Laboratory investigations into **solids solubilisation** of black water and faecal matter

Effect of
additives
and
internal physical chemical pit latrine aspects

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BILL & MELINDA GATES foundation

Bill & Melinda Gates foundation goal:
to enable universal access to sustainable sanitation services

New Concepts for On-site Sanitation based on Bio-Additives and Pit Design

LONDON SCHOOL of HYGIENE &TROPICAL MEDICINE

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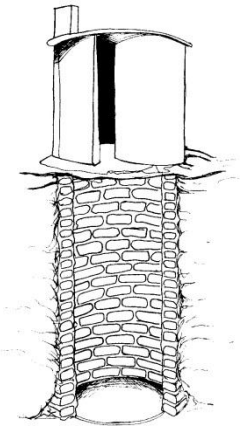
Aim: increase pit latrine lifetime

Input: Human excrements = mainly liquid

Combined maximum input
2.02 kg/day/person with at least **86%** moisture

Pit fill = liquid balance
Pit fill ≠ COD issue



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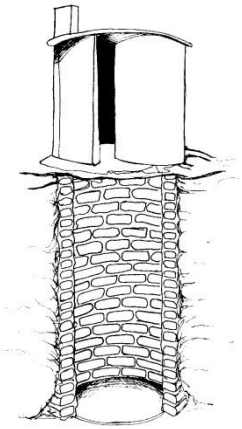
Desired pit working:

1. Organic material degradation (stabilisation)
2. Pathogen removal
3. Solubilisation of particulate matter
4. Liquid out-flow

3 + 4: key factors pit latrine fill mass balance



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Can (bio)additives increase solubilisation of solids (hydrolysis)?

Additive types tested

- 2 Soils, 3 inorganic conditioners
- 4 Commercial bio-additives
- 6 Enzymes, 1 mix
- 1 Fungus mix
- 15 Pure and 5 mixed cultures of microbes
- 10 Active herbivore dung extracts

Can (bio)additives increase solubilisation of solids (hydrolysis)?

Experimental set-up:

- Substrate: black water
- Test conditions: in batch bottles, mixed
  Gas phase: aerobic, anaerobic and
  aerobic + anaerobic

- Compare

substrate + additive <-> substrate (blank) = nett solubilisation

Can (bio)additives increase solubilisation of solids (hydrolysis)?

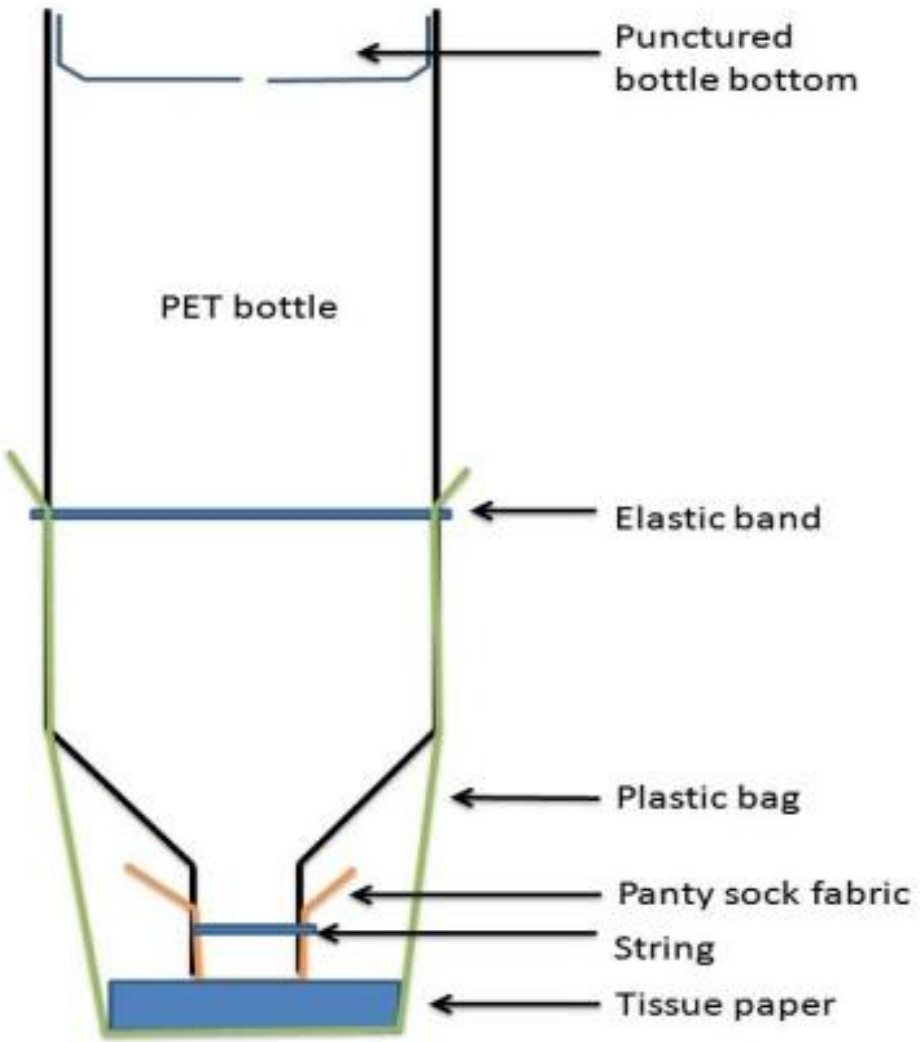
Results additives nett solubilisation:

- 2 Soils, 3 inorganic conditioners <0
- 4 Commercial bio-additives <0
- 6 Enzymes, 1 mix <0
- 1 Fungus mix <0
- 15 Pure strains and 5 mixed culture microorganisms added as spores/live <0
- 10 Active herbivore dung extracts <0

Can (bio)additives reduce pit fill height?

Additive types tested

- Blank (no additives added) in duplicate
- Mixed microbe cultures: 3 mixes
- 1 Commercial bio-additive
- Blank + aeration



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5 SPEED

Can (bio)additives reduce pit fill height?

	Blank duplicate	Commercial product	Air
End height pit (cm)	19.5/18.5	18.5	14
COD_{total} removed (%)	4.4/5.8	8	11

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Can (bio)additives reduce pit fill height?

Results:

- Suspended bio-additives tend to run off the waste to the pit wall
- Crust formation within 3-5 hrs
- Crusts persist
- Compared to blanks aeration reduced both COD_{total} and pit fill height

Can physical chemical pit aspects increase solubilisation of solids (hydrolysis)?

Experimental set-up

- Physical chemical pit aspects tested
  - pH
  - Gas phase
  - Moisture
  - Temperature

- Test conditions
  - Substrate: black water and faeces
  - In batch bottles

Can physical chemical pit aspects increase solubilisation of solids (hydrolysis)?

Gas phase: aerobic / aerobic + anaerobic

Black water At 30°C, pH 7	Solids solubilisation % (stdev)
Aerobic Aerobic + anaerobic	82 55.8 (3)

Can physical chemical pit aspects increase solubilisation of solids (hydrolysis)?

Initial pH

Black water At 30°C, aer + anaer	Solids solubilisation % (stdev)
pH 5 (end pH 5.2) pH 7 (end pH 7.2) pH 9 (end pH 7.4)	25.3 (1) 55.8 (3) 65.3 (2)

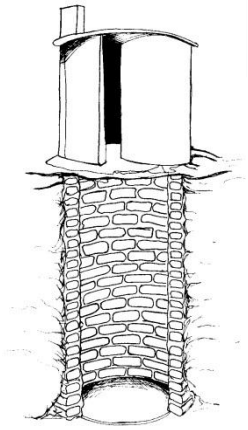
Conclusions

- Additives <-> solids solubilisation
  - No nett increase of solubilisation in batch
- Additives <-> pit fill height
  - No pit height reduction in a simulation pit
- Additives <-> COD
  - Little or no COD_{total} reduction in a simulation pit

Conclusions

- O_2 and pH <-> solids solubilisation
  - Nett increase of solubilisation in batch
- O_2 <-> pit fill height
  - Pit height reduction in a simulation pit
- O_2 <-> COD
  - COD_{total} reduction in a simulation pit

Expected additive effect in real pit latrines



additive = extra solids (fill)

no good contact (time) additive <-> substrate

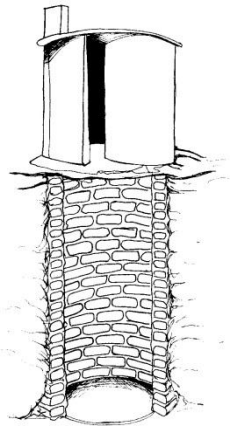
- little mixing
- crust formation/persistence
- run-off of additive suspension

low temperatures <-> slow conversions

Expected physical/chemical aspects effect in real pit latrines

Aeration of the pit top layer +
Increased pH by adding ash on pit top layer
-> More solids solubilisation
-> NH_4 -> NO_3 inside pit

Covering aerated layer with new waste
-> anaerobic
-> NO_3 -> N_2 inside pit



Bio-additives
Physical-chemical pit aspects
<->
Solubilisation
Pit fill height

Thank you!

Questions?