Low carbon support project (LCASP)

Mission report
by
International CSAWMP Consultant

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Chapter 1.
Introduction

Background

This document is made as a result from a 6 week mission in Vietnam from 27th of November 2017 to 11th of January 2018 as part of the LCASP project. The mission included several field visits, participation in workshop and meetings with provinces. The following provinces where visited: Ben Tre, Bac Giang, Lao Cai, Nam Dinh and Phu Tho. The following tasks was given the highest priority during the mission:

- Progress in the research and demonstration packages
- Overloading of SBPs and MBPs.
- Effective use of excess biogas and its full utilization
- Utilization of bio-slurry in the fields and full utilization of fertilizer value.
- Methodology for measuring and quantification of GHG emissions.
- Composting technology for medium and large scale livestock farms

The research and demonstrations packages have been delayed and it was decided to mainly focus on demonstration packages 32, 33 and 36 (Table 1-1)

Table 1-1

Package	Task
32/33	Supply of manure separating system to treat livestock waste to produce material for organic fertiliser demonstration
34	Supply of biogas generator and manure separating system for comprehensive management of livestock waste demonstration
35	Supply of mobile manure separating system to treat livestock waste to produce material for organic fertilizer demonstration at household scale
36	Supply of biogas generator system for demonstration
37	Supply of utilisation system for treatment of biogas digested effluent demonstration as the fertiliser of the crops
38	Supply of utilization system for treatment of cattle dung as the feedstock for red worm raising demonstration

Chapter 2.

Evaluation and assessment of sedimentation and separation efficiency

The demonstration packages 32/33 aims at utilization of manure separators to improve manure management and reduce overloading of biogas digesters. Manure separators are a well known technology to separate part of the dry-matter and nutrient from liquid animal manure slurry. There are different systems for separating slurry into a nutrient and dry-matter rich fraction and a liquid fraction; for instance, mechanical screen separators, screw presses, sedimentation, centrifugation and reverse osmosis. In the LCASP project mechanical screw press separators from the Austrian Company Bauer and from Italian company Cri-man have been selected. Screen separators are in general very reliable and cost efficient equipment but the efficiency is only high when treating slurry with a dry-matter at 6% or above, usually up to 35% of the initial dry-matter of slurry can be separated to a solid fraction with a dry-matter content about 30%. In this chapter an initial description and proposal of methodology for evaluation of separation efficiency is developed and observations from the visited provinces are evaluated and recommendations are included.

2.1 Overall methodology

The used separators are Bauer or Cri-man screw press used on liquid manure after an initial sedimentation. The reason implementing an initial sedimentation step is to increase the dry-matter concentration in the liquid manure to a suitable level where the separator works optimal. The dry-matter concentration in liquid manure in Vietnamese pig production is very low, often less than 1% due to high use of water for washing and cooling the pigs. This very dilute manure will not give an optimal separation with a screw press where more than 6% is desirable. For this reason an initial sedimentation tank is installed. By natural sedimentation, the fact that the particles and liquid in the liquid slurry have different densities is exploited and require low throughput. Low throughput sedimentation tanks collects the precipitate, which has consistency as a viscous slurry.

2.2 Sedimentation

Sedimentation (gravity settling) is one of the many solid-liquid separation techniques, which have been used to remove solids from dilute swine manure (Ndegwa et al., 2001). Suspended solids with densities greater than that of the water in which they are suspended tend to settle under the influence of gravity. Large or coarse solids settle much faster than fine suspended solids that contain most of the P. In contrast, fine suspended solids contained in liquid swine manure take much longer to settle by natural sedimentation. In fig. 1 the different categories of particles in liquid animal manure is illustrated. The drymatter (TS) can be divided between the dissolved solids (TDS) and suspended solids (SS). Only the suspended solids can be settled.

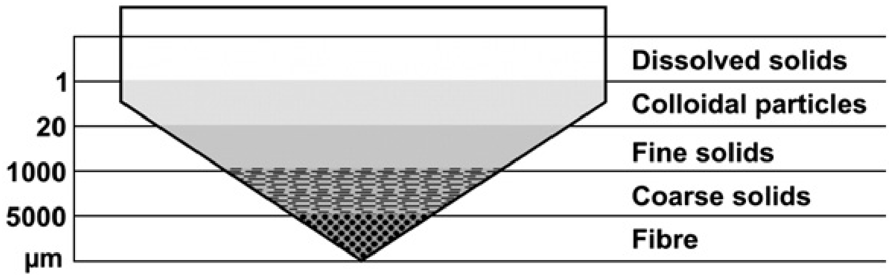


Figure 2-1. The division of the solid matter of animal manure into fractions.

The settling time of particles depends on different factors and it seems that the dry-matter concentration of the manure is the most important factor. The effects of solids concentration on the natural sedimentation are presented in Fig. 2. In general, the sedimentation process seems to have been complete during the first hour of retention time and only a marginal improvement was achieved with a retention time of 4 h. The effective SS removals were approximately 8, 39, 62, 66, and 37% for manure solids levels of 6.0, 4.0, 2.0, 1.0, and 0.5%, respectively. These data suggest that both too high and too low levels of solid content in the manure result in a reduced removal of SS by sedimentation. In this study, 1.0 and 2.0% solids levels gave a much better SS removal after 4 h. The general trend of these results compared well with the trend of the results of a similar study by Moore et al. (1975). Their sedimentation study with swine manure (although conducted for a longer duration) simulated at 0.01, 0.1, and 1.0%, showed that solids removal after 1,000 min were 59, 68, and 70%, respectively, i.e., the separation efficiency decreased with decreasing solids levels below 1.0%. Martinez et al. (1995) also reported somewhat similar results. In their studies, dilute slurries with less than 25 kg/m3 (2.5%) TS were found to be most effective for natural sedimentation, while solids with more than 40 kg/m3 (4.0%) TS did not separate effectively.

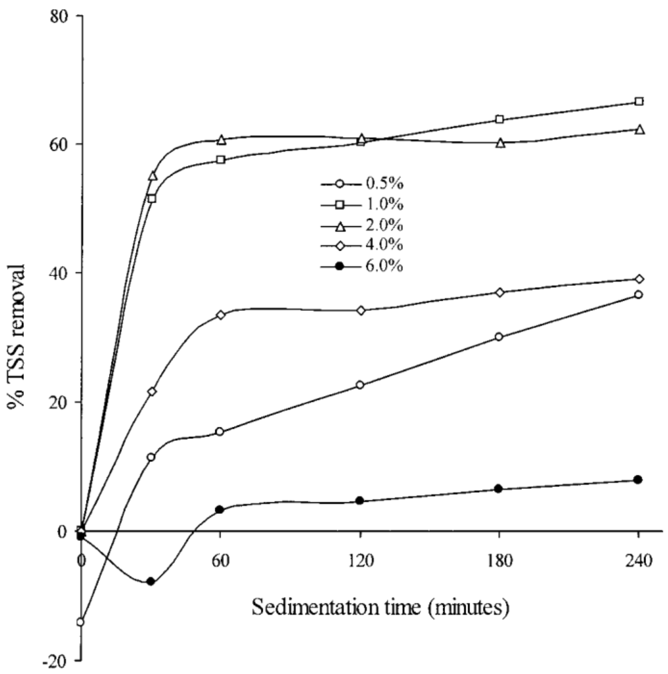


Figure 2-2. Effects of Solids Concentration on Natural Sedimentation of Swine Manure (Ndegwa et al- 2001)

In another study by Zhu et al. 2004 made an experiment with liquid pig manure with 1,9% TS and the sedimentation as a function of time is illustrated in figure 3.

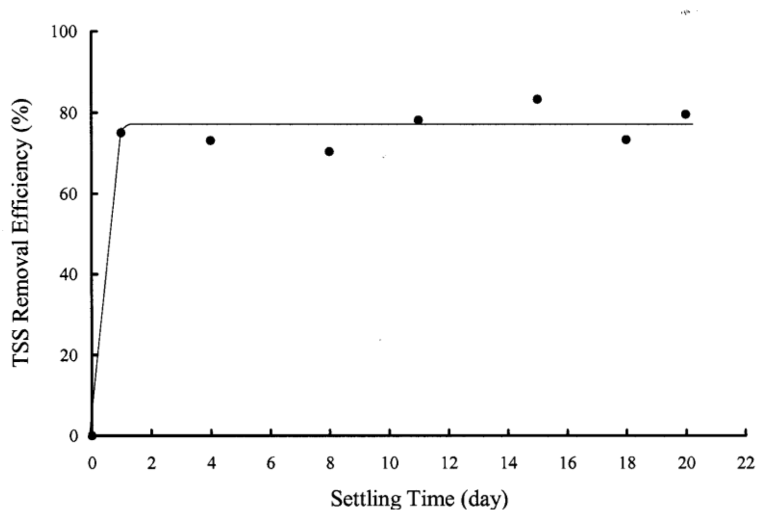


Figure 3. The effect of preliminary settling time on TSS removal efficiency.

From the different studies it seems that the optimal drymatter (TS) concentration in the liquid manure before separation is around 2% and that the sedimentation is quite fast at this dry-matter. Less than 24 hours seems sufficient and some studies shows that sedimentation of most of the TS takes place within 2-4 hours.

2.2.1 Design of sedimentation tanks

Sedimentation tanks may function either intermittently or continuously. The intermittent tanks also called quiescent type tanks are those which store water for a certain period and keep it in complete rest. In a continuous flow type tank, the flow velocity is only reduced and the water is not brought to complete rest as is done in an intermittent type.

Sedimentation tanks may be either long rectangular or circular in plan. Long narrow rectangular tanks with horizontal flow are generally preferred to the circular tanks with radial or spiral flow. Long rectangular basins are hydraulically more stable, and flow control for large volumes is easier with this configuration. A typical long rectangular tank have length ranging from 2 to 4 times their width. A long rectangular settling tank can be divided into four different functional zones:
Inlet zone: Region in which the flow is uniformly distributed over the cross section such that the flow through settling zone follows horizontal path.
Settling zone: Settling occurs.

Outlet zone: Clarified effluent is collected
Sludge zone: For collection of sludge below settling zone.

There is several parameters to consider for optimal sedimentation below some of the most important is listed

1. Detention period: for plain sedimentation: 3 to 4 h,
2. Velocity of flow: Not greater than 30 cm/min (horizontal flow).
3. Tank dimensions: L:W = 3 to 5:1.
4. Depth 2.5 to 5.0 m (3 m).
5. Surface Overflow Rate: For plain sedimentation 12000 to 18000 L/d/m2 tank area;
6. Slopes: Rectangular 1% towards inlet is preferred

Furthermore devices for retaining parameters like perforated tubes where the slurry has to penetrate before flowing out could be a good option.

In Ben Tre, Bac Giang, Phu Tho provinces information on the design of sedimentation tanks has been collected. In Ben Tre a standard design of sedimentation tanks has been used at all farms consisting of two tanks where the fist tank is a small pre-sedimentation (1mx1mx0,9m) and main sedimentation tank (3mx3mx2,7m) with 24,3 m3 of volume. In two of the visited farms a daily amount of around 25 and 45 m3/day was loaded to the sedimentation tank giving a detention period of 1-1,9 days. This means a very high dedention period which is longer than recommended. Therefore it seems that the tanks are two big for the given number of animals and the pre-sedimantion tanks seems not necessary. Ideally the tank should also have been longer and narrower.In Bac Giang the visited farm had 1 rectangular sedimentation tank with two chambers in total 6 m long, 2,5 m broad and 3,5 m deep. It is only the first tank that is used for sedimentation and separation of solid manure giving a tank with the dimensions 3mx2,5mx2,7m equal to 20,25 m3. The calculated amount of manure for the farm is 43 m3/day giving 11,1 hour detention period which is in the higher end of what is recommended but still at a reasonable level. In Phu Tho the standard design of sedimentation tanks are 3mx3mx3m.

2.3 Separation

2.3.1 Cri-man separator

The selected Cri-man separator is a 260/50Mini with a capacity of 5-8 m3/hour with a 0,5 mm screen size. The engine max. capacity is 3 Kw but during visit it seemed that only 50% of the capacity of engine was used meaning an energy consumption of 1,5 kwh/h corresponding to 0,2 kwh/ton treated with a treatment capacity of 7 m3/hour. By assuming 1,5 kw for pump and mixing in average this will result in a total consumption of 0,4 kwh/tons material treated.

Picture. Cri-man separator and sedimentation tank in Ben Tre province.

2.3.2 Bauer separator

The selected Bauer separator is a Bauer compact with a capacity up to 15 m3/hour with a 0,5 mm screen size. The engine max. capacity is 3 Kw. With a capacity of 10 m3/hour and 70% load of the engine it means 0,21 kwh/tons of material treated. Besides the separator need a pump to feed the separator and a mixer is running during the first 15 minutes. By assuming 1,5 kw for pump and mixing in average this will result in an estimated total consumption of 0,46 kwh/tons material treated.

Picture. Bauer separator and sedimentation tank in Bac Giang province

2.4 Separation efficiency

The separation efficiency of elements like dry-matter can be expressed in term of percentage of constituents removed from manure. The equation [1] allows determining this efficiency when the concentrations of the analyzed constituent are known. The easiest component to measure is the dry-matter and hence focus in initial phase will be on that parameter:

$$Eff(\%) = \frac{W_{solid} \times C_{solid}}{W_{manure} \times C_{manure}} \times 100 \qquad [1]$$

Eff.:	Separation efficiency (%)
W_{solid}:	Weight of separated solid phase (kg)
Csolid:	Concentration of component in fraction, dry-matter concentration in %
Wmanure:	Liquid slurry weight (kg)
Cmanure:	Concentration of component in liquid slurry, dry-matter concentration in %

When the separation is done in two step with an initial sedimentation followed by a screw press, there will be two separation efficiency to deal with. Because of this the overall separation have to be optimized by having optimal separation in both step and a very high sedimentation efficiency is needed to have a good subsequent separation.

The maximum efficiency for dry-matter by sedimentation will in general be around 80%. Only the particulate matter in the form of suspended solids can sediment while the dissolved solids will not be able to sediment and since at least 15% of the dry-matter in liquid slurry is dissolved solids it will not be possible to exceed 85%. However, in practice sedimentation of less than 80% of the dry-matter is considered as more realistic. The separation of dry-matter with a screw press depends on several parameters like the screen size, pressure induced etc. In literature a separation efficiency of more than 35% is not found as realistic.
The amount of solid fraction produced by separation depends besides the separation efficiency on the dry-matter concentration in the solid fraction. In most studies the concentration of dry-matter is at around 30%.

2.5 Economical efficiency

The economic efficiency of a separation can be calculated as the yearly income subtracted all costs and expenses. The only income from separation is the selling value of the organic fertilizer either directly or after a composting process. The cost of separation can be divided in fixed costs (FC) and variable costs (VC). Fixed costs are independent of how much the equipment is used. Fixed costs include depreciation (D) and interest on construction and machinery investment. Depreciation measures the amount by which the value of a machine/plant decreases with the passage of time whether used or not. The value declination of machinery/plant with the passage of time is the depreciation cost

Operating cost of a separator is reflected by the cost of daily labor, repair & maintenance, lubrication and electricity consumption.

a) Labour cost per yr, LC = No. of labour x Rate of labour (VND/hr) x Labour used (hr/yr)

b) Repair and maintenance cost per year, R&M = Annual repair & maintenance cost (VND)

c) Lubricant cost (VND/yr)

d) Electricity (VND/yr)

Total variable cost (VND/yr) VC = (a + b + c+d)

Total Operating Cost (VND/Yr) = Annual Fixed Cost + Total Variable Cost i.e, OC = FC + VC

Annual cash flow/Net cash flow refers that the difference between annual revenue (REV) and annual operating cost (OC) of the biogas plant.

NCF (VND/yr) = REV- OC

The only revenue for the farmer is the selling of the organic fertilizer meaning that the selling price and the amount of the solids produced is the most important parameters.

2.6 Calculations and results

The overall success criteria for the separation is that as much solid material as possible is produced at the lowest possible costs. The amount of solid fraction that can be produced depends on several factors such as: 1) the overall efficiency of sedimentation and separation (SEP) 2) the amount of dry-matter being produced in the farm, 3) Dry-matter concentration in the solid fraction.

The SEP efficiency depends on several factors and is depending on both sedimentation and separation. The sedimentation efficiency depends on how efficient the particles are retained in the sediment tank while the separation efficiency depends on the dry-matter concentration obtained in the sediment tank, which preferably should exceed 6%.

The amount of dry-matter being produced at the farm depend on the number animals, the size of the animals, the animal category and the amount and type of feed being used. However for initial assessments it is recommended to only consider the amount of animals and average weight where the fattening pigs are the most abundant category often with an average weight around 50 kg. In general an amount of feces and urine around 2,5 kg per animal (50 kg average weight) per day with an average dry-matter content of 10% is regarded as representative for Vietnamese conditions. If the average weight is higher than 50 kg the amount of dry-matter excreted from the pigs will increase and it is suggested to use a factor of 10% increase for each 10 kg higher weight than 50 kg, but this should be further elaborated. For sows it is suggested to use 50% higher dry-matter excretion than for fattening pigs but this value should also be confirmed by literature review.

To be able to compare the efficiency between the farm is suggested to introduce the term fattening pig equivalent (FPE) where one FPE corresponds to 1 fattening pig with an average weight of 50 kg, and for each 1 kg higher average weight one fattening pigs count 1% extra and one sow is equal to 1,5 FPE.

The following formula can be used:

$$Amount\ of\ FPE = N_{FP} * (1 + \frac{1{,}01*(AWeight-50)}{AWeight})) + N_{sows} * 1{,}5$$

Where N_{FP} is the number of fattening pigs AWeight is the average weight of fattening pigs and N_{sows} is the amount of sows. The minimum AWeight value that can be used in the formula is 40 kg and if the actual average weight is lower than that 40 kg should be inserted in the formula.

The SEP efficiency can differ and overall efficiency of separation of 30% is regarded as achievable by having 85% efficiency of sedimentation and a 35% efficiency of separator but if sedimentation and separation are optimized 40% might be achieved. However if sedimentation and separation is not optimal and done with long intervals lower efficiency will be obtained (20% or less).

The amount of solid that can be obtained also depends on the dry-matter concentration in the solid fraction. The higher dry-matter concentration the lower the amount of solid fraction will be. In general a high dry-matter concentration is desirable but since more water is squeezed out of the fibers but the amount will be lower when the dry-matter concentration is high. In general a dry-matter concentration around 30% is expected and will be used in calculations when there is no measured data available.

In figure 4 the amount of solids produced is calculated as a function of FPE and with different assumptions of overall dry-matter separation efficiency. The overall technical success criteria would be an amount of solid equal or higher to the 30% total separation efficiency.

In Bac Giang province data has been collected at two farms and the points for the farms are included in the graph. For the two farms the amount of solid fraction is at the 30% breakeven line for one farm and for the other well above the line indicating that the separation from a technical point of view have an very efficient separation.

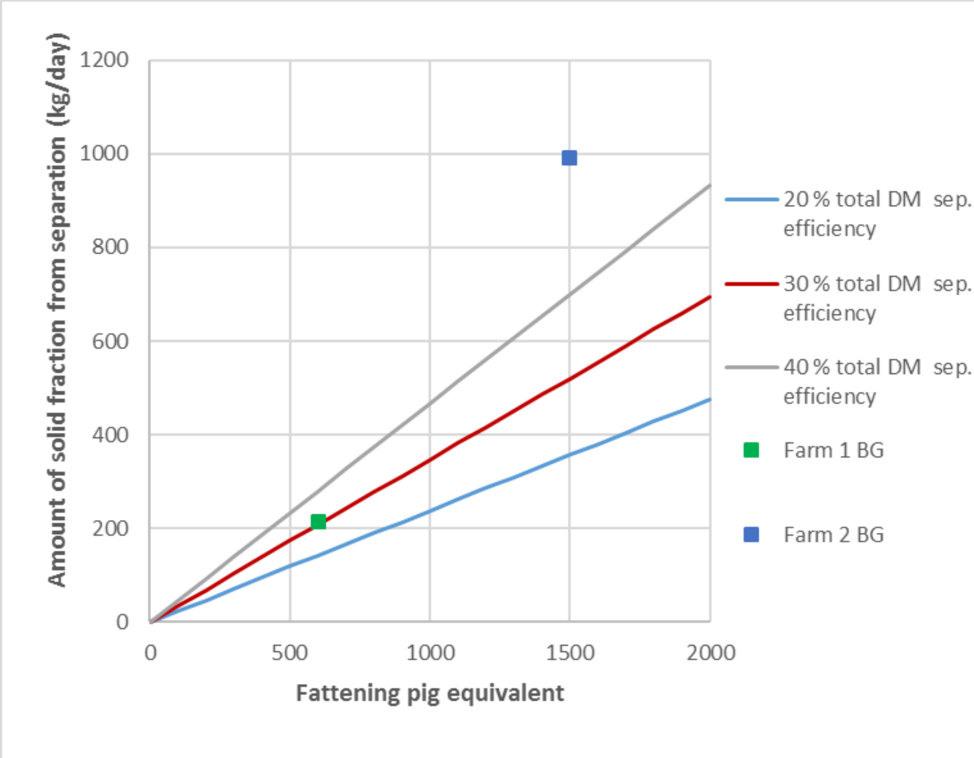


Figure 2-4. Calculation of theoretical amount with different assumptions if overall separation efficiency. Actually observed amount of solids produced in two farms in BG province is included.

To calculate the amount of solid fraction produced by different assumptions a spread sheet model has been developed and the outline is shown in appendix.

2.6.1 Sedimentation tanks

The sedimentation process is essential to achieve a good separation since dry-matter flushed out of the sedimentation or particles converted from suspended solids to dissolved solids due to long detention time can't be subject for separation. The dry-matter concentration in the liquid manure entering the sedimentation tank can both be too low and too high for efficient sedimentation. The optimal dry-matter concentration is between 1 and 2%. In Vietnamese pig production a high amount of water is used and around 40-50 liter per pig is often used resulting in dry-matter concentrations that is not ideal for sedimentation. In figure 5 the influence of the amount of washing water on the dry-matter concentration is illustrated and it can be seen that the optimal amount of water for good sedimentation is 15-30 liter/head/day which is significant lower than what most farmers use. Farmers should therefore be encouraged to use maximum 30 liter/head/day.

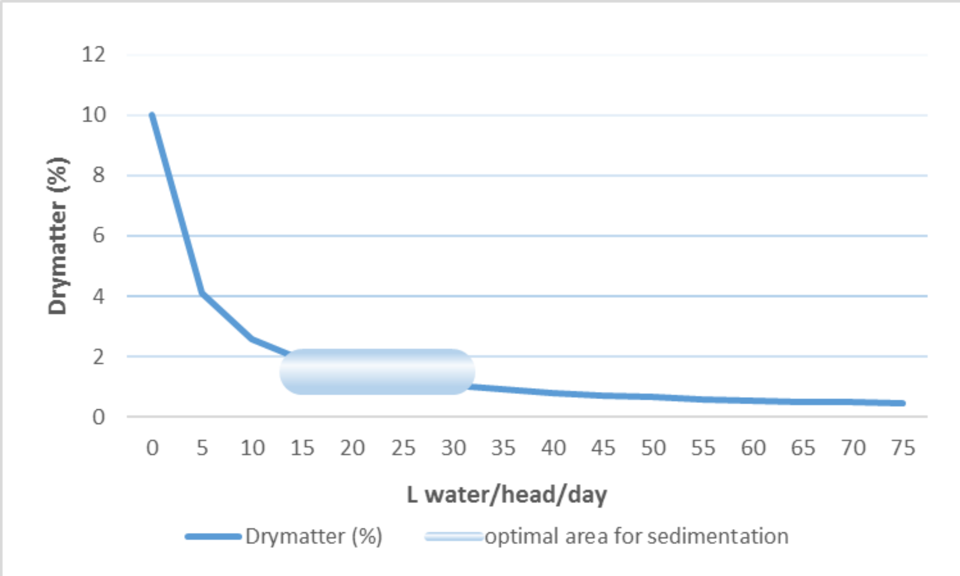


Figure 2-5. Dry-matter concentrations in pig manure and the influence of the water use. The area for optimal separation is indicated in the shaded area between 15 and 30 liter of water per head per day.

The average detention time in sediment tank is the theoretical (calculated) time required for a given amount of water or wastewater to pass through a tank at a given rate of flow. The detention time in hour is calculated by dividing the tank volume in m^3 with the average amount of wastewater entering the sedimentation tank in m^3/hour. It is recommended that this value should be around 3-4 hours.

The actual detention time in the sedimentation tanks in farms visited in the different provinces is shown in figure 6. It can be seen that the detention time in general is much higher than the recommended meaning that it will take too long time for the sediment to build up and the particles will stay too long in the tank and start to degrade before the dry-matter concentration reach a level where separation is optimal (around 6% dry-matter). This is especially a problem in the provinces in south where temperature is high and the degradation of particles will take place much faster than in colder regions.

In general the sedimentation tanks are build too large and it is recommended to make the sedimentation tanks smaller and make the sizes so they comply with the actual amount of animals instead of making the same sizes of sedimentation tanks for all sizes of farms.

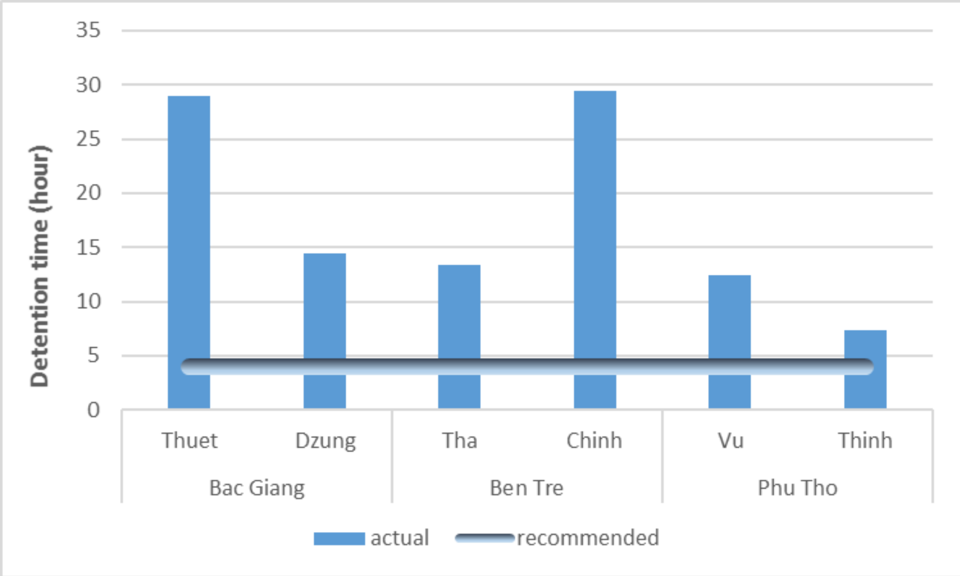


Figure 2-6. Detention time at the different farms

In figure 7 the average detention time as a function of the amount of pigs is illustrated and it can be seen that the present size of sedimentation tanks is only well dimensioned for farms with 2500 fattening pigs and most farms has less pigs than this.

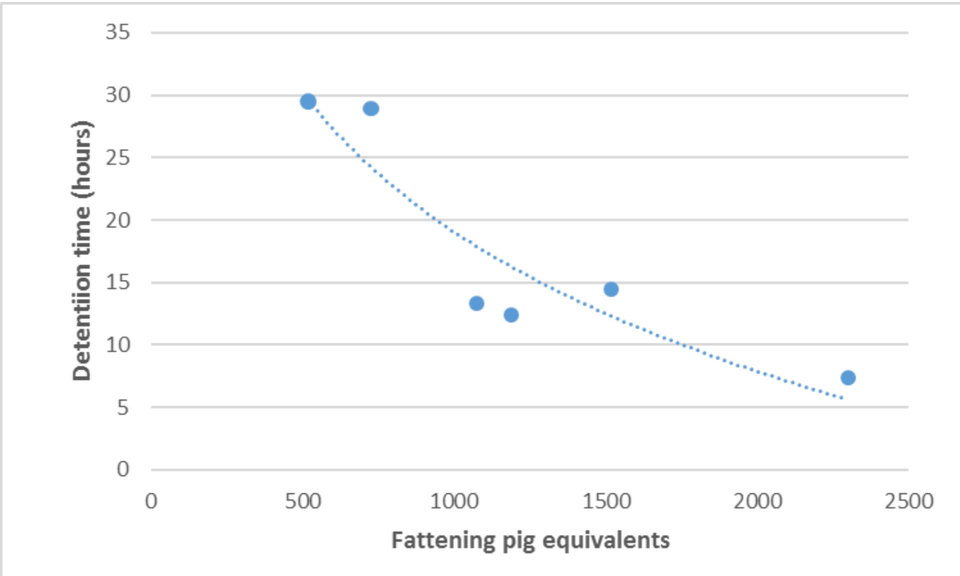


Figure 2-7. Detention time at the different farms as a function of fattening pigs.

The form of the sedimentation tanks are also very important. The forms of sedimentation tanks today are made with almost the same length and width (design 1 in figure 8) which is not optimal for efficient sedimentation where it is recommended that the sedimentation tanks are 3 to 5 times longer than they are broad as illustrated in design 2.

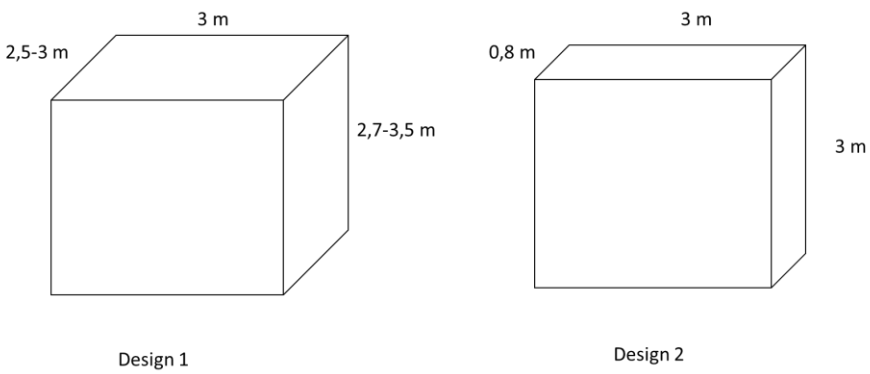


Figure 2-8. Dimensions of sedimentation tanks. Design 1 are the present design used in most provinces whereas design 2 is optimized design for an animal size of 1000 fattening pigs (50 kg average weight)

The general picture is that the sedimentation tanks are build too big for the amount of pigs unless the farms has 2500 fattening pig equivalents or above and that the dimensions are not ideal. It is recommended that the sizes should be reduced to fit the actual size of farms and that the design should be changed so that they are 3-4 times longer than they are broad.

2.7 Economical evaluation

2.7.1 Electric consumption and operational costs

The electric consumption will depend on the amount of animals and how often the separator will run. The necessary time for running the separator will depend on how well the sedimentation takes place and the dry-matter concentration that can be obtained in the sedimentation tank. In figure 9 the daily electric consumption and the time the separator need to run in average per day. It can be seen that with 1000 fattening pigs the separator needs to run 0,7 to 1,25 hours per day with respectively 6% and 3% drymatter in sediment and the capacity of the separator is therefore much higher than needed even with 2000 fattening pigs.

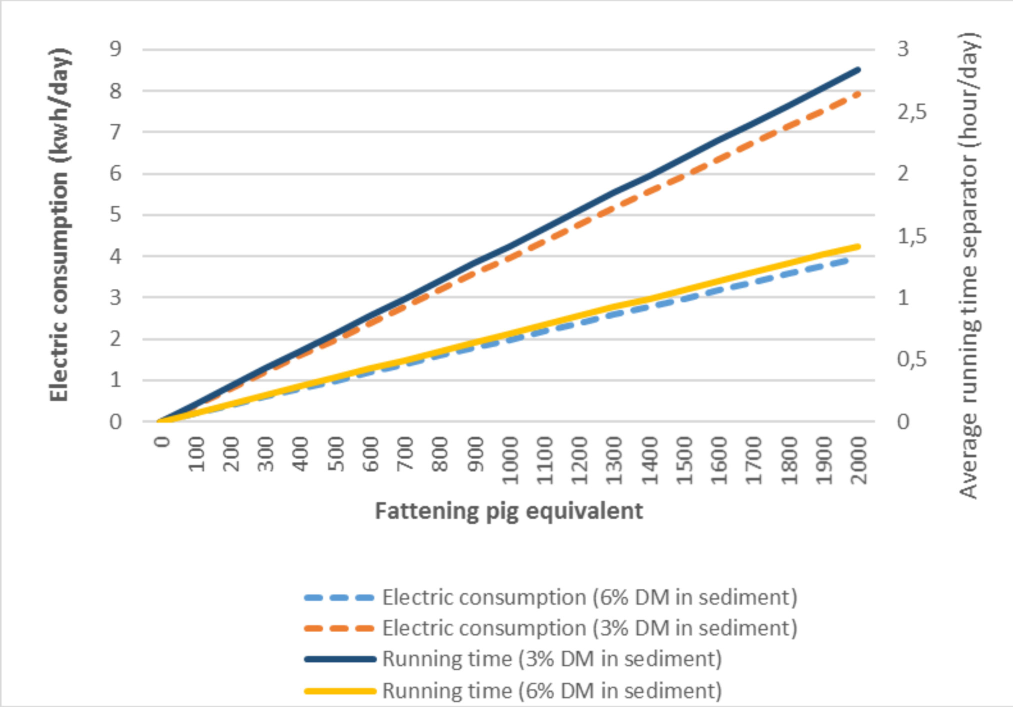


Figure 2-9. Electric consumption and average time needed for running the separator with different dry-matter concentrations obtained in sedimentation tank. 85% of dry-matter is assumed to be in sediment and the capacity of the separator is set to 7 m3/hour (Cri-man) and 0,46 kwh/tons material separated.

Since the produced organic fertilizer is the only income from the separation process the electric consumption should be related to this fraction. In figure 10 the electric consumption per tons of solid fraction produced is illustrated. With an efficient sedimentation process the average electric consumption will be around 6 kwh/tons corresponding to ca. 9.600 VND/tons solid produced (1.600 VND/kwh). However If sedimentation is poor the electricity cost will be the double.

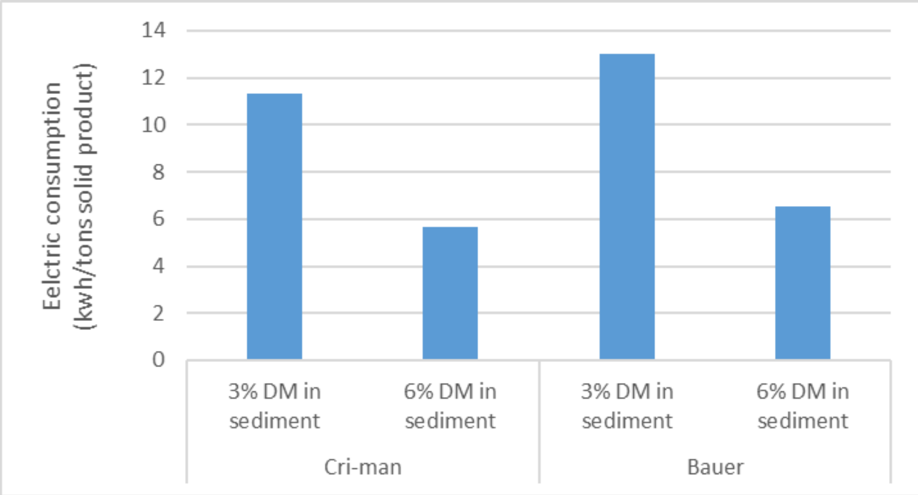


Figure 2-10. Electric consumption for producing in tons of solid material with different dry-matter concentrations in sediment assuming 70% load of engines max. capacity, including pump and mixers**.**

2.7.2 Sales value of organic fertilizer

The value of the solid fraction is the only income from the separation and thus is a very important parameter.

The value seems to differ significant among provinces with the highest values being in the provinces in the South. In Bac Giang province the visited farmer could sell the solid fraction in 37 kg bags for around 1000 VND/kg, while in Ben Tre province the selling price for the solid fraction is 2-3000 VND/kg with an average 2500 VND/kg.

2.7.3 Investment

The investment in the separation system includes besides the separator a sedimentation tank, house for separator, mixer and pump. In the table below estimated investments are given.

Table 2-1 **Investment**

Category	**Unit**	**Units**	**Unit price**	**Total mill. VND**
Sedimentation tank	mill. VND/m3	25	0,8	20
House for installation	VND/m2	30	1	30
Separator and installations	VND	1	520	520
Total Investment				**570**

In the LCASP project the farmers are not paying for the separators, but to evaluate viability of the investment it is recommended that the economical evaluation is including the total investment though this in not the case in the project period.

The capital cost for a given investment depends on the interest rate and the expected period the equipment will last (depreciation period). I the table below the yearly capital costs are calculated with assumptions of 10 years depreciation and 4% interest rate (Table 2).

Table 2-2 **Capital costs for separation**

Investment	570	mill VND
Interest	4%	
Depreciation period	10	Year
Yearly capital costs	70	Mill. VND

2.7.4 Overall assessment

In table 3 the income, costs and revenue is calculated with the assumptions of an efficient separation and a selling price of 1500 VND/kg for the solid fraction. In the calculation the labor cost are not included since there is little knowledge on how much time is needed. The calculations indicate that if a reasonable economic surplus should obtained at least 750 fattening pigs are needed. For farms with more than 1500 fattening pigs the technology seems like a very good business case if the solid fraction is sold.

Table 2-3 Income and costs for a farm with 250-1500 fattening pig and a selling price for the solid fraction of 1500 VND/kg.

FPE	250	500	750	1000	1500	
Income	47	95	142	190	285	mill VND/year
Capital costs	70	70	70	70	70	mill VND/year
Electricity costs	0,3	0,6	0,9	1,2	1,8	mill VND/year
Repair	2,5	5,0	7,5	10,0	15,0	mill VND/year
Total revenue excl. Labour costs	-25	19	64	108	198	mill VND/year

2.8 Case studies

2.8.1 Bac Giang province

In Bac Giang province data has been collected from two farms where amounts of solid fractions has been registered. The data and the calculations for the farms are listed in table 4.

Table 2-4	Calculation of theoretical and actually observed amount of produced solids in two farms.				
Parameter	**Unit**	**Farm 1** (Nguyen The Thuyet)	**Farm 2** (Pham Van Dung)		
Animal category		**Fattening pigs**	**Fattening pigs**		**Total**
Amount of pigs		**600**	500	500	**1000**
Average weight	kg	**85**	90	120	**105**
Fattening pigs equivalent		**600**	724	795	**1519,**
Manure	kg ab animal/day	**3,5**	3,5	35	**3,5**
Manure	DM (%) ab animal	**10**	10	10	**10**
Drymatter	kg DM/day	**210**	254	278	**531**
Washing water	kg/day	**24000**	20000	20000	**40000**
Total slurry	kg/day	**26100**	21750	21750	**43500**
Drymatter in slurry	%	**0,80**	1,2	1,3	**1,81**
Solid fraction					
Calculated	kg/day	**208**			**527**
Produced	kg/day	**214** (average 7 days)			**992** (average 9 days)

The assumption are 80% sedimentation efficiency, 35% separation efficiency and 30% drymatter concentration in solid fraction. The value for maximal separation is theoretical if 100% of drymatter ends up in solid fraction.

In the table it can be seen that the actual amount of solid fraction produced during first test period is higher than the theoretical calcualted with the assumptions used. In farm 2 almost double amount is produced compared to the expected while for the first farm the calculated and measured amount is almost the same. However the data survey need to take place over longer time and with precise data collection to have a clear picture of the long term efficiency.

2.9 Recommendations

In the LCSAP project a large number of separators has been installed and more will be installed in the coming period. This offers unique possibilities to collect data from a large number of installations with many varying parameters like number and type of animals, amount of washing water, size and proportion of sedimentation tank, detention in sedimentation tank etc. To be able to make statistics and evaluate which parameters determines the efficiency of separators data, it is recommended to collect data for all separator and a survey and test report should be developed for all installations. The test should be done for a period of at least one month and the separator should run 2 times per week. Each time the separator is running the sedimentation tanks need to be emptied for sediment as well as possible, i.e. until the pump can not pump any more material. During the test period the table in appendix should be filled in every day the separator is running.

In general it seems that the dimensions of the sedimentation tanks are too big and they don’t have the ideal proportions between length and width. If possible some of the sedimentation tanks that have not yet been installed should be constructed in the recommended size and proportions and in general the sedimentation tanks should be designed so that they fit the actual animal population on the farm instead of using standard design.

In cases where sedimentation tanks are too big in relation to the amount of animals on the farm, addition of organic bulk material could be an option to increase the amount of solid fraction produced and making a suitable dry-matter concentration for separation in the sedimentation tanks (>6%) by adding bulk material so that separation can be done with frequent intervals (2 times or more per week). The bulk material could be fibrous material in the form of straw, ricehusk, sawdust, residues form coconuts or similar which could be added to the tank some hours before separation.

For all farms there should be initiatives to reduce the water consumption to maximum 30 liter per pig per day to reach the ideal dry-matter concentrations for separation.

Literature

Ndegwa, P.M., J. Zhu, and A. Luo. 2001. Effects of solid levels and chemical additives on removal of solids and phosphorus in swine manure. J. Environ. Eng. 127:1111-1115.

Martinez, J., Burton, C. H., Sneath, R. W., and Farrent, J. W. (1995). ‘‘A study of the potential contribution of sedimentation to aerobic treatment processes for pig slurry.’’ *J. Agric. Engrg. Res.*, 61, 87–96.

Moore, J. A., Hegg, R. O., Scholz, D. C., and Strauman, E. (1975). ‘‘Settling solids in animal waste slurries.’’ *Trans., ASAE*, 18(4), 694–698.

Zhu, K., M. Gamal El-Din, A.K. Moawad, and D. Bromley. 2004. Physical and chemical processes for removing suspended solids and phosphorus from liquid swine manure. Environ.Technol. 25:1177-1187.

Chapter 3.
Overloading SBPs and MBPs

In the LCASP project several demonstrations have been initiated in terms of reduction of overloading and better use of biogas. Several of the SBPs and MBPs are designed too small for the present livestock production resulting in overloading. This means, that the bio-slurry is not properly digested and still contains large amounts of easily digestible material, which will emit greenhousegases and create other environmental problems like bad smell, high content of pathogens etc. Furthermore the gasproduction will be low with high sulfur content and low CH_4 concentration and in extremes if overloading is too high, both the gasquality and gasproduction will be too poor for utilization as a fuel. However today there is no clear definition of overloading, but among scientists the general opinion would be that the content of volatile fatty acids (VFA) and the residual gas potential will be high and when exceeding certain levels, it can be defined as overloading.

The VFA is an intermediate in the conversion of organic matter to methane and the content will increase and be very high if overloading occurs. The residual gas is the amount of gaspotential, that can still be recovered from the bio-slurry if extending the retention time. In the extreme cases of overloading the residual gaspotential, thus will be equal to the gaspotential of the untreated manure entering the BP. The residual gas potential can be measured in an incubator or at ambient temperature when average daily temperatures is above 20 C and will be a measure on how much gas is still present in the bio-slurry.

It is suggested that the following parameters should be measured on a selection of biogas plants to validate methodology and have snapshot of the situation:

- Biogasproduction, gas composition and temperature in the digester
- Biogaspotential in raw manure and bio-slurry (residual biogas)
- Volatile fatty acids in raw manure and bioslurry
- Drymatter, ash and COD in raw manure and bio-slurry

Biogasproduction, gas composition and temperature

The volumetric biogas production and the gas composition is important parameters to assess the performance and efficiency of digesters. The gas composition can be measured by different portable instruments or by cheap simple chemical methods. However the gas production can be very difficult to measure and due to leaks some might be lost prior to measuring. Equipment can be procured for gas measurements but most of the equipment work at a small positive pressure and if there is leaks in the digester part of the gas escape without being measured.

In general it is expected that gas production will not differ significant over certain time periods so it if a snapshot measurement can be done it is expected that it will be representative so it is recommended to make some simple measurements.

Simple measurement of gas production:

For small scale biogasplant the following procedure could be implemented for taking a snapshot of biogas production.

1. Avoid adding new manure or removing manure from the biogas digester before and during experiment.
2. Release all pressure of gas in the biogas digester. If there as valve in the top of the digester this will be recommended to open this for 10 minutes if not the connection for the cooker can be dismantled.
3. A 25 liter gasbag is connected to the gas pipe with a flexible hose somewhere between the gasoutlet of digester and the gas cooker. If no gasbags are available a rubber tube for car or a water displacement systems with a 25 liter drinking water bottle put reverse full of water in a water bath and a hose manually inserted connected to the gassystem.
4. Gas system should be kept pressure less during hole experiment and should be stopped before gas bags are completely full to avoid buildup of any pressure.
5. Register the time for filling the back or reaching a certain level in water displacement system.

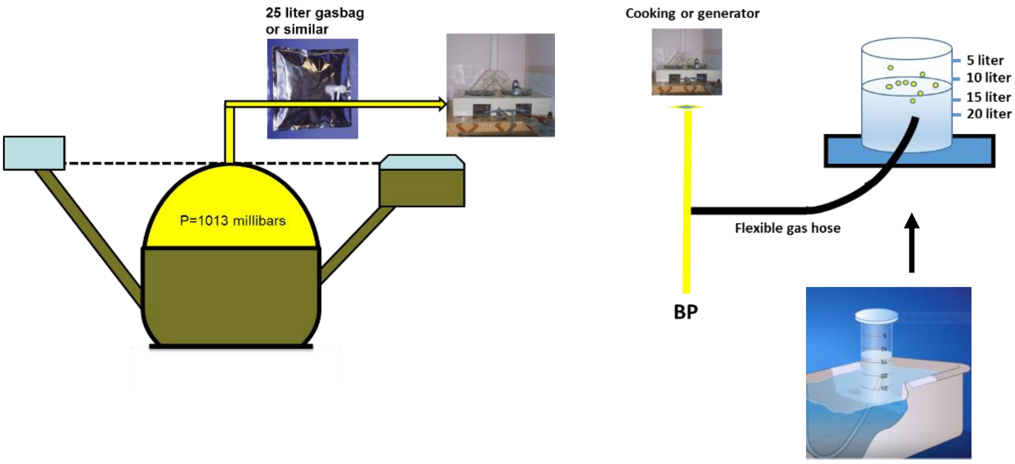


Figure 3-1: Illustration of gas measurement either with bag or water filled tank reversed connected with tube (water displacement system)

The time for filling the bag will be an indicator of the gas production. Ideally it should be repeated 3 times over some weeks to have a representative average. The gas production will probably have some seasonal variations according to temperature meaning high production during summer and low during winter

An example of calculations of gasproduction are given in table 1. In the example it will take around 8 minutes to fill a 25 liter gasbag, which gives a gasproduction of 4,5 m3 of biogas/day.

Table 3-1 Example of expected gasproduction and time to fill a 25 liter bag.

Parameter	Unit	
Reactor capacity	**20**	**m3**
Amount of fattening pigs	40	(average 50 kg)
Amount of manure excreted	2,5	kg/day/pig with 10% DM
Amount of manure with water dilution	12,5	kg/day/pig with 2% DM
Amount of manure excreted total	500	kg/day
Volatile solids (% of DM)	90	%
Hydraulic retention time	40	days
Gasproduction CH4	300	liter CH4/kg VS
Gas quality CH4	60	%
Gasproduction CH4	2,7	M3/day
Gasproduction (biogas)	4,5	M3/day
Gasproduction (biogas)	187,5	Liter/hour
Gasproduction (biogas)	3,125	Liter/minutes
Bag size	25	liter
Time	8,0	minutes

Gas composition can be measured with handheld monitor using infrared systems and electrochemical cell. An example of a handheld system from Geotech is shown below. If the purpose is mainly to monitor the sulfur contents tubes is sufficient to give a reliable indication.

Picture 3-1: Geotech 5000 gas analyser and simple one time use test tubes

Since biogas almost entirely consists of CH4 and CO2 and trace amounts of sulfur (<5000 ppm) a very simple methodology for measurements of CH4 and CO2 can be adapted using a syringe and a alkaline solution that trap the CO2 (appendix).

Temperature in the bulk liquid of the BP is an important parameter for the biogas process and is easy to measure. A thermometer with an electric wire mounted on a stick can be pushed to the middle of the anaerobic digester (around 2 m) and temperature can be registered.

Picture 3-2: Thermometer that can be mounted on a 2 meter stick.

Biogaspotential in raw manure and bio-slurry (residual biogas)

For measuring gas potential and residual gas potential a known amount of bio-slurry is added to infusion bottles. The bottles are subsequent closed with rubber lid that can be penetrated with a needle and a screw cap. If possible the bottle is flushed with an inert gas like N2 or CO2 to remove oxygen. The amount of gas produced should be monitored at regular intervals depending on the amount of gas produced in the start every 3-5th day and later on every 14 days. In total 60 days is recommended. The gas can be measured with a connection of a tube and water displacement or if only small amount of gas is produced a syringe can be used (30 ml or bigger) but in that case it need to be ensured that the gas is measured at atmospheric conditions meaning that there must be no over pressure in the syringe. If water displacement is used slightly acidified water should be used to avoid CO2 to be dissolved in the water (pH<4).

The gas quality can be measured by Geotech 5000 analyzer after adding the gas to a bag and making a loop so the gas sucked out of the bag is returned back to the bag to have enough gas through the monitor.

Ideally the infusion bottles should be kept at a constant temperature at 25 C or above to have the ideal conditions for the methanogenic bacteria but if not possible ambient temperatures above 20 C will be possible but then temperature should registered on a daily basis.

If the manure prior to the anaerobic digestion is included in the study a 1:1 mixture of the manure and bio-slurry should be added to ensure that the right bacteria is present. When evaluating the gas potential in raw manure the amount of gas coming from the bio-slurry should be subtracted.

Volatile fatty acids in raw manure and bio-slurry

Volatile fatty acids can be measured by Gas chromatography (GC) or by titration. GC are complicated and need investment in expensive equipment. In most cases auto titration is a sufficient good option for measuring total VFA. The methodology that can be used is described by Moller and Ward (2011). If an autotitrator is available this is the fastest way but else a simple burette and a pH meter will do. The bio-slurry should be titrated to 5,1 and 3,5 and the

Moller, Henrik B.; Ward, Alastair J. 2011. Modeling Volatile Fatty Acid Concentration in Livestock Manure-Based Anaerobic Digesters by Simple Titration ENVIRONMENTAL ENGINEERING SCIENCE

Chapter 4.

Utilization of bio-slurry and biogas in the fields of full utilization of fertilizer value and energy in gas

The Design and Monitoring Framework (DMF) of the Project indicates that at least 70% bio-slurry should be converted to organic fertilizers and at least 80% energy produced by Biogas Value Chains (BVCs) is utilized. There will be implemented solid-liquid separators in the demonstration packages and this is expected to demonstrate how a part of the livestock waste can be converted to a valuable fertilizer product and the gas production will be reduced. However this will only be limited to demonstrations and the major part of the livestock waste will still be in liquid form and converted to bio-slurry in the biogas plants. This means that on a volume base most of livestock waste will be converted to a liquid bio-slurry and subsequent be used as a liquid fertilizer. Today the technology for spreading the bio-slurry is not well developed and there is little knowledge about the content of nutrients and the value as fertilizer. Furthermore the value will differ very much between farms depending on the use of water etc.

In the mountainous area the liquid bio-slurry can be used for fruit trees but there is probably no simple procedure on how to determine the nutrient content and the amount that should be used and there is no well-defined best practice on how to spread, which types of pumps to be used etc.

In the lowland the use is more complicated since there is no tradition for use in rice cultivation, but some of the experiences form the mountainous areas might be adopted. Furthermore there is some legal restrictions on the use of liquid bio-slurry, which limits the possibility to use it as a fertilizer.

Today several MBPs have no proper gas use and only part of the gas is used, while a considerable amount is expected to be released to the atmosphere. The emitted methane is limiting the value of the biogas technology as a tool to reduce GHG emission and for MBP without a power unit installed, the only way to avoid the release of excess methane is to flare it or find neighbors that can use the excess. To achieve the goal of using or flaring a higher share of the biogas, there is a need to demonstrate reliable systems with low risks for the users.

The main options today for using excess gas on MPB, besides cooking is power production, but other options should be considered. As a default an amount of 0,2 m^3 CH_4/m^3 digester/day is produced and the amount of gas used for cooking is 0,3 m^3 CH_4/person/day.

Drying the solid fraction from manure could be one option but the technologies available are quite expensive, but cheap and simple solutions might be developed.

When biogas is used for power production, sulfur cleaning is essential to protect the engine and increase the lifetime. However there is not sufficient knowledge about which technologies are most efficient

During the mission several provinces was visited and examples of problems of using bio-slurry and biogas are addressed and farmers with good practices is highlighted. Information was collected from the follow:

- Lao Cai
- Ben Tre
- Nam Dinh
- Phu Tho

4.1 Gas use and gas quality

Gas use

In general most biogas is mainly used for cooking and in some cases for alcohol production and heating lamps for piglets. In some cases the gas is distributed to several households which is mainly seen in the south where distances between houses are smaller than in other provinces. In figure 4.1 the estimated amount of gas used for the visited farms is illustrated.

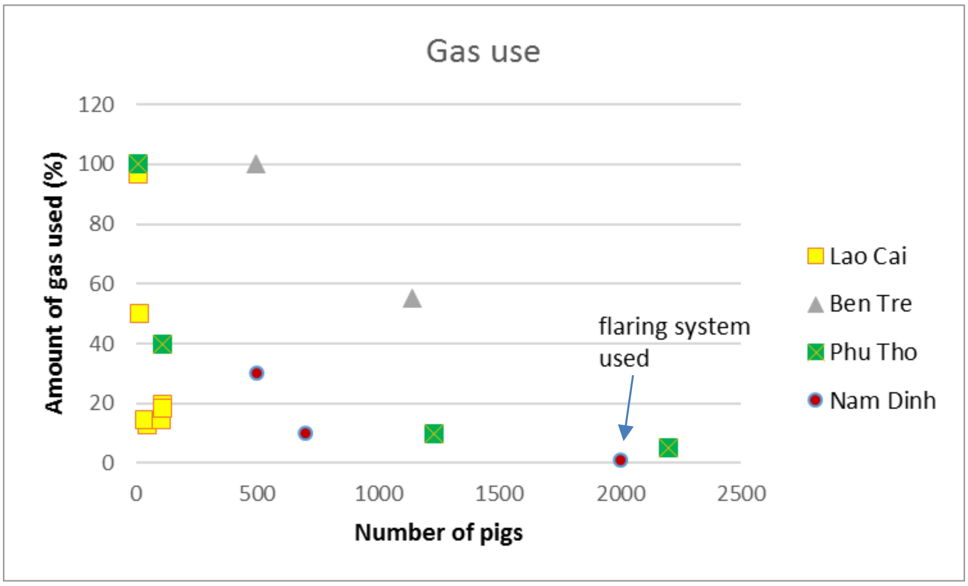


Figure 4-1: Amount of gas used as a percentage of the production

It can be seen that most farms use less than 50% of the gas and some of the big farms use only very little of the gas. However in the south there is some interesting cases where gas is distributed to several farms with pipes. However this is only feasible when the distances between houses are small.

Picture 4-1: Gas pipe connecting 20 households from a farm with 450 pigs in Ben Tre

In some small farms with around 10-20 pigs the percentage of gas use is also very high. The share of gas use can be increased by using gas for heating lamps for piglets, producing alcohol etc. but for the big farms generators or flares seems as the only option. The flaring is only done in very few cases but it can be done very simple by a pipe and a brick installation, but since there is no automatic systems meaning that the farmer need to monitor and at regular intervals put a new fire to the pipe.

Picture 4-2: a) Simple self-made flaring system in Nam Dinh. b) Heating lamp for piglets running on biogas in Phu Tho.

For the farms that will have the generators in future the share of gas being used can be very high but often a gas storage is needed to be able to produce the electricity when needed. The electricity can often be used for pumping water, bio-slurry and grinding feed.

Picture 4-3: Simple gas storage system mounted under the roof.

Gas quality

When generators in the future will be installed on several farms the gas quality will be very important for a successfully use for electricity production. Especially the content of Sulfur in the form of H_2S will be very important and if the content is two high gas cleaning will be essential. During the field visits the gas quality was measured at several farms and it seemed that the dimension of digester size per animal plays a major role as illustrated in figure 4-2. Overall it seems that many digesters are too small compared to the livestock size and there is a very high amount of sulfur in the gas when the digester size (m3/animal) is lower than the recommended value of 0,5-1 m3 digester per fattening pigs at respectively 50 and 100 kg average weight. This means that when the digesters are under dimensioned there will be some big challenges to use the gas in generators since there will be a huge demand for cleaning sulfur with corresponding high costs associated. Therefore it is recommended that the size of the digesters should comply with recommendation when generators is installed.

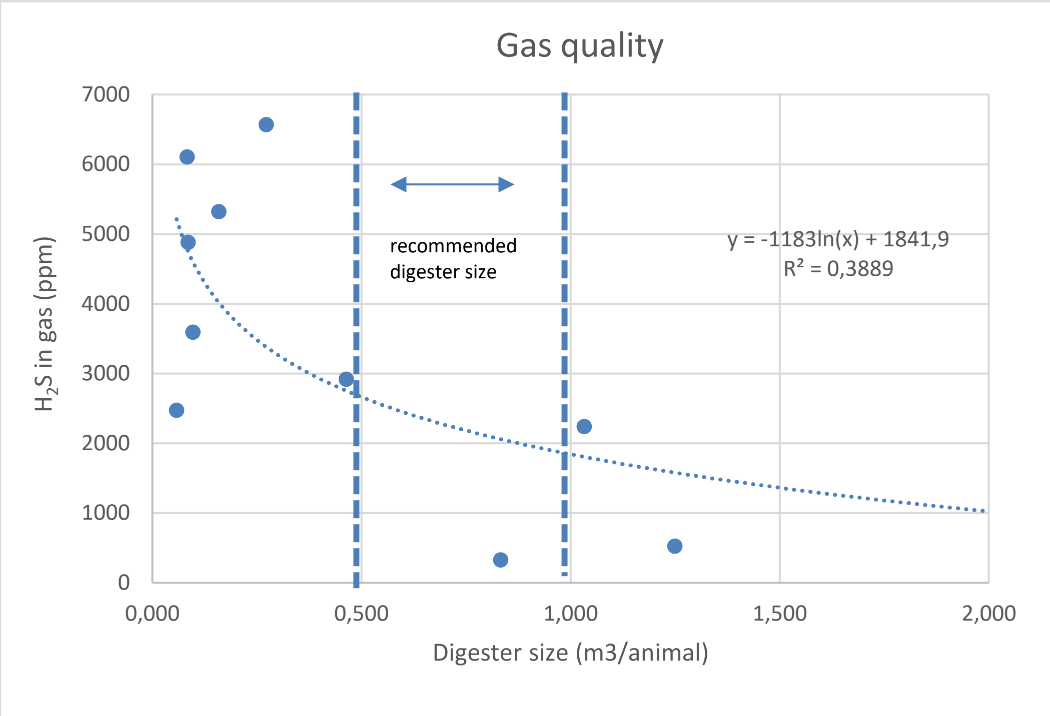


Figure 4-1: The sulfur content in gas as a function of digester size

4.2 Use of bio-slurry

The use of bio-slurry is one of the important framework indicators of the LCASP project and the aim is that at least 70% should be converted to organic fertilizers. The installation of separators is one way to make solid fertilizer but to have an environmental sustainable solution for using the nutrients from the livestock especially pig breading the liquid bio-slurry should be used for crops. However in many cases very little land is available at the farms and the bio-slurry need be used at neighbor areas. One other big obstacles for the farmers to use more of the bio-slurry is that there is some legal constraints in using liquid organic fertilizers for crops and to have a widespread use of the bio-slurry in Vietnam it is vital that this legal barrier is changed.

During the field trip information was collected on the use of the bio-slurry and there was big differences in the different provinces. The amount of land needed for a sustainable use depends on several factors as the type of crops cultivated, amount of crop rotations in a year, climatic conditions etc. In general the amount of nitrogen up-taken by a crop is in most cases less than 500 kg/ha/year. The estimated amount of nitrogen excreted by one pig is 0,05 g/day meaning that if a farm have 1000 pig the total amount of nitrogen produced in one year is: 360*1000*0,05=18000 kg/year. This corresponds to an area of around 36 ha if 500 kg nitrogen/ha is applied.

In figure 4-2 the area available for use of bio-slurry at the visited farms is illustrated and only 4 of the small farms has sufficient land whereas 3 of them are from Lao Cai province.

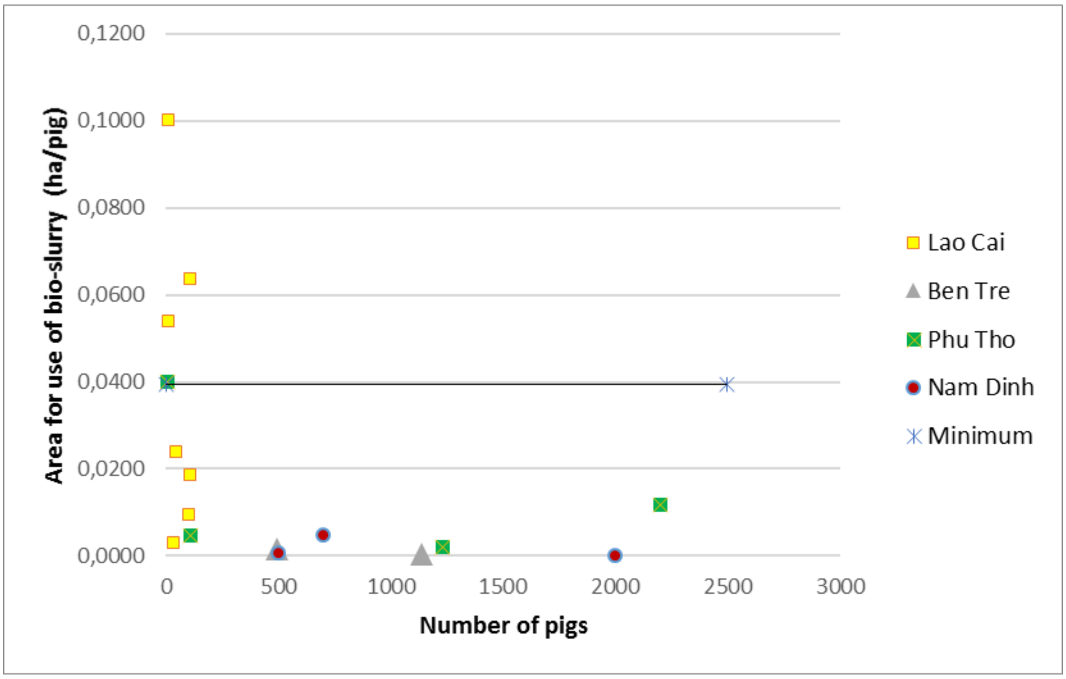


Figure 4-2: The area for use of bio-slurry at visited farms in the provinces. The minimum area needed is calculated with 500 kg N/ha.

The typical crops where bio-slurry is used is:

- Vegetable
- Fruit, especially Pomelo and orange
- Grass
- Elephant grass

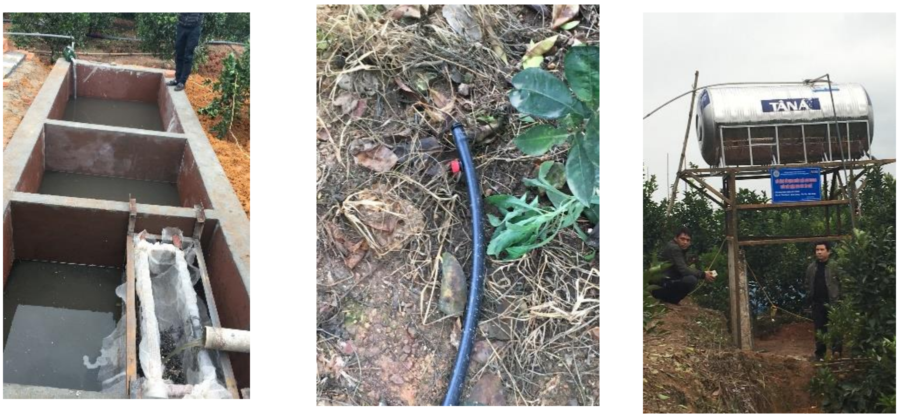
The use of bio-slurry for rice is not developed and in many provinces where rice is a dominant crop it seems that a more widespread use for rice and development of technologies for this is the only solution to deal with the high surplus of nutrients. The recommended nitrogen need for Pomelo cultivation is 290 kg/ha/year meaning that around 1 ha of Pomelo can use the bio-slurry from 15 pigs, but since there is some losses compared to chemical fertilizer 20-25 pigs/ha would be a good estimate if there is no supply of chemical fertilizer. The need for nitrogen for vegetable depends on the type amount of crop rotations etc.

Technologies for use of bio-slurry

The most success full use of bio-slurry until now is for fruit trees and vegetables.

There has been developed systems that apply the nutrients by irrigation through nozzles as a separate stream or by mixing with irrigation water system. To be able to apply via nozzles the bio-slurry should be completely free of particles to avoid clogging.

In picture 4-4 a system is illustrated where the bio-slurry is screened for big particles and subsequent sedimented in 3 chambers. Before application the bio-slurry is pumped to a buffer system where it is mixed with irrigation water and by gravity let though pipes to the nozzles placed close to each tree.



Picture 4-4: Technology for sedimentation (a), application via nozzles (b) and buffer system (c) in Bac Giang province.

For vegetables the bio-slurry is usually pumped through flexible hoses and spread manually by hand. This system is efficient for small areas but it is difficult to know if the crops get the right amount of nutrients. Furthermore the system is difficult to use on larger areas with grass, maize etc. Picture 4-5 shows how bio-slurry can be pumped and spread for vegetables.

It is recommended to develop and test systems where the liquid bio-slurry can be applied more automatically to vegetables and grass.

Picture 4-5: Use of bio-slurry for vegetables Lao Cai province. a) pump for bio-slurry in Lao Cai province. b) Spreading of bio-slurry for vegetables in Lao Cai province. c,d) Pumping of bio-slurry for vegetables in Nam Dinh province

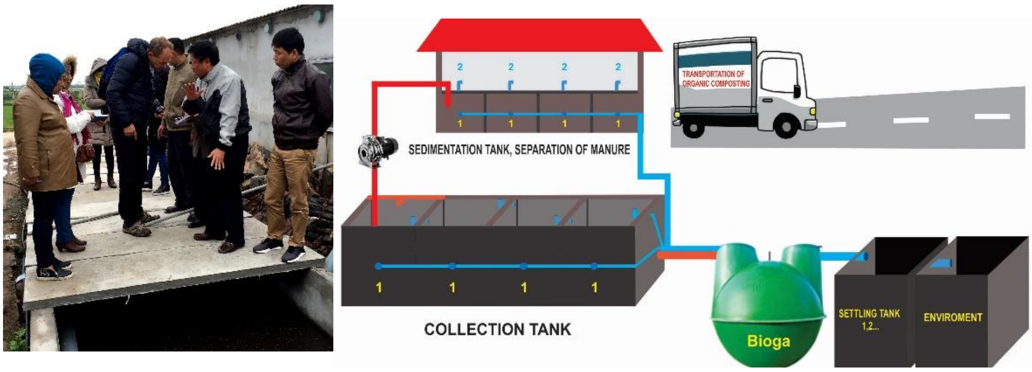
Alternatives for bio-slurry use

In some provinces new alternative systems for bio-slurry use has been developed. In Nam Dinh province sedimentation combined with composting and constructed wetland has been installed at one farm (picture 4-6).

After the biogas plants the bio-slurry is led trough 11 sedimentation tanks with total dimensions of 2m x 13,7m x2,5m (deep). Sediment from the 3 first tanks are pumped to a building for composting with rice husk. This is done once a month. The last chambers are used for extra cleaning and the last 3 chambers have active carbon where the last particles are trapped. The water after the 11 sedimentation tanks are led trough a constructed wetland made in concrete (4mx13,7mx1m). The almost clean water is finally used in vegetable garden (4000m2).

Picture 4-6: Sedimentation tanks for bio-slurry in Nam Dinh province (Nguyen Van Tuc)

In another farm in Nam Dinh, manure is pre-sedimented before biogas. Pre-sedimentation tank is 4 chambers. The sediment from tank 1 and 2 is pumped to the top of the tank of the 4 tanks and left for drainage of water to increase solid concentration. The drained material is taken to building for earthworm raising and final composting.



Picture 4-7: Sedimentation tanks for liquid manure sedimentation before biogas digester (Tring Van Kien)

Chapter 5. Appendix:

Field visit to Nam Dinh/Binh Dinh

8/1 2018

Name: Thuan Van Trung

Binh Dinh.

Livestock: 4000 fattening pigs and 2000 sows

Area: 6,7 ha with vegetable, 1 ha fishpond (15 ton fish/year)

Separator: A Cri-man separator has been running for 4 year.

Sedimentation: 5x5x4m

Separator is running 2-3 hours every day and 1200 kg solid fraction is produced daily. Solid fraction is not sold but used for vegetable or given away to workers.

There is a biogas reactor HDPE type with dimensions 15x40x4,5m. The gas is used for cooking, heating for piglets, cooking dead piglets for fish feed.

Name: Pham Thi Nhuan,

Nong Van Quas, Nam Dinh Provinces

Livestock:

1000 fattening pigs (10-30 kg), 1000 fattening pigs (30-120 kg)

There is a 4000 m3 BP HDPE. Biogas is used for cooking 10 persons, the rest is flared with homemade solution. In future a 75 kw generator will be installed.

Pig houses are closed with forced ventilation.

There is an old Chinese screw press separator which is not used at the moment due to few pigs.

Bio-slurry is aerated with compressors in 9 aeration chambers to remove nitrogen and odor. The farm has no area but there is neighbor who could use the bio-slurry. Today there is no use of bio-slurry. When separator was running the price for the solids was 700 VND/kg.

Name: Nguyen Van Tuc,

Truc-Thai commune, Truc Ninh district, Nam Dinh province

Livestock: 500 Fattening pigs (50 kg average)

There are two biogasplants: 16+20 m3.

After biogas plants bio-slurry is led trough 11 sedimentation tanks with total dimensions of 2 x13,7 (length) x2,5 (deep) m. Sediment from the 3 first tanks are pumped to a building for composting with ricehusk. This is done once a month. The last chambers are used for extra cleaning and the last 3 chambers have active carbon where the last particles are trapped. The water after the 11 sedimentation tanks are led trough a constructed wetland made in concrete

(4mx13,7mx1m).The almost clean water is finally used in vegetable garden (4000m2).

9/1 2018

Name: Tring Van Kien,

Hai An commune, Hai Hau district, Nam Dinh province

Livestock: 600 fattening pigs, 100 sows

1,1 ha including fishpond with scrimp. The bio-slurry is used for vegetables by neighbors on around 3 ha.

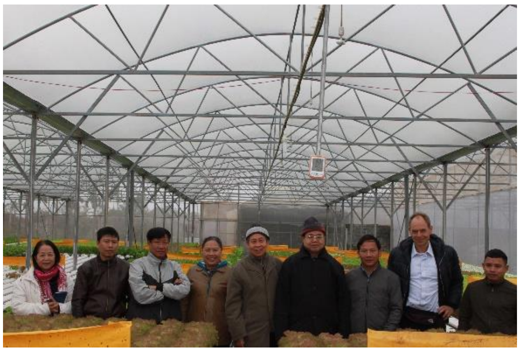
The manure is pre-sedimented before biogas. Pre-sedimentation tank is 4 chambers. The sediment from tank 1 and 2 is pumped to the top of the tank of the 4 tanks and left for drainage of water to increase solid concentration. The drained material is taken to building for earthworm raising and final composting.

The compost can be sold for 20000 VND/30 kg. (700 VND/kg)

Biogas plant is 10 units: 2x15 m3 and 8x10 m3

Company with vegetable production: Ngoc Anh

Produce 35-40 ton vegetable per day for supermarket in Hanoi and Nam Dinh. The fertilizer is 50% by chemical and 50% by organic origin. The organic fertilizer is compost from cattle and chicken manure. In future they also plan to use solid pig manure. Most of crops are produced in greenhouses (salad, tomatoes, cucumbers. They have around 8-10 crops per year and use around 20 tons of compost and 4-500 kg NPK (16:16:8) per crop rotation.

Field visit to Phu Tho

10/1-2018

Name: Vu Thi Hao

Khu 4, Chi Tien Commune, Thanh Ba District, Phu Tho province

Livestock: 600 fattening pigs (5 kg-10 kg) and 600 fattening pigs (60-70 kg) normally there is around 2000 fattening pigs. 30 Beef cattle.

Water consumption is 25 liter/head/day.

Area: 6 ha where 2 ha is grass and 2 ha with special tree used for medicine. Besides 12 ha of fish pond (10 tons fish/year).

Separator: A Cri-man separator.

Sedimentation: 3x3x3m

Separator is running one time per week for 2-3 hours and 1000 kg solid fraction is producedeach time (50 bags with 20 kg). Solid fraction is not sold but used for medicine plant. If sold the value would be around 7-800 VND/kg

There is a biogas 2000 m3 reactor HDPE type. The gas is only used for cooking.

Bio-slurry is used for grass by manual sprinkling or led to fishpond.

Name: Vu Van Thanh,

Khu 10, Chi Tien Commune, Thanh Ba District, Phu Tho province

Livestock: 100 fattening pigs, 10 sows.

Biogas consists of 2 units of 15 m3.

All bio-slurry used for 0,5 ha with pomelo applied 3-4 times/month.

Gas used for cooking (5 people) and for biogas lamps for piglets. The lamps last around 1 year.

Gasquality: 6565 ppm H_2S, 65,6 CH_4, 34,1 CO_2

Name: Nguyen Xuan Khoa,

Khu 5, Yen Noi Commune, Thanh Ba District, Phu Tho province

PhuTho Province

Livestock: 6 fattening pigs (used to have 20), 3 cattle.

Bio-slurry used in 360 m2 garden for vegetables.

Biogas plant: 7,5 m3

Gas quality measured: H_2S 325 ppm, 71,5 CH_4, 28,3 CO_2

Name: Can Thi Thin,

Khu 5, Phu Ho Commune, Phu Tho town, Phu Tho province

Separator: A Cri-man separator.

Livestock: 2000 fattening pigs (30-60 kg) and 200 sows.

Area: total of 30 ha, 5 ha pomelo, 3 ha fishpond, 21 ha forestry.

Sedimentation: 3x3x3m

Separator is running one time every 4 days for 4 hours and 80 bag with 25 kg produced (2000 kg) solid fraction is produced each time but data seems not to be collected precise. Solid fraction is not sold but used for fruit trees.

Biogas digester consists of 5 unit each 70 m3.

Gas is only used for cooking, no gas flare installed.

Gasquality: 5317 H_2S, 82,6 CH_4, 15,6 CO_2

Field visit to Lao Cai

27/12

Name: Luong Van Kag, Then Thuong Village, Lao Cai Province

19 cows for meat production plan to increase to 70 cows, slaughtered at 300 kg, 25 fattening pigs (at the moment only 5), 3 sows

BP: 70,7 m3 BP is under construction.

Area: in total 5 ha, where 2 ha with elephant-grass, 0,5 tea and the rest is forest.

Gas will be used for cooking, drying tea and making alcohol.

Bio-slurry will be used for tea and grass. The solid part from cows will be composted and it is planned to sell it and maybe produce earth worms.

Name: Nguyen Duc Nhat. Village 2, Gia Phu commune, Bao Thang district, Lao Cai.

Livestock: 100 fattening pigs, 8 sows,

A new biogas plant is almost finished. 52,2 m3 and there is an existing 9 m3 digester.

Area: 1 ha

Bio-slurry can be used at neighbors cultivating 1,0 ha sugarcane and 1,0 ha vegetable. Solid fraction is collected from sows and fattening pigs and sold for 15.000 VND per bag with around 20 kg.

The biogas is used for cooking for the family (8 persons) and the biogas will be used for alcohol production. Each day 2 times 70 liter of fermented liquid will be produced (around 4,5 hours)

Biogas quality: 68,3% CH_4, 30,6% CO_2, 6105 ppm H_2S

Name: Lo Van Truyen, Muong Lo Village, Thanh Lu Commune, Sa Pa district, Lao Cai province.

Livestock: 5 cattles (+10 next year, 25 fattening pigs, 4 sows), Dung from cattle will not go to biogas

Area: around 1 ha, 1000 m2 grown with elephant grass.

A new biogas plant is almost finished. 52,2 m3

Biogas will be used for cooking and alcohol.

28/12

Name: Do Dien Hinh

Nam Dang village, Lao Cai Province

5 sows, 100 fattening biogas

New installed biogasplant not yes started, at 52,2 m3 with 30 m3 storage and 8 m3 expansion. Old 9 m3 composite digester,

In total 1,9 ha with 1 ha with fruit (leachy, pomelo, orange)

Today 50% of bioslurry used for fruit but in future plan to use 100%. He will only add K fertilizer (2 kg/tree/year). Bio-slurry is mixed with water in a ratio of 1:1 and pumped in pipes to trees.

Biogas quality: 64,8% CH_4, 32,6% CO_2, 4877 ppm H_2S

Name: Do Van Lang, Tao Criang Village, Va Lang Vai commune, Maug Khuag district

100 fattening pigs and 11 sows.

BP: 48,7 m3 digester from 2015.

The gas is used for cooking, feed for pigs and biogas lamp for piglets

Will install generator 5 KW. The electricity will be used for milling maize (3 kw) and 3 pumps for water (0,8 kw each)

Area: 1000 m2

Bio-slurry is only used on little land today but there are neighbors besides the farm (family) that can use the bio-slurry. There is a plan to pump the bio-slurry to 3x10 m3 composite tanks and from there distribute it to crops with pumps. (6 ha with tea and 1 ha maize). The pipes from bio-slurry tank to buffer tank will be placed 0,5 m under ground level.

This is planned to take place first quarter of 2018.

Biogas quality: 70,3% CH_4, 29,2% CO_2, 2917 ppm H_2S

Name: Nguyen Ngoc Minh. Coc Mui Village, Ban Son Commune, Muong Khuy district, Lao Cai province.

Animal: 2 sows, 11 fattening pigs.

Area: 0,3 ha with vegetables, 0,4 ha with tea

BP: 15 m3

Biogas quality: 70,1% CH_4, 28,5% CO_2, 523 ppm H_2S

Biogas is used for cooking for 5 persons and for cooking of animal feed (100 kg/day)

Very good use of bio-slurry, system with pumping for vegetable and fruit. Bio-slurry.

Effluent is spread with pump and pipes connected to effluent tank. Before he used 500 kg NPK and 2-300 kg Urea nitrogen, but today only effluent is used

Visit 4:

Name: Nguyen Trong Huy. Coc Mui Village, Ban Sen Commune, Muong Khuy district, Lao Cai province.

Livestock: 9 fattening pigs, 1 sow.

Area: 1,2 ha with 0,7 ha with rice and 0,3 ha with vegetable. All bio-slurry is used.

BP: 9,3 m3

Biogas quality:65,8% CH_4 33,3% CO_2, 2240 ppm H_2S

Field visit to Ben Tre

The main purpose with the field visit was to assess the progress with manure separators and secondly look at comprehensive waste management.

Manure separators

3 farm with manure separators was visited, for one farm it was not possible to get any detailed information since the farmer was not present. The separators has been installed within the last month and at one farm the separator had still not been tested while at the other two farms the separator had only been running one time after a 3 weeks sedimentation period. The amount of solid fraction seemed quite low when separators was operated during the visit. Visually the dry-matter content in the sedimentation tank seemed around 3% which in the lower end of what is needed to get an efficient separation.

All sedimentation tanks was square formed with a pre-sedimenttion tank (dimensions=1mx1mx0,9m) to collect stone and sand and a sedimentation (3mx3mx2,7m) tank for sedimenting material for the separator. All sedimentation tanks has a mixer installed, which was mixing 15 minutes during start of separation. All separators was Cri-man.

Problems

In general the sedimentation tanks didn't seem to produce a slurry with sufficient high dry-matter concentration for efficient separation and the separators seems to produce too little solid fraction.

Recommendation

It is recommended to have more frequent separation and instead of waiting several weeks it should be done at least twice a week in a test period to assess the efficiency. The more fresh the manure is the bigger particles are present and separation efficiency will be higher compared to manure stored over several weeks at high temperature.

Since the dry-matter concentration in sedimentation tanks is lower than optimum the separators will not work efficiently. To have a more efficient separation fibrous material in the form of straw, ricehusk, sawdust, residues form coconuts or similar could be added to the tank prior to separation.

Visit 1

Full name of household owner: Nguyen Thanh Phuc
Address: Ben Tre province
Size of BP (m3): 24 + 24 + 10 m3 KT2
Area : 1,0 ha.
5000 m2 fish pond
Crop cultivation and area with each crop: only coconuts and a little fruit
The solid part from sows are collected manually and sold at the market for 2000 VND/kg in bags with each 15 kg
Use of biogas: Cooking, 3 other household connected for biogas use.

General information about the livestock

Animal categories:

Category	Average weigth	Washing water
	Kg	Kg/day
1000 FP	50 kg (sold at 100 kg)	40-50 liter/pig/day
140 sows	120 (20 piglets/year)	

Type of separator (Bauer): Cri-man

Mixer installed, 1 rectangular sedimentation tank and 1 pre-sedimentation tank for sand and stone. Mixer installed for mixing 15 minutes during start of separation.

Sedimentation (3x3x2,7), pre-sedimenttion (1x1x0,9). There is only little experiment with separation until now with very long intervals 10-15 days and no data has been collected.

Recommendation: The separator should run every or every second day, bypass of some washing water could also be recommended to increase solid content. Pre-separation is not necessary and solids accumulate.

Gas quality was measured: 79,8% CH4, 16,1 CO2%, 2471 ppm H2S, før filter,

Gas quality was measured: 79,8% CH4, 16,2 CO2%, 2385 ppm H2S, after filter (Iron, Chinese),

Visit 2

Full name of household owner: Nguyen Van Be Chinh
Address: Ap Thanh Pho, Ben Tre province

Category	Average weigth	Washing water
	Kg	Kg/day
450 FP	50 kg (sold at 100 kg)	45 liter/pig/day
45 sows	120 (20 piglets/year)	

Size of BP (m3): 48 m3 KT2
Area : 0,68 ha.
500+250 m2 fish pond, production around 1 tons of Catfish every year, no other use of bio-slurry.
The solid part from sows are collected manually and sold at the market for 2-3000 VND/kg solid.
Use of biogas: There was a very efficent use of the gas and 20 houses (4 people in average/house) was connected to BP and besides it was used for alcohol (20 liter of alcohol/day)

Unit for composting and forces aeration of the solids together with straw is installed.

Visit 3

Animal categories: No information

Type of separator (Bauer): Cri-man.

Mixer installed, 1 rectangular sedimentation tank and 1 pre-sedimentation tank for sand and stone. Mixer installed for mixing 15 minutes during start of separation. Sedimentation (3x3x2,7), pre-sedimenttion (1x1x0,9). There is only little experiment with separation until now only one time with long sedimentaton (15 days) and no data has been collected.

Recommendation: The separator should run every or every second day, bypass of some washing water could also be recommended to increase solid content. Pre-separation is not necessary and solids accumulate.

Gas quality was measured: 67% CH_4, 31,6 CO_2%, 3591 ppm H_2S, before filter.