Design Principles for Decentralized Wastewater Treatment Systems (DEWATS)

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Background
Lack of Water and Sanitation

- No access to adequate Water: 1,200
- No access to suitable sanitation: 2,500
- World population: 6,000
- India population: 1,100
Illnesses and deaths in developing countries due to contaminated water.
India
Sewage Treatment at medium and large cities

2,902 Cities
93% Without STP

217 Cities
7% With STP
A few basic findings:

- Wastewater treatment is one of the last priorities of public and private investment.  
  -> nobody is interested, “arrangements” are easier

- Conventional treatment units are too expensive.  
  -> difficult to demand their installation

- Conventional treatment units require skilled operators.  
  -> often not performing, most of the time out of order

- Conventional treatment units operational costs are high.  
  -> switched off to safe energy

- Conventional treatment units require regular maintenance.  
  -> often not performing, most of the time out of order

- Nobody likes handling wastewater
Reconsideration of the WW treatment approach.

There is a technological gap between pit latrines and centralized highly sophisticated WW treatment plants.
Our Response:

DEWATS
Our Response:

DEWATS = Decentralised Wastewater Treatment Systems
Discrepancies we do need to overcome

- The technology offered does not match with the technical skills available.
- The investment costs do not match with the possibility/willingness to pay.
- The required input for operation (financing, time, labor, skills) do not match with the readiness to provide it.
- The discharging standards do not match with the possibility to enforce them.
- The urgency of pollution control do not match with the awareness and information levels.
- The assigned responsibility for WW do not match with the capacity to deliver accordingly.
DEWATS is an approach, rather than a hardware package.

That is why....
This means, DEWATS is led by some principles, which represent the guide frame for designing:

- **Decentralization:** Responsibility, Capacity, Treatment, etc.
- **Simplification:** Process, Technology, O&M,
- **Conservation:** Water, Nutrients, Energy
  
**Recycling**
Decentralization
Centralized WW Collection and Treatment
Decentralized WW Collection and Treatment
Decentralize responsibility

• Application of the principle “The polluter pays”
  – In industrial sector accepted
  – For domestic sector not accepted
  – A treatment unit near to the producer allows specific control
• Assign responsibilities
  - Individuals (demand)
  - Builders (technical offer)
  - NGO (Awareness, Training, DEMO)
  - Research institutions (develop option)
  - Municipalities (enforcement, control)
  - Legal entities (legal provisions)
Decentralize technology

- Treatment close to where it is generated
  - Reduction of trunks and collector sewer
  - Reduction of intermediate pumping stations
Decentralize technology (cont.)

- Re-use close to where it is generated
  - Irrigation
  - Gardening
  - Recharge underground water
  - Use sewage for agriculture (sewage farm)
Decentralize Capacity

• Centralized design capacity
  – Capacity centers (CDD)
  – Training centers

• Decentralized implementation
  – Certified builders, architects, engineering offices
  – Service units
Simplification
Simplification

Means LOW-TECH,
but not necessarily easy.

*Natural processes
maybe simple from a technical point of view,
but complex from an ecological point of view.*

Means CLEVER
Integrated, interdisciplinary work
• Diminish the treatments volume by reducing the catchments area through decentralization

  - Less volume = easier management
  - Small surfaces become available for treatment (sidewalks, private yards, parking lots, alleys, parks, etc.)
  - Wastewater composition becomes more accountable
  - the risk of failure is reduced (all systems fail)
Simplification (cont.)

- Separation of WW-Streams
Composition of domestic wastewater

<table>
<thead>
<tr>
<th>Yearly Loads</th>
<th>Volume</th>
<th>Greywater 25,000 - 100,000</th>
<th>Urine</th>
<th>Feaces</th>
</tr>
</thead>
<tbody>
<tr>
<td>kg/(P²/year)</td>
<td>~(P²/year)</td>
<td>~3%</td>
<td>~87%</td>
<td>~10%</td>
</tr>
<tr>
<td>N</td>
<td>~4-5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>~0.75</td>
<td></td>
<td>~50%</td>
<td>~40%</td>
</tr>
<tr>
<td>K</td>
<td>~1.8</td>
<td></td>
<td>~54%</td>
<td>~12%</td>
</tr>
<tr>
<td>COD</td>
<td>~30</td>
<td></td>
<td>~12%</td>
<td>~47%</td>
</tr>
</tbody>
</table>

Treatment

Reuse / Water Cycle

Biogas-Plant Composting

Fertiliser

Soil-Conditioner
Domestic WW Streams

Stream
- Yellow Water (Urine)
  - Hygienization by storage and drying
  - Liquid or solid fertilizer
- Brown Water (Faeces)
  - Anaerobic digestion, drying, compost, Mixing with org. residues
  - Biogas, Soil conditioner
- Gray Water (Shower, Kitchen, Laundry etc.)
  - Sand/gravel filter, ponds, biol. Treatment, EM membrane technology
  - Irrigation, Recharge ground water
- Rain Water
  - Filtration, biol. treatment
  - Water supply, Recharge ground water
Simplification (cont.)

• Reducing water for transport of residues
  – Reduced volumes to be treated
  – Increased concentration of pollutants
Simplification (cont.)

- Treatment until re-use is possible
  - 1st Identification of re-use options then, planning the treatment unit
- Most pollutants are substances needed for agriculture
  - Organic
  - Phosphorus
  - Nitrogen
  - Potassium
Simplification (cont.)

• Selecting the right technology

  - Priority given to anaerobic technology in warm climates
  - Priority given to aerobic technology in cold climates
  - Using gravity instead of pumps
  - Avoiding valves
  - Oxygen incorporation by helophytes (swamp plants)
  - Aeration by vorticity
  - Opting for condominial sewer lines
  - Integrating treatment modules in unused spaces (alleys, roads, parking areas, gardens, private yards, parks, etc.)
Simplification (cont.)

- Standardization
  - Assign treatment systems to specific decentralized pollution sectors
    - Identify sectors and their clusters
  - Prefabrication of modules (mass production)
    - Single House units
    - Baffle modules
    - Distribution boxes
• Applied research
  – Distribution systems
  – Filter material
  – Odour reduction (EM, biofilter)
Simplification (cont.)

• Including wastewater treatment unit in the planning and designing task of architects and builders
  – Design buildings taking into account the requirements of treatment units
    – Ensure correct slop to operate per gravity
    – separation of streams,
    – reduction of wastewater
    – integration in the landscape
  – Trained local craftsmen offer technology assessed by certified planning units
Conservation / Recycling
• Conservation of Fossil Energies
  - Reducing electrical equipment
  - Applying anaerobic technology; using biogas
  - Selecting and reducing construction material
• Conservation of fresh water resources
  – Reducing water for transport (water-saving devices, water-saving attitude)
  – Substituting fresh water by treated wastewater (agriculture, cleaning)
• Conservation of nutrients
  - Returning nutrients contained in the wastewater to the fields (peri-urban agriculture)
Conservation and Recycling

• Use of the treatment products

- **Treated wastewater** (Irrigation, water recharge, technical water, landscaping, micro-climate)

- **Nutrients** (agriculture, horticulture, forestry, aquaculture)

- **Biogas** (heating, electricity generation)
  	Methane = greenhouse gas
Conservation and Recycling

• Locate the treatment where the products are needed
  – Public recreation areas
  – Farm land
  – Industry (co-fermentation)

• Centralized utilization of WW treatment products
  – Sludge digestion centers at focal points
    • Cogeneration
    • Compost
  – Treated wastewater pipeline
  – Urine collection centers
DEWATS technical approach
DEWATS concept incorporates the following attributes:

- Treatment for organic wastewater from domestic and industrial sources
- Affordable prices
- Fulfillment of discharge standards
- Treatment of wastewater flows from 1-1000 m$^3$/d
- Tolerance to inflow fluctuation
- No dependence on energy
- Minimal maintenance
- Reliability and longevity
- Reuse of wastewater and its contents
DEWATS Modules

- Septic-Tank
- Facultative-Lagoon
- Baffled-Reactor
- Anaerobic-Filter
- Planted Gravel-Filter
- Sludge Drying Bed
1. Sedimentation and floatation
2. Fermentation of bottom sludge
1. Sedimentation / floatation of solids
2. Anaerobic digestion of suspended and dissolved solids through sludge contact
3. Anaerobic digestion (fermentation) of bottom sludge
4. Sedimentation of mineralised (stabilised) suspended particles
Principle of Anaerobic Filter

1. **Sedimentation / floatation**
2. **Anaerobic digestion of suspended and dissolved matter inside the filter**
3. **Anaerobic digestion (fermentation) of bottom sludge**

![Diagram of an anaerobic filter system](image)
1. Continuous oxygen supply to the upper layers
2. Helophytes provide oxygen to the lower layers
3. Roots of plants provide favorable environment for bacteria diversity
4. Anaerobic - facultative conditions in the lower layers

**Principle of the Horizontal Filter**

- Continuous oxygen supply to the upper layers
- Helophytes provide oxygen to the lower layers
- Roots of plants provide a favorable environment for bacteria diversity
- Anaerobic - facultative conditions in the lower layers
DEWATS system

The right combination and dimension of the modules make DEWATS successful.
DEWATS Examples
Anaerobic baffled reactor

- Gas manholes
- Inflow
- Scum
- Outflow
- Sludge
- Sedimentation
- Inoculation of fresh wastewater with active sludge
- Final settler

Anaerobic Baffled Reactor
Planted Horizontal Sand/Gravel Filter Off-plot System Horizontal Planted filter
Community Based Sanitation
Thanks for your attention!

For more information, please do not hesitate to contact us:

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