Challenges in Wastewater Treatment and Management in Asia: Appropriate Technological Solutions

Thammarat Koottatep

Areas of Technology Innovation

**Reinventing the Toilet**
- $0.05/person/day
- No pathogens
- User demand
- Sustainable

**Onsite Management**
- Remove pit contents
- Separate trash, sand and
- Treat water for local reuse

**Treatment & Reuse**
- Remove 100% pathogens
- Recover energy, nutrient/fertilizer and clean water
- Profitable business for investors and operators

**Toilet**
- DEWAT
- Fecal Sludge Management
CONCEPT OF TECHNOLOGY

ONSITE WASTEWATER TREATMENT TECHNOLOGY

Limitations of the on-site treatment processes:
- Effluents contained high concentration of pathogens and organic matters
- High accumulation rate of septage
A modified conventional septic tank with solar-heated water called as "Solar septic tanks" was considered to be an effective on-site sanitation technology.

1.) Low rate of sludge accumulation, and extending the desludging period
2.) Effluents can be reused in agriculture
3.) Optional to use biogas

CONCEPT OF TECHNOLOGY

PROOF OF PRINCIPLE (RESEARCH AND DEVELOPMENT)

Hydraulics characteristic
Pathogen inactivation
Microbial community

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CONCEPT OF TECHNOLOGY

Enhanced sludge reduction in septic tanks by increasing temperature

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Modeling of pathogen inactivation in thermal septic tanks
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ABSTRACT
Thermal application has been widely used for pathogen inactivation in various types of wastewater. However, this research was to develop a model of pathogen inactivation in septic tanks with a range of temperatures from 30, 40, 50 and 60°C and 60°C. E. coli was selected as the pathogen indicator. The

Hydraulic Evaluation and Performance of On-Site Sanitation Systems in Central Thailand
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This study was conducted to investigate the hydraulic performance and effluent quality of on-site sanitation systems in Thailand. The systems were classified into four categories: (1) dry pit systems, (2) dry pit systems with a leach field, (3) dry pit systems with a septic tank, and (4) dry pit systems with a septic tank and a leach field. The data were collected from 21 systems located in the three regions of the country. The results showed that the hydraulic performance of the systems varied depending on the type of system and the location.
CONCEPT OF TECHNOLOGY

MONITORING AND TESTING
Operating condition of solar septic tank

- Usage/ d = 18±13
- Water used = 174±180 L/d
- Average temperature in solar septic tank = 38±3 °C

Operating condition of Conventional septic tank

- Usage/ d = 20±6
- Water used = 129±55 L/d
- Average ambient temperature = 29±4 °C
**TREATMENT PERFORMANCE**

- Mainly organic solid sedimentation
- Temperatures higher than ambient temperature could activate microorganisms and increase the removal efficiencies of COD and BOD

**INNOVATIVE ONSITE WASTEWATER TREATMENT**

- Integration of solar septic tank and constructed wetland systems as a highly efficient, low investment and simple technique

- A modified conventional septic tank with solar-heated water called as “Solar septic tanks”
- Considered to be an effective on-site sanitation technology
- Solar septic tank can provide:
  - Low rate of sludge accumulation
  - High quality of effluent
- Constructed wetlands offer high abilities to remove soluble organic/micro pollutants, solids and nutrients contained in the wastewater which produce better quality of discharged wastewater.
Previous Wastewater Treatment Systems

- **Gravity-flow sewerage**
- **2 waste stabilization ponds**
- **Capital cost ~ about 40 million bath** ➔ not function well

Tsunami-hit Phi Phi Island and wastewater treatment plant
February 2005
Design of constructed wetlands at Phi Phi Island

Treatment capacity = 400 m³/day
Area = 5,600 m²
Cost = 28.5 million baht

The Flower and The Butterfly

Operation of constructed wetlands at Phi Phi Island

Expected performance:
\[ \text{BOD}_{in} = 100 - 200 \text{mg/L} \Rightarrow \text{BOD}_{eff} < 20 \text{ mg/L} \]
\[ \text{TKN}_{in} = 20 - 30 \text{ mg/L} \Rightarrow \text{TKN}_{out} < 5 \text{ mg/L} \]
Treatment Performance of Phi Phi CW System

<table>
<thead>
<tr>
<th>Parameter*</th>
<th>Unit</th>
<th>Influent</th>
<th>Effluent</th>
<th>Standard</th>
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<tbody>
<tr>
<td>pH</td>
<td>-</td>
<td>7</td>
<td>8</td>
<td>5.0 – 9.0</td>
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<tr>
<td>BOD</td>
<td>mg/L</td>
<td>270</td>
<td>22</td>
<td>≤ 20</td>
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<tr>
<td>SS</td>
<td>mg/L</td>
<td>127</td>
<td>15</td>
<td>≤ 30</td>
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<tr>
<td>Fecal coliforms</td>
<td>MPN/ 100 mL</td>
<td>2.73E+06</td>
<td>2.68E+05</td>
<td>n.a.</td>
</tr>
<tr>
<td>TKN</td>
<td>mg/L</td>
<td>61</td>
<td>36</td>
<td>≤ 35</td>
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</tbody>
</table>

* Annual average from 15 samples during 2007 - 2008

AIT academic building

[Image of AIT academic building with labels for Solar heated water system, Influent pipe, Constructed wetland units, Effluent pipe, Solar septic tank]
Solar septic tank: Public toilet

- Solar septic tank includes
  - 1,000 L conventional septic tank
  - Disinfection chamber
  - 12 m² solar water heating
  - Maintained temperature in the range of 35 - 42 °C

- Temperatures inside septic tank
  - Increased by circulating hot water generated from solar water heating device through a heat transfer equipment (copper coil), the hot water is pumped at rate of 5 L/min

- Collected the black water from a communal toilet (4 flush toilets)
  - Wastewater flow rate: 400-10,000 L/d
  - Organic loading rate: 2-17 kg/m³.d
  - Nitrogen loading rate: 0.1 - 0.6 kg/m³.d

Constructed wetland as a Post treatment

- Effluent from Solar septic tank pumped to Constructed wetland units
- 4 m² - constructed wetland
- Soil layers
  - 20 cm of clay soil (upper soil layer)
  - 5 cm of lateritic soil (Lower soil layer)
- The underdrain layers comprise
  - 5 cm of fine gravel and 25 cm of coarse gravel
- The plants for constructed wetland
  - Vetiver grasses
  - Canna flower
- Organic loading rate
  - 16-192 g/m².d
- Nitrogen loading rate
  - 1-36 g/m².d
- Solid loading rate
  - 4-13 g TSS/m².d
Characteristics of effluent of Integration of Solar Septic Tank and Constructed Wetland

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Concentration</th>
<th>National Thailand standard (MNRE, 2010)*</th>
<th>ISO standard (non-sewered sanitation system standard) **</th>
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<tbody>
<tr>
<td>TCOD</td>
<td>mg/L</td>
<td>45 ± 9</td>
<td>&lt;50</td>
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<tr>
<td>BOD5</td>
<td>mg/L</td>
<td>7 ± 3</td>
<td>&lt;200</td>
<td></td>
</tr>
<tr>
<td>TKN</td>
<td>mg/L</td>
<td>10 ± 4</td>
<td>&lt;15</td>
<td></td>
</tr>
<tr>
<td>NH(_3)-N</td>
<td>mg/L</td>
<td>8 ± 2</td>
<td>&lt;15</td>
<td></td>
</tr>
<tr>
<td>TP</td>
<td>mg/L</td>
<td>1 ± 1</td>
<td>&lt;2</td>
<td></td>
</tr>
<tr>
<td>TSS</td>
<td>mg/L</td>
<td>19 ± 7</td>
<td>&lt;60</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Total Coliform</td>
<td>MPN/100ml</td>
<td>6.83 × 10(^2)</td>
<td>&lt;10 per 100ml **</td>
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<tr>
<td>Escherichia coli</td>
<td>MPN/100ml</td>
<td>3.37 × 10(^2)</td>
<td></td>
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</tbody>
</table>


**Liquid output thresholds and rationale for their selection, Category A

***Thermo-tolerant coliforms

Applications:
Applications:

- Mobile public toilet of Bangkok city
- Design condition
  - > 50 User/d
  - 5 Flush toilets
  - 3 Urinals
  - 4 Wash basins
- 1,000 L solar septic tank
- 12 m² of solar heated water
- 4 m² of constructed wetland as “vertical garden”

Sanitation is not only a “Treatment” business but Infrastructure Development

- Regulated sanitation services
- Job creating industry
- Promote resource recovery
- Local investment
- Market structuring
- Licensing / contracts / tender
- Service provision standards
- Competitive business environment
- Local / regional manufacturing or assembly
- Marketing of the product
- new equipment
- Innovative systems
- Waste-to-energy processor
We create a bridge for sanitation innovations