**Background**

Malodor nuisance is a major risk factor in fecal sludge management (FSM). Filter and smelly latrines can motivate people to practice open defecation. The challenges of mitigating odor nuisances are significant, owing to the highly odorous nature of fecal matter, the multiple ways that odors can be released to the atmosphere, and the very low concentrations at which these odors cause nuisance. Yet, very little is known about the odor emissions and odor management practices in FSM. The overall objectives of this project are to:

1. Conduct a broad survey to define the landscape of odor nuisance and control efforts in FSM.
2. To determine the applicability of 1) adsorption and 2) biotrickling to control fecal odors using biochars and other low-cost materials.

**Survey of Malodor Landscape**

A broad survey (20-50 questions/10-20 minutes) was developed to assess locations, causes, intensity and impacts of malodor along the chain of fecal sludge management. The survey was administered using Qualtrics through direct emailing, posted on Facebook, and emailed to FSM participants (take a card if you wish to participate).

**Highlights of Preliminary Results**

- 250 Respondents.
- Heavily weighted towards solution providers (47%) and researchers (39%). 30% of respondents considered themselves as users.
- Wide range of developing countries represented: India (40%), Kenya (30%), Uganda (16%), Bangladesh (17%).
- Sanitation systems spread equally across urban, peri-urban and rural.

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

- Not very important: 22%.
- Important: 44%.
- Very important: 34%.

Based on your experience, how do you rate the level of malodor nuisance from the following Odor nuisance types?

- Very low: 32%.
- Low: 36%.
- Medium: 15%.
- High: 12%.
- Very high: 8%.

**Biochar and zeolite removal low concentrations of H2S very well.**

**Odors are intimately connected to fecal sludge management practices and adoption of toilets.**

**Odor nuisance occurs at many points along the chain of fecal sludge management.**

**Toilet type, design and maintenance practices have a profound impact on odor nuisances.**

**Activated carbon was shown to successfully absorb odorind odor compounds alone as well as in mixtures.**

**Cresol has the lowest adsorption saturation capacity of all odorants.**

**Fecal char has a comparable adsorption capacity for odors as activated carbon.**

**Simple biofilters and biotrickling filters are effective removing fecal odors. Biofilters packed with biochar completely removes low levels of hydrogen sulfide.**

**Future work will focus on obtaining reliable olfactometry data.**

**Higher odor levels need to be established and validated through extensive odour testing.**

**Medium to long term plans include field testing of odor control prototypes in selected fecal sludge management settings.**

**Odors in Fecal Sludge Management: Sources, Impacts, and Effects using Adsorption and Biofiltration**

**Adsorption of Fecal Odors**

**Static Adsorption Experiments**

A 5-compound odor concentration solution (ORS) was made with 6 compounds commonly found in fecal odors: butyric acid, 3-methylbutyric acid, 3-phenylpropanoic acid, p-cresol, indole, and skatole. All were dissolved in methanol.

- Activated carbon (Hori ROZ 3) and different types of biochar produced a drop in smell: Horse Manure, Bamboo, Pine, and Polyurethane cubes.
- The bag was then filled with odor free air (30 or 40 L).
- Odor strength dilution to threshold (ODT) values were in O.U./m³.
- These values were obtained using an odor removal capacity, qc.

\[ qc = \frac{\text{Time of\ odor\ retention\ in\ m}^3}{\text{ODT}} \]

**Dynamic Adsorption Experiments with the Odor Mixture + H2S**

**Fig. 3 - Dynamic adsorption schematic, picture of the portable olfactometer**

**Char particles used for the dynamic tests were 0.30 to 0.5 mm.**

- Results indicated odor levels rising (i.e., breakthrough) much earlier than H2S levels, except for Horse Manure Char.
- qc values obtained indicate 1% of O.U./g for AC, 11.8 ± 3.6 for fecal char, and 34.6 ± 9.3 for horse manure char.
- qc values for dynamic adsorption were lower than for static adsorption.

**BIOFILTRATION OF FECAL ODORS**

**Setup #1: Biofilter and Biotrickling Filter**

Two lab-scale columns were operated continuously:
- Biofilter (BF) packed with lava rock.
- Biotrickling Filter (BTF) packed with open pore polyurethane foam cubes.
- Inoculated with activated sludge mixtures.

**Specifications**

- Packing: 75 cm in 3 sections of 25 cm each
- Inlet flow odorous air: 10 LPM (upflow)
- Empty bed retention time: 12 sec. per section
- Goal: Successfully treat the fecal odor air stream.

**Fig. 4 - H2S breakthrough (left), and ODT breakthrough (right) as a function of all volume passed through the adsorption columns**

**Setup #2: Column Design and Operation**

- Columns: 40 cm packing + activated sludge at start
- ODT concentration: Deionized water as solvent.
- Measured COD using headspace gas chromatography.
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**CONCLUSIONS AND FUTURE WORK**

- Odors are intimately connected to fecal sludge management practices and adoption of toilets.
- Odor nuisance occurs at many points along the chain of fecal sludge management practices and adoption of toilets.
- Toilet type, design and maintenance practices have a profound impact on odor nuisances.
- Activated carbon was shown to successfully absorb odorind odor compounds alone as well as in mixtures.
- Cresol has the lowest adsorption saturation capacity of all odorants.
- Fecal char has a comparable adsorption capacity for odors as activated carbon.
- Simple biofilters and biotrickling filters are effective in removing fecal odors. Biofilters packed with biochar completely removes low levels of hydrogen sulfide.

**Future work will focus on obtaining reliable olfactometry data.**

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