Development of Ecological Sanitation Projects in Urban Areas

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CONTENTS

• Introduction
• Types of the suitable toilets for ecological sanitation systems in urban areas
• Treatment processes for different wastewater flows
• Case studies
• Conclusions
Domestic wastewater treatment ratio and COD discharge amount in urban areas of China (EPA of China)

Domestic Wastewater Amount in 2006:
29660 Mio. M³

Treated Domestic Wastewater Amount in 2006:
13040 Mio. M³

Main treatment process (centralized sewerage system):
Primary treatment + secondary biological wastewater treatment process
Table 1: Domestic wastewater treatment ratio and COD discharge amount per m³ wastewater in urban areas of China (EPA Data)

<table>
<thead>
<tr>
<th>Year</th>
<th>Domestic WW Treatment %</th>
<th>COD discharge amount (kg COD per m³ WW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>100</td>
<td>0.0000</td>
</tr>
<tr>
<td>2002</td>
<td>90</td>
<td>0.0500</td>
</tr>
<tr>
<td>2003</td>
<td>80</td>
<td>0.1000</td>
</tr>
<tr>
<td>2004</td>
<td>70</td>
<td>0.1500</td>
</tr>
<tr>
<td>2005</td>
<td>60</td>
<td>0.2000</td>
</tr>
<tr>
<td>2006</td>
<td>50</td>
<td>0.2500</td>
</tr>
</tbody>
</table>

Graph: Domestic WW Treatment % and COD discharge amount (kg COD per m³ WW) over years 2001 to 2006.
Table 2: Domestic wastewater treatment ratio and \( \text{NH}_4-\text{N} \) discharge amount per \( \text{m}^3 \) wastewater in urban areas of China

<table>
<thead>
<tr>
<th>Year</th>
<th>WW Treatment Percentage</th>
<th>kg NH4-N per m3 WW</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>0.0310</td>
<td>0.0310</td>
</tr>
<tr>
<td>2002</td>
<td>0.0320</td>
<td>0.0320</td>
</tr>
<tr>
<td>2003</td>
<td>0.0330</td>
<td>0.0340</td>
</tr>
<tr>
<td>2004</td>
<td>0.0340</td>
<td>0.0350</td>
</tr>
<tr>
<td>2005</td>
<td>0.0350</td>
<td>0.0360</td>
</tr>
<tr>
<td>2006</td>
<td>0.0360</td>
<td>0.0370</td>
</tr>
</tbody>
</table>
Table 3: Relationships of the treatment ratios among domestic wastewater amount, COD and NH$_4$-N in urban areas of China

![Graph showing the relationships of treatment ratios among domestic wastewater amount, COD, and NH$_4$-N from 2001 to 2006. The graph indicates an increase in treatment ratios over the years.]
Figure 1: Conventional sewerage system
Figure 2: Conventional, “open” system (also called “end-of-pipe technology”)
Problems of the conventional sewerage systems in urban areas in the viewpoint of sustainable development

1. high demand for water leads to dilution
2. Mixture of diff. flows
3. Little Recovery ratio, valuable nutrients are destroyed
4. large costs for construction and operation, energy and chemicals
5. management requirements,
What does sanitation system consist of?

1. Excreta management (faeces, urine)
2. Greywater management
3. Solid waste management
4. Drainage (for rainwater / stormwater)
Table 4: Characteristics of different wastewater flows from household wastewater

<table>
<thead>
<tr>
<th></th>
<th>Greywater 25,000 - 100,000</th>
<th>Urine ~ 500</th>
<th>Feaces ~ 50 (option: add biowaste)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yearly Loads</td>
<td>kg/(P*year)</td>
<td>Volume l/(P*year)</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>~ 4-5</td>
<td>~ 3 %</td>
<td>~ 87 %</td>
</tr>
<tr>
<td>P</td>
<td>~ 0.75</td>
<td>~ 10 %</td>
<td>~ 50 %</td>
</tr>
<tr>
<td>K</td>
<td>~ 1.8</td>
<td>~ 34 %</td>
<td>~ 54 %</td>
</tr>
<tr>
<td>COD</td>
<td>~ 30</td>
<td>~ 41 %</td>
<td>~ 12 %</td>
</tr>
</tbody>
</table>

also to be considered S, Ca, Mg and trace elements

Treatment
- Reuse / Water Cycle
- Treatment
- Fertiliser
- Anaerobic or aerobic
- Soil-Conditioner

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Figure 3: Conventional Decentralized Sanitation System in rural areas

NUTRIENTS RECOVERY
WITH HEALTH RISK

closing the loop between sanitation and agriculture

FOOD
WASTE WATER

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Figure 4: Ecological Sanitation System

closing the loop between sanitation and agriculture

Pathogen destruction

Food

Waste Water

Nutrients Reclamation

Separation Sewers

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Types of the applied toilets for Ecosan systems

1. Composting Toilet
2. Dry Urine Diversion Toilet
3. Vacuum Toilet
4. Urine Diversion Toilet
Composting toilet

composting toilet, Germany (Berger Biotechnik)
Dry Urine Diversion Toilet
Vacuum-Toilet
one litre/flush
Roediger Sorting-Toilet

Non-diluting Urine collection
Table 5: flush water consumptions daily per capita of different types of toilet

<table>
<thead>
<tr>
<th>toilet system</th>
<th>conventional without water saving measurement</th>
<th>flush cistern with two different amounts of water</th>
<th>composting toilets</th>
<th>vacuum toilets</th>
<th>Urine separation Toilets with water flushing</th>
</tr>
</thead>
<tbody>
<tr>
<td>water amount per flush</td>
<td>(9 l)</td>
<td>(9 l or 4 l)</td>
<td>(0,2 l)</td>
<td>(1 l)</td>
<td>(9 l or 0,2 l)</td>
</tr>
<tr>
<td>water consumption (l/p*d) - daily one faeces flush - daily four urine flush</td>
<td>45</td>
<td>25</td>
<td>1</td>
<td>5</td>
<td>10</td>
</tr>
</tbody>
</table>

Diagram of toilets
# Possible treatment of different wastewater flows

<table>
<thead>
<tr>
<th>Blackwater</th>
<th>Yellow water</th>
<th>Brown water</th>
<th>Greywater</th>
</tr>
</thead>
<tbody>
<tr>
<td>• to be treated together with biowaste</td>
<td>• to be treated separately</td>
<td>• to be treated together with greywater</td>
<td>• to be treated with filtrate from composting tank of black water</td>
</tr>
<tr>
<td>• 1. anaerobic treatment together with biowaste</td>
<td>• 1. storage in tank for min. 6 months (adding acid to prevent ammonium from volatilization is possible)</td>
<td>• 1. pre-composting</td>
<td>• 1. SBR</td>
</tr>
<tr>
<td>• 2. pre-composting together with biowaste</td>
<td>• 2. concentration or drying processes (air stripping, reverse osmosis, evaporation etc.)</td>
<td>• 2. anaerobic treatment (biogas reactor)</td>
<td>• 2. biofilm technology</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Pre-composting</td>
<td>• 3. constructed wetlands</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• 4. aquatic treatment</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• 5. lagoons</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• 6. MBR</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• etc.</td>
</tr>
</tbody>
</table>

- not recommended

Table 6: Possible treatment of different wastewater flows
Case Study: ecological sanitation system applications in urban areas

In last ten years, more and more pilot projects integrated with ecosan concept are being implemented in urban areas all over the world, especially in Europe.

Now there are also some large scale pilot projects which are under construction in China

In the following, some case studies are introduced.
Case Study: ecological sanitation system applications in urban areas

• Case 1: Settlement with 300 inhabitants, Bielefeld, Germany, 1994
• Case 2: 4-storey building with public Kindergarden
• Case 3: GTZ House 1 Renovation
• Case 4: Office building of company Huber
• Case 5: Sino-Sweden Eco-Town Project in Erdos, Inner Mongolia
• Case 6: Ecological Settlement Lübeck-Flintenbreite
• Case 7: Large scale urine collection and utilization in Olympic Forest Park
Case studies - I

Settlement with 300 inhabitants, Bielefeld, Germany, 1994

Family houses with common gardens

4-storey flat houses
Case studies - II

4-storey building with public Kindergarten

10 m down-pipe with 0.3 m diameter, 14 m exhaust air pipe, 0.15 m diameter, section
Germany: GTZ House 1 Renovation

Urine diversion toilets and waterless urinals
Case studies - IV

wastewater treatment system with separation toilet

(德国琥珀公司办公楼采用的分流处理系统)
Figure 5: Schematic of wastewater treatment system with separation toilet (Company Huber, Germany)
Case studies – V

Sino-Sweden Eco-town project in Erdos, Inner Mongolia Autonomous Region, China
Figure 6: Faces system in Erdos Eco-Town Project
Figure 7: Urine Transportation Vehicle
(a) The S-typed trap  (b) The odor isolator  (c) The toilet with an odor isolator

Figure 7: The measures of controlling odor related to urine drainage system
Case studies - VI

Ecological Settlement Lübeck-Flintenbreite

Double-Houses

Terraced Houses

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Figure 8: Schematic of wastewater treatment system with vacuum toilet
Vacuum pipe
Transport of blackwater and biowaste

Biowaste-shredder

Vacuum-toilet

stormwater infiltration in swales

Central technical building

Greywater treatment in constructed wetlands

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Vacuum-Toilet
0.7 litres/flush

Roediger, Hanau
Existing problems for Ecosan system application in urban areas:

1. systematic closure of local material flow-cycles is still not reached in most pilot projects;

2. Technology problems

3. User acceptances

4. In some cases, construction quality and management have alos some problems which have a negative effects for promoting Ecosan project.
Case studies - VII

Large scale urine collection and utilization in Olympic Forest Park

Total area of 700 ha in Olympic Forest Park
Annual produced waste amount in Olympic Forest Park

It is estimated:

• Wastewater amount: 121980M³;
• Yellow water (urine): 3230M³;
• Sludge amount with 90% water content from septic tanks: 3912M³,
• Sludge amount with 70% water content from septic tanks: 1304M³
• rubbish from trees and grasses in the south part of the Park: 3000M³
Source control system

Applied different kinds of urine diversion toilet as well as waterless urinals
Figure 7: Schematic of sanitation system in Olympic Forest Park of Beijing

- Urine
- Storage tank
- Fertilizer production
- Wastewater
- Aerobic processes + MBR
- UV Disinfection
- Reuse
- Feces sludge (brown water)
- Septic tank
- Two stage dewatering
- Composting
- Fertilizer production
Totally about 3000 – 4000 m3 urine will be collected and treated as fertilizer
Urine management system

Public toilets

Urine Collection tanks (42 tanks, 7-day retention)

Urine Storage Septic tanks (3 groups, 48 Apartments, 6 months retention)

Chemical dosing

MBR effluent

Acid tank

adjustment tank for Urine fertilizer

Water cycling tank

NH₃ absorption plant

Trees, grasses and flowers

To air
The urine storage tanks are under construction
MBR Biological Wastewater Treatment:

Schematic of decentralized WWTP
Conclusions and suggestions:

1. Ecosan systems have good chances and great potentials for application in urban areas;

2. For a successful application, proper design, construction, operation and maintenance play important roles;

3. Users should be educated and the acceptance by users is also very important;

4. Technology improvement and development are also very important for Ecosan system application in urban areas in order to make it more competent in consideration of convenience, maintenance, etc. for users.
5. Generally, Ecosan system have a lot of advantages. In the pilot projects, these advantages like heath safety, economical competence, technology advance and robust should be easily perceivable by users.

6. Demonstration projects should be constructed based on the different conditions and usage purposes, the closed loop system should be demonstrated.
Thank You Very Much For Your Attention!
Centre of Sustainable Environmental Sanitation of USTB

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