India Field Testing of an Integrated Sanitation Platform with Electronic Public Toilet (eToilet) and Off-grid Anaerobic Membrane Bioreactor (NEWgenerator)

Robert Bair & Midhu S.V.,
J. Calabria, O. Ozcan, W. Sutton, P. Zydekk, D.H. Yeh
University of South Florida & Eram Scientific Solutions
Slum Sanitation

- Dependence on communal toilets
- High density and land value
- Compact treatment technology needed
- Low infrastructure coverage
Project Goal

Field testing of off-grid sanitation and resource recovery platform

International Faecal Sludge Management Conference
International Convention Centre, Durban, South Africa
29-31 October 2012
Front End: eToilet

- Indian company
- Focused on improved sanitation through automation
- Over 2100+ units installed throughout India
- Automated eToilets with remote monitoring capabilities
Back End: NEWgenerator

- Decentralized, onsite
- Safely processes wastes
- Modular & Off-Grid
- Compact design
- Water recycling
Pilot Design

Funding through Reinvent the Toilet Challenge India

- Coupled with 2 eToilets
- Designed for 100 uses/day
- Completely off-grid
- Onsite water recovery
Features of eToilet

- Easy to Install and Service
- Solar Powered System
- Stainless Steel Closet with SS Floor
- Remote monitoring
- Self-cleaning
- Ceiling light & exhaust fan
- Sensor enabled water saving design
NEWgenerator Construction
Location

- Pulluvila, Kerala (South India)
- Coastal community
- School with approx. 1500 students
  + usage by local community
Installation and Interfacing
Site Layout
## System Usage

### #Uses

<table>
<thead>
<tr>
<th></th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg</td>
<td>220</td>
<td>47</td>
<td>120</td>
<td>40</td>
</tr>
<tr>
<td>Max</td>
<td>454</td>
<td>163</td>
<td>314</td>
<td>179</td>
</tr>
</tbody>
</table>

### Daily Combined Toilet Usage: Entire Project Timeline

- **P1**: Project Initiation
- **P2**: No classes
- **P3**: School Resumes
- **P4**: Construction Work

![Graph showing daily combined toilet usage over the entire project timeline](image)
Flow Data

34% of avg. daily hygiene water demand in 1 hr
23% of avg. daily flush demand during in 1 hr
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Influent</th>
<th>Post Membrane</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg.</td>
<td>60</td>
<td>14</td>
<td>4</td>
</tr>
<tr>
<td>% Removal</td>
<td></td>
<td></td>
<td>91</td>
</tr>
<tr>
<td>Max</td>
<td>725</td>
<td>80</td>
<td>24</td>
</tr>
</tbody>
</table>
### Table:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Influent</th>
<th>Post Membrane</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg.</td>
<td>407</td>
<td>132</td>
<td>52</td>
</tr>
<tr>
<td>% Removal</td>
<td></td>
<td></td>
<td>85</td>
</tr>
<tr>
<td>Max</td>
<td>1096</td>
<td>479</td>
<td>197</td>
</tr>
</tbody>
</table>

### Graph:

The graph shows the change in color units over time (days), comparing Influent Color (brown squares) and Product Color (blue squares). The data indicates significant removal of color, with an average removal of 85%.
*Average removal throughout trial period. When influent COD increases above 100 mg/L – the removal increases to 86%
System Pilot: Pulluvila, Kerala

- Operated in 2016
- Successful integration of two technologies
- Off-grid operation
- Water recycling
Lessons Learned

• High seasonal and flow variability
• Low strength wastewater in institutional settings
• Integrated system capable of operating off-grid
• High quality water production from integrated system
• System meets many of the criteria for slum implementation
Acknowledgements:

Additional Contact Info:
Robert Bair
USF, Technical Lead
rbair@mail.usf.edu

Midhu S.V.
ESS, R&D Manager
midhu@eramscientific.com
Highlighted Challenges: Anaerobic MBR

Remaining Challenges:

• Enhancing permeate polishing for optimized ammonium and residual organics removal (improve energy and performance)
• Further miniaturization / process intensification– footprint reduction
• Beneficial small-scale biogas utilization (e.g., fuel cell for direct conversion to electricity)
• Testing over wide range of conditions (wastewater and fecal sludge characteristics, cultural and site conditions)
COD: Comparisons

COD Ramp up in a smaller-scale unit in Tampa, Fl. 150 mg/l – 12,000 mg/l COD
# External Testing

Testing conducted by the Dept. of Environmental Technology, CSIR-NIIST.

<table>
<thead>
<tr>
<th>Date</th>
<th>Fecal Coliforms (CFU/ml)</th>
<th>BOD (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Influent</td>
<td>Product</td>
</tr>
<tr>
<td>6/4/2016</td>
<td>1.12*10⁴</td>
<td>ND¹</td>
</tr>
<tr>
<td>22/4/2016</td>
<td>2.98*10⁴</td>
<td>ND¹</td>
</tr>
<tr>
<td>13/5/2016</td>
<td>7.1*10²</td>
<td>ND¹</td>
</tr>
<tr>
<td>22/6/2016</td>
<td>1.2*10²</td>
<td>ND¹</td>
</tr>
<tr>
<td>29/6/2016</td>
<td>1.8*10⁴</td>
<td>ND¹</td>
</tr>
<tr>
<td>13/7/2016</td>
<td>1.9*10³</td>
<td>ND¹</td>
</tr>
<tr>
<td>29/7/2016</td>
<td>2.2*10²</td>
<td>ND¹</td>
</tr>
<tr>
<td>12/8/2016</td>
<td>2.11*10⁴</td>
<td>ND¹</td>
</tr>
<tr>
<td>19/8/2016</td>
<td>7.1*10³</td>
<td>ND¹</td>
</tr>
<tr>
<td>30/8/2016</td>
<td>4.92*10³</td>
<td>ND¹</td>
</tr>
<tr>
<td>21/9/2016</td>
<td>2.61*10³</td>
<td>ND¹</td>
</tr>
<tr>
<td>5/10/2016</td>
<td>1.28*10⁵</td>
<td>ND¹</td>
</tr>
<tr>
<td>14/10/2016</td>
<td>7.88*10³</td>
<td>ND¹</td>
</tr>
<tr>
<td>21/10/2016</td>
<td>8.7*10³</td>
<td>ND¹</td>
</tr>
</tbody>
</table>

ND¹: Non detection – Parameters were below the detection limit of the respective test.

N/A: Not applicable – Parameter was not tested for that particular sample date.

Pending: Awaiting values from external lab
2. **eToilet Design and Development** - Data analysis, requirement specification finalization, Feasibility study design and development, modules procurement and testing, design validation, approval for production.
6. **Integrated System Testing Using Real Wastewater and Ambient Conditions** - Integrated system testing using recycling of treated water, testing of product water with all necessary parameters, eToilet functional study and refinements.

7. **User Feedback and Education**

8. **Lifecycle Cost Analysis of Membrane System** - In progress

9. **Design Improvement and Manufacturing Docs** - Improvements and refinements in eToilet and NEWgenerator - In progress

10. **Completion of final report** - Documentation in various data collection and testing reports - in progress
Flow Data

Avg. Water Demand

Water Demand (L/day)

- Flush Water
- Hygiene Water

[Bar chart showing water demand for each month from February to October.]