DECENTRALIZED SANITATION SYSTEMS FOR THE SOUTHERN ECUADORIAN ANDES, ASSESSMENT AND CHALLENGES

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• **Introduction**
  - The southern Andes of Ecuador
  - climate / morphology / domestic sewage
• **Long-term sanitation objectives**
• **Methodology**
  - A review of existing technologies
    - Organic matter removal
    - Pathogen removal
    - Sustainability
  - Assessment of existing systems
  - Organization capacity
• **Conclusions / Perspectives**
Southern Andes of Ecuador

Rural and sub-urban population: +/- 700 000
20% still missing improved sanitation; wastewater treatment < 5%
Southern Andes of Ecuador

- **Climate-morphological conditions**
  - 1500 – 3200 m.asl
  - Temperatures 12 – 24 °C
  - No scarcity of fresh water resources
  - Rainfall 660 - 3400 mm/year
  - Mountain rivers… high self-purification capacity

- **Domestic wastewater**
  - Highly diluted: drinking water 150-300 l/hab-day
  - Low organic concentration: 100-250 mgBOD/l
  - Pathogen concentration: 6-9 log units
  - Infiltration and illicit connections
  - High concentration of particulate runoff material
Southern Andes of Ecuador

- Sanitation long-term objectives
  - Efficiency and sustainability: Decentralized systems
  - However, efficiency means prioritizing
    1. Resource recovery
    2. Public health (pathogen removal)
    3. Environment (organic matter and nutrients)
    4. Construction and O&M cost
The review: potential technologies

• **Methodology:**

  • Review of good technological examples at comparable climate conditions
  • Interview to managers and users of DWWT systems
  • **Assessment of many decentralized system constructed in the last two decades**
  • Assessment of Community capacities and willingness for the operation and maintenance of the systems
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<tr>
<td><strong>Place of study</strong></td>
<td><strong>Temperature</strong></td>
<td><strong>Population</strong></td>
<td><strong>Objective / Methodology</strong></td>
<td><strong>Applied Technology</strong></td>
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<tr>
<td>(Elmitwalli et al., 2003)</td>
<td>Netherlands</td>
<td>T: 13 °C (Winter), 18 °C (Summer)</td>
<td>1000-20000</td>
<td>Feasibility of anaerobic wastewater treatment at low temperatures and low costs of investment and maintenance.</td>
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<td>(Langergraber and Muellegger, 2005)</td>
<td>Peri-urban in: Uganda, Germany, Denmark y Finland.</td>
<td>Variable.</td>
<td>No Data</td>
<td>Introduction to EcoSan principles and concepts including re-use aspects</td>
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<tr>
<td>(Kujawa-Roeleveeld and Zeeman, 2006)</td>
<td>Peri-urban areas in low-income DC</td>
<td>Temperature: 20°C y 13 °C.</td>
<td>Varies</td>
<td>Gray and black water are analyzed, comparing their composition with their location, lifestyle, customs and facilities</td>
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<td>(Abegglen and Siegrist, 2006)</td>
<td>Solothurn (Switzerland)</td>
<td>Temperature: 16°C.</td>
<td>250,000</td>
<td>In-situ domestic wastewater treatment, effluent reuse, low drinking water demand.</td>
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<td>(Mendez et al., 2008)</td>
<td>Orizaba, Veracruz (Mexico)</td>
<td>Temp max 25; min 16 °C; rainfall 2238 mm; y 1232 mm</td>
<td>120,995</td>
<td>After a primary and advanced treatment, the best conditions for pathogen removal and reuse</td>
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<td>(Fach and Fuchs, 2010)</td>
<td>Gunung Kidul (Indonesia)</td>
<td>Temperature: between 21 °C and 32 °C</td>
<td>Varies</td>
<td>Potential of reuse of effluents and stabilized sludge from septic tanks</td>
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<td>(Rojas-Higuera et al., 2010)</td>
<td>Bogotá (Colombia)</td>
<td>Temp: 13 °C, Rainfall: 890 mm/y, 2600 m asl</td>
<td>36 km from Bogotá.</td>
<td>Treatment of sludge from oxidation ponds, and reuse in agriculture.</td>
</tr>
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<td>(Nanninga et al., 2012)</td>
<td>Xochimilco (Mexico)</td>
<td>Temp 15 °C, rainfall 60 mm/y, 2240 m asl</td>
<td>415,000</td>
<td>Acceptance of people to decentralized technologies for recover and reuse water, nutrients and energy.</td>
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<td>(Ghaitidak and Yadav, 2013)</td>
<td>Perth (Aus), Calicut (Ind), Dakar (Sen), Amman (Jor), South Africa, Sana-a (Yem).</td>
<td>Different conditions</td>
<td>Varies</td>
<td>Advantages of treating grey water separated with a focus on reuse.</td>
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<td>(Silva-Leal et al., 2013)</td>
<td>Cañaveralejo, Cali (Colombia)</td>
<td>Temp: 23°C, rainfall 908 mm/y, 1018 m asl</td>
<td>2,060,000</td>
<td>Elimination of pathogens in treated and drying biosolids to get class A qualification.</td>
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<tr>
<td>Reference</td>
<td>Place of study</td>
<td>Population</td>
<td>Current infrastructure</td>
<td>Social aspects</td>
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<td>(Sundaravadivel and Vigneswaran, 2003)</td>
<td>India: Andipatti, Bodinayakanur, Cumbum and Theni</td>
<td>5000-10000</td>
<td>Dry latrines. WW collected in open channels; effluent used in irrigation.</td>
<td>The communities receive little attention from authorities.</td>
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<td>(Parkinson, 2003)</td>
<td>Peri-urban, low-income areas in developing countries</td>
<td>Different range</td>
<td>Not access to safe drinking water and sanitation facilities.</td>
<td>WW in direct contact to people. No interest for environment and health problems.</td>
</tr>
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<td>(Heymans et al., 2004)</td>
<td>South Asian countries: Bangladesh and Vietnam</td>
<td>No Data</td>
<td>A small percentage of homes have latrines and septic tanks.</td>
<td>Deficient environment and public health knowledge in communities, disconnection to government</td>
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<td>(N. Viet Anh et al., 2004)</td>
<td>Hanoi, Vietnam</td>
<td>1.7 millions</td>
<td>65% have sewage connection. Black waters are treated in STs and discharged in a river.</td>
<td>The population density is rapidly growing, due to industrialization. High pressure on natural resources</td>
</tr>
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<td>(Kamal et al., 2008)</td>
<td>Urban and Peri-urban areas of south and southeast Asia</td>
<td>1-100 homes</td>
<td>Big cities have poor treatment. Small towns without any collection or treatment.</td>
<td>Lack of coordination between different levels of government with rural communities.</td>
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<td>(Kema et al., 2012)</td>
<td>Mwara rural district, Tanzania</td>
<td>203000 people 375 homes</td>
<td>Scarce or no access to ventilated or traditional latrines.</td>
<td>Only 40 out of 118 villages have access to sanitation. Low quality of life</td>
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<td>(Meleg, 2012)</td>
<td>Bahía, Ceará, Piauí, Brazil</td>
<td>No Data</td>
<td>There are access to latrines and primary treatment to small scale.</td>
<td>Low-income communities accept help from private entities or governments.</td>
</tr>
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<td>(Fam et al., 2014)</td>
<td>Melbourne, Australia</td>
<td>3.6 millions</td>
<td>Separate sewage systems (sanitary and storm). Artificial wetlands systems.</td>
<td>Melbourne inhabitants are well aware of planning and collaboration for a good quality of life.</td>
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<td>(Van Dijk et al., 2014)</td>
<td>Dar es Salaam, Tanzania and Kampala, Uganda</td>
<td>Dar es Salaam (5 millions), Kampala (1.2 millions)</td>
<td>Shared toilets and latrines in poor condition. Open defecation.</td>
<td>Unhealthy environments and high rate of diseases. No investment in sanitation from authorities</td>
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<td>(Kouamé et al., 2014)</td>
<td>Yamoussoukro, Côte d’Ivoire</td>
<td>300,000 people 492 homes</td>
<td>Dry latrines. STs. No sludge disposal. Effluent reuse in agriculture without any treatment.</td>
<td>High levels of diarrhea and malaria, directly associated with the lack of sanitation.</td>
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</table>
• Assessment of existing decentralized system constructed in the last two decades
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• More than a half of the systems are not receiving O&M for years
• 1/3 are collapsed and abandoned
• Some few are in operation
• No one is accomplishing the ultimate objective: pathogen reduction
• **The main goal:** disinfection
• **The challenge:** to get an adequate effluent for applying any disinfection technology (chlorination, UV radiation, photo catalysis with TiO₂)
• **For highlands > 2400 m.asl**

1. Two stage: Septic Tank + Anaerobic filter. Hybrid ST (Sharma et. al. 2014) + D

   ![Diagram of Septic Tank + Anaerobic filter]

2. Three stage + D

   ![Diagram of Three stage treatment]

3. Two stage: Septic Tank + Constructed wetland

   ![Diagram of Septic Tank + Constructed wetland]
• **For lowlands**

1. Two stage: UASB + Anaerobic filter + D
   
   ![Diagram](image1)

2. Three stage + D
   
   ![Diagram](image2)

3. Two stage: Septic Tank + Constructed wetland
   
   ![Diagram](image3)
Organization capacities at users level

- The need of **users awareness** about the **benefits** of domestic effluent treatment to preserve the public health and the environment.
- The community **organizational capacities** could be noticeably **improved** with the involvement of community leaders in the O&M responsibilities.
- The public institutions should aim to decentralize and **reinforce** the administrative and organizational capacities of the communities.
- In Ecuador, it is still necessary to reinforce **scientific research** towards decentralized WWT technologies and to strengthen the **capabilities** of the **engineers** in the whole process of technology selection, design, and operation and maintenance of the decentralized DWWT systems.
• Public Health as the main objective in the sanitation program at Ecuadorian Andes
• Disinfection is feasible when the effluent presents adequate characteristics
• The temperature is a determinant factor when considering the technical feasibility of the systems
• The anaerobic systems are a feasible alternative, particularly septic tank units or UASB reactors.
• Septic tanks followed by an anaerobic filter or constructed wetlands are good alternatives for both BOD and pathogen reduction.
• These technological alternatives require, however, a validation by pilot experiences
• The level of success of the decentralized system is directly proportional to the level of community involvement.
Thank you for your kind attention

Acknowledgements: