RESEARCH AND APPLICATION OF BIOGAS DECONTAMINATION SYSTEM

Mianzhu Rural Energy Bureau, Sichuan, Wang Yongzhi, Wang Hu
Mianzhu Environmental Protection Bureau, Sichuan, Ouyang Yunchun

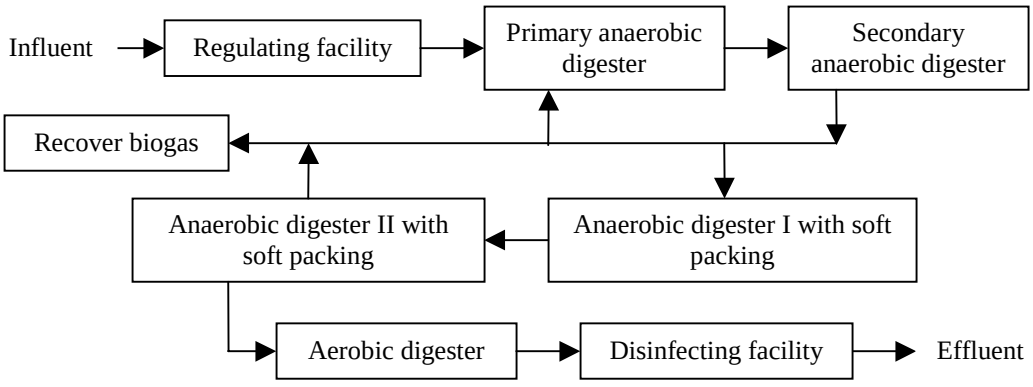
Biogas decontamination system is a device to treat urban domestic wastewater by eliminating poison, reducing waste, treating sewage, and preventing the wastewater from over nutrient steadily. It is designed in accordance with biogas plant, discharge project, and hygienics. Not only is it a decontaminating digester, but a small device for secondary treatment. Mianzhu Rural Energy Bureau began to research on treating urban domestic wastewater applying biogas decontamination technology. Repeating experiments on effluent show that the removal rate of parasitic ova is as high as 99.9%, that of colititre is 77%. The removal rate of organic compounds, such as COD_{cr}, BOD_5, SS, TS, and chroma are respectively 95.6%, 98.3% 98.2% 93.9% and 93.6%. All the removal rates have reached GB7959-87 Sanitary Standards for Innocent Manure, and reached the first level of GB8978-88 Standards for Discharge of Integrative Wastewater. Since 1988, biogas decontamination technology has been applied to urban toilet, residents, buildings, hotels and sight spots. By the end of 2000, totally 850 biogas decontamination systems have been set up spotting towns, traveling places and hospitals, treating domestic wastewater 45,000 tons per day, covering 92% of the whole city.

I. Technical characteristics of biogas decontamination system

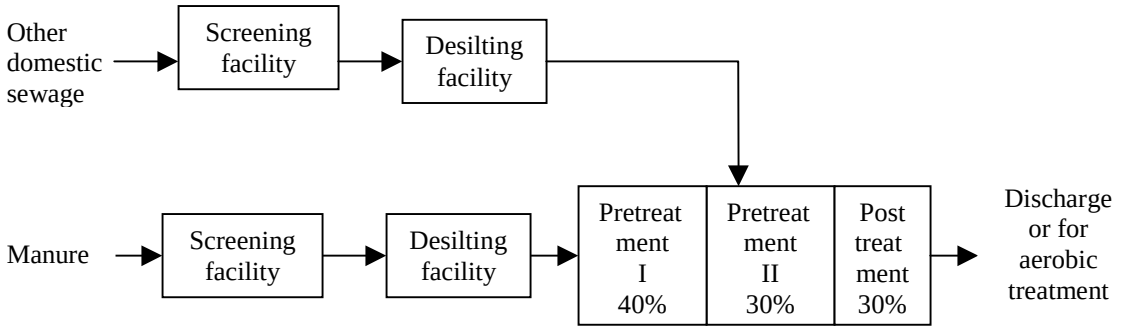
Biogas decontamination system is composed of pretreatment pool and post treatment pool. The former can be divided into primary and secondary phases, both being Anaerobic digestion chambers. The difference is PVC pipes are fixed in secondary chamber by space between every 200 cm to feed in soft packing. Post treatment pool is for filtration. The dimension ratio of primary, secondary and filtration pool is 4:3:3. The parameter considered to determine dimension is 0.5~0.7 m^3 per capita. In human wastewater and domestic washing wastewater, density of organic compounds, various bacteria and parasitic ova are comparatively less. Only when the dimension of digester is determined by HRT (hydraulic retention time) and duration of discharging biomass could organic compounds be degraded, and all variety of bacteria and parasitic ova be killed.

II. Technical process

Urban domestic wastewater is treated in the following process:



i. The indoor sewage net work goes distributarily. That is, toilet wastewater and other domestic wastewater are discharged in separate system.



ii. Characteristics. The HRT for manure is longer. The treated domestic wastewater can meet the requirement of sanitation and environmental protection and recover biogas as energy fuel.

III. Proceeding

Anaerobic treatment of wastewater is to degrade organic matters and produce biogas by anaerobic microbes (including facutative microbes) without oxygen. It is also called anaerobic digestion or anaerobic digestion. This technology is widely used in dealing with environmental pollution and exploiting bio-energy.

Biogas fermentation is very complex, in which varieties of bacteria interact under different matrix and conditions in a complicated relationship.

Since a long time ago, biogas fermentation has been divided into two phases. For the first phase, complex organic compounds are dissoluble to simple organic matters, and the accumulation of organic acids decrease pH value, thus called acid-producing phase. Then simple organic matters ferment to make methane. Further research brings forward the theory of three phases for biogas fermentation. Only a few compounds like acetic acid, formic acid, H_2, CO_2 are accepted the substrate for microbes to produce methane. Therefore, Anaerobic digestion is usually phased into liquefaction, acid producing, and methane producing.

i. Liquefaction

Complex organic matters, such as fibre, protein and fat are degraded to basic structure by hydrolyzing bacteria. Protein is made into polypeptide and amino acid, fat into glycerin and strand fatty acid, amylose into monosacride and polysacride. These hydrolyzing bacteria are heterotrophic, or facutative microbes and a few anaerobic bacteria, widely existing in surroundings.

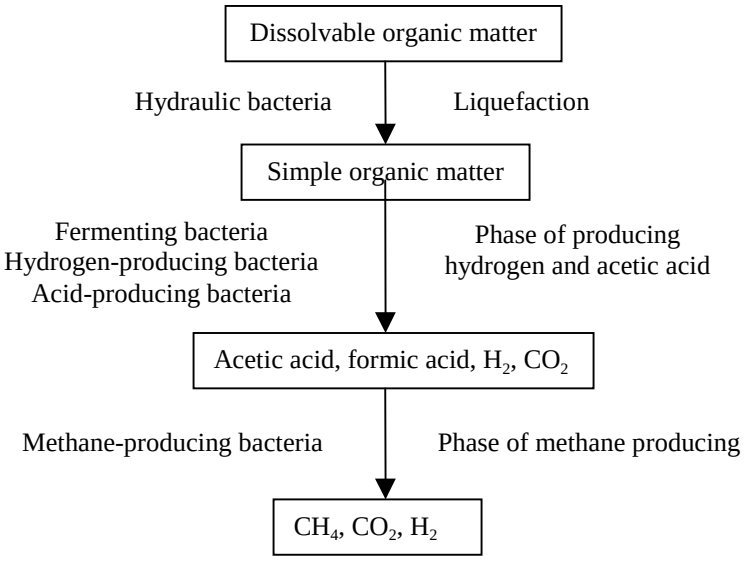
ii. Production of hydrogen and acetic acid

Mainly the simple organic matters produced or contained in material are converted into H_2 and CO_2 by microbes, in which the acting bacteria are called bacteria for production of hydrogen and acetic acid, such as bacillocin, microglobal bacterium, and pseudominas.

iii. Methane producing

Methane-producing bacteria, acetic acid (formic acid), H_2, CO_2 are transformed into methane. There are two methods for the production of methane. One is to directly transform CH_3 in the molecule of acetic acid to CH_4; the other is by redox of CO_2 and H_2. About 70% of the methane is from acetic acid, and the rest 30% from CO_2 and H_2.

Methane-producing bacteria are sort of strict anaerobic bacteria sharing the same morphometrics and different forms. Some usual categories are Methanomicrobium, Methanosarcina, Methanococcus, and Methanothrix, etc. Methane-producing bacteria have a strict requirement to pH value, 6.8-7.8 is adaptable, while 6.8-7.2 is the best range. Such kind of bacteria have low adaptability to temperature. The bacteria, cultivated at a certain temperature, can destroy digestion when the temperature is lowered 1-2℃. They can reproduce very fast, and the reproduction of a generation needs only 4-6 days.



Classification of three-phase methane fermentation

Viewed from above, biogas fermentation s the result of interaction between non-methane bacteria and methane-producing bacteria. Hydrogen transfers between the two bacteria herein. The H_2 produced by the former can be provided to the latter to reduce CO_2 to CH_4.

Acid producing bacteria have better adaptability to pH and temperature than methane-producing bacteria, and reproduce faster. Because of the diversity in speed of reproduction and sensitivity to surrounding, methane-production is the phase to limit the speed of the whole process of biogas fermentation. Nevertheless, speed of the anaerobic digestion of undegradable complex organic matters, such as degradation of fibre and hydraulic liquefaction is also limited.

Limited velocity step as methane producing is throughout fermentation, to remain the amount and activity of methane-producing bacteria in digestion is very significant for anaerobic treatment of wastewater. The technique of the overall system is improved in the two aspects. It is adoptable to prolong HRT of water (for average anaerobic digestion), or to refluence sludge (for anaerobic contact method and UASB), or attach packing with

microbes (in anaerobic filtration chamber). Because there are amount of suspends in domestic wastewater, and the density of resolvable CODcr is low, a compounded technique of average digestion and anaerobic filtration is a usual adoption to the treatment of domestic wastewater.

iv. Various kinds of pathogens, colititre, and virus in parasitic ova, as well as flies and mosquitoes in air, can be treated anaerobically, to meet the national sanitation standard. Further chemical treatment can settle, degrade, consume and kill the bacteria.

IV. Characteristics of biogas decontamination system

i. To save governmental finance by dispersive investment
Since biogas decontamination system is to treat domestic wastewater separately, the principle for construction is that construction side of the building shall build, invest, and afterwards, benefit from biogas decontamination system.

ii. To save lands
It is not necessary for construction side to provide special land for the decontamination system. Designers can make use of vacant place, humid corner, grassland and alleyway (bearing ability should be considered).

iii. To operate steadily at low cost to save human resource
It is constructed underground with bricks and reinforced concrete. It needs no mechanical or power instruments, or any energy consumption. The fluid goes automatically. It operates steadily without management. The system is cleaned by technical group every three to five years.

iv. To maintain in a long time effectively
The technology of biogas decontamination system is mature. It is all constructed with bricks and reinforced concrete without mechanical or power instruments under ground. Therefore, it is unlikely to be weathered or eroded. The usage time can be as long as 30-40 years or more effectively and steadily.

V. Comparison between the effect of biogas decontamination system and sewage treatment plant

i. Benefit of investment
Mianzhu City had planned to set up a sewage treatment plant to treat wastewater 50,000 tons per day in Jiannan Town in the year of 2000. (Failed because of big investment.) The balance list of the investment between sewage treatment plant to treat 50,000 tons of wastewater and biogas decontamination system built already to analyze the investment, environment and social effectiveness.

Comparison list of investment and effectiveness between biogas decontamination system and sewage treatment plant

Year	2000	
Population of city	150,000	
Device	Sewage treatment plant	built biogas

		decontamination system
Construction scale	To treat sewage 50,000 tons/day	105,000 m^3 (dimension)
Total investment	RMB 96 million yuan	RMB 31.5 million yuan
Capacity of treatment	50,000 tons	30,000 tons
Pipe line	22km	None. Effluent discharged into sewage net work
Building attached	Office, mechanical repairing room, storage, house	None
Annual operating fee	RMB 5.7682 million yuan	RMB 1.4 million yuan
Annual management fee	RMB 930,000 yuan	0
Management staff	35 persons	None
Electricity consumption	6.56 million	None
Annual energy consumption	RMB 2.23 million yuan	0
Land occupation	150 mu	0
Treatment of sludge	Piling	Feed to fish, pig, or high efficient fertilizer
Resource recovery	Water	Biogas
Investment resource	Governmental finance (one-off)	Construction side (separately)
Sewage treatment fee	0.80 yuan/ton	0
Usage time	25 years	40 years
Total investment	RMB 96 million yuan	RMB 31.5 million yuan
Remarks	From research report	Provided by Rural Energy Bureau

It shows from above, we can conclude: i) Anaerobic digestion requires less investment than sewage treatment plant to treat the same amount of domestic wastewater. Moreover, separate investment to the former is another advantage. ii) The management and maintenance of the biogas decontamination system cost much lower than a sewage treatment plant which needs a high operation and management fee every year as a heavy financial burden to local government and users.

ii. Environmental benefit

Anaerobic digestion technology applied to treat domestic sewage can reduce wastes and recover some bio-energy. Because it is constructed under ground and occupies no land, biogas digester can save land and make full use of the limited room in city. The process of auto-flow underground in a close line, can not only save a large amount of energy, but prevent harmful microbes and pathogens from breeding. Practice shows that some pathogens and parasitic ova are reduced obviously after the treatment of anaerobic digestion. Biogas decontamination system has made great contribution to Mianzhu to the prize of National Sanitation City in 1999. Mosquitoes and flies are checked regular once and for all. Anaerobic digestion can also remove volatile matters, reduce odour in water and minimize rest sludge. Of course, sewage treatment plant can either decontaminate wastewater. After comparison with anaerobic digestion, it is tested not be able to do as

efficiently as the latter does to reduce wastes and energy consumption, and to kill pathogenic microbes, as well as to recover bio-energy and use land.

iii. Social benefit

The technology of anaerobic digestion holds the principle of “investor benefits.” Furthermore, biogas decontamination system is managed separately as attachment to the building with no financial cost and lower burden, so it is financially acceptable to the construction side. The economic benefit lies obviously on that sewage is treated and managed separately costing no human resource, material or land, and can recover such clean energy as biogas. From the above, anaerobic digestion to treat domestic sewage can bring conspicuous social benefit.

Besides, viewed from civil programming, sewage treatment plant can only collect wastewater through special pipeline set underground. It is quite a delicate lay out and a big investment of finance and material for some cities with backward infrastructure facility to inform their sewage network. Sewage, after being treated by anaerobically to reach discharging standard, can be discharged directly into sewage network of city, thus to reduce construction of underground network. With the development of city and economy, sewage treatment plant can be set up on the base of biogas decontamination system as the primary treatment, then sewage treatment plant as the secondary treatment. The process can not only bring good effect, but also reduce the investment and operation fee of sewage treatment plant.

Conclusively, the technology of treating toilet sewage applying biogas decontamination system is surely mature. It has contributed much to the sanitation and environmental protection of cities, and to the improvement of people’s civilization and life quality. It is a way of less investment, high efficiency, obvious effectiveness, lasting usage time and low operating fee. It meets local conditions of middle or small sized cities, towns, sight spots and factory residents, as well as developing countries, which have no ability to build mechanical plant for integrative treatment of sewage. This technology is worth great disseminating and wide application.