THE DISINFECTION OF LATRINE FAECAL SLUDGE WITH AMMONIA NATURALLY PRESENT IN EXCRETA

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Oct 29, 2012

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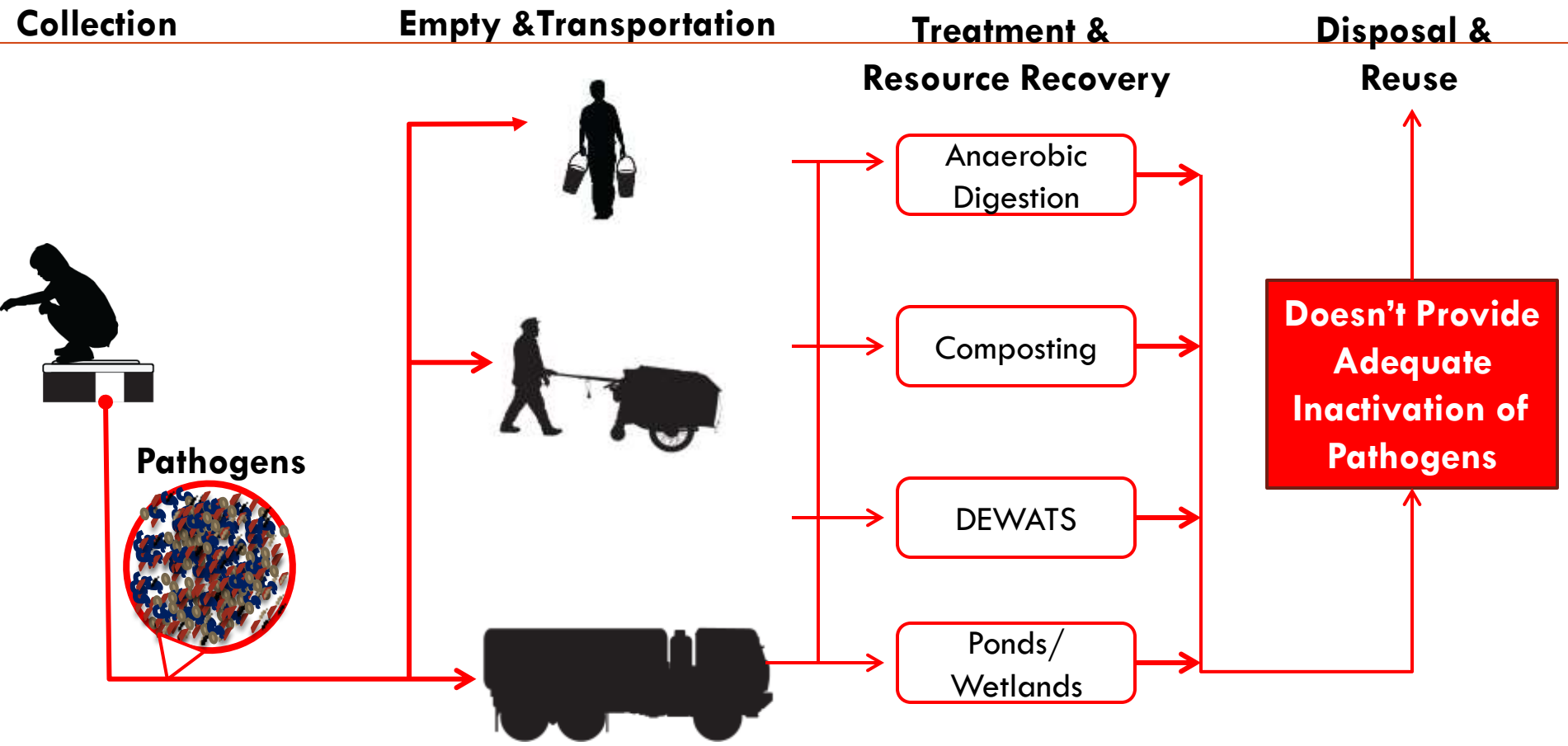
Sanitation Value Chain

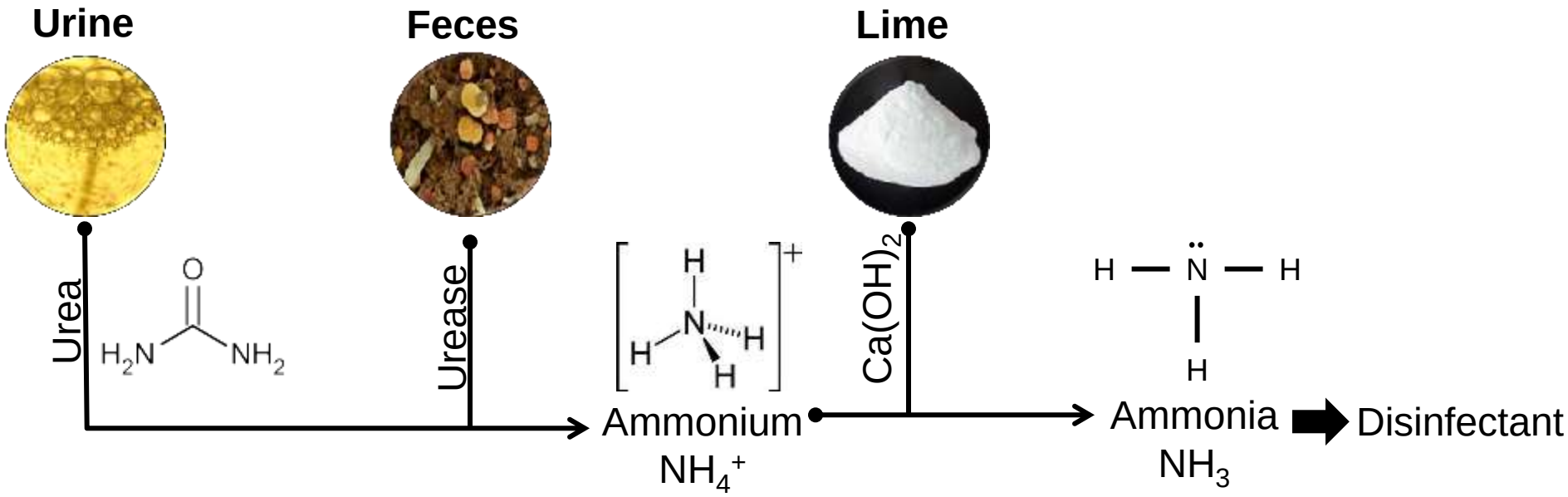


Research Objective

- Treat excreta at the point of collection by harnessing ammonia from human waste

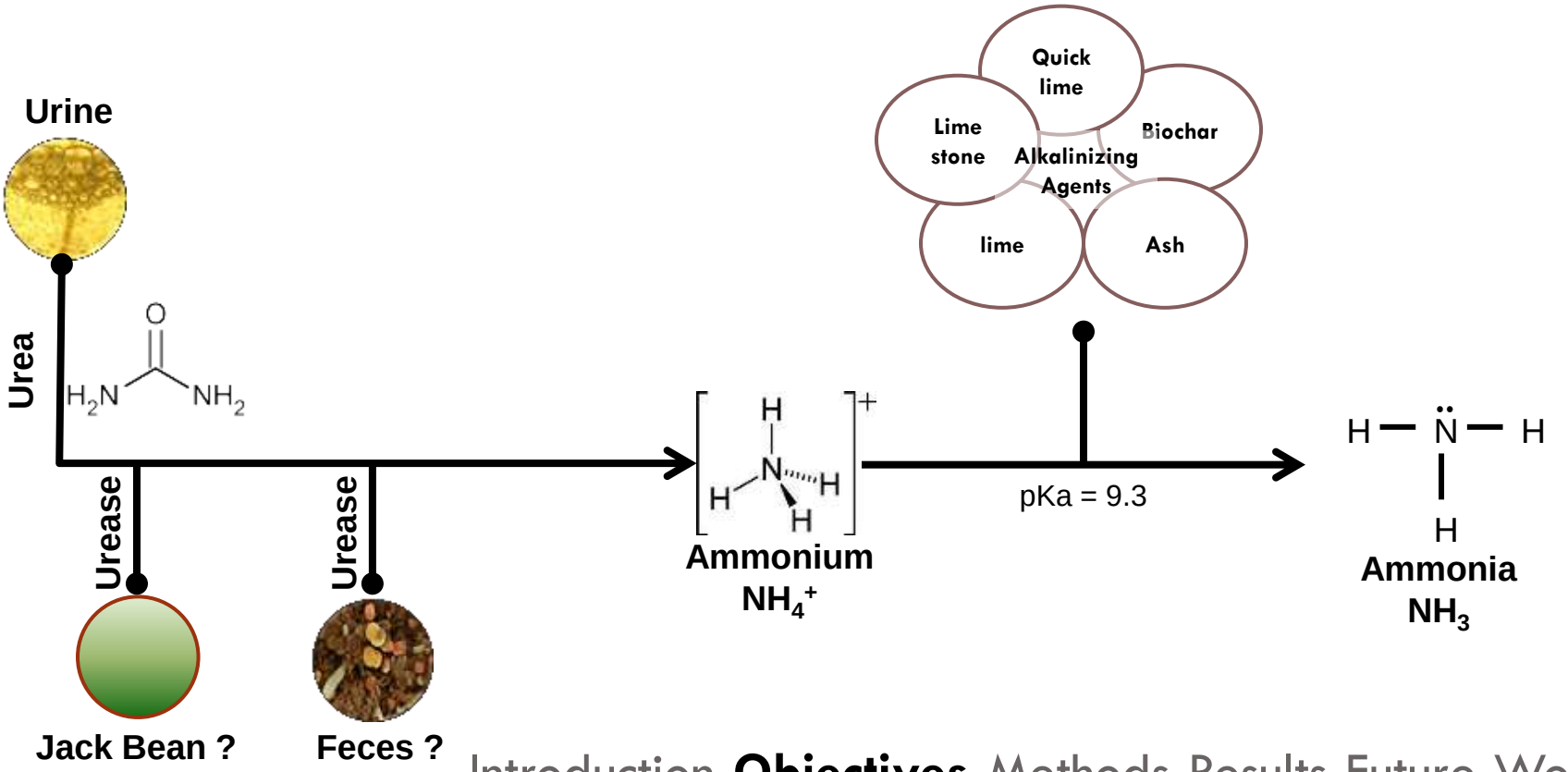
- Compatible with downstream treatment and resource recovery

Safe Sludge Disinfection Approach



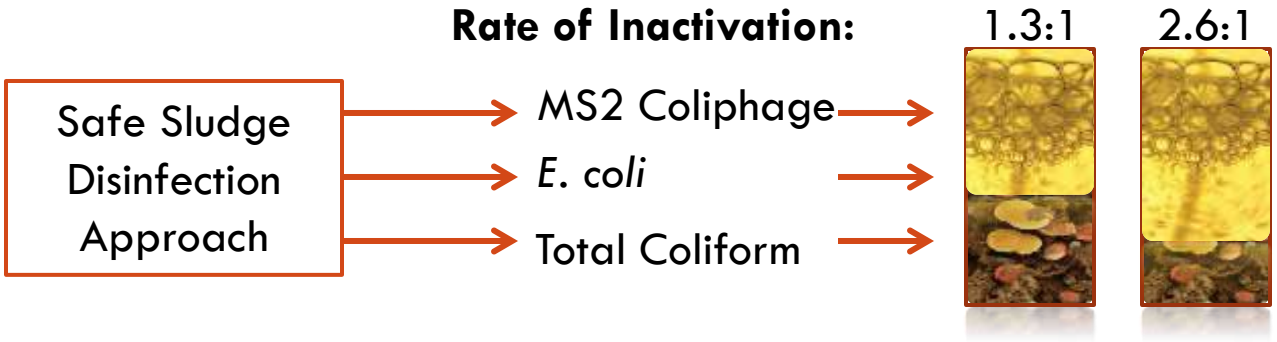
Research Questions

- What is the Hydrolysis Rate of Urea in:
- What is the best alkalinizing agent?

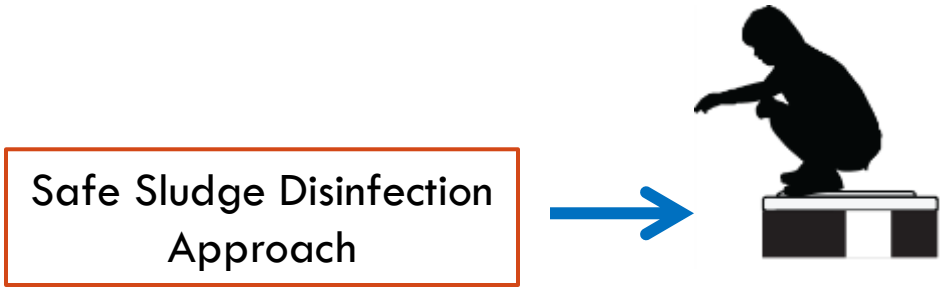


Research Questions

- What are inactivation rates of pathogen indicator organisms using Safe Sludge Process?



- How can the Safe Sludge Process be incorporated into toilets?



Hydrolysis Rate of Urea

4 to 6 individual urine samples collected & mixed

Mixed with Ca(OH)2 to obtain pH 8 - 12

No Urease

Jack Bean

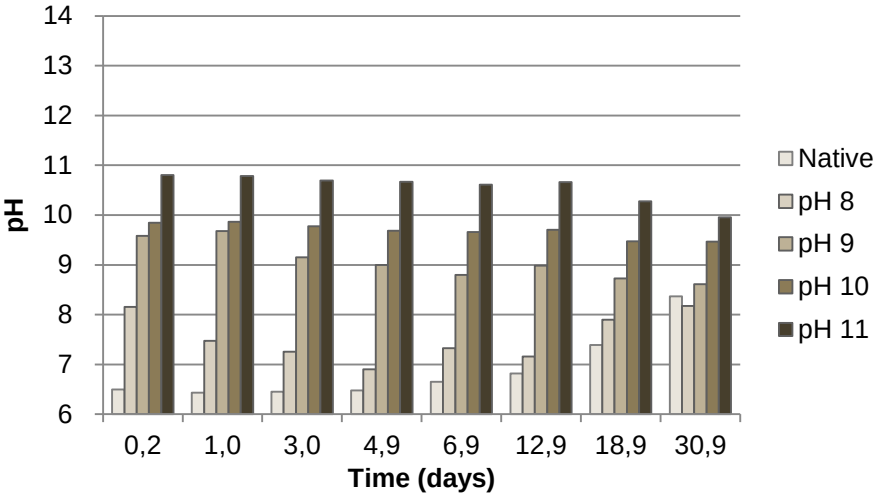
Feces

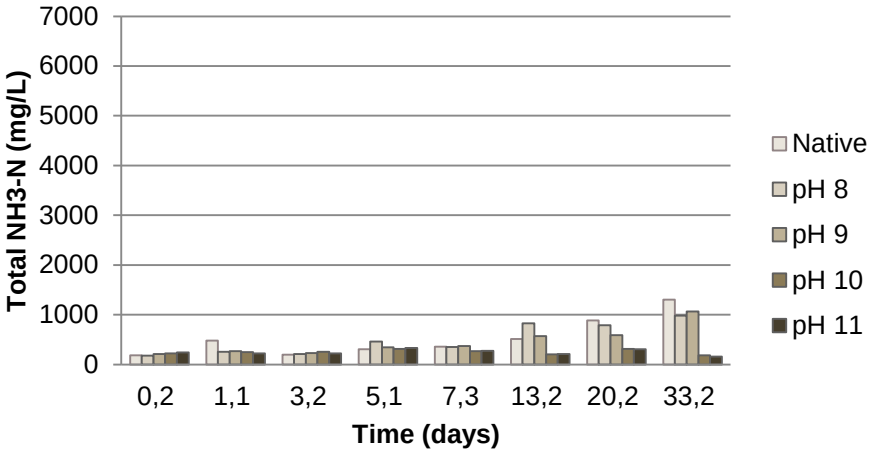
Urease source

Duplicate samples were analyzed for total NH_3 and pH

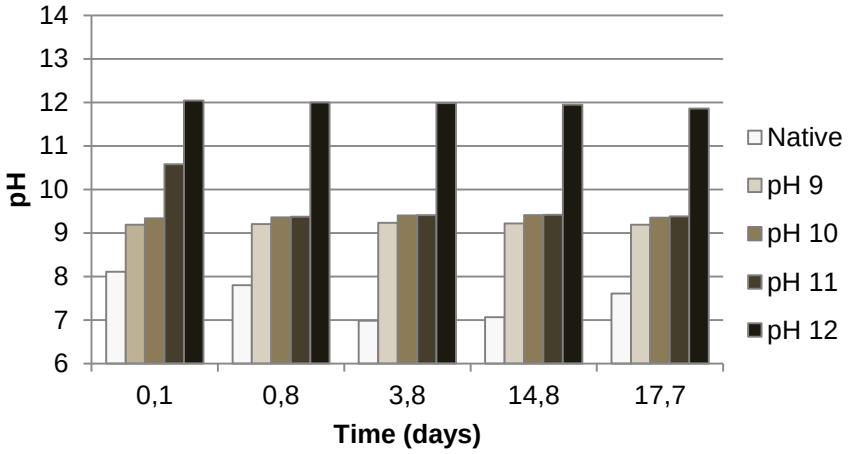
8 time points

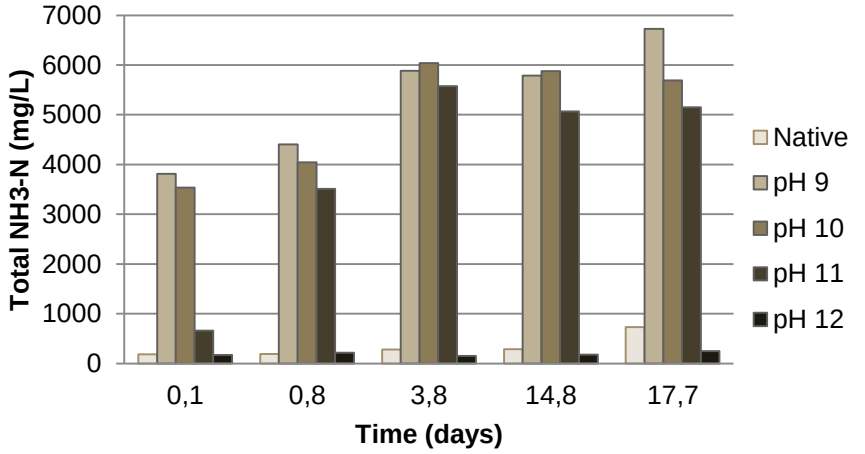
Pure Urine:





Urease Jack Bean:

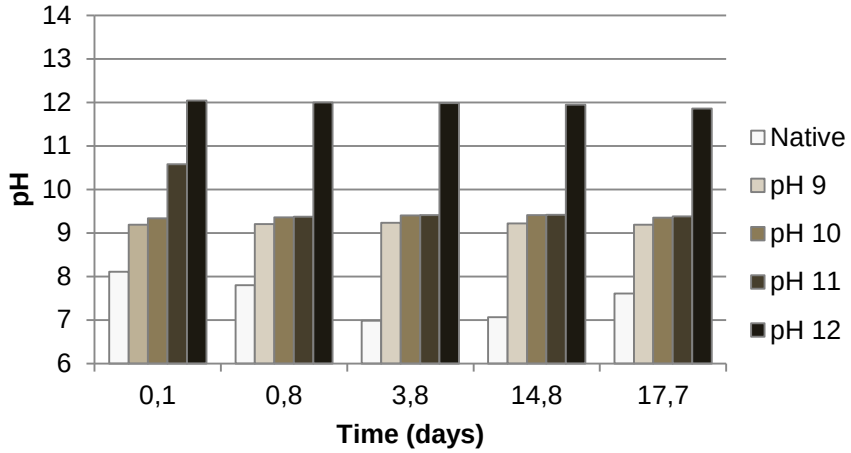


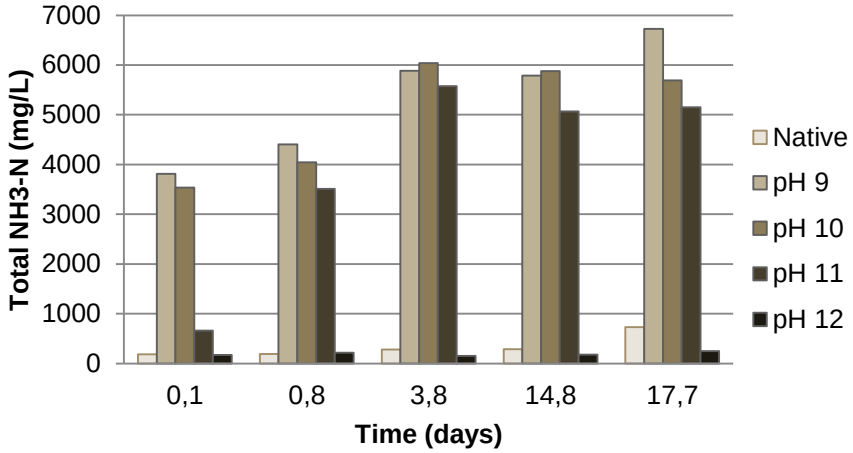


Implications of Urine & Jack Bean

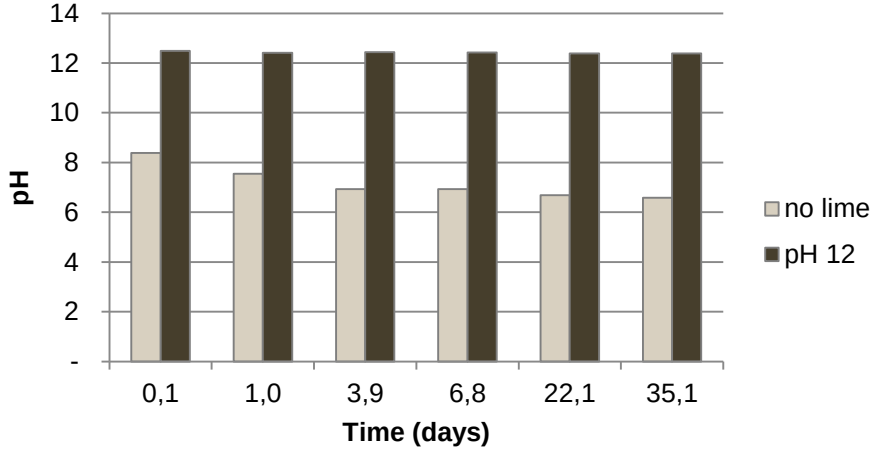
- Urease is needed to achieve conversion of urea to ammonia
- Urease from jack bean was not active at pH 12
- It was necessary to raise the pH to 12 to maintain stable alkaline pH

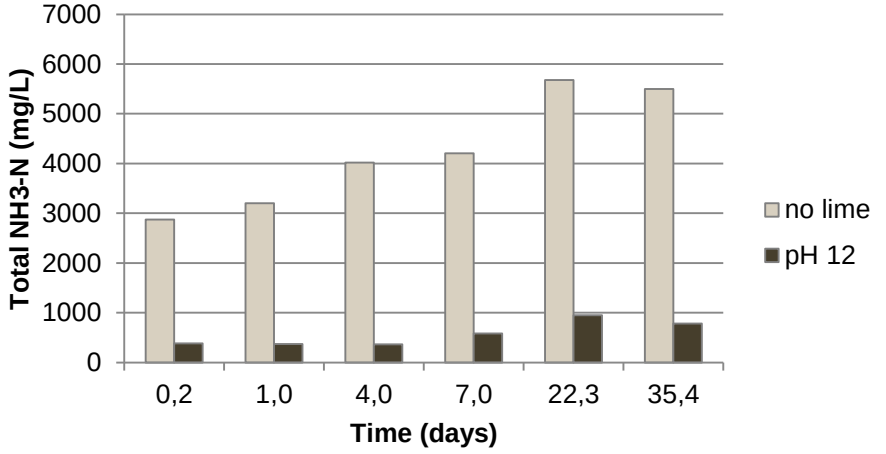
Urease from Jack Bean:





Urease from Feces:





Implications of Jack Bean & Feces

- Natural urease in feces is the best source
- Confirmed that pH 12 is stable
- Urease has minimal activity at pH 12, therefore a two-stage process is necessary for the hydrolysis of urea

Different Ratios Urine to Feces

1.3:1 **2.6:1** **5.2:1**

Urine to Feces Ratio	Total NH_3-N (mg/L)
1.3: 1	5,800
2.6: 1	7,400
5.2: 1	9,000
Pure urine*	8,700

* Spiked with urease from jack bean

Which Alkalinizing Agent is Best?

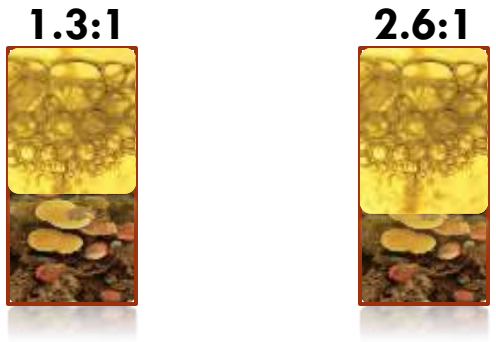
$$NH_4^+{}_{(aq)} + OH^-{}_{(aq)} \leftrightarrow NH_{3\,(aq)} + H_2O_{(l)}$$

$$NH^+_{4\ (pH\ 7)} \xrightarrow[\text{High pH (alkalinizing agent)}]{\text{pKa = 9.3}} NH_{3\ (pH\ 12)}$$

Alkalinizing Agent (6 grams)	pH (water 1:3)	% NH3 @ 24 °C
Limestone (6.35 mm)	8.30	9.96
Limestone (0.354 mm)	7.67	52.3
Biochar (0.354 mm)	9.81	82.3
Ash (0.354 mm)	10.1	86.7
Calcium Hydroxide (0.044 mm)*	12.7	99.9

*2 % by weight of $Ca(OH)_2$ is needed to maintain pH 12

Inactivation Rates of Pathogens



Spike with MS2 coliphage and incubated 24 hrs

↓

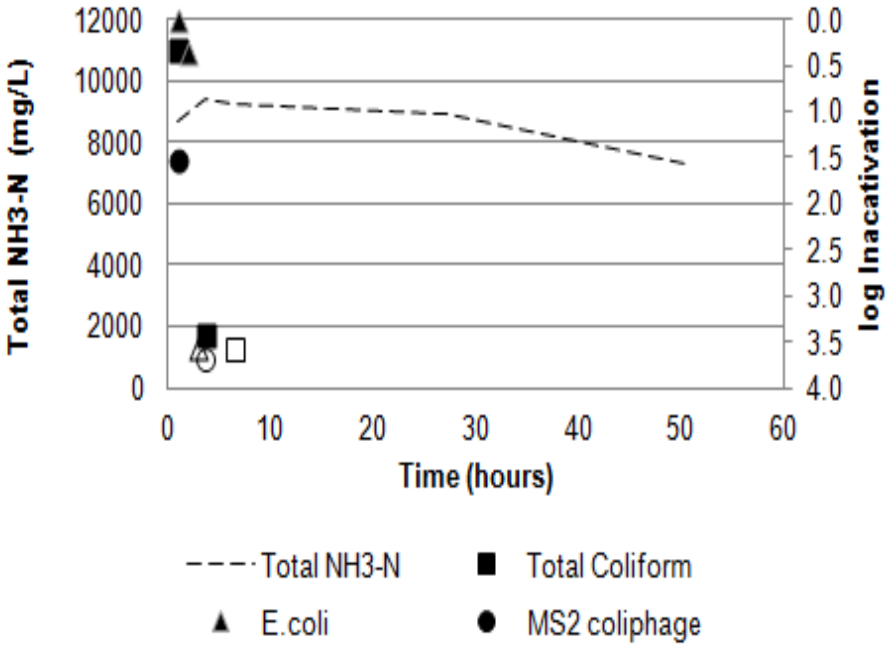
Slurries split in half; one portion was amended with $Ca(OH)_2$

↓

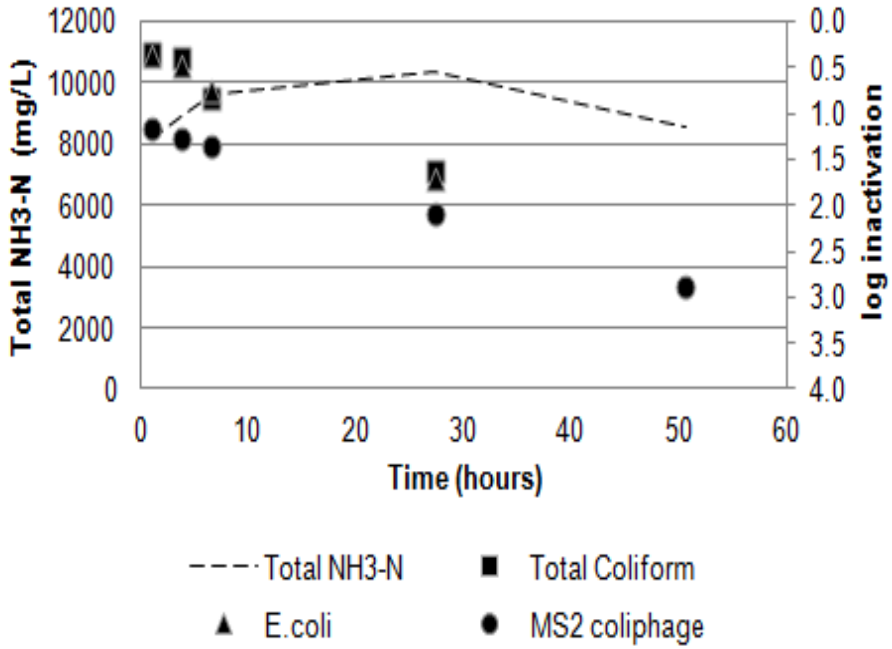
Duplicate samples were analyzed for *E. coli*, total coliforms, MS2 coliphage, total NH_3 and pH

} 6 time points

Inactivation Rates: 1.3:1 Slurry

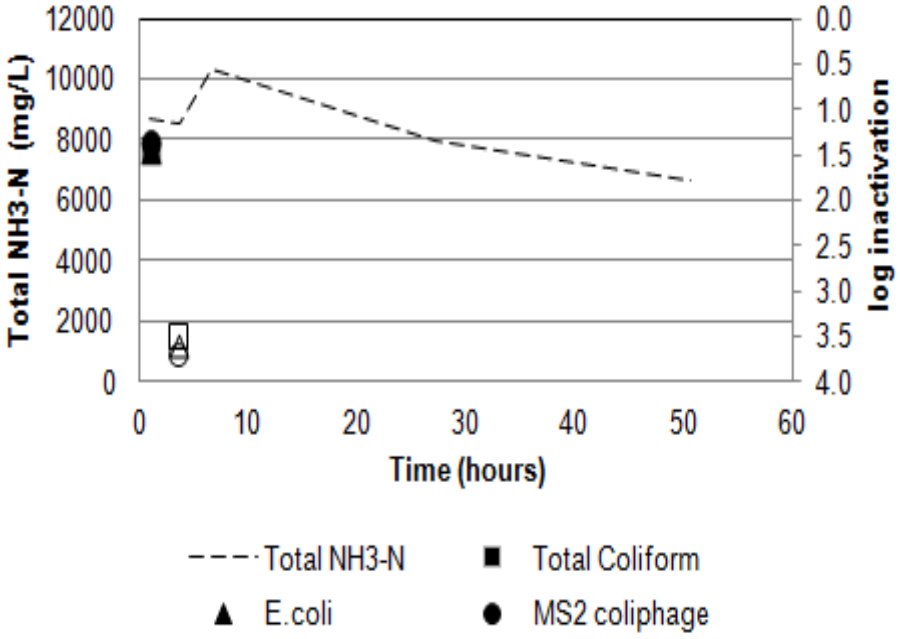


Lime Addition

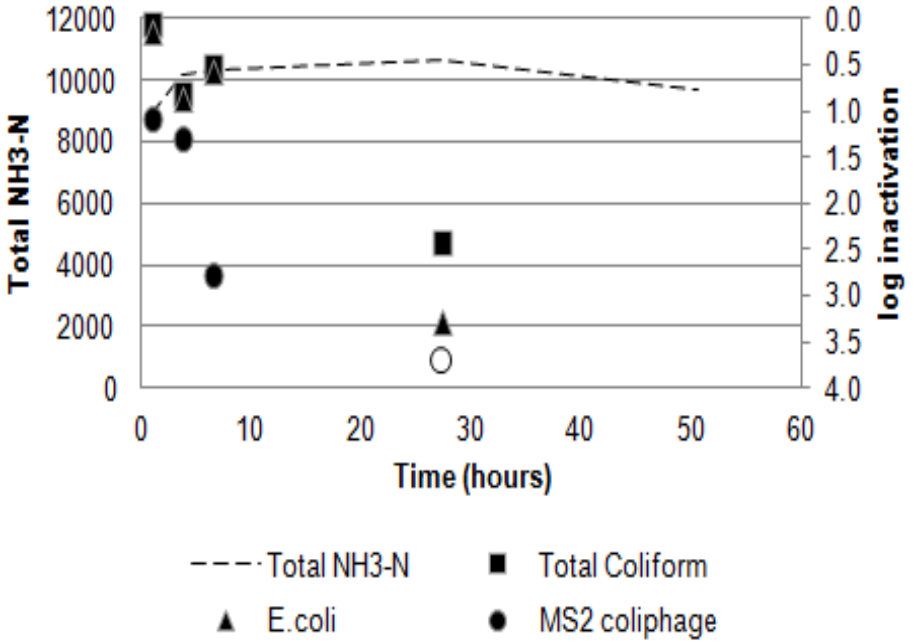


Control

Inactivation Rates: 2.6:1 Slurry



Lime Addition



Control

Implications of Inactivation

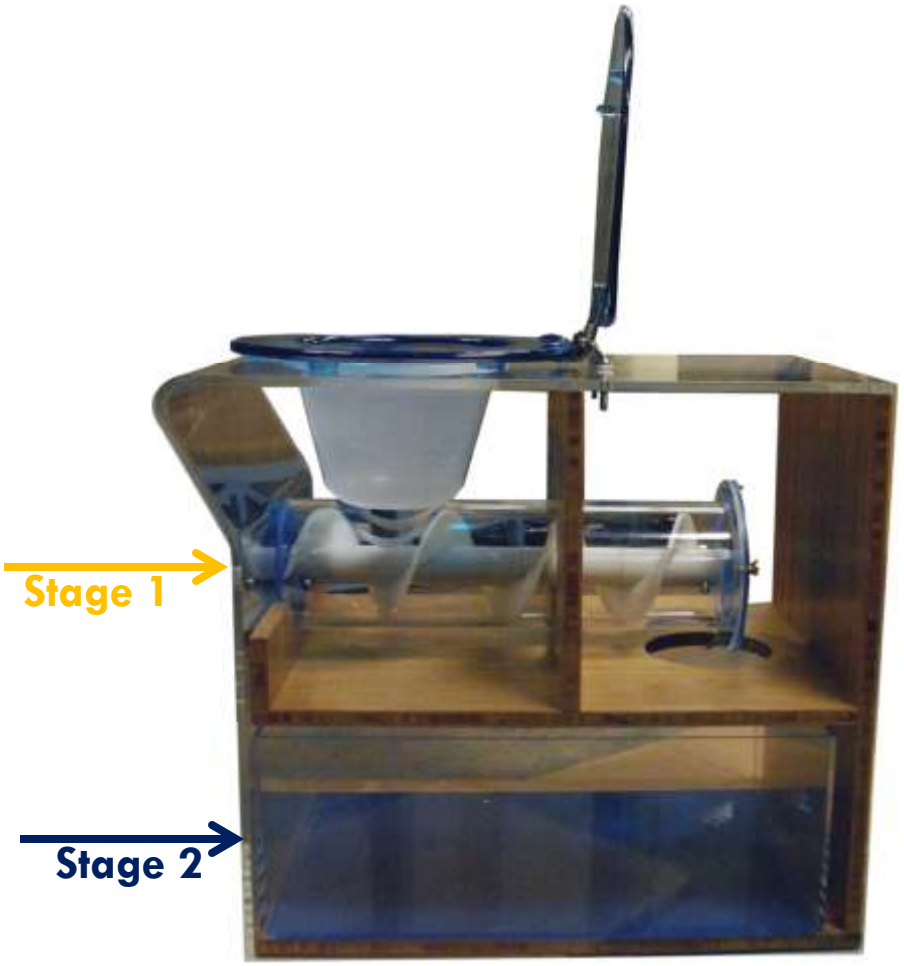
- Safe Sludge Disinfection process inactivated pathogens at a faster rate than control
- After one day the Safe Sludge process > 3 log removal of *E. coli* and MS2 was achieved

Safe Sludge Toilet Design

- Objective: Incorporate Safe Sludge Disinfection Approach into toilet
- Design Requirements:
  - Two stage process
    - Detention time for hydrolysis to occur
    - Followed by addition of alkalinizing agent
  - No water, electricity

pHree Loo (Pathogen Free Toilet)

- Designed for family of 5
- Service Delivery model
- **Stage 1:** hydrolysis of urea; mixing and detention time of ~2 hours
- **Stage 2:** NH_3 production & inactivation ; transfer of slurry from Stage 1 into a collection bin containing $Ca(OH)_2$ solution

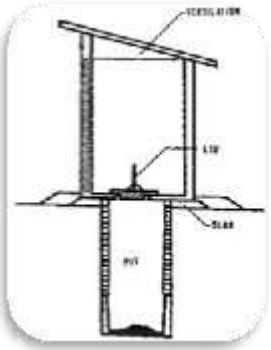


Field testing of Safe Sludge approach (ongoing)

- Start Date: Nov 2, 2012
- Partners: **Sanergy** in Nairobi, Kenya
- Determine the minimum amount of urine needed to be mixed with feces to create the NH_3 concentrations needed for disinfection
- Retrofit an existing Sanergy toilet to divert a portion of the urine into the feces receptacle to see if we get comparable results

Future Goals

Apply Safe Sludge Approach that was developed during Phase I to:



Further develop the household pHree Loo

Adapt pHree Loo to shared toilets

Develop chemical additives to disinfect waste in existing pit latrines

Iterative design & testing, manufacture, install and monitor performance in Nairobi, develop micro-enterprise service models

Based on results, develop recommendations for scaling up

Acknowledgments

BILL & MELINDA GATES foundation

- University of California, Berkeley
- Prof Kara Nelson's Research Group
  - Selam Habebo
  - William Tarpeh
- Hyphae Designs Laboratory

THANK YOU

QUESTIONS?

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