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Cemagref

Consultants report on manure management systems required for specific livestock farms in visited in Thailand, Vietnam and Guangdong province, China

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COMMERCIAL - IN CONFIDENCE

SUMMARY

Technical support was provided by the Cemagref consultant, Mr C H Burton, to meet specific requirements for the project, "Livestock Waste Management in East Asia" which started in 2006. Inputs were made during a mission arranged by the FAO that took place from the 9th to the 20th October 2006. This comprised visits to each of the three participating countries, Thailand, China (Guangdong province) and Vietnam and a subsequent 3-day regional workshop with all partners present. In each country, meetings were arranged with local teams to discuss specific manure treatment proposals for specific farms which were subsequently included in study tours. Technical feedback was given at the meetings some of which is included in this report. The principle message arising is that even with national and project subsidies, widespread uptake of manure treatment still requires some degree of reward for the farmer himself. Thus anaerobic digestion, especially with electricity production from the biogas produced is the most popular method but it is only really suitable for the larger farms. However, by itself, AD does not greatly reduce the excesses of N and P and where electricity generation is not feasible, there needs to be a clear use for the biogas produced. Compost and similar schemes producing organic products for sale are also popular and have the clear advantage of enabling the exportation of some of the nutrient excesses that are the root cause of many of the water pollution problems. Methods to encourage land application to growing crops can meet the project objectives whilst bringing some reward in a reduction in the quantities of purchased fertilisers. Farms with integrated fish production provide another route but hygiene issues must also be addressed. Community schemes will enable the many smaller farms in Northern Vietnam to be included in the project initiative.

RESUME

L'appui technique a été fourni par le consultant Cemagref, M. C H Burton, pour répondre à des exigences spécifiques pour le projet, "Gestion des effluents d'élevage en Asie du sud-est " qui a commencé en 2006. Ses contributions ont été effectués pendant une mission organisée par la FAO qui a eu lieu du 9 au 20 octobre 2006. Ceci a compris des visites dans chacun des trois pays participants, la Thaïlande, la Chine (la province de Guangdong) et le Vietnam et suivi par un atelier régional de trois jours en présence de tous les associés. Dans chaque pays, des réunions ont été organisées avec les équipes locales pour discuter des propositions spécifiques pour le traitement des déchets pour les fermes spécifiques qui ont été plus tard incluses dans des excursions d'étude sur le terrain. Des réponses technique ont été fournis lors de réunions dont une partie est incluse dans ce rapport. Le message de principe qui survient est que même avec des subventions nationales et celle liées au projet, prise le développement du traitement exige toujours un certain degré de récompense pour le fermier lui-même. Donc, la digestion anaérobie, surtout avec la production de l'électricité du biogas produit, est la méthode la plus populaire mais il est seulement approprié aux fermes les plus grandes. Cependant seule, le DA ne réduit pas beaucoup les excédents de N et P et, quand la production d'électricité n'est pas faisable, il faut

un moyen d'utilisation claire pour le biogas produit. Le compost et les autres processus associes qui produisent les produits organiques à vendre sont également populaires et ont l'avantage clair de permettre l'exportation de certains des excédents nutritifs qui sont la cause de plusieurs des problèmes de pollution de l'eau. Les méthodes pour encourager l'épandage agricole aux cultures peuvent répondre aux objectifs du projet tout en apportant une certaine récompense dans une réduction des quantités d'engrais achetés. Les fermes avec la production intégrée de poissons fournissent un autre approche mais des questions d'hygiène doivent également être abordées. Le traitement centralisé permettra aux nombreuses plus petites fermes au Vietnam du nord d'être incluses dans l'initiative de projet.

COMMERCIAL - IN CONFIDENCE

CONTENTS

COMMERCIAL - IN CONFIDENCE

COMMERCIAL - IN CONFIDENCE

1. INTRODUCTION - THE PURPOSE AND BASIS OF THE REPORT

1.1 Report objectives

This report provides details of the work carried out by the consultant, Mr C H Burton of Cemagref, (Unité GERE) Groupement de Rennes, to fulfill contractual obligations with the Food and Agriculture Organisation (FAO). This is set out in the Terms and Reference document (reproduced in Annexe 1) and relates to the first activities for the project - *Livestock Waste Management in East Asia* which formerly started in August 2006. This project is being managed by the FAO for the GEF (Global Environment Facility - represented by the World Bank). The implementation of the project itself is expected to run over five years: this report only covers specified tasks relating to the initial phase running through to September 2007.

The substance of this document covers technical support work provided by C H Burton during, and immediately following, the mission to SE Asia (9 October to 20 October, 2006 - a including the Regional Workshop of 17-19 October) led by Dr Pierre Gerber from the FAO office in Rome, Italy. Described as a "Backstopping mission" the purpose of this and the subsequent workshop was to provide technical assistance to the local project teams in each of the three participating countries, China (Guangdong Province), Vietnam and Thailand. All three countries were visited as part of the mission including the identified pig farms where the various treatment technology would be installed.

1.2 Report context, structure and content

For the context of this report, the reader is directed to two previous reports prepared in the past 2 years.

The first of these is: *BURTON, C.H (2004) Consultants report on manure management technologies for livestock farms in Thailand, Vietnam and Guangdong province, China. Contract report: CR/1594/04/3475 Silsoe Research Institute, Silsoe, Bedford UK. November 2004.* This provides an initial overview of the situation of livestock farming in SE Asia and of technologies available for possible installation. In this same report is an evaluation of each of these technologies in terms of effectiveness against the principle concerns of nitrogen, phosphorous and organic matter release to surface water.

The second report is: *BURTON, C.H (2005) Consultants report on manure management systems required for specific livestock farms in visited in Thailand, Vietnam and Guangdong Province, China. Contract report: CR/1663/05/3689 Silsoe Research Institute, Silsoe, Bedford UK. June 2005.* This provides more specific detail of the farms identified in the selected study areas including examples of treatment system and corresponding design information.

The purpose of this mission was to assist in taking the technical process a step further. Thus the first section (2) is given over to a review of the local progress of the design and installation of equipment at the first farms identified for the scheme. Issues relating to procedures being developed for monitoring the technical performance of these first farms is covered in the following section (3). The final section provides an outline of requirements of the "Decision Support Tool" with respect to manure management systems. This is one of a series of inputs being prepared to support the local teams in implementing the technical aspects of the project.

1.3 Itinerary of mission and workshop

The mission in its entirety is set out in the programme given in Annexe 2. It comprised two principle parts: visits to the study areas of each of the three participating countries (including one day for site visits and one day for related technical meetings) and secondly, a regional workshop which brought together the technical teams from each country with the FAO team and representatives from the World Bank. The agenda is given in Annexe 3. The primary purpose of this event was technical assistance although the opportunity was also taken to address various administrative matters.

COMMERCIAL - IN CONFIDENCE

2. FEEDBACK ON SELECTED FARMS AND OF PROPOSED SCHEMES

2.1 Description of schemes as presented

Thailand

Dr Sommai has been appointed as the project engineer by the PMO in Thailand. He will in due course use the services of external consultants as appropriate but he was able to give detailed information of three schemes as provided in the project implementation plan (PIP) for Thailand. This concerned farms were at Kanchana, KOS (both in the Rachaburi province) and Sa-ard Farm in Chonburi province. Since the preparation of the PIP, the farm at Kanchana had withdrawn from the project thus discussion was limited to the two remaining. Details of each of these farms as presented are given as abstracts set out in Annexe 5. It is noted that although considerable detail is already included, the services of the consultancy (most likely CMS Engineering and Management Co. Ltd) will be used for the purpose of final design and installation.

At both of the remaining farms, schemes strongly based on anaerobic digestion with the production of electricity are being proposed. This is an important consideration as the farmers may be required to contribute the largest part of the investment cost and some return is thus necessary. At the KOS (King of Swine) farm, there is adequate space for a scheme based on a series of lagoons Total cost is estimated as 8.4 million Baht (210,000 USD) for a farm with a nominal 10,000 pigs. Investment would thus be 21 USD per pig.place. Initial estimates of revenue suggest an annual gross income of 2.3 M Baht less 0.6 M Baht operating costs. *If achieved*, the net income suggests a payback period of 5 to 7 years.

At the Sa-ard farm, lack space is the main problem. Land used of current water storage is identified for use for a compact design for a covered lagoon to produce biogas. Reduction of offensive odour was cited as an important factor in this work although it was noted that no formal complaints had been received. Options are given with and without an aerated lagoon costing between 4.3 and 4.8 M Baht (105,000 to 120,000 USD) for 3000 pigs. Investment in this case would equate to 35 to 40 USD per pig place. Again a net revenue is anticipated, this time around 0.4 M Baht per year suggesting a payback time of 10 to 15 years depending on the cost of finance.

China

There is no specific individual appointed by the local PMO as a project engineer. Instead, it is intended to draw from a pool of local experts to work on each farm as it joins the scheme. As for Thailand, the number of farms in the initial phase has been reduced with some withdrawing from the scheme for various reasons. Designs for the two farms remaining were presented by a local engineer (see Annexe 6).

For the first and larger farm (Ma Shigang), a biogas scheme was proposed with the gas used both for local domestic needs and for a small electricity generator. Some post digester treatment is included for the digestate in the form of an facultative lagoon. Overall investment costs are estimated as 117,000 USD for a farm of around 3,500 pigs equivalent to 33 USD per pig place.

COMMERCIAL - IN CONFIDENCE

For the second farm (Foling 3), a simpler scheme is proposed reflecting a much smaller enterprise (around 400 pigs). AD is again proposed but in this case, there is no electricity generation expected the gas being used directly for domestic needs. It is expected that the digestate will be landspread on local farms possibly using pump and pipeline technology for transfer purposes (up to 500 metres). It was noted that once digested, local arable farmers are much more ready to accept effluents on their fields.

Vietnam

Dr Chinh remains the project engineer and reported good progress on the developing scheme at Tu Duong village in Hay Tay province near Hanoi. Farms in the original study area in the south have been withdrawn from the scheme but a new group of 7 in the same area have been identified. These were presented at the Regional Workshop but not discussed in any detail. Only the study area in Hay Tay was visited during this mission.

The proposed scheme is summarised in an extract taken from a "mini PIP" in Annexe 7. This presents a scheme comprising three levels or 'types'. For the majority of farms in the village, a single centralised facility will be installed using part of a large existing pond. As part of the scheme, the existing (and very limited) drainage scheme will be extended using surface covered drains to bring most effluent to the proposed facility. This will comprise of a series of lagoons, the first being covered and used for the production of biogas for local distribution and use. Wastewater will be kept separate. Although as many as 200 households will be linked into the scheme, this may not involve more than 1300 pigs: with an investment cost of around 40,000 USD (mostly for the drainage channels) unit cost is expected as 30 USD per pig place.

Within the same village, there was one farmer with around 30 pigs who could not easily connect into the scheme for whom a traditional AS digester was proposed. Costs would be 670 USD for the installation. Separately in the same village, there is one cluster of three farms also not conveniently linked into the proposed scheme but having enough land for their own scheme. This follows a similar process of three connected lagoons, the first covered to enable gas collection for local domestic needs. Without the need for channels, the cost was 4000 USD for a scheme serving 350 pigs or 12 USD per pig place.

Detailed and comprehensive engineering drawings had been produced for all schemes and work is expected to start before the end of 2006.

2.2 Comments on the schemes as presented from each country

In addition to individual and specific feedback given to project engineers, some common information was presented as a formal lecture given at the Regional workshop (Annexe 8). There were four main messages given; in addition to these, Annexe 8 includes a worked example which was not presented owing to a lack of time.

The first message was to re-emphasise the overall objective of manure treatment within the scope of this project, *ie:* to reduce substantially the nutrient load (especially nitrogen, phosphorous and organic matter) from manure reaching surface water and thus rivers and estuaries. It is noted that offensive odour and especially the reduction of decease risks and the related hygiene and food safety issues were important local factors.

The second factor to be considered is one of mass balance concepts when considering the fate of the excess local nutrients. Of special note is that no system can accumulate nutrient for ever and that overall, what goes into a treatment system must be removed if it is not to become a source of pollution. Concerning the design of appropriate systems, guidelines were given including crucial constraints on cost and minimal performance. Finally, an evaluation framework was proposed to assist in the selection of suitable technology.

Schemes for Thailand

- The central importance of AD as part of any manure management investment (including electricity production) is clear. However, it is unlikely to be suitable for all farms, especially smaller units. Some none-AD options should be kept open such as composting and the production and export of manure products.
- The AD scheme proposed for the KOS farm is a strong option given the farm size (10,000 pigs) and availability of land and lagoons within the farm boundary (and arable land in the local area). This is quite likely to pay for itself as indicated but some additional note needs to be made for maintenance costs and especially the replacement costs of equipment.
- Optional collection (and drying of dung) but unlikely to account for more than 10% of the solids produced. Value of sales of dried dung noted. However, as maximizing gas production is important, perhaps everything should be directed to the digester. On the basis of bags of 25 kg of dried dung for sale. Then following the calculations set out in the next section, the equivalent as electricity savings can be calculated thus: the same bag has 15 kg VS producing 4,500 litres of biogas equivalent to 47 kWh_t equivalent to 9 kWh_e units worth 27 Baht @ 3 Baht per unit. Thus keep selling the bags of dry dung if price is more than 25 Baht per bag!
- The lagoon treatment of the AD digestate represents current technology which is suitable for such farms with plenty of space. The wetland and polishing stages are only necessary if discharge to the local stream is planned; easier to irrigate to local fields.
- Value put against recycle water seems optimistic.
- Some note needs to be made of the collection and removal of the accumulated sludges which will include most of the phosphorous load.

- In economic terms, the proposed scheme of the Sa-ard farm is not so strong as the farm is smaller and there is a serious shortage of available land at the farm. However, if electricity is not generated, it seems very unlikely that all the gas produced (estimated as around 90,000 m^3 per year) could be used locally for heating and cooking. Alternatively, to reduce gas production in (the absence of electricity production), as much of the solids as possible should be collected and exported (sale or otherwise); in this case a mechanical separator would be appropriate but there is inadequate space for a full composting operation.
- Even with adequate aerobic treatment of the digestate, the phosphorous load will remain a problem. Treatment of the post AD digestate is may be avoided if land spreading option can be developed. Pilot schemes with neighbours should be developed to carry

out limited landspreading on an agronomic basis. Ensuring savings in chemical fertiliser can be expected to encourage participation of arable farmers so long as the scheme is carefully monitored.

- As with the KOS farm, periodic removal of accumulated phosphorus-rich sludge in the lagoons must be planned in with the option of possible sale to defray transport costs.
- As a general note, neither farm includes fish ponds which may be part of the management scheme with other farms participating in the project in the later phases.

Schemes for Guangdong, China

- It is clear that fish ponds need to form part of the manure management system in an integrated package. In both designs, the AD with have a role in reducing hygiene risks; a minimum residence time of 15 days should be observed.
- Questions remain on the overall nutrient balance: how much can the fish pond absorb, what proportion needs to be directed to fields. Excess application even of a digestate can be expected to reduce the availability of oxygen.
- Collection and exportation of solid dung remains justifiable for the smaller Foling farm but for the larger scheme at Ma Shigang, it would be better to direct all material to the digester to maximise biogas production.
- For the Ma Shigang farm, post digestate treatment might also include removal of solids (by separator) and combination with vegetable wastes, removed sludges and/or straw in a compost scheme. As such, a large part of the nutrient surplus could be exported from the farm with sales covering related costs. The nutrient requirements of local orchards and vegetable fields can be expected to represent only a small proportion of the total manure produced.
- As a general note, surface aerators are not particularly energy efficient; alternatives such as bubbler systems (reported as three times more efficient) may be considered. In any case, some treatment benefit can be expected with regular aeration of ponds.
- Currently there is still some demand for biogas in rural China but for the larger farm, the amounts produced from AD is still likely to exceed farm and local domestic needs. Where electricity production is not required, the use of AD may cause the problem of excess biogas production: alternative uses around the farm still need to be explored.
- It is noted that rigid wall digesters are preferred in the designs put forward: covered lagoons may be considered as an alternative if investment costs become too high.
- For the Foling farm, the numbers of animals are too small to justify electricity production. However, local farms cover enough area to receive the digestate for land application. One purpose of AD is thus to enable this by building confidence with the local farmers in terms of hygiene matters. The option of pipeline transfer was discussed during the field visit - over short distances (< 400m) this is likely to be a strong option in keeping transport costs low.
- For the smaller farm, the use of biogas beyond that for domestic use locally remains unclear. Surpluses may need to be flared off to avoid methane emissions but better to look for constructive uses.
- More generally, the sustainable disposal of the sludges periodically removed from the drained lagoons needs to be explored further.

COMMERCIAL - IN CONFIDENCE

Schemes for Vietnam

- Provision of a centralised facility and the collection of piggery effluents from a large number of small (<100 pigs) farms within a village, will inevitably for a crucial part of any proposed scheme. This is best achieved by covered drains as proposed if costs can be covered.
- The broad policy is sensibly one of community schemes except where larger farms are common where individual or cluster schemes are appropriate as proposed.
- For longer distances pipeline transport may be considered as a cheaper option than surface drains or the use of smaller local schemes where practical.
- A series of comments were made on the engineering drawings made available during the visits. These included: note on risk of flooding from long runs of surface channel - good surveying necessary to avoid dips; inspection pits large enough to allow easy cleaning; entry point for the lagoons on side (rather than corner) - better multiple points (to avoid problems from build up of settled sludge need feed point); contour base of lagoon - deeper near entry point; increase diameter of underground feed pipe to 300 mm.
- Programme of sludge removal from lagoons every 2 to 4 years with an organised application to arable land. As with other schemes discussed above, the accumulation of a settled layer represents the temporary destination of much of the phosphorous content. Subsequent option of community compost schemes including the recovered sludge and separated fibre.
- The use of lagoon liners needs to be carefully considered; are they necessary in all cases? Biological activity under liners can lead to the formation of "whales" where the detached liner inflates and reduces the capacity of the lagoon.
- Irrigation of the final effluent on to fields; the value of the nutrients will be small but not insignificant; some estimation of crop needs important.
- Use of biogas; the current local demand of a large number of houses in the vicinity of the centralised scheme should be enough to take all the biogas produced. So long as this is the case, electricity production is probably not justified for a total of fewer than 1500 pigs. For large farms and clusters located further away from housing, electricity production may be considered.

2.3 Discussion on the role and scope of biogas

The high expectations on biogas require some basic analysis to identify realistic options.

One pig of 50 kg live weight typically produces 4 kg of dung per day with 10% dry matter.
Taking 70% of the solids as volatile gives 0.7 x 0.1 x 4 = 0.28 kg VS per day
Published figures for biogas production covers a range of 150 to 600 litres gas per kg of VS present in the animal wastes (Burton and Turner, 2003). The median value for pigs is 400.
Assume digestion efficiency of 75% of the available substrate: 300 litres/kg VS present.
Thus anticipated gas production is thus 300 x 0.28 = **84 litres per day per pig**

Thermal energy of *pure* methane is around 53 MJ/kg
Biogas at 60% methane will thus have a calorific value of around 32 MJ/kg
Biogas density is around 1.2 kg/m^3; calorific value is thus **38 MJ/m^3**

One kWh = 3.6 MJ hence 1 m^3 of biogas energy = 10.5 kWh units ***thermal***

Daily thermal energy production = 0.084 x 10.5 = **0.9 kWh_t** units per 50 kg pig per day
In SE Asia, the biogas from the manure of 10 pigs (around 840 litres per day) is adequate to meet domestic needs of one household.

Electricity generation implies a conversion factor reflecting both "Carnot efficiency" and system efficiency. Range of 15 % for small engines to 30% for larger generators. Take a figure of 20% for farm installations.

If **all** the biogas if available for electricity production = 0.2 x 0.9 = **0.18 kWh_e** units per 50 kg pig per day (Equal to a monetary value of @ 8 cents/kWh_e unit of 1.5 cents US per day)
Which is equivalent to 0.18/24 = **0.0075 kW** *continuous* electricity production.

Thus for a farm of just 1000 pigs, one might expect continuous power output of up to 7.5 kW with a savings value of up to 15 USD per day or 5,400 USD per year. **Note**: if the electricity is to be *sold,* rather than reducing the farm bill, a lower price should be applied, say 4 rather than 8 cents US per kWh_e

Equipment and investment costs per pig falls with farm size. In conclusion, schemes for farms with fewer than 1000 pigs are rarely economic whereas as those with more than 10,000 can be expected to be successful. A "grey" area exists for farms with between 1000 and 10,000 pigs: the economic case will depend on the true local value of the electricity and or biogas produced and of the local costs of specialist services and resources.

2.4 What are the realistic options for pig farms in the region?

At the current time, it is unlikely that there will be widespread uptake of any manure management technology in SE Asia that implies other than a small cost to a farmer - and even that only applies if there is sufficient pressure from the implementation of environmental legislation. More generally, a farmer will expect a financial return for any investment he makes, even if modest. Schemes that both cost him for installation and then cost him per pig for operating will not be well received for the most part even if subsidized. Thus it is important to consider the financially practical options at least for the wider implementation of appropriate technology in the current situation.

Other than anaerobic digestion to produce biogas (and in some cases, electricity), there are three other options available that impact some economic benefit to the farmer:

1. Compost production
2. Use of manure to fertilise fish ponds (enhanced fish production)
3. Use of manure to fertilise arable crops (in place of bought chemical fertiliser).

In the case of compost production, the transport and sale of a standardised and valued product can clearly bring a return to the farmer for an investment in manure management schemes. There is a trade off in the extent of the operation and the value of the product produced: basic schemes for small farms can be expected to produce small amounts of a product of low value for local use. For the larger farmer, the bigger volumes of manure are likely to require transport over longer distances to find adequate markets to take all that produced. The extra transport costs will need to be covered and a higher quality product sold at a higher price would be justified. This in turn would require the inclusion of higher quality adjuncts such as rice straw itself implying a cost both for purchase and transport and the overall increase in the volume of compost produced. In any case, the export of manure products from a farm implies the removal of excess nutrients to be incorporated gainfully in arable agricultural operations.

The economic value of using manure in fish production lies with the value of the increased fish produced. On might equate manure used with the value of fish food that doesn't need to be bought in although this is rarely done anyway. In any case, it is a widely accepted practice that provides uptake of some (but not all) of the surplus nutrients. The treatment issues are principally those to improve hygiene and possibly to treat run off water to reduce its nitrogen content. AD and solar drying of collected solid dung fit in well especially if there is a local demand for biogas and organic material. Aerobic treatment has some application in supporting fish production (by increasing oxygen availability) and which thus may be directed to simultaneously allowing a degree of water treatment in a modified system configuration. The sludge periodically removed from the pond will be rich in phosphorous and thus potentially a soil improver but with minimal value unless transport is relatively easy.

Organised landspreading of manure and related farm effluents is not well developed in SE Asia although it offers the most extensive and sustainable long term solution to the problems of animal wastes. Potentially, it can offer some savings to the arable farmer in terms of a reduced purchase of chemical fertiliser if a structured regime is followed. This means a degree of assurance that crop requirements will continue to be met. As a means of disposal, manure effluents can be transported to local farms; fears of disease can be alleviated by AD treatment. However , in any case, little monetary value can be ascribed to such a scheme unless there is some saving in the existing purchase of chemical fertiliser products and even this will not benefit the livestock farmer.

The economic case of anaerobic digestion alone is easily made but in terms of impacts on the environment, the process alone is incomplete with all phosphorous and most nitrogen remaining in the digestate. Treatment does improve the acceptability for landspreading and in that, there is a possible route to enabling nutrient use in a constructive way. The central issue remains one of transport especially if suitable cropland is not available in the local area. In many cases, distances of more than 2 or 3 km will often rule out transport economically although still a practical option. In such cases, manure schemes are unlikely to pay for themselves unless the whole investment including the AD operation is treated as a single investment package.

3. SAMPLING STRATEGIES FOR SYSTEM MONITORING

3.1 Why and how should installed systems be monitored?

The requirements for technical monitoring covers three related areas. Firstly, monitoring can demonstrate that the implemented technology is producing, *on a local scale*, environmental benefits and that if this is scaled up to include many farms, there could be an overall marked improvement for the region. This is related to the concept of background measurements carried out prior to commencing with the project. For this, an ideal might be a farm currently discharging final effluent to a small river which is monitored up and downstream of the farm before and after the implementation of treatment technology. Otherwise, the scheme becomes more complex with broader environmental monitoring including groundwater sampling in the region combined with modelling. In such a case, a simpler approach may be to simply measure the release from the farm using an “end of pipe” concept to demonstrate a reduced impact.

Secondly, and more relevant to system engineering are monitoring schemes that ensure consistent and satisfactory operation of the installed system. This is to confirm that the system is operating as expected. Hence, this will include system measurements such as temperature, gas volume production, stream flowrates, pH and redox as well as a series of analyses of raw and treated effluent to demonstrate the expected removal of key components.

Lastly, there is the actual demonstration of the value of the system in meeting the project objectives (system performance). This concerns the overall effect of the system and it is only really concerned with what goes in, what accumulates and what comes out. Crucial is the related sampling plan for this which may well address some of the first two objectives as well. Representative sampling and the subsequent chemical analysis is necessary of both the raw effluent and of all the product stream(s). Flowrate measurements of each stream must also be made. Analyses may include some or any of a long list but minimally, forms of nitrogen, total phosphorous and organic matter. However, the frequency of analysis may not be the same for all depending on the variability of the component.

3.2 The central role of mass balances

This issues of mass balances have already been covered in a presentation reproduced in Annexe 8. When developing sampling schedules to confirm system performance, ir is crucial to allow for variability so not to be misled by temporary accumulation effects. Soil and wetland filters are a classic example where the initial performance seems excellent when considering only the treated water running out from the discharge end. The accumulation of nutrients in the system is not immediately evident but given time, once saturation is reached, the quality of the treated effluent can be expected to fall as the true performance of the system emerges. In some cases, given time, problems of blockage or of a developing sludge layer can bring a system to a crisis point beyond which it can not function without some remedial action.

A second consideration is the variability of the manure feed stream both in volume and concentration as one might expect from the normal seasonal changes in the farming and weather cycle. Numbers of animals and their mean size may also change throughout the year. Monitoring schemes needs to allow for this noting that a variable raw feed will produce a variable product at the discharge end but not at the same time! Most systems will produce a "lag effect" where a step change at the feed end is not apparent until some time later (which is often, but not always, related to the mean residence time).

To deal with these problems, it is important that system performance is assessed over a prolonged period following the principle of "how much is produced and where does it all go?" The total manure found to be generated by the livestock operation can be checked against farm records of numbers and size of animals over the study period; published figures can be used to estimate daily quantities of N, P and organic matter. This is compared to estimates of the same from the analysis of the manure products and waste streams. Typically, up to a third of the organic matter can be broken down to CO_2 and/or methane by the action of aerobic or anaerobic activity; the rest remains in the exported products or the effluent released. For nitrogen, losses either as ammonia or NOx gases can account for up to three quarters of the original amount but this leaves at least a quarter in the final streams. Phosphorous is not volatilised and the same amount as that produced by the animals should be expected in the exported and locally spread products of treatment.

3.3 Where and how frequently should effluent be sampled?

During the course of the workshop, there was a great deal of discussion various sampling plans that might be practical as well as keeping within budgets whilst meeting project objectives. This remains to be resolved. A presentation of minimal requirements is reproduced in Annexe 9. There are effectively three factors to consider: (a) how many sample points, (b) how many samples at each point and (c)what to analyse for. The example scheme given in Annexe 9 is proposed as typical of the minimum that permits a reliable analysis both in terms of covering *system* variability (eg: changing manure feed rates or composition) and to provide some confidence in the variability of the sampling and analysis itself. The second is a statistical concept and depends on the representativeness of the sample, the laboratory standards and the difficulty of the analysis itself. Some appreciation of variability of analysis can be found by repeated sampling (and analysis) from the same source. One might expect +/- 5% for dry matter but as high as +/- 30% for BOD.

Sample points should be the feed effluent, treated products and accumulation in sludge layers. The feed may be simple if everything goes to a single well mixed vessel otherwise samples and flow estimates are needed for each separate collection. Sludge sampling is not easy and it may be easier to do the occasional analysis and then to monitor the growing volume (depth) of that forming in the lagoon(s). Outflow of treated effluent is easily monitored but any solids or sludges removed along with composted products should be noted for the purpose of accounting for all key components.

Reactive organic matter is represented by BOD_5 but the more general COD is easier, cheaper and more reliable. Kjeldahl nitrogen (all forms except nitrates and nitrites) represents total nitrogen in most cases. Ammoniacal nitrogen like Kjeldahl ends up with a steam distillation procedure and is thus easier enough to add on as an analysis procedure to distinguish the reactive nitrogen component. Total phosphorous (rather than phosphates) clearly needs to be done although not an easy procedure. Total solids is not essential but so easy that it is usually worth including. Microbial faecal indicators such as coliforms can be included in system monitoring but the value is limited as they are bound to be present in most cases. Many of the pathogens are not reliably present. Specialist advice really needs be sought in this respect as the cost of many microbial procedures is relatively high and the true interpretation of the results produced may be obscured.

The recommendation as far as numbers of concerned are batches of four samples from each stream, once a month, analysing for COD, total phosphorous, Kjeldahl nitrogen and total solids. Once a month , one sample for BOD_5 and ammonia and pathogens. Use indicator sticks to check for nitrates and nitrites in treated streams only. Accumulated sludge samples once an month, one sample (or three samples once every three months) for phosphorous, Kjeldahl nitrogen, COD and total solids.

4. THE DECISION SUPPORT TOOL (DST)

4.1 Introduction - the expected role of the DST

Part of the development of the project is the provision of a set of decision support tools. A total of five are anticipated as set out in Annexe 4. Of concern here is that for the "*selection and technical validation of on-farm manure management options*". This will be developed over the first part of the project and will both serve (within the project teams) in the implementation of the later stages of the project and (outside the projet teams) for in the further capacity building beyond the project programme. Crucially, it needs to be a tool of the preferred form that meets the required technical content of the national project teams in their implementation of their duties within and beyond the project. The first stage of development will be the production of a report planned for end-2006 detailing recommendations on the scope and content for such a support tool.

4.2 Feedback from the workshop on the structure and form of the DST

Discussion with the technical representatives from each country at the Regional Workshop was stimulated by a series of questions on the form of the DST for manure management systems:

- Who would use it?
- What are the key questions asked when choosing a treatment system?
- What information is especially wanted?
- What format is preferred (excel, expert system, ….)
- What style - report, reference document, guide, FAQ, ….
- What level of detail is needed
- Any other comments at this stage?

The responses were generally positive and summarised as follows:

There was some concern that such tools may become prescriptive and thus present an unwelcome limitation on the project engineers. Thus such questions as "Are such tools really required" and "Who decides what is needed - the national project teams or the FAO" etc. It was clarified that the tools were an *optional* device to assist as appropriate in the selection and specification process. To further clarify, the role of the full set of tools expected under the project was explained.

It was emphasised that the intention was that the DST would apply to all technical aspects but that inevitably, it would be limited. The request was noted that to some extent tools should be country specific reflecting the differing local situation.

In response to questions on biological systems, it was noted that they can be difficult to design and variable in performance even if well set up.

Other requests of the content included:-

- provision of aids for promotion of management technologies to farmers and local people: eg: videos, illustrations, publicity
- inclusion of cost calculation models
- Inclusion of help routines. Noted that training is essential but this can also be in the form of a "self-teaching" program
- Analytical procedures such as checklists to identify problems on a farm and question and answer routines (eg: EXPERT analysis approach).
- Operation manual to support the sustainable running of the systems after the formal project is finished.

5. CONCLUSIONS

5.1 The objective of the project is the management of livestock manure to achieve the reduction of components that can pollute water (N, P and reactive organic matter) and the reduction of health risks and offensive odour.

5.2 However, the uptake of manure management in SE Asia seems unlikely even with stronger environmental legislation unless the farmers themselves can draw some clear benefit from the schemes.

5.3 There are four options that provide some degree of financial return: anaerobic digestion with the production of biogas and/or electricity; compost schemes and manure products; organised land spreading schemes onto growing crops (to enable some reduction of applied chemical fertiliser) and hygienic integration with fish ponds.

5.4 Although popular, AD schemes by themselves do not deal with the nutrient content on the effluent. However, it can provide a degree of treatment sufficient to enable the subsequent use in land spreading and in fish ponds.

5.5 Excess phosphorous can only be removed by the export of some of the solid products away from the farm. This includes that which can be expected to accumulate in the deposited layers in the lagoons.

5.6 For the large farms of Thailand, AD schemes producing electricity are envisaged with increased land spreading of the digestate on to growing crops. There is scope for the development and exportation of manure products including composts.

5.7 Many of the solutions in Guangdong will be based around fish ponds with some application of digestate to local fields. Farms tend to be smaller hence relatively few are likely to include electricity production but those with AD for gas production alone may have insufficient uses for the volumes produced. An alternative to explore may be the use of manures in the production of compost and manure products for export.

5.8 At present, biogas is still greatly used in Vietnam hence community biogas schemes for villages with many small farms seems the best strategy although the collection systems may present special problems. Community and small compost schemes may have a place but the demand for such material in the local area is unclear. Alternative uses for biogas may be worth exploring.

5.9 System monitoring is crucial to establishing satisfactory performance of the installed system. This needs to take into account the manure load to the system (in terms of N, P and organic matter) and to demonstrate the reduction achieved at the end of pipe. Validation by the demonstration of the fate of the removed components using a mass balance principle is an important principle which needs to also take into account the temporary accumulation of nutrients in settlement layers in lagoons and vessels.

COMMERCIAL - IN CONFIDENCE

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APPENDICES

1. Terms of reference document for Colin Burton
2. Schedule for project mission - October 2006
3. Agenda for the FAO Regional Workshop at the Thangloi Hotel, Hanoi - 17-19 October 2006
4. Decision support tools - detailed description
5. Farm site and proposed process description - Thailand
6. Farm site and proposed process description - China
7. Farm site and proposed process description - Vietnam
8. Technical considerations - presentation by C H Burton
9. Proposed sampling strategy for system validation - C H Burton

Annexe 1: Terms of reference document for Colin Burton

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E-Mail Address: FAO-RAP@FAO.ORG

RAP Ref GCP/RAS/203/WBG Your Ref.:

LIVESTOCK WASTE MANAGEMENT IN EAST ASIA

Terms of Reference for International Consultant
Animal waste management Engineer

Duration: 12 Months (50 working days, including 3 missions)

Duty Station: first mission: Thailand, Vietnam, and China (11 days), other missions to be arranged.

The 'Livestock Waste Management in East Asia' project is funded by the Global Environmental Facility (GEF) through the World Bank. The five year project is designed to assist China, Thailand and Vietnam; countries in which waste generated by rapidly expanding livestock sectors is causing significant environmental and public health concerns. The assistance includes waste management technology demonstrations, policy and regulatory development, monitoring of the outcomes and regional synergies and mutual learning. FAO is also a grant recipient under this project, with particular responsibility for providing regional support services, including decision support tools development and regional coordination and dissemination.

The Consultant will work under the overall supervision of the Regional Facilitation Office (RFO) in RAP and the specific technical supervision of the Livestock Policy Officer in HQ in close collaboration with the Project Management Offices (PMO) in the respective countries and their subject matter experts, the other project consultants and the farmers.

The consultant will provide technical support to countries to operate pilot schemes in the project's first year, to assist countries on environmental performance monitoring and to develop decision support tools for nutrient fluxes modeling. The study areas are Thailand (Rachaburi and Cholburi provinces), Vietnam (Ha Tay and Dongnai provinces) and Guangdong Province of China (Boluo County).

In each country, the responsibility of implementing component 1 and 3 is with the PMO and the consultant will play a support role. He/she should provide assistance responding to the PMO's needs and requirements while maintaining the objective of ensuring the technical quality of project activities and the comparability of the project's results across countries. His/her specific tasks are to:

- Assist countries to build and operate pilot schemes for farms included in project's first year.
  - Provide technical assistance to the countries to finalize pilot schemes' detailed construction plans. He/she will pay particular attention to the technical soundness of the plans, the discussion and agreement with farmers and the level of details of the plans that shall be sufficient to serve for biding.
  - Identify needs for technical capacity building among PMOs staff members, extension services and farmers and provide assistance to PMOs towards the preparation of training programs;
  - Provide technical support to the technical backstopping expert, especially for the finalization of detailed construction plans and operation of the pilot schemes. He/she will pay particular

attention to the technical soundness of the plans, the discussion and agreement with farmers and the level of details of the plans that shall be sufficient to serve for biding.

- Prepare guidelines for the development of a decision support tool on the technical validation and selection of on-farm manure management strategies. Specific tasks are to:
  - Be a resource person at the First Regional Workshop which will be held in Hanoi during 17-18 October 2006;
  - Lead a discussion on the decision support tool on “technical validation and selection of on-farm manure management strategies”, including the partners' needs, the basic components of the tool, and the practical arrangements for developing the tool (data supply, operational responsibility at country/province level, etc);
  - Prepare a report for use by FAO and project partners with detailed recommendations for the development of a decision support tool on “technical validation and selection of on-farm manure management strategies”, on the basis of the workshop results and work done during the project preparation phase.

Consultant Requirements

The consultant must have an advanced degree in agricultural and/or environmental sciences, 10 years of relevant experience in organic waste management engineering, and be willing to work with local consultant teams in all three project countries.

Reporting and Documentation

The consultant shall submit a back to office report to FAO within a month following completion of each mission, submit the report providing detailed recommendations for the development of a decision support tool by December 31st, 2006 to RFO and Livestock Policy Officer. The report shall be revised as needed.

Annexe 2: Schedule for project mission - October 2006

Livestock Waste Management in East Asia Project

Backstopping mission – Monitoring and Evaluation and technical design
9 to 19 October 2006
Final schedule

Day	Time	Meetings	Travels / Overnights
Sunday 8			Colin Burton's arrival in Bangkok (evening)
Monday 9	am		Pierre Gerber's and Harald Menzi's arrival in Bangkok (early morning)
	pm	Meeting with PMO at DLD *Discussions on technical design and policy*	Hong Lim Choi's arrival in Bangkok (evening) *Overnight in Bgkk*
Tuesday 10		GROUP A: Visit of KOS (Rachaburi); GROUP B: Visit of Saard farm (Cholburi).	*Overnight in Bgkk*
Wednesday 11	am	Meeting with PMO at DLD *Discussions on Monitoring and Evaluation*	
	pm		CB, HM, HLC, PG: Travel to Guangzhou *Overnight in Guangzhou*
Thursday 12	am	Meeting with PMO in Yanzhou township *Discussions on technical design and policy*	CB, HM, HLC, PG: Travel to Yanzhou township
	pm	Meeting with PMO in Yanzhou township *Discussions on Monitoring and Evaluation*	*Overnight in Yanzhou township*
Friday 13	am	GROUP A: Review of Monitoring capacities GROUP B: Farm visits in Yanzhou township	
	pm		CB, HM, HLC, PG: Travel to Hanoi (evening) Kurt Roos' arrival in Hanoi (evening) *Overnight in Hanoi (as all following nights - hotel changes on Monday!)*
Saturday14	am	Meeting with PMO at MONRE *Discussions on technical design and policy*	
	pm	Meeting with PMO at MONRE *Discussions on Monitoring and Evaluation*	
Sunday15	am	Internal meeting / WS preparation	Gerrit Jan Carsjens' arrival in Hanoi (noon)
	pm	Internal meeting / WS preparation	
Monday 16	am	GROUP A: Review of monitoring capacities GROUP B: Visit to Thuong Tin district, Ha Tay province	
	pm	Internal meeting / WS preparation	
Tuesday 17		Regional WS	
Wednesday 18		Regional WS	
Thursday 19		Regional WS (am) + RCG (pm)	

Annexe 3: Agenda for the FAO Regional Workshop at the Thangloi Hotel, Hanoi - 17-19 October 2006

GEF LWMEA project
Combined Regional Workshop & RCG Meeting
October 17-19 2006, Hanoi

Agenda

Tuesday 17 October

8.30 – 9.00	Introduction: *Regional Facilitation Office (RFO)*
9.00 – 9.30	Introduction of participants
	Session 1: Technology demonstration
9.30 – 10.00	Introductory remarks: *Colin Burton*
10.00 – 10.30	Country discussion: China - Current status and planned activities for 1st year's demonstration sites: *Project management Office (PMO) China* - Observations arising from backstopping mission: *Colin Burton, Hong Lim Choi* - Plenary discussion
10.30 – 11.00	Coffee brake
11.00 – 11.30	Country discussion: Thailand - Current status and planned activities for 1st year's demonstration sites: *PMO Thailand* - Observations arising from backstopping mission: *Colin Burton, Hong Lim Choi* - Plenary discussion
11.30 – 12.00	Country discussion: Vietnam - Current status and planned activities for 1st year's demonstration sites: *PMO Vietnam* - Observations arising from backstopping mission: *Colin Burton, Hong Lim Choi* - Plenary discussion
12.00 – 12.30	Plenary discussion
12.30 – 14.00	Lunch
	Session 2: Environmental monitoring
14.00 – 14.20	Current environmental monitoring plan in China: *PMO China*
14.20 – 14.40	Current environmental monitoring plan in Thailand: *PMO Thailand*
14.40 – 15.00	Current environmental monitoring plan in Vietnam: *PMO Vietnam*
15.00 – 15.45	Presentation on Environmental monitoring: parameters, methodology, capacities and data management: *Hong Lim Choi and Harald Menzi*
15.45 – 16.00	Coffee brake
16.00 – 17.00	Plenary discussion led by *Hong Lim Choi and Harald Menzi*

Wednesday 18 October

Session 3: Decision support tools and capacity building needs

8.30 – 8.45	Introduction: *RFO*
8.45 – 10.00	Group A. Nutrient fluxes and Manure management strategies: Discussion led by *Harald Menzi and Colin Burton* Group B. Spatial planning: Discussion led by *Gerrit-Jan Carsjens*
10.00 – 10.30	Coffee break
10.30 – 12.30	Group A (continued). Nutrient fluxes and Manure management strategies: Discussion led by *Harald Menzi and Colin Burton* Group B (continued). Spatial planning: Discussion led by *Gerrit-Jan Carsjens*
12.30 – 14.00	Lunch
14.00 – 15.00	Group A and group B presentations followed by general discussion
15.00 – 15 30	Use of PHRD grant: *Kurt Roos*
15.30 – 16 00	Coffee break
16.00 – 17.00	Capacity building needs: Discussion led by the *RFO*.

Thursday 19 October

Session 4: Policy and replication strategy development

8.30 – 8.40	Introduction: *RFO*
8.40 – 9.00	Planned activities in China: *PMO China*
9.00 – 9.20	Planned activities in Thailand: *PMO Thailand*
9.20 – 9.40	Planned activities in Vietnam: *PMO Vietnam*
9.40 – 10.00	Presentation on policy and replication strategy: *RFO*
10.00 – 10.30	Coffee break
10.30 – 11.00	Plenary discussion on Policy and Replication strategy led by *RFO*.

Session 5: Communication

11.00 – 12.00	Communication strategy; Internal and external communication: Proposal by *RFO* Discussion
12.00 – 12.30	Closure
12.30 – 14.00	Lunch
14.00 – 17.30	**Regional Coordination Group Meeting**

Annexe 5: Farm site and proposed process description - Thailand

Extracts from Annex 2 of the Project Implementation Plan
Waste management technologies options for first-year demonstration farms

2. Demonstration farms

KOS Farm

General Information

1. Farm location
   This farm is surrounding with the paddy field and space land. Total farm area is 100 rai (1 rai equal to 1,600 square meter). There are 18 pens or feeding hosing.
2. Number of pigs
   Twenty boars, 1,200 Sows, large fattening pigs 4,500 units, medium fattening pigs is about 2,500 units, weanling pigs is about 2,000 units and small is about 1,000 units.
3. Water consumption
   Daily water consumption is about 450 cubic meter where the water pump from deep well. There was no shortage of water during dry or summer season.
4. Waste management
   Daily wet manure was collected about 1,000 kg per day. All solids manure will be sun dry before sale to farmer for paddy field grow.
   Waste discharge from water toilet that was drained for every 2 or 3 days. Pen will be cleaned by flushing water for twice a day. All waste water was discharged to receiving open concrete gutter and gravity flow to receiving pond (currently appeared as anaerobic pond). After anaerobic pond, there are 3 ponds in series which total receiving area is about 8 rai (12,800 square meter) with about 3 meter depth. Total holding capacity is about 38,400 cubic meter. There is more 20 rai available for waste treatment system.
5. Farmer requirement and intention
   Farmer wants to have a proper waste treatment system and reuse the treated water. Biogas from treatment system is required for electricity generation. Farmer will improve their solids manure collecting system and try to collect more volume.

Proposed Treatment Strategy

1. Consider for the following issues ; Requirement of electricity generating from biogas, availability of land, low operating and maintenance cost and existence of ponding system. Proposed plan for KOS farm is similar to Kanchana farm.
2. Cover lagoon should be the most suitable treatment unit to meet the above mentioned. Construction is easy, because it is only the earth pond and cover with PVC or HDPE sheet to collect the producing biogas.
3. Because the effluent after cover lagoon still contain the organic load including phosphorus and nitrogen. So the post treatment is required.
4. Anaerobic pond is the unit after the cover lagoon. The advantage is the anaerobic pond can stand for fluctuating load. Treating efficiency is not high but good to have before the aerobic system.
5. Series pond of facultative, wet land and polishing pond will be provided. Expected treated water quality is to meet the standard.

Construction Plan

1. Site survey will be done, layout will be arranged. Land contour or leveling will be provided as need. Civil engineer will evaluate for a requirement of retaining wall to protect the land slide during construction. It will be provided as recommended.
2. Preparation for pond modification. See fig. 2 for the existing ponds lay out. Fig.3 for the proposed modified pond layout.
3. Collecting tank will be constructed near the existing collecting pit.
4. Cover lagoon will be located on the free land near the breeding house. Two units of cover lagoon will be offered for flexible operation.
5. New anaerobic pond will be constructed next to the cover lagoon..
6. Then, all existing ponds/lagoons will be re-shape for facultative, wet land and polishing pond. Pump out of water, de-sludge, soil excavation and filling with compact will be done to meet design dimensions.
7. Inter connecting piping will be provided between ponds.
8. Waste collecting piping may have to re-route to the design collecting tank.
9. The control housing will be constructed near the cover lagoon. Gas pipe will be routed to the control housing where gas purify unit will be provided before delivery to the biogas engine.
10. The biogas engine will be installed in the control housing. Two units of engine will be provided. Operation will be one working one standby basis. Alternating run for every 12 hours.

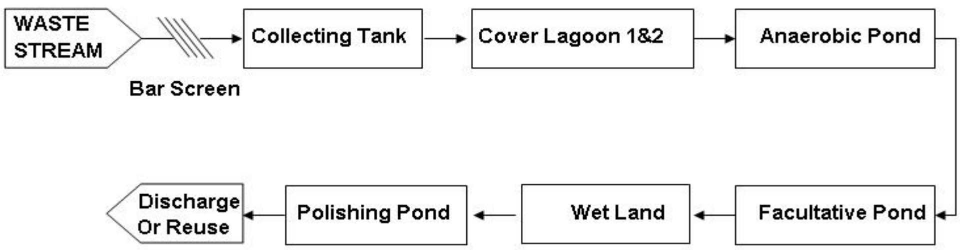


Fig 1. Proposed Waste Treatment Diagram for KOS Farm

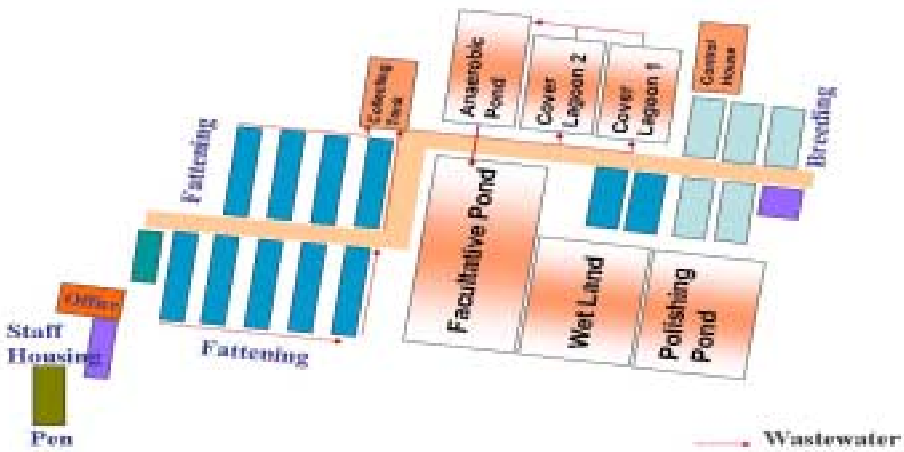


Fig3. Proposed Plan Layout for KOS Farm

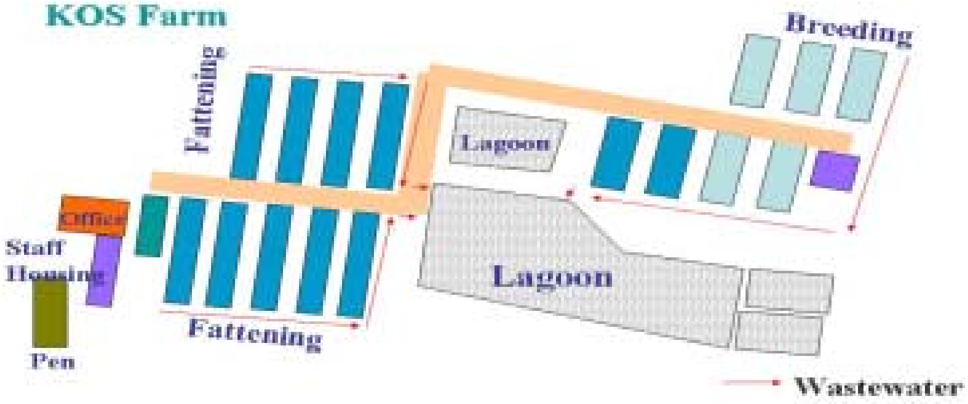


Fig2. Existing Plan Layout for KOS Farm

Table 2.2: Summation cost: KOS Farm, Ratchaburi

Expense		Baht	Baht per year	Total (baht)
Investment for construction		8,410,279		
Operating cost				
	Equipment maintenance		389,000	
	De-sludge		31,000	
	Electricity		125,552	
	Total			545,552
Revenue				
	Electricity		1,624,980	
	Solids manure		393,600	
	Digested sludge		23,000	
	Reuse water		219,000	
	Total			2,260,580
Balance				1,715,028

Sa-ard Farm

General Information

3. Farm location
   North of farm is closed to poultry farm. Local school is in East where South and West are village. Total farm area is 13.3 rai (1 rai equal to 1,600 square meter). There are 12 pens or feeding hosing with total area 11,200 square meter.
4. Number of pigs
   Ten boars, 300 Sows, large and medium fattening pig is about 1,200 units each and small (weanling) is about 300 units
3. Water consumption
   Daily water consumption is no record so estimation will be based on 0.45 liter per kg pig. Water sources are from ground water and nearby surface reservoir. In summer or dry season when water is shortage, farmer will take water from the large reservoir where it is a little bit far from farm..
4. Waste management
   Daily wet manure is collected with no record. All solids manure was kept in collecting house and distribute to farmer, neighbor for fish feed and use as fertilizer in paddy field.
   Waste discharge is from pen flushing. Pen will be cleaned after collected solids manure every 1-2 days. All waste water is discharged to open concrete gutter and gravity flow to public wastewater discharged channel. Then all wastewater will flow down to large reservoir. Besides solids manure collection, there is no any waste treatment in this farm.
   Farm has an area to construct a waste treatment system about 4,800 square meter. At the present time, Farmer had dug three ponds in this area where can be adapted for ponding system.
6. Farmer requirement and intention
   Farmer wants to have a wastewater treatment system to protect the environmental. Biogas from treatment system is required for heat stove and electricity generation. Farmer will improve their solids manure collecting system and try to collect more volume.

Proposed Treatment Strategy

6. Central treatment system may have many difficulties to proceed. Because TOU has capability not enough to manage and showed less intention to involve in this project. The problem is too complicated to explain. Only selection that we can do is on site treatment.
7. Because biogas is required so considering treatment systems should be anaerobic. There are several type of anaerobic to goal this target such as anaerobic ponding system, anaerobic fixed or floating dome digester, up flow anaerobic sludge blanket or anaerobic filter.
8. Considering in term of investment , it seems to be that ponding system is a good selection for low construction cost.
9. Operation and maintenance, ponding system is also required minimum operating attention and maintenance. The only required is de-sludge from the pond for every 3-5 years. Digested sludge may send to sun dry or use as fresh for farming as fertilizer.

10. Availability of land, Sa-ard farm has provided 4,800 square meter to construct the treatment system where three ponds were dug there and now is no function for treatment.
11. At the present time, cover lagoon should be the most suitable treatment unit to meet the above mentioned. Construction is easy, because it is only the earth work and cover with PVC or HDPE sheet to collect the producing biogas.
12. Because the effluent after cover lagoon still has high organic load including phosphorus and nitrogen. So the post treatment is required.
13. Due to the land constrain, post treatment by anaerobic treatment would require more space as compare with aerobic system. Considering for existing conditions such as existing pond at site and investment. Aerated lagoon would be a selected system and possible to adapt from the existing pond. Required energy for aerator will be from the biogas engine. However, the settling pond will be constructed after cover lagoon to pre-settle the suspended solids that may remain in the effluent and lower loading for aerated lagoon.
14. Final settling will be provided after the aerated lagoon to remove and settle the solids before discharge to public drain or reuse by pumping system.
15. Proposed treatment diagram is in fig. 1

Construction Plan

11. Site survey will be done, layout will be arranged. Land contour or leveling will be provided as need. Civil engineer will evaluate for a requirement of retaining wall to protect the land slide during construction. It will be provided as recommended.
12. Then, remaining water in all ponds will be pumped out and do sun dry before proceeding the earth work.
13. Preparation for pond modification. See fig. 2 for the existing ponds lay out. Fig. 3 for the proposed modified pond layout.
14. Collecting tank will be constructed with bar screen at the waste accumulating point. Transfer pump may need to transfer flow to the treatment system.
15. The existing pond 1 and about half of the pond 2 will be adapted to the cover lagoon. Soil excavation, filling and compaction is required for this modification. Excavation will be for re-shape and depth adjust of the pond to meet the designed value. Filling and compaction is for construction of pond edge and new bank.
16. The remaining half of the pond 2 will be modified for the settling pond 1. Excavation, filling and compaction of soil will be done to meet the designed pond size. The remaining space near pond 2 will be constructed for the control house to install the biogas engine.
17. Aerated lagoon will be constructed on some part of the pond 3. So excavation, filling and compaction of soil will be done to meet the designed pond size.
    After pond bank and slope was compacted, mortar lining would require to prevent the bank erosion caused by aeration waving. Floating low speed aerator will be selected to install in the lagoon.
18. The settling pond 2 will be located after aerated lagoon. With same process, excavation, filling and compaction of soil will be done to meet the designed pond size.
19. Then pump house will be provided for discharge pump installation. Because the outlet point level is lower than the public discharge channel or reuse point at the farm. So pumping station is required.
20. All piping will be installed between interconnecting pond and route to discharge or reuse.

21. The manure house will be maintained if there is no obstruction or damage during construction period.
22. The biogas engine will be installed in the control housing. Two units of engine will be provided. Operation will be one working one standby basis. Alternating run for every 12 hours.

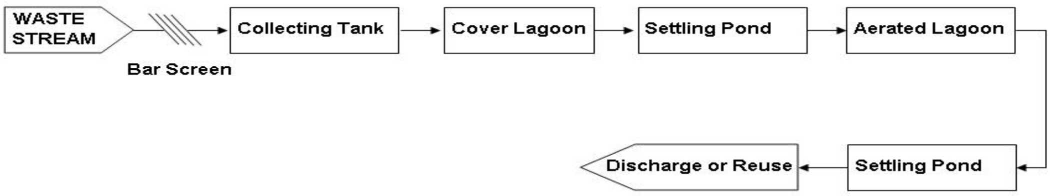


Fig. 1 Proposed Waste Treatment Diagram for Sa-ard Farm

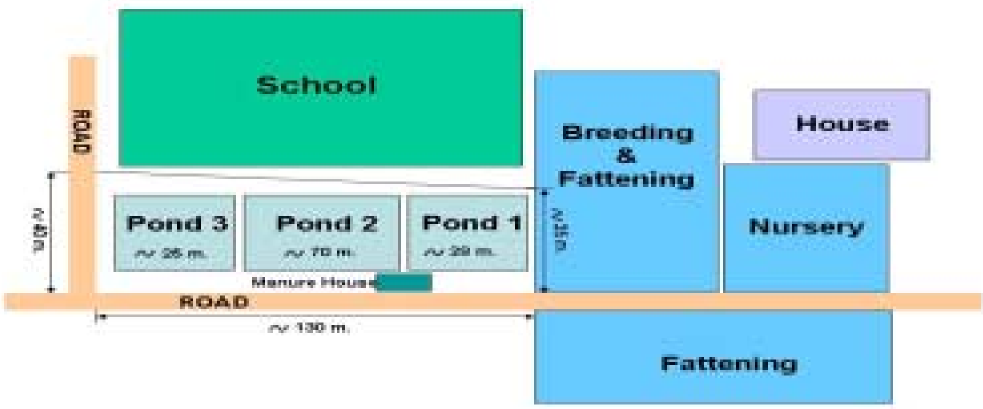


Fig.2 Existing Plan Layout for Sa-ard Farm

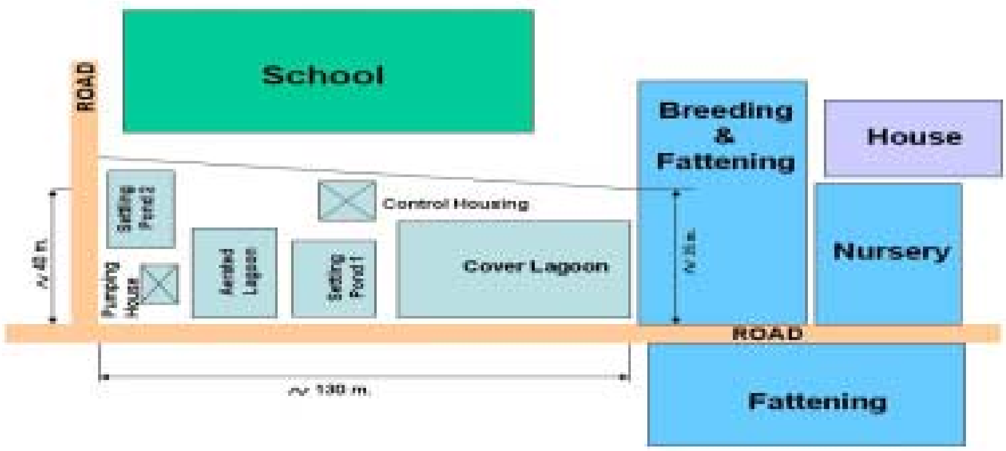


Fig.3 Proposed Plan Layout for Sa-ard Farm

Expense		Baht	Baht per year	Total (baht)
Investment for construction		4,854,952		
Operating cost				
	Equipment maintenance		218,000	
	De-sludge		16,400	
	Electricity		164,972	
	Total			399,372
Revenue				
	Electricity		613,200	
	Solids manure		50,000	
	Digested sludge		6,400	
	Reuse water		54,750	
	Total			724,350
Balance				324,978

Table 2.3: Summation cost: SA-ARD farm , Chonburi

Proposed Treatment Strategy (option with no aerated lagoon)

1. To reduce the operating cost from electricity charge by using aerator, post treatment will be facultative pond with the final storage pond.
2. Proposed treatment diagram is in fig. 4

Construction Plan (option with no aerated lagoon)

1. Similar to the above plan but facultative pond and final storage pond will be constructed instead of settling pond 1 &2 and aerated lagoon.
2. Preparation for pond modification. See fig. 5 for the proposed modified pond layout.

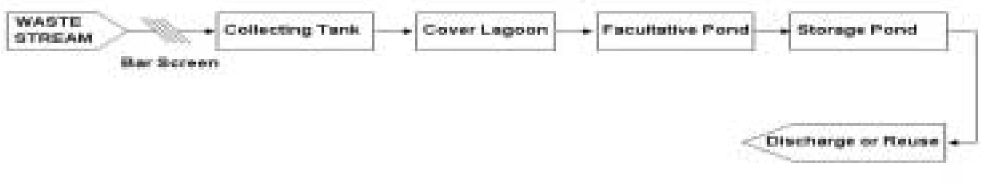


Fig. 4 Proposed Waste Treatment Diagram for Sa-ard Farm (Option)

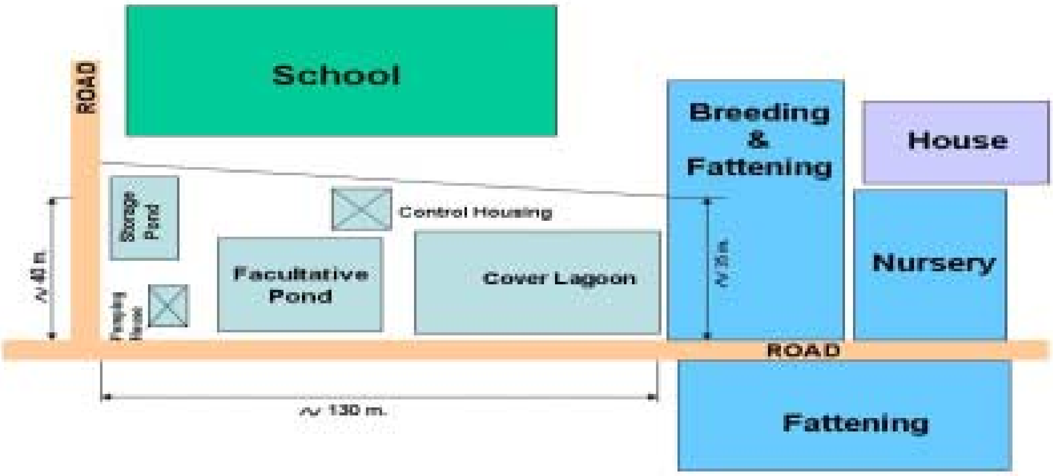


Fig.5 Proposed Plan Layout for Sa-ard Farm (Option)

Table 2.4: Summation cost (Option): SA-ARD farm , Chonburi

Expense		Baht	Baht per year	Total (baht)
Investment for construction		4,359,400		
Operating cost				
	Equipment maintenance		188,000	
	De-sludge		43,900	
	Electricity		66,422	
				298,322
Revenue				
	Electricity		613,200	
	Solids manure		50,000	
	Digested sludge		6,400	
	Reuse water		54,750	
				724,350
Balance				426,028

Annexe 7: Farm site and proposed process description - Vietnam

Extracts from:-

Livestock Waste Management in East Asia Project
Mini project implementation plan for Hatay province
Tu Duong village, To Hieu commune, Thuong Tin district, Ha Tay province: 19/10/2005

1. General information of demonstration site

1.1. Location, geographical position:
Duong Tu village, To Hieu commune, that is nearby national road number 1A, the Northern part bordered with Thang Loi commune, the Western part is nearby Nghiem Xuyen commune, the Southern part bordered with Van Tu commune, the location of Duong Tu village is very comfortable for the model propagandation and announcement to the areas in around.

1.2. Population:
610 households containing 2.400 persons.

1.3. Data of climate:
a) Average of rain per year: 1690 mm/year.
b) Average of temperature per year: 23,5^{o}C
c) Average of humidity per year: 84%

1.4. Animal diseases and Public health:
So far, Ha Tay province do not have specific survey of each village or commune, therefore some survey information bellow have been collected at district level.
a) Animal diseases in Thuong Tin district, Ha Tay province
Livestock production in family farms, small size, scattered farms and when animal disease breakout, the farmers don't want to inform ate Sub department and Government about that because the reparative policy for sick animals dissatisfactory so that they often treated themselves or sale off. The date of Sub Department animal health is not really (lower than on fact)

Table 1 The infected rate of pig in Thuong Tin and 5 villages

Disease	Red delta *	Ha Tay**		Thuong Tin***	
		cases	(%)	cases	(%)
Hogcholera	9,2	88 000	8,2	2450	2,6
pasterellera	17,0	16 8000	14,0	1955	2,1
salmonellosis	15,6	144 000	12,5	872	0,95
E.coli	-	121 000	11,0	3197	3,5
leptospirosis	5,6	39 000	3,6	2937	3,2
internal parasite	9,9	130 000	12,5	9363	10,2
A.suum	-	165 000	15,1	11475	12,5

*Source: * IFPRI, ASPS-Danida and ICARD, 2001* *b) Public health in Ha Tay – Thuong tin*

Table 1: the number of infected people cases was discovered

diseases	2002		2003		5 months of 2004	
	Ha Tay	TT dist	Ha Tay	TT district	Ha Tay	TT district
Poisoning food	174	73	213	7	41	1
E.coli	63	49	136	12	0,00	5
Salmonella	10	5	47	0,00	23	0,00

Source: Center of Venerology, Center of Preventive Medicine, Center of Eyes, Center of Protective Mother and Children province.

In the reports of villages: food born diseases rate < 1% total population, cause of E.coli 12%, salmonella > 90% , gynaecology diseases 46,5 –47%, and interparasite 30 –33,2%

1.5. Total of pigs:

The total number of pigs in whole village in 2004 is about 1.500 pigs.

1.6. Ground water level:

- In summer: depth of ground water level is about 2 m
- In winter: depth of ground water level is about 4 m

3. Proposal treatment system and cost estimate

a) Type I: (The Biogas vault for two separated households)

- Fixed Dome Digester (or other name is Chinese Digester): This is a biogas vault form was designed by the Chinese sample. The bricks and cement mortar are materials for making this type of vault. The vault is build underground by the cylinder sharp and have an arch cap (this cap can be easily open and close but very airtight). In the design, there is an existing pipes for the biogas that generated in the vault. This pipe system leading gas to the stoves, ovens or lighting purposes.

- In the Tu Duong village, this type of biogas vault has been applying proposed for 02 households that are Mr. Hoc and Mr. Hong. Capacity of the vault is about 8 to 10m^3 and most of biogas generated will be used for the cooking activities.

Table 3: Estimate cost for 1st type

System Summary - On-farm #1 Mr. Hoc	
Farm Type: Finish	
Proposed Process Train: 8m3 Chinese digester Gas Use: Cook Fuel	
PROJECT COSTS	
8m3 Chinese Digester	$667
Total	$667
Contingencies	$0
Total	$667
Cost/pig	$22

ENERGY & CARBON REDUCTION		
Est. Cooking Gas Available at Capacity	9	People
kWh/hr	0.18	
Methane MT/year	0.37	
CO2 MT/Year	8	
CE/MT Year	2	

System Summary - On-farm #2 Mr. Hong		
Farm Type: Finish		
Proposed Process Train: 8m3 Chinese digester Gas Use: Cook Fuel		
PROJECT COSTS		
8m3 Chinese Digester	$667	
Total	$667	
Contingencies	$0	
Total	$667	
Cost/pig	$33	
ENERGY & CARBON REDUCTION		
Est. Cooking Gas Available at Capacity	6	People
kWh/hr	0.13	
Methane MT/year	0.26	
CO2 MT/Year	6	
CE/MT Year	2	

b) Type II: (for three close together households)

- It was proposed building a dung processing system for the **three** close together households (Mr. Ca, Mr. Vuong and Mr. Hat)

- The designed system included: one cover lagoon (the size is based on the statistics data on the pig heads of these three households), the bottom of this cover lagoon was lining by the thin polyetylene layer, the cover lagoon is also roofing by polyme sheets (it can be polyme sheets which imported from America) and with high durable. This system must be operating in the closed medium so could accumulate the biogas that can supply for the cooking activities by the pipe system.

- The waste water from Cover Lagoon should be lead to the next system is Storage Pond that have a bottom covered by thin polyetylene layer. Here the waste water is continue processing and deposit.

- Finally, the waste water after processing in the Storage Pond is running to the pipe system that serve for the irrigating.

Table 4: Estimate cost for 2^rd^ type

System Summary - Cluster Farm (3 families)
Farm Type: Finisher (some sow)
Proposed Process Train: Lined covered lagoon w/ solids extraction - lined storage pond
Gas Use: distributed cooking fuel

LAGOON VOLUME AND SURFACE AREA		
Volume	13691	Cu. Ft.
Surface Area	1200	Sq. Ft.
Storage Volumes	0	Cu. Ft.
COST INPUTS	**US $'s**	
Screen Separator Installed (3,000 SPP)	na	
Concrete m3 poured	na	
Cover Cost/Sq. Ft Installed	1	
Lagoon Excvation Cost m3	$3	
Liner Cost/Sq.Ft. Installed	$0.40	
Gas distribution System	$30	
Irrigation????	$0	
Under Roof Settling Basin - Geomembrane/Sq. Ft.	$3	
PROJECT COSTS		
Seperation - Settling Basin	$0	
Construct New Fenced Lagoon	$1,292	
Lagoon Cover	$1,200	
Lagoon Liner	$1,152	
Gas distribution System	$30	
Canals	na	
Effluent Storage	$337	
Irrigation Tractor Tank setup	na	
Fish Ponds in Series	na	
Total	$4,011	
Contingencies	$0	
Total	$4,011	
Cost/pig	$12	
ENERGY & CARBON REDUCTION		
Est Cooking Gas Available	99	People
kWh/hr	2	
Methane MT/year	4	
CO2 MT/Year	86	
CE/MT Year	24	

c) Type III: (Village system that concentrated processing for about 200 livestock breeding households)

- This is a system processing the waste dung from breeding activities for about 200 households that was closed together with estimated 1200 to 1300 pigs.

- The water and pig dung from these 200 households has been leading to the common system then running to the big vault that have a fences around covered lagoon, with the bottom covered by a thin polyetylene layer and roofing by polyme sheets. The waste water from covered lagoon should leading to the irrigated system and continue deposit processing in about 10 days then pouring to the fish pond or irrigating.

- The water use for cleaning pigsties and pig dung will be build separately with the drainage system.

- From the covered lagoon processing system will be installed a leading biogas to the each households and serve for the cooking purposes.

Table 5: estimate cost for 3rd type

System Summary - Centralized Village Digester Project		
Farm Type: Multiple		
Proposed Process Train: Lined covered lagoon w/ solids extraction - settling basin/step dam - lined storage pond Gas Use: Distributed Cook Fuel		
LAGOON VOLUME AND SURFACE AREA		
Volume	56983	Cu. Ft.
Surface Area	5700	Sq. Ft.
Storage Volumes	0	Cu. Ft.
COST INPUTS	**US $**	
Screen Separator Installed (3,000 SPP)	na	
Concrete m3 poured	$80	
Cover Cost/Sq. Ft Installed	$1	
Lagoon Excvation Cost m3	$3	
Liner Cost/Sq.Ft. Installed	$0	
Flare + Gas Meter/handling	$0	
Irrigation????	$0	
Under Roof Settling Basin - Geomembrane/Sq. Ft.	$3	
PROJECT COSTS		
Seperation - Settling Basin	$0	
Construct New Fenced Lagoon in Fishpond	$4,926	
Lagoon Cover	$5,700	
Lagoon Liner	$3,768	
Gas distribution System	$550	
Canals	$25,000	
Effluent Storage	$199	
Irrigation Tractor Tank setup		
Fish Ponds in Series	na	
Total	$40,143	
Contingencies	$0	
Total	**$40,143**	
Cost/pig	**$34**	

Annexe 8: Technical considerations - presentation by C H Burton

Issues relating to technical design

Part 1

- What is the purpose of treatment
- Mass balance concepts
- System objectives and constraints
- Technical evaluation factors

Part 2

- Worked examples

Technical design of appropriate treatment systems for livestock wastes

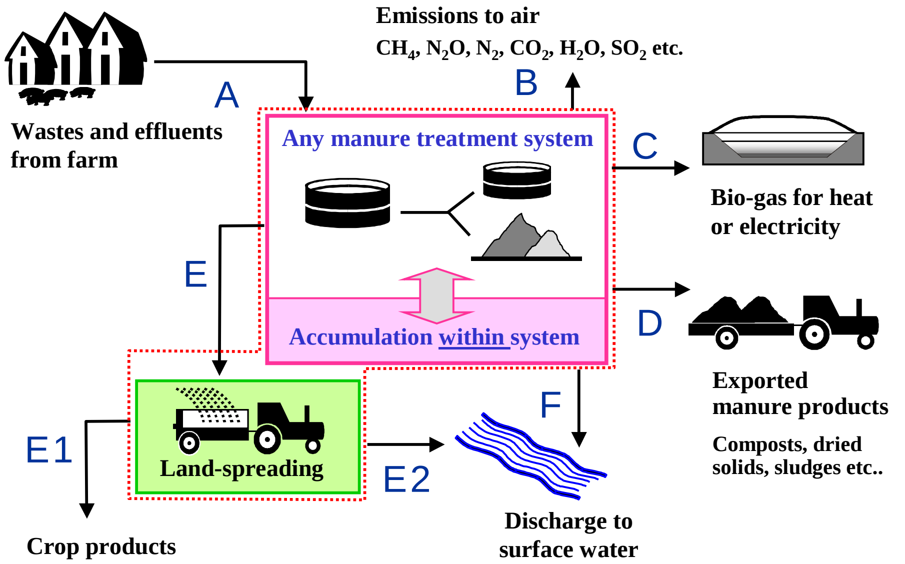
What are the pollution issues?

- Ammonia (to air)
- Ammonia (to water)
- Nitrates to water
- Phosphorous to land and water
- "Heavy" metals to land (especially copper and zinc)
- Organic load (BOD_5)
- Nitrous oxide emissions
- Methane emissions
- Odour nuisance
- Disease and health issues

These directly affect water quality: Ammonia (to water), Nitrates to water, Phosphorous to land and water, Organic load (BOD_5)

These are of special local concern: Odour nuisance, Disease and health issues

Mass balance concepts



Technical design of appropriate treatment systems for livestock wastes

Nutrient accumulation in system

It is rare for steady state to exist in a farming system. Nutrients can readily accumulate in:

- **Lagoons and fish ponds as sludge**
- **In Wetlands as debris entrained in the media**
- **In fields entrained in soil**
- **In vessels as sludge**

The significance of this is that a treatment or management system can give the *appearance* of working when it is merely accumulating the problem.

Mass balances and accumulation

For a component X, the general mass balance for the farm can be summarized:

$$A_X = B_X + C_X + D_X + E_X + F_X + t \, . \, dX/dt$$

"t" is time and the term "t . dX/dt" represents the accumulation of component X in the system. But:

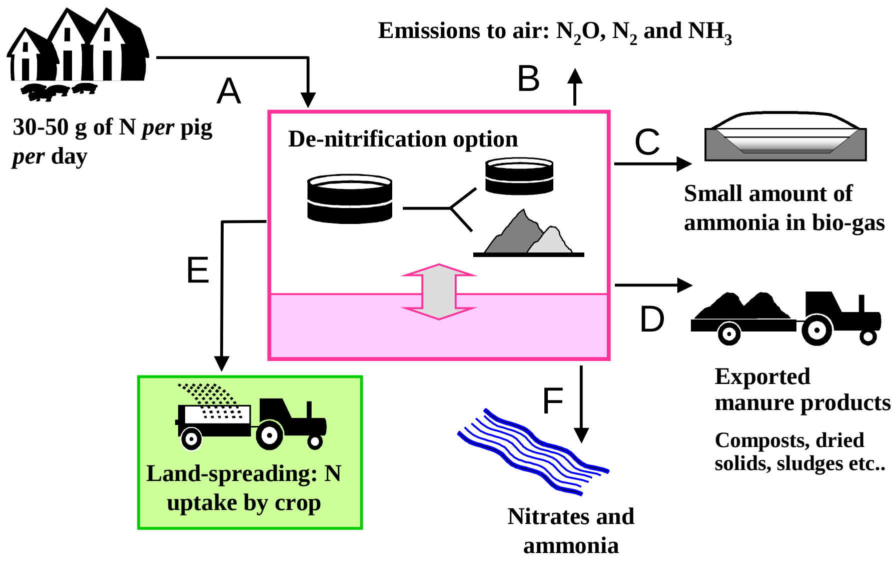
$$t \rightarrow oo \quad \text{then} \quad t \, . \, dX/dt \rightarrow 0$$

Thus given time, the mass balance becomes:

$$A_X = B_X + C_X + D_X + E_X + F_X$$

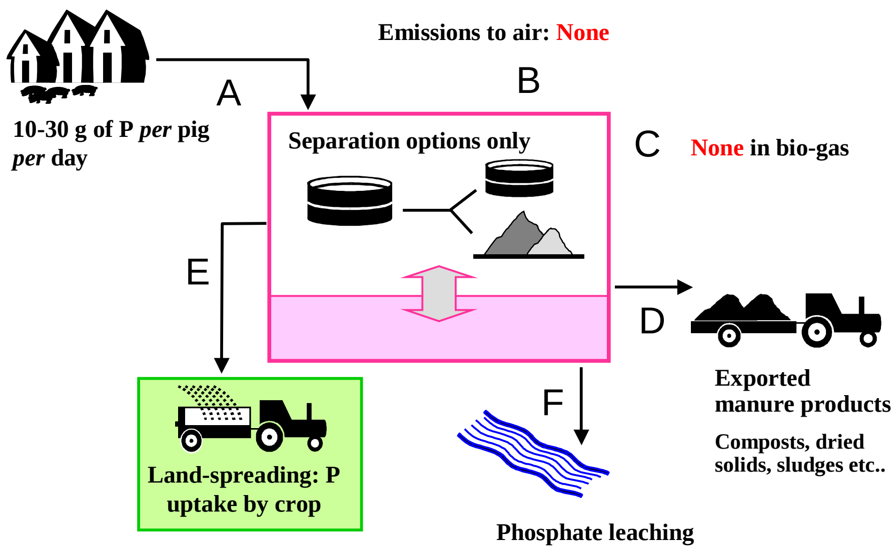
What goes in the system must come out eventually!!

Mass balance for nitrogen



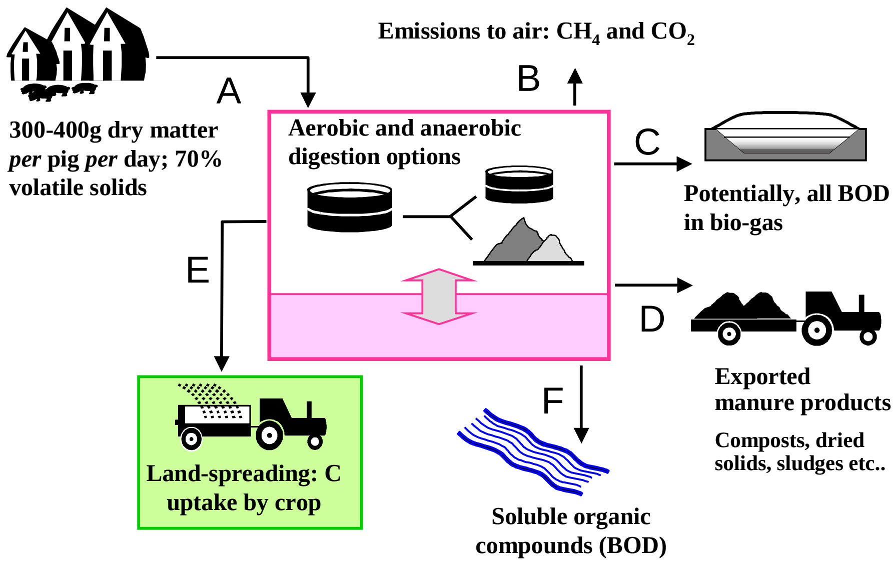
Technical design of appropriate treatment systems for livestock wastes

Mass balance for phosphorous



Technical design of appropriate treatment systems for livestock wastes

Mass balance for organic matter



System objectives and constraints

- To meet the environmental target of substantially reducing the release of the polluting elements (specifically N, P and organic matter) into the wider water environment;
- To meet the set investment budget of 12-15 US$ per pig place
- To meet local needs including concerns over public health;
- To meet special farmer needs such for the use of manure within the farming system
- To represent a practical option that can be run by the farmer with minimal assistance from outside bodies.

Evaluation of a manure management option

For reduction of nitrogen, phosphorous and organic matter

o	Poor: below 5%
*	Okay: between 5 and 40 %
**	Good enough: between 40 and 90%
***	Excellent: over 90%

For disease issues

o	Poor: increased risk
*	Okay: no change in risk
**	Good enough: reduced risk
***	Excellent: removal of risk

Evaluation of a manure management option

For reduction in odour nuisance

o	Poor: odours much worse
*	Okay: no change
**	Good enough: some odour reduction
***	Excellent: odour elimination

For installation costs

o	Poor: over 40 $ per pig place
*	Okay: 20 - 40 $ per pig place
**	Good enough: 10 - 20 $ per pig place
***	Excellent: below 10 $ per pig place

Part 2: Worked examples

Typical values assumed for example calculations that follow:

Mean daily excreta + urine for a 50kg pig:

- **4 litres (= 4 kg) or 8% of body weight.**
- **Mean dry matter of 10%**
- **Thus total dry matter 400 g per standard 50kg pig per day**
- **Half of this is in the soluble phase; half SS (suspended solids)**

Manure composition:

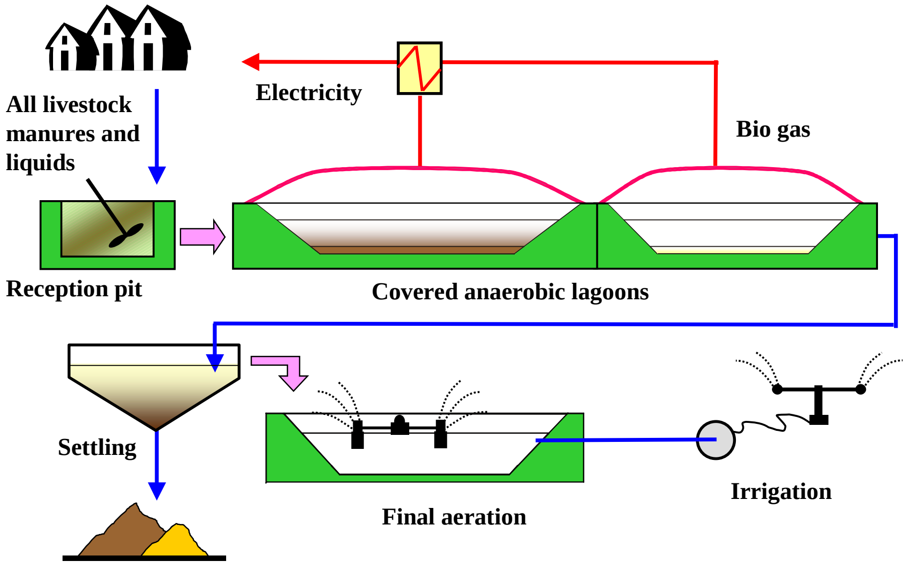
- **Nitrogen - 10% of dry matter or 40g per 50 kg standard pig per day**
- **70% of nitrogen as ammonia, remainder organic-N**
- **Phosphorous - 5% or 20g per 50kg standard pig per day**

Worked example 1

Large farm with 20,000 pigs : anaerobic digestion with the production of electricity

Technical design of appropriate treatment systems for livestock wastes

General scheme



How the scheme meets project environmental objectives

- **Organic matter: the reactive organic (BOD_5) matter is digested by the AD units; some is removed with solid dung and sludge that is removed from the farm as dried solids. Some oxidized to carbon dioxide in the aerobic surface layers of the pond.**
- **Phosphorous: removed with solids or as sludge in one of the settling processes. Some applications to the local land. It is important that arable farmers using the solid products reduce the applied chemical P to prevent accumulations of P in the soil in excess of plant needs (and thus eventual release to surface water).**
- **Nitrogen: small amounts removed with solids. Some losses as ammonia from the lagoons. Main losses by nitrification - de-nitrification (resulting in emissions of di-nitrogen gas, N_2) in the pond process especially in the final aerobic step.**
- **Public health: reduced risks by keeping manure products (and other farm effluents) away from surface water; any ingress only via soil purification. Effluent irrigated only after treatment - a combination of AD, storage, drying and aeration all have large effects on reducing microbe numbers.**

Design calculations

General:

- No screening is proposed for this farm hence all the indigestible suspended matter can be expected to end up in a sludge layer.
- 5% collection of solids as dung. Total solids produced is, 20,000 x (400- 5%) g/day = 7,600 kg (dry matter) per day.
- All of the 50% or so suspended matter in the raw slurry effluent can be expected to end up as sludge *somewhere*; ie: 7600 x 50% = 3,800 kg equivalent to 63 tonnes of sludge at 6% dry matter or 19 tonnes per day of sediment at 20% dry matter.
- 40 litres/day water - effluent flow expected of 800 m^3/day

Design calculations

Reception pit

- Two days residence time = 2 x 800 = 1600 m^3 capacity
- Depth 5 metres, area 260 m^2 - eg 16 m square.
- Mixer - 15 kW mixer with 300 mm marine turbine impeller - operated for 1 hour before daily feed.
- Feed pump (timer and float switch operated) - centrifugal type; 5,000 litres per minute - operate for 1.5 hours twice a day - 10 kW motor.

Design calculations

Anaerobic digesters

- Covered lagoon. Two operated in parallel (half of the flow through each). Each 20 days residence time.
- Volume required each = 20 x 800/2 = 16,000 m^3 Mean depth of 4 metres.
- Thus area of 4,000 m^2 4:1 ratio gives dimensions of 30 x 130 metres

Anticipated gas production

- Maximum of 500 litres per kg of VS *consumed* - *a*ssume 60% or 300 litres/kg
- Solids feed = 7,600 kg per day = 70% x 7,600 = 5,300kg of VS per day - thus anticipated gas production of 300 x 5300 = 1,600 m^3 per day.
- Thermal energy of biogas 35 MJ/m^3 = 9.7 kWh thermal
- Each day, 1,600 m^3 gas produced and burnt to release 15,500 kWh heat.
- Electricity generation assumed at 15 % conversion efficiency
- Thus energy output per day is 0.15 x 15,500 = 2300 kWh (units) per day = 2300/24 = 96 kW continuous electrical output.

Design calculations

Aeration system (final lagoon)

- Minimum 5 days residence time to ensure nitrification
  - thus min volume of 4000 m^3.
- Oxygen demand - assume 10% of that for raw pig slurry.
- Original BOD load taken as equivalent to 40% of the total dry matter in the original liquid manure
  = 10% x 40% x 380 g per pig x 20,000 pigs
  = 305 kg of BOD per day to be removed.
- This requires 305 kg of oxygen per day.

Air flow required at 20% oxygen utilisation

- 1 m^3 weighs 1.2 kg and contains 21% oxygen or which 20% utilised. thus 1 m^3 provides 50 g of oxygen.
- Air flow required per day = 305 / 0.050 = 6,100 m^3 per day (510 m^3 per hour with 12 hours per day of operation).

Investment costs

- Pit - 1600 m^3 capacity (260 m^2) - concrete - below ground; grid cover - digging cost as for lagoon - 10 $/$m^2$ plus 50% for concrete lining - cost 4,000 $
- Mixer - 15 kW mixer with 300 mm marine turbine impeller - 2,000 $
- Feed pump (timer and float switch operated) - centrifugal type; 5,000 litres per minute - 10 kW motor - 2,000 $
- Covered lagoon - two identical installations each 20 days residence time
  - lagoon cost - digging (re-building existing lagoons)
  - normal costs 10 $/$m^2$ for 4 m depth
  - a lower figure is expected this time as less earth moving needed - 5 $/$m^2$.
  - earth moving costs - 20,000 $ each = 40,000 $
- Liner costs (optional but needed is soil permeability high) 5$ per m^2 (installed) x 4000 = 20,000 $ each = 40,000 $
- Cover costs - estimated as 10$/$m^2$ or 40,000 $ each = 80,000 $

Investment costs

- Generator - 100 kW estimated as $30,000
- Control equipment - estimated as $10,000
- Brick housing for generator and control equipment - $10,000
- Settling vessel - volume 1,600 $m^{3.}$
- Constructed from concrete part below ground - cost as pit plus 2,000 $ to allow for construction of pyramid base - 6,000 $
- Sludge pump 3,000 litres/hour - 1,000 $
- Use of bubbler system = 6,100 m^3 per day 12 hours per day of operation - 2000 $
- *Irrigation pump* mean - 75 m^3/hour - 5 kW motor on pump - 1,000 $

  Pipeline - 500 metres of 100 mm (3$ per metre) - 1500 $

  and irrigating boom - 500 $

Total estimated investment cost for this example 230,000 $ for a farm of 20,000 pigs or 11.50 $ per pig place

Technical design of appropriate treatment systems for livestock wastes

Operating costs

- **Reception pit 15 kW mixer - 1 hour per day - 15 kWh**
- **Feed pump 10kW - 3 hours - 30 kWh**
- **Sludge pump 1 kW - 3 hours - 3 kWh**
- **Aerator compressor - 305 kg O_2 per day - efficiency 3 kg of oxygen per kWh - 102 kWh**
- **Irrigation - 5 kW pump - 8 hours per day - 40 kWh**

- **Total power costs per day - 190 kWh @ 0.10 $ per unit = 19 $ per day**

Which comes to 6,700 $ per year plus labour costs

Financial return

- **The main benefit from the electricity generated. This is estimated as 2300 units (kWhe) per day (70,000 per month). If the farm itself needs 60,000 units per month this is close to all the electricity available. Electricity bought costs 0.08 $ per unit. Principal saving around 4,800 $ per month.**

- **The estimated surplus of 10,000 units per month may be sold to the grid but at a much lower price than the purchase price - assuming around 50% or 0.04 $ suggests an income of 400 $ per month. *Annually*, this is thus an effective income to the farm of 62,400 $**

- **Sale of removed sludge from the lagoons is indicated as 500 $ for the 800 tonnes or so removed every 2-3 years - 200 $ per year. Such revenue is very small when compared to that from the electricity.**

Equipment

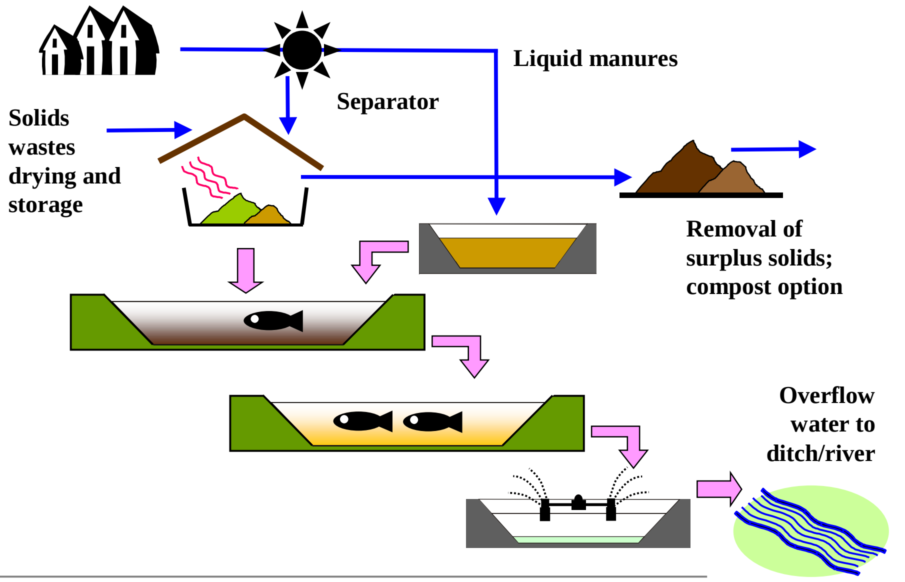
A common design for anaerobic digester is a mixed contents in which there is no separation in vessel (as for UASB). Construction is often concrete but like steel, it can be damaged by the corrosiveness of the manure and acidic gases produced.

The alternative is a covered lagoon. This is cheaper but installation of the cover is a critical operation. There are a series of options that include channelling to induce plug flow in the covered lagoon.

Example 2

Medium farm with fish ponds and 1,000 to 5,000 pigs : compost production

General scheme



Solid products from manure

Organised drying of solids is rarely done other than at the largest of farms. A modern facility (left) under cover with good management enables a larger marketing exercise for the product produced. Covered areas are also needed for drying sludges, the product being blended into the dried dung. The alternative is composting which avoids the need for drying but which still needs design effort to sustain the 60 deg.C + essential for the biological process.

How the scheme meets project environmental objectives

- **<u>Organic matter</u>: some removed with dung and sludge being used by fish or as soil improver for local crops. Some removed with sludge taken out of the ponds. Some oxidised to carbon dioxide in the aerobic surface layers of the pond. Removal as product from composting process.**

- **<u>Phosphorous</u>: removed with solids or as sludge in one of the settling processes. Some applications to the local land. Some reduction in the applied chemical P necessary to prevent accumulations of P in the soil in excess of plant needs and thus eventual release to surface water. Removal as product from composting**

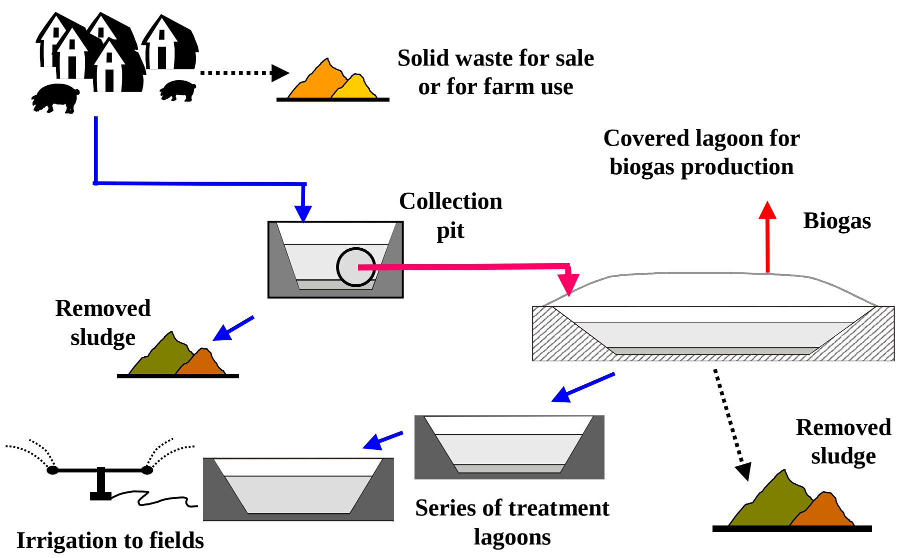
- **<u>Nitrogen</u>: small amounts removed with solids. Some losses as ammonia from the animal houses. Some losses by nitrification - de-nitrification in the pond process especially in the final aerobic step.**

- **<u>Public health</u>: reduced risks by encouraging drying (and/or composting + storage) of dung before use as fish feed. Reduced pathogen load in the water released to the river by the treatment process.**

Example 3

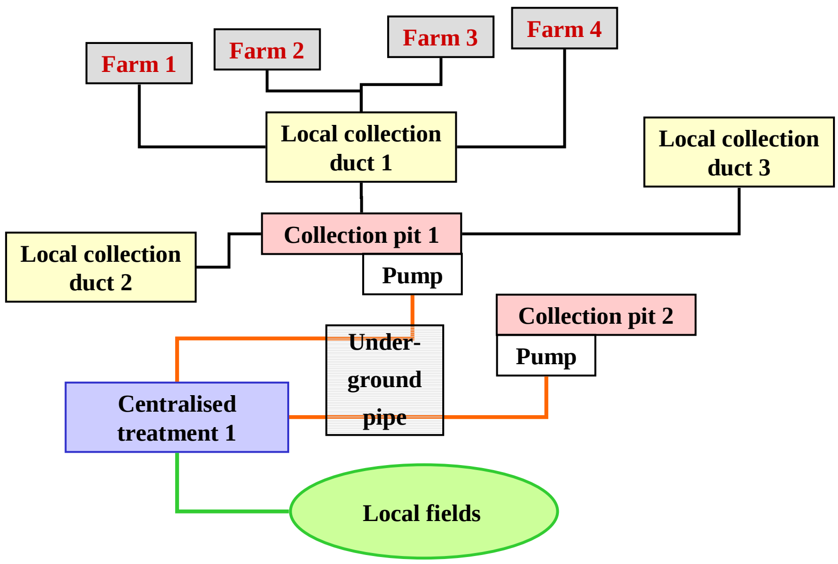
Small farm with 200 to 1000 pigs : anaerobic digestion with the production of gas and land spreading

General scheme



Technical design of appropriate treatment systems for livestock wastes

General scheme - central facility



Technical design of appropriate treatment systems for livestock wastes

Collection of effluent from farms in area

Where poor or unregulated drainage occurs, installation of new surface (covered) drains will be necessary. Farmers will be required to connect to this public service using their own resources.

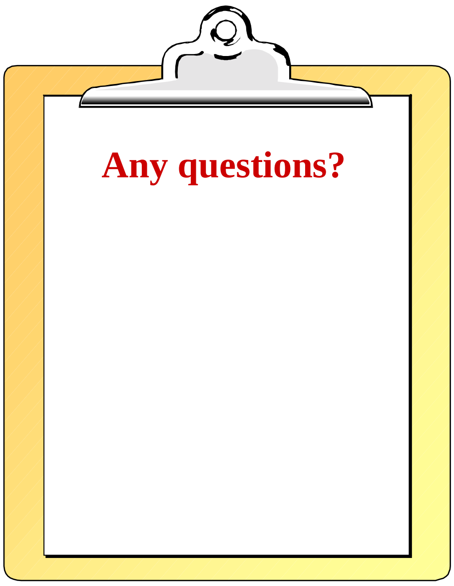
Where good drains exist, these can be included into the network scheme. However, covers should be provided for this example both for protecting the local people and for keeping rain water out.

How the scheme meets project environmental objectives

- **Organic matter**: some digested by farm AD units; some removed with dung and sludge being used by fish or for local crops. Some removed by the lagooning process (either as biogas or oxidized to carbon dioxide in the aerobic surface layers. Residues filtered out by the soil following land applications.
- **Phosphorous**: removed with solids and sludge in one of the settling processes. Final applications to the local land. Some reduction in the applied chemical P necessary to prevent accumulations of P in the soil in excess of plant needs and thus eventual release to surface water.
- **Nitrogen**: small amounts removed with solids. Some losses as ammonia. Some losses by nitrification - de-nitrification in the lagoon process. Some enters the crop cycle as nutrient.
- **Public health**: reduced risks by encouraging drying (and/or composting + storage) of dung before use as fish feed or fertiliser for vegetable crops. Reduced risks by (a) more efficient removal of manure from village area and (b) by the centralised treatment stations.

Conclusions

- Investment in manure management schemes to meet needs of (a) farmer, (b) local concerns and (c) reduction of nutrient release
- To avoid nutrients such as N and P going to the river, they must be directed somewhere else - a mass balance analysis should be satisfied.
- Beware of accumulation of nutrients in the system or environment which can be deceptive
- For any system, design and evaluation must be on a clear scientific basis
- Nitrogen can be removed by de-nitrification, ammonia emission (not encouraged), in local crops (including fish) or exported as manure products.
- Phosphorous can only be removed by using in local crops or exported as manure products.
- Organic matter can be removed by anaerobic digestion (producing biogas) or aeration or by use in local crops or exported as manure products.
- A large improvement is sought not total purification - nonetheless, this means that most nutrient previously released must be usefully used or destroyed.

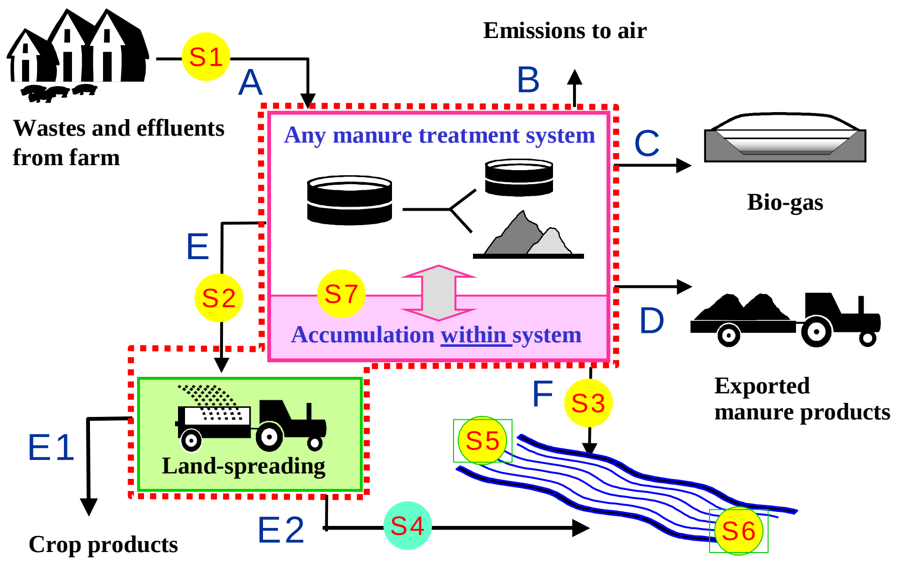


Annexe 9: Proposed sampling strategy for system validation - C H Burton

The purpose of system sampling and analysis

- **Verification that the system removes P, N and organic matter**
- **Observing the system response to the variations of conditions throughout the year**
- **Confirmation of consistent performance over time**
- **Supply of data for subsequent land application (where followed) - amounts of N and P required**
- **Information in relation to process performance - eg: expected and actual generation of biogas**
- **Confirmation of stabilized manure product streams.**
- **Identification of any specific operational problems**

Sampling concepts



Sampling points

S1 - raw effluent from the farm; values should be checked against published data.

S2 - effluent leaving system "end of pipe" and entering field or lagoon for fish

S3 - effluent directly discharged to ditch or surface water sampled at end of pipe

S4 - from field - predicted from model

S5 - stream upstream of discharge point

S6 - stream downstream of discharge point

S7 - accumulation in system

- **Not all points need to be sampled!**
- **If no river/stream, no S5 or S6 (surface water monitoring)**
- **S2 *or* S3**
- **S4 when land spreading or discharge to fish ponds**
- **S7 when likely accumulation within system**

Which analyses

	S1	S2 or S3	S5 & S6		S7
	Raw	End of pipe	*Up and down stream*		Accumulated in sludge
COD	1	4	*1*	*1*	1
BOD_5	1	1	*1*	*1*	0
Total P	1	4	*1*	*1*	1
Kjeldahl N	1	4	*1*	*1*	1
Ammoniacal N	1	1	*0*	*0*	0
Nitrates + nitrites	0	4	*1*	*1*	0
Total solids	1	4	*0*	*0*	1
Total coliforms	0	1	*1*	*1*	0

Number is samples analysed each month

Sampling regime over one year to observe full cycle

Option of reduced sampling after 6 months if resources limited

Questions relating to the decision support tool

1. Who would use it?
2. What are the key questions asked when choosing a treatment system?
3. What information is especially wanted?
4. What format is preferred (excel, expert system, ….)
5. What style - report, reference document, guide, FAQ, ….
6. What level of detail is needed
7. Any other comments at this stage?

Résumé

L'appui technique a été fourni par le consultant Cemagref, M. C H Burton, pour répondre à des exigences spécifiques pour le projet "*Livestock Waste Management in East Asia (Gestion des effluents d'élevage en Asie du sud-est)*" qui a commencé en 2006. Ses contributions ont été effectuées pendant une mission organisée par la FAO du 9 au 20 octobre 2006. Des visites ont eu lieu dans chacun des trois pays participants, la Thaïlande, la Chine (la province de Guangdong) et le Vietnam, suivies d'un atelier régional de trois jours en présence de tous les associés. Dans chaque pays, des réunions ont été organisées avec les équipes locales pour discuter des propositions spécifiques pour le traitement des déchets pour les fermes concernées par ce projet. Chaque ferme a ensuite fait l'objet d'une visite. Des réponses techniques ont été fournies lors de réunions dont une partie est incluse dans ce rapport.

Le message de principe qui survient est que même avec des subventions nationales plus celle liée au projet, le développement du traitement exige toujours un certain degré de récompense pour le fermier lui-même. Donc, la digestion anaérobie, surtout avec la production de l'électricité du biogas, est la méthode la plus populaire mais elle est seulement appropriée pour les fermes les plus grandes. Cependant, utilisée seule la DA ne réduit pas beaucoup les excédents de N et P et quand la production d'électricité n'est pas possible, il faut un moyen d'utilisation clair pour le biogas produit. Le compost et les autres processus associés qui produisent les produits organiques à vendre sont également populaires et ont l'avantage clair de permettre l'exportation de certains des excédents nutritifs qui sont la cause de plusieurs des problèmes de pollution de l'eau. Les méthodes pour encourager l'épandage agricole aux cultures peuvent répondre aux objectifs du projet tout en apportant une certaine récompense dans une réduction des quantités d'engrais achetés. Les fermes avec la production intégrée de poissons fournissent une autre approche mais des questions d'hygiène doivent également être abordées. Le traitement centralisé permettra aux nombreuses plus petites fermes au Vietnam du Nord d'être incluses dans l'initiative de ce projet.

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