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Influence of Pig Farms on the Environment in Northern Vietnam, Effect of Some Solutions – A Review.

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Abstract
In the last decades, the population of Northern Vietnam increased significantly (Northern midlands and mountain areas and Red River Delta increased by 8.8% and 7.48%, respectively), which led to the increase in food demand, forcing the food industry to increase its products to meet the nutritional requirements.
Pork products are highly consumed by the Vietnamese population because they are not only healthy but also cheap. To achieve increased production, more hog farms have been established. However, pig farms become a potential source of contaminants released into the environment surrounding the farms. It causes eutrophication in lakes, rivers, increase of greenhouse effect, crops pollution and other impacts we discuss in this paper.
The research found out that the contaminating element, which can be controlled the most, is the animal waste. To treat the animal waste, biogas digester is considered as the best method suiting to Vietnamese farmers and reducing the amount of wastes discharged into environment.
Despite the fact that government considers pig farms as a potential risk of contamination of the environment, in the laws it has drafted to control this fact they are brief since sometimes they only mark limits and goals, but they do not give guidelines for solution for pig farmers.

Key words: pig farm, environment, pollution, policy, Vietnam.

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I. Introduction

According to General Statistical Office, population growth in Vietnam increased significantly over the past decade, in the period 2011-2018, Northern midlands and mountain areas and Red River Delta increased by 8.8% and 7.48%, respectively. Therefore, to meet the growing needs of the population, there has also been a remarkable increase in the number or farms in the same period, being 368.02% and 223.17% in Northern midlands and mountain areas and Red River Delta, respectively.

For two decades, Vietnam has experienced exceptional advancement in economics and thus increases residents' living standard. Animal husbandry was a main sector in developing economy (Giao, 2019); the number of animal husbandry farms meeting the farm economy criteria is increasing (Giao, 2019), especially in Northern midlands and mountains, becoming the third most abundant region in the country (Chu et al., 2019).

The livestock industry in Vietnam plays an important role in agriculture. It accounts for 28% of total agricultural value added (World Bank Group, 2017) and is one of the fastest growing agricultural industries. The growth rate of farms is similar in every year and it is also different in each region. Northern Vietnam has many advantages to develop animal husbandry due to the rich pastureland system (Nguyen, 2015). Since reformation period cattle smalls farms have been increasing in Northern Vietnam (Nguyen, 2005). Northern provinces, such as Ha noi, Thai Binh, Vinh Phuc, Thai Nguyen, Hung Yen and Ha Nam, were greatly affected due to their huge increase in the number of farms. To face this situation, the material and technical facilities of the farms in the North of Vietnam have made significant changes (Giao, 2019).

The demand of livestock products in Vietnam is increasing, mostly in the urban areas (Nguyen, 2005). Pig and poultry are the predominate livestock species in Vietnam, reaching 28.151'9 heads and 409 million heads in 2018, respectively. Specify the year, the total weigh of pig reached 3.816'4 thousand tonnes (71'46% of the total living weight of buffaloes, cattle and pig and slaughtered poultry) (General Statistical Office).

In this paper we focused on the environmental impact of the pig farms on Northern Vietnam and the available and effective options that exist to try to reduce this pollution while continuing to produce farm animals.

Pig farms in Northern Vietnam

Pig production in Vietnam is composed of mainly three systems: (a) small - scale householders with low level of hygiene; (b) small - scale commercial pig producers with minimum hygiene standards; and (c) large commercial scale producers with high hygienic standards. In 2015, 70% of pig heads and 60% of pork production are produced by the small-scale farm householders (Dzung and Tu Liem, 2015).

Pig keeping is of great importance in Vietnam: 71% of farm households own pigs and pork accounts for 70% of all livestock products. Around 80% of pig production is small-scale. Pigs contribute up to 41% of the income of smallholder farmers in North Vietnam (Lemke et al., 2007). The pig production is unequally distributed all around the country, being concentrated on Red River Delta in the North and Mekong River Delta in the South, between these areas account about 40% of the pigs country's pig population and about half of the pork output (Tung, Thuy and Thang, 2005). The North-West has a low per-capita-income and income density from pig production, but it is one of the regions with the highest share of household income derived from pigs (Lemke et al., 2007).

Pork production by the main ecological areas are as follows: The Red River Delta is approximately 33%; Northern Midland and Mountainous areas: 13%; North Central and Central Coastal areas: 19%; Central High Land: 5%; South East area: 12% and Mekong River Delta:18% (Dzung & TuLiem, 2015).

Pig production in Northern Vietnam was based mainly on small-scale farms, in 2011 71.63% of the farms had less than 4 pigs (Tung, Thuy & Thang, 2005; Dzung & Tu Liem, 2015). Infrastructure investment in farm pig production farm is limited; the proportion of big and integrated farms with automatic feeding system, drinkers and cooling system is very low (Dzung & Tu Liem, 2015). However, pig production is driven by the market demand for pork (Lemke et al., 2007). The size of pig farms has increased slowly. In 1994, pig farms with more than 6 pigs only accounted for 2.2% of the total of pig farms (Tung, Thuy & Thang, 2005). Pig production has grown up twice after 10 years from 2001. In the period of 2001-2006, the number of slaughtered pigs and sows increased quickly with the annual rate of 5.9% and 7.7%, respectively, leading to pork production which has been increasing by 10.9% per year. After 2006, production became slower primarily because of continuous disease outbreaks (Dzung and Tu Liem, 2015).

Environmental impact of livestock farms

The global increase in demand of livestock products has led to many concerns about the associated negative impacts of livestock rearing on the environment and on human health. In northern mountains in Vietnam, the farming development had significant effects on greenhouse gases emissions and carbon storage (Leisz et al., 2007). Particularly, the management of livestock waste has become a considerable challenge in this country due to the rapid increase of animal production, mainly swine (Le Thi et al., 2017).

Livestock production produces a large volume of gases, organic material, bacteria and other substances which are released to the environment. This is a threat for air, soil and water resources pollution (Ganguly et al., 2015; Abdeshahian et al., 2016). Accordingly, livestock production contributes to many dangerous environmental problems to our planet, including global warming, land degradation, air and water pollution, and loss of biodiversity (FAO, 2006). We have grouped these consequences in five categories: (1) air pollution, (2) water pollution, (3) land pollution, (4) biodiversity loss and (5) human and animal health problems. Despite this classification, all groups are interconnected.

Air pollution

Livestock overproduction leaves high amounts of livestock wastes that produces offensive odors, release CO_2, CH_4, nitrous oxide and NH_3 into the atmosphere, which favor the acid rain and the greenhouse effect (Ganguly et al., 2015).

Accordingly, livestock contributes 18% of greenhouse gas emissions to environment, a bigger number than that of transport (FAO, 2006). Besides, livestock farming in Northern Vietnam contributes significantly to the increase in greenhouse gases and NH_3 emissions and it shows an upward trend in theses emissions in the future (Truong et al., 2018).

Anaerobic fermentation of organic matter in open lagoons also results in high methane emissions, and a danger that toxic gases can be released during the biological decomposition of the manure, with negative consequences for farmers and livestock (Ganguly et al., 2015). On the other hand, emissions of manure dropped in pastures represent an insignificant contribution due to the lower methane conversion factors (Marañón et al., 2011).

Ruminant livestock is the principal source of enteric methane emissions into the atmosphere from the rumen fermentation process, such as manure storage and treatment, are the most important sources of CH_4 and N_2O emissions (Borhan et al., 2012).

The continuously rising concentrations of these gasses are leading to an increase of earth's climate temperature (Borhan et al., 2012). Global warming is one of the major concerns arisen in the natural environment of human beings (Abdeshahian et al., 2016).

Besides, pigs make an annoying sound that shows the highest values inside the building farm at feeding time, reaching 71.951.41 dB. Outside the farm we can perceive these noises because they can be propagated through the wind (Sistkova, Broucek and Bartos, 2016).

Water pollution

Pig farms require large amount of water for their production process. The resulting waste waters contain high concentrations of organic matter, dissolved and suspended solid, turbidity, colour and pathogenic microorganisms and should be disposed (Venkatachalapathy and Usha, 2011). The phenomenon of discharging manure into water bodies close to the pig farms is the main cause of water environment pollution around these farms (Thanh, 2018).

Generally, this untreated farm wastewater is discharged into rivers, seas, lakes and another natural water bodies next to the household (Venkatachalapathy and Usha, 2011; Roubík et al., 2018). Eventually, itcan dramatically change the pre-existing balance between biotic and abiotic components and leads to water acidification and eutrophication process. One of the main changes is that the dissolved oxygen in the water decreases, affecting the living organisms that live in that water. In addition, in turbid waters where appreciable amounts of particulate matter and dissolved organic matter are observed, there is a significant decrease in the light transmittance along the column, which is a handicap for phototrophic organism that live in the depths (Jewson and Taylor, 1978), leading to biodiversity loss.

Specifically, in Vietnam a total of 442.000 tons of nitrogen and 212.00 tons of phosphorus were discharged to public water resources in 2004, hereof 38% of nitrogen 92% of phosphorus was from pig farms (Thu et al., 2012). According to the results of surface water quality analysis of pig farms in Gia Lam, Hanoi, polluted surface water and groundwater of pig farms are the result of not fully controlling manure and wastewater from pig farms with parameters of organic substances exceeds the permitted level (Cao Truong Son et al, 2014). Despite all this, Vietnam currently has no regulations for BOD or COD levels of manure discharged to the public sewers by small and medium-sized livestock farms (Thu et al., 2012).

Land pollution

Fattening pigs produce approximately 4 Kg/head/day of feces and urine (Kinh, 2012). Manure waste obtained from livestock sector is one of the main organic wastes which are hazardous if not managed suitably (Abdeshahian et al., 2016). It is usually used to fertilize crops or it is disposed of in landfills.

Pig manure contains a high concentration of nitrogen (N) and phosphorus (P), thus, its over-production results in over fertilization and nutrient imbalance on crops and soil acidification (Ganguly et al., 2015; Abdeshahian et al., 2016).

Waste placed in landfills is subjected to either groundwater underflow or infiltration from precipitation. The dumped solid wastes gradually release water along with some of its decomposition by-products get into water. Such liquid containing innumerable organic and inorganic compounds is called leachate. This leachate accumulates at the bottom of the landfill and percolates through the soil. Groundwater in areas near landfills is likely to become contaminated because leachate is a potential source of contamination. Such contamination of groundwater resource poses a substantial risk to local resource user and to the natural environment (Mor et al., 2006).

On the other hand, if the farmers use pig manure adequately, it can be a significant source of fertilizer to farming. An adult pig can produce 600 - 730 kg of fertilizer/year. Pig dry manure contains nitrogen content (2.2%), phosphate (2.1%) and potassium (1.0%) (Global Fertilizer Corporation, 2018). Pig manure improves the soil, increases the porosity, adding organic matter, increases humus to improve soil, increases soil fertility, and helps plant roots grow strongly. In Vietnam, pig manure is the main source of organic fertilizer for crop production, especially for vegetable production.

Human and animal health problems

The livestock manure contains residues of harmful substances (such as growth hormone, antibiotics and heavy metals) and microorganisms in the animal manure could contaminate the environment resulting in health problems such as outbreaks of human and animal diseases and antibiotic resistance (Nguyen, 2005; Roubík et al., 2017). Many unforeseen infectious diseases will affect the community if pig farms are not handled properly and promptly. In addition, the inevitable growing human population trend produced an immense amplification of virulent pathogens (Chu et al., 2019). There are some main dangerous diseases from pig farms and pork: Antibiotic resistance, Zoonotic diseases, Swine influenza, Salmonella, Streptococcus suis, Ascariasis.

Pig production activities in Vietnam run at dense level, with most of the pig farms operated by small-scale farmers and control of diseases face many difficulties. Most of the pig houses are opened style with low bio-security level. While there are accesible veterninarians in the countryside, outbreak may easily occur and be quickly transmitted. It is difficult to control the diseases (Dzung and Tu Liem, 2105).

As an example, in 2019, the world suffered the outbreak and spread of the virus responsible for African Swine Fever (ASF). From February 2019 to the present, ASF has been detected in 8.548 municipalities in 667 districts in 63 provinces and cities with a total of 6 million pigs culled, with a total weight of 342.091 tons (approximately 9.0% of the total weigh of pigs in the country) (3tres3, 2020). Thus, this outbreak left many animal losses and a great economic impact on the pig sector. In Hanoi 20.7% of the swine census was culled. The localities that had to cull the largest number of pigs were Soc Son (65.983 pigs), Dong Anh (38.894), Quoc Oai (28.503) and Chuong My (26.337) (3tres3, 2019). This shortage of supply (about 340 thousand tons of deficits) produced the increase in the price of pork (Ministry of Industry and Trade of the Socialist Republic of Vietnam, 2019).

Currently, there are 8.200 municipalities (96% of the total number of municipalities with the epidemic) that have gone 30 days without new cases. Thus, they say that Vietnam is almost overpassed the ASF outbreak. However, the authorities are attentive to the ASF because there is not a rigorous biosecurity in small farms (3tres3, 2020).

II. Methodology

To carry out this review, the data collected from World Wide Science, Researcher Gate or Google Scholar has been used. A varied collection of publication to develop the main topic of this study were used the following keywords: "environment", "animal farms", "impact", "cattle", "pig farms", "Northern Vietnam" and "pollution". The specific information has been sought for each section of the paper, using the following keywords: "biogas plants", "pig manure", "biodiversity loss", "manure management", "greenhouse gases emission", "antibiotic resistance", "pig zoonosis", etc.

Both human and livestock farm data were obtained from the database collected from the General Statistical Office. In case of human population, the section of "Population and Employment" and the subsection of "Area, population and population density by province" were accessed. The provinces located in Red River Delta and Northern midlands and mountain areas were selected in all the years available in the database. We obtained the data for average population (Thous. Pers.). On the other hand, to obtain data on animal farms, we accessed the section "Agriculture, Forestry and Fishery" and the subsection "Number of farms by kind of economic activity and by province". Then we selected the same provinces and the same years as in human population case and the livestock farm manufacturing sector. To recollect pig specific data such as pig population and production, we used the same database selecting the section "Agriculture, Forestry and Fishery" and then, the subsection "Number of pigs as of annual 1st October by province" and "Main products of livestock and Year". The livestock population in the whole country was obtained in the subsection "Livestock population as of annual 1st October by Items, Year and Livestock". We obtained the data in the period 1995-2018 (all the available years).

III. Discussion

When the problem of pig farms occurred, the majority of people were extremely annoyed, asking the authorities at all levels to get involved, the provincial and the state promulgated policies and regulations. In addition, Vietnam Government advocates focusing on the development of pig herds to meet the need of the domestic market. The government has resolutions to encourage businesses to invest in the field of pig farming on a large scale. Accordingly, enterprises that have invested in a concentrated pig raising facility will be supported by the provincial budget 50% of the cost by not exceeding 3 billion VND/project construct waste treatment facilities, transportation, utilities, factory, and equipment purchases, simultaneously, ensure veterinary hygiene, food safety, environmental protection, or organic farming model (Minh, 2019). After the shortage of supply the ASF left in 2019, the Prime Minister gave specific instructions, such us taking timely steps to stabilize pork prices at the end of the year, focusing on preventing the spread and control ASF. In addition, MARD gave 6 solutions: (1) focus on working together to prevent the and control diseases; (2) herd in large enterprises farms, and households must commit to biosecurity; (3) to rapidly replicate biosecurity models in production; (4) promoting the grazing of cattle and poultry to ensure three principles (ensuring disease safety and biosecurity; supply-demand balance; ensure security); (5) strengthening the propaganda on disease prevention and control, solutions of the Party, State and Government to prevent and control epidemics to reduce losses; and (6) to prevent pigs and pig products from being sold illegally across the border and smuggling them into our country. Moreover, the Prime Minister also enacted Decision No. 793, June 27th 2019, to support farmers, ranchers, families, agencies and units belonging to the Ministry of National Defense, cooperative groups, production co-operatives (livestock farms) with pigs forced to be destroyed. Specifically, support 25.000 VND/kg of pork (about 70% of production costs); support 30.000 VND/kg of breeding pigs; and 500.000 VND/pig like the old cavalry and grandparents (Nguyen, 2019).

During the current COVID-19 pandemic, the Government also requested the authorities to promptly review and announce the end of the pandemic as prescribed, guide, urge and create favourable conditions,

especially land for people and enterprises to re-invest, increase their herds and expand the pig herds according to the principles of biosafety and safety. Pandemic and supply-demand strictly according to the guidance of the Government, the Prime Minister, concerned ministries and branches; Large livestock enterprises agreed to increase the breeding to provide enough for farmers (Socialist republic of Vietnam Government portal, 2020).

There is also a guidance on environmental protection in concentrated livestock areas (Decision 397 / QD-CN-MTCN dated 4/4/2017 of the Director of Department of Livestock Production, Ministry of Agriculture and Rural Development) that stipulates that breeding facilities are required to have a system and solution. This decision provides measures to control waste before being discharged into the environment: livestock and poultry-raising establishments of a staged areas of 1.000 m^2 or more must have an Environmental Impact Assessment Report and an area of 50-1.000 m^2 must have an Environmental Protection Plan. It also provides some guidelines on specific treatment technologies, such as: (1) the different measures to collected solid waste such as composting, biogas, bioproducts, biological pads and heat treatment; (2) other solutions prior to use in the facility or removal from the premises; (3) solid waste is treated outside the farms to comply with the current regulations on waste transportation; (4) wastewater must be treated by one or a group of solutions such as biogas works, sedimentation tanks, filtration tanks, biological ponds, bio-products or other methods to ensure that no odour is generated. or not flowing into the surroundings (Hinh, 2019). MARD also set up the goals for pig sector development by 2020. One of these goals was to develop the sustainable systems of pig production in association with the rational exploitation of local advantages in natural, economic, and social conditions (Dzung & Tu Liem, 2015).

In addition, farmers are aware of the importance of pig farms by themselves, they apply and explore many different methods for best farm development; there are three main methods that are common in Nothern Vietnam:

Biogas digesters

One inexpensive, simple, and eco-friendly way to reduce pollution through recycling animal and human faeces is biogas digesters (Nguyen, 2005), using manure as biogas and biofertilizer (Ganguly et al., 2015).

The outputs of anaerobic digestion are biogas (a mix of CH_4 and CO_2) and a digestate wastewater (or biogas effluent), which is the digested slurry exiting the biogas reactor (Le-Thi et al., 2017). We can produce biogas from a variety of biomasses such as animal manure, food waste and plant residues (vegetables, leaves, grass and weeds) (Cu et al., 2015).

The main objective of biogas digester and direct advantage is to remove organic waste from animal manure from the environment (Roubík et al., 2017), but it also has other advantages such as the following: (a) It provides enough energy to be used for family cooking (economic saving and reducing of firewood use), warming chicks, boiling water for nursery piglets, or for liquor production (Dan et al., 2004; Nguyen, 2005); (b) It produces a renewable and efficient energy source (Le-Thi et al., 2017); (c) biogas effluent produces no offensive odor, not attracting flies and that can be used for irrigation or for fish production (Dan et al., 2004); (d) it can lead to improvements in manure management on farms and prevent the dangerous flux of effluents into the waters **(**Ganguly et al., 2015) and into soil sources decreasing the amount of slurry on landfills (Yang et al., 2013); (e) It can be used to replace the chemical fertilizers, because the wastewater is nutrient-rich (Nguyen, 2005) and; (f) It contributes to avoiding burning of fossil or firewood, therefore reducing deforestation (Le Thi et al., 2017) and avoiding negative environmental consequences such as CO_2 emission, producing less environmental pollution (Dan et al., 2004; Ganguly et al., 2015). In short, biogas has the potential of generating renewable energy, while complying with the reduction of waste discharges and minimizing environmental impacts (Roubík et al., 2017). With these many proven benefits, biogas technology has become widespread throughout Asia (Le-Thi et al., 2017).

However, biogas plants also have important limitations such as: (a) it requires large areas, so it is not suitable for farms having limited areas. Moreover, building underground biogas tanks needs high initial investment; (b) It may be not able to treat all the wastes produced from big farms or the gas from bigger plants might not be fully utilisable; (c) It can't be practised for farms that have very small number of animals (less than two cattle or less than five grower pigs); (d) in some areas in Vietnam, flooding happens every year from July to October; so, in those areas, biogas plants cannot be maintained; (e) the biogas digestor has almost no effect on the of nitrogen and phosphorous content of the effluent, which means that the effluents still must be managed adequately (Dan et al., 2004) and; (f) the slurry stored to produce biogas must be mixed, therefore, it will produce higher methane emissions than if it would not be mixed (Hilhorst et al., 1998). Covering the slurry storage will reduce the methane emission from the manure mixing and will also reduce the NH_3 emissions (Hilhorst et al., 1998).

Manure management on livestock farms with a biogas system in Vietnam often results in environmental pollution due to discharge of a large proportion of the digester (60 %) into watercourses in the vicinity of the farm instead of using it to fertilise in crop production (Vu et al., 2012). The hygienic quality of

this biogas effluent does not meet the required quality values of discharge into surface water bodies and reuse for irrigation. Because of this case, wastewater carries high concentration of pathogens such as *E. coli*, *G. lamblia*, *C. parvum* (Le-Thi et al., 2017), *Salmonella* spp., *Listeria* spp., *Campylobacter* spp., *Mycobacteria* spp., *Clostridium* spp. and *Yersinia* spp. (Sahlström, 2003). Thus, wastewater of biogas effluent should be biologically treated or used for fish (if the farm has land) or it should be led to and stored in underground tanks that should be periodically collected (Dan et al., 2004). Nevertheless, many Vietnam farmers still discharge the biogas effluent into the environment or use it as a valuable source of fertilizer (Le-Thi et al., 2017). Such activities, resulting exposure to pathogens, pose potential health risk to humans as diarrhea remains one of the most important health problems (Le-Thi et al.,2017).

The biogas technology can be a promising low-cost sustainable energy source while potentially solving problems with livestock manure management in Vietnam (Roubík et al. 2017), but the farmers must treat the digester correctly to avoid the pollution.

This measure was promoted and economically driven by the Government to handle the greenhouse gas emissions from pig farms (The Asian Post Team, 2018). Since the inception of the biogas tank initiative, more than 250.000 biogas digesters have been built in the country, contributing to Vietnam's goal of reducing eight percent of GHG emissions by 2030. (The Asian Post Team, 2018). However, there are doubts about whether they will be able to supply the growing energy requirements of houses and how the government will finance this technological update (Roubík et al., 2017).

Housing system

The structure of a housing system, for example the combination of the floor-system, manure collection, and the manure removal system, largely determines the level of the emission of gaseous compounds, especially the emission of ammonia. Housing systems that reduce the gaseous emission basically comprise of at least one or more of the subsequent abatement principles (Borhan et al., 2012):

- Reduction of emitting manure surface
- Fast and complete removal of the liquid manure from the pit to external slurry storage
- Applying an additional treatment, such as aeration, to obtain flushing liquid
- Cooling the manure surface
- Changing the chemical/physical properties of the manure, such as decreasing.

The housing systems that have been developed to include the above principles, reduce ammonia emissions to the atmosphere form approximately 30% to 80% (Borhan et al., 2012).

Compositing

Solid manure fraction may be composted after mixing it with one or more of the ingredients such as straw, plant waste products, ash, or lime. Low cost buildings or pits covered with mud or tarpaulin are good composting. Composting manure without cover will result in poorer manure quality due to emission of ammonia. Composting and storage periods vary from 3 to 5 months. The volume of the containers depends upon the size of the farm (minimum 0.5 m^3 to maximum 11 m^3) and may be constructed of concrete or bricks. The mud pits for manure storage may cause N leaching and pathogen spread into ground water. Uncovered pits will increase ammonia emission. The distance from manure stores to the drinking water source depends upon the size of the unit (min:10m to max: 50 m), but the Danish standard stipulates a minimum distance of 50 m to any drinking water source (Venkatachalapathy and Usha, 2011).

IV. Conclusions

Despite the impact that pig farms have on the environment, they suppose a great economic activity and they are a genetic reservoir that contributes biodiversity. Also, pork is a source of essential nutrients that must be on the human diet.

The biogas technology can be a promising low-cost sustainable energy source while potentially solving problems with pig manure management in Vietnam. Thus, we must make some adjustments, for example, farmers must treat the digester correctly to avoid the pollution, the government must promote the implementation of biogas digesters economically, and the density in Northern Vietnam must be reduced. Although experimental and deeper investigation on this alternative should be done.

While the government considers pig farms as a potential risk of contamination of the environment, the laws drafted to control this fact are meager since sometimes they only mark limits and do not give guidelines for solution for pig farmers. They should include which method is best to reduce the pig contamination.

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