Challenges and practices of decentralized domestic wastewater treatment in China

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Mission & Goals

To build scientific and technological platforms, gather national scientific and technological forces, serve rural pollution control, and provide technical support for the formulation of relevant policies, regulations and administrative management.

Pollution characteristics

- National survey and evaluation of rural sewage
- Source and proportion of rural household sewage
- Spatial and temporal characteristics of rural sewage

R&D

- Oxidation ditch
- MBR
- Demonstration in Yunnan: 200t/d
- Demonstration in Guangxi: 2t/d
- First demonstration county: Changshu

Administrative support

- Planning
- Technical guidelines
- Standard specification
Environmental pressure factors

Contaminant emission intensity: ton/km².year

Average in towns: COD 74.0, TN 14.8, TP 1.0
Average in villages: COD 52.2, TN 10.4, TP 0.7

➢ The high intensity is in Southeast China: Shanghai, Jiangsu, Zhejiang, Guangdong, Fujian, Guangxi and Sichuan;
➢ The intensity in Jingjintang area and northeast China is also high.
1. Current situation of pollution control in rural area

1.1 The inevitable requirement of building a moderately prosperous society in all respects

By the end of 2017, the pollution-free disposal rate of urban household garbage will reach 97%, and only 55% in rural areas;

Urban residents generally use water flush toilets, while only 36 percent of rural households use water flush toilets.

The overall look of the countryside has not fundamentally changed. We must conform to the expectations of farmers for a better life.
General Secretary Xi proposed to "launch a toilet revolution" at a peasant family of Yanbian Prefecture, Jilin Province.
1. Current situation of pollution control in rural area

Different climate, geographical features, economic development level, drainage habits……
1. Satisfy the demand of public health and various water quality goals;

2. Economic suitability of processing technologies;

3. Operation simple and easy routine management.
13th Five-Year Plan: Rural Residential Environment Improvement Actions

1.3 Actions

- Integration of urban and rural development
- The development of social undertakings in rural areas
- Urban public services extend to rural areas
1.3 Actions

Rural household toilet renovation

Three kinds of patterns

- Black water treatment is preferred
- Health dry toilet
- Combination of rural sewage treatment
2. Case study

2.1 Experience in Shandong province

Determine governance patterns appropriately

General village

- three-squared septic tank
- Double urn funnel toilet
Basic principles of septic tanks

Function: the primary treatment structures of suspended matter, organic matter and pathogenic microorganisms in fecal sewage or other domestic sewage are removed by precipitation and anaerobic microbial fermentation.

Removal rate: after 12-24h precipitation, 50% to 60% of suspended matter is removed, and the precipitate is decomposed by anaerobic fermentation for more than 3 months, and becomes stable mature sludge.
We will actively explore and innovate to provide policies, funds and technical guarantee for the sewage treatment of rural toilets.

To explore the operation system of toilet.
2.1 Experience in Shandong province

villages in a mountainous area or in a water-deficient area

Fecal urine collection toilet

**composition**
- Store tank of the urinal
- Fecal and urine diverter
Ecological toilet
Separation of fecal and urine
2.1 Experience in Shandong province

- Villages covered by a town sewerage network
- New rural community
- Villages in key drinking water sources protection areas

Flush toilet
2.2 Experience in Changshu

Demonstration of one hundred counties

Unified
• Planning
• Construction
• Management
• Operation

Regional integrated propulsion
Government purchase service
Unified operation of the company

Changshu model

<table>
<thead>
<tr>
<th>Wastewater treatment ratio</th>
<th>Facilities good rate</th>
<th>Working rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>10%</td>
<td>40%</td>
<td>20%</td>
</tr>
<tr>
<td>65%</td>
<td>95%</td>
<td>98%</td>
</tr>
</tbody>
</table>

2008 2014
2.2 Experience in Changshu

Since 2008, local governments have broken administrative boundaries, drawn up special plans for the treatment of domestic sewage, removed, upgraded and built high-standard centralized sewage treatment plants, and rationally laid out decentralized sewage treatment facilities in rural areas.
About 70% of the households in Changshu have their sewage treated in the urban pipe network. Other farmers choose three decentralized treatment modes, namely relatively centralized, village group treatment and household treatment, according to the classification of village shape and scale.
2.2 Experience in Changshu

Information-based monitoring platform of rural sewage treatment

The operation of decentralized sewage treatment facilities is clear at a glance. The monitoring center can monitor the running status of fans and pumps in real time, and then make analysis and statistics to generate operation reports, so as to reduce labor maintenance costs and improve work efficiency.

Remote control for centralized management
Online to off-line
Management

- Funding
- Appropriate system design and selection process
- Operator training

Promotion Plan —Funding

- PPP （Public-Private-Partnership）

- The main body of construction and operation management: Enterprises
- Local government is mainly to buy services included in the annual budget
## Wastewater in different regions

### Domestic water use (L/P.day)

<table>
<thead>
<tr>
<th>Types of village</th>
<th>Northeasts</th>
<th>North south</th>
<th>North</th>
<th>West north</th>
<th>West south</th>
<th>South</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good economic, bath, flush toilet, wash machine</td>
<td>80-135</td>
<td>90～200</td>
<td>100~145</td>
<td>75~140</td>
<td>80-160</td>
<td>100~180</td>
</tr>
<tr>
<td>Good economic, bath and kitchen</td>
<td>40-90</td>
<td>80～100</td>
<td>40~80</td>
<td>50~90</td>
<td>60-120</td>
<td>60～120</td>
</tr>
<tr>
<td>Normal economic, simple toilet</td>
<td>40-70</td>
<td>60～90</td>
<td>30~50</td>
<td>30~60</td>
<td>40-80</td>
<td>50~80</td>
</tr>
<tr>
<td>No flush toilet</td>
<td>20-40</td>
<td>40～70</td>
<td>20~40</td>
<td>20～35</td>
<td>20-50</td>
<td>40～60</td>
</tr>
</tbody>
</table>

### Characters of wastewater (mg/L)

<table>
<thead>
<tr>
<th>Region</th>
<th>pH</th>
<th>SS</th>
<th>COD</th>
<th>BOD₅</th>
<th>NH₄⁺-N</th>
<th>TP</th>
</tr>
</thead>
<tbody>
<tr>
<td>West south</td>
<td>6.5~8.5</td>
<td>100~300</td>
<td>100~400</td>
<td>50~300</td>
<td>3~50</td>
<td>1.0~6.0</td>
</tr>
<tr>
<td>Northeast</td>
<td>6.5~8.0</td>
<td>150~200</td>
<td>200~450</td>
<td>200~300</td>
<td>20~90</td>
<td>2.0~6.5</td>
</tr>
<tr>
<td>North south</td>
<td>6.5~8.5</td>
<td>100~200</td>
<td>70~300</td>
<td>150~450</td>
<td>20~50</td>
<td>1.5~6.0</td>
</tr>
<tr>
<td>North</td>
<td>6.5~8.0</td>
<td>100~200</td>
<td>200~450</td>
<td>200~300</td>
<td>20~90</td>
<td>2.0~6.5</td>
</tr>
<tr>
<td>West north</td>
<td>6.5~8.0</td>
<td>150~200</td>
<td>150~400</td>
<td>100~150</td>
<td>20~50</td>
<td>2.0~6.0</td>
</tr>
<tr>
<td>South</td>
<td>6.5~8.5</td>
<td>100~200</td>
<td>100~300</td>
<td>60~150</td>
<td>20~80</td>
<td>2.0~7.0</td>
</tr>
</tbody>
</table>
Technical guide for rural domestic wastewater treatment in different regions

**Northeast**: septic tanks, anaerobic biofilter, bio-contact oxidation tank, land treatment, constructed wetlands, lagoon

**North China**: septic tanks, sewage digesters, aeration tank, sequencing batch bio-reactor, oxidation ditch, biological contact oxidation, constructed wetlands, land treatment

**Northwest**: septic tank, anaerobic digesters, anaerobic biofilter, constructed wetlands, land treatment

**Southwest**: septic tanks, wetland, land treatment, anaerobic technology, bio-contact oxidation tank, oxidation ditch, anaerobic biofilter

**Middle south**: septic tanks bio-contact oxidation, oxidation ditch, constructed wetland, lagoon, floating islands could be applied for sewage treatment.

**Southeast**: septic tank, anaerobic biofilter, anaerobic digesters; biological contact oxidation tank, oxidation ditch, constructed wetlands, ecological filter.
Typical modules in China

- **Mode 1**: Septic tank → Biofilm/MBR/Activated sludge (A/O or A2/O) → Farmland
- **Mode 2**: Septic tank → Anaerobic/Anoxic biofilm → Farmland
- **Mode 3**: Septic tank → Biofilm/Activated sludge → Constructed wetland/Soil treatment/Lagoon → Farmland

Pie chart:
- 61% for Mode 1: Biofilm treatment
- 23% for Mode 2: Anaerobic treatment
- 16% for Mode 3: Aeration and ecological treatment
Influent

Septic tank

- Inexpensive
- Simple to maintain

• Sludge may cause an odor problem
• Not effective in removing nitrate and phosphorus and pathogenic organics
• Potential pollution source of groundwater
**Constructed wetland**

- constructed cost
- flexible land use
- Low removal rate
- Management

Small-scale decentralized system

0.2-5m³/d
Case study: anaerobic tank + ladder eco-filter

- Energy save
- Amonium and phosphorous removal
- Odor

**HRT:**
- 10-20 min
- 20-30 min
- 30-60 min

**Volume:** 15 m³·d⁻¹

<table>
<thead>
<tr>
<th>item</th>
<th>COD</th>
<th>BOD₅</th>
<th>NH₄⁺-N</th>
<th>TN</th>
<th>TP</th>
<th>SS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Influent</td>
<td>400</td>
<td>150</td>
<td>25</td>
<td>40</td>
<td>4</td>
<td>200</td>
</tr>
<tr>
<td>Effluent</td>
<td>60</td>
<td>20</td>
<td>8</td>
<td>20</td>
<td>1</td>
<td>20</td>
</tr>
</tbody>
</table>
Case study: Anearobic+ drop aeration + constructed wetland

Anaerobic tank  Oxic  Constructed wetland
Case study: Bio-rotation + vegetable tank

3～10t/d, COD concentration is 100～100mg/L

- Suitable in south area
- Vegetable management complex
Case study: Cluster system

• Cluster system
• High quality of effluent

- 60m³/d, for 900 persons
- floor area: 250m²
Decentralized wastewater systems

For COD removal

Aeration process

For nitrogen removal

Bio+Eco Treatment
Ecological toilet
Separation of fecal and urine
Technical Specification of wastewater treatment facilities for village (CJJ/T163-2011)
How to choose the suitable technology for rural area?

1. General provisions
2. Terms and symbols
3. General requirement
4. Treatment technologies
   - Anaerobic biofilm tank
   - Biological contact oxidation tank
   - Biological aeration filter
   - Oxidation ditch
   - Rotating biological contactor
   - Activated-sludge process
   - Ecological treatment of wastewater
   - Chemical phosphorus removal
   - Disinfection
5. Wastewater treatment facilities in village
6. Wastewater treatment station in village
   - Wastewater treatment station for COD removal
   - Wastewater treatment station for nitrogen removal
   - Wastewater treatment station for nitrogen and phosphorus removal
7. Construction and acceptance of engineering quality
Main contents

Discharged standard:

- Discharge
- Reuse

<table>
<thead>
<tr>
<th>Items</th>
<th>Grade IA</th>
<th>Grade IB</th>
<th>Grade II</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD</td>
<td>50</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>T-N</td>
<td>15</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>NH₄-N</td>
<td>5(8)</td>
<td>8(15)</td>
<td>25(30)</td>
</tr>
<tr>
<td>T-P</td>
<td>0.5</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

Unit: mg/L

3.0.3 污水的排放要求直接关系到污水处理程度和技术选择，因此，农村生活污水的排放要求需根据国家和地方的排放要求因地制宜地确定，以保证污染物消减目标的实现和降低成本。在没有排放要求的农村地区，针对地区的特征，建议按表1参考不同的排水去向的排放要求。

<table>
<thead>
<tr>
<th>表1 乡村污水排放执行的相关参照标准</th>
</tr>
</thead>
<tbody>
<tr>
<td>排水用途</td>
</tr>
</tbody>
</table>
Thanks for your attention!