Determining the Economically Optimal Capacity Of A Decentralized Faecal Sludge Treatment Plant

Presenting: Philip Watson
Andrea Stowell, Laura Morrison, Jamie Cajka

The Sanitation Technology Platform

Please Note: This report is a good faith effort by RTI International to accurately represent information available via secondary and primary sources at the time of the information capture. The report is confidential and proprietary and only for internal uses and not for publication or public disclosure.
Outline

Introduction
Approach
Illustrative Results
Summary
As a supplier of pre-engineered FS treatment technologies, what capacity should I offer?

Increasing Scale

- 6 m³ / day
  - Devanahalli Plant
  - Devanahalli, India

- 80 m³ / day
  - Dumaguete City
  - Dumaguete, Philippines

- 150 m³ / day
  - Lapulapu-Cordova
  - Septage Treatment Plan
  - Cordova, Philippines

Why does capacity matter?

Manufacturer’s perspective:
Product must capture significant share of market

Society’s perspective:
Minimize cost of Fecal Sludge Management

↓ $ / m³
Introduction

Approach

Illustrative Results

Summary
To establish economically optimal capacity, the evaluation needs to be conducted at city level and then synthesized.

1. Determine economically optimal OP at city-level

2. Synthesize across countries of interest

<table>
<thead>
<tr>
<th>Country Name</th>
<th>Population Density (people/km²)</th>
<th>Optimal OP scale (m³/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Côte d'Ivoire, Touba</td>
<td>2,263</td>
<td>50</td>
</tr>
<tr>
<td>Congo, the De Aketi</td>
<td>8,415</td>
<td>0</td>
</tr>
<tr>
<td>Congo, the De Bandundu</td>
<td>4,438</td>
<td>50</td>
</tr>
<tr>
<td>Congo, the De Basoko</td>
<td>4,890</td>
<td>50</td>
</tr>
<tr>
<td>Congo, the De Beni</td>
<td>5,198</td>
<td>50</td>
</tr>
<tr>
<td>Congo, the De Binda</td>
<td>172</td>
<td>50</td>
</tr>
<tr>
<td>Congo, the De Boende</td>
<td>23</td>
<td>0</td>
</tr>
<tr>
<td>Congo, the De Bolobo</td>
<td>527</td>
<td>0</td>
</tr>
<tr>
<td>Congo, the De Bonia</td>
<td>5,205</td>
<td>200</td>
</tr>
<tr>
<td>Congo, the De Bonio</td>
<td>220</td>
<td>0</td>
</tr>
<tr>
<td>Congo, the De Biosoba</td>
<td>629</td>
<td>0</td>
</tr>
<tr>
<td>Congo, the De Bukama</td>
<td>11,331</td>
<td>0</td>
</tr>
<tr>
<td>Congo, the De Bulungu</td>
<td>6,701</td>
<td>50</td>
</tr>
<tr>
<td>Congo, the De Bumba</td>
<td>6,433</td>
<td>50</td>
</tr>
<tr>
<td>Congo, the De Bunia</td>
<td>16,101</td>
<td>50</td>
</tr>
<tr>
<td>Congo, the De Businga</td>
<td>229</td>
<td>0</td>
</tr>
<tr>
<td>Congo, the De Buta</td>
<td>1,087</td>
<td>50</td>
</tr>
<tr>
<td>Congo, the De Duremba</td>
<td>4,210</td>
<td>100</td>
</tr>
<tr>
<td>Congo, the De Demba</td>
<td>1,710</td>
<td>0</td>
</tr>
<tr>
<td>Congo, the De Gandjika</td>
<td>3,787</td>
<td>100</td>
</tr>
<tr>
<td>Congo, the De Gbadolite</td>
<td>2,089</td>
<td>50</td>
</tr>
<tr>
<td>Congo, the De Gemena</td>
<td>4,264</td>
<td>50</td>
</tr>
<tr>
<td>Congo, the De Illebo</td>
<td>2,854</td>
<td>50</td>
</tr>
<tr>
<td>Congo, the De Inongo</td>
<td>135</td>
<td>0</td>
</tr>
</tbody>
</table>
Economically optimal capacity is the capacity at which a city’s total fecal sludge management cost is minimized.
A city’s population density has a significant influence on economically optimal capacity.

Illustrative Example: radius required to collect 100 m$^3$ / day from two urban areas in Bangladesh:

- Mirzapur: 3,000 / km$^2$, 3 km radius required
- Dhakar: 23,000 / km$^2$, 1 km radius required
### Other aspects of the approach

1. **Illustrative OP / FSTP Model**

2. Performed analysis for ~4,000 towns & cities (>10,000 pop) across 13 countries*

3. Modeling considered a range of country & city-specific variables:

<table>
<thead>
<tr>
<th>Collection and Transport</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Country-specific factors</strong></td>
<td></td>
</tr>
<tr>
<td>• Labor requirements &amp; costs</td>
<td>• End product prices</td>
</tr>
<tr>
<td>• Truck capacity &amp; speed</td>
<td>• Labor costs</td>
</tr>
<tr>
<td>• Truck capital &amp; operating costs</td>
<td></td>
</tr>
<tr>
<td>• Diesel costs</td>
<td></td>
</tr>
<tr>
<td><strong>City-specific factors</strong></td>
<td></td>
</tr>
<tr>
<td>• Population density</td>
<td>• Target FSM population.</td>
</tr>
</tbody>
</table>

* Côte d'Ivoire, Congo, the Democratic Republic of the, Dominican Republic, Ghana, Haiti, India, Kenya, Nigeria, Pakistan, Philippines, Senegal, South Africa, Bangladesh
The biggest category is for 50 & 100 m$^3$/day scale systems, but there is still potential need for larger scale systems.

Number of OPs required and population served by economically optimal OP capacity

- **Percent of total OPs required**
- **Percent of population requiring FSM**

**Results**

79%
The economically optimal scale of OP increases with increasing population density and target FSM population.
Larger African cities may benefit from larger capacity systems due to relatively low transport costs.

### Share of Larger Capacity Economically Optimal OPs

- **Capacity (m$^3$/ day):**
  - 350, 400
  - 450, 500
  - 550, 600
  - 650, 700
  - 750, 800
  - 850, 900
  - 950, 1000

- **Regions:**
  - Africa
  - Americas
  - Asia

Percentage distribution for each region is shown in the bar chart.
Outline

Introduction
Approach
Illustrative Results

Summary
In summary

• Matching capacity and city size minimizes costs.

• Total FSM cost is a trade-off:
  • Transport costs increase with scale.
  • Treatment costs decrease with scale.

• Population density significantly influences this trade-off.

• Consider other local & technology specific variables.

• Based on the example OP technology:
  • Need for small-scale solutions (e.g. 50-100 m³ / day).
  • Smaller but important opportunity for larger systems.