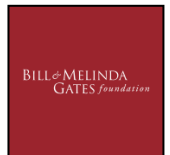


Improvement of FS Dewatering and Drying by Incorporation of a Breathable Membrane Latrine Liner

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Babak Ebrazi; Dr. Paul Imhoff.

University of Delaware, USA



India's sanitation problem

- 638 million people – No access to toilets
- 59% of the 1.1 billion people in the world who practice open defecation (OD) live in India
- 40% urban population without access to improved sanitation
- More number of cell phones (~545 million) in India than toilets (~366 million).

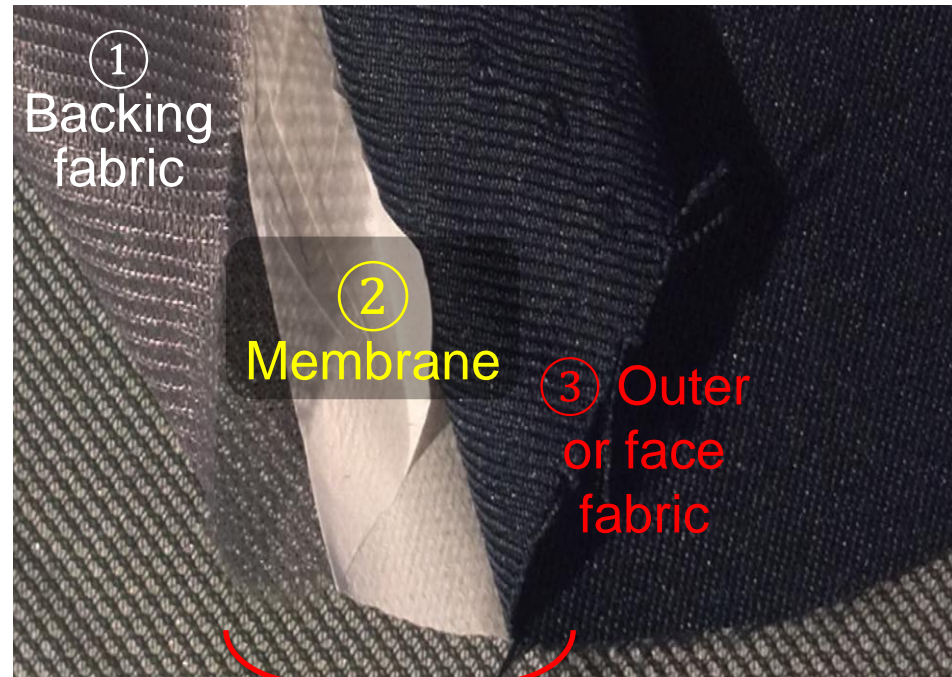
Solution to OD is a matter of Space, Money and Attitude change in people.

Statistics from WHO/UNICEF and United Nations.



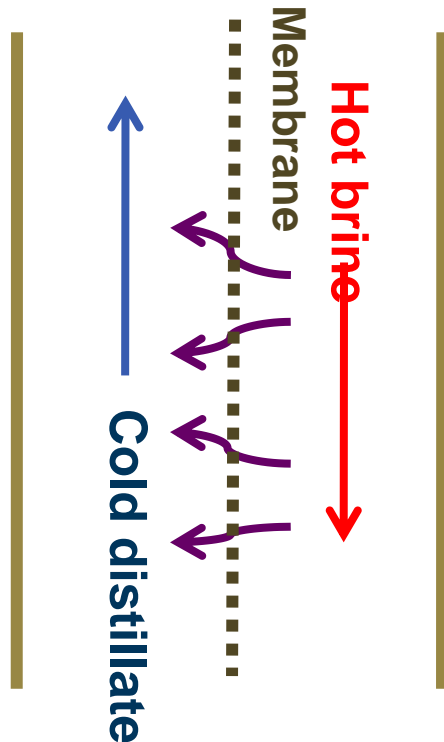
Breathable membrane

- Hydrophobic membranes
 - Permeable to water ‘vapor’
 - Not permeable to liquid water
- Passages/pores only contain air or water vapor
- The membrane blocks transfer of dissolved and particulate constituents



The membrane is contained between a two-layer fabric

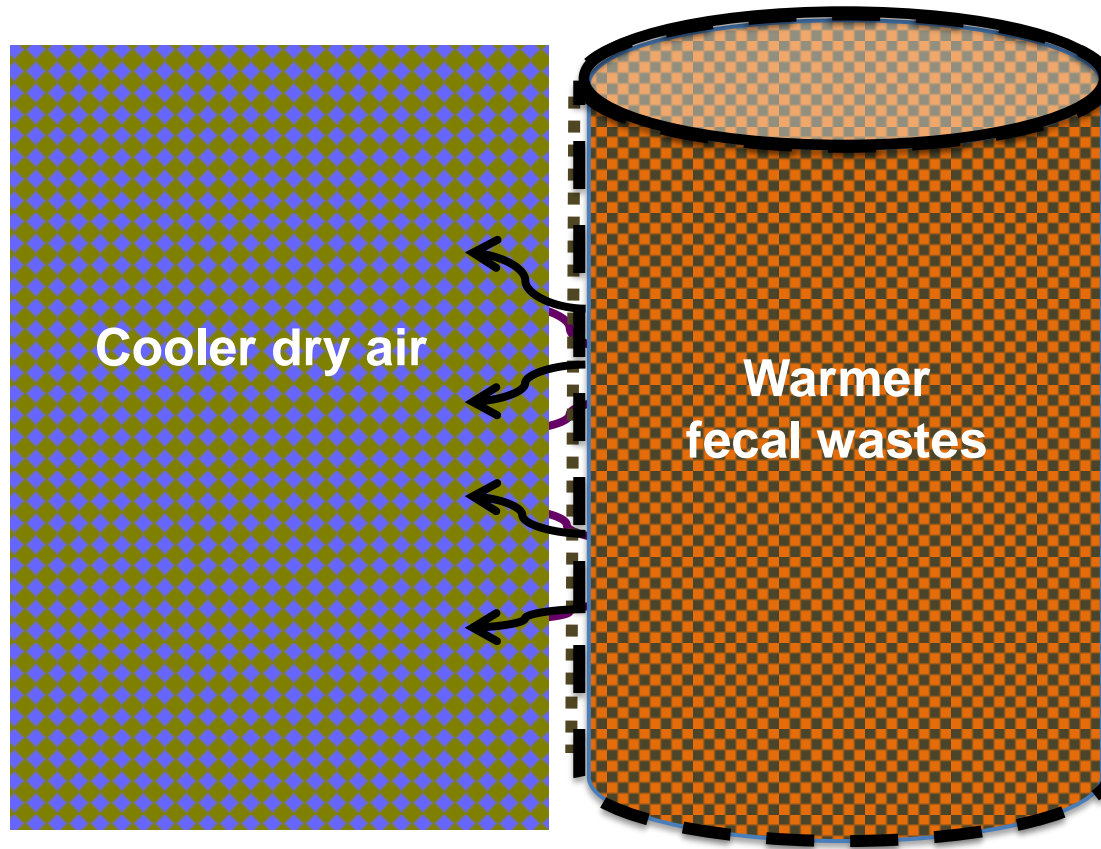
Membrane drying process



Similar to membrane distillation -

- Input side: Hot brine solution
- Distillate side: Cold water/air flow
- Driving force: partial pressure gradient (or temperature gradient)
- Breathable membrane in between facilitates gradual escape of water vapor

Membrane drying process

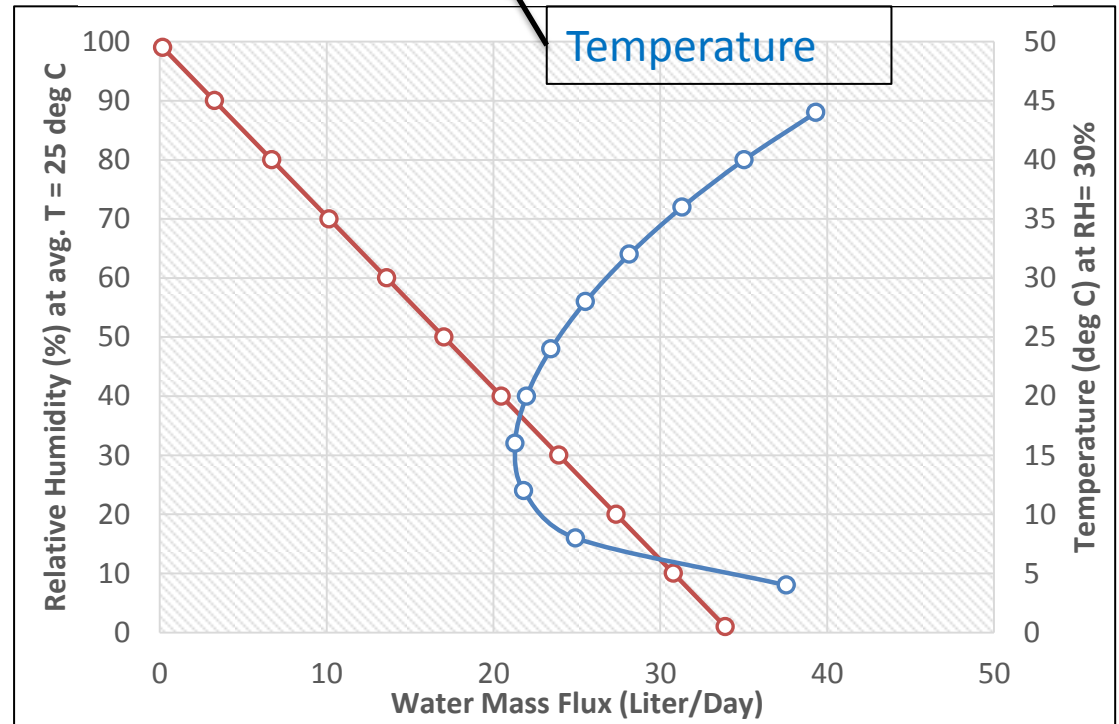


Field application

Relative Humidity

Stagnant Film Model

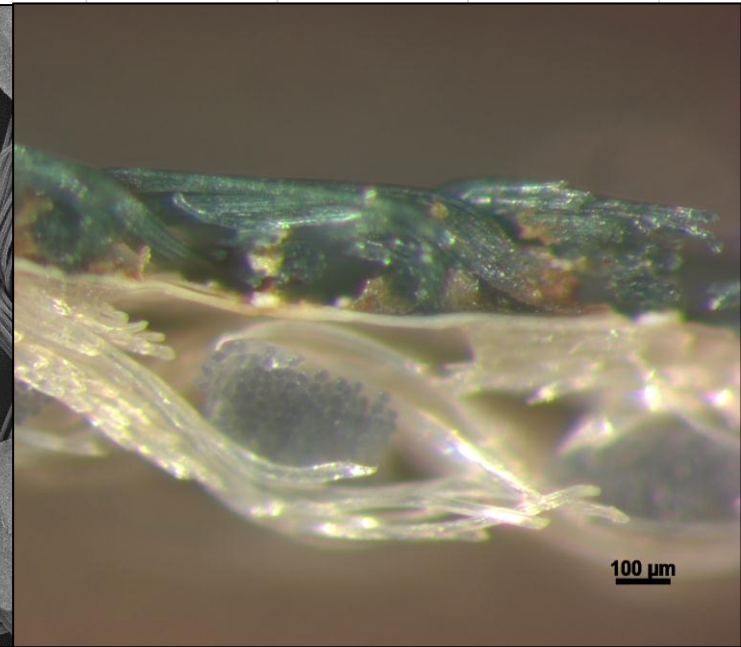
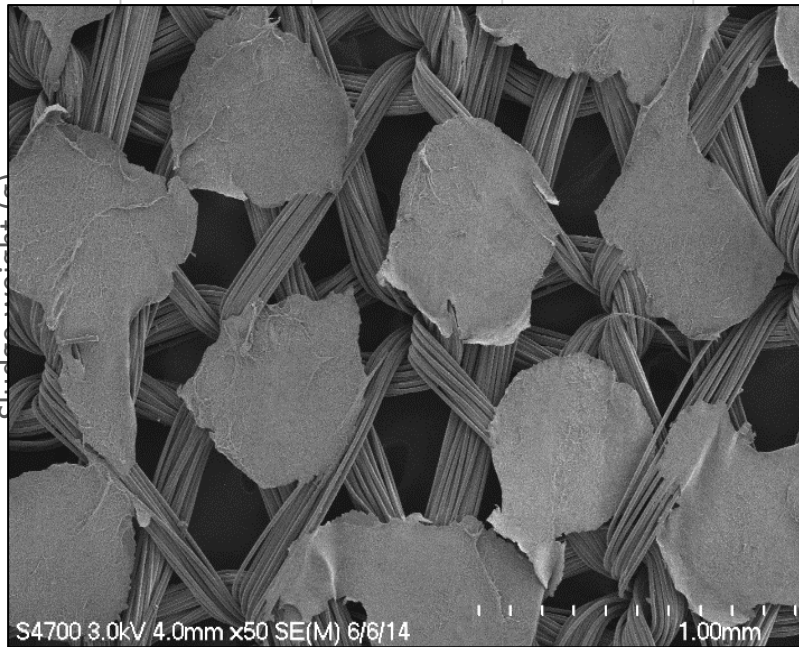
$$N_A = \frac{P}{R} \frac{D_{water-air@T_{ave}}}{T_{ave}} \frac{1}{\lambda} \ln\left(\frac{P - p_{A1}}{P - p_{A2}}\right)$$



Repeated sludge drying

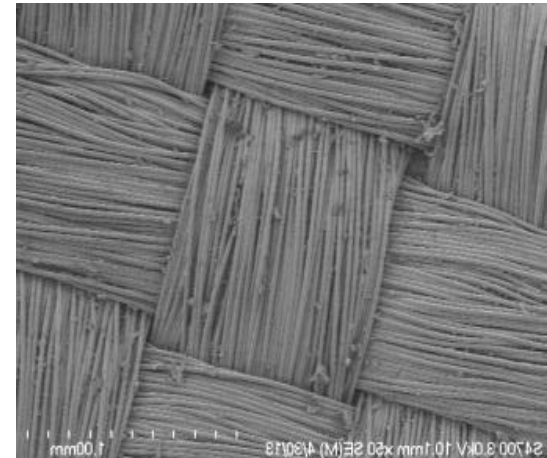
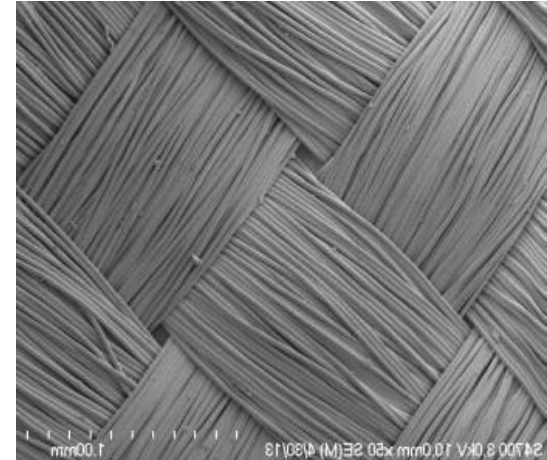
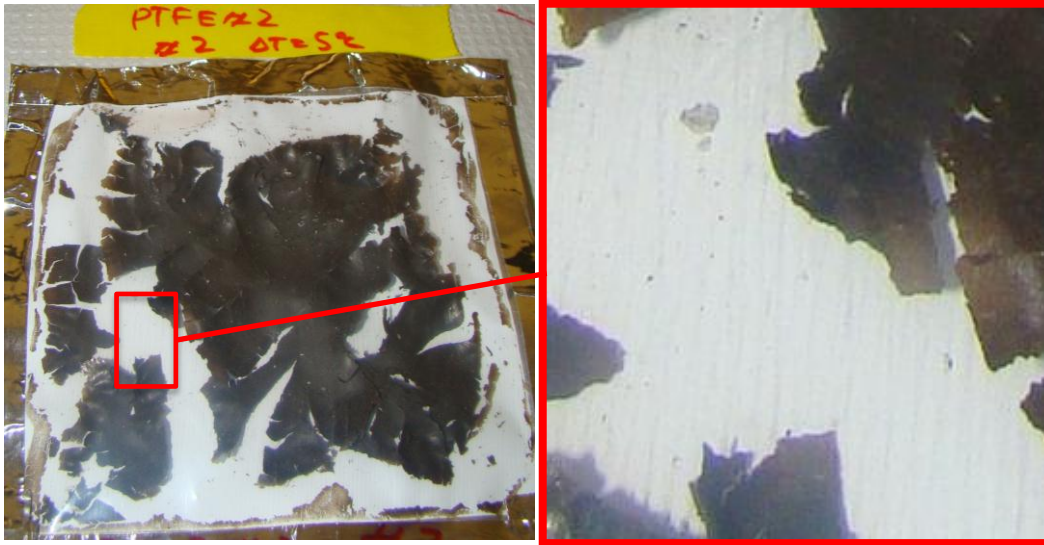
Drying rates over 5 cycles are comparable to each other.
Sludge particles do not cross the middle membrane layer.

120



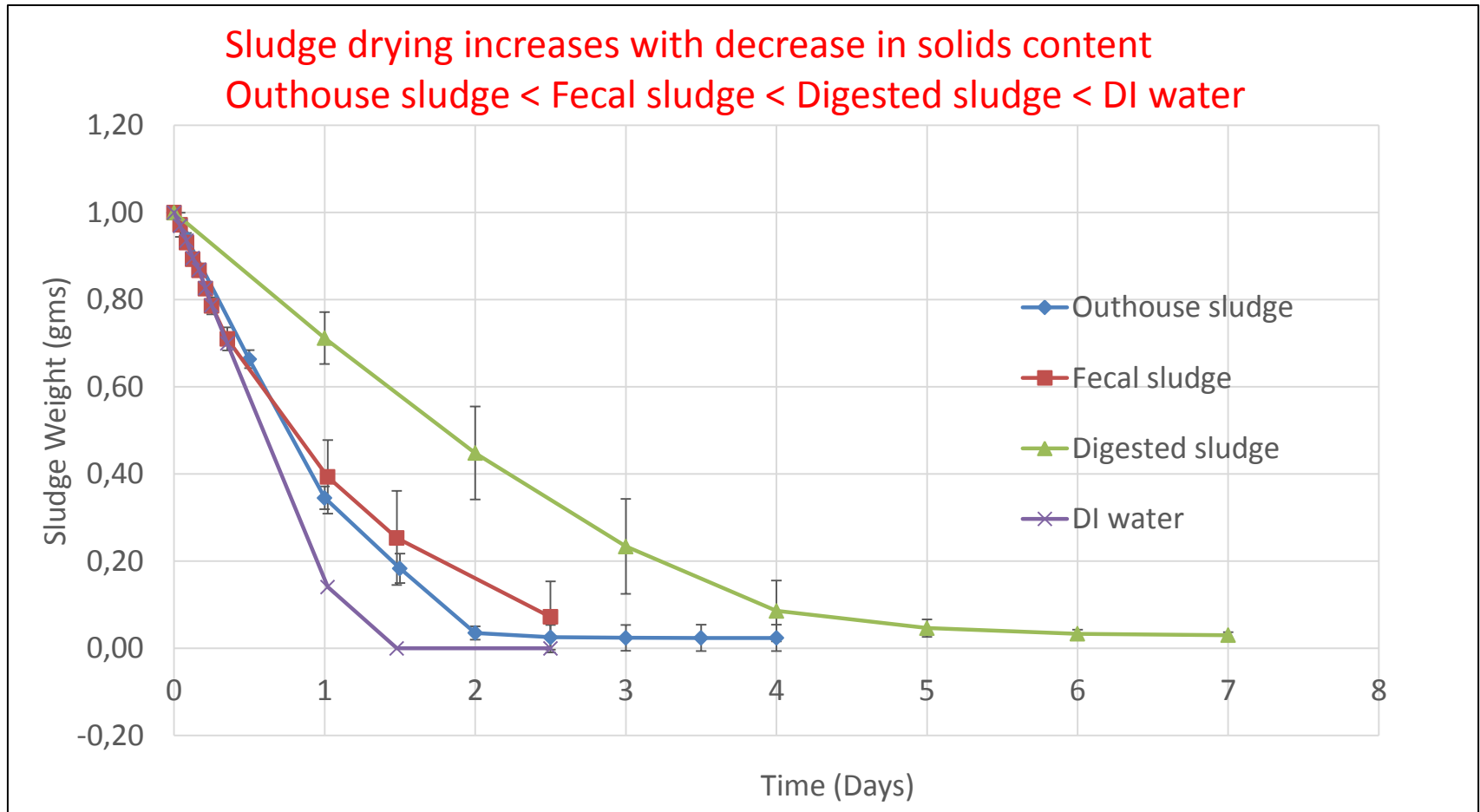
Time (day)

Membrane can be re-used



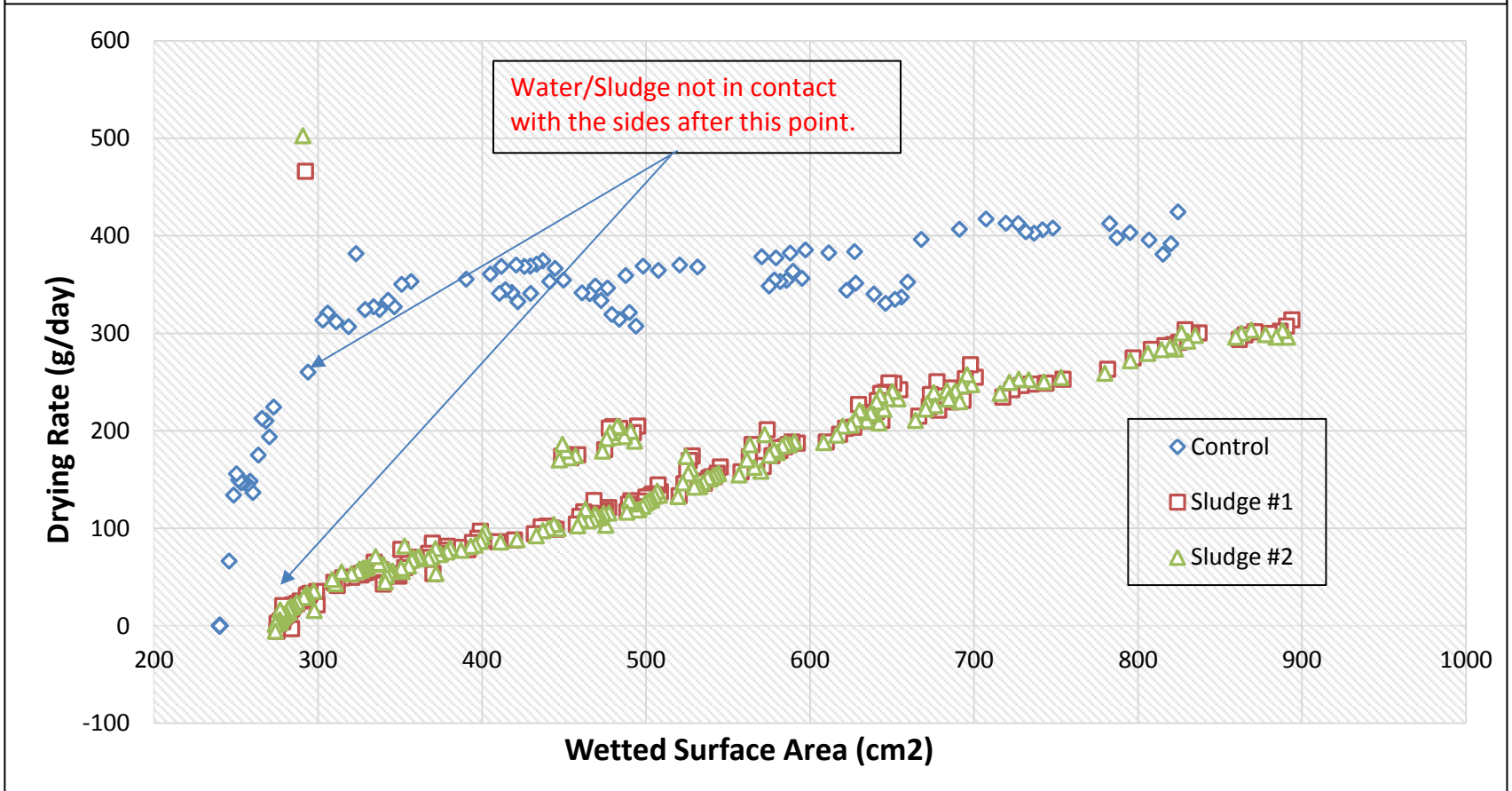
- No significant deposition on fabric
- Deposits can be rinsed off fabric.
- Drying is quite complete. Forms a thin layer on the membrane surface.

Some additional drying characteristics



Some additional drying characteristics

Step injection: increase in Wetted Surface Area(WSA) increases drying rate.



Conclusions

- Breathable membranes can dry faecal sludge at point of collection and storage.
- Should work well in hot and dry climate areas.
- Clogging is not significant and membranes can be re-used to maintain cost effectiveness
- Barrel design makes sludge disposal and transport easy, safe and less costly.

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References

- [Dentel, S.K.](#), [Marzooghi, S.](#) and [Shi, C.J.](#), 2012. Breathable membrane enclosures for faecal sludge stabilization : a paper presented at the second conference on developments in faecal sludge management in Durban, South Africa, October 29 -31, 2012 . <http://www.washcost.info/docsearch/title/180308>
- Smolders, K. & Franken, A.C.M. (1989). Terminology for membrane distillation, *Desalination*, Vol. 72, No.1-2 (April/May 1989) 249–262, ISSN: 0011-9164
- The Science of Biosolids: current research and implications for management, MABA Conference presentation, UMBC–19 Nov13; <http://www.mabiosolids.org/uploads/MABA%20Annual%202013/Saxena%20-%20membrane%20drying%20of%20biosolids.pdf>

Thank you. Any Questions?

