approaches



Odor Control Methods

Prevention
Avoid formation or release

Control
Capture
Destruction
Transformation

Sensory Methods
Masking
Interference

Our odor survey showed that malodor is a critical issue in FSM

~260 responses from a variety of people around the world: 57 countries
Top 3: India, Kenya, Uganda = only 23% of responses

How important is malodor as a barrier to toilet/latrine adoption?

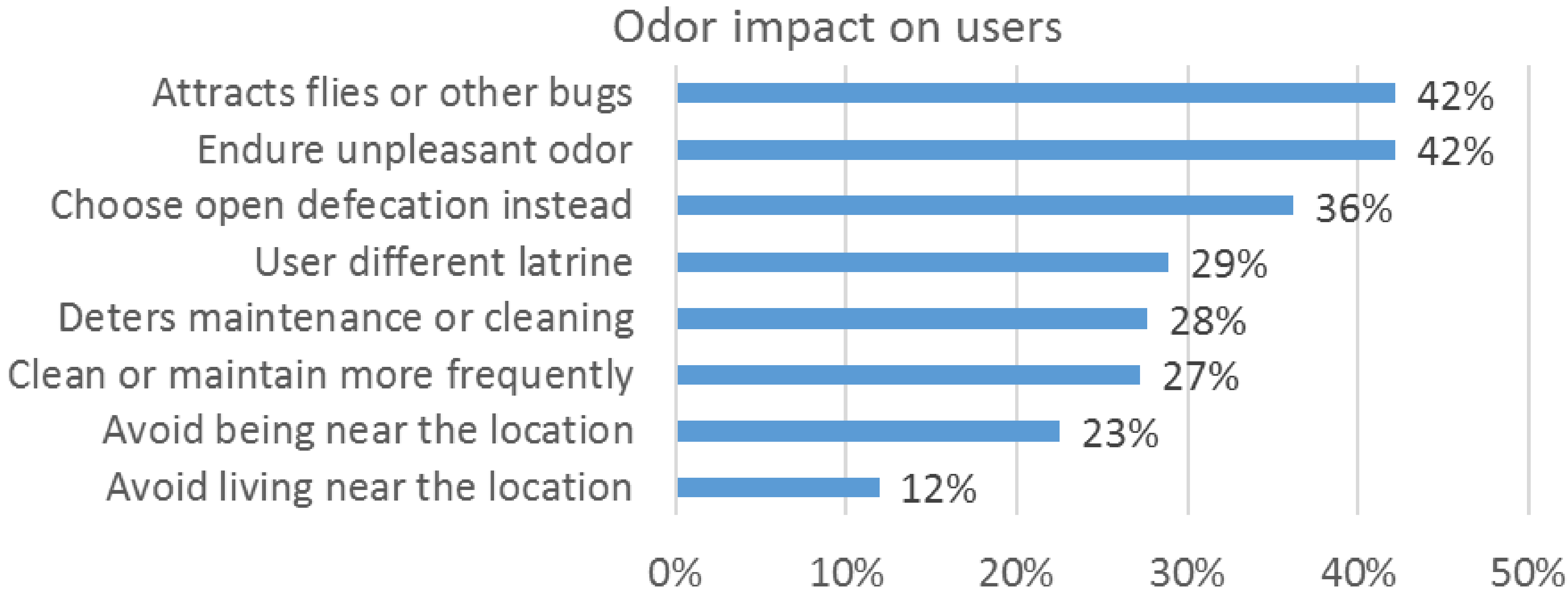
Answer		Response	%
Irrelevant		1	0%
Not very important		12	5%
Important		124	50%
Very important		113	45%
Total		250	100%

95% (Important + Very important)

See full survey report at http://tinyurl.com/FSM-odor-report

FSM4

Malodors have a significant impact on behavior and toilet use



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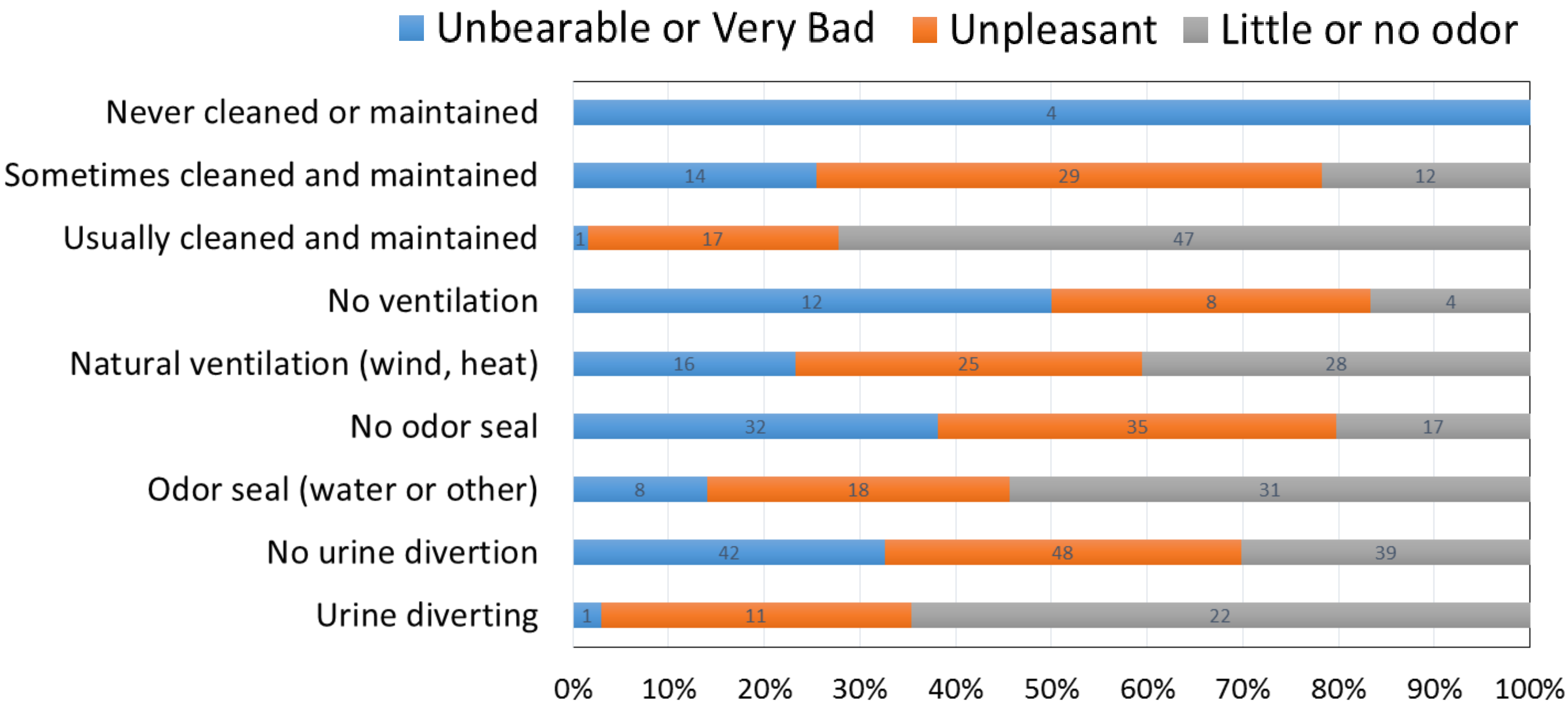
Toilet or latrine odor vs. characteristics



- Ventilation, cleaning, odor seal and urine diversion all play a role
- Urine diversion and cleaning perhaps most influential

See full survey report at http://tinyurl.com/FSM-odor-report

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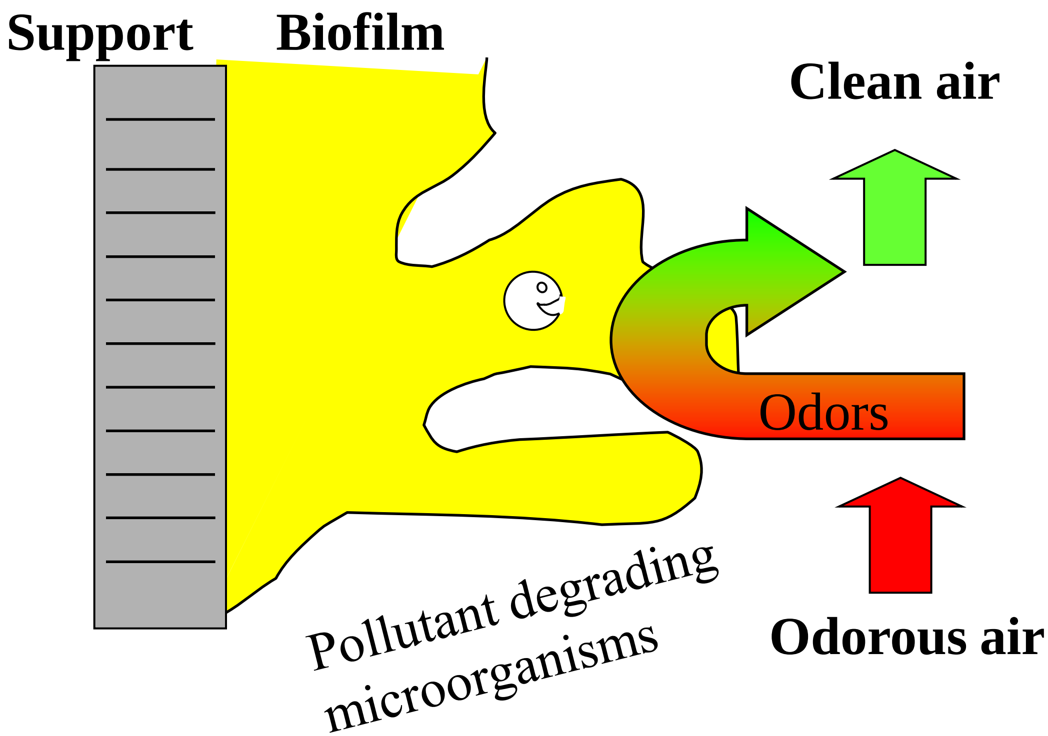
Biofiltration of fecal malodors

Pollutant, odor or air toxic +  ⟹ **Harmless end-products**

- Simple to build and operate
- Made of inexpensive materials
- Easily scalable



Lab-scale biofilters (10 L_{air}/min each)

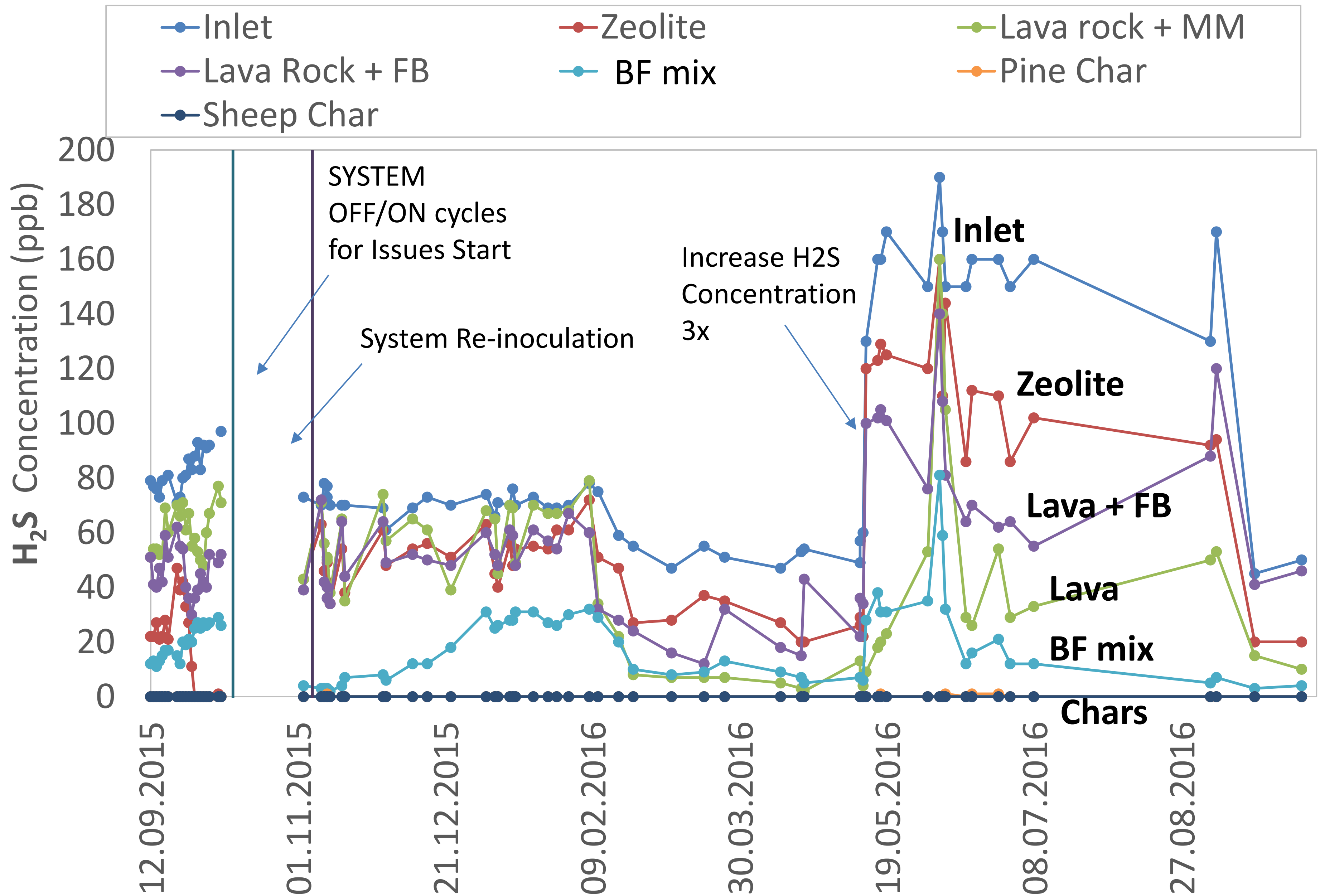
Continuous biofiltration of fecal malodors: Objectives

- Determine fecal odor removal efficacy
- Determine effect of packings:
  - Zeolite
  - Lava rock (LR) w/ and w/o Febreze
  - Improved BF mix
  - Pine char
  - Sheep dropping char
- All inoculated with activated sludge
- Odor makeup very similar to field latrine

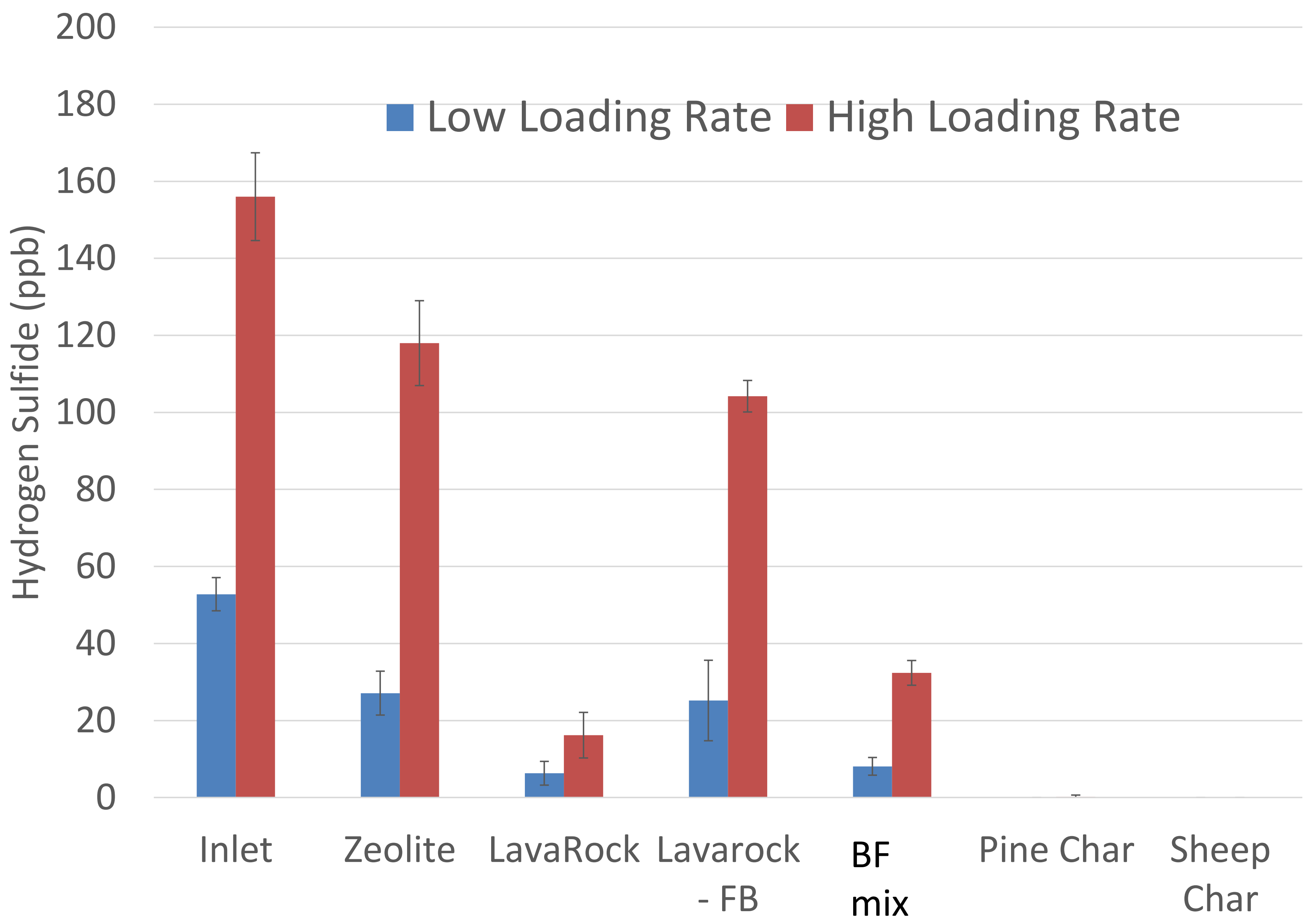
Flowrate each column	
Odorous air flowrate	11 LPM
Gas residence time	10 s
Concentrations (µg/L-air)	
Hydrogen sulfide	0.10
Butyric acid	0.0050
P-cresol	0.0030
Indole	0.00030

- ~1 year continuous operation with detailed monitoring
- Regular H_2S and olfactometry assessment

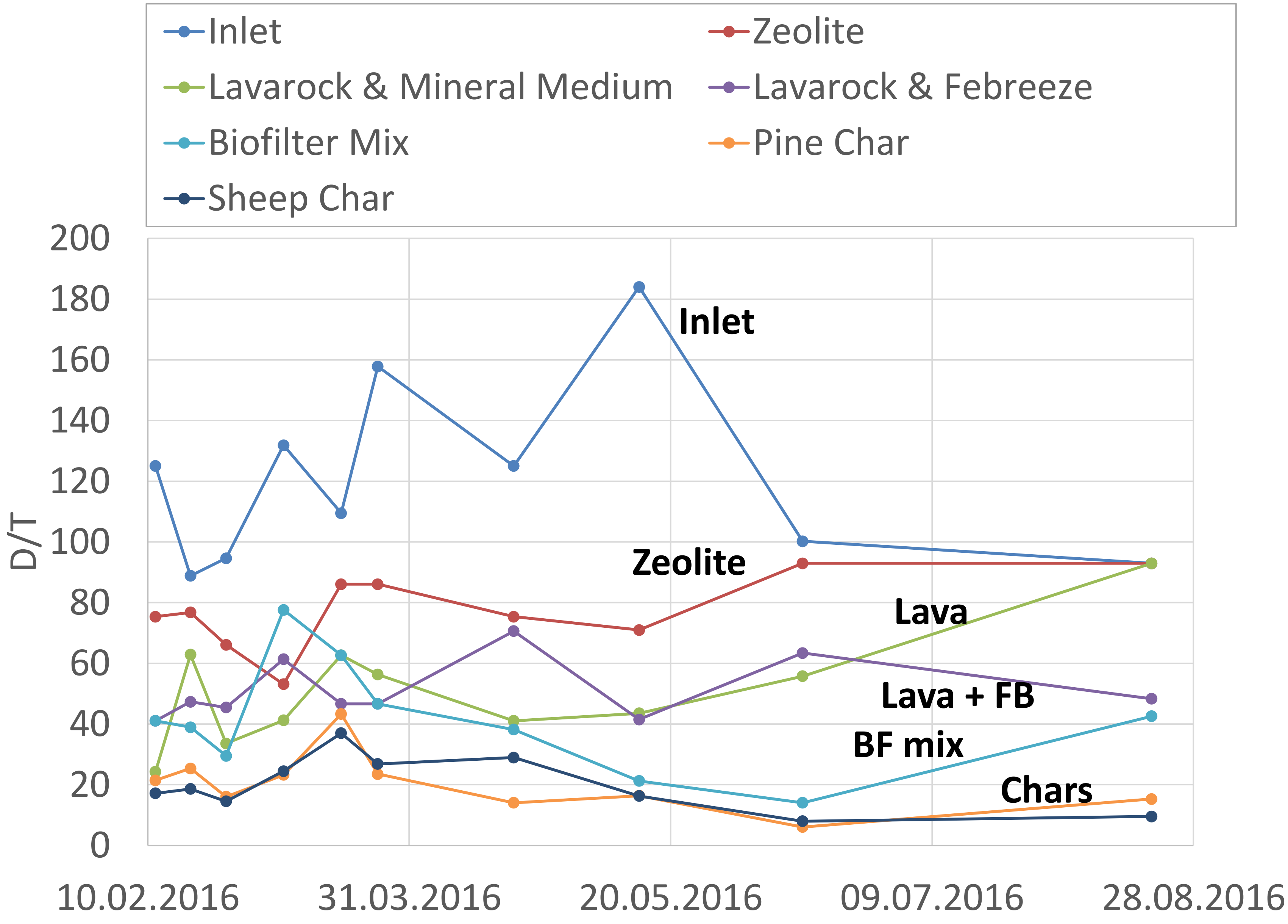
Biofiltration results: H_2S



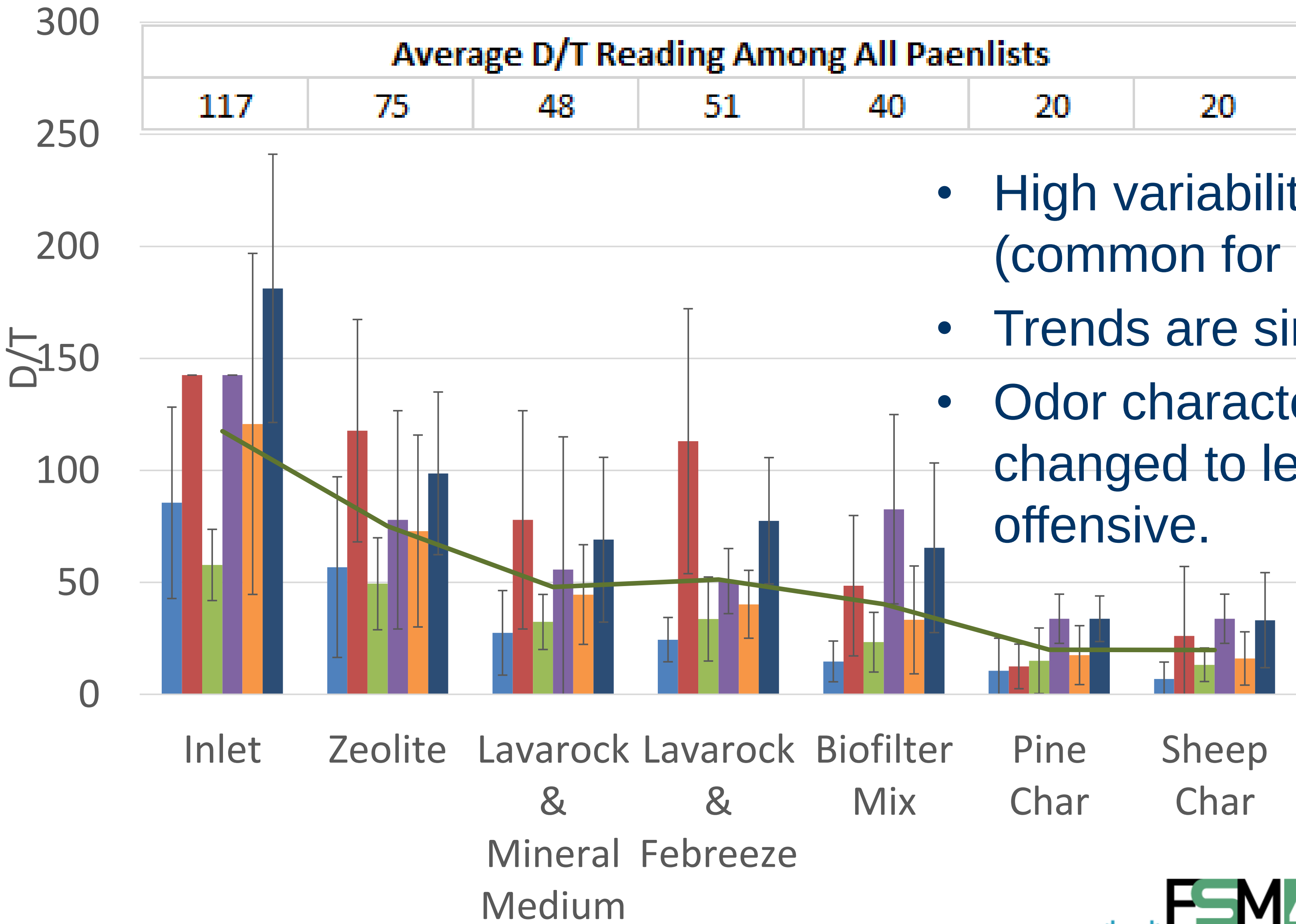
Biofiltration results: H_2S



Biofiltration results: Odor



Biofiltration results: Odor



Average D/T Reading Among All Paenlists						
117	75	48	51	40	20	20

- High variability (common for odor)
- Trends are similar
- Odor character changed to less offensive.

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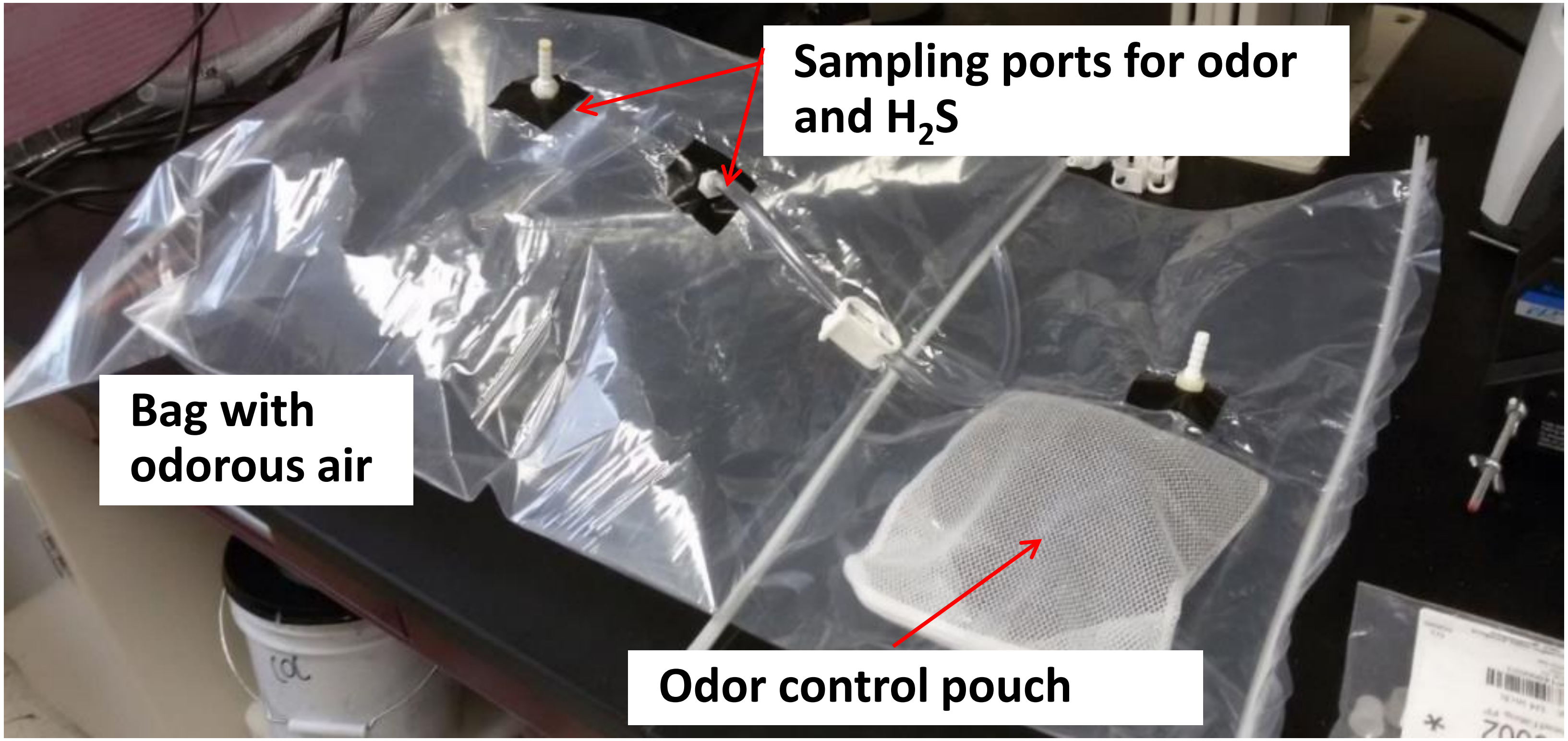
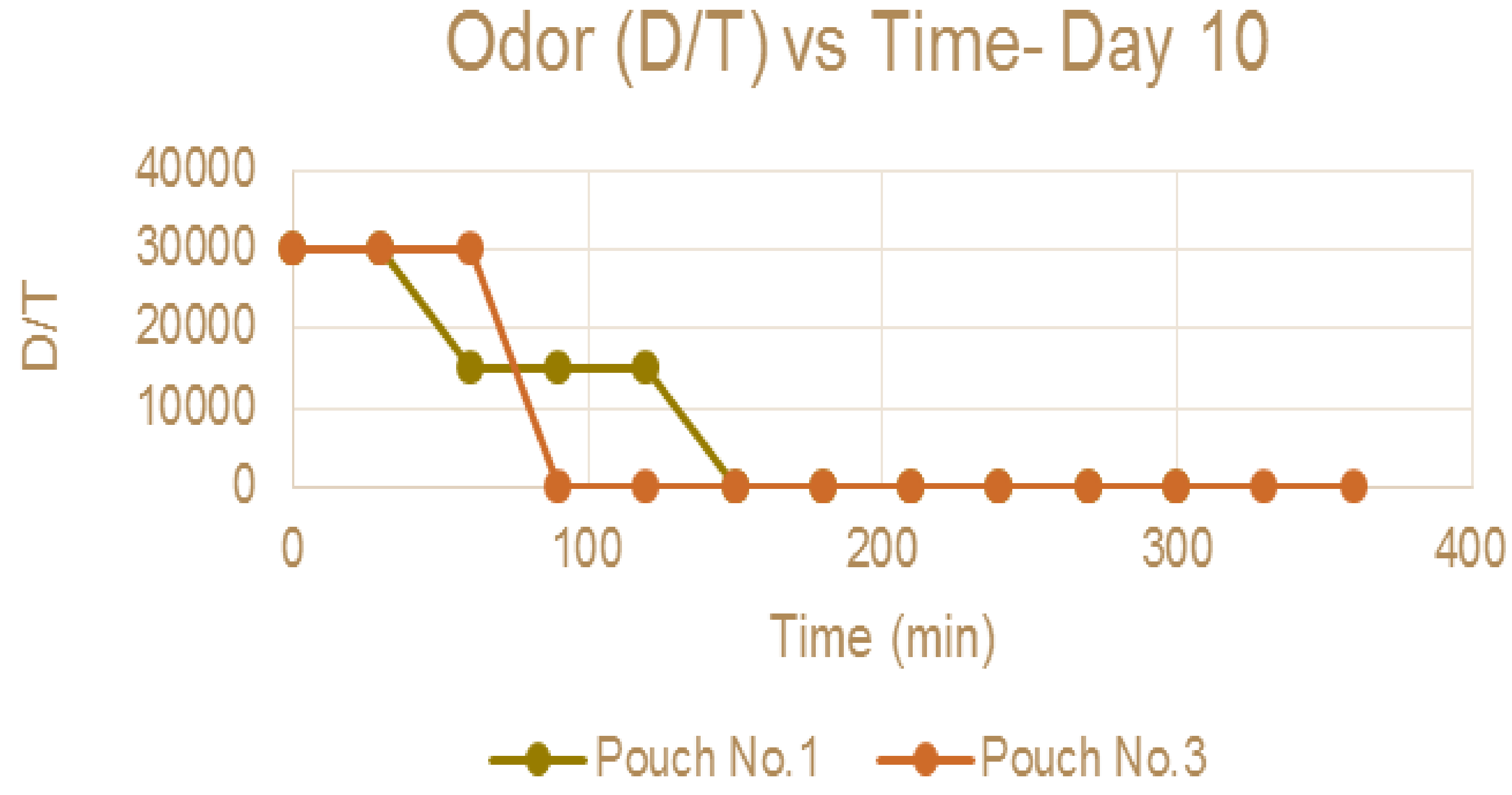
Static biofiltration = Odor control pouch… A versatile means to control odor?

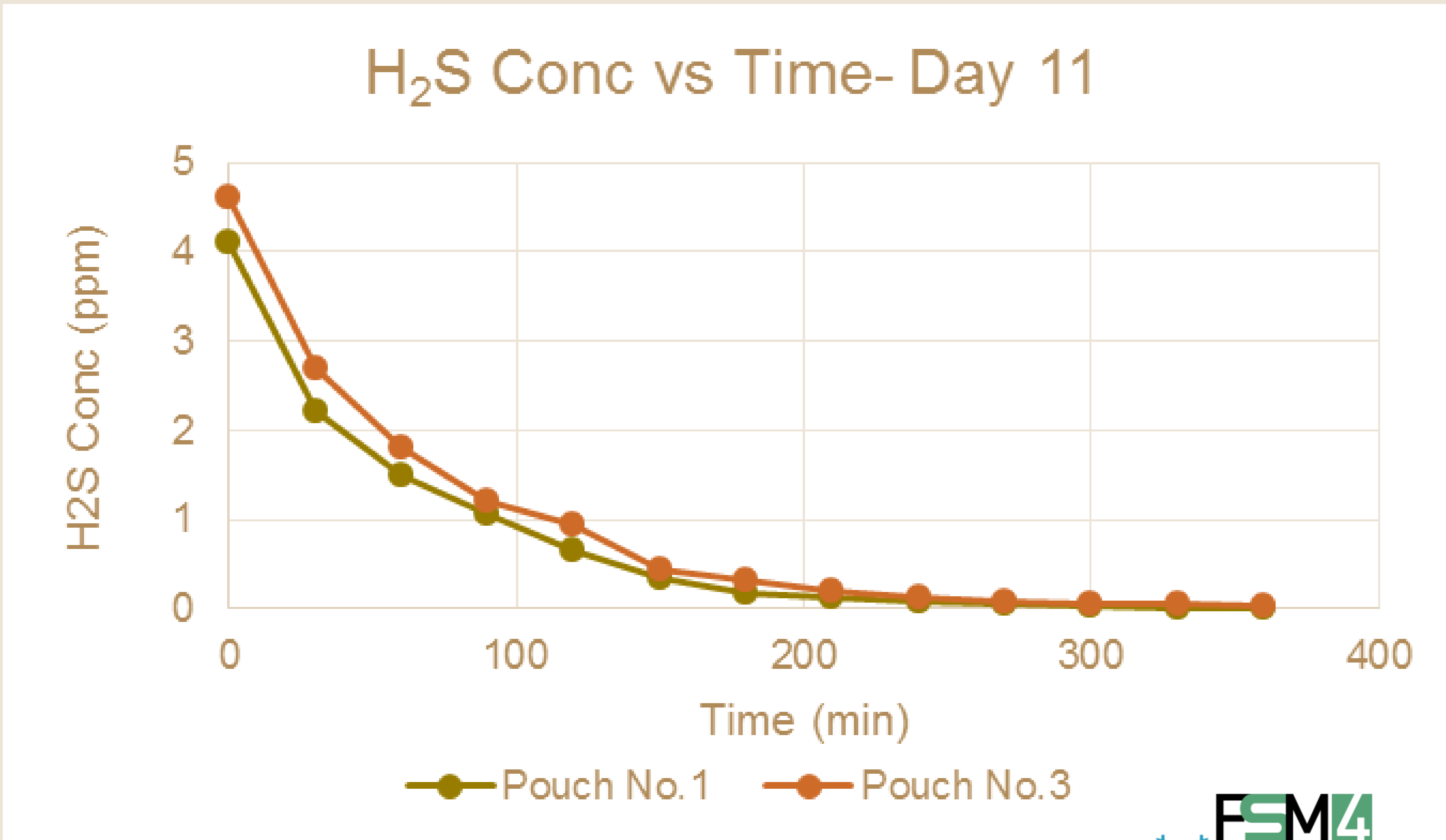
- **Idea: adsorbent and biologically active material in a pouch to remove odors where needed**
- Test pouch with different mixes (compost, bark, activated carbon, mineral nutrients, etc.) for the removal of fecal odor
- Odor mix: indole, butyric acid, p-cresol and H_2S



Typical results from static biofiltration Odor



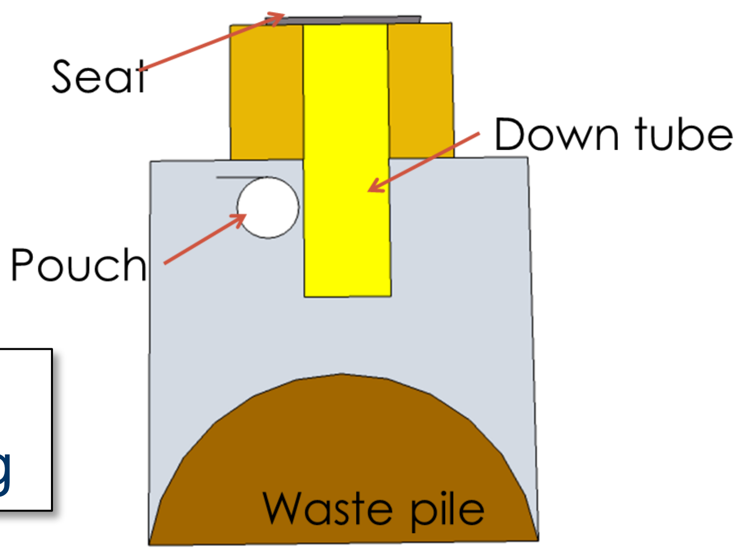
Typical results from static biofiltration H_2S



Odor control pouch: empirical evidence of odor control efficacy

We have used them in a variety of applications

- Odorant chemical storage in the lab
- Trash cans
- Effluent tank of anaerobic digester
- Outhouse near campus



We need more "real-life" testing

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Odor measurements in the field

At RTI's system, North Carolina

- Identified odor emission points: drying plate, fecal fuel additions, main extruder
- Significant odor emissions **~400-700 D/T**
    - Odor character was barnyard and manure during drying
    - Extruder odor mainly fecal odor, was most offensive
- Highest odor associated with non-continuous operations

Measurements at RTI Reinvented Toilet prototype in Ahmedabad

- To be conducted after FSM4

Odor monitoring before and during pit emptying in Blantyre, Malawi

- Measured 7 unimproved pit latrines
- Odors varied with pit construction and maintenance
- Generally odor levels were ~**60 – 120 D/T**
- Worst two pits were about **400-800 D/T**
- One had strong ammonia smell,
- One well kept clean latrine had almost no odor

- Measurements during pit emptying were too dynamic As soon truck was on, the surroundings stunk **(~60-200 D/T**)

Bioaerosols measurements

Sampled for bioaerosols during pit emptying in Blantyre, Malawi

- Direct counting total coliforms and *E. coli* on selective medium
- Growth on plate, DNA extraction, RT-PCR (Luminex Gastrointestinal Pathogen Panel) at Georgia Tech (Joe Brown's lab)
  = presence / absence test

Findings

- Total coliforms were found in bioaerosols
  4-20 CFU/m^3 (350 CFU/m^3 during fluidization)
- **Of the 7 pits, 4 air samples tested positive for enterotoxigenic *E. coli* (ETEC)**
- Data showed a large variability

Similar sampling **at RTI** during their testing showed some **coliforms were found in bioaerosols** near the system, but **no *E. coli*** was found.

See poster R8 for more details

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Conclusions

- Odor is an important risk factor
- R & D with odor is challenging
- We have several means to treat fecal odor: continuous biofilters, adsorption onto biochar, or odor control pouches, and more
- Enteric pathogens can be aerosolized during pit emptying… Are they a health risk?

- Many knowledge gaps remain
  - Spatial-temporal odor emissions during FSM
  - Odors from fecal sludge combustion, other unknown odors
  - Small scale odor transport (CFD)
  - Field validation of odor control systems
  - We don't know much about bioaerosols and FSM

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