NoWaste Toilet

Function and nutrient recovery

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7 billion people defecating
7 billion people defecating

1.2 billion people defecating in the open
7 billion people defecating

1.2 billion people defecating in the open

4.1 billion people defecating with no post-treatment

(Baum et al., 2013)
OPPORTUNITY
Nutrient recycling

Food consumption

Improved soil structure

Soil Amendments

FAECES

Increase organic matter

Decreased use of non-renewable fertilizers

Crop Production

Organic Fertilizer

URINE

Decreased use of non-renewable fertilizers

Pee & poo images by Andry Rajoelina (ELSHANGOWUZHERE.BLOGSPOT.SE/)

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Food consumption

- Improved soil structure
- Increase organic matter
- Soil Amendments

- FAECES
- URINE

- Decreased use of non-renewable fertilizers
- Organic Fertilizer
- Crop Production

Challenges

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Pee & poo images by Andry Rajoelina (ELSHANGOWUZHERE.BLOGSPOT.SE/)
CHALLENGES

Food consumption

- Improved soil structure
- Soil Amendments
- Increase organic matter

- FAECES
- URINE

- Decreased use of non-renewable fertilizers
- Crop Production
- Organic Fertilizer

Increase organic matter

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CHALLENGES

Food consumption

- Improved soil structure
- Increased organic matter

Soil Amendments

- Decreased use of non-renewable fertilizers

Crop Production

- Organic Fertilizer

FAECES

URINE

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OBJECTIVES
To develop a toilet for commercial fertilizer production

1. In-situ treatment

2. Minimize mass
   • Preliminary goal 90% reduction

3. End products
   • Dry fertilizer from urine
   • Hygienic soil amendments from faeces
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Concept

In-situ treatment system

Contain
Treat
Concentrate

Dry powder fertilizer (N-P-K)
Soil amendments (hygienic)

mass reduction

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Urine modules 🌿

Alkaline
• Increase pH by ion exchange

Dehydration
• Evaporate liquid with wood ash

Dry fertilizer
• N-P-K
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Urine modules

Alkaline treatment

Ratio (urine:ion exchanger) = 8.6:1

1. Chloride ions (Cl\(^-\)) are exchanged for hydroxide ions (OH\(^-\))

pH < 7

Charged ion exchanger

pH > 10

Image adapted from waterboss.ca

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**NoWaste Toilet**

**Urine modules**

**Alkaline treatment**

1. Chloride ions (Cl\(^-\)) are exchanged for hydroxide ions (OH\(^-\)).

Ratio (urine:ion exchanger) = 8.6:1

2. pH of fresh urine is increased.
1. Chloride ions (Cl\(^-\)) are exchanged for hydroxide ions (OH\(^-\))

2. pH of fresh urine is increased

3. Urease enzymes are inhibited

Ratio (urine:\text{ion exchanger}) = 8.6:1
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Urine modules

Dehydration

Urine (pH >10)
(0.6-0.04-0.08)
(N-P-K)

99% moisture

Image adapted with permission from www.dianewrightfineart.com
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Urine modules

Dehydration

Urine (pH >10)
(0.6-0.04-0.08)
(N-P-K)

99% moisture

H₂O vapor
0.28 kg hr⁻¹

Vent pipe
Fan
(16 m³/hr)

High ventilation

35°C
5% ash (w/w)

Image adapted with permission from www.dianewrightfineart.com
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Urine modules

Dehydration

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(0.6-0.04-0.08)
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0.28 kg hr⁻¹

Fan (16 m³/hr)
Vent pipe

High ventilation

Dry fertilizer
(9-3-11)
(N-P-K)

5% moisture
85% N recovery

No liquid disposal

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Faecal module

Vermicomposting
- Degradation of organic material

Maturation
- Stabilization of vermicompost

Ammonia treatment
- Sanitization of matured vermicompost

Soil amendment
- Carbon source

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Vermicomposting

Worms located in the toilet bin

Increased retention time

Aim: 90% reduction (weight wet)

Compost

Llander, C., et al. (2013)
Ammonia sanitization

Organic fertilizer
(N-P-K = 0.5-1.5-3)
Matured compost with potential pathogens

Dry fertilizer
(N-P-K = 9-3-11)
Urea from urine

Soil amendments
(N-P-K = 0.7-1.6-3.5)

Hygienic

Nordin et al., 2009
Fidjeland et al., 2013
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Schematic

- Urine diverting toilet seat
- Alkaline treatment module
- Vermicomposting module
- Vent to wind turbine
- Dehydration module
Table 1 – Required volume of the NoWaste Toilet modules to service a family of five people year round

<table>
<thead>
<tr>
<th>Module</th>
<th>Size (L)</th>
<th>Maintenance frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkaline module</td>
<td>6</td>
<td>1x week</td>
</tr>
<tr>
<td>Dehydrating module</td>
<td>38</td>
<td>1x 2 months</td>
</tr>
<tr>
<td>Vermicomposting module</td>
<td>492</td>
<td>1x year</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>534</strong></td>
<td></td>
</tr>
<tr>
<td>Required surface area</td>
<td>2.0</td>
<td>m²</td>
</tr>
</tbody>
</table>
NoWaste Toilet
Mass reduction

Food consumption

Improved soil structure

Pathogen removal

Soil amendment
$35 \text{ kg}$

Faeces $in$: $328 \text{ kg}$

Mass of excrement from a family of 5, annually

Dry fertilizer
$180 \text{ kg}$

3 kg

Urine $in$: $1802 \text{ kg}$

Commercial value:
$52 \text{ $ /family*yr}$

85% N recovery

Crop Production

Commercial value:
$52 \text{ $ /family*yr}$
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Next steps

- Test urine modules in series
- Fate of pathogens in end products
- Construction of the toilet

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Thank you
Questions & comments, most welcome!

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