Innovative technology for biogas production from pig slurry

Lili Mézes – Tibor Bíró – Csaba Juhász - Gergely Hunyadi
University of Debrecen, Faculty of Agronomy, Dept. of Water and Environmental Management, Debrecen
mezes@gisserver1.date.hu

Introduction

During the research we examined a possible way of how to utilize pig slurry for biogas production. Producing biogas from liquid manure is not a new process *(Lastella et al., 2002; Köttner, 2002)*. Many biogas plants based on liquid manure are constructed in different countries in Europe *(Bai, 2007).* These – in almost every case – mean (sometimes more than one) fermentation tank- system, made of ferroconcrete or steel with a prior thoughtful planning procedure. The tanks are heated with pipe-systems at the bottom and in the inner side. The mixing is solved with inner turbines. The fails are mostly connected to these two technological elements: the injuries of the pipes, and the break-down of the turbines. These tanks are constructed or assembled on-site, resettling is impossible or very difficult. The insulation is posterior. The study is introducing and analyzing a new technological solution which makes the possibility biogas production for livestock farms with minimized construction. A preassembled tank plantation is utilized. The heating and the insulation is integrated, extruding the possibilities of injuries. The pump which is built up on the tank is mixing and serving the filling and the unloading. To determine the fermentation parameters we made researches in a laboratory which was followed by the construction of the prototype and the experiments in the innovated tank. According to the researches we determined the adaptability and operation conditions for the tank.

Materials and methods

Experiences in the laboratory

We examined the fermentation process in the laboratories of Debrecen University Faculty of Agronomy, Department of Water and Environmental management.

The fermentation areas were 2 stainless steal tanks (the volume was 6 l per each) in incubation cases. To ensure the optimal conditions electric radiators and controlled thermometer probes were used. The pressure was the same as in the air. The produced gas-mixture went to the detector through a doubled valve-system or to the output pipe. Before the detector the gas went through a carbon-filter, a safety gas-washer bottle and a cryogenic inventory. The gas-washer bottle was utilized to remove the organic acid while the cryogenic installment to remove the water. To determine the content of the gas mixture Fisher-Rosemount gas analyzer (CH_4, CO_2, O_2), and MX42A gas analyzer (H_2S, NH_3) were used.

The pH and the temperature of the biomass mixture was determined and checked. The dry material content, the C and N content and the C/N ratio was examined for the input and output materials. Brachthaeuser (2004) made similar researches. The effect of rotation was analyzed by Karim and his colleagues (2005). Borole and his colleagues made experiences with dairy manure in 2006.

Experiences during the operation

The model fermentation reactor was a 10 m^3 cope-heated, acid-proof, pressure-proof (until 5 bars) tank. The tank was covered with concrete-cap to ensure the anaerobe conditions. The pump which was built up on the tank was mixing and serving the filling and the unloading. The optimal temperature was controlled with a heating inventory and a temperature-controller. The number of rotation was automated. The produced gas went through a 50 l standing, gravel-bed tower which ensured the removal of H_2S and NH_3. The amount of produced gas was measured with gas-meter. Researches in operation conditions, based on dairy manure fermentation (also a monorecipe), were made by Aoki and his colleagues in 2006.

Results and discussion

Experiences in the laboratory

The optimization of the inventory was forerun by experiments in the laboratory. The aims of the experiments were: model the processes in the reactor; the examination of the parameters that influence the degradation; and analyzing the components of the biogas.

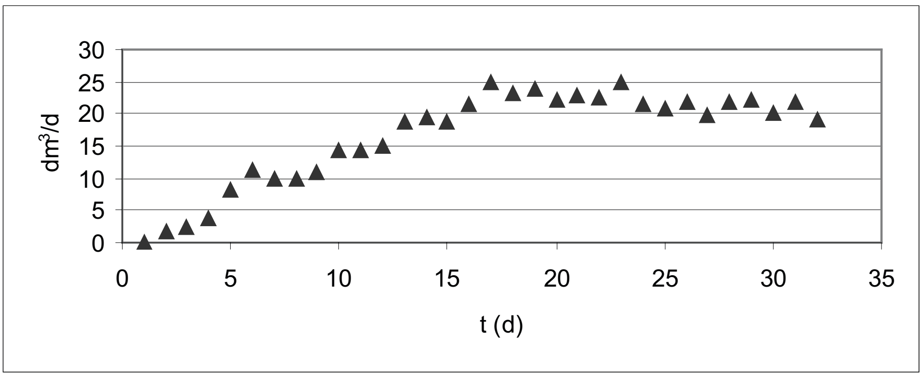
We analyzed the degradation of pig slurry in anaerobe conditions during thermophil and mezophil temperature. We also compared the processes if inoculum were used or not. The results according to the different installations are shown in *Table 1*. When inoculum was utilized, the thermophil process produced 31,8% loss in the C/N ratio, while the mezophil produced just 24%. The maximum value of the loss in C/N ratio was 22% when inoculum was not used. The trend of dry material content loss was the same as the trend of changes in C/N ratio.

Table 1: The C/N ratio of the input and output materials

Fermentors / Parameters	1. fermentor (without inoculum, 52°C)	2. fermentor (with inoculum, 35°C)	3. fermentor (with inoculum, 52°C)	4. fermentor (without inoculum, 35°C)
Input C:N	15,10	15,75	11,14	11,95
Output C:N	10,30	11,83	9,11	9,34

During the thermophil fermentation the maximum of biogas production was reached after 31 days when inoculum was not used. In the cases where we used inoculum the maximum was reached after the 23rd day.

Figure 1. Gas production of the pig slurry



The maximum of the methane production was 72% in each case. The biogas production of pig slurry is shown on *Figure 1*. The production increased in the first 18 days, then it stood on the same level during the next 15 days.

The hydraulic retention time reduced because of the inoculum utilization. During the experiences in the laboratory the composition of the gas was favourable, the methane content was optimal for economical use. The technological hazardous gas emission was minimal, the amount of produced ammonia and H_2S was not deterministic (less than 50 ppm).

Experiences during the operation

The researches in the laboratory were followed by test during operation. The temperature was 52°C and the pressure was 3 bar during the first experiences (*Table 2*). The ratio of carbon-dioxid was large in the beginning of the fermentation but after the realization of the anaerob condition it decreased and the methane production started. The produced amount and the concentration of methane was unfavourable so changes in the technological parameters were needed. The temperature was 52°C during the second experiences. The pressure was not determined. The maximum of methane content was 33% but the produced gas was never above 4 m^3.

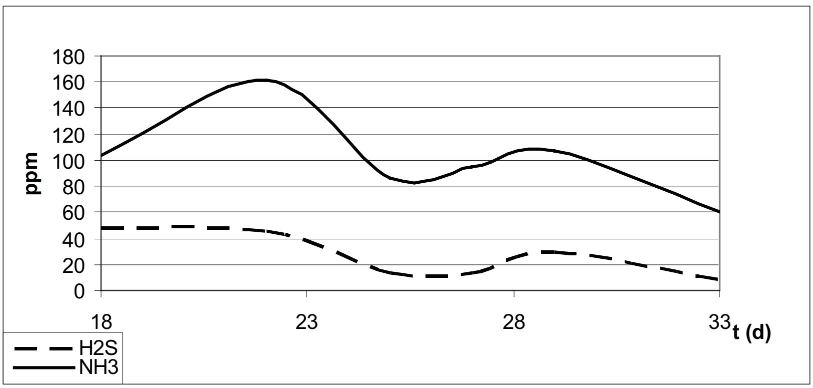
The third installation (37°C, no determined pressure) was optimal. The maximum of methane concentration was 62%, the daily maximum was 11 m^3 biogas. This production lasted for 10 days.

Table 2. Parameters of installations during operation

Installations	Parameters		Methane-content	Produced gas
	Pressure	Temperature		
1. Install	3 bar	52°C	Too low	Low
2. Install	-	52°C	Max. 33%	Max. 4 m^3
3. Install	-	37°C	Max. 62%	Max. 11 m^3,
				Lasted for 10 days

The production of hazardous gases continuously decreased during the process, because the rate of protein components, containing sulfur and nitrogen, was larger in the beginning of the degradation (F*igure 2.*).

Figure 2.The amount of produced ammonia and H_2S during the fermentation



During the operation a 28 days cycle is optimal for the fermentation. During effective degradation the amount of produced gas is 200 m^3 if the operation is discontinuous. During continuous operation the amount is 290 m^3. The heating value of the gas was 19,3 MJ/kg.

Conclusions

The developed 10 m^3 tank can be settled easily and the size can be adjusted to the amount of produced pig slurry and the size of the farm. This developed system can be effectively installed where the produced gas can be used during the whole year. The needed and opitmal size depends on the numbers of the installed tanks. For economical plantation at least 10 tanks are required where heating value of the produced gas is equal with the heating value of 21-22 m^3 natural gas (if pig slurry used as input material).

The installed system increases the satisfaction of the authority and the society. The odourous gas emission of pig farms is also reduced by the utilization of the developed system because the fermentation process goes in closed conditions. The pathogenic organisms also die during the fernmentation. The composition of the output material is favourable and can be utilized in plant production effectively because the phosphor and potassium is metabolised and the easy uptake is ensured.

The tested system has manpower-observer ability. The labour-need is low so it probably will not make new workplaces. Meanwhile, it can increase the competitiveness of a farm which can give an economic benefit so reaches the long term observe of manpower. The utlization of biomass may add to the population-observer ability of the county *(Kovács, 2005).* The investment helps the match to the environmental and soil protection requirements. The animal farms can ensure the long-term subsistence with the ensured IPPC requirements. In the integrated permitting process for the use of the environment they can certify such energy effectiveness and emission reduction which is a term of the inspection and auditing process.

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