

# **Urban & Rural Sustainable Development: Grey Water Treatment**

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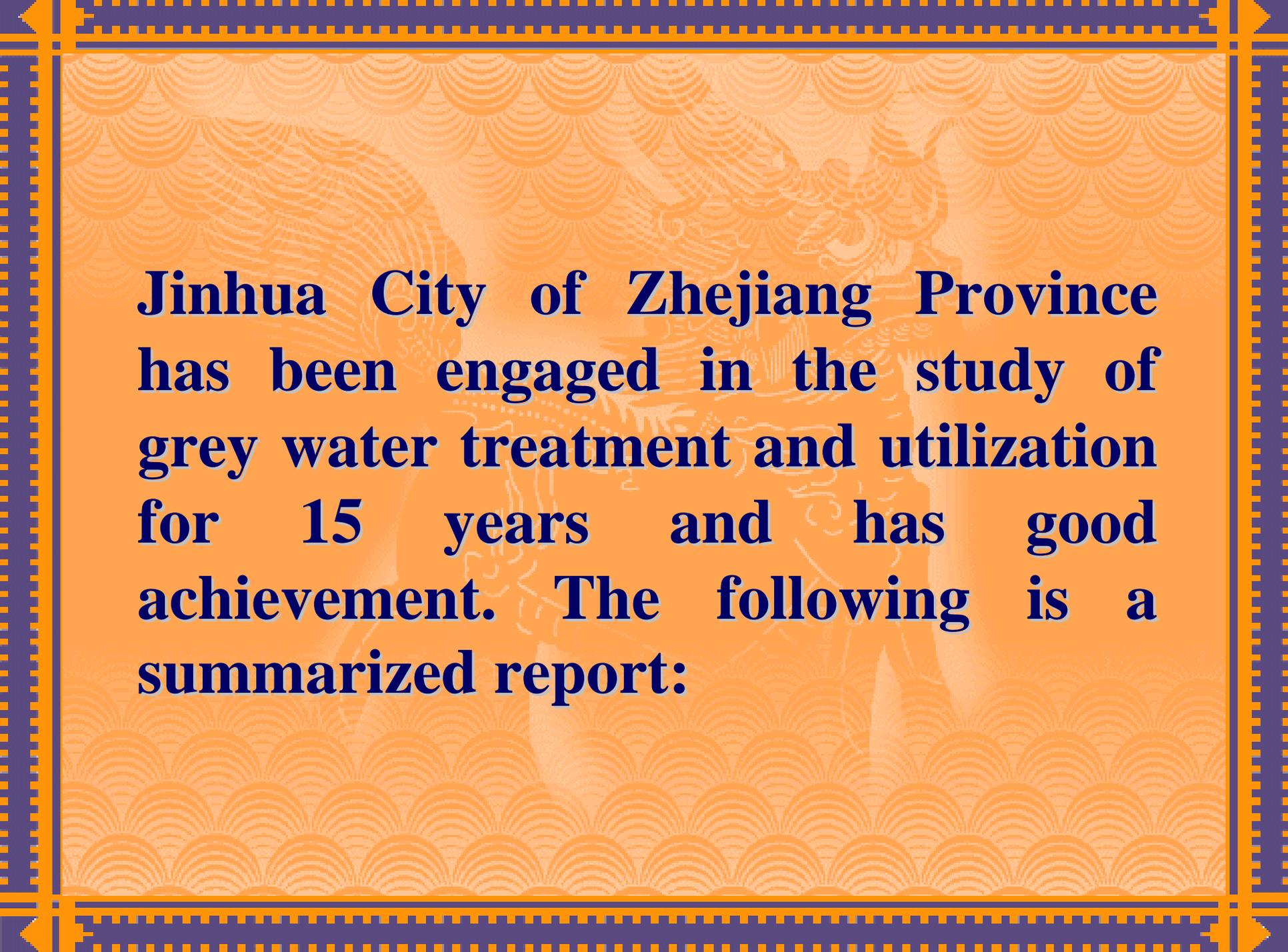
**Ecosan Toilet Research of Jinhua, Zhejiang, P. R. China**

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**Sustainable Development is the kind of development of economy & society well coordinated with protection of natural resources & environment. That is to say, economic development is to be achieved along with conservation of resources & environment, so that our children and grandchildren will be able to continue with the development.**

**Nowadays in China's urban areas, the household waste water is mostly restrained in sewage piping networks leading to a water treatment plant, where the grey water is properly treated. But in the vast rural areas, the traditional mode of life and farming is undergoing an evident change. They are breaking the thousands-years-old "cycling economy" of reverting roughly treated grey water to farms and orchards. This reckless conduct has made grey water pollution stand out. The natural environment, which is the basis of human survival, is now under threat.**

- **According to an official report published in 2006 on the national environment monitoring authority's website, the result of a survey shows that the surface water cross section data sampled at 745 spots indicate that China's overall surface water pollution was at medium level: Among all, 40% is Grade I-III water, 32% Grade IV water, and 28% Grade V/ V—water.**
- **Nanhai Sea and Huanghai Sea's offshore water is good quality. Bohai Sea's offshore water has a pollution of light level, and Donghai Sea's offshore water has a pollution of medium level.**

The background features a repeating pattern of stylized, overlapping figures in shades of orange and yellow. The figures appear to be in various poses, possibly representing a traditional dance or a group of people. The entire scene is framed by a decorative border consisting of a blue outer line and a yellow inner line with a repeating geometric pattern.

**Jinhua City of Zhejiang Province has been engaged in the study of grey water treatment and utilization for 15 years and has good achievement. The following is a summarized report:**

# **I. Urban Grey Water Treatment**

## **1. Ecological Toilets**

**In 1991, Jinhua start the study of ecological public toilet and built 4 experimental toilets. In September of 1992, after appraised by Zhejiang Provincial Science & Technology Committee, they were awarded a third-class SciTech Prize by China's Ministry of Construction. The Ecosan technology was patented in 1994 by the National Patent Office. The Ecosan project was popularization project for Zhejiang's Eighth & Ninth Five-Year Plans. In 1996, it won a second-class provincial SciTech Prize for its contribution to the Eighth Five-Year Plan.**

**From 1992 to 2006, Jinhua has built 117 ecosan public toilets. In 1996, China's Ministry of Construction called on all China to learn and follow Jinhua's ecosan experience and technology and Zhejiang included ecosan program in performance evaluation for all the cities in the province.**

## **2. Urban Ecobuildings**

**From 1992 up to June 2007, Jinhua has built about 500 ecobuildings for office, commercial, factory, school, and residential purposes. These buildings cover a total area of 320 thousand sqm with 1.84 million sqm floor space and 1.50 million sqm roof greening. Besides, the city has built 5381 biogas tanks of 137128 sqm total volume with a handling capacity for grey water generated by 650 thousand persons.**

**Small-scale biogas tanks here and there treat and sanitize grey water right on the spot. The grey water is collected, treated, utilized, and expelled right on the spot.**

**Simple construction; Low building and running cost; Easy management**

**Suitable for both densely populated areas and areas with sporadic households, sparse population, and little restriction for waste discharge. After treatment, the water can be up to China's national standard for Grade II discharge water.**

**After treated at depth of marsh land, the water will be up to China's national standard for Grade I discharge water.**

## **II. Rural Grey Water Treatment**

**In 2003, Zhejiang Provincial CCP Committee and Provincial Government launched “Operation 811” and environment pollution regulatory plan aimed at speeding up construction of rural grey water treatment facilities in Qiantang River drainage area. Qiantang River’s upper waters areas of Hangzhou, Shaoxing, Jinhua, and Quzhou, etc. have a large rural population, whose domestic waste water (gray water) is polluting Qiantang River’s water in a serious way.**

## **Work Basis I: Small-Scale Local Treatment Technique**

- Since 1993, twenty-eight biogas tanks have been built at Shuanglong Scenic zone's Jinhuan, tourist center, Dongqian Village, Lutian Village, the post office, and some hotels & restaurants, etc. Small scale biogas tanks have been employed for treatment of grey water.**
- According to the test on December 11, 1993, the treated water has COD<sub>Cr</sub> of 84.8mg/l and BOD<sub>5</sub> of 27.15mg/l.**
- It is up to China's national standard for Grade I discharge water.**
- The environment of the national scenic zone is under good and long-term conservation.**

## **Work Basis II: Centralized Treatment and Utilization of Natural Marsh Land**

- Since 1997, large scale grey water treatment pilot centers have been built at the No.5 Provincial Prison, the No.8 Compound of Jinhua Prison, and The Women's Prison.**
- Treatment in combined technologies of anaerobic treatment, biological filtration, and natural marsh land approaches.**
- 300 cbm of anaerobic treatment and biological filtration tanks; 1200 cbm of natural marsh land**

- **Sufficient to provide for users of 1700 persons;**
- **According to the test by Jinhua Environmental Monitor Station on August 3, 2005, the treated water has a removal rate of 99.9% for CODcr, BOD5, SS, NH3-N, etc.**
- **The ten-year overall quality of discharged water is constant and up to China's national standard for Grade I discharge water.**
- **It is up to the standard for farm field irrigation water.**



**Quality of  
Discharged Water**

## **I. General Conditions of Rural Pilot Village**

- Location, Population, Economy**
- Dongxi Administrative Village, Bailongqiao Town, Wucheng District;**
- In the south of Bailongqiao Town at western outskirts of Jinhua City;**
- Composed of three natural villages: Yeya, Yecun, and Dongxi;**
- 277 permanent households of 789 persons; 5200 migrant workers;**
- 213 industrial enterprises;**
- Average annual income per person is 8000 Yuan in 2004.**

## **Terrain:**

- **The village is longer from north to south than from east to west.**
- **North to south in sequence: Yeya, Yecun, and Dongxi**
- **A private enterprise zone locates between Yeya and Yecun. There are industrial zones in the east and west of the village.**
- **Dongxi natural village has 10 newly established homes at the west wing, and 56 new homes almost completed; Yeya has over 50 newly rebuilt homes. The other half of the Yeya homes are still under rebuilding. Yecun has only 3 homes.**

## **Original Status:**

- **Homes built a few years ago, were provided with a simple septic tank.**
- **Most of the tanks did not meet relevant standards. Some had tanks that could not contain water; some had broken covers; others were not fully furnished with necessary piping, so that there was leakage of excrement everywhere.**
- **Pail closets were in use at some old homes.**

- **The village is higher on south than on north.**

- **Two aqueducts:**

**One is the 4m-wide artery traversing the whole village, and collecting most of grey water, industrial wastewater, and rainwater.**

**The other one is 1.5m wide, branching out from the artery at the southern end of village, winding its way to the north in the eastern part of the village, and collecting waste water in the east of the village.**

- **Originally, the aqueducts were constantly overflowing with stinking dirty water.**
- **Especially the artery which traversed the whole village. In dry season, weeds grew all over it; garbage piled up; dirty water either stuck fast to the bottom, or over flew. Flies and mosquitoes bred rapidly. There were stinky smell everywhere.**
- **The dirty sewage water contaminated the natural water, both overground and underground, in a direct way seriously threatening the villagers' health and access to clean water resource.**
- **Pollution control has become a biting issue.**

## **II. Summary of Rural Grey Water Treatment Pilot Technologies**

- Adopting a combined technology for local & centralized treatment of grey water**
- “Local Treatment” is to treat and sanitize grey water right on the spot by means of a small-scale gravityflow-overflow anaerobic digesting tank combined with a biological filtration tank. The treated water can be either discharged directly, or diverted to a “centralized” system for further treatment.**

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- **“A Centralized Treatment System” is made up of an unpowered multi-level gravityflow-overflow anaerobic digesting system, a multi-level biological contact filtration system, a multi-level underflow system, and a multi-level bio-purifying oxidation tank system.**

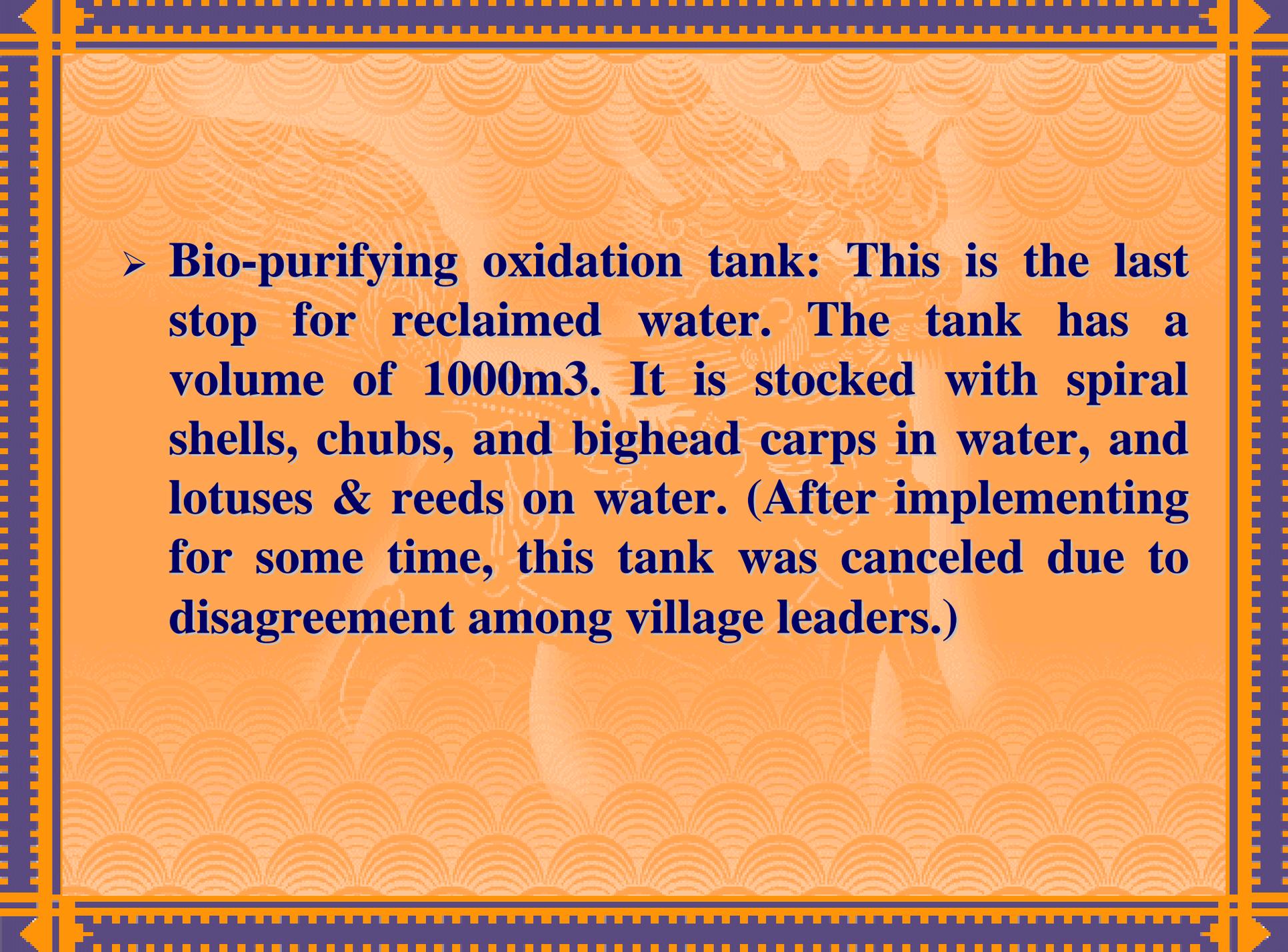
## **Project Profile:**

**Dredging for aqueducts over 1000 m long; Laying of main pipes 1046m and branch pipes 304.4m; Installation of anaerobic digesting system and biological filtration system 96m<sup>3</sup>; Installation of underflow system 300 m<sup>3</sup>; Planting of 24 willow trees, 800 *Jasminum mesnyi* plants, and 5000 calami. Stocking of spiral shells, chubs, and bighead carps in bio-purifying oxidation tanks.**

## **Project Cost:**

- Cost of the project of water treatment systems and ducts is 450 thousand Yuan in total, or 150 Yuan per capita based on a user size of 3000 persons, including the permanent & the migrant. .**
- Cost of the water treatment systems is 140 thousand Yuan in total, or 200 Yuan per capita on basis of a user size of 700 persons in 200 households, excluding the migrants.**

- **Late stage treatment tanks: underflow bio-treatment tanks, bio-purifying oxidation tanks**
- **Underflow bio-treatment tank: 25m long, 10m wide; Walls on four sides with rendering on the inner surface and clay plaster on the outer surface; Bottom of 200mm thick clay that prevents pervasion, topped with 400mm thick cinder, 100mm thick pebble stones of  $\phi 30-40$ , and 800mm mool at the very top; On top of the tanks, willow trees, Jasminum mesnyi, and calami are planted. There is a 5m space between adjacent tanks linked by a filtration trough, so that multilevel filtration, absorption, and digestion can be realized.**

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- **Bio-purifying oxidation tank:** This is the last stop for reclaimed water. The tank has a volume of 1000m<sup>3</sup>. It is stocked with spiral shells, chubs, and bighead carps in water, and lotuses & reeds on water. (After implementing for some time, this tank was canceled due to disagreement among village leaders.)

The background of the slide is a golden-yellow color with a repeating pattern of stylized, overlapping scallop or shell-like shapes. In the center, there is a faint, golden illustration of a lion standing on its hind legs, facing right, with its front paws raised. To the left of the lion, there is a faint, golden illustration of a person in traditional attire, possibly a woman, with her hands raised in a gesture. The entire slide is framed by a decorative border consisting of a blue outer band and a yellow inner band with a repeating pattern of small squares.

### **III. Waste Water Collecting & Treatment Technique: Technical Principle & Treating Effect**

## 1. “Local” Treating System

- Adopting a small-scale gravityflow-overflow anaerobic digesting tank and a biological filtration tank
- Can serve either for treatment of individual-household grey water, or as early-stage of “centralized” treating system.
- Tank Volume: Tank volume is 0.2 cbm multiplied by number of actual users.
- Tank Structure: There are two types. The type for sporadic households is made up of a sedimentation tank, a single- or multi-level anaerobic digesting tank, a dual- or multi-level biological filtration tank. The type for rebuilt integral homes is made up of a pretreatment tank, a dual- or multi-level anaerobic digesting tank, and a multi-level biological filtration tank.

- **The pretreatment tanks and the anaerobic digesting tanks are called early treatment tanks. The biological filtration tanks are called late treatment tanks.**
- **The proportion between early treatment tanks and late treatment tanks is 3 : (0.5~1) optionally.**

- **Technical Process: Sedimentation Tank (Pretreatment Tank) --- First-level Anaerobic Digesting Tank --- First-level Water Pressure Room --- Second-level Anaerobic Digesting Tank --- Second-level Water Pressure Room --- ... Final-level Water Pressure Room --- biological filtration tank --- Discharged or Utilized locally**

- **Referential Standards: Anaerobic digesting tank can be designed as per China's national standard of GB4570~4752-84 for 4-10 m<sup>3</sup> marsh gas tanks. The other tanks can be designed as per patent techniques for ecosan toilets.**

## **Technical Key Points:**

- A sedimentation tank can be built in a way that resembles a sink hole, with a volume of 0.5 cbm.**
- A pretreatment tank should have a preferable volume of 6 cbm, which is a full load of an excrement wagon.**
- An anaerobic digestion tank shall have larger volume than its next level counterpart.**
- Marsh purifying tank shall have a maximum design air pressure of 950mm of water.**

## **Implementation Formula:**

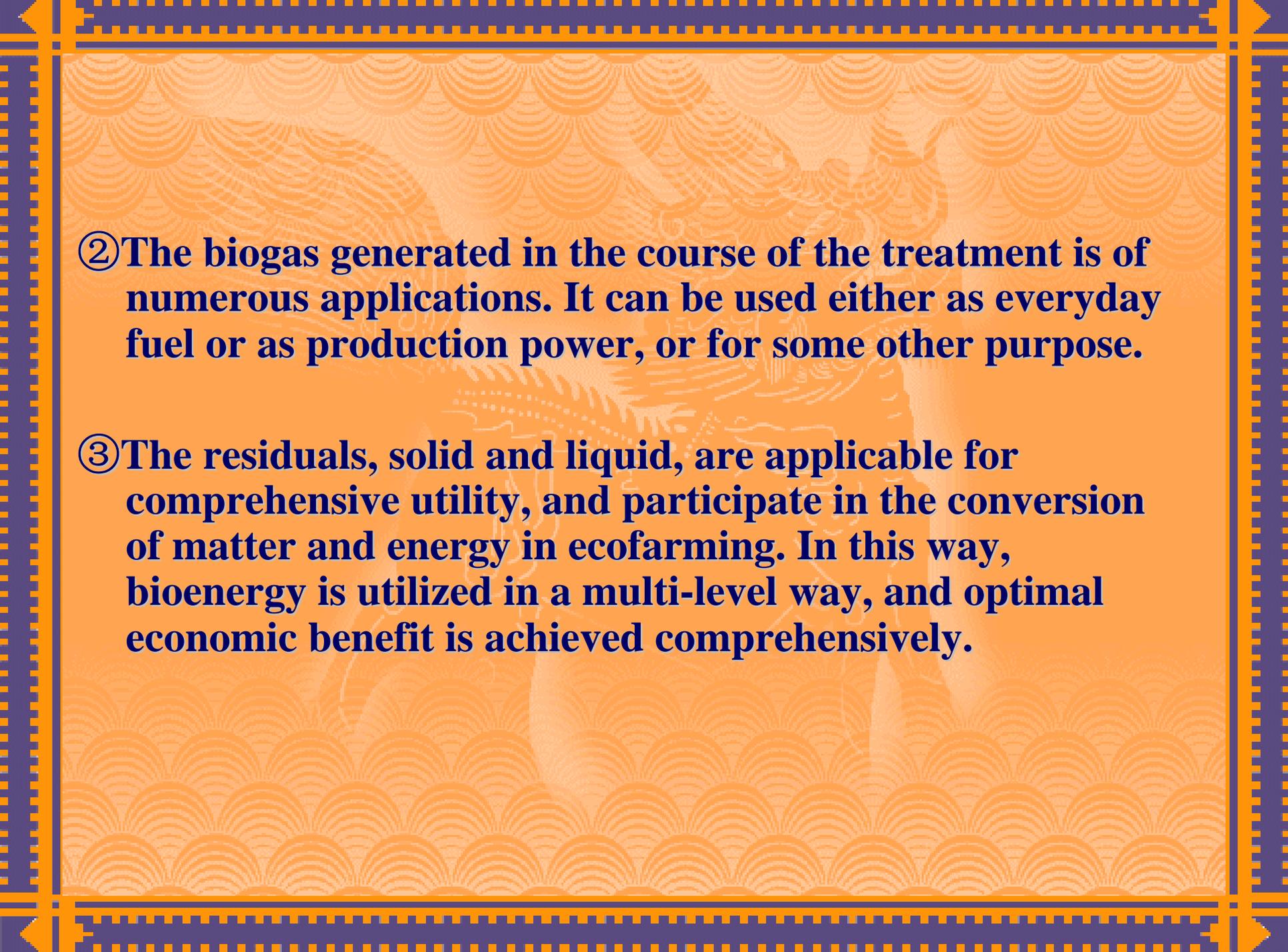
- Build 1 small-scale gravityflow-overflow anaerobic digesting tank and 1 biological filtration tank for every 1-7 households, with a tank volume of 6 cbm.**
- Build 1 treatment tank for every 8-12 households, with a volume of 10 cbm.**

## **2. “Centralized” Treating System**

- The preliminarily treated grey water is collected by the piping network and divert to a centralized purifying plant for further treatment before either utilized or discharged.**
- A centralized purifying treatment system is made up of a multi-level gravityflow-overflow anaerobic digesting system, a multi-level biological filtration system, a multi-level underflow bio-treatment system, and a bio-purifying oxidation tank system.**
- 0.2 cbm per capita**

## Multi-level gravityflow-overflow anaerobic digesting system:

- Adopting the technique of gravityflow-overflow anaerobic digestion to break down the organic matters – such as carbohydrate, protein, and fat – into biogas and carbon dioxide by means of anaerobic bacteria
- Three merits for environment improvement:
  - ① Anaerobic digesting purification turns insoluble organic matters contained in grey water into soluble organic matters, so that they are sanitized, and environment is purified. The pathogens and parasites in grey water are killed after entering biogas tank and staying there for long.

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- ② The biogas generated in the course of the treatment is of numerous applications. It can be used either as everyday fuel or as production power, or for some other purpose.**
- ③ The residuals, solid and liquid, are applicable for comprehensive utility, and participate in the conversion of matter and energy in ecofarming. In this way, bioenergy is utilized in a multi-level way, and optimal economic benefit is achieved comprehensively.**

## Multi-level Anaerobic Bio-filtration System

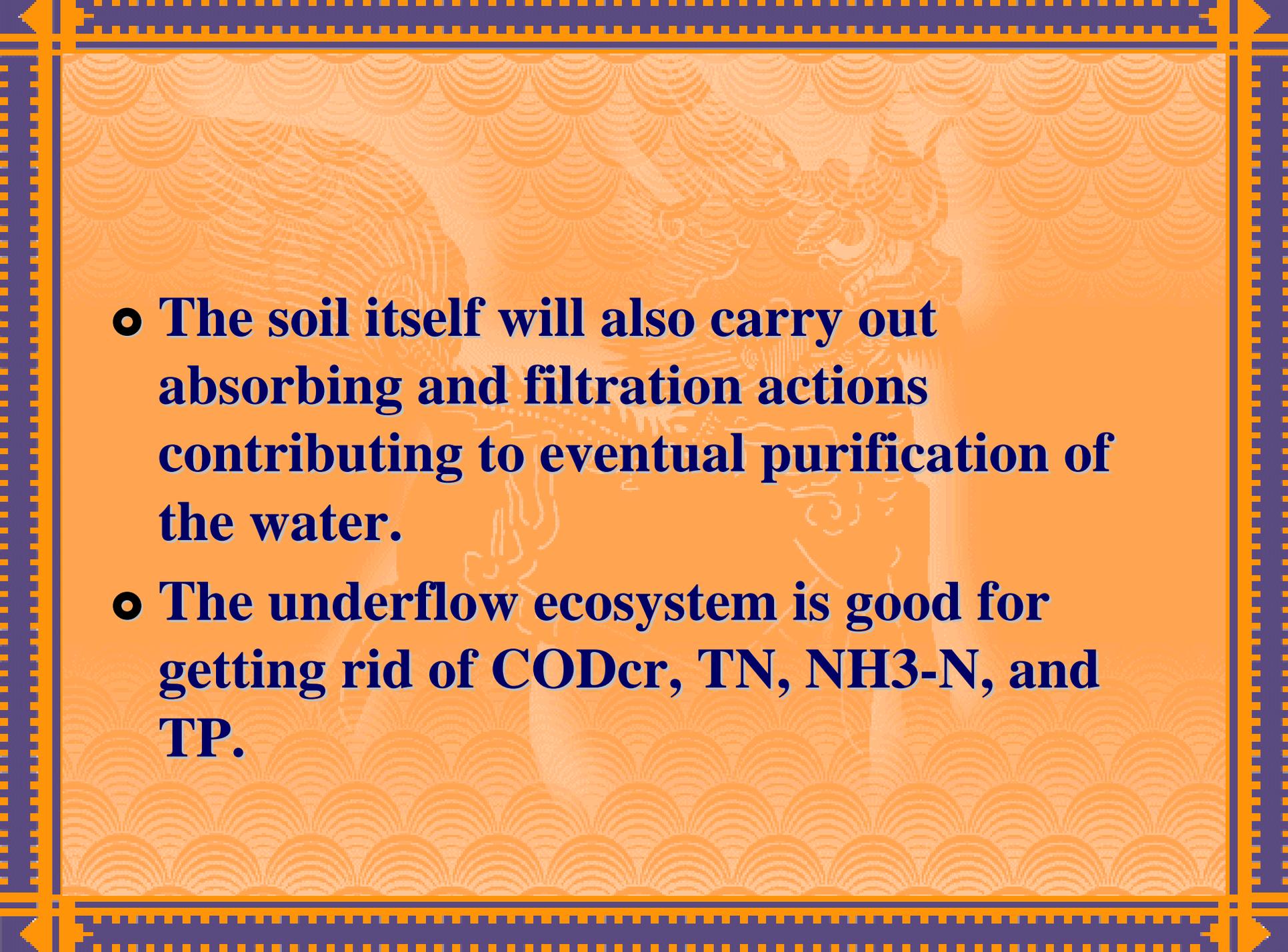
Adopting biomembrane technology. This approach is to allow mass breeding of bacteria and bacterial organism on top of some filling stock so that a thin layer of membranous filth, the biomembrane, is formed. The biomembrane will function as purifier for the water as it feeds on the organic pollutants.

## **Multi-level Underflow Ecological System**

**The system will provide second-level treatment by creating artificial marsh land, which treats grey water in depth.**

**On the bed of the artificial marsh land, with all media well proportioned, various marsh plants are cultivated to constitute an artificial ecosystem.**

**When grey water goes through the marsh land, the bacteria in the soil adjacent to the plants' roots will effectively absorb and decompose the pollutant elements along with nutrients.**

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- **The soil itself will also carry out absorbing and filtration actions contributing to eventual purification of the water.**
  - **The underflow ecosystem is good for getting rid of COD<sub>cr</sub>, TN, NH<sub>3</sub>-N, and TP.**

## Bio-purifying oxidation tank treatment system

In the landscape pool, some bionts are cultivated on, amid, and under the water, such as emerging / hovering plants and fish. Water treatment is thus combined with beautification of environment. The cultivated fish & plants will bring economic benefit in addition to environmental benefit.

### 3. Treatment System: Technology vs. Effect

#### ① Treating Effect Against Relevant Standards

Table 1: Test Result of Dongxi Grey Water  
Tested on August 3, 2005

Sampling Spot	PH	COD <sub>Cr</sub> (mg/l)	BOD <sub>5</sub> (mg/l)	NH <sub>3</sub> -N (mg/l)	suspended matter (mg/l)	Sample Appearance
Dongxi Inlet	7.17	655	325	25.9	$1.76 \times 10^3$	Black
Dongxi Biogas Tank Exit	7.49	147	95	23.7	43	Turbid
Dongxi General Outlet	7.65	57	23	2.98	69	Yellowish
Dongxi Aqueduct Water	7.32	36	14.1	2.74	36	Clear

**Table 2: China National Waste Water Composite Discharge Standard**  
**Unit: mg/L (Except for pH)**

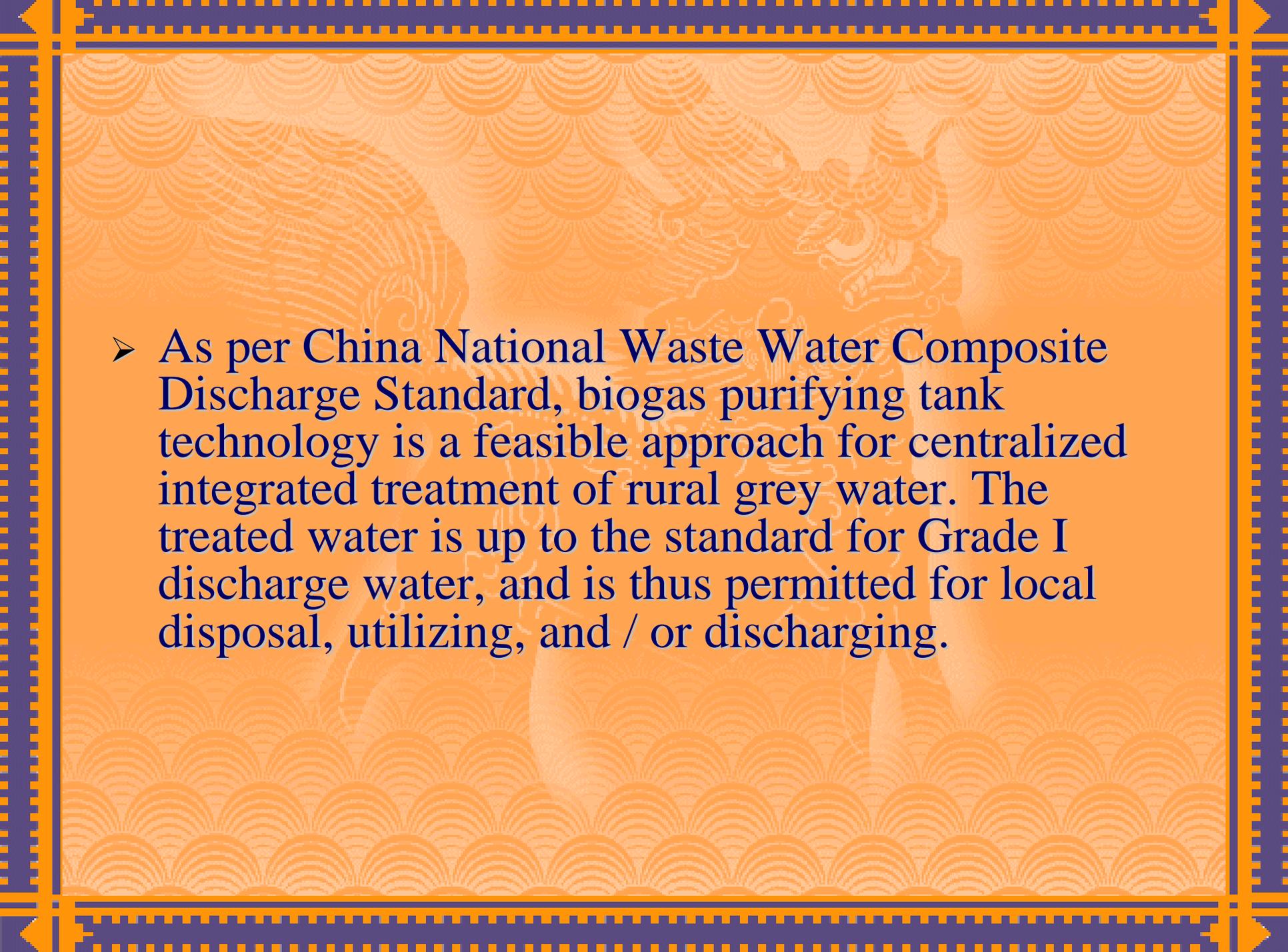
<b>Pollutant Grade</b>	<b>PH</b>	<b>COD<sub>cr</sub></b>	<b>BOD<sub>5</sub></b>	<b>NH<sub>3</sub>-N</b>	<b>Suspended Matter</b>
<b>Grade I</b>	6-9	100	30	15	70
<b>Grade II</b>	6-9	150	60	25	200

**Table 3: Standard for Reclaimed Water Used as Scenic Water**  
**Unit: mg/L (Except for pH)**

<b>Pollutant Grade</b>	<b>PH</b>	<b>COD<sub>cr</sub></b>	<b>BOD<sub>5</sub></b>	<b>NH<sub>3</sub>-N</b>	<b>Suspended Matter</b>
<b>No Contact with Human Body</b>	6.5-9	60	20	15	20

**Table 4: Jinhua No.8 Prison Grey Water Test Result  
Teated on August 3, 2005**

<b>Sampling Spot</b>	<b>PH</b>	<b>COD<sub>Cr</sub> (mg/l)</b>	<b>BOD<sub>5</sub> (mg/l)</b>	<b>NH<sub>3</sub>-N (mg/l)</b>	<b>Suspended Matter (mg/l)</b>	<b>Sample Appearance</b>
<b>No.8 Prison Inlet</b>	6.08	10400	1120	49.9	6830	<b>Black &amp; Turbid</b>
<b>No.8 Prison Biogas Tank Exit</b>	6.79	317	148	51.6	54	<b>Clear</b>
<b>No.8 Prison General Outlet</b>	7.76	37	13.2	0.474	28	<b>Clear</b>

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- As per China National Waste Water Composite Discharge Standard, biogas purifying tank technology is a feasible approach for centralized integrated treatment of rural grey water. The treated water is up to the standard for Grade I discharge water, and is thus permitted for local disposal, utilizing, and / or discharging.

- **Sludge treating rate is over 95%. Grey water daily intake is 350 tons, which is sufficient capacity for handling grey water generated by 3000 persons. During half a year's operation of the tank, a total of 6000 tons of grey water and 800 tons of sludge has been treated. The tank has a sludge deposit of about 20 tons, therefore, the actual treating rate of sludge is 97.5%.**
- **Treated water is up to China National Waste Water Composite Discharge Standard GB8978-1996: Grade I Discharge Water**
- **Up to GB7959-87 Standard for Sanitized Excrements. Parasite ova sedimentation rate is over 95%. Fecal coliform bacteria value is  $1 \times 10^{-4}$ .**

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- **Investment for the project is to be kept under 500 Yuan for every ton of water treated. The actual amount is 400 Yuan per ton water. Cost for treatment is 0.05Yuan per ton water. Annual operation cost is about 600 Yuan.**
  - **Investment for the grey water treatment system project is 150 Yuan (for 0.2 cbm) per capita, excluding the part for piping network.**



THANK YOU  
RESPECTED LEADERS,  
EXPERTS, AND FRIENDS!

Thank you.