



Analysis and Evaluation of the Application and Benefits of "Reinvented Toilets" in the Improvement of the Rural Living Environment

15th Nov 2023

Cai Ting

为人居环境更美好
Making our living environment better

www.bewg.net

Contents

- I. Project Background
- II. Market Investigation and Analysis
- III. Application of Reinvented Toilets
- IV. Conclusion

为人居环境更美好
Making our living environment better

I. Project Background



1.1 BEWG

- Beijing Enterprises Water Group Limited
- Founded in 2008
- **Water recycling** and **Water ecology protection**
- **Top tier** water treatment service provider in China



I. Project Background

1.2 BEWG & BMGF's objective



Analysis and Evaluation

Analysis and Evaluation of the Application and Benefits of "Reinvented Toilets" in the Improvement of the Rural Living Environment

Project design

Project design and solutions based on RTs application scenarios

Project implementation

Reinvented Toilet (RT) as a utility service large scale commercial application

The partners agreed that the main research outcomes should meet the following objectives:

- To understand whether wastewater treatment and reduction at the source can improve influent and effluent water quality of wastewater treatment facilities;
- To study the configurations and use cases of RTs (Type A, C₁, C₂, and D models);
- To characterize the unique value proposition of RTs and understand their cost-saving potential.

附件9： "服务" 描述
Annex 9: Description of the Services

目标:
该项目旨在研究分析" reinvented Toilets" (RTs) 在村庄人居环境改善领域早期取得成效并分析其中的潜在应用和益处。研究范围集中于解决以下问题:
This program aims to research and analyze the potential applications and benefits of reinvented Toilets (RTs) in the early-stage segment, in the context of rural living environment improvement. The research should focus on addressing the following topics:

- 考察在不同地区、流域农村地区人居环境改善工程现状，调研基于不同模型、配置和基础设施的现有不同形式的污水收集处理方案，并评估 A 型、C₁、C₂、D 型等不同形式的应用场景和适用性。
Examine the reality and progress on rural living environment improvement projects in the Yangtze River Delta and Chengde-Chongqing regions; investigate different wastewater collection and treatment methods used in river basin network areas, hilly terrain, and communities around tourist areas; and evaluate the application potential and scenarios of A, C₁ C₂, and D1 RTs.
- 基于京津冀地区、黄土高原地区村庄人居环境改善工程现状，调研基于不同模型、配置和基础设施的不同形式的污水收集处理方案，并评估 A 型、C₁、C₂ 型等不同形式的应用场景和适用性。
Examine the reality and progress on rural living environment improvement projects in the Beijing Enterprises Water Group (BEWG) in the Beijing, Tianjin, Hebei region, and Northwest China; investigate the current living environment improvement situation and local application in these regions; the research team will identify and map out possible future application scenarios and related conditions, conduct interviews and discussions with Chinese experts engaged in related on this basis, generate a research report that will be as follows:
考察黄土高原地区村庄人居环境改善工程现状和现状配置，调研基于不同模型、配置和基础设施的不同形式的污水收集处理方案，并评估 A 型、C₁、C₂ 型等不同形式的应用场景和适用性。

II. Market Investigation and Analysis



2.1 China's policies related to rural wastewater treatment

The Chinese government has always attached great importance to the improvement of the rural living environment. During the 13th Five-Year Plan period, the Chinese government promulgated the **"Three-Year Action Plan for Rural Living Environment Improvement"** and the **"Strategic Plan for Rural Revitalization"**, to drive efforts to improve the rural living environment.

At the beginning of the 14th Five-Year Plan period, China promulgated the **"Rural Revitalization Law"** and the **"Five-Year Action Plan for Rural Living Environment Clean-up and Enhancement"**, requiring the improvement of the living environment at the county level. This has led to rapid progress.



II. Market Investigation and Analysis

2.2 Status quo of rural wastewater treatment and toilet renovation in China

Rural domestic
wastewater treatment

Year2016

22%



Year2020

25.5%

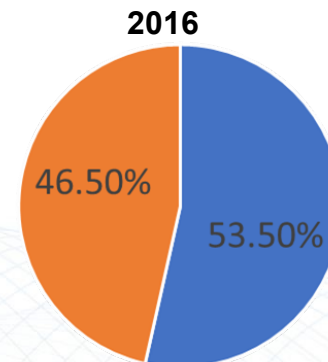
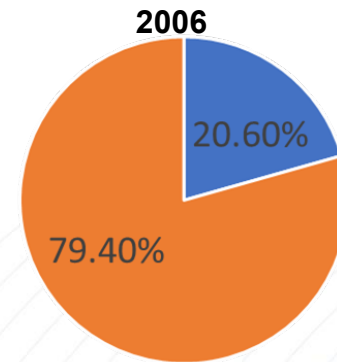


Year2025

40% (Goal value)

a large market space

Toilet renovation



Blue: Completed or partially completed
Orange: To be completed

As of 31 December 2021, the sanitary toilet penetration rate in China's rural areas **exceeded 70%**.

Since 2018, a total of **40+ million** rural household toilets have been renovated.

II. Market Investigation and Analysis

2.3 Reality and challenges of rural living environment improvement in China

① Large regional differences

Typical flush toilet in southern China



Typical dry latrine in northern China



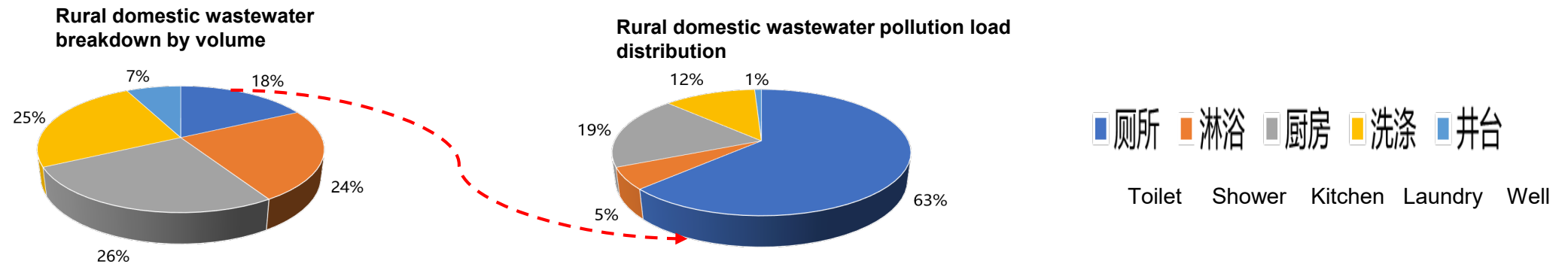
Nine modes of fecal sludge treatment

Mode	Fecal sludge collection and treatment method	Region
Mode 1	Small three-compartment + large three-compartment septic tanks	Hubei
Mode 2	Black and grey water centralized treatment facilities + toilet waste centralized treatment facilities	Henan
Mode 3	Domestic wastewater treatment facilities (household toilets + public toilets)	Zhejiang
Mode 4	Domestic wastewater treatment facilities	Fujian
Mode 5	Centralized treatment facilities	Hebei
Mode 6	Centralized fecal sludge treatment sites	Shandong
Mode 7	Centralized wastewater treatment sites	Hebei
Mode 8	Household biogas digesters	Sichuan
Mode 9	Eco-sanitary dry latrines	Henan

II. Market Investigation and Analysis

2.3 Reality and challenges of rural living environment improvement in China

② The contribution of each wastewater stream to the volume and pollution **varies significantly**.



③ **End-point treatment** model as the mainstay with a focus on total pollutant reduction. Wastewater is collected by the pipe network for centralized treatment. **The pipe network infrastructure is built on a large scale.**



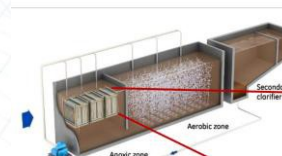
Separation at the source



Collection system



Modular products



MABR integrated equipment



Phosphorus adsorption

Traceability: Collection systems

End-point: Centralized pollution treatment

Synergy: Waste to resources

II. Market Investigation and Analysis



2.3 Reality and challenges of rural living environment improvement in China

④ Discharge standards vary from place to place, making it difficult to unify equipment standards

- **Thirty-one** provinces, autonomous regions, and municipalities (excluding Hong Kong, Macau, and Taiwan) have **issued provincial standards** for pollutant discharge from rural domestic wastewater.
- Multi-tiered products are needed to meet differing project standards.

⑤ Comparing ISO 30500 with Chinese rural wastewater pollution control standards

- The control limit values for most pollutants (such as TSS, COD and pH) are **similar**.
- ISO 30500 has **more stringent requirements** in terms of **pathogenic bacteria**.

Indicator (mg/L)	Rural wastewater treatment facility discharge standards	ISO 30500
pH (dimensionless)	6-9	6-9
COD	≤50 (municipal water)	≤50 (municipal water)
	≤50-80 (discharged into river)	≤150 (discharge into river)
TSS	≤10 (municipal water)	≤10 (municipal water)
	≤20 (discharge into river)	≤30 (discharge into river)
Ammonia nitrogen	≤1.5 (2.5)-8 (15)	/
Total nitrogen ^a	≤15-20	Removal rate ≥70%
Total phosphorus ^b	≤0.3-1	Removal rate ≥ 80%
Fecal coliform (pcs/L)	≤1,000-10,000	≤100

➤ ISO 30500-compliant products in China need to perform better in terms of **the removal of COD, TN, and TP**.

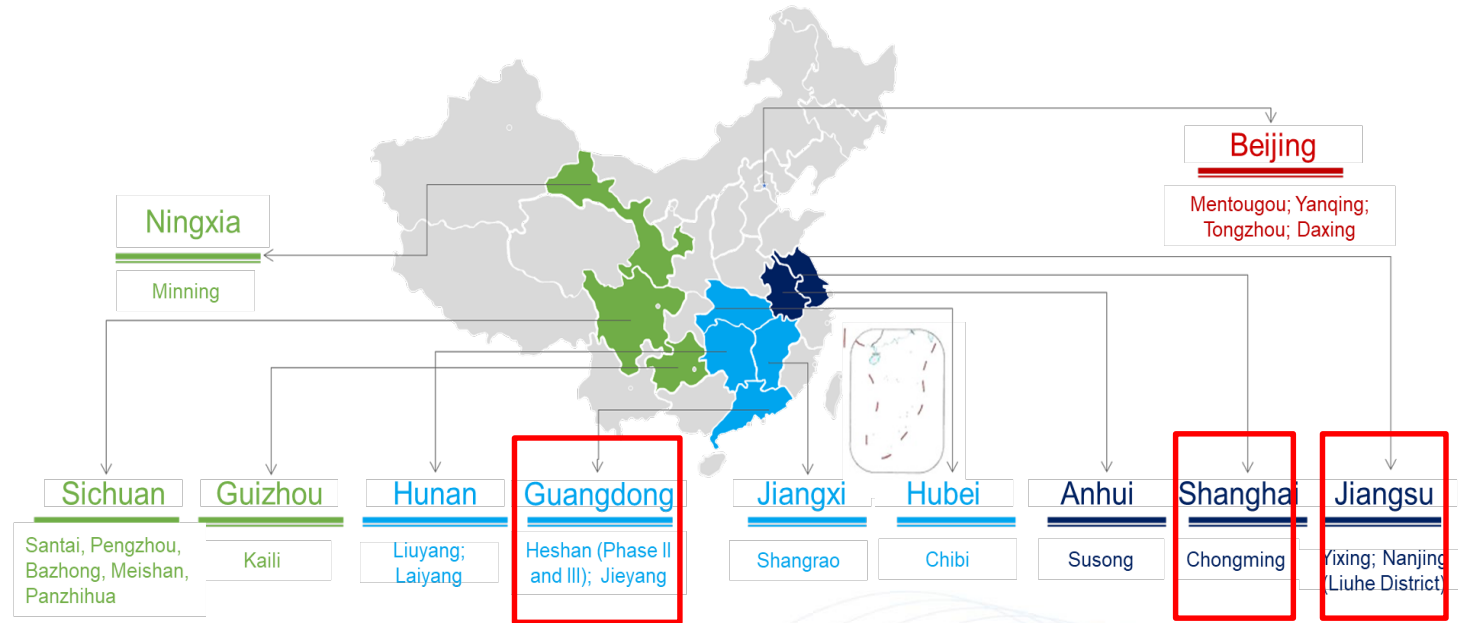
➤ Products that comply with the Chinese rural wastewater pollution control standards should benchmark towards ISO 30500 in terms of the **removal of pathogenic bacteria**.

a. The total nitrogen concentration in rural domestic wastewater is usually in the **range of 70-100 mg/L**. Based on the removal rate, ISO 30500 sets a discharge limit for total nitrogen at **21-30mg/L**.

b. The total phosphorus concentration in rural domestic wastewater is usually **≤6mg/L**. Based on the removal rate, ISO 30500 sets a discharge limit for total phosphorus at **≤1.2mg/L**.

II. Market Investigation and Analysis

2.4 Selected reference projects



BEWG has invested **RMB10+ billion**, invested in and operates more than **30+** projects, and serves **5,000+** villages across water supply, wastewater treatment, and waste-to-resource recycling.

The selection criteria include the following:

1. Rural wastewater treatment projects directly installed in **organic villages**
2. The projects have effectively **entered into operation and maintenance**
3. The projects use no less than two treatment methods of **decentralized and centralized treatment**
4. The project locations have at least two topographic features of **plains or river networks**

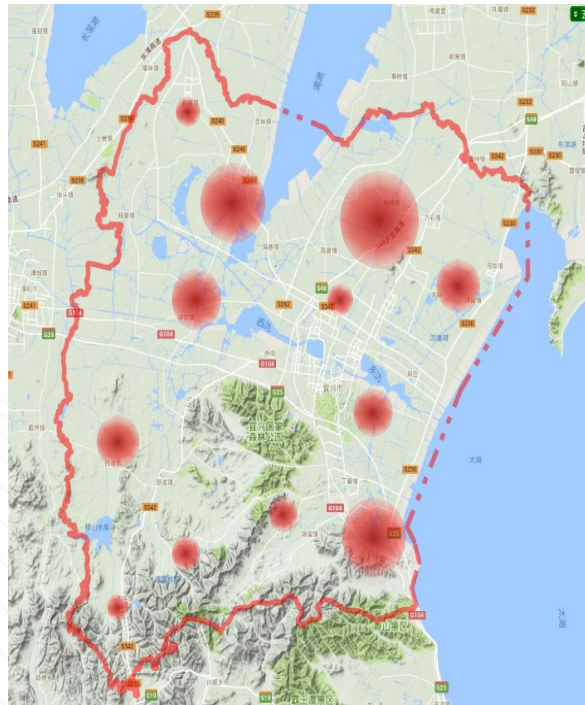
Eastern region: Chongming District in Shanghai
Yixing City in Jiangsu Province

Southern region: Heshan City in Guangdong Province

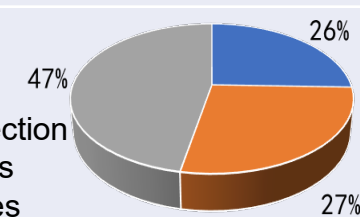
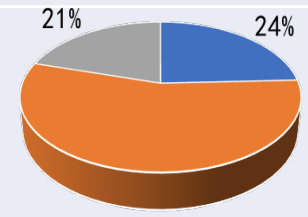
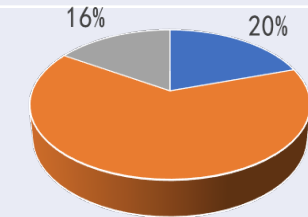
II. Market Investigation and Analysis

2.5 Reference project – Yixing

- Yixing's terrain predominantly consists of plains, but it also has well-developed water systems.
- Some mountain villages are also scattered due to differences in elevation.
- Villages in the plains areas have high pipe network utilization rates.
- Villages surrounded by river networks and in mountainous areas require **tremendous** pipe network construction.



Investment cost analysis

Terrain and landform	Plains	Mountainous	River Network
Main treatment process	Purification tank	Integrated A ² / O	Integrated A ² / O
Average investment per household	RMB11,000-18,000	RMB17,000-20,000	RMB19,000-22,000
Investment			

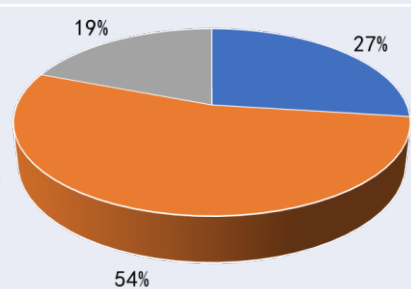
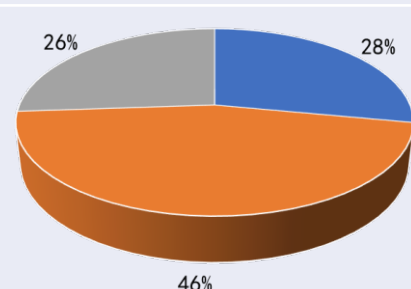
II. Market Investigation and Analysis

2.5 Reference project – Chongming District

- There are more than 10,000 rivers and most of the villages are built on or separated by a network of rivers.
- The efficiency of water collection and difficulty of building the pipeline network are similar among the different villages.



Investment cost analysis

Terrain and landform	Baodong Village	Zhendong Village
Main treatment process	Integrated MBR + purification tank	Integrated MBR + purification tank
Average investment per household	RMB13,000-16,000	RMB12,000-15,000
Investment		
	<ul style="list-style-type: none"> ■ Household connection ■ Main/branch pipes ■ Treatment facilities 	

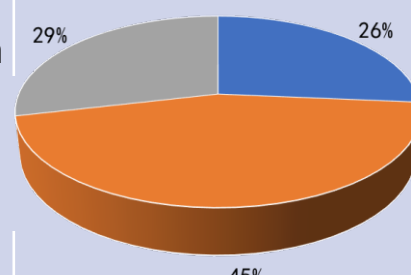
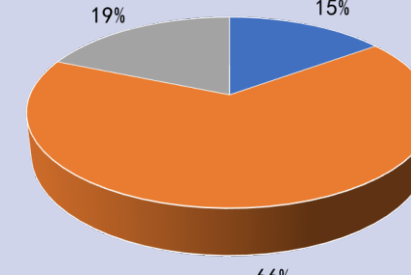
II. Market Investigation and Analysis

2.5 Reference project – Heshan City

- Highly-developed water system with many rivers, ponds, and lakes.
- Some towns and villages are completely surrounded by rivers and lakes.
- Land availability is tight. No space for pipeline construction and limited pipeline choices.
- Construction on water is very difficult and costly.



Investment cost analysis

Terrain and landform	Flatland	River network
Main treatment process	Integrated A ² /O	Integrated A ² /O
Average investment per household	RMB11,000-15,000	RMB18,000-25,000
Investment breakdown	 <p>29% 26% 45%</p>	 <p>19% 15% 66%</p>

- Household connection
- Main/branch pipes
- Treatment facilities

II. Market Investigation and Analysis



2.5 Reference projects' investment cost analysis

Projects	Chongming District, Shanghai		Yixing City, Jiangsu Province			Heshan City, Guangdong Province		
	Terrain and landform	Main treatment process	Average investment per household	Investment breakdown	Terrain and landform	Main treatment process	Average investment per household	Investment breakdown
	Baodong Village	Zhendong Village	Plains	Mountainous	River Network	Flatland	River network	
	Integrated MBR + purification tank	Integrated MBR + purification tank	Purification tank	Integrated A ² /O	Integrated A ² /O	Integrated A ² /O	Integrated A ² /O	
	RMB 13,000-16,000	RMB 12,000-15,000	RMB 11,000-18,000	RMB 17,000-20,000	RMB 19,000-22,000	RMB 11,000-15,000	RMB 18,000-25,000	

- If the total retail price plus installation cost of an RT does not exceed **RMB15,000 per household**, then it enjoys a competitive advantage.

II. Market Investigation and Analysis



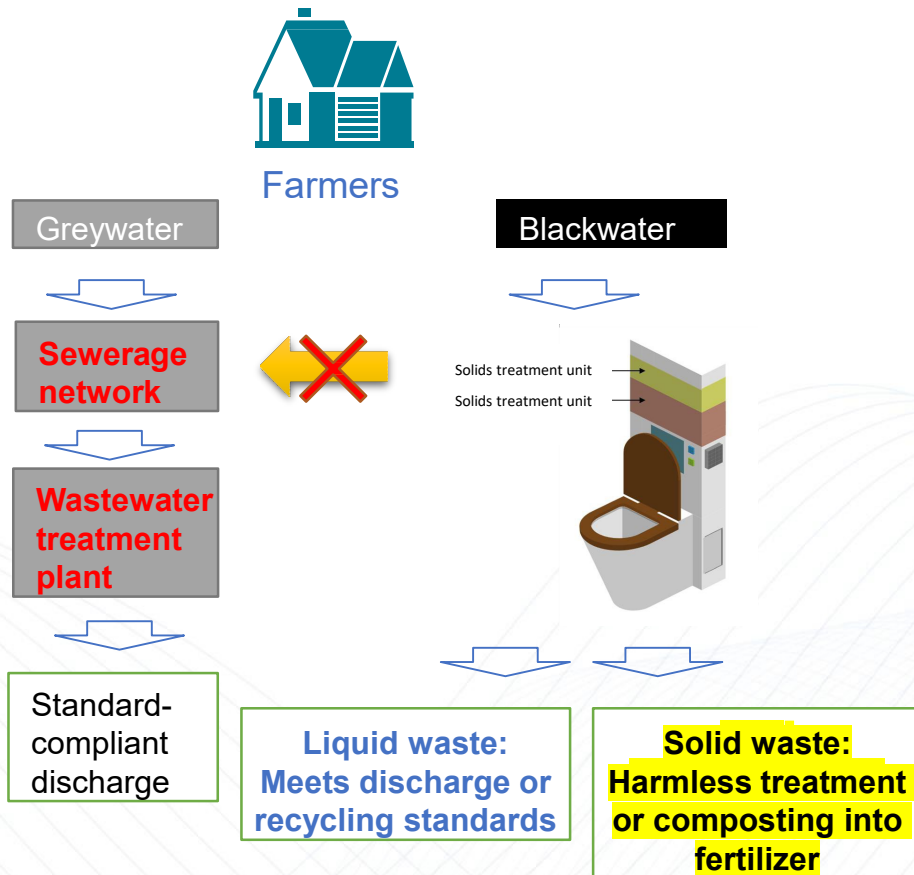
2.6 Reference projects' O&M cost analysis

Projects	Chongming District, Shanghai		Yixing City, Jiangsu Province		Heshan City, Guangdong Province	
Village covering	300+		1900+		1000+	
Household covering	~42,000		~196,000		~63,000	
Service population	~139,000		~589,000		~244,000	
Franchise models	EPC/O Government investment and BEWG O&M		PPP BEWG investment and O&M		First two Section: EPC/O Government investment and BEWG O&M Third Section: PPP BEWG investment and O&M	
Contract duration	Renew every 5 years		20 years		First two Section: Renew every 8 years Third Section: 29 year	
Treatment process	Decentralized	Relatively concentrated	Collection pipelines	Relatively concentrated	Collection pipelines	Relatively concentrated
Operation and maintenance costs	~ RMB 220		~ RMB 230		~RMB 150	
<ul style="list-style-type: none"> ■ Fecal sludge removal and transfer ■ Labor costs ■ Electricity bill ■ Pipelines ■ Terminal Cost components						

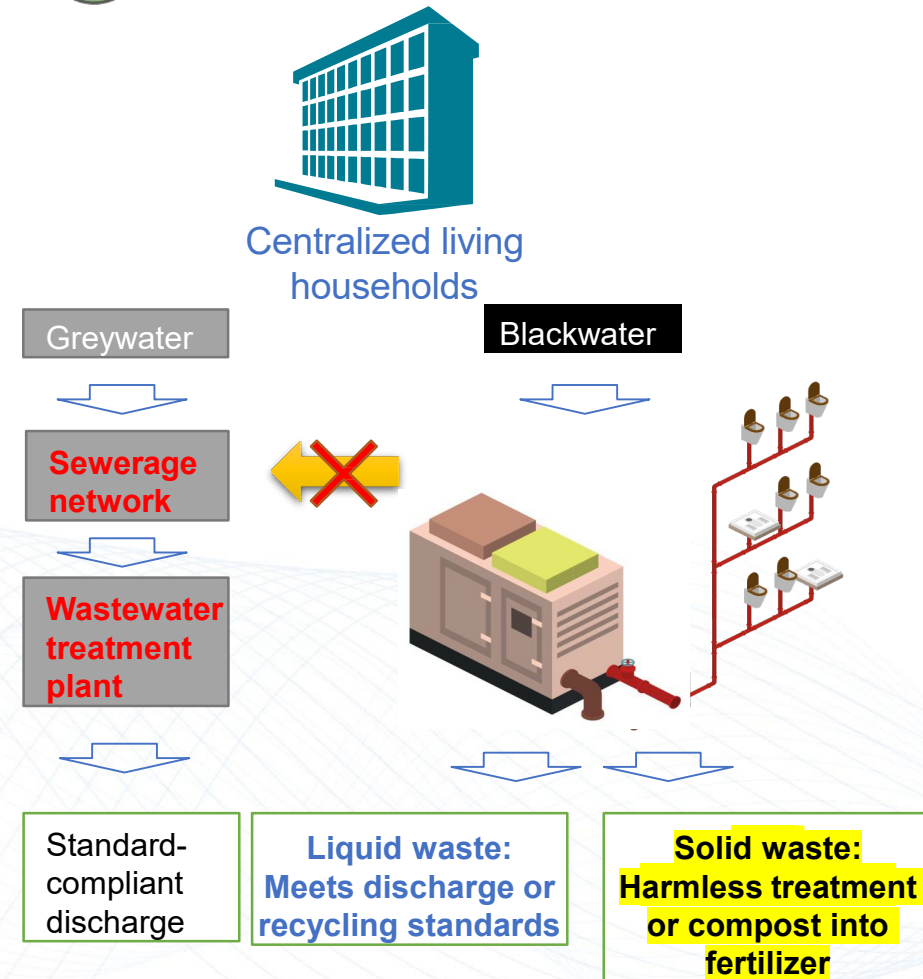
III. Application of Reinvented Toilets

3.1 Type of Reinvented Toilets

A Household toilets for full treatment of black water



D₁ Centralized black water full treatment toilet

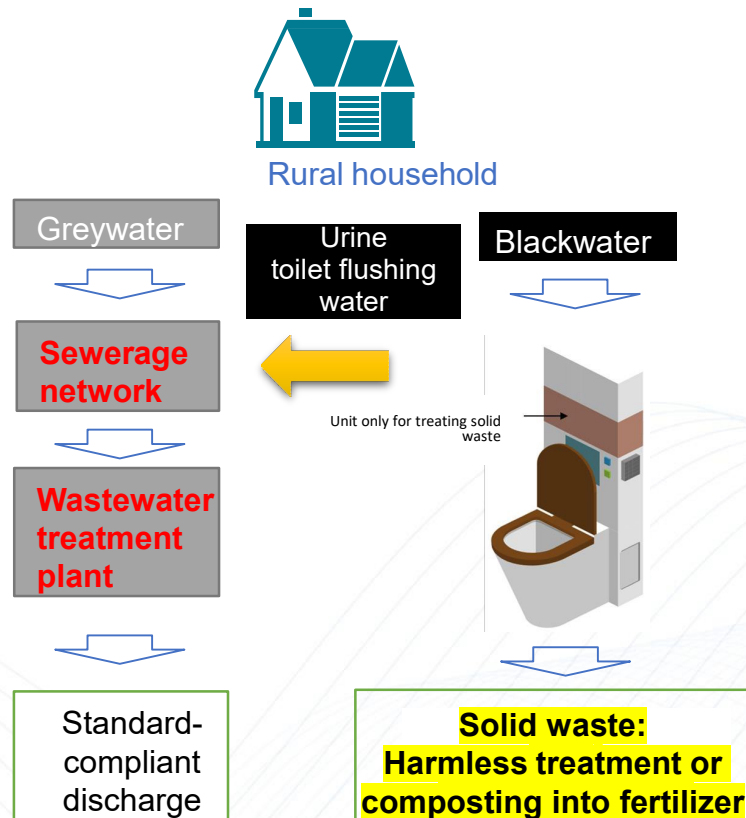


III. Application of Reinvented Toilets

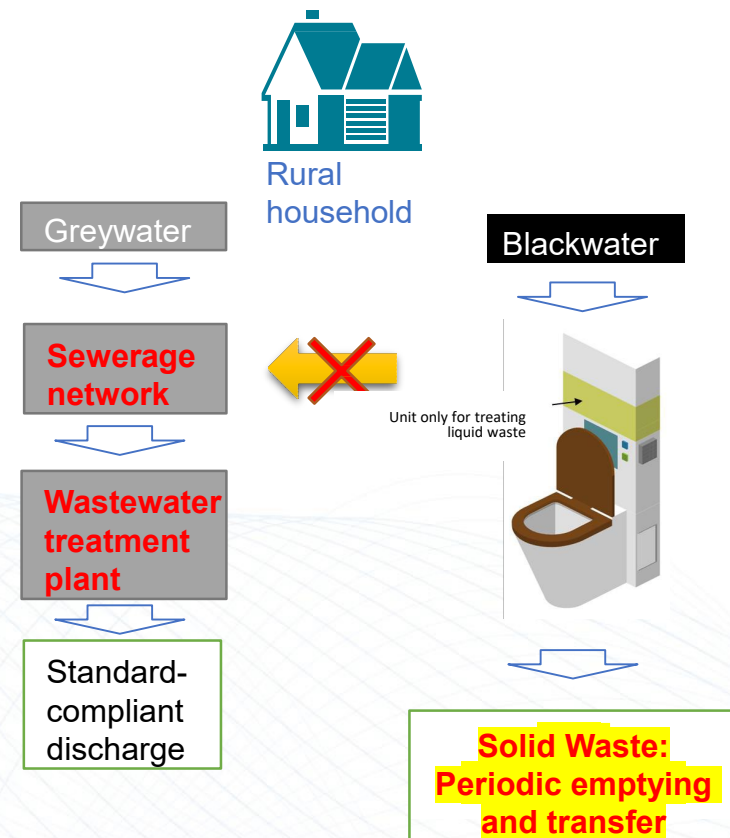
3.1 Type of Reinvented Toilets



Pure solid waste treatment type household toilet



Pure liquid waste treatment type household toilet



III. Application of Reinvented Toilets



3.2 Advantage and disadvantage of RTs

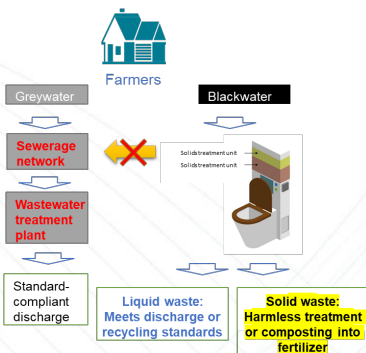
	Advantage	Type A	Type C1	Type C2	Type D
Construction	Avoid neighbor disputes over land occupation	√	√	√	
	Save one wastewater outlet pipe	√		√	
	Smaller main branch pipe diameter	√		√	√
	Smaller plant and station size selection	√		√	√
Operations and Maintenance	Reduce need for solid waste removal, disposal, and de-clogging	√	√	√	
	In situ disposal of liquid waste, Save downstream Investment	√		√	√
	Extend the emptying and de-clogging cycle	√		√	√
Water Quality	Reduce the influent waste loads for the end-point treatment facilities.	√		√	√
	Better effluent water quality	√		√	√
	Blackwater can be discharged on site to meet standards or resource utilization	√		√	√

III. Application of Reinvented Toilets

3.2 Advantage and disadvantage of RTs

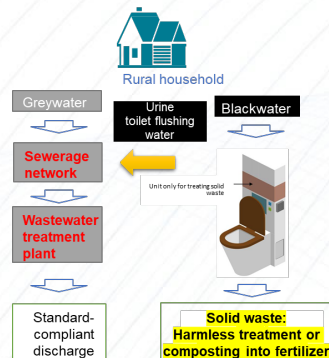
	Disadvantage	Type A	Type C1	Type C2	Type D
1	Grey water can not be treated locally and still requires the construction of a wastewater pipe network.	√			√
2	No significant savings in construction investment.	√	√	√	√
3	Solid waste still needs to be emptied and transferred out periodically			√	
4	No significant savings in O&M workload and costs.			√	
5	No optimization conditions for water quality in and out of the end-point treatment facilities.		√		

A Household toilets for full treatment of black water



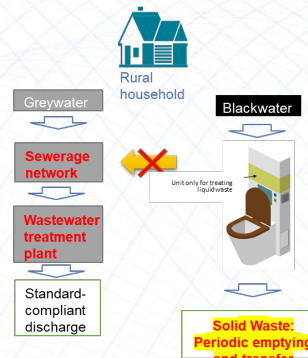
Scattered households Flush toilet

C1 Pure solid waste treatment type household toilet



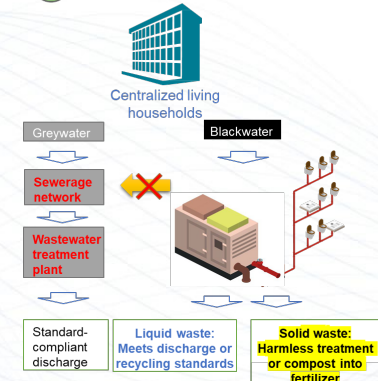
Scattered households Dry latrine

C2 Pure liquid waste treatment type household toilet



Scattered households Flush toilet

D1 Centralized black water full treatment toilet



Centralized multi-story building Flush toilet

IV. Conclusions



- ISO 30500 is comparable to some of China's rural pollution control standards. The standard is **available for the application of RTs in China**.
- Chinese products that meet Chinese rural pollution control standards may be subject to ISO 30500 evaluation and testing, and if they **pass**, they can become **one of the sources** of RT products.
- **Type A and D** are better positioned to treat black water and better suited for a greater number of application scenarios. **Type C1 and Type C2** are not well-suited for the current reality of rural wastewater management in China. However, centralized dormitories, farms, and other areas that require **centralized collection** may be better application scenarios.
- If the total retail price plus installation cost of an RT does not exceed **RMB15,000 per household**, then it enjoys a competitive advantage.
- RTs as a class of technical products **have in-situ collection and treatment** capabilities, and are effective for **controlling pollution** and achieving **waste-to-resource** conversion. Once production costs and maintenance difficulties are reduced through research and development iteration, RTs may enjoy **broad market prospects** in China and Africa.



Thank you!

Email: caiting@bewg.net.cn

Tel: +86-18046559233



为人居环境更美好
Making our living environment better