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ScienceDirect
Livestock Science 112 (2007) 288–297
LIVESTOCK SCIENCE
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A survey of manure management on pig farms in Northern Vietnam

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Abstract

Animal manure can provide nutrients for crop and fish production and input for biogas production but, if managed inappropriately, can also have a negative impact on the environment. The objective of this survey was to provide information about pig production and manure management practices in the Northern part of Vietnam in order to identify and prioritize research needs for future improvements in pig manure management. A survey was conducted by in-depth interviews on 54 pig farms in two Northern Vietnamese provinces, Thai Binh and Bac Giang. In addition to the survey, also key informant responses were obtained in the two provinces to help identify problems with existing manure management. The survey showed that large-scale pig producers (>100 fatteners or 20 sows) had more pigs per hectare than medium-scale (19–99 fatteners, 5–19 sows) or small-scale (<19 fatteners, <5 sows) producers. Biogas was produced from 43% of the total manure produced on all surveyed farms, and was used for cooking. The proportion of total manure applied to crops was only 5% in Thai Binh and 35% in Bac Giang. Large-scale producers tended to operate smaller fishponds, and medium-scale farms operated larger ones. The farmers were of the opinion that fish in ponds fertilized with pig manure grew significantly faster than did fish in ponds supplied with other feed or types of fertilizer. Twenty percent of pig producers reported that they raised pigs just to provide manure to feed their pond fish. A large proportion (19%) of the total manure produced was discharged into public sewage systems, rivers and lakes. Of the 54 householders interviewed, 46 believed that animal manure caused serious damage to the environment. Farmers interviewed had little or no expertise in handling liquid manure, composting solid manure, or reducing contamination by means of microbial reduction of pollutants during manure management. In general, specialized pig production is seen as a commercial operation, while manure management remains non-commercial. The survey implied that more information to farmers, as well as stronger regulation of manure management, is needed in Vietnam.

Keywords: Animal manure; Biogas; Crop cultivation; Fish farming; Pig production; Pathogens

1. Introduction

Livestock manure represents a valuable resource which, if used appropriately, can replace significant amounts of mineral fertilizers (Bouwman and Booij, 1998; Chau, 1998). On the other hand, animal manure is not only a source of valuable plant nutrients, but can also be a source of air pollution and a threat to aquifers and surface water (Burton and Turner, 2003) unless managed carefully in order to minimize nutrient losses.

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doi:10.1016/j.livsci.2007.09.008

Animal production, especially commercial pig production, is increasing rapidly in Vietnam and tends to be concentrated on larger production units, which also implies changes in animal production technology (feeding, housing etc.). This trend increases the risk of air, water and soil pollution (An et al., 1997; Gerber et al., 2005).

Livestock manure contains many microorganisms, protozoa and viruses that may pose a risk to human and animal health. Recent reviews on the current status of parasitic diseases in Vietnam, including those of food-borne trematode zoonoses and cysticercosis, have highlighted the risks of disease transmission through animal manure and human excreta (De et al., 2003). Highly contagious and pathogenic viral diseases such as foot and mouth disease, classical swine fever and Aujeszky's Disease, may spread through animal effluents into waterways and, when one farm is infected with one of these diseases, may cause downstream farms to be exposed to a considerable risk of infection (Johansson et al., 2005).

Recycling of manure onto crop land will reduce the risk of spreading pathogens and contribute plant nutrients to crops, thereby reducing the need for mineral fertilizers. In animal manure, nitrogen (N) is present in an inorganic form (ammonium) which is readily available to plants, and as organic N which becomes available through mineralization to inorganic N (Jarvis et al., 1996).

The recycling of animal excretes to fish ponds is an integrated part of Vietnamese farming. The manure is feed for the fish or fertilizes phytoplankton, zooplankton, and zoobenthos that are feeds for the fish to reduce the requirement for expensive feeds and fertilizers.

The increased risks of environmental pollution and spreading of disease related to the recent intensification of Vietnamese livestock production can be alleviated through a more careful and efficient recycling of manure on crop land and in fishponds (Burton and Turner, 2003). For the producer, the costs of treatment and manure spreading may be offset by a reduction in the use of mineral fertilizers and decreased disease in livestock.

Pig production development and animal waste management were investigated in a case study conducted within the Thai Binh province, Northern Vietnam (Pophyre and Medoc, 2006; Porphyre and Coi, 2006). Problem identification, suggestions to solutions, and strategies for environmental protection and the efficient use of pig manure were proposed in the case study. However, pig production and manure management practices in Vietnam are often very different from farm to farm and from province to province. Therefore, this paper presents existing pig production and pig manure management in Bac Giang and in province Thai Binh provinces in Northern Vietnam, where a significant and increasing numbers of pigs are being produced under commercial management conditions (Gerber et al., 2005). This study also collected additional information to provide a comprehensive picture of conditions for pig production and pig manure management in the northern part of Vietnam, in order to identify future research needs. The findings are related to farming practises in Denmark where manure management is state-of-the-art due to a very restrictive regulation of livestock production and animal manure recycling.

2. Survey methodology

Based on the experience from preliminary visits to 25 farms in Northern Vietnam, a group of specialists in manure management, plant nutrition and epidemiology conducted in-depth interviews on 60 pig farms in August 2006. Bac Giang and Thai Binh provinces (about 150 km north of Hanoi) were selected as being representative of both large-scale and small-scale farming in Northern Vietnam. These provinces were also targeted because of their (1) high pig population density, estimated at around 1000 pigs per hectare, which is mainly due to a rapid expansion of commercial feed supply and meat processing, (2) rapidly increasing pig production, (3) high usage of mineral fertilizers, and (4) availability of data and information from a previous study (Pophyre and Medoc, 2006). A questionnaire was completed after a draft version had been tested on 10 pig-producing households.

Three districts were randomly selected from each of the two provinces, and one commune in each selected district was chosen randomly. Lists of pig producers and farm scales in surveyed communes were provided by the communes and by the Department of Agriculture and Rural Development (Anonymous, 2005a). Based on the information collected in preliminary visits and categories used by the government, the farms were categorized as small-, medium- or large-scale (Table 1);

Table 1
Categorization of small-, medium- and large-scale pig farms in Thai Binh and Bac Giang (cf. Porphyre and Coi, 2006)

Farm scale	Number of animals	
	Fatteners	Sows
Small	<19	<5
Medium	19–99	5–19
Large	>100	>20

similar categories were used in the study of Porphyre and Coi (2006). Ten farms under different farm-scale categories (3 small-, 4 medium- and 3 large-scale farms) were randomly selected from each selected commune. Unfortunately, information from 6 of the 60 farms visited was incomplete and had to be omitted; therefore all subsequent results of the survey presented are based on 54 household interviews (Table 2).

The survey (Table 3) concentrated on identifying (1) pig production related to farm land, (2) feeding practices and housing systems, (3) methods of manure management and manure flows, (4) pathways by which pathogens are disseminated in manure, (5) farmers' perceptions in relation to manure management, and (6) training needs.

Key informant interviews with officials in charge of livestock production and animal health at the district and provincial levels were also conducted in the two provinces, for the purpose of identifying problems related to existing manure management practices.

3. Results and discussion

3.1. Pig production

In Bac Giang there are fewer large-scale pig farms, compared with Thai Binh (Anonymous, 2005a). Thai Binh is a province with a higher than the national average rate of increase in pig production, whereas the increase in pig production in Bac Giang is parallel to the average growth in Vietnam as a whole (Anonymous, 2005b).

All surveyed farms were located in villages with a scarcity of land. The large-scale pig producers tended to have a smaller land base than medium- or small-scale farmers (Fig. 1). The medium-scale farms had the largest fishpond areas in both provinces. Two large-scale farms in Bac Giang had no fishpond. Consequently, farms of the different farm-scale categories had different patterns of manure disposal flow. Pig densities in small- and medium-scale farms were much lower than in large-scale farms in both provinces, and may therefore have fewer problems with pig waste handling. The highest pig population density at farm level was equivalent to more than 7000 pigs/ha (equivalent to 1750 livestock units per ha) for large-scale farms in Thai Binh (Fig. 1).

Table 2
Distribution of 54 pig farms in Thai Binh and Bac Giang among the production-scale categories presented in Table 1

Farm scale	Number of farms	
	Thai Binh	Bac Giang
Small	3	8
Medium	15	14
Large	12	2
Total	30	24

Table 3
Main input data gathered from 54 pig farms in Thai Binh and Bac Giang

Heading	Input data
1. Pig production related to farmland	Agricultural land area, crop types, crop rotation
	Farm specializations (pig numbers and types)
	Pig starting and slaughter weight
	Pond size, fish breeds
2. Housing system and feeding practices	Types of floor, roof, ventilation and heating system
	Cleaning times/day, consumption of water
	Disinfectants used for animal house cleaning
	Types, amount of feeds
	Feeding methods and strategies
	Minerals and vitamins
	Antibiotics and growth promoters
3. Manure management and manure flow	Manure collecting methods: scrape solid or hose by water
	Pig waste management categories: no treatment, compost, biogas and storage
	Storage: types, covers and capacity of tanks
	Biogas: types, capacity of biodigester
	Compost: additives used, composting procedures
	Amount of manure used for crops
	Amount of fertilizer used for crops
	Amount of manure for fish
	Manure proportion used for fish, biogas, sale and discharge
4. Pathogen flow and hygiene	Protective clothing, masks, gloves or boots when cleaning pig sheds
	Water source for animal and human consumption
	Levels of odour and fly density around animal housing
	Vaccines used
	Handling sick and dead animals
5. KAP (Knowledge, Application and Practices) of farmers	Animal waste impact on the environment
	Hygiene, animal disease prevention
	Animal waste management
	Solutions to minimize negative impacts of animal waste
6. Training need assessment	Types of training courses on livestock production attended
	Lessons learned from these training sessions
	Organizers for training courses
	Types of training courses the farmer would like to attend in future
	Desirable training contents on animal waste management

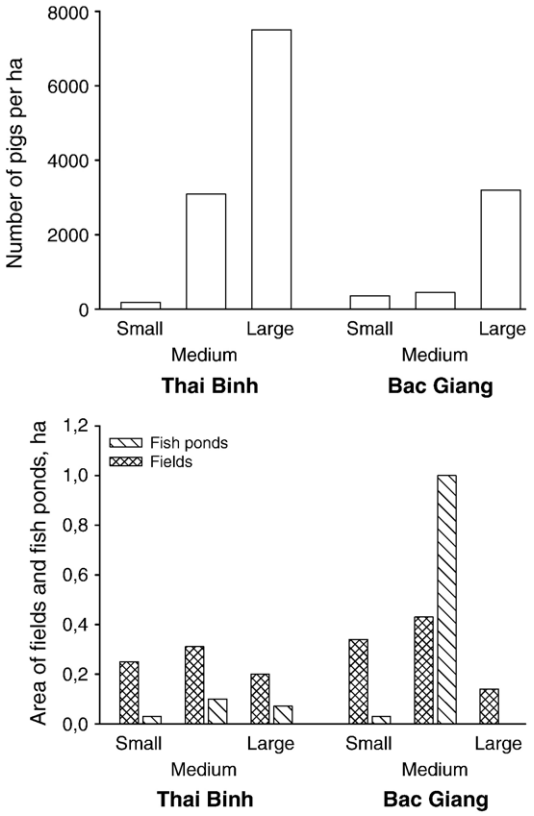

Fig. 1. Area of land, number of fishponds and pig population density at farm level at large-, medium- and small- scale pig farms in Thai Binh and Bac Giang provinces, Vietnam.

In Europe, farmers are permitted to raise up to about 2 livestock units per hectare (Burton and Turner, 2003), whereas in Denmark only 1.4 livestock units are allowed per hectare of cultivated land (equivalent to 140 kg N/ha) (Anonymous, 2006a). The extremely high pig densities observed in Northern Vietnam are the result of a lack of regulations for pig production. The result indicates that authorities should improve environmental regulations and specify the target objectives taking into account existing practices and perceptions of stakeholders affected by the livestock production (Pophyre and Medoc, 2006).

Farrow-to-finish producers raise piglets and produce finishing pigs. This 'closed production cycle' is, according to the farmers, more profitable and transfers less disease than producing finishing pigs alone, but the investments are higher. The majority (28 of 54 pig farms) preferred to operate a 'closed production cycle' (Table 4). However, this result is different from the previous findings in districts of the Thai Binh, where more pig farms had specialized in producing finishing pigs (Vu Tien commune,) or suckling piglets for export to Hong Kong and Singapore (Porphyre and Coi, 2006). The piglets are exported or sold as pre-fattening pigs from 7 to 10 kg and sold to finishing pig producers at 25 kg (Emonet-Denand et al., 2006). The Government wishes to increase this export. However, the pig production is not competitive on a global market due to the poor quality of Vietnamese pork having a high fat content and high production costs (Porphyre and Coi, 2006).

The weight of 5–6 month old fatteners sold for slaughtering was about 70–80 kg due to problem with fat deposition after 70–80 kg. The slaughter weight of Vietnamese finishing pigs is lower than that of Danish slaughter pigs, which reach about 105 kg at 174 days (Anonymous, 2006b), i.e. at almost the same slaughtering age as in Vietnam. This indicates that there is scope for improvement of the production efficiency in Vietnamese pig production.

3.2. Feeding practices and use of antibiotics

The results show that feeds and feeding practices varied between farms and within farms, depending on available feed resources. Traditional feeds (rice and rice bran), which are cooked before feeding, were used by all of the small- and medium-scale farmers, and by 40% of the large-scale farmers. Commercial feed was added as dry feed in different amounts in all surveyed farms, but as sole feed in 60% of the large-scale pig farms. Different types of rations and feeding practices resulted in a high variability of manure volume and composition at the outlet from farms, as shown in the previous case study by Tuan et al. (2006). This indicates that there is a need for predictions of manure output and composition at the animal and farm level, based on feed intake.

The use of antimicrobials (chloramphenicol and tetracyline) as feed additives was widespread on pig farms, and more than 20% of farms surveyed reported such practices. The common prophylactic usage of antimicrobials will increase the risk for development of antibiotic-resistant bacteria in the gastro-intestinal tract, in the external environment to which manure/slurry is

Table 4
Specialization of the pig production on 54 pig farms in Thai Binh and Bac Giang

Specialization	Number of households	
	Thai Binh	Bac Giang
Farrowing	3	2
Fattening	15	6
Farrow to finishing	12	16
Total	30	24

deposited, and in pork products. It is likely that, as is the case in Europe and the United States, the development and spread of antimicrobial resistant food-borne and human bacterial pathogens may be associated with prophylactic and therapeutic use of antimicrobials in animal husbandry. Studies are needed in Vietnam to assess the development and spread of antimicrobial resistance associated with spread of animal manure, e.g., in integrated pig–fish production systems (see below).

3.3. Housing systems

All pig producers surveyed housed their pigs in concrete pig sheds with natural ventilation. Two large-scale farms had pens and metal cages with natural ventilation panels located in the roofs. About two-thirds of the pig farms had animal sheds with concrete floors. The rest, mainly small-scale farms, had brick floors. These solid floors were smooth and slightly sloping. At the lower end of the pens a back channel allowed manure and urine to be drained off. None of the pig producers in the survey had installed slatted floors in their animal sheds. The impression from the survey was that housing systems were not improving at the same rate as the increase in pig production.

Farmers cool and clean the pigs and pens twice a day in summer and once a day in winter. Large amounts of liquid waste are generated due to the volume of water needed to flush the pigs and wash away solid manure. It was measured that about 40 L of water were used per pig per day. This water consumption is similar to that found in Singapore (Taiganides, 1992) and Malaysia (Sommer et al., 2005), but is higher than the amount measured by Tuan et al. (2006) who reported that 47 L and 7–10 L were used per 100 kg of pig in summer and winter, respectively.

Many households used chloramine, iodine solution (10%), or powdered lime for cleaning pig-pen floors; all three disinfectants are produced in Vietnam. On 17% of the farms disinfectants were used once per month, while others used disinfectants 2–6 times per month. On 35% of the farms disinfectants were never used. Two farmers said that they used disinfectants for purposes of both disinfecting and deodourising.

3.4. Manure management

The three main manure types on the surveyed farms were slurry, liquid manure and solid manure. Slurry is a mixture of urine, faeces and water; solid manure is faeces and litter scraped of the floor, and liquid manure is a combination of urine, faeces remaining after scraping and cleaning water. Manure management in Thai Binh and Bac Giang provinces can be divided into four categories: no treatment with direct disposal to the field or to fishponds; composting; storage without treatment; and biogas production.

Four of the farms (all medium-scale) surveyed in Thai Binh did not treat the manure, while all the farmers treated the manure in Bac Giang (Fig. 2). On one of the four farms in Thai Binh, some manure was transferred directly to the fishpond. The remaining farmers discharged manure into a lake, water channels or the public sewage system, or gave it free-of-charge to other farmers. The discharge to recipients may cause spread of pathogenic microorganisms into watersheds (Petersen and Dalsgaard, 2003), and was considered the major source of water pollution in the study of Emonet-Denand et al. (2006). The survey results and observations indicate that watersheds in Thai Binh with its large pig production are more polluted by livestock waste than in Bac Giang.

On 22 of the farms, the solid manure fraction was composted after being mixed with one or more of the ingredients straw, plant waste products, ash or lime, as it was also seen in the survey of Tuan et al. (2006). Manure was composted in buildings or in pits covered with mud or tarpaulin. Composting manure without cover was observed on four farms, which results in poorer manure quality due to emission of ammonia. Composting and storage periods were up to about 3–4 months depending on crop growth periods. Manure composting and storage procedures were similar in both provinces. The volume of

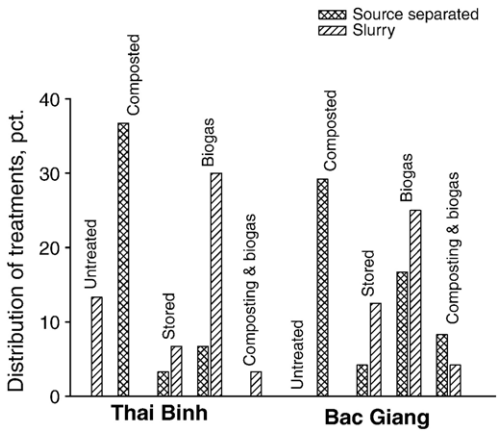

Fig. 2. Manure management and treatment technologies used on 54 pig farms in Thai Binh and Bac Giang provinces. In Thai Binh 47% of the households manually source separated excreta from the pig production in a liquid and solid fraction, and in Bac Giang 59% did so. Source separation is the technology where solids are scraped off the floor and the remaining fraction is liquid manure composed of urine and washing water.

the containers in which manure was stored was on average 3.8 m^3 (min: 0.5 m^3; max: 11 m^3). The containers were constructed of concrete or bricks. Five farmers dug pits for manure storage, which is not allowed in Denmark because of risk of N leaching and pathogen spread into groundwater. The pits were not covered, which will increase ammonia emission. The distance from manure stores to the drinking water source was about 17 m on average (min: 3 m; max 50 m), and only five farms met the Danish standard of a minimum distance of 50 m to any drinking water source. This standard has been included in the Danish regulation to avoid surface runoff into the water abstraction plants. The 49 farmers may thus face a high risk of using polluted drinking water.

The value of manure as a nitrogen fertilizer is affected by losses via ammonia (NH_3) volatilization, denitrification and leaching (Jarvis and Pain, 1990; Smith et al., 2000; Sommer et al., 2003), and by the rate at which manure organic N is mineralized to become available to the crops. Therefore, guidelines for using animal manure should include strategies for reducing losses of NH_3 and nitrate-N, and for improved utilization of organic N.

3.5. Sale of manure

The pig producers surveyed carried out manure collection and cleaning themselves in order to prevent disease transmission, as they were afraid that middlemen might spread pathogens from farm to farm. The middlemen were only allowed to stop at the farm gate to buy manure. This result differs with a survey carried out between April and October 2005, in which the buyer of manure came to the supplier to collect manure (Colson and Boutonnet, 2006). The reason for this different finding is that a serious food and mouth disease had broken out in the Northern part of Vietnam while the survey was carried out in August 2006.

In Bac Giang, about 20% of the total manure produced was sold, against only 4% in Thai Binh (Fig. 3). About 6% of total manure was given away to other farmers for free. Manure was sold from two of the large-scale farms and five medium-scale farms in Bac Giang, and from one from the large-scale farm in Thai Binh. Not all excess manure was sold, because buyers and sellers did not always have an opportunity to meet due to either a lack of established markets for manure, or because the cost of chemical fertilizer is relatively low and it is much more convenient to use. Transportation of manure is considered the most unpleasant and heavy work (Pillot et al., 2006). Furthermore, Colson and Boutonnet (2006) have shown that pig manure transport in one village has gradually disappeared because of its disagreeable smell.

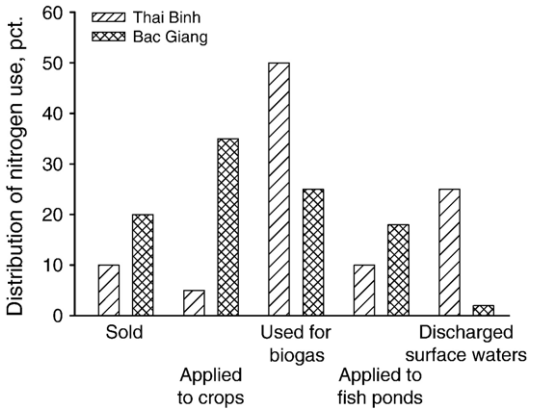

Fig. 3. Use of nitrogen in pig manure: sale, crops, biogas, fishponds and discharges to canals and rivers in Thai Binh and Bac Giang.

3.6. Use of manure for biogas production

Concrete biodigesters based on a Chinese design were present on 46% of the surveyed farms, a number that is higher than the 33% reported in the Thai Binh survey of Emonet-Denand et al. (2006). Biogas was produced by anaerobic digestion of 43% of the total manure output on surveyed farms (Fig. 4). 70% of the farmers having anaerobic digesters fed slurry to the digesters, the remaining 30% added liquid manure. The biogas produced was mainly used for household cooking, heating water and cooking pig feed; significant amounts, corresponding to manure from 20–40 pigs, are needed because the time used for cooking food and feed is estimated at 12–15 hours per day (Chinh et al., 2002). The large-scale pig farms had no need for all the biogas that could potentially be produced, and when a power distribution net is established, then electricity generation using a modified diesel generator may be introduced and more biogas could be produced. The distribution of biogas to neighbouring households was observed on three of the largest farms.

Slurry digestion was psychrophilic in winter and mesophilic during summer in the unheated biogas digesters. The capacity of digesters was on average 16 m^3 (min: 10 m^3; max: 30 m^3). The dimensions of digesters volume corresponded to treatment of manure from about 10 pigs per m^3 digester volume in Thai Binh and only 2 pigs per m^3 in Bac Giang. Thus, the dimensions of the digesters in relation to the amount of treated manure in the Bac Giang province corresponded to the recommendations of the National Institute of Animal Husbandry (Chinh et al., 2002), while this proportion was 5 times higher in Thai Binh province. Retention time in the digesters was estimated from the

biodigester capacity and the number of pigs, and assuming the amount of excreta and water used for cleaning and cooling the animals was about 40 L per animal. Average retention time was calculated at 13 days in Bac Giang and 2.5 days in Thai Binh. These retention times in the digester in Thai Binh were much shorter than the recommendation, which is 11 to 15 days for mesophilic digestion (Ferreirra, 2006).

Fermentation of manure in biogas digesters may reduce the spread of pathogens and of noxious odour emissions. However, this survey indicates that in Thai Binh a large proportion of manure is treated with a short retention time at a low temperature in the biogas digester, and with subsequent discharge of treated slurry into rivers or lakes. Such treatment is unlikely to eliminate pathogens in the slurry, in particular parasite eggs which show high resistance to environmental stress compared with bacterial and viral pathogens.

3.7. Use of manure for crops

The survey indicated that manure was used to fertilize crops on only 43% of the surveyed farms in Thai Binh, while 73% of the farms used manure to fertilize crops in Bac Giang. In Thai Binh province only 5% of the total manure volume produced on the surveyed farms was applied to fields belonging to the farm (Fig. 3). This number was much higher in Bac Giang province, where 35% of total manure was used on crop fields. The number of animals on medium- and large-scale farms was equivalent to more than 3000 per hectare and therefore much higher than the 2000 pigs per hectare found in Singapore, where pig production was stopped by the government because the pig waste effluents from pig production contaminated coastal waters and jeopardized shrimp production (Taiganides, 1992). It is thus likely that many pig farms in Northern Vietnam are a significant source of pollution.

The rate of organic fertilizers applied for rice and maize was similar on farms in the same commune. Farmyard manure was in the past a most important source of plant nutrients in crop production, but the importance of manure has decreased due to the extensive use of chemical fertilizers (Phuong et al., 2006). According to Phuong et al. (2006), 90–95% of organic fertilizers used in agricultural production in Thai Binh province are derived from pig production.

Unsustainable use of manure on farms has also been observed in South Vietnam by Hedlund et al. (2003), who showed that large amounts of plant nutrients were lost due to direct discharge of liquid manure into waterways. Pig manure is not widely used for fertilization in the Southern Vietnamese provinces in the Mekong River delta, where pig manure is culturally considered to be 'hot', i.e. not suitable to fertilize all crops. Pig manure is considered suitable for rice production, but not useful for vegetables, coffee, and fruit-tree cash crops (Dan et al., 2004). In addition, cattle and poultry manures are considered to be better fertilizers than pig manure in the South.

3.8. Use of manure for fish production

Of the farms surveyed, 42% were integrated pig and fish production farms, on which part or all of the pig manure was used to fertilize fishponds, and about 10% of total manure produced on the farms was used for fish production (Fig. 4). Liquid manure from cleaning pigs was directly channelled into fishponds, and solid manure was either added to the ponds without treatment or composted for about a week before being used in fishponds. Waste water used for cleaning pigs was discharged into the fishpond in order to reduce transportation costs to the field.

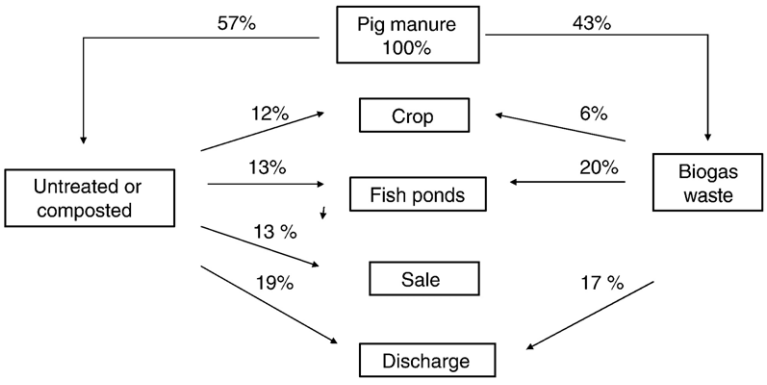

Fig. 4. Manure flows presented as average values for 54 selected pig farms in Thai Binh and Bac Giang provinces. The diagram indicates manure types ("untreated or composted" vs. "biogas waste"), as well as ultimate fate of the manure after treatment and/or storage.

However, many fishponds in Thai Binh are connected to rivers or other water sources, so that the actual manure proportion retained for fish production will be much lower.

Farmers surveyed reported that fish in ponds fertilized with pig manure grew better than fish in ponds treated with ruminant manure, because pig manure has higher nitrogen content than ruminant manure (Mikolasek et al., 2006). Chicken manure has not been used to any great extent since the outbreak of avian influenza, because farmers fear transfer of the disease. Moreover, chicken manure containing bedding materials such as rice husks is thought to pollute the ponds and cause a build-up of sediment. The alternative to animal manure as a source of fish feed is to use commercial feed, but its cost is very high compared with the manure available free on the farms.

The fish produced were common carp, silver carp, Nile tilapia and pirapitinga. Farmers traditionally produce all four fish species in the same pond, because these fish inhabit and feed at different water levels. About 20% of pig producers indicated that they raised pigs mainly for using their manure for fish production, and that fish production in many instances yielded a higher income.

Based on the colour of the water in the ponds, many fishponds in Thai Binh seemed to contain a surplus of nitrogen, while none did so in Bac Giang. Nitrogen surplus will encourage more rapid algae growth giving fishpond-water a green or dark green colour or, more seriously, blackish water, indicating heavy pollution. According to Mikolasek et al. (2006), the manure quantity corresponding to 60 pigs per hectare of pond provides the highest fish yield for farmers using a pig–fish integrated system. However, the quantity of manure applied to the fish ponds varied greatly from farm to farm, and as a consequence the ponds were often oversupplied with manure.

3.9. Manure and biogas waste discharge to recipient

Fig. 4 shows that 19% of the raw manure (excluding the proportion given to fishponds which is subsequently discharged into rivers) and 40% of the biogas waste is discharged into surface waters, i.e. the public sewage system, streams, lakes or rivers, where it may cause serious problems to the environment. The proportion of manure N discharged to surface waters in Thai Binh was higher than that in Bac Giang (Fig. 3).

Also in Southern Vietnamese provinces liquid waste is discharged to recipients. It was shown by Dan et al. (2004) from interviews with pig producers that 19% of solids and 60% of liquid manure was directly discharged to recipients.

3.10. Farmers' perceptions and training need assessments

According to the survey, 46 of 54 householders were of the opinion that animal manure exerts a serious negative effect on the environment. Farms with particularly poor manure management were identified as a source of unpleasant odour and poor air quality inside the animal houses (22 of 54 farms). Such conditions were considered to pose a risk to human health because farmers' houses were located very close to the livestock houses.

Most farmers were aware of the fact that animal waste may negatively affect the environment and their health. One-half of the householders believed that animal diseases could be transferred to humans. However, they were reluctant to provide their opinion concerning their own manure management and its effect on the surrounding environment. This is understandable, because most farmers produce pigs or raise animals as their main source of income and it is unlikely they will complain about the effects of livestock production on the local environment. In the survey, one family never opened the window because of the heavy smell from the neighbouring farm. According to the farmer, the relationship within communities in rural areas is very important, and to avoid conflicts with neighbours the farmer will therefore not complain about the smell.

Fly infestation and unpleasant odours were less prevalent on the farms where the farmer's attitude to animal waste management was considered serious. Most of these farmers used a clean water source for their pigs and properly buried dead animals. In the survey it was observed that, irrespective of farmers' attitudes, most did not use protective clothing, masks, gloves or boots when cleaning pig sheds. The farmers have little knowledge about manure composition as Pillot et al. (2006) has shown that none of the Thai Binh pig farmers interviewed in their survey were able to provide concise information on the quantities of effluents necessary for vegetable or fishpond production.

Farmers did not appear to improve their manure management skills with increasing experience in farming. As most of the sheds were closed, ventilation was generally inadequate. The farmers had little or no expertise in the collection of liquid manure, composting solid manure, or in reducing microorganisms and pollutants during manure handling. Six householders wanted to increase their number of pigs and were seeking better technologies for treating the animal manure. Therefore, there is a need to promote appropriate technologies and management practices, and also to

provide extension programmes to inform farmers about effective animal manure management.

At present, training courses on how to improve livestock farming performance are provided by various feed companies and extension programmes. However, no training courses on animal waste management are currently available in the two provinces surveyed. There is a need to improve the knowledge of local authorities and farmers about sustainable manure management to keep a balance between livestock, land and environment (Giao, 2006).

4. Conclusions

Based on this survey, the following conclusions can be made:

- Biogas production is practiced on a high proportion of farms, but there is a lack of experience to operate these systems efficiently.
- Traditions, cost of transportation, and lack of accessible markets is a barrier for efficient use of pig manure on croplands.
- Although pig manure is a valuable organic fertilizer for fishpond production, its appropriate use and management requires more skill than is currently available to most farmers.
- Markets for the sale and technologies for treatment of excess manure should be developed to avoid discharge of surplus animal wastes into watersheds.
- The negative impact of untreated pig manure on health and on the environment is well understood by most farmers, but there is no incentive to adopt environmentally friendly technologies due the lack of regulation or enforcement of regulations.
- The lack of effective extension services on animal waste treatment represents a serious knowledge gap for farmers undertaking commercial-scale pig production. This constraint will only grow more serious as pig production expands, if extension services fail to catch up.

Acknowledgments

This survey was carried out by participants of the SUSANE-research project, which is financially supported by the Danish Foreign Ministry and the Vietnamese Ministry of Agriculture and Rural Development.

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