TREANTMENT OF PUBLIC LAVATORY WASTEWATER BY FULL SCALE BIOGAS SEPTIC TANK

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Abstract
A 44.3 m^3 Biogas Septic Tank was used to treat public lavatory wastewater ($10m^3/d$) .The hydraulic retention time (HRT) was 4 day， and volume loading was0.25--0.40m^3/m^3.d. After 3 month's start-up， the steady-state for the system was achieved. Monitoring result of two years showed, biogas Septic tank could reduce most of the organic pollutants, parasite eggs and pathogenic bacteria. The removal rate of COD, BOD_5, parasite eggs and E.coli was about 87%, 66%, 91.3% and 99% respectively. Pollutants was mainly removed by digestor。 The volume biogas production rate of Biogas Septic Tank was 0.05~0.15m^3/m^3.d， and amount of biogas production was about 2~6m^3/d。 Compared with centralized wastewater treatment plant， Biogas Septic Tank has advantages in respect of operation cost, performance management , land occupation and energy consumption， but Biogas Septic Tank was inferior to the latter in respective of treatment efficiency and cost of capital。

Keywords
Biogas Septic Tank， public lavatory， wastewater treatment

Introduction

Before 80s， the soil night of people of towns was carried to village to be used as fertilizer by peasants. With the reformation of production system in county and great scale application of simple and high efficient chemical fertilizer，peasants didn’t carry fecal from town. So fecal sewage were not carried and eliminated, resulting in that fecal sewage overflow, seriously impacting sanitation of town， polluting environment。Although the new building constructed septic tank，the volume of which was not enough， the fecal sewage was discharged after short retention, the removal of COD was only 20--40%, did not meet the demand of sanitation treatment. Moreover it was necessary to remove the setting residues frequently. In fact, due to cost ， the residues was seldom removed， and full up. So the septic tank cannot play primly cleaning rules.

To treat fecal sewage of town, concentrated treatment plants are constructed in most of developed countries. The cost of construction and operation of concentrated treatment plants were very high. It’s too expensive to bear economically for the towns of developing countries. Beside, the necessary complex technology also leads to unfeasibility in near future for developing countries。 It is necessary to develop fecal sewage treatment system with low construction cost, low operation cost, simple management and low maintenance.

To treat fecal sewage，protect environment，improve condition of hygiene and open up energy of town， the department of research and spread on biogas and environmental set about to research anaerobic technology to treat sewage of town in China in 80s. Base on rural biogas digestor and septic tank ， Biogas Septic tank was exploited, and applied widely in south of China and other developing countries. However, former research and experiment was executed in laboratory. There wasn’t systemic research on design of process and performance of Biogas Septic Tank. Therefore, we selected representative public lavatory as demonstration plant of treat fecal sewage, to study removal efficiency and energy recover of fecal sewage treated by Biogas Septic Tank, and carry out economic and technological analysis for treatment system, so that provide foundation for design and performance of Biogas Septic Tank, and for formulating policy .

Profile of demonstration plant

The demonstration plant is located in Xioazi streets of the Zizhong County in Sichuan, China. The lavatory is a four-storey building with the first and the second as public lavatory and the third and the fourth as multipurpose. Five stools for man and woman are arranged in each of the first and the second storey.

The design of this treatment system referenced Zhao Xihui (1996), and the parameters for the design were as follows:

Serving of the lavatory: 200 times a day. Calculated on 50L sewage for each time, $10m^3$ of sewage would be resulted in one day.
COD, BOD_5 and SS in the influent were 1000~1600mg/L, 550~800mg/L, and 500~700mg/L respectively.
The designed volume of tanks: 44.3 m^3, and HRT, 4 days.
Volume loading: 0.25--$0.40m^3/m^3$.d;
Interior temperature: 15~25^{o}C.

The outline of Biogas Septic Tank for treating public lavatory fecal sewage was showed in Table 1.

Tab. 1 the outline of Biogas Septic Tank for treating public lavatory fecal sewage

Serve population (Person/day)	Amount of sewage (m^3/d)	Total Volume of tanks (m^3)	HRT (d)	Investment (Yuan)
200	10	44.3	4.0	29068

Treatment Process

Figure 1 shows the process of Biogas Septic Tanks for Public lavatory sewage treatment.

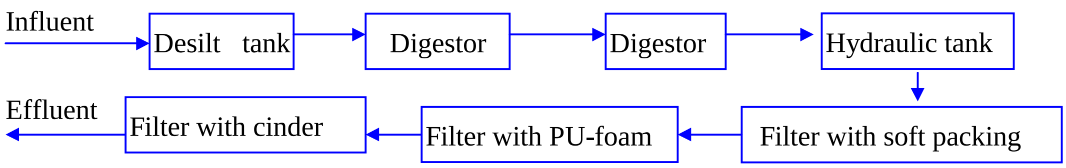

Fig.1 Flow chart of Biogas Septic Tanks for Public lavatory sewage treatment

The Biogas Septic Tank for the treatment of the public lavatory fecal sewage was divided into three functional parts with seven stages.

The first functional part was for silt setting with one desilt tank of a volume of $3.14m^{3.}$ The main function of the desilt tank was removing the inorganic suspended substances in the sewage such as mud and sand.

The second part was for sedimentation and digestion. It consisted of two digestors .The first digestor was spherical with a volume of $9.77m^3$, which was 21.9% of the whole volume of the plant. The second digestor was also the same shape with a volume 10.83 m^3, which accounted for 24.3% of the whole volume. The function of this part was precipitating insoluble organic and inorganic matters, removing parasite eggs and pathogenic bacteria sticking in insoluble solids, and degrading the organic matters too.

The volume of the second functional part was 25.54m^3, which make up 55% of the whole volume of the plant. For the purpose of better utilization of the biogas, a hydraulic tank with a volume of 3.94m^3 was installed, which was 8.8% of the whole volume of the plant.

The third functional part was for filtering. Three filters were installed. The main function of this part was degrading organic by microorganisms attached by packing, and intercepting the remaining suspended solids, parasite and pathogenic bacteria.

The first filter was equipped with soft packing. The volume was 5.64 m^3. Soft packing of D2 model was applied in it and the height of the packing room was 1m.

The second filter was equipped with PU-foam. The filter had volume of 5.64 m^3, and the filtering surface was 0.44 m^2, through which the average filtering rate was 0.95m/h with a maximum of 2.84m/h.

The third filter was a filter with cinder. The volume was 5.64 m^3. Cinder was used as filtering material, the depth of which was 1m and the filtering surface was 0.44 m^2, the average filtering rate was 0.95m/h with a maximum of 2.84m/h.

Start-up and performance

In order to speed up the start of the plant, Biogas Septic Tank was seeded with 300kg slurry and 50kg sludge of other Biogas Septic Tank. The plant produced biogas normally in the seventh day after seeding.

In the first three months, treatment effect was monitored every week. From the fourth month to thirteenth month, monitoring was conducted monthly. From the fourteenth month on, monitoring of the plant was carried out every three month. pH, COD, BOD_5, K-N, E.coli and parasite eggs were analyzed according to Standard Methods (APHA,1985).

Result and Discuss

Removal of E.coli and parasite eggs

Tab. 2 Removal of E.coli and parasite eggs in Biogas Septic Tank

Date of sampling	Items	Influent	Hydraulic tank	Filter with soft packing	Filter with Pu-foam	Effluent	Removal rate (%)
1996,7,16	E.coli Passite eggs (Unite./L)	4×10^{-6} 320				1.1×10^{-4} 28	99 91.3
1997,5,4	Ecli	4×10^{-6}	5.6×10^{-5}	4.3×10^{-5}	1.1×10^{-5}	5.6×10^{-4}	99

Table 2 indicated that the removal rate of E.coli was 99% and effluent reached the Chinese national discharge standard of <Harmless Standard of Excrement> (GB7959-87). The removal rate of the parasite eggs was 91.3% and the parasite egg in the effluent was 28 unit/L, which did not reached the discharge standard. Base on our former research result, Biogas Septic Tank had good removal effect on parasite eggs (Zhao Xihui 1996, Deng Liangwei, 1997). Because there was only one monitoring on parasite eggs, it was not much representative to explain the treatment.

Removal of suspended solids (SS)
Fig. 2 showed the concentration of SS in influent was very low, and it was only 44~68mg/L, Low SS concentration monitored may be caused by the sampling error, for the SS in common fecal sewage is between several hundreds to thousands mg/L. Effluent concentration was between 19~37 mg/, which can meet the demand of <Integrated wastewater discharge standard > (GB8978-1996). Based on the monitoring data, the removal rate of SS was 24%~62%, the actual removal rate should be greater than this data. The removal rate of SS by Biogas Septic Tank was keeping at about 25% during the initial period of performance and has reach 50% along with the operation of the system, and then become stable.

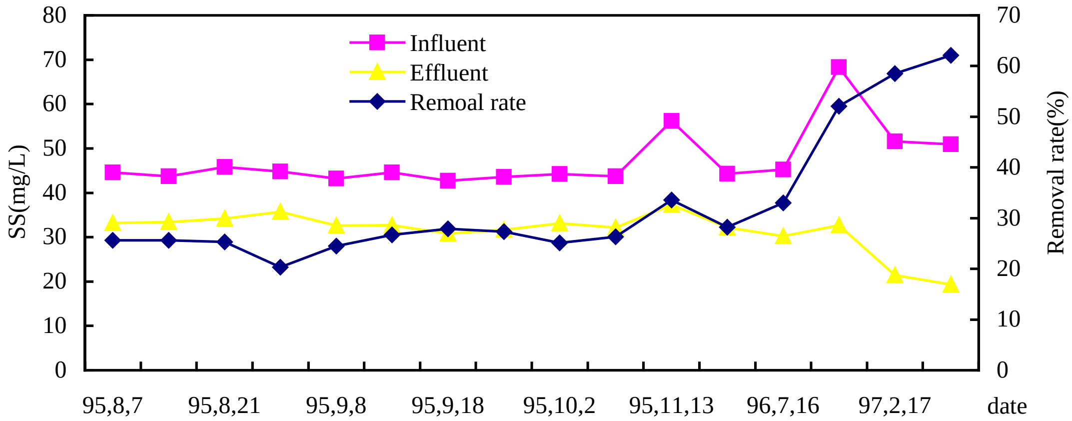

Fig. 2. Removal of SS

Removal of COD
For the sampling errors causing low SS concentration, COD monitored was also low correspondingly. Tab. 3 indicated that COD of influent was 1300~1800mg/L and it was basically soluble COD. In the first three months when the system started operation, the effluent concentration was about 390 mg/L and the removal rate fluctuated around 70%. After three months' operation, the effluent concentration maintained stable at about 250mg/L with removal rate of about 87%. That removal rate was not influenced by the variation of seasons illustrated the system started successfully after three months' operation and entered a steady state. The whole system had a better removal of organic pollutants and the COD removal rate kept at about 87%. The actual removal rate might be higher if there was not sampling errors. COD concentration in the effluent was still high and hasn't reached the discharge standard.

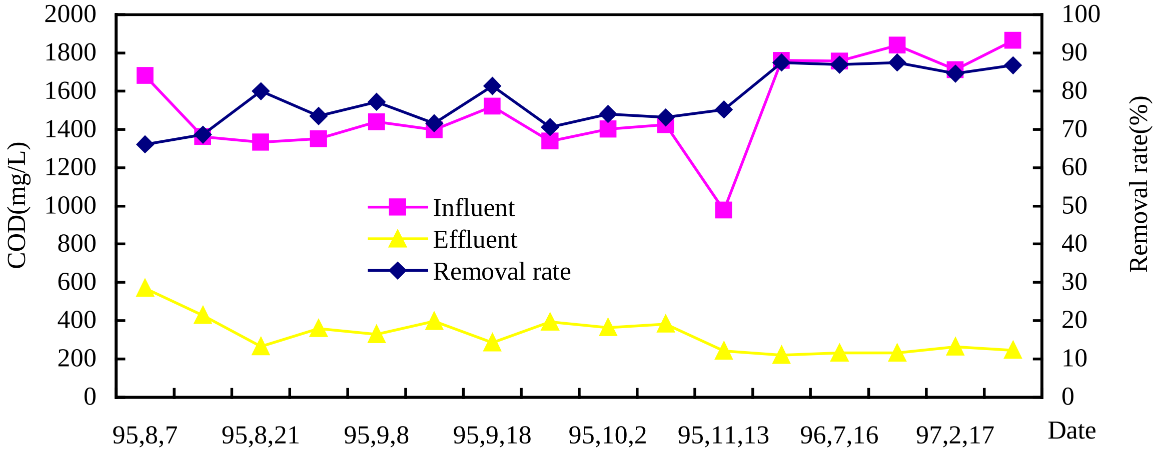

Fig 3. Removal of COD

Removal of BOD_5

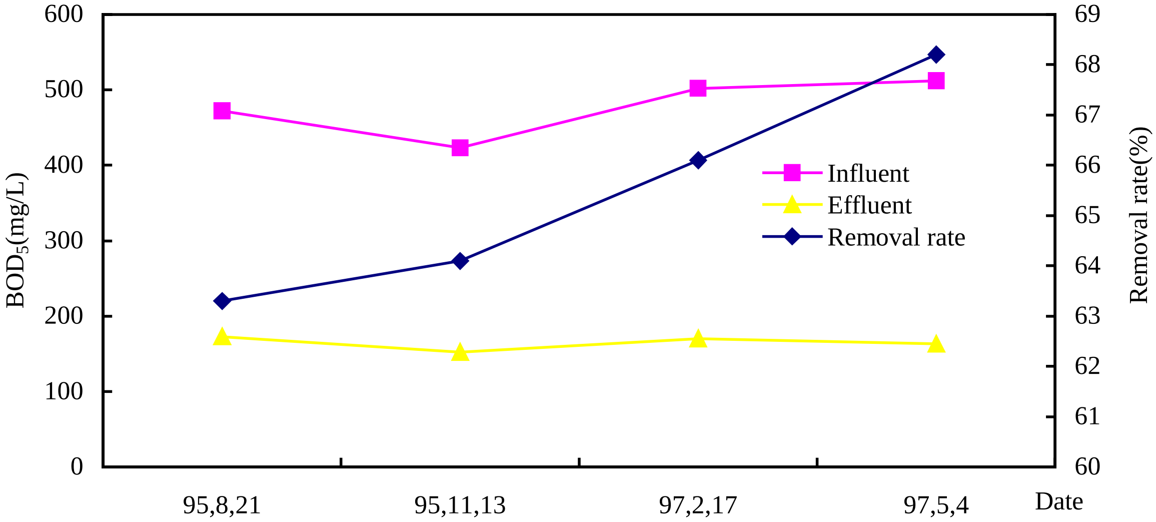

Fig. 4 Removal of BOD_5

Fig. 4 showed the influent BOD_5 of Biogas Septic Tank was between 423~512mg/L and the effluent BOD_5 maintained 150~170mg/L. BOD_5 Removal rate trended in increase with operation of system, from 63.3% on Aug. 21st, 1995 to 68.2% on May 4th, 1997. Though effluent BOD_5 has not reached discharge standard, yet, it greatly reduced organic pollutants.

Removal of K-N

Fig. 5 indicated that there was not much difference on K-N concentration between influent and effluent, and the removal of K-N was only 10%. It showed this system was not optimum for removing K-N.

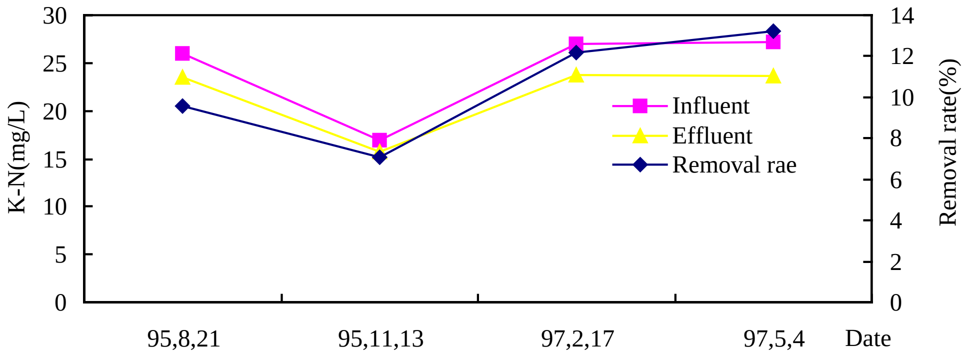

Fig. 5 Removal of K-N

Removal of pollutants in each treatment part

Use the average monitoring data in each treatment part from April 1996 to May 1997 to draw a curve in Fig. 6. The Fig. 6 showed the removal curve of SS dropped remarkably at the section of influent –hydraulic tank and filter with soft packing—filter with PU-foam. And it indicated SS was removed in these two sections. The reason was that sewage had gone through the desilting tank and two digestors at the section of influent-–hydraulic tank, which was good for removing SS. While PU-foam has good effect on intercepting SS at the section of filter with soft packing—filter with PU-foam. COD removal dropped remarkably at the section of influent –hydraulic tank and gradually slows down at the following section, especially at the section of filter filter with

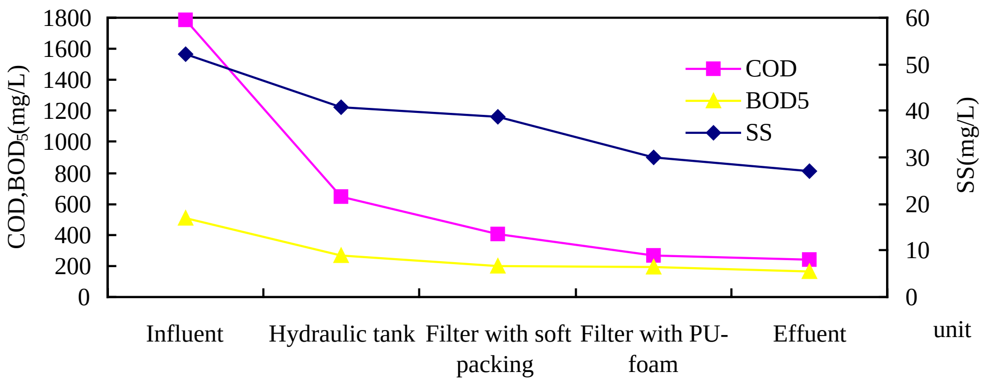

Fig. 6 Pollutants in each part

PU-foam--effluent. It showed COD was mainly removed in digestor, filter with soft packing, filter with PU-foam, of which digestor played mainly rules, the removal rate of COD in digestor was 64.3% which accounted for 73.3% of the total. Filter with coal cinder contributed a little to the removal of COD. The BOD_5 removal dropped obvious at the section of influent--hydraulic tank and it went on stable at the following sections, which implied that the removal of BOD_5 took place in digestor, with removal rate 47.7% which made up 71.2% of the total.

Sewage quantity and gas production

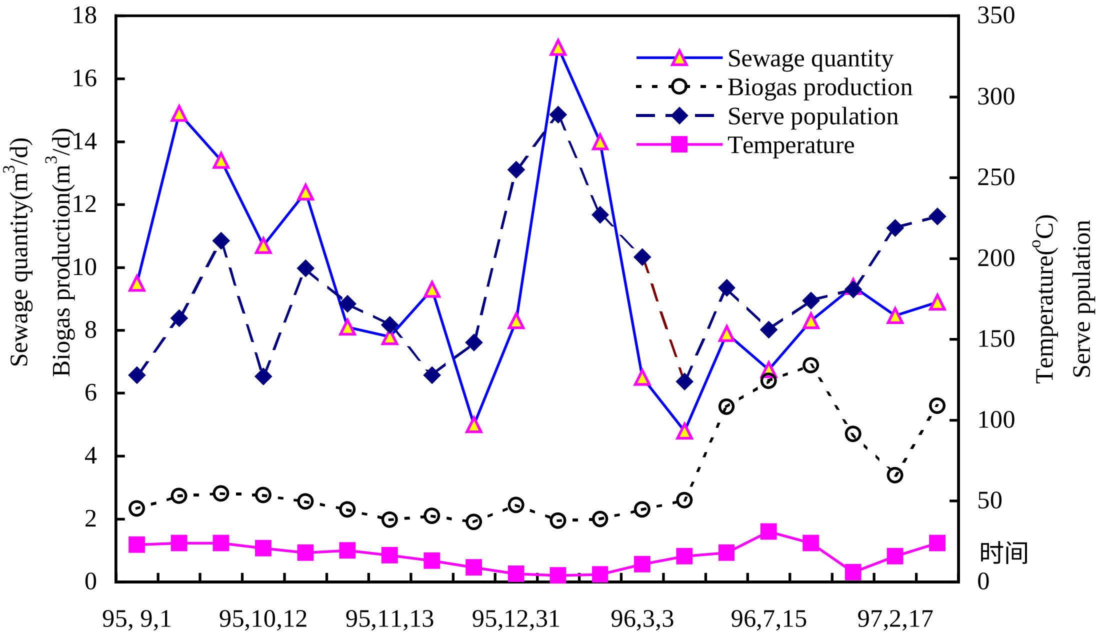

Fig. **7** Sewage and biogas production

Fig. 7 showed serve population of this treatment system fluctuated at about 180 person each day, and influent sewage quantity of Biogas Septic Tank was about $10m^3/d$, and went up and down with increase and reduction in numbers of people who use latrine. The daily gas production of Biogas Septic Tank was around $2m^3$ in winter and $5\sim6m^3$ in summer and can met cooking requirement for two households. Gas Production increased with temperature going up and variation in gas production well kept with temperature variation, and had no much relationship with the serve population and change of influent sewage quantity. It showed the temperature was mainly factor that influence gas production. Fig. 7 also indicated the second year's gas production was higher than that of the first year's.

Economic and technological analysis

Tab.3 Economic and technological analysis on Biogas Septic Tank

Way of treatment	Investment (yuan/m^3)	Operation cost (yuan/m^3)	Energy consumption (Kw.h/m^3)	Land occupation (m^2/m^3)	COD removal (%)	Effluent COD (mg/L)
Centralized treatment	1500	0.30	0.30	1~1.5	>90	<100
Biogas Septic Tank	2907	0.05	No	Almost no	87	220--263

The Biogas Septic Tank can removal most of the pollutants, parasite eggs and pathogenic bacteria in fecal sewage. The removal rate of COD, BOD_5, E.coli and parasite eggs was 87%, 66%, 99% and 91.3% respectively. Therefor, this treating system had significant effects on improving sanitation and reducing water pollution. Compared with centralized treatment system, Biogas Septic Tank had following advantages.

- The capital cost of this system was invested by the user of discharging sewage other than the government, which reduced the financial pressure on the government to prevent pollution. The fund was easy to be collected due to its decentralized investment, so it was feasible.

- The operation cost was quite low. Once the construction work of a system was finished, no operators were necessary. The sewage flew by means of gravity, so no power demanded. The only necessary work was removing the settling residues every other year and regular monitoring of treatment effect. Actually the operation cost was about ￥0.05/m^3, contrasting with that of centralized wastewater treating plant, i.e., ￥0.30/m^3, and power consumption 0.30Kw.h/m^3.
- The whole system was constructed under ground without any land occupation, while 0.5~1.0m^2 demanded for 1 m^3 wastewater treated by centralized ones.
- Methane can be recovered as energy.
- No drainage system was required due to sewage being treated nearby.
- Very little sludge produced, equaling to only 1/8~1/3in quantity of that of the active sludge process.

This system, however, still had some problems as follows.

- The cost of capital construction was high, the investment for 1m^3 capacity is￥2907, compared with ￥ 1500/m^3 of a conventional centralized one. Therefor, from viewpoint of the whole society, it's not economic due to a high total investment.
- The concentration of pollutants in effluent was higher than that of conventional treating system. In the effluent of Biogas Septic Tank，COD,BOD_5 and parasite eggs can't reach the national discharge standard, actually much distance to that of the standard was existed.
- High cost was required for a great deal of work to monitor the treating effect。

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