Pathogen Reduction in Small-Scale Biogas Plants in a Tropical Region - Bench-Scale Experiments

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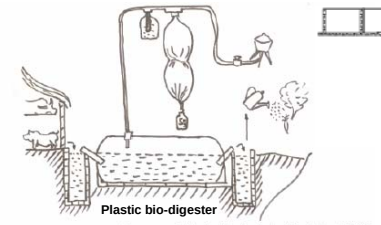
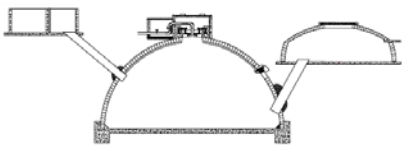
In tropical regions small-scale biogas plants are cost-effective and therefore a popular way to treat animal slurries and produce cooking gas. However, their pathogen reduction efficacy is not well documented. Some studies found *Escherichia coli* with high concentrations in the effluents of these plants (Kobayashi et al., 2003). Although these biogas plants improve household economies in developing countries, their unregulated design, construction and operation is associated with environmental and zoonotic risks in certain conditions. This research aims to evaluate the pathogen reduction in these plants.



Plastic bio-digester
Energy and Water for Sustainable Living,2006



Fixed-dome biogas plant
(Department of Environmental Engineering, College of Technology, Can Tho University, Vietnam)

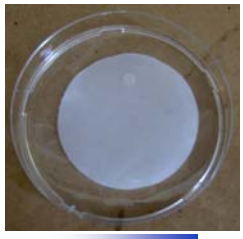
Methods

500 mL bottles connected to a gas collection system were used as batch digesters. Digesters were fed with 300 mL of slurry and seeded with 10% inoculum from a continuous reactor.

Substrates were spiked with micro-organisms (somatic coliphage, *Escherichia coli*, *Salmonella* spp., *Enterococcus* spp., *Clostridium perfringens* and *Ascaris suum* eggs). *Ascaris suum* eggs were placed in bags prior to incubation (10,000 eggs per bag).

The experiment was carried out at 30°C in 45 days with two types of substrates (swine and cattle slurry) and two different concentrations of phage (PFU/mL) and bacteria (CFU/mL) at inoculation (low: 10^3–10^4; high: 10^6–10^7).

Batch digesters



Bag of *Ascaris suum* eggs

Samples were taken on days 0, 1, 2, 4, 8, 16, 32 and 45 to evaluate bacteriophages and bacteria. Bags of *Ascaris suum* eggs were removed every two weeks for analysis. Fresh slurry samples were analysed for total and volatile solids, chemical oxygen demand (COD) and NH_4^+-N. The pH values were measured at sampling.

Table 1 Physio-chemical characteristics of raw substrates

Substrates	pH	Solids (%)		COD	NH_4^+-N
		Total	Volatiles	g/L	g/L
swine slurry	7.74 – 7.85	1.8	1.2	30.05	1.55
cattle slurry	7.78 – 7.92	2.6	1.7	30.45	0.85

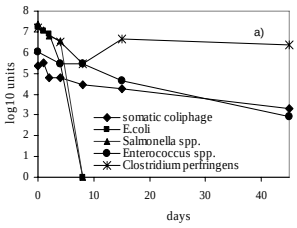


Table 2 T90 (decimal reduction time) values of tested phages and bacteria in different substrates and different initial concentrations at 30°C anaerobic treatment

Substrate	Initial concentration	Somatic coliphage		*E. coli*		*Enterococcus* spp.		*Salmonella* spp	*Cl. perfringens*
		Mean	SD	Mean	SD	Mean	SD	Mean	Mean
swine slurry	low	> 45		3.1	0.7	23.8	3	1.7	> 45
	high	22.5	3.64	2.9	0	15.2	4.4	3.5	> 45
cattle slurry	low	20.6	3.47	2.0	0.1	23.2	5.7	1.9	> 45
	high	13.9	0.91	2.6	0.5	15.3	3.5	1.4	21.6

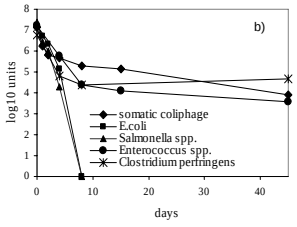


Figure 1 Survival curves of tested phages and bacteria (high initial concentrations) in swine slurry (a) and cattle slurry (b)

Results

The physiochemical values did not differ significantly between the slurries (Table 1).

Reduction occurred with all phages and bacteria. T90 counts varied from 1.4 to >45 days (Table 2). Only *E. coli* and *Salmonella* spp. were eliminated (after 8 days of treatment). *Clostridium perfringens* showed an initial reduction for up to 8 days, then an adaptation period at concentrations of between 4 to 6 $\log_{10}$ lasting until the end of the experiment (Fig. 1).

The viability of *Ascaris suum* eggs decreased from 82% to 25% after 45 days in both slurries and corresponded to a T90 of approximately 90 days. After 2 and 4 weeks the viability was not reduced significantly. This indicates a lag phase of 4 weeks before inactivation occurs.

The viability of the tested organisms, with the exception of *E. coli*, was related to their initial concentration. Except for *Enterococcus* spp., somatic coliphages and bacteria responded quite differently in swine and cattle slurries.

Conclusions

- Most of the organisms tested were reduced in number but not totally eliminated after 45 days of treatment. Thus, the usage of digested animal slurries on arable land should be considered in particular conditions to avoid zoonotic disease transmission. In addition, the quality of liquid effluent should be improved before discharging it in fishponds or applying it directly on crops.
- The slurry type and initial concentrations of most organisms examined affected their survival.
- Beyond the immediate economic benefits of small-scale biogas plants to households such plants pose a health risk due to the quality of their sludge and liquid outputs. Hence the design, construction and operation of these plants should be improved to reduce or avoid this health risk.
- A tentative conclusion is that slurry from one species should not be used for fertilisation of food or fodder consumed raw by the same species.

Reference
Kobayashi, H., Khai L. T. L., Phan T. T., Yamasaki S. & Taniguchi T. (2003). Prevalence of Pathogenic Escherichia coli in a Swine Breeding Environment in Can Tho Province, Vietnam. *JARQ*, 37(1), 59 - 63.

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