Food Waste recycling into animal feeding in Vietnam

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1. Introduction

Many developing countries have been facing challenges on environmental and sanitary problems because of incomplete food waste (FW) management systems. In a review of Ngoc Bao Dung Thi et al. (2015), FW sources were identified by different ways. FW sources may be classified into three categories based on the ways of food losses from production to consumption, inclusive of food losses (food products lost during the production phase), unavoidable FW (food products lost during the consumption), and avoidable FW (products that could have been eaten, but were lost during the consumption) (Parfitt et al., 2010). FW can be classified into five sources depending on single phase in the food supply chain, inclusive of agricultural production, postharvest handling and storage, processing, distribution and consumption. According to The Agriculture Organization of the United Nations (2014), the annual total amounts of global FW generation is about 1.3 billion tons, with the equal distribution from developed and developing countries (670 million tons and 630 million tons, respectively).

Five treatment applications for FW was listed by Ngoc Bao Dung Thi et al. (2015) including animal feeding, anaerobic digestion, composting, incineration, and land fill. In which, using FW to feed animals is encouraged in some countries having a high demand for animal feed (e.g.: Taiwan, Japan, South Korea) where the separation and collection of FW are applied. While land fill is applied by all most developing countries including Vietnam for about 90% of total FW. FW management is strongly affected by income level, population grow and public participation, and therefore, every country need to identify and implement the suitable FW management systems, including prevention, recycling and disposal (Ngoc Bao Dung Thi et al., 2015). Recycling of FW is still rarely applied in developing countries due to poor policies (Suchada et al., 2003, cited by Ngoc Bao Dung Thi et al. (2015)).

According to Paul Olivier (2008), more than half weight of landfill in Vietnam is FW. As organic wastes are rapid deterioration and contamination by microorganisms and pathogen (Pérez, 1997), landfill method is considered as one of reason in transmission of disease (Louis, 2004) and increase in greenhouse gas mission (Adhikari et al., 2009; Hoa Huu Nguyen et al., 2014)). The utilization of kitchen wastes and the use of some other organic wastes to feed livestock would help to reduce environmental pollution. The current paper aims to review and understand the overall context of the current practices and regulations of Food Waste recycling into animal feeding in Vietnam.

Study methods: Literature review includes published articles and books; Unpublished papers and students theses; Data published by GSO, MARD/DLP, Agri-info, private industries; and Interviews with resource persons.

2. National context of Food waste

2.1. Estimation of food waste (FW)

National State of Environment report (2011, chapter 2) reports that total FW in Vietnam is about 5,743,056 tons per year, accounts for 60% of the entire municipal solid waste (MSW). FW per capita is estimated around 0.06 kg/day. Urban people consume energy, goods, food 2-3 times higher than those in rural areas and produce same volume of wastes. Hoa Huu Nguyen et al. (2014) found that currently although urban population accounts 30 % of total population, but produces about 42–46 % of total solid wastes. Municipal solid wastes those come mainly from households, residential quarters, street wastes, markets and trade centers, offices, research centers, schools share up 60-75% of urban solid wastes (National State of Environment report, 2011, chapter 2). The amount of FW can be estimated based on the MSW generation rate, population growth in urban areas and the organic fraction. The estimation of FW in Vietnam from 2007 and predicted to 1025 is presented in table 1.

FW contributes large proportion in MSW, makes from 54 to 77 % of the municipal solid waste depending on the city. The data in 2009 – 2010 show the highest proportion of FW in MSW was in Hue city (77.1%), following by Da Nang city (68.5%), and HCM city (62.8 - 64.5%). The proportion of FW in Hanoi ranged from 53.8 to 60.8% (Hoa Huu Nguyen et al., 2014). Research result of Dieu T. M. Tran et al. (2014) in Ho Chi Minh City shows that, household solid waste shared about 50% of total MSW in the city with the generation rate is about 0.53 – 0.63 kg/capita/day (approximately 2.1 – 2.5 kg/household/day). In which generation rate of the FW ranges from 0.31-0.40 kg/person/day. Food waste consists of 80– 90% of food refuse.

Table 1: Estimation of food waste in Vietnam from 2007 to 2025

Contents	2007	2010	2015	2020	2025
Urban population (million)	23.8	26.2	35.0	44.0	52.0
Ration of total population (%)	28.2	30.2	38.0	45.0	50.0
Total municipal solid waste per day (ton)	17,682.0	26,220.0	42,000.0	61,600.0	83,200.0
Total food waste per day (ton)	10,945.0	16,299.0	25,200.0	36,960.0	49,920.0
Total FW collected per day (ton)	-	-	21,420.0	33,264.0	49.920.0

Source: Modified from Hoa Huu Nguyen et al. (2014)

According to Byer et al. (2006), in Ha Long bay, compostable materials those consist of mainly fruit, vegetable waste account about 60 – 70% of the waste stream from hotels, this figure for households in Da Nang province is 63 – 65%. In Hoi An, 60% of about 45 tons of daily waste is

kitchen waste that contains of 75% organic waste (Ngô Thị Hòa et al., 2010) and therefore, composting kitchen waste was suggested.

2.2. Management of food waste (FW)

Vietnam faces many environmental challenges due to the strong urbanization and economic growth. Solid waste in which with a large share from FW mainly generated from households, buildings, commercial activities and other sources such as wastes from restaurants, hotels, supermarkets, etc. (Hoa Huu Nguyen et al., 2014). Vietnam has faced with many problems in waste management and finding different methods rather than only applying incineration and landfill (Paul Olivier et al., 2011a). The waste management systems in which solid wastes are classified at source, collected, reused, renewed, and treated with progressive technologies is currently encouraged by Vietnamese government.

In Vietnam landfilling is applied for mostly FW and other components in the MSW stream (National State of Environment report, 2011, chapter 2; Ngoc Bao Dung Thi et al., 2015). This method has many disadvantages in terms of creating lasting detrimental impacts to the environment (emissions to the atmosphere, hydrosphere, risk in landfill stability, and scarcity of land) (Hoa Huu Nguyen et al., 2014).

Anaerobic digestion (AD) has been developed worldwide and introduced to Vietnam over 15 years ago. Compared to landfilling, AD is fully enclosed systems and produce biogas from FW together with other renewable organic sources, reducing gas emissions which can be harmful to the environment. This method has been suggested as a good solution for FW management. However, AD was introduced to Vietnam at a small scale and still does not yet make a significant contribution to resolving urban waste problem in Vietnam because of lack of information, data and experience. It was disregarded by the government for dealing with municipal solid waste (Hoa Huu Nguyen et al., 2014).

Ngoc Bao Dung Thi et al. (2015) suppose that the stimulation of FW production markets is important in Vietnam as well as in other developing countries those based on agriculture. The recycling of FW for providing bio-composts and bio fertilizers should be encouraged. The offers of financial incentives from government are required to motivate domestic facilities as well as agro-forest systems in recycling FW. Byer et al. (2006) suggest that composting is a promising option for managing waste from wastes in the market, hotel and household as the high percentages of compostable waste found in this waste stream.

The institutions, policies and legal system of waste management of Vietnam have been in progress. However, these are still inappropriate and insufficient. The implementation could be fail in wide applications in Vietnam because even though FW management policy is promulgated but is not enforced by governments. On another hand, national policies and

regulations relevant to FW are promulgated. However, the policies and regulations deal with waste in general, and are not specifically adapted to the FW issue (National State of Environment report, 2011, chapter 7).

2.3. Industrial development of collecting and processing food waste

Paul Olivier et al. (2011a) argue that for efficient use of waste treatment technologies in Vietnam, these must be suitable with the socio-economic situation of Vietnam, i.e. small scale, not very high technology, and easy applicable. The authors suggest the idea on FW management and changing FW into valued resource using combined technologies such as thermophilic compost and microbio thermophilic compost, biotechnology using black soldier fly and red worm, and lactic fermentation.

Paul Olivier (2008) and Paul Olivier et al (2011 b) proposes FW treatment process at households in Ho Chi Minh city using the larva of the black soldier fly (Hermetia illucens) in microbio thermophillic compost in plastic barrels, and given that this insect has lived alongside humans for thousands of years and has never been associated with the transmission of disease. The process results in rapid reduction within less than 24 hours in weight and volume of FW as high as 95%. This process eliminates much of the cost of transport and all costs related to the land-filling of FW. In HCM city, with the application of this process, a scavenger would be able to get daily revenue of 96,000 VND or $6.00 US, and monthly revenue of 2,880,000 VND or $180 US from harvesting larvae. This method also reduces the emission of CO2 to environment (Paul Olivier et al., 2011a). In the reality, red worm and black soldier fly can be used together and digest all organic matters. The secrete form red worm can be used as a good fertilizer source for crops.

Lactic fermentation is one of most simple method to treat wastes of vegetables and fruits in Vietnam as well as other Asian countries. Combination of these wastes can be put closely in plastic bags or barrels. When the pH is under 4.2, the nutrition will be reserved safely. Lactic acid is good for human and animal digestion tract (Paul Olivier et al., 2011a).

Phùng Chí Sỹ and Vũ Thành Nam (2015) have introduced the models applying microbio thermophillic compost (ủ phân vi sinh ưa nhiệt) to treat FW and agricultural waste at households. All organic components of household wastes such as FW, vegetables, fruit peels, leaves, animal manures, etc. are composted in plastic barrels for 4 months. Composted fertilizer from this method is in good quality and no bad smell with the C/N ration ranges from 12.2 to 30.0, the concentrations of H2S, NH3 and CH4 surrounding the compost barrel meet the standard. Composting kitchen wastes were introduced by Ngô Thị Hòa et al. (2010) in Hoi An city and applied by 450 households. This method was proposed to reduce environmental pollution in the city and to improve ecological environmental management of the community.

“Anaerobic digestion (AD) is a series of natural processes in which microorganisms break down biodegradable material (organic matter) in the absence of oxygen, producing biogas and a stabilized digestate” (Hoa Huu Nguyen et al., 2014). An energy model of FW digestion was introduced by these authors in order to provide energy sources from FW in urban areas of Vietnam in forms of electricity, heat, and biogas under two scenarios. Results of this study found that if FW is separated from municipal solid waste (MSW) and applied AD, this could contribute 2.4 – 4.1% of the electricity demand or 2.2 – 4.7% of fuel consumption for transportation in Vietnam. The authors consider AD is a promising method to deal with MSM in the cities of Vietnam while having more advantages compared to landfilling, composting, and incineration. Kitchen waste with livestock manure can also be put into the pond for manuring the pond (Le Thanh Luu, 2001).

The development of technologies to produce compost fertilizers from the organic wastes was encouraged in Vietnam (National State of Environment report, 2011, Chapter 2). Organic wastes, mostly from food and garden waste are main contents (65%) in the domestic solid waste in rural areas. These organic materials are easy to decompose (National State of Environment report, 2011, Chapter 3). In Hanoi, it was estimated that about 60 tons organic fertilizer were produced by the method of production of micro-biological organic compost from organic waste including kitchen waste, vegetable and fruits (National State of Environment report, 2011, Chapter 2). This was implemented in the frame of the JICA in the 3R-HN project in three wards those were Phan Chu Trinh ward, Hoàn Kiếm district, Hanoi (since 7/2007); Thành Công ward and Láng Hạ ward (2008). A total of 18,000 households have been involved in this project. The project reported that the volume of municipal wastes decreased about 31.2 - 45.1%, the volume of landfill wastes reduced by 30%, and about 10.000 tons of organic fertilizers were produced from the 25.000 tons of organic wastes collected. In Ho Chi Minh City, the organic wastes have been also used to produce compost fertilizers in a pilot program in 10 districts since 2004. In Hung Yen province, the organic waste including FW, ruined vegetables and fruits as well as other organic waste from households were collected and composted. These were implemented by 400 households. The compost could be applied in the holds or using plastic barrels. This method could save more than 1 million VND/ household/year, in which, about43.8% for transport cost, and 56.2% for the value of composted fertilizer. Furthermore, applying this method, the households could reduce more than 70% the pollutants. The composted fertilizer was very good for crops and can avoid the termination of parasites to crops (Mai Ngoan - TTXVN, 2014).

3. Food waste for livestock

3.1. Historical perspectives in the use of food waste for livestock

According to Deka et al. (2014), confined pig production system in rural and peri-rural areas of South Asia, pigs are mainly fed with kitchen wastes, inclusive of leftover foods and vegetable peels, together with other available crops and crop by-products. FW from kitchen of households, restaurants, markets, hotel, food shops, food processing plants with a huge amount that is uneaten food for human but contains of cellulose, hemicelluloses and lignin, and can contain other compounds of protein, nutrient, etc. (Parfitt et al., 2010). Ramesh et al. (2012) carried out an experiment on the effect of swill feeding on reproductive performance of pigs. The results of this study found that the overall weight gain and average daily gain as well as litter size at birth and at weaning were significantly higher from weaning to one year of age when replaced 50% of concentrate by FW compared to the feed ration with full concentrate even though the feed conversion efficiency was better in the later. In addition, gilts fed with 50 % swill feed produced piglets with higher birth weight and weaning weight than those fed with the ration of full concentrate.

Paul Olivier et al. (2011a) state that, pigs play an important role in stable FW management. Pigs can eat and digest different feeds and considered as FW collectors. Many farmers have been searching for different types of feed for their pigs. FW are available with a large quantity from different sources as mentioned above. These sources of FW were available for pig keeper within or around cities. However, farmers are still reluctant to feed these wastes directly to their pigs for fear of the transmission of disease. There is a fact that the application of heating and fermentation technologies, the FW would be free from disease termination and transmission. Therefore, pig keepers could feed cooked or fermented FW to their pigs. This was saving the feed cost for farmers (Integrated Pig Farming, 2011; Paul Olivier et al., 2011a).

According to Parfitt et al. (2010), in Ho Chi Minh City, about 70% of 197 tons of FW each year was treated and used as livestock feed. About 50% of 10,610 tons waste from vegetables each year was used for livestock, especially pig feeding. More than 70% of FW from households and from private or state company was used for livestock. Furthermore, the by-products as industrial FW could be used for livestock. It was estimated that about 196 tons of yeast from the Sai Gon Beer Company were collected and sold to livestock feed processing company each year.

Paul Olivier et al. (2011a) proposed different methods of using FW in livestock production, particularly for pigs in Vietnam. He the author stated that, eating fermented waste from vegetables and fruits, pigs would reduce the diseases related to intestinal tract. For example, in Da Lat, 50 ton of waste from cabbage would be fermented and used as feed for about 16,000 pigs per day with the estimated the value of 100 million VND/day. The waste from sea food

processing could be fermented and used as high quality feed for pigs, fish and poultry. These feeds do not need to cook, and therefore, labor would be reduced and remain the protein value of feeds. The wastes of vegetables and fruits from market could be directly feed pigs or fermented or composted. Wastes from slaughterhouse can be cooked to feed pigs.

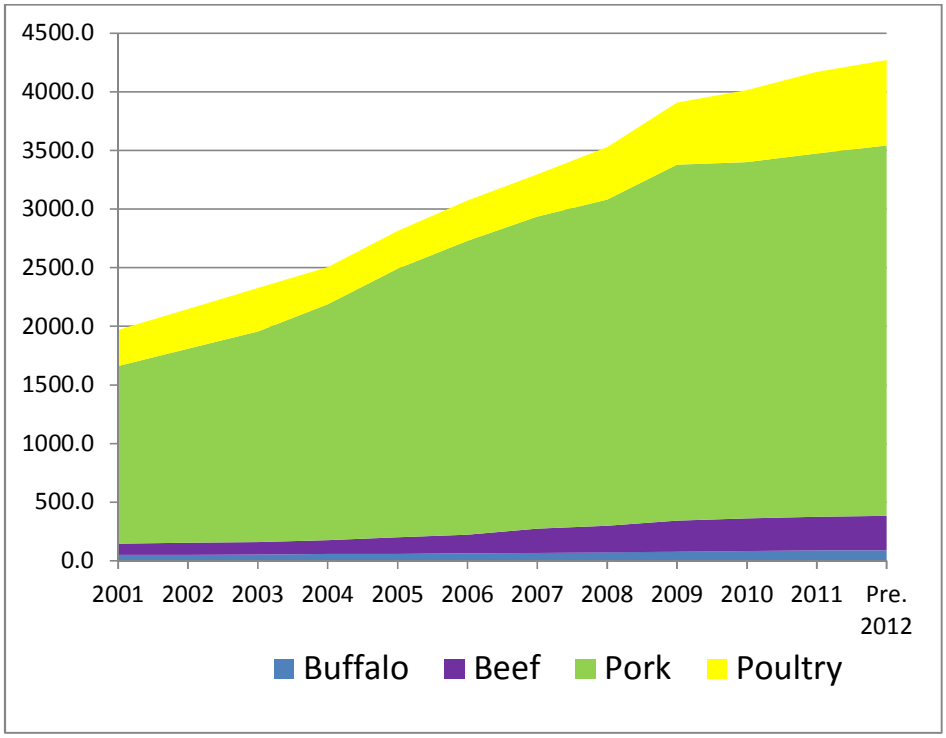
3.2. Estimation of total livestock

Livestock production plays an important role in Vietnam in terms of providing protein, increase income and poor alleviation in rural areas. Vietnam has the highest pig population (26.26 million) among the Southeast Asian countries (FAOSTAT, 2014). On average, numbers of livestock have been increased (more details in table 2)in accordance with the increase in the yield of livestock production (see figure 1).

Table 2. Number of Livestock and Poultry (1999 to 2009)

Year	Buffalo (million)	Beef (million)	Dairy Cattle (million)	Pigs (million)	Chicken (million)	Ducks, geese (million)	Goats and sheep (1 000 heads)	Horse (1 000 heads)
1999	2.95	4.06	29.40	18.88	153.76	43.56	516.00	149.6
2000	2.90	4.13	35.00	20.19	147.10	51.00	543.90	126.5
2001	2.82	3.90	41.20	21.76	158.00	57.97	569.00	113.4
2002	2.82	4.06	55.85	23.17	159.45	73.84	621.90	110.9
2003	2.84	4.39	80.00	25.46	185.20	68.84	780.40	112.5
2004	2.87	4.91	95.80	26.14	159.20	58.92	1 022.00	110.8
2005	2.92	5.54	104.10	27.43	220.00	60.10	1 314.00	110.5
2006	2.92	6.51	113.20	26.90	214.60	62.60	1 525.00	87.3
2007	2.99	6.72	98.60	26.50	157.90	68.00	1 777.00	103.5
2008	2.90	6.34	107.89	26.70	176.04	71.18	1 483.50	121.0
2009	2.89	6.10	115.52	27.63	199.99	80.18	1 375.13	102.21

Source: General Statistics Office, 2000 - 2009



Source: GSO (2013)

Figure 1: livestock production in Vietnam

FAO (2011) estimated that small scale household farms in Vietnam shared about 70% of pig population and supply about 75% of pork. Smallholder farmers use locally available feedstuffs. Pigs are fed mainly with kitchen wastes and rice bran, and occasionally limited amounts of purchased concentrates Deka et al. (2014). For example, on smallholder farms in some provinces in Red River Delta such as Hai Duong, Thai Binh, Nam Dinh, pigs were fed with both commercial feed and swill FAO (2011). While prices of animal feed in Vietnam are 15-20% higher compared to the neighbor countries.

Changes in pig density after 10 years from 2001 to 2011 in North of Vietnam are described in the maps in figures 2 and 3 (Cesaro, 2015). In general, pig densities in the Northern part of Vietnam increased, especially in Bac Giang and Thai Nguyen, the two provinces nearby Hanoi. The pig densities in center of Hanoi and Hai Phong cities decreased (see figures 2 and 3).

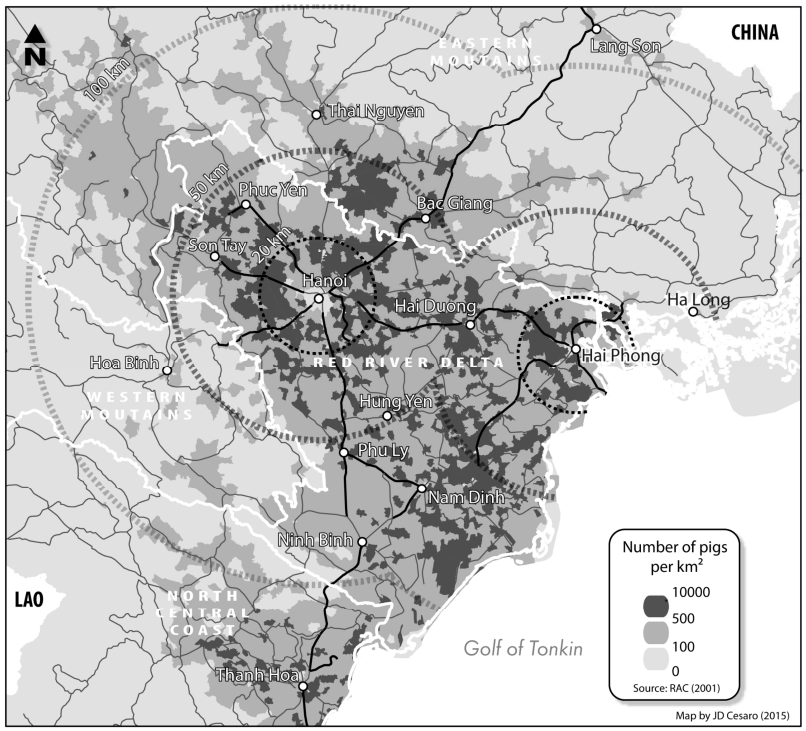


Figure 2: Pig density in 2001 the North of Vietnam (Cesaro, 2015)

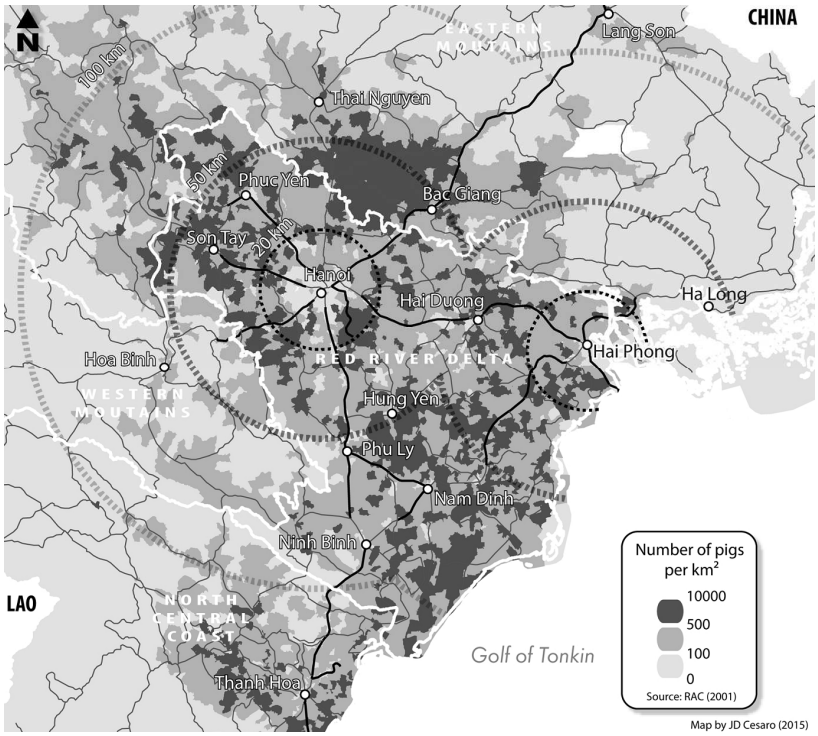


Figure 3: Pig density in 2011 in the North of Vietnam (Cesaro, 2015)

3.3. Current Practices on food waste to animal feed

Le Thanh Luu (2001) found that, in mixed farming systems in Vietnam, pigs and poultry were normally fed with kitchen wastes and other available farm products and by-products such as cassava, rice bran, sweet potato, banana trunks and water hyacinth. Many pig keepers from different cities and provinces in Vietnam have been collecting FW from restaurants, hotels, cantins, etc. to feed their pigs and sometimes to poultry and fish. Lao Động newspaper (2013) wrote about the pig keeper (Mr. Huỳnh Văn Nới at A11/52 đường Bờ Sông, KP2, phường Tân Tạo, quận Bình Tân) in Ho Chi Minh City who has been collected FW since 1996 from big factories in the industrial zone. FW were cooked and feed up to five hundreds fatteners. He sold the redundant FW to other small scale pig producers. Currently, he does the business on collecting and selling FW as feed for pigs and fish to farmers in surrounding districts. His enterprise can sell on average of 5 – 6 tons FW/ day with monthly income of some hundreds million VND. This enterprise provides job for about 20 labors with an average income of 2.2 million VND/ person/month and does other supports to the poor. NongNghiep.vn (2015) also wrote about a man in Ninh Kieu district as an example of collecting FW at small scale to feed pigs. He collected FW from many restaurants, 2 -3 times every day. He raised about 40 fatteners and 2 sows. Collecting FW helps him reduce feed cost in pig production.

In Hue city, many women have been also collecting FW to feed their pigs to reduce feed cost Quỳnh Anh - Yên Thường (2014). They collected FW from different sources such as restaurants, households, hotels. They could collect FW one to twice daily within the distance of 15 km. These farmers raised about 15 up to 40 fatteners per litter. They might have to pay 200,000 VND/month to restaurants or exchange their labor by washing dishes there. They also sell an amount of collected FW to other farmers.

In Da Nang province, collecting FW for pigs has also commonly practiced by farmers for long time (Cadn.com.vn, 2012). These farmers could raise 40 - 60 pigs with collected FW from restaurants with the net benefit was 60 – 80 million VND per year. The cost for collecting FW was about 1 million VND/month, much cheaper than raising pigs using concentrates. According to the farmers, pigs fed with cooked FW growing fast, could be off taken after 3 – 4 months. Pork from pigs fed WF was preferred by traders and got higher price compared to other commercial pigs. Collecting FW may create job for old people with income of 20,000 – 30,000 VND/person/day.

In Quang Ngai province, many households in the cities and surrounding districts have made use of FW from restaurants and hotels as feeds for their pigs and increase their income from pig production such way (Báo Quảng Ngãi, 2015). These farmers raised 40 – 50 fatteners using cooked FW with addition supplement of maize and cassava meals. Pig production brought an average of more than 100 million VND/ household/year. According to a farmer, keeping 40

fatteners, the feed cost would be about one million per day if fed with concentrates, but utilizing FW, he paid only 75,000 VND per day for additional concentrate supplement.

In the suburb of Hanoi, the collection of FW for feeding pigs has been practice for many years. FW were collected from restaurants, resident zones in the city within the distance of 10 to 15 km. Farmers paid for FW and should keep good relationship with the restaurant and households where they collected FW (Đức Hải, 2011). The payment might be 200,000 – 300,000 up to 500,000 VND/year for restaurants (Báo Hà Nội Mới, 2015; Tuyển Trần; 2015) or even 2 - 4 million VND per month for big restaurants and hotels. FW was sorted and cooked then mix with concentrates or maize/cassava meal. Many farmers could increase production scale and number of off taken litters per year. There was also a case as in Ho Chi Minh City, that the farmer used a semi-van to transport FW from restaurants, and hotels in the center. According to farmers, feeding pigs using FW could avoid the pressure from increase in the feed cost, and therefore, the benefit increased. However, this method is more suitable with medium scale production. A farmer could get benefit of about 2 million VND per month from keeping 10 – 12 pigs using FW with additional supplement of purchased maize and cassava meals as well as collecting other available vegetables (Báo Hà Nội Mới, 2015). There were larger scale pig farms in Hanoi also using FW to feed their pigs. A farmer who kept 200 pigs said that he could save 60% of feed cost from using FW, on average, he could save about 60 million VND per month from feeding 200 pigs using FW (Tuyển Trần (2015).

In the frame of the current study, five FW collectors those carried blue barrels behind their motorbikes were randomly interviewed on the roads of Eastern Hanoi city. Tables 3 and 4 summarize the information on these FW collectors and how they use collected food waste for their pigs and other livestock species.

Table 3: Summary of major information on interviewed FW collectors

ID	Home address	Experience (year)	Frequency (time/day)	Weight of FW (kg/time)	Where FW collected
1	Phường Thượng Cát, HN	10	1	70	Kinder garden, Đông Ngạc
2	Huyện Đan Phượng, HN	5	1	240	Industrial zone, North Thăng Long
3	Huyện Đan Phượng, HN	6	1	180	5 restaurants in Mai Dịch
4	Huyện Hoài Đức, HN	3	1	170	5 restaurants in Từ Liêm district
5	Phường Thượng Cát, HN	1	1	160	Surrounding schools

Key person interviews (2015)

Table 4: Summary of using FW for livestock production by interviewed collectors

ID	Pig keeping	Monthly payment for FW ('000 VND)	FW treatment	Other species
1	8 sows, 12 fatteners; 5-6 months/ offtaken	750	Cooked and mixed with concentrates	Chicken, duck
2	3 sows, 30 fatteners, 40 piglets; 6 – 7 months/ off taken	1,000	Cooked and additional supplement of 2 kg concentrates	Chicken, fish (little)
3	40 fatteners, 5-6 months/ off taken	2,000	Cooked and mixed with concentrates	Chicken
4	4 sows, 80 fatteners, 40 piglets; 6 – 8 months/ off taken	1,000	Cooked with rice bran, maize meal, vegetable and 2-3 kg concentrates	Chicken
5	40 fatteners; 7 months/ off taken	1,000	Cooked with by-products of tofu and alcohol processing	Chicken, duck

Key person interviews (2015).

It could be seen that, medium scale smallholder pig farms in the districts surrounding center of Hanoi have tried to reduce feed cost by utilizing available FW for their pigs and also for poultry. They could collect plenty of kitchen wastes from restaurants and big cantins in the center not very far from their place (about 5 - 10 km), those provided about the same amounts of FW every day, i.e., the supply is stable for farmers. The key person interviews of the current study found that, these farmers could save their labor in collecting and transporting FW when they had done the collection only one per day compared to the farmers in other smaller provinces/ cities mentioned in the above review. Due to Hanoi is big city with number of big restaurants and especially crowded cantins from schools and the industrial zones. Therefore, these produced large amounts of FW at a certain time in a day. Farmers could make use of the collection from few sources.

FW became a major component in the pig feed ration of these interview farmers with little supplement of industrial concentrate. All of farmers cooked FW before feeding their pigs. This method seems to be the easiest application for the farmers. All of them did not report any serious problem in terms of disease in their pig production related to the use of FW. The interviews also show that collecting kitchen wastes have been practiced for long time. Farmers with such medium scale pig production still kept collecting FW for 5 – 10 years, and also other farmer just started to practice this (1 – 3 years). This implies that using FW for pigs is suitable, economic efficient and easily practical for these medium scale smallholders. Farmers tend to learn from each other. They would learn and keep doing what they think it can bring better benefit and suitable for them.

4. Swill feed's quality and animal health hazards in Vietnam

4.1. Animal health hazard reported with food waste

According to Furedy and Maclaren, many farmers in Asian countries practice reusing organic wastes come from agricultural and aquaculture sectors. The authors summarize main practice of urban organic waste reuse in some developing countries (see table 5).

Ngô Thị Hòa et al. (2010) doing an analysis of kitchen wastes from 30 households found that residue of vegetable, fruit peels accounted 50%, waste of food accounted 40% and the rest was head of fishes, shrimps, and octopus (10%). In the context of urbanization, both aspects of economic and health need to be concerned. The constraints regarding to the impact of the contamination on these aspects in the reuse of organic wastes should be reduced. Furedy and Maclaren reviewed that FW were used extensively for animal production in Hanoi and Ho Chi Minh City. However, the separation of wastes was limited by lack of space in Hanoi.

Table 5: Type of organic wastes and reusing practices in the developing countries

Type wastes	Materials	Practice	Remarks
Kitchen and yard wastes	Kitchen wastes and some vegetable residues	Backyard composting for home gardening, domestic animal feed (poultry, pigs goats, cows); composting.	Kitchen wastes composted over long periods may concentrate pesticide residues in plants. Rats, flies, etc., may cause problems for small scale compost plants.
Restaurant and canteen food wastes	Raw peels and vegetable residues and food waste	Feeding livestock (pigs, poultry)	Direct feeding of household livestock is relatively low-risk.
Market, kitchen and yard wastes	Vegetable wastes, food waste	Household compost plant	Potential in cities. Little known of pathogens survival.

Source: Modified from Furedy and Maclaren

"Owning farm animals" warned that feeding FW to pigs might bring a huge risk for the entry and spread of animal disease. The outbreak of food and mouth disease (FMD) outbreak in UK in 2001 was considered as a result from using swill feeding (Biosecurity.govt.nz). According to "Owning farm animals" and "Biosecurity.govt.nz", FW might contain of meat, other animal by-products, some dairy products must not be fed to pigs. Deka et al. (2014) state that selling of

diseased pigs in the market or feeding of leftover meat to pigs is common in many South and South East Asian countries and those were important contributors for transmission of diseases. Swill feeding is considered as the source of infection of FMD (Elbers, 2002), especially in peri-urban systems where this is more often practiced (Perry et al., 2002). The authors gave an example on the currently circulation of FMD in Vietnam due to pig adapted strain, and resulted in the impact of antibiotic use. Exotic animal disease newsletter (2008) reported that the most path of entry of PRRS to Australia would be resulted from the feeding uncooked swills to pigs those contain of infected meat. The study of Truong and Gummow (2014) also found that feeding uncooked swills was one of significant factor associated with the household infected with PRRS.

4.2. Technical Solutions to decrease animal health hazard

Organic wastes can be completely decontaminated and safely used as a feedstuff source after ensiling, or by thermal treatment, preferably complete sterilization (Pérez, 1997).

Biosecurity.govt.nz recommended that FW that contains or contacts with meat must be treated before fed to pigs. Heating at 100^{o}C such as boiling for one hour is suggested as one of FW treatment methods, both for commercial FW and household FW. This is the easiest way and can treat any disease-causing bacteria and viruses present will be destroyed.

4.3. Legislation on food waste to animal feed, legislation on animal health and feeding practices

Sang-Arun reports that, some countries including Vietnam have developed national strategies on the 3Rs (reduce, reuse, recycle) to expand composting and anaerobic digestion. This is considered as a suitable method of waste management based on a philosophy of cascading where the full resource value of materials is utilized. However, organic waste can be reduced but it cannot be completely eliminated. Reuse of organic wastes using FW as animal feed is a good method to avoid greenhouse gas emission Recycling of organic waste (e.g. composting and anaerobic digestion) can reduce net GHG emissions, but its efficiency depends on the technology and operating conditions (Sang-Arun).

According to Sang-Arun, organic waste quantity has increased with the urbanization of developing Asia, accounting for on average of 63% of total municipal solid waste. Linh Thi Huong Dong (2014) reviews that the population growth and rapid urbanization were the main reasons for a significant increase in waste in Hanoi city. Hanoi produced the most waste in the Northern Vietnam with an average of 0.61 kg/capita/day and second most in the whole nation. Food residue was major component of the commercial waste in Hanoi, particularly in restaurants, open – markets and shopping center (see figure 4).

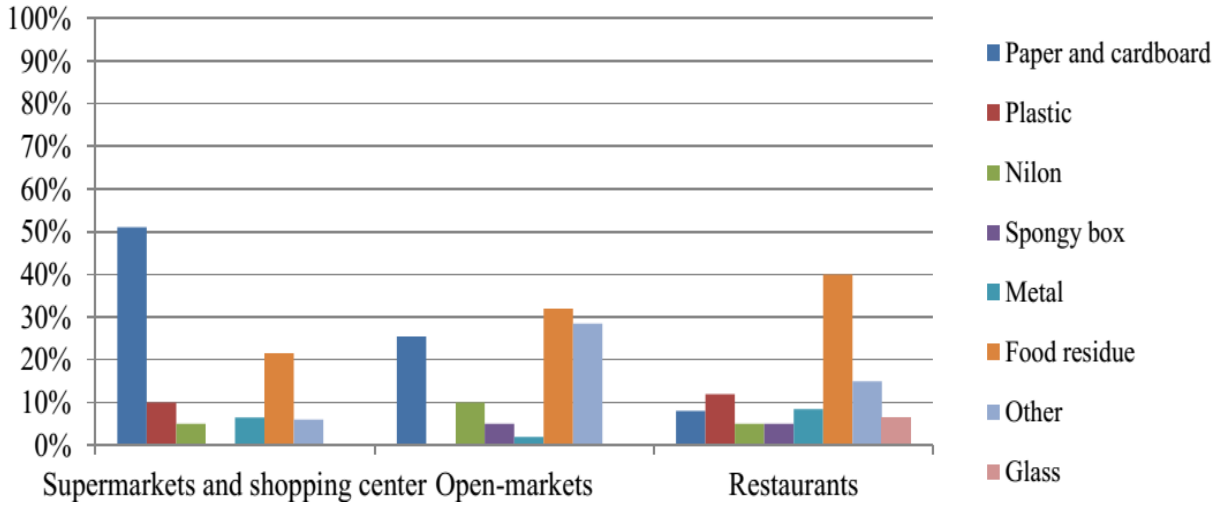


Figure 4: Commercial waste fractions in Hanoi
Source: Ngo et al., 2012, cited by Linh Thi Huong Dong (2014).

FW was transported to livestock farms as animal feed or to the composting sites (Ngo et al., 2012, cited by Linh Thi Huong Dong (2014). However, the waste separation in Hanoi was different between restaurants. Some big restaurants had strict regulation for waste separation, while other smaller ones did not. It was estimated that about 13,260 tons of composting products could be get if 50,000 tons/ year of solid waste were processed.

Given the forbidden of keeping pigs in the city center, plenty of FW from restaurants and households would cause environmental pollution. Therefore, the collection of FW using for pigs by farmers brings good benefits for both, FW suppliers and consumers, particularly, this reduced environmental pollution in the crowded cities (Cadn.com.vn, 2012) and Đức Hải (2011).

5. Conclusion

Environmental pollution due to solid wastes is common problem in many developing countries including Vietnam. In Vietnam, numbers of treatment methods have been applied for organic waste as well as food wastes. However, almost of these were implemented only in the demonstration models or zones. There have been numbers of regulations and policies regarding to solid waste management in Vietnam, however, the implementation is still inefficient and insufficient. Still there are many difficulties in carrying out the waste separation in the wide application in Vietnam. The most popular practices of reusing FW in Vietnam is feeding to livestock, especially to pigs by smallholder farms in peri-urban areas. Cooking FW before feeding to animals was most common and simple way to avoid the risk of disease transmission from using FW in Vietnam. Treatment and recycling of FW as livestock feed are potential solution in improvement of income for pig producers as well as disease in environmental pollution.

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