Wastewater and Fecal Sludge Reuse Business Model – Select Examples for India

Krishna C Rao
**Waste Flow**

- Human Excreta
- Detergents
- Organic Residues
- Animal Manure
- Other Residues (e.g., oils, soil, litter)
- Household and commercial Used Water
- Industrial Process Water
- Storm Water

**Recoverable Resources**

- Energy
  - Gas and dry fuel production
- Nutrients
- Organic Matter
- Water
- Other (e.g., valuable materials)

**Reuse**

- Plant Fertilizer
- Soil Conditioner
- Other Outputs (e.g., protein, seed, building materials, trace elements)
- Ecosystem Services (e.g., environmental flows)
- Water Reuse and Recycling (e.g., irrigation, industrial, potable and non-potable, groundwater recharge, fish farming)
Wastewater and Fecal Sludge Reuse Universe
Why do we not see more of this and at scale?

• Most initiatives aimed at RRR have been characterized in low-income countries by:
  - High dependence on *subsidies*;
  - **Limited up-scaling** potential.

Most donors and governments envision investment plans which do not require their continuous support for impact.

**Fundamental gaps in:**
- Business planning and management strategies, market knowledge;
- Economic aspects and institutional linkages

Resulting in more **failures than successes**.
Wastewater Reuse Business Models
1. Farmers are encouraged to use treated urban wastewater which also supports the local aquifer and wetland functions. Farmers’ payments for water conveyance is being discussed but might be a disincentive while the swap costs are easier recovered via the urban water bill.

2. Local industry pays urban water agency for reclaimed water.

3. Farmers accept the more reliable reclaimed water in times of drought and stop using freshwater, securing its availability for urban water users.

4. The swap will not change total water availability in the river basin context but more freshwater could get reallocated to higher valued uses, which finance the exchange.

Inter-Sectoral Water Exchange
Water-Swap Business Model

**Iran – Mashhad plain**

- **REGIONAL WATER COMPANY** Swapping wastewater against freshwater
- **FARMERS** Increased crop irrigation
- Exchange of higher quality of water against higher volume of water
- **CITY** Increased drinking water supply

**KEY INDICATORS (AS OF 2011)**
- **Land use**: Up to 3,000 ha under irrigation
- **Water use**: About 25 MCM treated effluent used for irrigation (15.7 MCM for Kardeh area)
- **Capital investment**: USD 6 million (Kardeh dam area only)
- **Labor**: -
- **O&M cost**: USD 650,000 (Kardeh dam area only)
- **Output**: Release of ca. 21 MCM of freshwater for municipal use (13 MCM from Kardeh area)

**Llobregat delta, Spain**

<table>
<thead>
<tr>
<th>CHARACTERISTICS</th>
<th>EL PRAT</th>
<th>SANT FELIU</th>
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<tbody>
<tr>
<td>Irrigated farmland (ha)</td>
<td>801</td>
<td>275</td>
</tr>
<tr>
<td>Effluent volume applicable for irrigated agriculture (MCM/yr)</td>
<td>13.0</td>
<td>7.3</td>
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</table>

**UNIT COSTS AND BENEFITS**

<table>
<thead>
<tr>
<th></th>
<th>EUR/M³</th>
<th>EUR/M³</th>
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</thead>
<tbody>
<tr>
<td>Unit cost of water reuse and exchange</td>
<td>0.40</td>
<td>0.22</td>
</tr>
<tr>
<td>Unit total economic benefit for agriculture and city</td>
<td>1.14</td>
<td>1.17</td>
</tr>
<tr>
<td>Unit cost/benefit ratio</td>
<td>2.85</td>
<td>5.3</td>
</tr>
</tbody>
</table>
Rural-Urban Water Exchange through Managed Aquifer Recharge

Mezquital Valley, Mexico

**KEY PERFORMANCE INDICATORS (ONLY ATOTONILCO WWTP, STATUS 2016)**

- **Land use:** 159 ha (plant area)
- **Water use:** 35 m$^3$/s wastewater treated
- **Capital investment:** USD 786 million (numbers vary with source and reference year)
- **O&M:** USD 81 m per year
- **Output:** Up to 90,000 ha of irrigated fodder and food crops, aside large-scale wastewater driven aquifer recharge of about 25–39 m$^3$/s, which is retrieved in the valley for different purposes including domestic water supply (6.2 m$^3$/s envisioned for Mexico City)

Hoskote, Bangalore, India

**KEY PERFORMANCE INDICATORS (2014/15)**

- **Land use:** 20 km of wastewater pipeline / open canal
- **Water requirements:** Lifting capacity of 0.26 m$^3$ per second
- **Capital investment:** USD 674,000
- **Labor requirements:** Low in public sector, but high among benefiting farmers and private sector
- **O&M:** USD 3000–3500 per month (mostly for pumping)
- **Output:** 5-6 MCM per year for up to 171 ha under irrigation
Innovation in P recovery

Full-scale struvite production facility
West Boise Canada (Pharmer Engineering)

Struvite as commercial fertilizer

Full-scale struvite production facility
West Boise Canada (Pharmer Engineering)

www.pharmereng.com 2013 (Ostara)
Wastewater for Aquaculture production

Performance Indicator – Bangladesh Agriquatics

<table>
<thead>
<tr>
<th>Category</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land use</td>
<td>1.6 ha</td>
</tr>
<tr>
<td>Wastewater</td>
<td>300 m³/day</td>
</tr>
<tr>
<td>Capital</td>
<td>USD 20,000</td>
</tr>
<tr>
<td>Labor</td>
<td>4 persons for 1 hour – 7 days a week</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>USD 3,000 to 5,000</td>
</tr>
<tr>
<td>Output</td>
<td>About 7.5 tonnes/yr of mixed carp species fish sold on-site at an average price of USD 1/kg, earning USD 7,500 from fish (an equal amount possible pilfered) and about USD 1,000 from crops.</td>
</tr>
<tr>
<td>Payback</td>
<td>6 years</td>
</tr>
</tbody>
</table>
Wastewater for Energy Generation

**Performance Indicator – Draga, Morocco**

- **Land use**: Plant: 2 ha; up to 16 ha irrigated (under potential)
- **Water Treated**: 1,800 to 2,700 m³ per day (design capacity 600–1,000 m³ per day)
- **Capital**: USD 1.7 million
- **Labor**: About 5; ca. 27% of the O&M costs
- **O&M**: USD 2,300 to 3,600 per month
- **Output**: Tertiary treated wastewater
Reuse Business Models for Fecal Sludge Management
Energy Recovery from Fecal Sludge
Public toilet – Energy Recovery Model
**Bio-center in Nairobi**

<table>
<thead>
<tr>
<th>Business Scale</th>
<th>~ 2 tonnes FS treated per day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population served</td>
<td>Up to 2,000 people</td>
</tr>
<tr>
<td>Biogas production</td>
<td>About 50 m3/day</td>
</tr>
<tr>
<td>Investment required</td>
<td>INR 5 lakhs to 15 lakhs for toilet and biogas plant</td>
</tr>
<tr>
<td>Annual operation cost</td>
<td>INR 2.5 lakhs to 6.5 lakhs</td>
</tr>
<tr>
<td>Annual revenue</td>
<td>INR 7 lakhs to 10 lakhs</td>
</tr>
<tr>
<td></td>
<td>• INR 6 lakhs to 9 lakhs from toilet fees</td>
</tr>
<tr>
<td></td>
<td>• INR 50,000 to 75,000 from rentals</td>
</tr>
<tr>
<td>Land required</td>
<td>• 0.01 ha (biogas plant)</td>
</tr>
</tbody>
</table>
Residential Institution model
ICRC Prison Biogas

Cases: Nepal, Philippines, Rwanda in Prisons

- In mates: 100 to 5,000
- Biogas plant – 10 to 500 m³
- Capital cost: INR 9 lakhs to 45 lakhs; about INR 1,500 to 2,000 per m³
- Energy savings from INR 165 to 300 in Rwanda, reduced firewood expense by 17% to 41% in Nepal
<table>
<thead>
<tr>
<th>Aspect</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>Plant capacity</td>
<td>30 TPD</td>
</tr>
<tr>
<td>Gas generation</td>
<td>~400m³</td>
</tr>
<tr>
<td>Power generation</td>
<td>The operator has an agreement with the NMC to provide electricity for the STPs through an Open Access Agreement for Wheeling of Electricity</td>
</tr>
<tr>
<td>Capital investment</td>
<td>Rs. 8 crores (6.8 crores provided by GIZ; 1.2 crores provided by NMC)</td>
</tr>
<tr>
<td>Annual maintenance</td>
<td>The operator has an O&amp;M contract with NMC. The O&amp;M contract is for Rs. 5 Lakhs / month.</td>
</tr>
</tbody>
</table>

**FACTS & FIGURES**

- 10 tons of organic waste and 20 tons of Septage
- Generation of 3,300 kWh per day to be fed into Maharashtra power grid
- The project is implemented in DFBOOT (Design – Finance – Build – Own – Operate – Transfer) mode.
- PPP Model with monthly costs for Nashik Municipal Corporation of 5 lakh INR
Nutrient Recovery from Fecal Sludge
Farmer-Truck operator partnership
Co-Composting

Containment

Collection/Transport

Treatment

Disposal/Reuse

<table>
<thead>
<tr>
<th>($) /ha</th>
<th>Users</th>
<th>Non-users</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total fixed costs</td>
<td>191</td>
<td>137</td>
</tr>
<tr>
<td>Total variable costs</td>
<td>314</td>
<td>323</td>
</tr>
<tr>
<td>Revenues</td>
<td>919</td>
<td>606</td>
</tr>
<tr>
<td>Net Income</td>
<td>414</td>
<td>146</td>
</tr>
</tbody>
</table>

Yield in MT/ha

- **MAIZE**
  - Sheshegu
  - Tuu-tengle

- **SORGHUM**
  - Sheshegu
  - Tuu-tengle

Users vs. Non-users

Total fixed costs: 191 vs. 137
Total variable costs: 314 vs. 323
Revenues: 919 vs. 606
Net Income: 414 vs. 146
## Co-Composting Cases

<table>
<thead>
<tr>
<th>Country/Location</th>
<th>Owner/Operator</th>
<th>Waste Description</th>
<th>Population</th>
<th>Capital (INR)</th>
<th>O&amp;M (INR/month)</th>
<th>Technology</th>
<th>Revenue Description</th>
</tr>
</thead>
</table>
| Balangoda, Sri Lanka             | Public         | 12 ton MSW/day and 10 m³ FS/day                                                  | 36,000           | 2.1 crores          | 85K/month       | Ponds with attached growth system, Drying beds, Windrow composting and Landfill for MSW | • FS collection: INR 1,800 to 2,000 per trip  
  • Compost: INR 4 per kg (2 tons/day)  
  • Recyclable & MSW fees |
| Accra, Ghana                     | PPP            | 50-60 m³ FS/day and 3 tons/day organic waste (saw dust)                          |                   | 3.3 crores          | 6.5 to 8 lakhs   | Drying beds, Ponds and Windrow composting                                 | • Tipping fees: INR 130 per truck  
  • Compost: INR 18 to 20 per kg (2 to 4 tons/day)  
  Operational cost breakeven in 3 to 5 years |
| Budhni, MP & Mughalsarai & Gangaghat, UP India | (feasibility study) | 30 to 64m³ FS/day with 3 years scheduled desludging and 15 to 70 tons MSW/day | 35,000 to 100,000 | 4.4 to 6.5 crores | 4 to 12 lakhs/month | Drying beds, DEWATS, Windrow composting and Landfill for MSW | • FS collection: INR 1,000 to 1,900 per trip  
  • Compost: INR 1.4 to 4 per kg – 4.5 to 9 tons/day |
Cost Recovery from Reuse – User Charges

Reuse can reduce user charges by almost 30% in India
150+ business cases analysed for domestic and agro-waste
- 50 cases have in-depth analysis
- 18+ business models developed
FSM Business Models

18 FSM Business Models developed

BUSINESS MODELS FOR TOILET ACCESS AND IN-SITU ENERGY RECOVERY
- Public toilet with energy recovery

MODELS FOR EMPTYING AND TRANSPORT OF FECAL SLUDGE
- Commonly occurring private emptying and transportation
- Franchise
- Nonprofit
- Transfer station

MODELS LINKING EMPTYING, TRANSPORT
- Commonly occurring public FSM
- Licensing
- Call center
- Scheduled desludging sanitation tax
- Incentivized disposal
- Full private

MODELS EMPHASIZING REUSE AT THE END
- Farmer-truck operator partnership
- Co-composting
  - Town cluster approach
  - Pull-push

MODELS COVERING THE ENTIRE SANITATION SERVICE CHAIN FROM TOILET ACCESS TO REUSE
- Non-movable UDDT installation
- Container-based sanitation (CBS)
Thank You.