# Sanitation from biogas in China

10th WEDC Conference

Water and sanitation in Asia and the Pacific : Singapore : 1984

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Dr Li Nianguo

As was known, biogas production is an anaerobic digestion process. Microbes of acid-forming bacteria and methanogens appearing in the forms of sarcina, bacillus, coccus or spirillum are reacting under anaerobic conditions, producing acids and successively methane the major component of biogas. The anaerobic process in a conventional biogas digester takes a retention period exceeding 25 days, aerobes are mostly killed then, including a great variety of pathogenes and parasite ova, epidemic diseases were thus eliminated. In case thermophilic digestion being applied, the higher temperature would kill even more.

In the application of biogas, conventional firewood/animal dung cooker stoves were substituted by biogas burners. This made it possible to reduce eye/lung diseases formerly caused by smoke from cooking. To supply feeding to the biogas digester, latrines are motivated to build in villages, human/animal manure once spread everywhere are collected together with grass and weed, so the environment is in better shape. Since digested slurry has a lower biological oxygen demand (BOD) than undigested wastes, the digestion of the waste helps maintaining oxygen level in ponds and streams, producing a more favourable environment for fish.

In industrial sector, anaerobic digestion has been applied in brewery, slaughter houses, sugar refineries and their subordinating workshops treating paper pulp black liquid and furfuraldehyde sewage, and in soy sauce manufacturer for the disposal of monosodium glutamate wastewater. The process has also been applied upon the treatment of other organic wastes. Besides biogas generated for supplementary energy, environmental pollution has been controlled to a certain extent.

## EXCRETA TREATMENT

The studies for sanitary effects of anaerobic digestion were concentrated in the treatment of human/animal excreta which is the most common feeding to the biogas digesters in Chinese rural area. Bad management of the excreta leads not only to environment pollution as flies and mosquitoes breedding, but also to epidemic and parasitic diseases such as:

Bacterial diseases -- bacillery dysentery, typhoid/para-typhoid fever;

Virosis -- virose hepatitis, poliolities, and others;

Parasitic diseases -- schistosomiasis, ancylostomiasis, ascariasis, cestodiasis, fasciolopsiasis, amoebic dysentery, etc.

Many of the diseases are infectious to both human beings and animal. Sorts of pathogens and parasites or their ova often adhere to straws spread in piggeries and cowsheds. The straws would bring the germs and parasites back to the farm when spread as manure, if they were not properly treated.

There are various ways to dispose excrements. Sanitation criteria were set up in China for pollution control , normally investigating :

(1) Observation on fly breeding , focuses upon the density of fly maturity, death rate of maggots and eclosion rate of fly chrysalis.

(2) Value and index of coli-bacillus. Since coli-bacilli are of greatest amount in large intestine and being of largest living period among pathogenic intestine germs under identical ambient conditions, the bacteria were taken as the criterion for determination. There are two ways for indication, i.e., value of coli-bacillus and index of bacillus.

Value of coli-bacillus applies to the smallest amount (in gram or litre) of sample needed to detect one coli-bacillus. The higher the value, the smaller the amount of such germ. The value is indicated by negative index, for the sake of convenience.

Index of coli-bacillus terms the total amount of the bacilli existing in each litre of liquid. The larger the index, the greater the amount of such germ.

(3) Death rate of ascarid ova. The parasite ovum is most commonly exists in excrements, and it is of strongest viability among parasite ova. So the death of ascarid ova covers that of other parasite eggs. In practice not only the amount is counted but more importantly the death rate of which is to be discriminated.

The sanitarian criteria demanding excreta treatment with biogas digestion are: no living ovum of blood fluke nor that of hookworm is detected in digester effluent, and the decrease rate of living ascarid ova approaches 95%; value of coli-bacillus being around $10^{-4}$--$10^{-3}$; and effectively preventing breeding of flies and mosquitoes. While for disposed biogas sludge, the death rate of ascarid ova should be 95-100% and the value of coli-bacillus should be $10^{-2}$ -- $10^{-1}$.

## DATA OBTAINED

Massive researches and investigations have been undertaken in some health-care institutions in several provinces and all the results obtained had proved that biogas digestion affects positively to sanitation.

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Table 1. Time Required to Kill Microbes at Various Temperature

| Category \ Temperature range (°C) | 35-38 | 45 | 50 | 53 | 55 | 60 |
|---|---|---|---|---|---|---|
| blood fluke ova | 13 days | | | 1 min. | | |
| hookworm ova | 23 " | several hr. | | | imm. | |
| ascarid ova | 18 " | | 20 min. | | 10 min. | imm. |
| leptospira | | | 10 min. | | | |
| coli-bacillus | | | | | 1 hr. | |
| lung fluke ova | 8 days | | | | | |
| bacteriophage | | | | | 9 days | |

( "imm." stands for 'immediately' )

1. Results of Treatment Affected by Temperature

Temperature is an important factor affacting the killing of parasite ova and pathogenes in excreta treatment. Generally speaking, the temperature favourable to living and growing of parasite ovum is some $22^{o}-30^{o}C$, and the temperature for non-gemma pathogens is around $37^{o}C$. For pathogenic microorganism, it is within the range of $24^{o}-40^{o}C$. Thermophilic fermentation (above $39^{o}C$) and mesophilic process ($35^{o}-38^{o}C$) would suppress the growth or even kill the microbes. The reaction period is also a factor affects the death rate of microorganism. The higher the temperature, the shorter the time required for killing. The constant of velocity for thermal purification of germs is larger than 0.1/min. at $55^{o}C$. Under higher temperature, the thermal elimination to pathogens is more effecacious than that against bacteria. Table 1 shows the effect of temperature as a function in killing the microbes. The time listed in the table applies to the duration for killing.

One example showing real effect was taken from a 320-$m^3$ and three 680-$m^3$ digesters. At $53^{o}C$ internal temperature the value of coli-bacillus in excreta of $10^{-6}$--$10^{-12}$ before digestion had been reduced to $10^{-1}$--$10^{-2}$ afterwards. For ascarid ova, the living rate was 64% before and all were killed after the anaerobic digestion. Another example taken in a 384-$m^3$ thermophilic digester, typhoid and dysentery bacilli as well as blood fluke and hookworm ova were all killed in a 24-hr. detention period; and ascarid ova stood no longer than 48 hrs.

2. Results of Treatment under Ambient Conditions

The annual averaged digester temperature in large areas of central and southern China is within the range of $8^{o}-29^{o}C$. Since most of the rural digesters run under such condition, extensive investigations viewing from various aspects have been carried out.

(1) Detecting parasite ova in digesting liquid and sludge. From one example the data obtained from several experiments are listed in Table 2.

From another example, the data taken from a night soil treatment plant may be seen in Table 3.

Still for coli-bacillus, another example taken from a rural digester showed that the indices being $1.218 \times 10^{11}$ and $7 \times 10^{7}$ at the inlet/outlet respectively.

(2) Viability of parasite ova. Parasite ova precipitated and gethered from the supernatant and sludge of a biogas digester would die along with the period they are steeped in the digested liquid under anaerobic condition. Table 4 shows the effect.

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Table 2. Living/Reduction Rates of Parasite Ova/Miracidia

| Category | Retention period | Sampling point: inlet | Sampling point: outlet | Reduction rate(%) | Living rate(%) |
|---|---|---|---|---|---|
| hookworm miracidia | (3 months) | 53-3499 | 0-259 | 83.7-99.9 | |
| ascarid ova | 3 months | 1173 | 710 | | 60.5 |
| " " | 6 months | | | | 53.5 |

Table 3. Bacteria and Parasite Ova Killed During Anaerobic Digestion

| Sampling point | No. of parasite ova | Removal rate(%) | Death rate(%) | Value of coli-bacillus |
|---|---|---|---|---|
| inlet of digester | 396 | | 38.75 | $10^{-6}$ |
| sedimentation tank | 116 | 70.7 | 62.5 | $10^{-4}$ |
| outlet of storage tank | 31 | 92.2 | 68.06 | $10^{-3}$ |

The decomposition of microorganism fermentation would generate freestate ammonia which may permeate the shells of parasite ova and spore membrane. Ammonia strength in digesting liquid is generally 0.07%. In 0.2% concentration blood fluke ova would die in 6 days, while ova of hookworm and ascarid could only stay a little longer.

Under anaerobic condition the pathogenes could stay no longer, e.g., 17 days for dysentery bacilli and leptospira, 30 days for typhoid bacilli, and 41-44 days for bacillus paratyphosas B.

## PREVALENCE CONTROL

Once the domestic biogas digesters were built linking up with lavatories and pigstys, digested sludge was composted or macerated before applying, thus enhanced management of excreta. Three years have passed since this application was brought about in a village where was prevalent of ancylostomiasis. The 63.8% infectees of the total population from 500 hookworm ova per gram of excreta were all cured and new cases has not been observed as the ova/gram reduced to 50, i.e., 90% reduction.

Only in 2 years' time, the figure of 1,500 patients in a county prevalent of entiritities and bacillery dysentery was reduced for two-thirds since the practice of biogas utilization.

Experiences proved that, in connexion with medical treatment and other sanitary measures, the management and the treatment of excrements with biogas digesters is effecacious in sanitation and environmental pollution control.

## REFERENCES

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Table 4. Duration for Parasite Ova Living/Before Go Dysplasia

| Category | Living (days) | | | | Go dysplasia (days) | |
|---|---|---|---|---|---|---|
| | summer | autumn | winter | spring | sum.-aut. | win.-spring |
| blood fluke ova | 8-14 | | 13-22 | | | |
| " " miracidia | | | | | 76-87 | 70-79 |
| hookworm " | ---- 93 ---- | | | | | |
| ascarid ova | 90(75%) | | 100(53%) | | | |

Note : percentage in brackets refers to death rate