

# CONSTRUCTION AND SANITARY EFFECT OF THE 'SIX-IN-ONE' TOILET MANCHENG COUNTY, NORTHERN CHINA

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**Abstract:** 300 'Six-function' toilets were constructed in Zhongdian village, Mancheng county, Hebei province. Each consists of toilet, shower, pigsty, henhouse, biogas digester and greywater disposal. 100 of the 300 homes installed porcelain urinal and solar energy water heater on the toilet roof. The 'Six-function' toilets are functioning well and have been followed for two years. Our studies indicate that the destruction of *Ascaris lumbricoides* ova in the biogas digester was 99.9% and that the removal of COD and BOD was 87.3% and 90.4%, respectively. When the temperature outside the digester is between minus 12 degrees C and plus 10 degrees C in winter, temperature inside the digester is 10 to 12 degrees C. The digester can produce 1.5 to 2m<sup>3</sup> of gas in winter, and 2 to 4 m<sup>3</sup> in summer. It need not change the raw material as long as the digester is running properly. It is a cost-effective and feasible way for treating domestic sewage treatment and is welcomed by local farmers.

**Key words:** country six-function toilet anaerobic fermentation sanitary effect

A toilet is one of the indispensable sanitary facilities in a rural area. In Dianzhuang village, Mancheng country, Hebei province, 300 'Six-function' toilets were constructed with the combination of biogas development and treatment of faeces from humans and domestic animals, domestic wastes and sewage. Our investigations and tests confirmed that the sanitary effect of the faeces treatment in the methane generating digester is good.

## 1 Design and construction of six-function toilet

### 1.1 The construction of the six-function toilet

This six-function toilet was constructed near the pigsty. The methane generating digester was built at the bottom of the pigsty, in the form of a rectangle 6 by 3m. The digester is 2m deep, with a diameter of 3.1m. The diameter of the effluent digester and the automatic residue-cleaning digester is 1.4m and 70cm, respectively. The total cubage of the digester is about 6-8m<sup>3</sup>, with a thickness of 60cm. Each digester was built using 1 ton cement and 2.5m<sup>3</sup> sand. The henhouse was built on the roof of the pigsty, 25m of long and 1.5m wide. The toilet is 1.8m high and 1.7m wide. A solar water heater was installed on the toilet roof. A shower and a porcelain urinal were fixed in the toilet. Under the toilet there were two-case septic digester: 66 by 50cm and 1.3-1.5m deep.

### 1.2 Technical flow

From *toilet* to *shower* with solar energy to *pigsty* to *henhouse* to *greywater trench* to *methane generating digester* to *effluent digester* to *biogas* to *consumer*.

The temperature of this special six-function toilet is about 25 to 35degrees C in summer, and the average daily production of biogas is about 4m<sup>3</sup>; while the temperature of the toilet is about 10 to 12 degrees C in winter, and the average daily

production of biogas is about 1.5 to 2m<sup>3</sup>. The digester utilized domestic sewage and the bath water rather than the domestic drinking water as the substrates. In addition, the digester did not consume any electricity.

## 2 Testing and method<sup>[2]</sup>

Testing items are: 1/ colour (Visual identification); 2/ odour (description by classification); 3/ pH (pH25 acidimeter); 4/ number of colibacillus (Sanitary Standard for Excrement and Urine, GB7957-87, see Annex A); 5/ number of Ascaris eggs (Dilution and inoculation method); 6/ COD (Permanganate method); 7/ BOD(Dilution and inoculation method)(GB7488—87); 8/ Turbidity(Turbidimetry)

## 3 Sanitary effect

After the construction of the six-function toilet, the colour , pH, number of the Ascaris eggs and colibacillus, COD and BOD, and turbidity were tested.

### 3.1 Colour and odour

Mixing with the faeces, the liquid at the inlet is dense with snuff colour and 3-4 class of odour; while the liquid at the outlet is watery liquid with light snuff colour and 0-1 class of odour, which is not mixed with the faeces.

### 3.2 PH

The pH of the samples from the inlet and outlet are about 6.7-7.4 and 7-8, respectively. The pH value will be enhanced to some extent after the anaerobic fermentation of the excrement and urine. For example, when the concentration of the organic acid (mainly acetic acid) amounts to 2000-3000ppm, the fermentation will be greatly affected, and even stopped.

### 3.3 Number of Ascaris eggs and coniforms

The number of Ascaris eggs is considerable in the inlet sample. The average number is about 2-10<sup>4</sup>/100ml, and the maximum number can amount to 2.88-10<sup>5</sup>/100ml. After treatment in the methane generating digester, the number of Ascaris eggs decreased to 2/100ml, i.e. the destruction rate is about 99.9%. The number of colibacillus is about 10<sup>-7</sup> ~ 10<sup>-6</sup> in the inlet samples. After treatment, the number increased by magnitude a magnitude of 2-3. The results all meet the sanitary standards, see Tab.1.

**Tab.1** The number of Ascaris eggs and colibacillus in inlet and outlet samples

Sample	Number of Ascaris eggs(/100ml)				Number of colibacillus ( ml )		
	Number of samples	R	G	Kill rate ( % )	Number of samples	R	G
Inlet	6	400 ~ 288000	2000	99.9	6	4 × 10 <sup>-7</sup> ~ 4 × 10 <sup>-6</sup>	4.67 × 10 <sup>-7</sup>
Outlet	6	0 ~ 10	0		6	4 × 10 <sup>-4</sup> ~ 4 × 10 <sup>-2</sup>	2.14 × 10 <sup>-4</sup>

### 3.4 Test results of COD and BOD

COD and BOD are the indicative indexes, which could not only indicate the content of organic pollutants and deoxidized substances but also assess the effect of the wastewater treatment. After the treatment of the excrement and sewage, COD and BOD were removed by 87.3% and 90.4%, respectively (see Tab.2). Comparing with the control, COD and BOD were all lower than the control (P<0.01).

**Tab.2** COD and BOD in inlet and outlet samples

Sample	COD			Removal rate(%)	BOD			Removal rate(%)
	Number	S	G		Number	S	G	
Inlet	11	4680.0 ~ 5822.8	5299.9	87.3	11	2800.7 ~ 3602.4	3219.9	90.4
Outlet	12	609.4 ~ 782.4	675.51		12	251.11 ~ 386.34	308.98	

### 3.5 Turbidity(see Tab.3)

**Tab.3** Turbidity of inlet and outlet

Sample	Number	S	G	Removal rate(%)
Inlet	11	3500 ~ 4800	4093.75	86.2
Outlet	12	400 ~ 750	564.2	

## 4 Social benefits

After the collection and treatment of faeces from humans, domestic animals and poultry, organic wastes, domestic sewage in the methane generating digester, we can gain several benefits. First of all, we can get high-quality energy. The odours from the toilets can be controlled. Also breeding of mosquitoes and flies are controlled effectively. Thus the sanitation condition in the rural areas can be greatly improved. Second, it solves the problem of lack of bath, limited coal resources, and the problems of dirty and malodorous toilets. Third, liquids contain large amounts of N, P, K, amino acids and digestive enzymes. In addition, the application of biogas fertilizers contributes greatly to the production of food because it can reduce plant diseases and insect pests and the products are beneficial for human health. Fourth, due to the application of biogas fertilizer, crop straws need not be used as the cooking fuel. Thus the number of straw poles decreased and the living condition was improved. In addition, the return rate of the crop straw to the field was increased, which adds organic fertilizer and decreases the dosage of chemical fertilizers and pesticides required. Fifth, the biogas could be used for cooking and lighting, which can save coal and electricity and also reduce environmental pollution. The thousand-year history of cooking with crop straws, firewood and grass can come to an end in Chinese rural areas. Sixth, after the construction of the four-, five- and six-function toilet in rural areas, water will be saved and crop yield increased, which is beneficial both for the whole country and its people. Seventh, the pollution of water source was decreased, specially during floods.

## 5 Commercial profits

The cost of a new six-function toilet is about RMB500-800. After it is supplied with substrates and materials, the biogas generating from it can be used for cooking for 9-12 months. Comparing with liquefied petroleum gas (LPG) and coal, the cost of cooking fuel will be reduced by RMB 600-700. One six-function toilet will produce 3-5 tons anaerobic digested slurry each year, which contain large amounts of N, P, K and amino acids. The contents of N, P, K per liter of the liquid are 0.96g, 62mg and 800mg, respectively. As a high-quality biofertilizer, the application of it is a substitute for chemical fertilizer. RMB 120 could be saved for 1 mu crop land. Crop yield was increased, the profits per mu were increased by RMB 2500 and the net annual profit will be RMB 2500.