NGUYEN GIA

The Government of Japan

REPORT

SITUATION ASSESSMENT OF COLLECTION, TRANSPORTATION AND ENVIRONMENTALLY SOUND DISPOSAL OF INFECTED ANIMAL/ ANIMAL CARCASS CAUSED BY EPIDEMIC DISEASES AND POLLUTION CONTROL OF AREAS WHERE ANIMAL CARCASS IS DISPOSED

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Ha Noi, April 2020

ACKNOWLEDGEMENTS

Situation assessment of collection, transportation and environmentally sound disposal of epidemic-infected animal carcasses and pollution control of areas where animal carcasses are disposed of has been conducted by the Nguyen Gia Environment Technology and Equipment, Technical Advice Company Limited (Nguyen Gia Entech), with the World Bank's financial support and the technical assistance from Vietnam Environment Administration (VEA) - Ministry of Natural Resources and Environment (MONRE). Nguyen Gia Entech would like to acknowledge the contribution and cooperation of organizations and individuals involved in the analysis and completion of this report.

Firstly, we would like to thank the World Bank (WB) for its financial support and the Vietnam Environment Administration (VEA) - MONRE for its technical assistance.

We would like to thank the Environmental Quality Management Department, Northern Environmental Protection Department Central and Central Highlands Environmental Protection Department, Departments of Natural Resources and Environment (DONREs), Departments of Agriculture and Rural Development (DARDs) and District and Commune People's Committees of Ha Noi, Can Tho cities, Nam Dinh, Thai Binh, Hai Duong, Hung Yen, Quang Nam, Thua Thien Hue, Dong Nai, Vinh Long provinces for their effective and close cooperation in the process of data collection at the assessment sites.

We especially acknowledge the contributions of Ms. Nguyen Thuy Anh (WB), and some staff from VEA-MONRE for comments on the assessment proposal, data collection toolkit and final results report.

Nguyen Gia Environment Technology
and Equipment, Technical Advice Company Limited

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ABBREVIATIONS

ASF	African Swine Fever
ASFV	African Swine Fever Virus
AI	Avian Influenza
DARD	Department of Agriculture and Rural Development
DONRE	Department of Natural Resources and Environment
FAO	Food and Agriculture Organization of the United Nation
FMD	Foot-and-Mouth Disease
MARD	Ministry of Agriculture and Rural Development
MONRE	Ministry of Natural Resources and Environment
OIE	World Organization for Animal Health
PRRS	Porcine Reproductive and Respiratory Syndrome

EXECUTIVE SUMMARY

Recently, animal epidemics have occurred on a continual basis and with complex evolution in many countries and Vietnam, causing huge economic losses and affecting the environment and people's health. In Vietnam, African Swine Fever (ASF) has been serious in terms of scale and number of infected pigs, not only causing economic losses but also difficulties in prevention, control and disposal of infected pigs. Non-compliance with the authorities' guidance on disposal has caused environmental pollution and affected livestock production. The report on assessment and analysis of environmentally-sound collection, transportation and disposal of infected pig carcasses has been developed to identify constraints and causes as well as to provide recommendations on policies and techniques for epidemic prevention and control and for disposal of animal carcasses in the event of an epidemic. The report also includes recommendations on ways to strengthen the capacity for proactive response to epidemics and to provide information and data for the study and improvement of the existing legal and technical regulations in relevance with the evolving epidemic situation in Vietnam.

Objective of the assessment

The report is to serve the purpose of assessing the current situation of animal epidemics, the use of measures for environmentally-sound collection, transportation and disposal of animal carcasses, and environment pollution caused by animal epidemics. The ultimate aim is to propose solutions on mechanisms, policies and technological solutions that can be adopted for prevention and resolution of environment pollution and for improvement in capacity for disposal, as well as for effective multi-sectoral collaboration in epidemic prevention control and in disposal of animals in the event of future epidemics.

Content of the Assessment

The report provides an overall assessment of animal epidemic prevention and control and existing methods for collection, transportation and disposal of infected animal carcasses in the world and in Vietnam. The write-up of the report involves conducting field surveys and site visits, taking samples for analysis, and conducting an assessment of the environmental impacts caused by the different methods for disposal of animal carcasses in some provinces and cities. It also provides a summary of the various solutions being adopted at present for environmentally-sound collection, transportation and disposal of animal carcasses, as well as measures for pollution control at disposal sites for epidemic-infected animal carcasses. These provide the basis for the recommendations in the report on strengthening inter-sectoral collaboration in epidemic prevention and control and in disposal of diseased animal carcasses.

Methods employed in the assessment

Below are some methods employed in the assessment:

- Questionnaires for 02 target groups at provincial level (Department of Natural Resources and Environment (DONRE) and Department of Agriculture and Rural Development (DARD) and at lower local levels (People's Committees of

districts and communes) in the 10 provinces and cities selected to be covered in the study, namely Ha Noi, Hung Yen, Hai Duong, Thai Binh and Nam Dinh in the North, Quang Nam and Thua Thien Hue in the Central Region, and Dong Nai, Vinh Long and Can Tho in the South. The provinces and cities are selected on the basis of the following criteria: (i) The province/city is the most prone to epidemics (bigger scale of production and large quantities of animals to be disposed of); (ii) The province/city has undergone epidemics for more than 6 months, from 3 - 6 months, and less than 3 months; (iii) The province/city has higher or lower natural disasters risks.

- Face-to-face meetings/working sessions with Vietnam Environment Administration under Ministry of Natural Resources and Environment (MONRE); Department of Animal Health - Ministry of Agriculture and Rural Development (MARD); Environmental Protection Agency (EPA) - Department of Natural Resources and Environment (DONRE) of provinces and cities; Sub-Department of Animal Health - Department of Agriculture and Rural Development (DARD) of provinces and cities; District Division of Agriculture/agriculture officers - District and Commune People Committees in 10 provinces and cities (Hanoi, Hung Yen, Hai Duong, Thai Binh, Nam Dinh, Thua Thien Hue, Quang Nam, Dong Nai, Vinh Long and Can Tho) to get clarity on and discuss specific issues related to disposal of diseased animals.
- Desk review and collection of legal documents, guidelines, local and international studies on epidemic prevention and control and disposal of animals in the event of an epidemic.
- Analysis of samples to assess the magnitude and extent of environment pollution (water surface environment, ambient air environment, soil environment) at the disposal sites for ASF-infected pigs.

Results of the assessment

International experience in terms of measures for disposal of diseased animals and lessons for Vietnam

Experience from recent epidemics shows that effective measures for epidemic prevention and control are biologically safe livestock production and vaccination. In the event of a pandemic, disposal must take place as soon as possible if the disease is to be prevented from spreading. There are many methods for mass disposal of animal carcasses in the event of an epidemic that are considered for adoption or being adopted by many countries, such as Canada, Australia, USA, and South Korea. However, each method has its own pros and cons, and the choice of the method for disposal is contingent upon the conditions and resource availability of each locality and each country. Some commonly employed methods include: Burning (open-air burning) and incineration; burial; composting and anaerobic decomposition, etc. There are some lessons learnt for Vietnam in disposal of epidemic-infected animals in terms of selection of methods and sites for disposal; epidemic management and response, and post-epidemic monitoring.

Epidemic situation in Vietnam in the recent past

In the past few years, the predominant animal epidemics that have occurred have mainly been avian influenza (AI), foot-and-mouth disease (FMD), Porcine reproductive & respiratory syndrome (PRRS) and ASF, with different scales

observed. In 2019, AI hit 70 livestock producing households in 44 communes, 41 districts of 24 provinces and cities, leading to disposal of 133,203 poultry heads. By 24 December 2019, there was only one H5N1 AI cluster in Vinh Long that had not exceeded 21 days in duration (14 days had passed since disposal of the last infected poultry head). FMD occurred in 468 communes, 127 districts of 42 provinces and cities, with 28,011 livestock heads infected (23,862 pigs and 4,149 buffaloes and cows/bulls). 18,623 livestock heads died and had to be disposed of (18,512 pigs and 111 buffaloes and cows/bulls).

Especially, ASF occurred in 8,532 communes in 667 districts of 63 provinces and cities, with 5,965,173 pigs being disposed of in total, and the total weight was around 341,000 tons. Hung Yen and Thai Binh were the first two provinces with ASF occurrence, and Ha Noi was the locality with the biggest number of pigs that had to be disposed of in the whole country (543,752 pigs with the total weight of around 37,160.7 tons).

Due to the impact of the ASF, by the time the survey was conducted in 10 provinces and cities, livestock production had dropped by 11.5% on a year-on-year basis. By 31 December 2019, 03 localities had announced the end of ASF, namely Hung Yen, Hai Duong and Thai Binh.

Review of prevailing legal documents and regulations on environmentally-sound collection, transportation and disposal

The review of prevailing legal documents covers three laws (Law on Environment Protection 2014; Law on Animal Health 2015, and Law on Livestock Production 2018); 02 Decrees of the Government; 01 Resolution of the Government; 01 Circular of the MONRE; 01 Circulars of the MARD; 01 Document of the MONRE, and 01 Guidance Document of the MARD. These documents provide for prevention and control of different types of animal diseases and epidemics, and environment protection measures to be taken in handling and disposal of carcasses of animals dying of epidemics, including ASF. All the legal normative documents issued by the Ministries and line agencies specify in detail the requirements on and technical measures for handling and disposal of carcasses of animals dying of epidemics, and the current legal and regulatory frameworks on biologically safe collection, transportation and disposal are quite comprehensive and complete. However, due to variations in the socio-economic contexts as well as geographical and climatic conditions of provinces and cities, there are a number of issues and gaps in implementation as follows:

(i) Disposal sites:

- Selection of disposal sites;
- Regulatory requirements on distance from disposal sites;
- A number of irrelevant stipulations in regulatory and guidance documents;

(ii) Burial technology:

- The regulatory requirement that the depth of burial pits must be 1.2 - 1.5m is not relevant for regions and areas with high groundwater level (such as the Mekong River Delta);

- There have yet to be specific stipulations on the types of waterproof materials to be used to ensure biosafety and sanitation for the burial pits;
- There are missing technical guidelines on dealing with gases that are emitted in the initial stage of decomposition of animal carcasses that may cause explosion, subsidence, and severe cracks in burial pits;
- The burning method involves many risks of causing environment pollution. After burning, landfilling is still necessary, whereas the quantity of carcasses of animals dying of epidemics at a point in time may be huge. Therefore, this method is not the appropriate option for prompt response to achieve the goal of eliminating the epidemics;
- The legal force of stipulations on environment quality monitoring and surveillance at disposal areas is not strong yet (there have yet to be stipulations on the parameters, frequency, and milestones for actions);
- Supplies and chemicals to be used for disposal as per the guidelines are always scarce at the time of an epidemic.

Steering, guidance, implementation and practices, and mechanism for inter-sectoral collaboration in disposals of ASF-infected pigs as currently the case

There have been strong and timely steering and guidance for response to ASF at all levels and sectors in accordance with Decision No. 302/QD-TTg of the Government dated 21 March 2019 on establishment of the National Steering Committee for ASF Prevention and Control. In provinces, Steering Committees for ASF Prevention and Control have been established with charters of operations in place at all 03 levels (provincial, district, and commune levels). There have been adequate guidelines issued on environment protection measures in collection, transportation, and disposal of diseased animals/ carcasses of animals dying of epidemics, which have been put into implementation in a timely manner with collaboration of relevant stakeholder agencies. DARDs, the lead agencies in epidemic prevention and control, have issued a number of documents and been providing guidance and overseeing efforts on prevention and control, sanitary practice, and disinfection of livestock sheds and stables as well as taking actions for timely disposal of pig carcasses in livestock farms to ensure environmental sanitation. DONREs have issued guidance documents with guidelines on environmental protection and have been working with DARDs and People's Committees of lower levels in environment monitoring and surveillance as well as on selection of disposal site selections. District People's Committees have prepared their respective emergency response plans and instructed communes/towns to set up their task forces to be in charge of disposal of infected pigs. Commune-level People's Committees have been closely monitoring the epidemic situation for early detection and warning, taking measures for prevention and control, consolidating data and reporting on the damage caused by animal epidemics, guiding the implementation of policies to support prevention and control, as well as managing and storing information about disposal.

Current situation of infected animal disposal in localities

Two main methods for disposal of infected animal disposal have been employed in Vietnam: burial and incineration.

Burial is chosen by most localities because of the relatively simple technical requirements involved and its appropriateness for quick resolution of epidemic clusters within 24 hours. On the whole, the procedures followed by localities in burial are in line with the stipulations under Circular No. 07/2016/TT-BNNPTNT, Document No. 1025/BTNMT-TCMT and guidance documents of DARDs and DONREs.

Incineration/burning is chosen by some localities (to dispose of a small number of carcasses, 5 - 10 heads) in the Mekong River Delta since these areas have high groundwater level and are prone to flooding. Ho Chi Minh City is the only one that has opted for centralized carcass incineration at the medical waste disposal area.

Several shortcomings in the implementation include:

- During collection, animal carcasses are put into sacks and waterproof materials are used to line vehicle's tanks;
- Bad odour is emitted into the air in the surrounding area due to the absence of a ventilation and gas release system, which leads to the leakage of biogas generated in the decomposition of carcasses, which in turn, causes the bottom lining to be torn and leads to subsidence of the pit surface;
- Burial pits are small in size and have no bottom lining; the monitoring and surveillance of burial sites is not frequent enough, leading to untimely response in resolving issues with burial pits that affect the environment;
- As Mekong River Delta provinces are in a low-lying region, the amount of soil available for landfilling is less than needed, and so the elevated soil cover layer on top of the burial pit is not adequate;
- No warning signage was put up at the burial pits in the landfilling sites.

Assessment of the current situation with regards to environment in the burial and disposal sites, and environment protection measures

Localities predominantly perform examination and assessment of current environment of landfill/burial pits based on sensory perceptions (unpleasant odour, subsidence). At some disposal sites, when the local residents complained about unpleasant odour, local authorities have taken swift action to spray biological de-odourizing liquids, put soil covering at the sites where subsidence is found, as well as putting up warning signages.

Surveys of burial sites for ASF-infected pigs, monitoring and sampling for environmental analysis have been carried out in some localities. However, due to the insufficient funding, the results have been very limited.

Below are findings of the environmental quality monitoring and assessment at a number of burial sites as part of this consultancy assignment:

- Surface water: micro-organism index (E.coli) in all the monitored sites were high; the parameters of some surface water samples exceeded the permissible limits under QCVN 08-MT:2015/BTNMT - National technical regulation on quality of surface water (column B1 shows the quality of water to be used for irrigation or other uses requiring similar quality).
- Underground water: Most disposal sites have 01 index exceeding QCVN 09-MT: 2015/BTNMT - National technical regulation on groundwater quality, namely

NH_4^+-N. Microorganisms (E.coli) was not found in the groundwater.

- Ambient air: All air parameters were within the permissible limits as per QCVN 06:2009/BTNMT - National technical regulation on some toxic substances in the ambient air. High NH_3concentration was found at the new pits (<30 days); after 30 days from the date of the burial, all parameters of the ambient air met Vietnamese standards.
- Soil: No pathogens were found in most of the burial sites; a number of soil samples taken at the locations of 5m from the burial pit contained pathogens.

Observations and assessment: At some monitoring sites, there are signs of surface and groundwater contamination, but it has been due to a combination of many factors, such as geological characteristics/processes, farming activities, and daily activities of households residing around the burial sites (irrigation canals are to drain 60 - 70% of domestic wastewater discharged in rural areas). Another factor is the decomposition of animal carcasses in the burial pits (the burial process did not fully comply with technical guidelines: no bottom lining was put in place, disinfection was not thorough, backfilling was not proper, leading to subsidence and leakage of pollutants and pathogens into the environment). Besides, as the burial pits are located in landfill sites and cemeteries, the quality of the environment in the pig disposal sites located within waste treatment areas or landfill areas may be affected by leachate, etc.

Proposed solutions

Policies and mechanisms

For prevention and control of animal epidemics: It is necessary to review and revise the guidelines and procedures for environment protection on disposal of epidemic-infected animals. To be specific, it is necessary to:

- Issue guidelines on the timing of sampling for monitoring purpose and the endpoint of environmental monitoring program at the livestock and poultry burial sites as appropriate and determine the time to release the burial pit and options for using the biologicially decomposed products in the pits, as well as guidelines on rehabilitation and restoration of sites used for burying infected animals.
- Set clear stipulations on the number of samples, locations and frequency of sampling as well as environmental parameters and components to be monitored. Specifications are to be issued to allow for benchmarking/comparison and assessment of performance of the pits and the level of pollution involved.
- Issue guidelines on development of cost norms and unit costs for disposal and sources of funding for environment monitoring and surveillance at epidemic-infected animal disposal sites.
- Issue guidelines on disclosure of information about environment quality at epidemic-infected animal disposal sites.
- Issue guidelines to localities on how to implement measures to disinfect surface water in the event of an adverse incident during the disposal process in orer to minimize the spread of epidemics. It is necesary to conduct further studies on the survival time of pathogens in the external environment and the transmittability and susceptibility of the virus to disinfectants to enhance effectiveness of the process, with a view to ensure biosafety and sanitation.

It is necessary to revise Circular No. 07/2016/TT-BNNPTNT on epidemic prevention and control in terrestrial animals and QCVN 01-41:2011/BNNPTNT - National technical regulation on requirements for sanitary handling in disposal of animals and animal products. The revisions to be made are to be related to the regulations on transportation and disposal because at present, epidemic-infected animals are considered hazardous waste under the Law on Environment Protection 2014. It is necessary to specify the types of waterproof materials to be used to ensure uniformity across localities.

MONRE and MARD jointly consider and submit to the Prime Minister for issuance of the document to provide unified guidelines to local levels on handling/disposal (burial and burning) in ways that meet the specialized requirements on animal health and environment.

Solutions related to inter-sectoral collaboration mechanism/action to improve performance in disposal of epidemic-infected animals

For effective animal epidemic control and prevention in Vietnam (new or not new epidemics), an Action Plan to respond to epidemics is critical. At the same time, it is necessary to review the composition and strengthen the functioning of the Steering Committee on epidemic prevention and control from the central to local levels to engage relevant agencies in the direction, execution and promulgation of documents, regulations, specific guidelines in relevance with the actual epidemic situation. At the same time, the working regulations of the Steering Committee should be promulgated, assigning specific responsibilities to specific sectors and levels. The Steering Committee at all levels should conduct weekly, ad-hoc or online meetings to update about the evolution of epidemics and to provide guidance and instructions for actions. The Steering Committee members at all levels should also conduct site visits to the areas hit by epidemic or areas with risk of epidemic to inspect, urge and organize the implementation of measures for epidemic control.

In order to improve the performance of relevant sectors in animal epidemic prevention and control, it is necessary to:

- Communicate and provide adequate and truthful information to avoid excessive worries about the epidemic situation and advocate for proactive and voluntary actions by local people in implementation of measures for epidemic prevention and control;
- Make stronger efforts to disseminate information and provide training to improve the awareness and knowledge of relevant target groups (officials, businesses, people, etc.) on animal epidemics and encourage community members, agencies and organizations to actively participate in the prevention and control of epidemics;
- Invest in the construction and upgrading of laboratories for virus analysis to serve the purpose of doing research, testing and putting into use safe and highly protective vaccines for animals;
- Share and disseminate information on epidemic situation and epidemic prevention and control among relevant agencies through Steering Committees' meetings and the media;
- Develop a national database on epidemics and epidemic prevention and control, as well as on disposal of epidemic-infected animals.

Technological solutions

Methods to be employed for disposal of epidemic-infected animals must meet the requirements on biosafety and environmental protection set by specialized agencies and are suitable for each region, area, and locality where the epidemics occur given their geographical location, climatic and socio-economic conditions in order to minimize the spread of epidemics and environmental pollution. At the same time, financial capacity or affordability must also be considered in selection of methods for disposals.

Four methods for disposal of epidemic-infected animal carcasses and animal products recommended for use in Vietnam in the near future are burial (safe burial pits and jumbo bags), burning/incineration, composting and autoclaving to kill pathogens (the autoclaved animals are to be buried thereafter or used for animal feed production). However, for the methods that have not been used in Vietnam (composting, autoclaving for animal feed production), studies and piloting are required before they are put into use on a wider scale.

- Burial can be employed for disposal of infected animals in different quantities (from 1 head to thousands of heads) in localities where land is available, rather than those in low-lying areas or areas that are prone to landslides and flooding.
- Incineration can be used for disposal of infected animals in small quantities (<50 heads) in low-lying areas, areas that are prone to landslides and flooding (such as the Mekong River Delta), areas where there are specialized vehicles available for transporting the animals to factories (which may be located outside the epidemic areas), and areas where there are incinerators available that meet the technical requirements on treatment of hazardous waste such as incinerators for medical waste, incinerators for hazardous industrial waste, or cement kilns.
- Composting can be used for disposal of infected animals in different quantities (from 1 head to thousands of heads) in localities where land is available, areas with composting factories or facilities in place for treatment and composting of waste. It is necessary to conduct tests and assessment of product quality to ensure that the compost produced is pathogen-free.
- Autoclaving for production of animal feed can be used for disposal of infected animals in small quantities (<50 heads) in all localities. However, this method requires animal feed processing facilities and cold storage facilities to be in place to store the animals while waiting for the animal health agencies to come and take samples for testing. It is necessary to ensure that an animal health agency come and take samples for testing and to certify that the animal carcasses are pathogen-free before they can be processed.

PART 1. GENERAL INTRODUCTION

1.1. Practical basis/Rationale for the study

In recent years, animal diseases have occurred continuously and been complicated in many countries in the world, causing great losses to agriculture, affecting environment and human health.

From 2003 to September 2018, tens of countries in the world had reported the avian influenza status and millions of disposed of birds. Meanwhile, foot and mouth disease was a very dangerous infectious disease caused by virus on hooves of animals such as pigs, cows, buffaloes, deer, goats, etc. ASF was first detected in Kenya in 1921 and quickly spread to other African countries. According to the World Organization for Animal Health (OIE) and the Food and Agriculture Organization of the United Nations (FAO) on 19 December 2019, ASF has been occurring in 31 countries territories. The number of diseased pigs destroyed has reached hundreds of millions and the countries have spent billions of dollars to support farmers and epidemic prevention. The epidemic is still complicatedly occurring in many countries in the region (Indonesia, Philippines, etc.).

In fact, the outbreak of ASF on a large scale has caused difficulties in the disposal of animal carcass. In many places, the technique of unsecured destruction, diseased pigs are transported from farming households to the place of destruction by rudimentary means, unshielded, lined bottom leading to waste, pig manure, assorted secretions, even pig blood spilled into the environment. The detection and disposal of diseased pigs, pig carcass recently have not been carried out promptly and comprehensively; many localities failed to perform correctly and failed to assure technical requirements as instructed by the MARD and the MONRE. In many places, people only disposed of diseased pigs and pig carcass while they still kept other pigs in the same piggery for monitoring in a persistent manner, and finally, all those pigs died that led to repeated disposal in one household. It is also difficulty for selecting disposal site due to insufficient land in many places. Many large-scale farming households must dig holes inside their gardens, their farms; although it assures the minimum distance of 30m or more between the breeding area and the house, it still affects badly the production, especially the breeding of new herds of pigs in the future.

Therefore, the urgent requirement now is to evaluate and analyze the situation of safely collect, transport and dispose of dead animals for the environment and pollution control in animal culling areas to make recommendations for application in the animal disease and epidemic prevention and control process, as well as to use in the process of capacity building to proactively cope with the disease (such as training, capacity building for environmental and veterinary management agencies at all levels and farmhouses/farms; preparing necessary equipment, especially labor protection equipment for the men who participate in preventing epidemic diseases, etc.). This assessment will also help to provide information, evidence and data for the development of the legal and technical regulations including the circular, technical guidelines, operational manuals in this area.

1.2. Objectives and scope of work

1.2.1. Objectives of work

Overall objectives

Assessing the current situation of (i) animal diseases and (ii) collection, transportation and environmentally sound disposal of animal carcass caused by epidemic diseases and environmental pollution caused by animal diseases; and

Providing recommendations for prevention and treatment of environmental pollution and improvement of the capacities and practice of environmental sound pollution disposal of animal carcass and improvement of multisectoral coordination.

Specific objectives

1) Assessing and classifying in overall the development of some epidemic animal diseases that have occurred in Vietnam recently, analyzing the causes (focusing mainly on factors which are directly related to the environment); assessing the disposal measures applied for each type of animal with different epidemic disease; classifying forms of disposal;
2) Assessing the impacts on the environment which are caused by the applied forms of disposal (focusing mainly on ASF);
3) Assessing current situation of coordination mechanism among the related Ministries and agencies on environmental protection in the disposal of diseased animals; evaluating the current regulations and guidelines for the disposal of animal carcass to inform the development/revision of the related legal documents/technical guidelines for adaptation with the current development of epidemic diseases in Vietnam;
4) Proposing of measures of collection, transportation and sound environmental disposal of animal carcass caused by epidemic diseases and pollution control of areas where animal carcass is disposed of (in accordance with each geomorphologic terrain and burial scale); proposing the measures for improvement of multisectoral coordination.

1.2.2. Scope of work

1) Review of the overall related documents, including documents on applied measures to treat diseased animals;
2) Field survey, analysis of samples and assessment of the impacts on environmental by forms of disposal that applied to ASF epidemic;
3) Measures of collection, transportation and sound environmental disposal of epidemic-infected animal carcasses and pollution control of areas where animal carcass is disposed of and improvement of multi-sectoral coordination for disposal of infected animal carcass.

1.3. Locations of assessment

10 representative provinces/cities were selected based on the following criteria:

1) Having been most affected by epidemic (large numbers of infected and disposed of animals);
2) Having the epidemic/outbreaks more than 6 months; from 3-6 months; less

than 3 months of epidemics (the final location where epidemics occurred is Ninh Thuan and announced on 3 September 2019);

3) Having high natural disaster risks and areas with low natural disaster risk;
4) Representing the geographical locations: North, Central and South.

Table 1: Provinces covered by the survey based on selection criteria

No.	Name of province/city	Criteria for selection			
		Region	Scale of livestock production and level of impacts by ASF (by 30 Sept. 2019)	Duration of the epidemic	Level of natural disaster risks
1	Ha Noi	The Northern Vietnam	Disposed of: 525,231 animals with total weight of 35,875.2 tons	More than 6 months	Low
2	Dong Nai	The Southern Vietnam (Southeast)	Disposed of: 396,634 animals with total weight of 20,755.7 tons This province has the largest scale of livestock production in the country.	More than 6 months	Low
3	Vinh Long	The Southern Vietnam (Mekong River Delta)	Disposed of: 32,910 animals with total weight of 1,980.5 tons	From 3-6 months	High (flooding)
4	Can Tho	The Southern Vietnam (Mekong River Delta)	Disposed of: 57,974 animals with total weight of 3,295.,6 tons	From 3-6 months	High (high tides)
5	Quang Nam	The Central of Vietnam (South Central)	Disposed of: 119,165 animals with total weight of 6,695.6 tons	From 3-6 months	High (flood and flooding, landslides
6	Thua Thien Hue	The Central of Vietnam (North Central)	Disposed of: 65,183 animals with total weight of 3,724.5 tons	More than 6 months	High (flood and flooding, landslides)
7	Nam Dinh	The Northern Vietnam (Northeast)	Disposed of: 258,252 animals with total weight of 14,072.7 tons	More than 6 months	Low

8	Thai Binh	The Northern Vietnam (Northeast)	Disposed of: 376,567 animals with total weight of 18,758.6 tons	More than 6 months	Low
9	Hai Duong	The Northern Vietnam (Northeast)	Disposed of: 391,059 animals with total weight of 23,201.8 tons	More than 6 months	Low
10	Hung Yen	The Northern Vietnam (Northeast)	Disposed of: 196,888 animals with total weight of 11,150.6 tons	More than 6 months	Low

In each province, the team of researchers selected 01 district (which is the most prone to epidemics (by numbers and scale)), of which 2 - 3 communes/wards were selected depending on the local contexts after agreement was reached with the Provincial DONRE, DARD, and District-level People's Committee. After that, in each ward/commune, the team of researchers conducted a site visit to the burial sites for burying pigs dying of ASF, examining the site and taking environmental samples.

1.4. Objects of assessment

The system of relevant legal documents and related studies including: Regulatory documents, guidelines on operations (operational guidelines), domestic and overseas studies, and secondary data related to disposal of diseased animals (livestock and poultry), focusing on 04 diseases in the list of animal diseases subject to epidemic announcement and which tends to quickly spread on a wide area, or a new infectious disease pathogen is discovered in accordance with new regulations issued by the Government of Vietnam, namely: AI, PRRS, FMD, and ASF.

Figures from reports by the Department of Animal Health, Vietnam Environment Administration, DARD, DONRE, and People's Committees at district and commune levels on animal diseases or epidemics in the recent past, their causes and the spread of animal diseases or epidemics (with the main focus placed on factors directly related to the environment); and methods for disposal that have been applied in Vietnam.

Respondents/Stakeholders covered by the survey:

- At the central level:
  - ✓ Vietnam Environment Administration, MONRE;
  - ✓ Department of Animal Health, MARD.
- At the local level (in the 10 selected provinces):
  - ✓ DONREs of provinces and cities: Leaders of DONREs of the selected provinces and cities (Environment Protection Agencies);

Meeting with DONRE of Vinh Long

Meeting with Hanoi EPA

Figure 1: Some photos featuring meetings with DONREs

- ✓ DARDs of provinces and cities: Leaders of DONREs of the selected provinces and cities (Livestock Production and Animal Health Sub-Department);
- ✓ People's Committees at district and commune level: Leaders and technical units (District Divisions of Agriculture, Agriculture Officers).

Objects of environment sampling: Burial pits for burying pigs dying of ASF by region.

Site visit to 01 burial pit in Binh Trieu commune, Thang Binh Dist., Quang Nam province

Site visit to 01 burial pit in Thoi Lai Dist., Can Tho City

Examination in 01 burial site for burying pigs dying of ASF in Thua Thien Hue

Figure 2: Some photos featuring site visits to burial pits for burying pigs dying of ASF

1.5. Tools for collecting data

To achieve the objective, the assessment used 01 survey questionnaire for 02 groups of respondents at the provincial level (DONRE and DARD) and for lower local levels (People's Committees at districts and commune levels).

Besides the team of researchers also conducted meetings for face-to-face discussions with the stakeholders mentioned under Section 1.4 in order to get clarity on and discussed in details the issues related to disposal of diseased animals and collect documents and materials relevant for the study.

1.6. Collection of data

1.6.1. Review of existing data

The team of specialists/researchers collected and review regulatory documents, operational guidelines, and domestic and overseas studies, and secondary data related to prevention and control of diseases and epidemics (livestock and poultry), and figures/data from reports by the Animal Health Department, Vietnam Environment Administration, and provinces/cities on animal diseases or epidemics in the recent past, their causes and the spread of animal diseases or epidemics (with the main focus placed on factors directly related to the environment); international experience (including experience on humanistic treatment of animals during disposal); methods for disposal that have been applied in Vietnam; and relevant legal provisions.

The types of diseases covered in this study are the 4 diseases in the list of animal diseases subject to epidemic announcement and which tends to quickly spread on a wide area, or a new infectious disease pathogen is discovered in accordance with new regulations issued by the Government of Vietnam, namely: AI, PRRS, FMD, and ASF.

1.6.2. Field survey

The field survey was conducted in 10 selected provinces and cities (with focus placed on ASF*).*

1.6.2.1. Collection of information

Collection of field information was conducted in all the 10 selected provinces and cities mentioned in Table 1. The group of consultants was divided into teams (of specialists) to conduct the survey missions, as follows:

- The team of consultants consisting of 2 specialists/consultants (4 consultants in charge of the work in Ha Noi);
- The team of technical people consisting of 2 persons who were responsible for taking samples, site surveying and for conducting interviews with commune-level staff as tasked by the Team Leader.

Table 2: Schedule and participants

No	Field survey	Time	Location	Participants
1	The 1st field survey	From 9th to 10th January 2020	Ha Noi	- Le Hoang Lan - Nguyen Viet Hue - Van Dang Ky - Mai Duc Binh - Nguyen Van Nam - Vu Thi Thanh Nga
2	The 2nd field survey	From 12th to 17th January 2020	Hai Duong and Hung Yen	- Van Dang Ky - Mai Duc Binh - Nguyen Van Nam - Vu Thi Thanh Nga
3	The 3rd field survey	From 12th to 17th January 2020	Nam Dinh and Thai Binh	- Tran The Loan - Nguyen Ngoc Hung - Nguyen Ngoc Trung - Nguyen Manh Cuong
4	The 4th field survey	From 9th to 14th February 2020	Vinh Long and Can Tho	- Tran The Loan - Nguyen Ngoc Hung - Nguyen Ngoc Trung - Nguyen Manh Cuong
5	The 5th field survey	From 9th to 14th February 2020	Thua Thien Hue and Quang Nam	- Le Hoang Lan - Pham Ngoc Hoa - Pham Thi Vi - Do Dang Duc
6	The 6th field survey	From 26th to 28th February 2020	Dong Nai	- Le Hoang Lan - Pham Ngoc Hoa - Pham Thi Vi - Do Dang Duc

1.6.2.2. Collecting and analyzing environmental samples to assess the scale and level of environment pollution (surface water, underground water, ambient air, soil) in burial areas for burying pigs dying of ASF

- *Location of sampling in each locality:* Pits to bury pigs infected with ASF by region:
  - ✓ At household gardens;
  - ✓ Agricultural production area;
  - ✓ Near the area of the people's cemetery;
  - ✓ In the commune's waste disposal area.

- *The method and manner of sampling:*
  - ✓ Surface water samples: Water samples are taken in specialized sample containers for microbiological analysis purposes. The sample volume at a sampling location is 2.5 liters. Symbol - "NM" is attached with abbreviated name of the localities surveyed.
  - ✓ Underground water samples: Water samples are taken in specialized sample containers for microbiological analysis purposes. The sample volume at a sampling location is 2.5 liters. Symbol - "NN" is attached with abbreviations of the localities surveyed.
  - ✓ Samples of ambient air: Directly measured by fast measuring devices, picnics with specialized sensors for measuring criteria - the symbol for measuring air sample is "KK" attached with an abbreviation of the localities surveyed.
  - ✓ Soil samples: Soil samples are collected in specialized sample containers with a sample weight of about 2kg of soil. Samples were taken in dead pig burial pits in 2 directions with distance of 5m from burial pits and 25m from burial pits, according to the depth of the soil layers (upper surface, depth 0.4m, depth 1.0m, depth of 1.5m and next to the burial pits) and according to the soil characteristics at the burial sites (sandy soil, sandy soil, etc.). At locations 25m far from a dead pig burial pit, the sampling depth can be increased to 2.2m. The symbol of soil samples is “D” attached with an abbreviation of the localities surveyed.
  - ✓ Sampling standards and sample storage: TCVN 5999:1995, TCVN 6663-3:2008, TCVN 6663-1:2011, TCVN 6663-13:2000, TCVN 6663-15:2004. *(The sampling method is attached in Appendix 01).*
  - ✓ The sampling staff is equipped with protective equipment, using appropriate and prescribed sampling equipment.
- *Number of samples:* 2 samples/dump, total 27 dumps, exception soil samples at 18 dumps, 4 samples/dump.
  - ✓ For surface water sample: 54 samples (at 27 dumps: 2 samples/dump);
  - ✓ For underground water sample: 54 samples (at 27 dumps: 2 samples/dump);
  - ✓ For ambient air sample: 54 samples (at 27 dumps: 2 samples/dump);
  - ✓ For soil sample: 72 samples (at 18 dumps: 4 samples/dump).

For burial pits to be surveyed, basing on the list of planned districts/communes we selected according to the following criteria:

- ✓ Burial pits from 3-6 months; more than 6 months and less than 3 months;
- ✓ Locations of burial pits: At household gardens or at dumping sites or at local concentrated disposal planning areas.

The selection of burial sites for surveying and sampling was discussed and agreed upon at the meetings with the province, district/commune levels based on the above criteria.

Table 3: Number of pits and samples

No.	Location	Number of landfill pits	Quantity of samples			
			Surface water	***Underground water***	***Surrounding Air***	***Soil***
1	Hanoi	4 (1 soil sampling pit included)	8	8	8	16
2	Dong Nai	3 (2 soil sampling pits included)	6	6	6	8
3	Vinh Long	2 (1 soil sampling pit included)	4	4	4	4
4	Can Tho	2 (1 soil sampling pit included)	4	4	4	4
5	Quang Nam	2 (1 soil sampling pit included)	4	4	4	4
6	Thua Thien Hue	2 (1 soil sampling pit included)	4	4	4	4
7	Nam Dinh	3 (2 soil sampling pits included)	6	6	6	8
8	Thai Binh	3 (2 soil sampling pits included)	6	6	6	8
9	Hai Duong	3 (2 soil sampling pits included)	6	6	6	8
10	Hung Yen	3 (2 soil sampling pits included)	6	6	6	8
	Total	**27 (18 soil sampling pits included)**	**54**	**54**	**54**	**72**

- *The parameters measured in the field and the sampling to a laboratory:*
  - ✓ *For surface water sample:* Sampling and analyzing parameters: pH; temperature; DO; Electrical conductivity (EC); Total dissolved solids (TDS); biochemical oxygen demand (BOD_5); Chemical oxygen demand (COD); Ammonium (NH_4^+ calculated with N); Nitrite (NO_2- calculated with N); Nitrate (NO_3- calculated with N), Phosphate (PO_4^{3-} calculated with P), Total oil and grease; E.Coli.
  - ✓ *For underground water sample:* Sampling and analyzing parameters: pH; temperature; DO; Electrical conductivity (EC); Total dissolved solids (TDS); permanganate index; Nitrite (NO_2^- calculated with N); Nitrate (NO_3^- calculated with N); Ammonium (NH_4^+ with N); E.Coli.
  - ✓ *For ambient air sample:* Sampling and analyzing parameters: Temperature; humidity; wind speed; wind direction; Ammoniac (NH_3);

Methyl mercaptan (CH_3SH); Hydrogen sulfide (H_2S).

- ✓ *For soil sample:* Sampling and analyzing parameters: ASF virus (ASFV).

For samples in the southern region (Can Tho city, Vinh Long, Dong Nai) and the central region (Quang Nam and Thua Thien Hue), the samples will be stored and transported to Ha Noi by plane, make sure the sample under the regulations.

Figure 3: Some photos of actual sampling at burial pits

- ➢ *Participants in the implementation*:

Table 4: List of participants

No	Content of the work	Participants	Position
1	Process monitoring	Master Nguyen Ngoc Hung	Deputy Director
2	Analysis of samples in the laboratory	Eng. Vu Thi Thanh Nga Eng. Vu Thi Thuy Eng. Phạm Thi Vi Eng. Vu Thi Hue Master Dam Thi Vui Dr. Ngo Thi Huong	Technician
3	Report preparation and summary	Nguyen Ngoc Hung; Pham Ngoc Hoa, Mai Duc Binh, Nguyen Van Bac	Experts and Leaders of the sample analysis unit

After sampling, all samples were maintained and transported to the laboratory of Nguyen Gia Engineering, Equipment and Environmental Technology Co., Ltd. for analyzing. Time for analyzing samples took 10 - 15 working days.

- *Quality assurance and quality control in sample processing at site:*

Analysis of physical and chemical indicators: Sample containers has a capacity of 1.5 liters, they must be clean, dry and rinsed at least 3 times with the same water source to be sampled. Particularly for the criteria of vegetable and animal fats and oils, when sampling, clean and dry glass bottles must be used to limit the grease adhering to the walls of the container to falsify results. Samples for analyzing physical and chemical indicators should be fully filled and tightly covered.

Analysis of microbiological criteria: The sample should be stored in a glass jar, which was autoclave sterilized at 120^0C within 2 hours and the sample should not be overfilled.

In the field, conduct basic measurements: pH, temperature, DO, TDS. The analytical criteria are performed at least 3 times to determine the repeatability (or reproducibility) to confirm the precision and accuracy of the test.

- *Quality assurance and quality control in the laboratory:*

The laboratory system has been assessed and approved in accordance with ISO/IEC 17025:2005 issued by the Quality Accreditation Office of the Ministry of Science and Technology and VIMCERTS 251 issued by MONRE in the field of chemistry, environment.

At the laboratory, quality control procedures have been promulgated to ensure the reliability of the analysis results. All data related to the analysis process and analysis results are recorded and kept. At the same time, many measures are taken to control internal quality.

For daily quality control, at each batch of samples analyzed, perform control samples including blank samples, repeatability samples, and standard addition samples and apply graphical statistical methods to control quality.

- *Applicable standards for evaluating analytical results:*

QCVN 08-MT:2015/BTNMT - column B1: National technical regulation on surface water quality;

QCVN 09-MT:2015/BTNMT: National technical regulation on underground water quality;

QCVN 05:2013/BTNMT and QCVN 06:2009/BTNMT (01 hour on average): National technical regulation for ambient air quality and National technical regulation on some hazardous substances in ambient air.

(The method of taking and analyzing samples is in Annex 1).

1.7. Mechanism for ensuring quality of the assessment

The consulting firm worked closely with the World Bank and the Vietnam Environment Administration to develop and finalise the detailed outline and the survey toolkit (survey questionaire) with comments from stakeholders.

The field survey plan developed by the consultants was very elaborate and comprehensive to make it easy for the field survey missions to conduct the field work, including details on types of samples, number of samples, locations for taking the samples, method for collecting and preserving the samples, and associated logistical arrangements, and the like; field surveying, including detailed guidelines on direct interview, collecting additional data available at the local levels, photographing, sampling, and the like.

Before conducting the field survey, the consulting firm conducted a 01-day meeting with specialists/enumerators in the field survey team to reach agreement on the content of the survey and the method for collecting field information. The items receiving special attention in the meeting was to reach agreement on the information collection plan and use of the information collection toolkit.

Data from the survey were entered into the computer twice and the data entry errors were fixed using the programme to cross-check between the two rounds of data entry.

1.8. Limitations of the assessment

This assessment is one of few assessments and studies on collection, transportation and disposal of diseased animals in Vietnam. However, due to time and resource constraints, the assessment was only conducted in 10 provinces/cities, and only one district was selected in each province/city, and 2 - 3 communes/wards were selected per district. Therefore, it is really necessary to have assessments conducted on a larger scale with larger sample size to make the picture of collection, transportation and disposal of diseased animals in Vietnam more comprehensive.

Review of data about disposal of diseased animals in this assessments was faced with more than a few difficulties as reported data on this are not stored in an adequate manner (mainly the commune level manages data about disposal sites), but the scale/magnitude of epidemics are too big and human resources are limited, leading to inadequate data updating. The team of researchers also requested stakeholders to provide information after the field survey and also called officers in charge a number of time to ask them to check information again so that more information could be collected.

Monitoring and oversight of environment quality at burial sites were also done to a limited extent due to time and funding constraints, and thus it was yet to be possible to assess the level of decomposition in these burial sites in order to make recommendation to the localities on the specific time to release the burial pits so that the land can be put into use.

PART 2. ASSESSMENT RESULTS

2.1. Overview on epidemic on animals and measures of diseased animal treatment in the world

2.1.1. Overview on animal diseases in the world

In recent years, many animal diseases have occurred in many countries around the world, affecting animal and human health. According to the OIE, as of early 2020, there are 117 infectious animal diseases listed in the list. In the framework of this task, this report will address the situation of some animal diseases as below:

2.1.1.1. Avian influenza (AI)

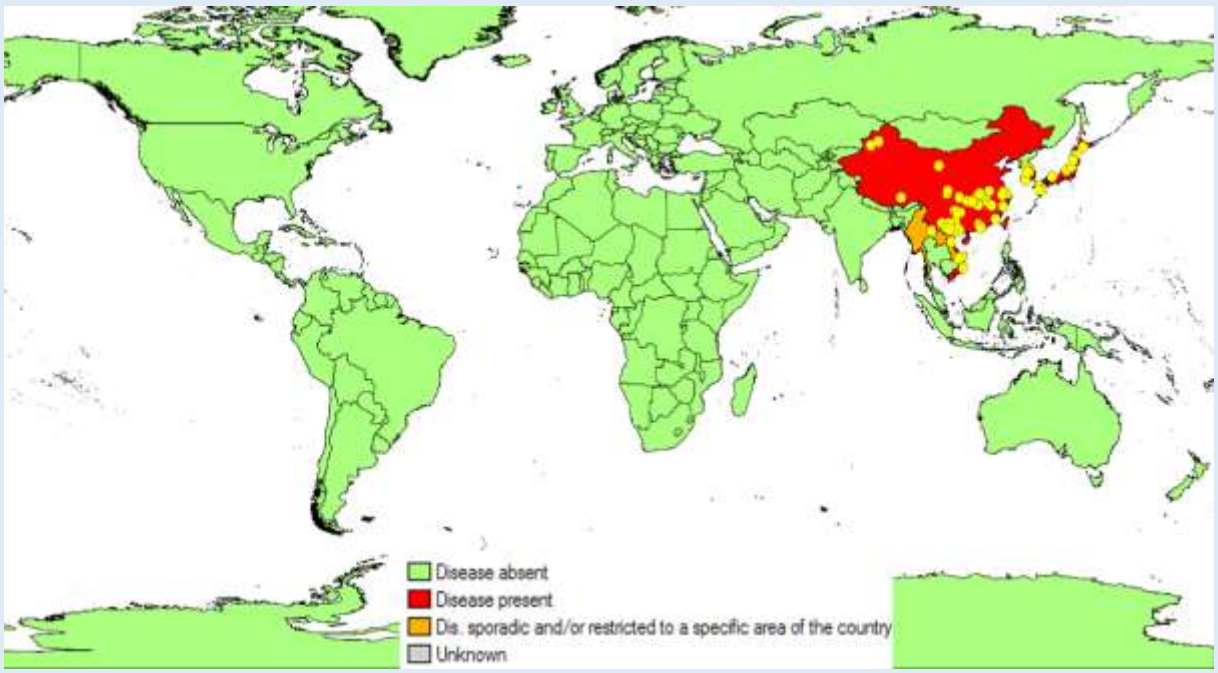
AI is a highly contagious viral disease affecting several species of food producing birds (chickens, duck, turkeys, guinea fowl, etc.), as well as wild birds. Occasionally mammals, including humans, may contract avian influenza.

There are many AI virus strains, which are usually classified into two categories according to the severity of the disease in poultry: low pathogenic (LPAI) strains, which typically cause few or no clinical signs in poultry; and highly pathogenic (HPAI) strains, which can cause severe clinical signs and potentially high mortality rates among poultry.

According to the OIE, H5N1 (a HPAI virus), was initially diagnosed in humans in Hong Kong in 1997. The virus then re-emerged in 2003 and 2004, and spread from Asia to Europe and Africa causing several hundred human cases and deaths, as well as destruction of hundreds of millions of poultry.

The HPAI that began in Italy in December 1999 continued in 2000. Several outbreaks of H5N1 HPAI infection occurred in 2016 in China, Indonesia and other southeastern Asian countries. The virus was also detected in Egypt, where a number of human cases were confirmed. In addition, following its incursion in December 2014, H5N1 HPAI was still circulating in western Africa, including Cameroon, Togo, Côte d'Ivoire, Ghana, Burkina Faso, Niger and Nigeria.

Nowadays, due to ongoing circulation of various strains (H5N1, H5N2, H5N8, H7N8, etc.), outbreaks of avian influenza continue to be a global public health concern. In 2016, H5N6 HPAI circulated extensively in China, where the infection was confirmed in poultry farms and in humans; and H5N8 HPAI has occurred by wild bird movements, starting from the summer breeding sites of migratory birds in Asia, the infection spread across the whole of Europe and into African countries along migratory flyways. No human cases of H5N8 infection have been reported to date.



(Source: Global animal disease intelligence report 2016 - FAO)

Figure 4: Global situation of H5N8 HPAI (2016)

From January 2014 to November 2016, AI has been identified in 77 countries and 13 strains have been detected (Source: Data from the World Animal Health Information System - WAHIS).

According to the Report No. 2 on HPAI of OIE in December 2019, 13 new outbreaks were notified in Chinese Taipei, Nigeria and South Africa in poultry. In this period, the total HPAI outbreaks worldwide is 97 distributed in the Americas (1), Africa (16) and Asia (56); and a total of 96,736 animals were notified as losses in Asia.

In Africa, Nigeria notified 1 new outbreak in poultry (H5N6) and South Africa 3 new outbreaks in poultry as well (H5N8), while no new outbreaks were reported during the period in America. Mexico is the only country affected H7N3 outbreak in poultry in the region. In Asia, Chinese Taipei reported 9 new outbreaks in poultry (H5N2 subtype). Outbreaks were reported by Afghanistan, China (PRC), Chinese Taipei and Korea (DPR) in poultry (subtypes H5N1, H5N2, H5N5, H5N6, H7N9) and by Afghanistan and China (PRC) in non-poultry (H5N8, H7N9). And no new outbreaks were reported during the period in Europe and Oceania.

2.1.1.2. Foot-and-mouth disease (FMD)

FMD is a very dangerous infectious disease caused by virus on hoof livestock such as pigs, cows, buffaloes, deers, goats, etc. Because it spreads very quickly through many different routes such as direct contact among animals, transmission through air, etc. That's why FMD was ranked as the top infectious disease in the animal diseases by OIE.

In 1897, Friedrich Loeffler first detected that FMD was caused by virus. Till now, 7 forms of viruses causing the disease, including A, O, C, SAT1, SAT2, SAT3 and Asia 1 are determined. In the Southeast Asia, three forms as A, O and Asia1 are

typical. According to the OIE, the disease is estimated to circulate in 77% of the global livestock population, in Africa, the Middle East and Asia, as well as in a limited area of South America.

In Europe, its outbreak was in the United Kingdom, the Netherlands and France in 2001. Millions of livestock were burned causing great losses to the livestock industry in particular and their economies in general. In the same year, it also occurred in Korea, Japan and Taiwan. Till the end of 2003, it did in the Southeast Asia (Thailand, Laos, Cambodia, Malaysia, Myanmar, Philippines and Vietnam). One year later, it spread to China, Russia, Mongolia and repeated in Myanmar.

In two years of 2005 and 2006, it spread to South Americas (Brazil, Argentina and Paraguay) and Africa as well (South Africa) [14]. Australia, New Zealand, Indonesia, Central and North America, and continental Western Europe are currently free of FMD.

2.1.1.3. Porcine Reproductive and Respiratory Syndrome (PRRS)

PPRS was first detected in the USA in 1987, because it was unknown at that time so it was called “Mystery Swine”, and then it was called: Mystery Swine Disease; Swine Infertility and Respiratory Syndrome; Hyperthermie Avortements des Truies; Blue Ear Disease; Porcine Epidemic Abrtion Syndrome.

It then spread to Canada in 1988. It also transmitted to European countries like Germany (1990), Netherlands, Spain, Belgium, England (1991); France (1992).

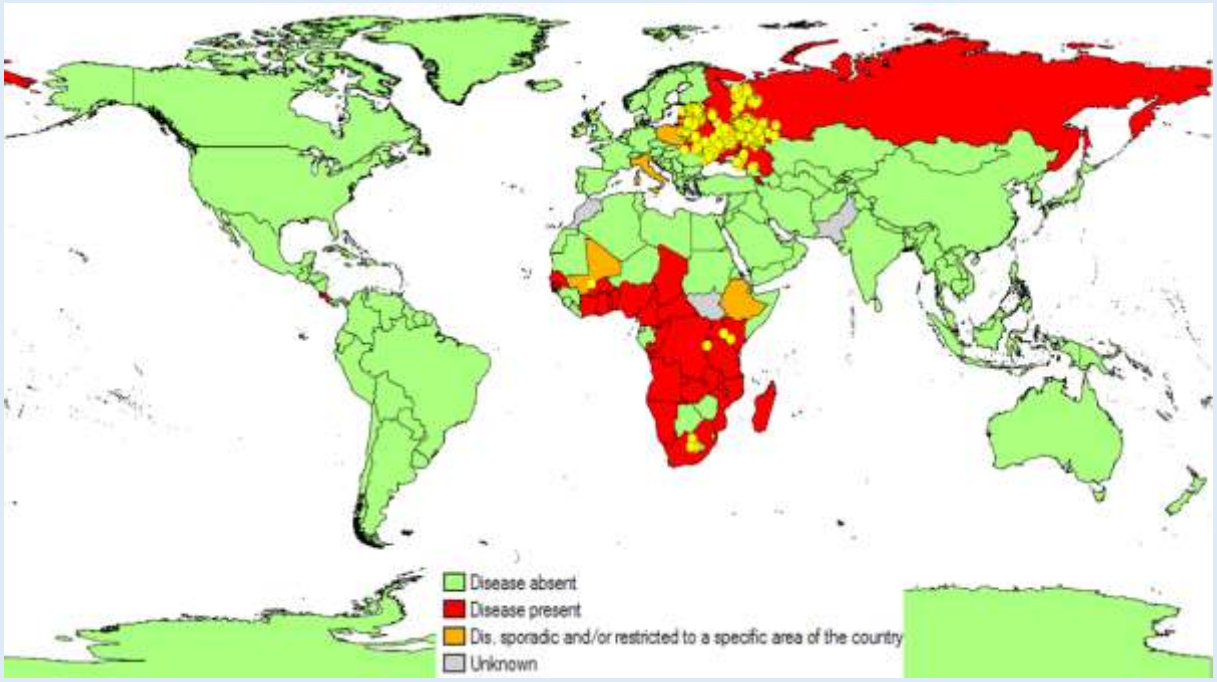
In 1992, at the international conference on animal health, OIE agreed and recognized this disease as Porcine Reproductive and Respiratory Syndrome (PRRS) [15]. Then it was detected in Asia: China (1995), Vietnam (1997), South Korea and Japan (1998). Australia, New Zealand, some European countries, parts of Africa and India have not had this disease.

2.1.1.4. African swine fever (ASF)

ASF was discovered by Montgomery in Kenya in 1921. Following decades ASF was observed in several Sub-Saharan countries. First occurrence of ASF outside African continent occurred in Portugal in 1957, near Lisbon. Three years later, in 1960, ASF reappeared in Portugal, rapidly spreading to the whole Iberian Peninsula. Since then, ASF remained present in Spain and Portugal for more than twenty years, until eradication was achieved in 1994 in Portugal and 1995 in Spain, consequent to great human and economic efforts.

According to the Report No. 17 (from 2016 to 2019) on global situation of OIE, the disease is present in the African, European, and most recently, the Asian continent (it was eradicated in the Americas in the ‘90s). Since 2016, 48/200 countries and territories have reported the disease (accounted for 24%). In Europe, the disease occurred for the first time in: Moldova in September 2016, then in June 2017 in Czech Republic, followed by Romania in July 2017 and more recently in Hungary, and Bulgaria, in April and August 2018 respectively. A recurrence of the disease in wild boars has been reported in Belgium in September 2018 (last event occurred and was resolved in 1985). In Asia, the disease was reported for the first time in China (People’s Republic of) in August 2018, in Mongolia in January 2019, then in Vietnam in February 2019, in Cambodia in March 2019, and in Hong Kong (SAR-PRC) in May 2019.

ASF is present in domestic pigs and wild boars in Europe, while Asia and Africa have notified outbreaks in domestic pigs mainly, and few cases in wild boar (300 cases reported in Asia since August 2018). During this period, Europe accounted for the majority of outbreaks with 96% (9,756) of all outbreaks, but the highest impact in terms of animal losses was reported in Asia (1,711,677 animals lost, which is 68% of the total global reported losses in this period).



(Source: Global animal disease intelligence report 2016 - FAO)

Figure 5: Global situation of ASF (2016)

Between 2018 and the first semester of 2019, this disease was notified in 3 countries in Europe (Estonia, Italy and Lithuania) and 23 countries in Africa (Source: the Report No. 34 (from 20 December 2019 to 3 January 2020) on ASF situation of OIE). In this period, 241 new outbreaks were notified. The total of ongoing ASF outbreaks worldwide is 12,219; 3,118 animals were notified as losses; 23 countries/territories notified new or ongoing outbreaks through immediate notifications and follow-up reports, 9 in Europe (Bulgaria, Hungary, Latvia, Moldova, Poland, Romania, Russia, Slovakia and Ukraine); 10 in Asia (China (People's Republic of), Indonesia, Korea (Democratic People's Republic of), Korea (Republic of), Laos, Myanmar, Philippines, Russia, Timor-Leste and Vietnam) and 4 in Africa (Cote D'Ivoire, Kenya, South Africa and Zimbabwe).

In general, the above-mentioned animal diseases are very common, and they have spread rapidly in many parts of the world with many different strains of virus, becoming epidemic in countries with developed livestock industries and causing great economic losses every year. Therefore, the prevention and control of animal diseases and measures to handle diseased animals have been actively implemented by many countries to protect the health of livestock and poultry.

2.1.2. Measures of prevention, control and disposal implemented

2.1.2.1. Measures of prevent and control

Facing the animal disease situation in recent years, many international organizations and countries have applied/used specific measures to control and prevent epidemics such as:

a) For AI

Disease reporting is a quick and vital response for containing avian influenza outbreaks, and in some cases, for minimizing the risk of zoonotic transmission. In addition to national notification requirements, HPAI viruses and LPAI viruses that contain H5 or H7 must be reported to the OIE by member nations. For example, veterinarians who encounter or suspect a reportable disease or unusual mortality among wild birds should follow their country-specific guidelines for informing/reporting the proper authorities (state, tribal or federal natural resource agencies; state or federal veterinary authorities) in USA (Fowl Plague, Grippe Aviaire, 2016).

To prevent the infectious risk of a virus to poultry or other birds, good biosecurity and hygiene should be applied which includes: Preventing any contact with other domesticated or wild birds, mechanical vectors and fomites including water sources; all-in/all-out flock management is helpful in poultry flocks, and birds should not be returned to the farm from live bird markets or other slaughter channels; preventing reassortment between human and AI viruses, people are encouraged to avoid contact with birds while suffering flu symptoms; control insects and rodents, handle contaminated materials and disinfect; due to different countries like USA, Mexico, Pakistan, etc., vaccines may either be used routinely to protect poultry flocks (vaccination in the USA is restricted and requires the approval of the state veterinarian, and in the case of H5 and H7 vaccines, the United States of Department of Agriculture - USDA approval).

b) For FMD

According to the OIE, the initial measures described in the global FMD control strategy are the presence of early detection and warning systems and the implementation of effective surveillance in accordance with the guidelines detailed in the OIE Terrestrial Code. They help monitor the occurrence and prevalence of the disease and allow characterization of FMD viruses. The implementation of the FMD control strategy varies from country to country and depends on the epidemiological situation of the disease. In general, it is essential for livestock owners and producers to maintain sound biosecurity practices to prevent the introduction and spread of the virus.

(i) Measures that are recommended at the farm level include:

- Control over people's access to livestock and equipment;
- Controlled introduction of new animals into existing herds;
- Regular cleaning and disinfection of livestock pens, buildings, vehicles and equipment;

- Monitoring and reporting of illness;
- Appropriate disposal of manure and dead carcasses.

(ii) Contingency planning for potential outbreaks will identify the elements included in a response effort to eradicate the disease, such as:

- Humane destruction of all infected, recovered and FMD-susceptible contact animals;
- Appropriate disposal of carcasses and all animal products;
- Surveillance and tracing of potentially infected or exposed livestock;
- Strict quarantine and controls on movement of livestock, equipment, vehicles, and;
- Thorough disinfection of premises and all infected materials (implements, cars, clothes, etc.).

(iii) Use of vaccination:

Depending on the FMD situation, vaccination strategies can be designed to achieve mass coverage or be targeted to specific animal sub-populations or zones. Vaccination programs carried out in a target population should meet several critical criteria, mainly:

- Coverage should be at least 80%;
- Campaigns should be completed in the shortest possible time;
- Vaccination should be scheduled to allow for interference from maternal immunity;
- Vaccines should be administered in the correct dose and by the correct route.

The vaccines used should meet OIE standards of potency and safety, and the strain or strains in the vaccine must antigenically match those circulating in the field. Vaccination can play a role in an effective control strategy for FMD, but the decision on whether or not to use vaccination lies with national authorities.

c) For PRRS

To prevent and control PRRS in countries, this requires knowing the health status of replacement gilts and boars, as well as proper isolation and acclimatization of incoming stock. Pigs should be retested on arrival at the isolation facility and 45 - 60 days later, before entry to the herd.

Where the disease breaks out in a farm, depopulation with subsequent cleaning and disinfection and proper disposal of the carcasses has been used to eliminate the infection. Commercial vaccines, both modified live and killed, have been used and they have been effective in controlling outbreaks and preventing economic losses. Vaccines must be produced following the guidelines in the OIE Manual of Diagnostic Tests and Vaccines for Terrestrial Animals.

Many countries, including Vietnam, have proactively prevented the disease by applying biosecurity measures such as: Keeping pigs in good condition (good food sources to ensure nutritional needs); keeping pigs in a protected environment (fence

to prevent contact with pigs outside the farm, limit the entry of people and other animals; farm employees must bathe and change clothes when accessing to the farm; veterinary staff are not allowed to bring tools from outside to the farm; have isolation areas for capturing newly arrived animals and applying effective isolation procedures; do not allow transportation entering farms; treating manure and wastewater according to regulations, etc.); breeding areas must be controlled (vaccination, disinfection, etc.).

d) For ASF

Currently, OIE encourages non-epidemic member states to implement sanitary measures such as: Careful import policy for animals and animal products; proper disposal of waste food from aircraft or ships coming from infected countries. In addition to reducing the risk of spread of the disease, biosecurity measures on the farm should be strengthened, including avoiding contact between pigs, wild boars and soft tick vectors or their habitats. So far, there has been no vaccine to treat the disease, so that proper disposal of cadavers and litter, detailed epidemiological investigation, surveillance of infected zone, and surrounding area, etc. are necessary.

2.1.2.2. Measures of applied disposal

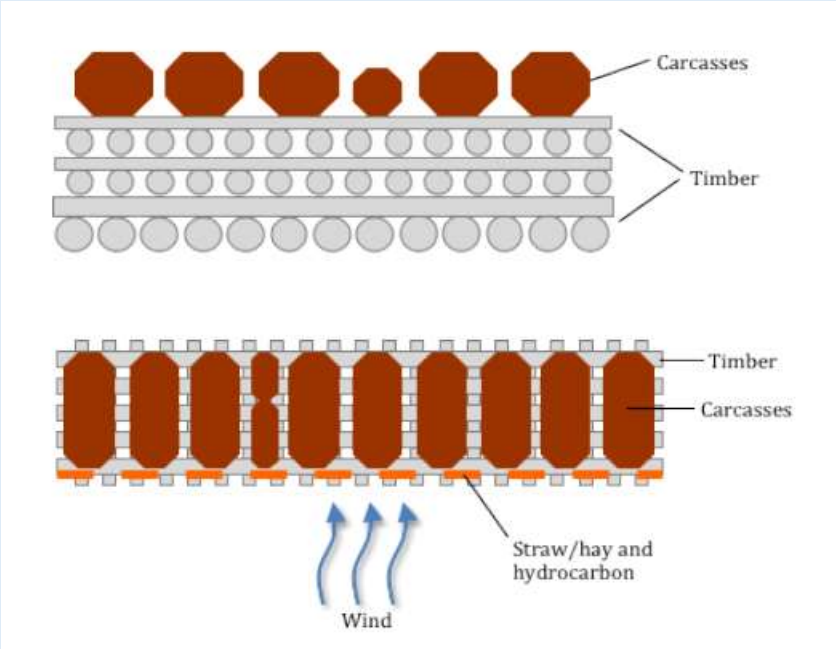
In addition to control and prevention of disease, in practice, disposal of large-scale carcasses is also considered. To treat carcasses to prevent the spread of the disease to animals, humans and the environment, many countries like as Canada, Australia, USA, etc. have applied specific measures, in details:

a) Burning

Burning ("thermal treatment") is one of the common measures applied in some countries such as Canada, Australia, etc. Burning or incineration with high temperatures is a chemical process that occurs many simultaneous and successive reactions to treat the waste materials and convert it to ash, gas and heat. Speed of reaction and temperature of incinerator are decisive for explicitly decomposition of waste materials in it. There are two broad categories of burning methods: open-air burning (pyre burning, air-curtain incineration) and commercial incineration.

(i) Open-air burning

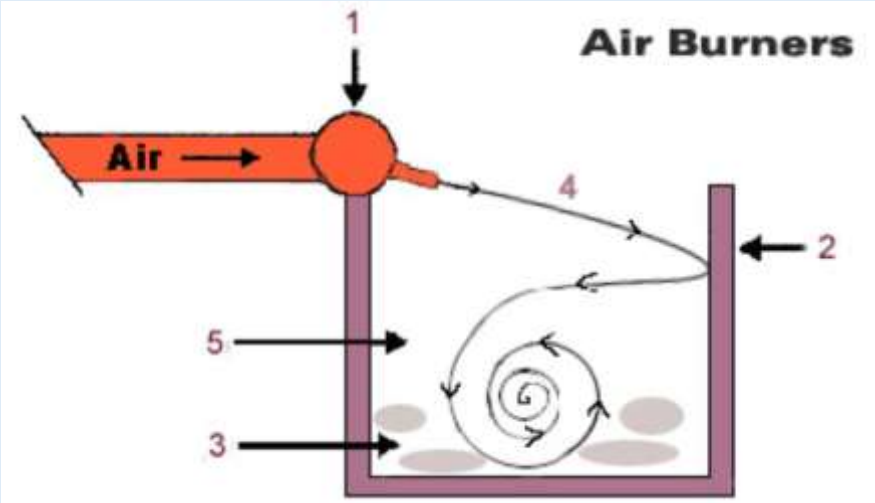
- Pyre burning: This is an open system of burning carcasses either on-farm or in collective sites on "pyres" constructed of solid fuels such as dry wood or coal briquettes. The carcasses are placed on top of the solid fuel, ensuring that there is sufficient airflow around them for efficient combustion. The pyre design and the quality of the solid fuel used will determine the efficiency of combustion. Generally, the more efficient combustion, the less smoke generated and the greater the temperature achieved (Ausvetplan, 2015).



(Source: Ausvetplan, 2015)

Figure 6: Construction of pyre burning

- Air-curtain incineration: Air-curtain incineration involves burning materials in either an earthen pit or a metal refractory box (firebox) using fan-forced air. A machine forces a mass of air across the length of the pit or box, creating a turbulent environment that greatly enhances incineration. The angle of the airflow results in a curtain of air acting as a top for the incinerator and provides oxygen, which results in a more complete burn. Unburned particles are trapped under the curtain of air in the high-temperature zone, where temperatures can reach 1.000ºC (Ausvetplan, 2015).



(Source: Air Burners Inc (www.airburners.com)

Figure 7: Air-curtain incineration

This includes air curtain machine manifold and nozzles direct high-velocity airflow into refractory lined firebox or earthen pit (1); refractory lined wall (firebox) or earthen wall (pit burner) (2); material to be burned (3); initial airflow forms a high - velocity “curtain” over fire (4); continued airflow oxygenates fire, keeping temperatures high. Higher temperatures provide a cleaner and more complete burn (5).

When operating an air-curtain incinerator, solid fuel (eg, dry wood) is loaded by an excavator into the receptacle to establish a base fire. Once the base fire is established, the solid waste (carcasses) can be loaded onto the fire. This process can be monitored by observing the volume of smoke leaving the receptacle and adjusting the fuel-to-waste ratio accordingly. Fuelgel - a combination of a powdered aluminum soap and a hydrocarbon - is a fuel source that has been trialed for burning carcasses in Australia. Findings from Australian trials (Worsfold and King 2006) indicate that fuelgel is not as volatile as straight hydrocarbon products (eg, petrol and diesel) and has a more sustained burn time, making it particularly useful for starting long timber pyres.

(ii) Commercial incineration (fixed facility incineration)

Commercial incineration (fixed facility incineration) involves the combustion of waste materials in contained and usually highly controlled chambers, which are typically fueled by gas. This is considered an efficient and safe method of disposing of contaminated waste. This category includes waste incineration plants, pet crematoriums, small on-farm incinerators, cement plants and power plants (Ausvetplan, 2015).

The minimum temperature of incinerator T >1,000^{0}C, for the fixed incinerator, heat is used to decompose harmful waste in the air with high temperature (T = 1,000 - 1,600^{0}C), storage time at least τ = 0,5s; and for cement kiln works, high temperature should be 1.450 - 2.000^{0}C, with its long body, the storage time is prolonged (τ > 5 - 6s).

In Australia, waste incineration plants are usually located in populated centers and are primarily designed to handle small quantities of material (e.g. medical waste, household or industrial waste). The facilities are usually well set up to transport, store and handle hazardous biological materials in a safe manner. They are licensed and regulated by environmental agencies, and their contained and controlled processes usually allow efficient high-temperature combustion and pollution control. However, during the poor flexibility and restrictions in quantity, large-scale application is limited.

Using power plants or cement plants for incineration of carcasses and contaminated materials may be an option. Co-incineration is a process in which meat and bone meal, carcasses or parts of carcasses are burned in conjunction with other substances, e.g.: hazardous waste incineration, clinical waste incineration, other industrial incinerations such as: power plants, cement kilns, blast furnaces, coke ovens. In practice meat and bone meal has been used as a secondary fuel on a large scale in cement kilns and power plants.

b) Burial

While burning is prioritized for some infectious diseases like anthrax, etc., in some countries like the US and Australia, burial is priority in most cases of animal diseases provided that ratio of death is high.

(i) Mass burial

Mass burial is used when large numbers of animal carcasses from multiple locations are disposed of. Unlined burial is usually used when soil types or local geology can control the risk of leachate leakage, whereas lined burial is used when there are risks of leakage of leachate into subsoil or the water table (Ausvetplan, 2015). It is often the most effective method of carcass disposal if pits are constructed, located and managed correctly.

(ii) Commercial landfilling

In the landfilling process, the carcasses are buried in an engineered, sealed containment area between layers of compacted solid waste and impermeable lining materials. If landfilling is chosen, make sure that the landfill can accept carcasses. Landfilling is an excellent option for disposing of carcasses if they can be moved in large vehicles that can transport them quickly and biosecurely.

(iii) Trench burial

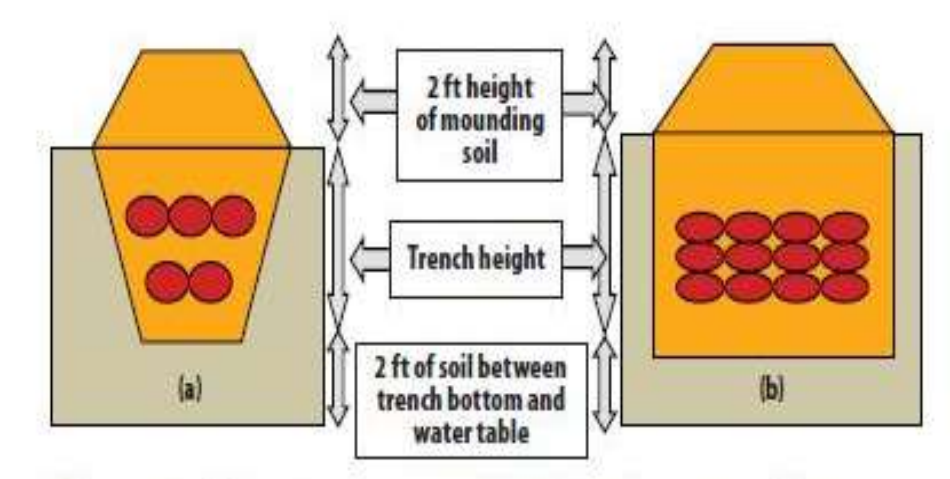
This method also applied in USA, Australia, etc., animal carcasses are placed in unlined trenches or pits that are then backfilled with excavated soil. The soil absorbs the leachate (carcass fluids) and microorganisms; the confined environment deters carnivorous scavengers and holds in heat, which speeds up the decomposition process.

Trenching have been under related regulations and standards to avoid risk and dangers for the people building or working in or around trenches/pits. The best cross-sectional shapes for the burial site are rectangular and trapezoidal (if the land in the area is not stable).

In USA (Texas), the ratio of trench volume to carcass volume for burying carcasses should be: 4:1 for one to two layers of large carcasses (1,000 pounds); 2:1 for two to three layers of medium-sized or small carcasses. For massive mortalities, make the trenches no more than 12 feet deep and bury no more than two 3-foot layers of carcasses. If digging more than one trench, maintain a minimum distance of 3 feet of undisturbed or compacted soil between two trenches.

The staging area should have a compacted bottom, preferably a compacted rock base or an existing concrete pad. Cover the staging surface with 12 - 18 inches of wood shavings, sawdust, cotton gin trash, compost, spent horse bedding, or any other material that will absorb and contain liquids from carcasses. Fence off or protect the staging area from scavengers. If water run-on or run-off is expected, you may need to build a temporary soil berm around the staging area.

Before placing ruminants into a burial pit, it must be vented (cut, lanced or punctured) the carcasses to prevent gases from accumulating, causing the carcass to rise up out of the pit or explode. Inside the trench, separate the layers of carcasses with soil cover: For small animals such as poultry or nursery pigs, the layer should be 1 foot thick; for large animals such as hogs or livestock, the layer should be 2 feet thick (Saqib Mukhtar, 2012).

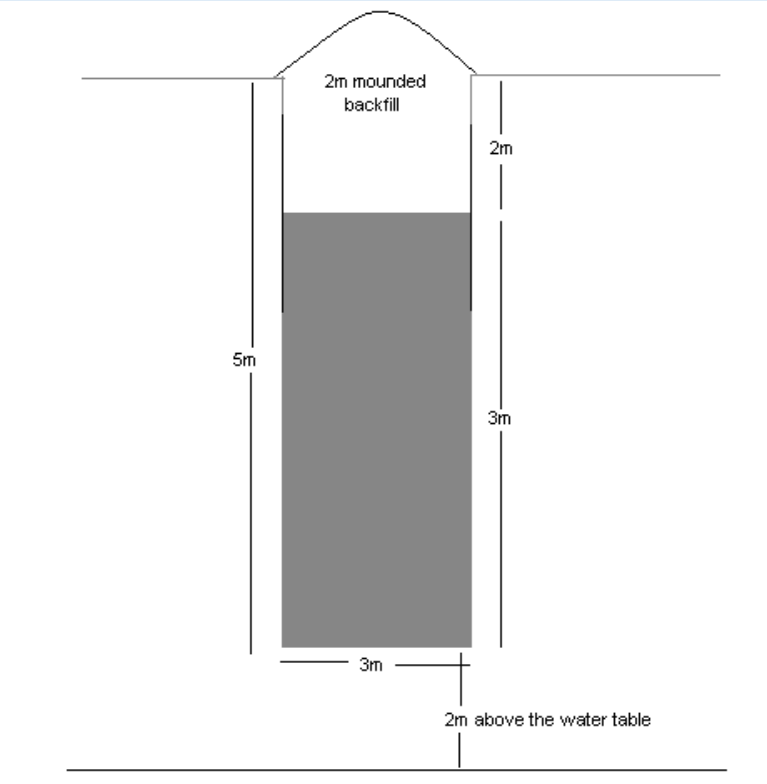


(Source: Routine and emergency burial of animal carcasses, Saqib Mukhtar, 2012)

Figure 8: Layout of trapezoidal (a) and rectangular trench (b) for burying carcasses

Whereas, in Australia, the preferred method of digging a pit is to construct a deep, narrow, vertically sided pit. The pit must be deep enough to allow the carcasses to be covered with at least 2m of soil. The cover soil can be slightly mounded after backfilling. Do not compact the earth-filled trenches; it slows the natural decaying process.

Suggested dimensions for constructing on-site burial pits are 4 - 5m in depth which results in 3m of carcass depth and the two required meters of soil cover (Figure 9). The pit should be no greater than 3m wide which helps create an even spread of carcasses in the pit. The length of the burial pit will be determined by the number of carcasses requiring disposal. Depending on the cause of livestock death and the number of carcasses to be disposed of, the pit may be required to be lined to prevent seepage of contaminated fluid into the soil and groundwater (Animal Biosecurity, NSW DPI, 2017).



(Source: Animal carcass disposal, Animal Biosecurity - NSW DPI, Australia)

Figure 9: Traditional trench style burial pit

(iv) Mounding (above-ground burial)

This involves placing carcasses on a natural surface of earth and covering them with earth obtained from another source. Typically, this takes place on the site where animals originate. However, this method should be consulted and considered environmental, work health and safety (WHS), and future land-use matters.

Lime (calcium oxide) has been used as a disinfectant, and in burial pits to increase the rate of decomposition of carcasses. It is now known that the disinfectant properties of lime are due to its ability to raise the pH. A pH above 10 will disrupt bacterial cell walls and hydrolyze viral genome nucleotides. Unfortunately, this counteracts the acidification of carcasses that occurs naturally as part of the decomposition process and destroys many disease organisms. In addition, it has been shown recently that calcium preserves anthrax spores (Himsworth 2008). Hence, addition of lime to burial pits is not recommended.

c) Composting

Composting is a natural biological process that transforms organic materials, in a predominantly aerobic environment, into a useful and biologically stable end product. The process, if carefully implemented and monitored, generates sufficient heat to destroy most pathogenic organisms.

Composting can be carried out on-site or at another appropriate location (eg, commercial composting facility). Sections of the poultry, pig, dairy and feedlot industries in some countries like Australia, etc. use composting for on-farm disposal of mortalities that occur under normal production circumstances (Ausvetplan, 2015).

There are general methods as follows:

(i) Windrow composting

Epidemic-infected animal carcasses and substances to be decomposed are mixed, piled into long rows and regularly turned. First, a 1m high layer of epidemic-infected animal carcasses is piled and then another layer of organic materials (agricultural residues and wastes, stems, leaves, etc.) is added to form a windrow of about 3.6m high. The width of the windrow is about 3 - 6m. The materials in the windrow are naturally supplied with air. In order to increase the air exchange in the windrow, the amount of raw organic materials (such as stems, leaves) must be greater than the amount of animal carcasses and infected animal products. The windrow size should not be too large, because if it is too large, the middle part of the windrow will be anaerobic, which leads to an unpleasant odor when the windrow is turned. In contrast, the size should not be too small, because it will not create a sufficiently high temperature to dry the compost, kill pathogens and weeds. The windrow must be regularly turned and the turning frequency depends on the rate of decomposition, moisture, porosity and composting time. As organic decomposition occurs fastest in the early stage, the turning frequency shall decrease over time. In the early stage, the it should be turned daily, then the frequency is gradually reduced to about once a week; The top layer is also covered with peat, straw or finished compost to isolate the compost, to prevent mosquitoes and flies, mitigate odors and reduce protein loss caused by evaporation. At the end of the composting process, turn, stir and mix the compost with the isolation material.

Figure 10: Windrow composting

(ii) Aerated static pile composting

This is a more advanced method derived from the passive aerobic windrow composting. Air supply pipes are used together with fans to push air through the composting mass. With this method, the composting materials must be mixed thoroughly before composting because, during the composting, the pile will not be turned or mixed. Typical height of the pile is 1.5 - 2.4m, depending on the materials used, weather condition and aeration level inside the pile.

Figure 11: Aerated static pile composting

(iii) In-vessel composting

This method confines the composting materials within a building, container, or vessel with an air blower or a system providing the optimum aerobic decomposition conditions to accelerate the organic decomposition. Below are several forms of this method:

- Bin composting: This is the simplest form of the in-vessel method, the bin is made of wood chips, installed to create gaps for air penetration. In principle, this method is similar to aerated static pile composting, as both of them involve the use of pipes to supply air to the pile, creating an aerobic condition without turning the materials.
- Pile composting in combination with the aeration process control and periodical turning.
- Silos composting: Stir and turn the composting materials daily, use an excavator to turn the material from the bottom of the pile to the top and then mix with the top raw material, creating an aerobic condition in the pile, etc.

Figure 12: In-vessel composting

This simple process, which can be conducted on site at low cost, can achieve temperatures of up to 70^{0}C. The first stage is characterized by increased temperatures and rapid rates of decomposition. These conditions result in the elimination of odour, the destruction of most pathogens and weed seeds, soft tissue decomposition, and the partial softening of bones. Compost piles will reach temperatures sufficient to kill most pathogens in 10 - 14 days for small carcasses (e.g, poultry), but longer for larger carcasses. Piles must be monitored for temperature, and the sinking or cracking of cover material. Temperatures decrease at the end of the first stage. The second stage has lower rates of biological decomposition, and its management will have an impact on the suitability of the end product. The pile can be moved, turned or mixed at the end of the first stage. Turning piles may increase the rate of decomposition of remaining materials (mainly bones) by increasing aeration, therefore reducing compost time.

However, it may be associated with biosecurity risks. The finished product can be recycled, stored or added to the land as a soil amendment. States or territories/countries have considered to use the product because it is difficult to verify the effectiveness of pathogen inactivation (it is difficult to insure a constant temperature throughout the material for the total time period).

d) Autoclave

Epidemic-infected animal carcasses should be treated as hazardous waste (infectious waste). Currently, there are 4 levels of disinfection of infectious waste (According to the US Centre for Disease Control (CDC) and the World Health Organization (WHO)):

- Level 1 (low level of disinfection): capable of inactivating almost all bacteria, fungi and viruses. At this level, it is unable to inactivate *Mycobacterium tuberculosis* and bacterial blastema/spores, and therefore it is not appropriate and not recommended for treating infectious wastes.

- Level 2 (medium level of disinfection): capable of inactivating bacteria, fungi, and viruses. However, it is unable to inactivate bacterial blastema/spores, and therefore it is appropriate for preliminary treatment of infectious wastes.
- Level 3 (high level of disinfection): capable of killing all microorganisms in infectious wastes (including *Bacillus anthracis*) and bacterial blastema/spores.
- Level 4 (sterilization): at this level, almost all microorganisms and bacterial blastema/spores are killed. Up to 99.9% of bacterial blastema/spores are killed.

(i) Low heat thermal method

This method uses thermal energy to disinfect infectious waste at a temperature that is not high enough to cause chemical destruction, typically ranging from 100 - 180^{0}C. There are two basic types:

- *Wet-heat/Steam-based treatment method (steam)*

Wet-heat method uses steam to disinfect infectious waste and is commonly performed in an autoclave or other microwave device combined with saturated steam. Some equipment used to disinfect waste with this method are as follow:

- ✓ *Autoclave*

Autoclave consists of a metal chamber designed to withstand high pressures with a sealed door and an arrangement of pipes and valves through which steam is brought in and removed. Steam is brought in the jacket and inside the autoclave chamber to reach the disinfection temperature level as requested. After the waste is brought in the autoclave chamber, the charging door will be closed. Steam is continuously pumped in the autoclave chamber to maintain the pressure and temperature mode as initially set to assure complete disinfection of the treated waste. After the disinfection process is completed, temperature and pressure will gradually decrease to the safe level for opening the charging door of the autoclave chamber and bring out the already treated waste.

Studies have indicated the ability of this device to kill off pathogens in case the waste is disinfected at the temperature of 121^{0}C; for 30 minutes, it can reduce the quantity of blastema/spores by 106. According to QCVN 55:2013/BTNMT - National Technical Regulation on Infectious Healthcare Waste Autoclave, if the device is operated at 121^{0}C, the treatment duration must last 60 minutes; if operated at 135^{0}C, treatment duration must last 45 minutes.

- ✓ *Advanced autoclave*

Basically, the schema and operation principle of this equipment is similar to an autoclave. However, this equipment involves additional steps, namely vacuuming and mechanical treatment before, during and after disinfection. To be specific, advanced autoclaves work on the basis of the following principles: vacuuming /steam-based disinfection/steam compression; steam-based disinfection/ drying/ shredding; shredding / steam-based disinfection combined with drying; steam-based disinfection combined with shredding / drying; steam-based disinfection combined with fragmenting / drying; shredding / steam-based disinfection.

- *Use of dry heat hot air*

Use of dry heat means not to add water or steam into the infectious waste treatment device. Usually, in this device, the infectious waste is heated by thermal conductivity, natural or forced convection or use thermal radiation or infrared radiation. Some equipment applies this method for infectious waste treatment:

A microwave disinfection device consists of a treatment chamber in which microwave energy is directly transmitted from magnetron. This device can be designed for batch-based or continuous treatment. The disinfection process in this device occurs due to the effects of humid heat and steam generated by microwave energy. Microwave is very short wave in the electromagnetic spectrum. A magnetron is an oscillator used to convert high-voltage power into microwave energy then move to conduction channel to target energy into a specific area (e.g., disinfection chamber). Microwave exerts impacts on water molecules in the infectious waste with super high vibration intensity to generate friction, heat and convert water in the waste into steam. The generated heat will destroy protein in bacterial cells and inactivate the pathogens.

Other studies have proved that the disinfection performance/effectiveness is considerably lower without water. Therefore, when a microwave device is used for infectious waste treatment, water or steam is usually added into the disinfection chamber to increase the disinfection performance/effectiveness. No microorganisms are left over after disinfection in the microwave device (tested with *Bacillus subtilis, Pseudomonas aeruginosa, Staphlococcus aureus, Enterococcus faecalis, Nocardia asteroides, Candida albicans, Aspergillus fumigatus, Mycobacterium bovis* and *Mycobacterium fortuitum*).

(ii) Hot air disinfection technology used for treatment of infectious waste

This is a technology that uses temperature in the form of hot air to disinfect infectious waste. Compared to the steam-based disinfection technology, the hot air disinfection technology uses higher temperature and run for a longer period to treat infectious waste. Depending on how the hot air is used, this technology is divided into 2 types, namely:

- *High-speed dry heat spray system*

The high-speed hot air spray equipment/ system used for disinfection of infectious wastes consists of a stainless-steel closed disinfection chamber and a waste shredder. This system is often attached with a post-treatment waste compressor that helps minimize the volume of treated waste. The equipment is designed with an embedded unit for deodorizing and for filtering toxic exhaust gases emitted during the activated charcoal-based treatment process.

Infectious waste is fed into the closed disinfection chamber and shredded to into pieces of 19mm in size. Hot air is directly sprayed onto the waste in the chamber until the temperature level of 171°C is reached and this temperature level is maintained for 4 minutes to ensure complete disinfection of the waste. After the disinfection process is completed, the temperature in the chamber drops gradually to a safe level for the treated waste to be discharged. Tests have shown that there is no existence of microorganisms such as *Bacillus subtilis, Staphylococcus aureus, Candida*

albians, Mycobacterium fortuitum, Mycobacterium bovis, E.Coli, Pseudomonas aeruginosa, and *Giardia sp*.

- *Dry friction heating system*

The system consists of a dry heating chamber and an infrared or resistor-based drying unit. In the dry heating chamber, the waste is dried with i an infrared or resistor-based drying unit. The waste is dried by thermal convection or radiation heat exchange. Temperature in the chamber is maintained at 177^0C for a minimum period of 90 minutes. After the disinfection process is completed, treated waste is cooled down and discharged. This technology usually produces exhaust gas from the heat chamber. However, an exhaust gas filter system is designed. Exhaust gas go through a double filtering system of a unit with activated charcoal-based filter and HEPA to eliminate odour and micro-organisms. Tests have shown that, treated waste after being disinfected by this technology, there is no existence of microorganisms (*Bacillus subtilis, Staphylococcus aureus, Candida albians, Mycobacterium fortuitum, Mycobacterium bovis, E.Coli, Pseudomonas aeruginosa* and *Giardia sp.*).

e) Rendering

Rendering is the process of heating raw materials to liberate fat from tissues and to separate fat from other solid tissues (ARA 2011). The general rendering process uses raw materials, which are cut, mixed and cooked; protein and fat materials are then separated. Concentrated protein is dried and ground.

Rendering systems produce either “edible” or “inedible” byproducts, and use various methods, such as wet, dry (the material properties), batch, continuous (operation characteristics), press dewatering and wet pressure (technology properties) (Auvermann et al 2004).

This method neutralizes pathogens (exception of the prion - a form protein with a multidirectional poly-structure that can transform into another prion, replicate and cause disease similar to the virus (infectious, hereditary and exposed), cause central nervous system degeneration, muscle structural damage).

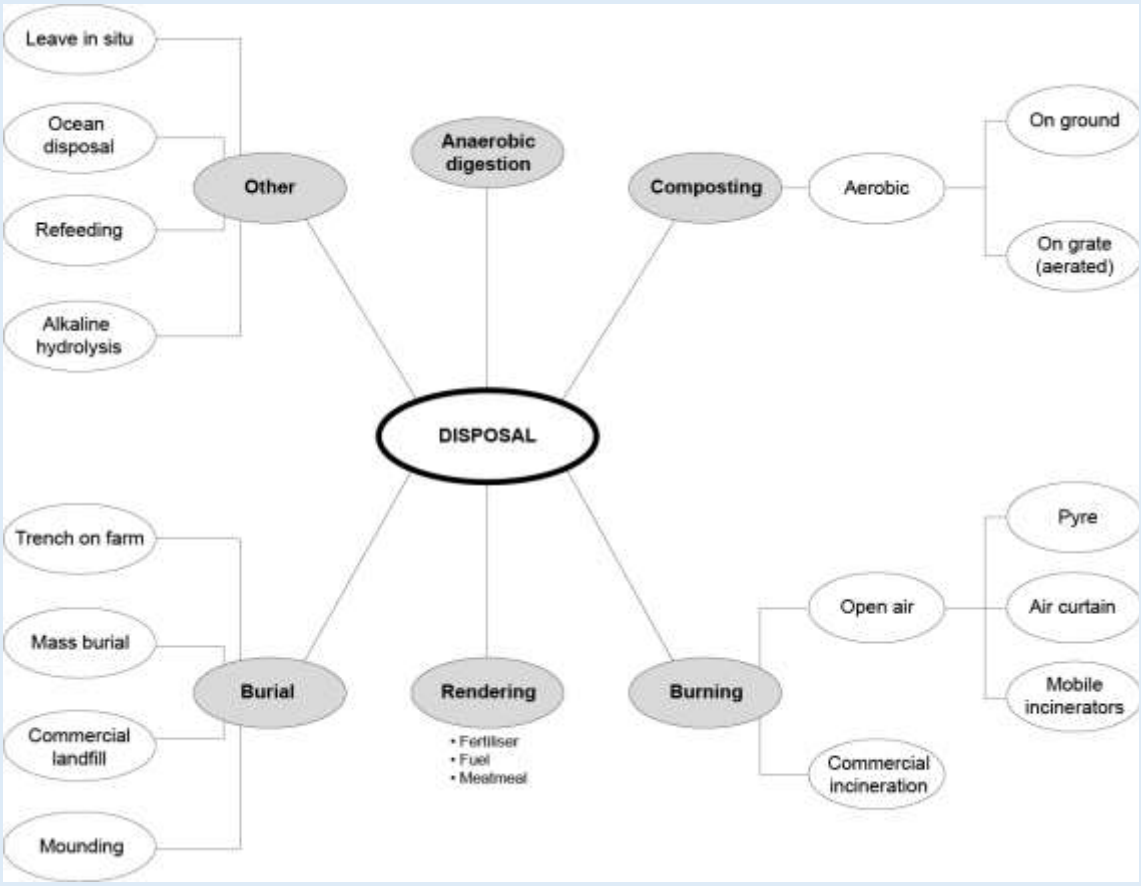
Byproducts of the rendering process include meat meal, fuel, methane and fertilizer. In Canada, a medium sized rendering plant could process 12 tons per hour of operation. Such plants can operate within environmental standards (Norman G. Willis, 2003). Whereas, there were 81 rendering plants operating in Australia in 2011 (ARA 2012).

f) Anaerobic digestion

Anaerobic digestion facilities are being built on farms to convert animal effluent to biogas (methane), which is then used for heating and/or electricity generation. Similar facilities could be used in the event of an emergency animal disease outbreak for the disposal of effluent and carcasses (NABC 2004).

The process of anaerobic digestion involves the use of a mixed bacterial ecosystem, without oxygen, to transform organic material into methane, carbon dioxide and a sludge. Initially, hydrolysis breaks down lipids, polysaccharides, proteins and nucleic acids into fatty acids, monosaccharides, amino acids, and purines and pyrimidines.

Acetogenic bacteria convert these to organic acids, carbon dioxide and hydrogen. The organic acids are then converted to methane and carbon dioxide. A balance between the various microbial populations must be maintained during this process.



(Source: Ausvetplan, 2015)

Figure 13: Overview of methods of animal disease disposal

g) Other methods

(i) Alkaline hydrolysis

Alkaline hydrolysis uses heat, pressure and an alkaline solution (sodium or potassium hydroxide) to dissolve and sterilize biological materials. It involves the hydrolysis of materials (proteins, nucleic acids, carbohydrates, lipids, etc.) into a sterile aqueous solution of small peptides, amino acids, sugars and soaps. What remains are the mineral constituents of the bones and teeth. This process requires specialized equipment and operates at 150^0C for 3 hours. It completely inactivates pathogens with the exception of prions where infectivity is reduced and is environmentally responsible. However, because of its high capital expense and relatively small throughput, its application is generally confined to specialized operations (e.g, research facilities, laboratories).

(ii) Biosphere Process

The biosphere process is a bio-refining technology which employs a biolytic hydrolyzer, operating under high temperature, steam pressure, and internal agitation

in a sealed steel vessel. The process produces hydrolysis of protein and carbohydrate materials, fracturing long chain molecules and yielding sterile, high nutrient fertilizer as an output. It operates at 180^0C under 12 atmospheres of pressure for a period of 40 minutes. It inactivates all pathogens and is environmentally sound. Inactivation of prions is still undetermined.

(iii) Refeeding to non-susceptible species

Refeeding is the use of whole or cut-up carcasses to feed other species. It has been used in the past for feeding of animals bred for the fur trade, in hunt kennels, and for feeding of zoo collections and farmed reptiles (crocodiles).

Although refeeding is a low-technology solution, it is associated with some risk of diseases jumping between species. In addition to refeeding is unlikely to be able to handle large numbers of carcasses.

(iv) Leave in situ ("destroy and let lie")

This could be used in extensive areas that have populations of unmusterable livestock or feral animals. The method involves leaving destroyed animals in situ and relies on changes in temperature and pH to reduce survival of the emergency animal disease agent.

However, this method needs to be conducted detailed risk assessments, include consideration of the potential for disease spread by scavenging species, and the potential for introduction of pathogens into wild or feral populations.

(v) Ocean disposal

Ocean disposal could be a practical solution with fewer environmental impacts than other disposal methods and it could provide a positive contribution to the ocean food chain. However, there is a lack of research means that there is little hard evidence to support this option. Transfer sites at ports that do not disrupt other commerce would need to be identified. Disposal of animal carcasses near land may promote the presence of scavengers, which could interfere with human activities, etc.

2.1.3. Experiences obtained

2.1.3.1. Selecting method and site of disposal

a) For burning method

As above mentioned, due to flexibility and restrictions in quantity, large-scale application of burning is limited. Selecting site of disposal will depend on the size of the operation and the materials to be disposed of, burning can affect surrounding neighbors and roads (smoke, odour, and reduced visual amenity, etc.). So, it is necessary to make good design and management of pyres or pits. In addition to, a suitable and cost-effective supply of solid, liquid or gas fuel is required, ensuring cost economy and all possible controls are implemented to reduce the risk of fire spread.

When selecting site of disposal, it should identify of underground and above-ground utilities to conduct initial property risk assessments, and deploy machinery to supply fuel, construct the pyre or pit, etc. Commercial facilities may not be available in some

areas, so transport methods will be required to enable access to the site for personnel and materials.

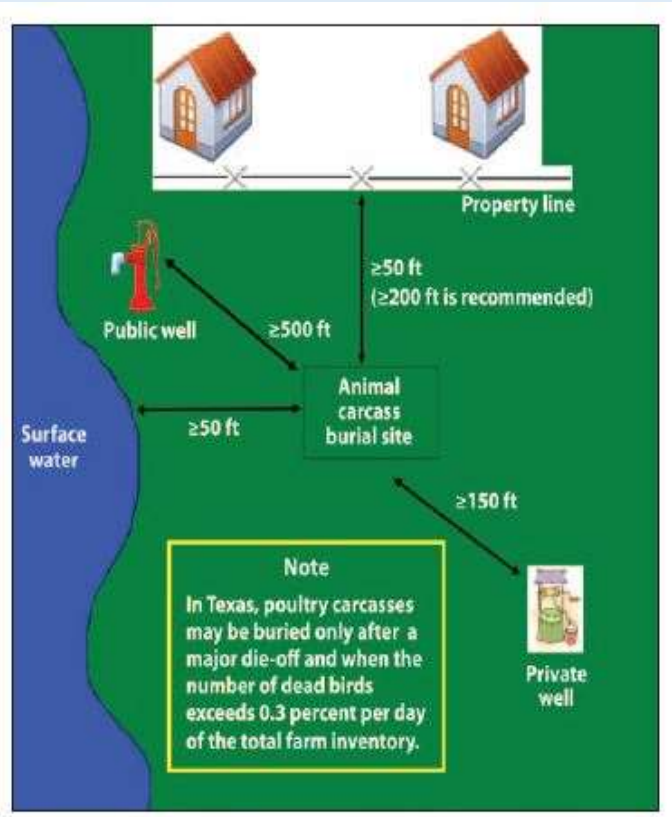
b) For burial method

To reduce the environmental impacts from landfilling, selection of site in this measure is essential, so the following factors need to be considered:

- It is preferable that the site is not in a catchment area or drinking water supply, it should be far away from any watercourses, lakes, ponds and so on, to prevent contamination of water supplies by decomposing animal carcasses.
- The safe distance should be defined by jurisdictional authorities.

To reduce the likelihood of contamination of water systems by leachate and runoff, the seasonal maximum groundwater level at the site should be below the base of the burial pits, whose level should be determined and approved by environment protection agencies.

According to requirements in Texas (USA), the site should avoid areas with seasonal high groundwater and shallow aquifers. It is not recommended to bury or leave carcasses in flood-prone, low-lying areas. Poultry carcasses must be buried outside the 100-year floodplain. The burial site must be more than 500 feet from any public well, at least 150 feet from private wells, and at least 50 feet from surface water and property lines (Saqib Mukhtar, 2012).



(Source: Routine and emergency burial of animal carcasses, Saqib Mukhtar, 2012)

Figure 14: Setback distances for burial of animal carcasses

According to guideline of New South Wales Government (Australia), the distance from any surface waters (rivers, creeks, dams etc.) is at least 200m; distance between the water table and the base of the pit is at least 2m; and distance from neighbouring houses, buildings or public areas is at least 300m (Animal Biosecurity, NSW DPI, 2017).

The site should be away from towns, dwellings and major roads to reduce the risk of undesirable exposure of the public to dust, odour and unsightly activities.

The site should preferably be on soils of low permeability (any soil with significant clay content). Even pits in clay soils should have their bases compacted during construction because fissures and porous sandy inclusions are a common occurrence. Where soils are not of low permeability, efforts should be made to stockpile clay from excavations or obtain clay from nearby sources for use in lining the pit base. In addition to it should be considered the distance from the coast to reduce the likelihood of coastal contamination by leachate because sandy soils near the coast are very permeable.

It should need a safe distance from underground and aboveground infrastructure (e.g. powerlines, telephone line, gas line, water pipes, sewerage), the World Heritage areas, conservation areas and Indigenous cultural sites, recreation area, etc.

The site should be designed to ensure accessible to trucks and earthmoving equipment, allowing them to enter easily and be effectively disinfected.

The site terrain should preferably not be on a slope greater than 6% and should allow digging of 5m deep pits with heavy equipment.

The site should be of sufficient size to accommodate the required burial activity without affecting neighbours.

c) For composting method

The following matters should be taken into account when selecting the method:

- In-shed and vessel composting provide security and protection from wind, rain and scavengers. However, older sheds with pillars or with little floor-to-ceiling clearance may prove to be more difficult, since manoeuvrability is restricted, and composting piles will need to be constructed between the pillars.
- Locating composting outside sheds (in windrows or bins) requires land with an adequate slope (to facilitate proper drainage and prevent water pooling).

d) For rendering method

The distance of the rendering facility to the affected premises must be evaluated. Where travel distances are large, or the only possible route is through intensive agricultural sectors or townships requiring biosecure transport, additional time and costs will be involved.

In fact, the above measures of animal carcass disposal have been given certain advantages and disadvantages. The selecting of application of any measures to prevent the spread of disease to animals, humans and the environment will depend on the conditions, resources, etc. of each locality and country.

Table 5: Analyzing advantages and disadvantages of disposal methods performed

No	Methods	Advantages	Disadvantages
1	Open-air burning (pyre burning)	- Low-technology option; - Can be initiated relatively quickly; - Can be used where the water table is high or where soil types preclude burial; - Should destroy all pathogens, except prions; - Requires only short-term monitoring; - Can accommodate all classes of animals; - Can be conducted in situ.	- Can be time consuming and labour intensive to construct; - Requires large volumes of solid fuel; - Cost of solid fuels can be considerable; - Can take time to consume whole carcasses; - High fire risk at certain times of year; - Public perception of poor environmental outcome and disease spread risks; - Large volumes of ash will need to be disposed of; - Short-term effect on air quality (smoke, smell); - Combustion efficiency can be affected by climatic conditions (eg, rain); - Requires 24-hour operation to maintain burning; - Cannot verify pathogen inactivation.
2	Open-air burning (air curtain incineration)	- Can be initiated relatively quickly (if machine available); - Machines are portable; - Efficient combustion achieves high temperatures and minimal smoke; - Should destroy all pathogens, except prions (unless operated at >850°C); - Requires only short-term site monitoring; - Burn site can be easily and quickly rehabilitated;	- Limited availability of purpose-built machines; - Requires suitable geology to construct the pit (not required for fireboxes); - Requires specialist operators to manage the site; - Requires significant site controls to monitor personnel safety; - Requires active monitoring during operation; - Requires large volumes of solid fuel; - Can handle only limited volume of materials;

No	Methods	Advantages	Disadvantages
		- Lower fire risk than pyres due to better containment; - Better fuel economy than pyres; - Can be used where the water table is high; - Can accommodate all classes of animals.	- Public perception of poor environmental outcome and disease spread risks.
3	Commercial incineration	- Should destroy all pathogens, including prions; - Highly efficient and controlled combustion achieves high temperatures; - Can be initiated relatively quickly (if close to origin of waste); - Environmental monitoring is managed by commercial operator; - Better pollution controls than other burning methods; - Management of materials by contractors is usually biosecure and safe to the operator; - No requirements for site remediation or monitoring.	- Capacity of facilities varies - some are limited to smaller animals and/or small volumes; - Carcasses and materials need to be transported to the site; - Difficult to engage specialist operators to manage the site in a timely manner; - Limited location of suitable facilities; - May require pre-planning arrangements for access to a facility, or access may take some time to arrange; - Incinerator loading mechanisms (eg, conveyor belts) may not be suitable for animal carcasses or easily decontaminated.
4	All categories of burial	- Allows any number of animals of all species to be disposed of; - Can be initiated relatively quickly if the site has prior approval; - Continuous process that minimizes exposure times; - Less visible than other disposal methods; - International acceptance;	- Potential risk to groundwater; - Requires suitable geology and land area- - Likely to require ongoing site monitoring; - Requires biosecure transport of materials to a site; - WHS risks for large operations (large equipment required); - Leachate and gas may need to be treated; - Potential local community resistance;

No	Methods	Advantages	Disadvantages
		- Allows disposal of other materials; - Minimizes odour risk.	- May affect future use and rehabilitation of the site; - Requires timely availability and acceptable cost of suitable equipment; - Not suitable for urban areas or near human habitation (unless it is a commercial landfill facility).
5	Mass burial (unlined)	- Can be initiated relatively quickly if the site has prior approval (the best choice to disposal of animal carcass in emergency); - Can be undertaken on suitable land close to the animals that need to be disposed of; - May be able to be used for large numbers of carcasses (tens of thousands).	- Difficult to engage specialized engineering and waste treatment personnel in a timely manner; - Requires careful management of work and health sanitary (WHS) risks for large operations with significant equipment; - May require treatment of leachate and gas.
6	Mass burial (lined)	- Less strict requirements for suitable impermeable soils; - Lower environmental risks from leachate leaking from the burial pit; - May be able to be used for large numbers of carcasses (tens of thousands).	- Suitable lining material is difficult to source and can be technically difficult to install; - Sourcing lining materials can lead to delays; - Difficult to engage specialized engineering and waste treatment personnel in a timely manner.
7	Trench burial	- Relatively low equipment requirements; - Volume or weight of carcasses and other materials to be buried from one premises may be small enough that environmental agency approval is not needed; - Usually fewer WHS risks because of the size of the operation and equipment used.	- If many properties are involved, many suitable sites will be required; - Number of carcasses able to be disposed of is lower than for mass burial method; - May limit future land use on farm.

No	Methods	Advantages	Disadvantages
8	Commercial landfill	- Sites may already be licensed to accept animal waste; - On-site facilities (power, water, machinery, personnel, security, decontamination facilities) are already in place; - Environmental protection measures are already designed and implemented (eg, infrastructure to treat leachate and gas); - WHS protocols and security arrangements are already in place; Many facilities are on government-owned land; therefore government manages the risks.	- Sites may not be in a suitable location to minimize risks associated with transport of infected carcasses and other materials; - Sites may not have capacity for burial of large volumes of animal carcasses and other materials; - May exhaust a local resource.
9	Mounding (aboveground burial)	- Can be initiated relatively quickly on the site where animals are destroyed; - Relatively low equipment requirements; - Volume or weight of carcasses and other materials to be buried from one premises may be small enough that environmental agency approval is not needed; - Carcasses and other materials can be disposed of rapidly; - Usually fewer WHS risks because of the size of the operation and equipment used.	- If many properties are involved, many suitable sites will be required; - Fluids from decomposition will need to be managed; - Higher risk of serious odour issues if carcasses and other materials are not covered effectively; - Requires large amounts of soil to cover carcasses and other materials; - May limit future land use on farm.
10	Rendering	- Existing, purpose-built facilities are available; - Facilities and process must meet industry standards; - Provides biological containment;	- Capacity of rendering and availability of facilities may be limiting in a large emergency animal disease response; - Complexities associated with cleaning and disinfection of the facility;

No	Methods	Advantages	Disadvantages
		- Produces low-risk products (eg, fertilizer, fuel, methane, fats); - Destroys most pathogens (except prions).	- Likely imposition of trading restrictions because many rendering facilities are attached to an abattoir; - Limitations on the use of meatmeal products because of prion survivability (e.g., ruminant feed ban restrictions); - Limited number of facilities available, necessitating transport over long distances; - Cost is higher if there is no available or accessible market for safe end product.
11	Composting	- Low-technology disposal method; - Can be done either on-site or off-site; - Can be used where a high water table or unsuitable soil types preclude other disposal methods; - Commercial operators are available; - Destroys all pathogens except endospore-forming bacteria (e.g, anthrax) and prions (e.g., Bovine spongiform encephalopathy - BSE); - Can be initiated immediately if adequate co-composting material is available; - Recycles carcasses and results in a saleable product (subject to acceptable use); - Can take all livestock, suitable fomites and some industry products; - Does not require long-term monitoring or remediation; - Promotes an environmentally responsible image.	- May require a large area; - May require a large supply of co-composting material; - Possibility of localized odour and soil contamination if poorly managed; - Requires daily control and monitoring during initial stages; - Biosecurity risk if required temperatures are not achieved; - May take longer than other disposal methods, which may affect release of quarantine (if conducted on-site); - Efficiency may be affected by adverse climatic conditions; - Limited experience in mass mortalities of large carcasses; - No data for composting of livestock with heavy fleece; - Potential local community resistance; - Transport required for off-site or commercial composting; - Access to commercial composters may require pre-planning or additional time to arrange; - May require final product testing to release compost.

No	Methods	Advantages	Disadvantages
12	Autoclave *(Low heat thermal method with steam-based treatment by autoclave)*	- Has been used for a long time, and proven its effective disinfection ability; - Simple, easy to use; - Accredited and accepted as an alternative technology in some countries in the world; - Able to determine requirements for time and elevated temperature enough for disinfection; - Have various capacity, from some kg to some tons per hour; - Relatively low initial investment cost; - Have many suppliers with various devices and options.	- Without additional shredding, the use of steam-based system will not alter physical appearance and reduce the volume of treated waste; - Pollution of air released from steam during the disinfection process occurs. However, air pollution can be minimized by additional appropriate emission filter; - As the steam is condensed so there is an amount of water to be handled; -Infectious waste can be restricted in direct contact with the steam, which reduces thermal conductivity and affects disinfection efficiency of the technology.
13	Autoclave *(Low heat thermal method with steam-based treatment by advanced autoclave)*	Similar to autoclave. However, thanks to additional shredding, drying, steam compaction, the advanced autoclave can help reduce the volume of treated waste by 80%.	- Without additional shredding, the use of steam-based system will not alter physical appearance and reduce the volume of treated waste; - Pollution of air released from steam during the disinfection process occurs. However, air pollution can be minimized by additional appropriate emission filter; - As the steam is condensed so there is an amount of water to be handled; - Infectious waste can be restricted in direct contact with the steam, which reduces thermal conductivity and affects disinfection efficiency of the technology.

No	Methods	Advantages	Disadvantages
14	Autoclave *(Low heat thermal method using dry heat system (dry heat))*	- Accepted as an alternative technology for incinerators in many countries for the past decades, and proven its disinfection efficiency; - No generated liquid waste; - Equipment is supported with shredders that help reduce the volume of infectious waste by 80%; - Automatic equipment, easy to use.	- If the infectious waste is mixed with chemicals, the disinfection process may spread the chemical to the air or the chemical may be retained in the treated waste after the disinfection; - May arise nuisance odour around the equipment area; - High investment, preventive and corrective maintenance costs.
15	Autoclave *(Dry-heat system using high-speed dry heat spray system)*	- Simple disinfection chamber design; - No generated liquid waste; - Internal shredder and compressor help reduce the volume of treated waste by 80%; - Automatic system and easy to use; - Little nuisance odour thanks to HEPA mixed with charcoal filter; - After dry treatment of waste, treated waste has altered its physical appearance and become compacted.	- If the infectious waste contains chemicals, the chemical may spread into the air or retain in the treated waste; - This is an uncommon technology with no validation data on actual quality, post-treatment quality, preventive and corrective maintenance costs, etc. of this system to compare to others.
16	Autoclave *(Dry-heat system using dry friction heating system)*	- Small-sized, light (about 15kg), portable even its design is for on-site operation. Can be used at sites where infectious waste is generated; - Accepted and verified as an alternative technology to replace other systems for infectious waste treatment; - Automatic system, easy to use, short operation time. Use microchip controller with safety contingency properties; - With double filtering system to eliminate nuisance odour	- Only used for treatment of infectious waste with small amount; - Very high investment, preventive and corrective costs

(Source: Ausvetplan, 2015; US CDC and WHO)

2.1.3.2. Managing disease response

For agriculture, the occurrence of animal diseases (AI, FMD, PRRS, ASF, etc.) has seriously affected livestock development, causing great economic losses and affecting the environment and human health. Therefore, the prevention and control of animal diseases such as: Monitoring high-threat areas of epidemics; ensuring source of vaccine; disseminating to raise awareness of prevention and control proactively to epidemics, etc. is always on top priority.

Meanwhile, early detection (early warning of diseases and early reaction to disease outbreaks) is key in animal disease control, because the earlier we detect the cause of a disease, the quicker we propagate prevention and control measures.

Early warning enables rapid detection of the introduction of, or sudden increase in, the incidence of any disease of livestock which has the potential of developing to epidemic proportions and/or causing serious socio-economic consequences or public health concerns (FAO, 1999). To be able to carry out this activity, we need to:

- Having good farmer and public awareness programs for high-threat epidemic livestock diseases that involve improving the veterinary/farmer interface; training of field veterinary officers;
- Enhancing laboratory diagnostic capabilities for emergency animal diseases within provincial and national veterinary laboratories; collection and transportation of diagnostic specimens for prompt action; developing strong linkages between national laboratories and regional and world reference laboratories;
- Monitoring diseases based on close coordination between field and laboratory/epidemiology veterinary services; monitoring and supervising abattoir to search for clinical disease; establishing technical capacity in animal slaughtering, storage and handling facilities;
- Establishing of reliable livestock identification and traceability systems for enhancement of disease-tracing capabilities;
- Developing emergency disease-reporting mechanisms for veterinary agencies at all level; implementing of an emergency disease information system;
- Conducting prior environmental assessment at appropriate burial sites; assessing the consequences of an outbreak (especially finance) to minimize negative impacts to relevant sectors; determining the effectiveness and effectiveness of the vaccine;
- Prompt and comprehensive international disease reporting to OIE and neighbouring countries.

In addition, early reaction means carrying out without delay the disease control activities needed to contain the outbreak and then to eliminate the disease and infection in the shortest possible time and in the most cost-effective way.

To react early the disease, it is necessary to develop the National Plan for prevention and control of animal health. The plan is going to be activated in the case of an

animal health emergency, of which describe what duties and functions the support agencies may be expected to perform under different circumstances. In addition to establish the National Animal Disease Emergency Planning Committee that would be actively involved by related ministries, industries, organizations and individuals experienced epidemiology, management of control and response diseases, etc., and veterinary office must play a key role.

When a disease outbreak has occurred, an urgent decision must be made immediately concerning the treatment and disposal of a large number of animal carcasses. That requires following factors should be assessed: Impact on the environment; the intensity of livestock production and the potential number of animals involved; the impact on trade and the economic implications; animal welfare considerations (good animal welfare requires disease prevention and veterinary treatment, appropriate shelter, management, nutrition, humane handling and humane slaughter/killing, etc.); the characteristics of the pathogenic organism; disease control implications; the impact on individual producers; financial and logistical considerations; the reaction of the public (Norman G. Willis 2003).

Speed of decision making is critical at the time of such a crisis. Therefore, to allow for the most appropriate decision, it should to carefully think through the options, in advance of the event to establish essential linkages, to pre-determine which options are possible for their particular areas, and to evaluate what this implementation would require. In this way, the best-balanced choice can be made and implemented in the shortest possible time.

2.1.3.3. Managing surveillance after the disease

After applying animal carcasses disposal methods (especially burial), elevated public concerns followed regarding the leachate released from the urgently built livestock burial sites during the decomposition of the carcasses. Leachate generated from an animal carcass burial site contains high numbers of chemical compounds (organic materials, antibiotics, and steroid hormones) and pathogens decomposed from the animal bodies (McArthur and Milne, 2002; Yuan et al., 2013; Kaown et al., 2015; Kwon et al., 2017; Pratt and Fonstad, 2017a).

Following livestock burial in a small-scale field test (Yuan et al., 2013), total steroid hormones and veterinary pharmaceuticals in leachate were detected at higher levels compared to those from other major sources such as municipal effluent and industrial sewage treatment plants.

Joung et al. (2013) and Kwon et al. (2017) observed fecal coliform and *Escherichia coli* in groundwater samples around the Korean FMD burial sites and raised concerns regarding groundwater quality deterioration resulting from carcass leachate. Thus, to generalize the impact of carcass burials on an aquifer system, intensive groundwater monitoring around the burial pits is necessary.

To monitor groundwater quality following construction of the animal carcass burial

sites in Korea, according to the guidelines of the Korean Ministry of Environment (2015), the groundwater monitoring wells were selected based on animal carcass disposal sites that were near pigpens and livestock sheds in a rural area within a 150m distance from the burial pits. In Korea, elevated NO_3^--N concentrations in groundwater often exceeding the drinking water standard of 10 mg/L have been reported by the national groundwater quality monitoring network (the Korean Ministry of Environment, 2013) and in several case studies in agricultural areas (Jun et al., 2005; Koh et al., 2007; Kaown et al., 2009; Koh et al., 2012).

To distinguish groundwater quality components only affected by leakage from the animal carcasses burial against other water quality impacts, principal component analysis (PCA) was applied. PCA is a multivariate statistical method that has been utilized for evaluating groundwater quality characteristics (Helena et al., 2000; Machiwal and Jha, 2015; Kim et al., 2017). PCA analysis reduces the water quality data into an inter-correlated smaller set of principal components (PCs). The determined PC group represents relationships among the water quality components that can characterize the evolution of groundwater quality and impacts by external contamination sources. The study determined the number of PCs when their eigenvalues were >1.

2.2. Overview on situation of animal epidemics in Vietnam

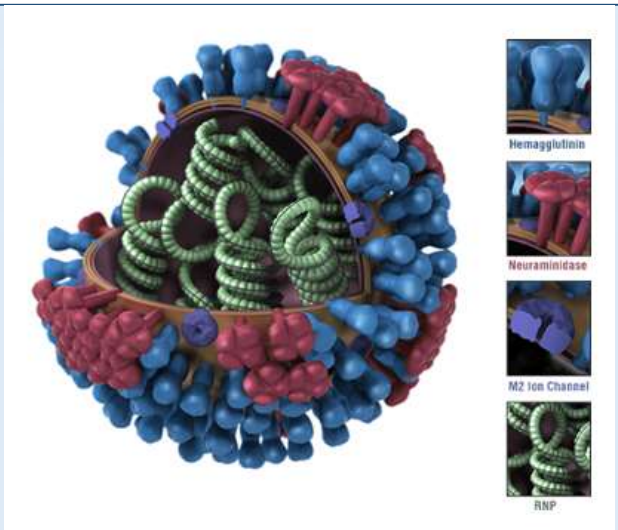
2.2.1. Overview on recent animal epidemics in Vietnam

2.2.1.1. Avian influenza (AI)

a) Epidemiological characteristics

AI (in general) are divided into four types: A, B, C and D. Influenza A virus is multi-host, causing disease in many animals, which can cause pandemic influenza. Influenza B and C viruses cause seasonal influenza in humans, usually causing only mild symptoms and no pandemic. Influenza D virus mainly causes disease in ruminates and has not been reported to cause disease in humans.

Influenza A viruses are divided into subtypes basing on two surface proteins, protein H (hemagglutinin) and N (neuraminidase). At present, it is known that there are 18 types of H and 11 types of N, if there is a combination between N and H, there will be 198 subtypes of influenza A and in fact, 131 subtypes are recognized in in nature. When subtypes are divided basing on genetic differences, we have the concept of “clade” and “sub-clade” (sometimes it is called “group” and “sub-group”).



(Source: CDC, 2019)

Figure 15: Avian influenza

According to data published by the Department of Animal Health and researches by scientists, high virulent AI viruses H5N1, H5N2, H5N6 and low virulent AI viruses H6N1 and H9N2 used to be present.

b) Epidemic status

According to MARD, AI H5N1 appeared in late December 2003 at the chicken farm of C.P Company located in Thuy Xuan Tien commune, Chuong My district, Ha Tay province (former name). At the same time, the epidemic also occurred in the chicken farm of Jafa Company in Vinh Phuc, then spread to the Northern provinces and appeared in the two southern provinces as Tien Giang and Long An.

In 2019, AI occurred at 70 farming households, 44 communes, 41 districts of 24 provinces and cities, in which 133,203 units were disposed of. As at December 24, 2019, there was only one outbreak of AI A/H5N1 in Vinh Long for less than 21 days (over 14 days from the date of disposing the last diseased poultry)

AI is a local disease, well controlled and not spread; AI occurs in scattered areas, at only one or two families which are small-scale farming households.

Influenza A/H5N6 virus is distributed nationwide meanwhile influenza A/H5N1 is mostly concentrated in the Mekong River Delta.

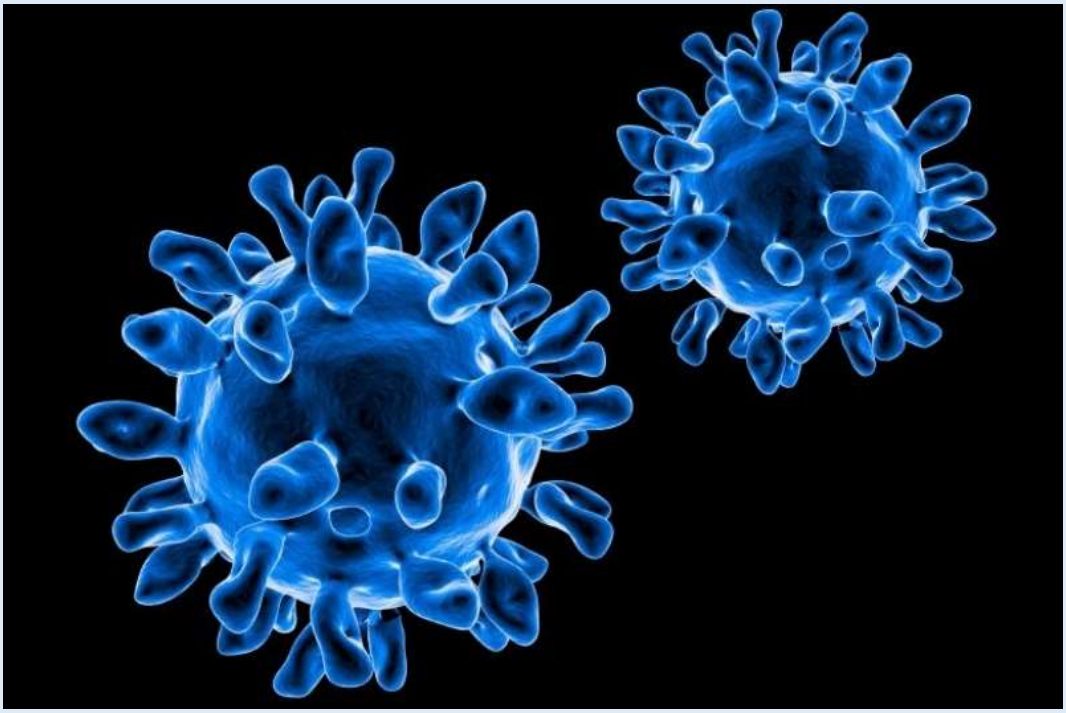
The Department of Animal Health made surveys in 26 provinces and cities with 3,966 samples (equivalent to 19,830 units) tested; of which 1,496 (37.72%) samples were positive for influenza A virus; 138 (3.48%) samples positive for H5 virus; 47 (1.19%) samples positive for H5N1 virus; 72 (1.82%) samples positive for H5N6 virus and 3 (0.08%) samples positive for influenza A/H7 virus, but negative for A/N7N9 influenza virus.

Recently, the contents of the National Plan on AI control, period of 2019 to 2025 including: (i) proactive monitoring, early detecting and treating cases positive for avian influenza virus; (ii) vaccinating poultry in high-risk areas; (iii) promoting the development of poultry raising disease-free regions, facilities and chains to serve domestic consumption and export have been being performed nationwide.

2.2.1.2. Foot-and-mouth disease (FMD)

a) Epidemiological characteristics

Pathogenic virus is of the Picornaviridae family, Aphthovirus genus. It is one of the most infectious animal diseases, causing economic losses. Livestock are main host although some species specially adapt to domestic pigs or sheep and goats. All ungulate animals are susceptible to disease, including livestock, pigs, sheep, goats and buffaloes. All wildlife is also susceptible, including deer, antelopes, wild boars, elephants, giraffes and camels. The virus is inactive at least 70°C for 30 minutes at minimum; pH <6.0 or >9.0; and inactive by sodium hydroxide (2%), sodium carbonate (4%), citric acid (0.2%), acetic acid (2%), sodium hypochlorite (3%), potassium peroxymonosulfate/sodium chloride (1%) and chlorine dioxide.



(Source: nhandan.com.vn/khoahoc-congnghe/item/43248802-su-dung-virus-gay-benh-lo-mom-long-mong-de-dieu-tri-ung-thu-tuy.html)

Figure 16: Foot-and-mouth disease virus

It survives in frozen marrow or lymph nodes; in milk and dairy products during regular pasteurization; however it will not work when pasteurization is at extremely high temperatures; it still survives after drying but can survive for days to weeks in organic matter under cool and humid environment and can exist in contaminated food and environment for up to 1 month, depending on temperature and pH.

FMD often occurs in some regions of Asia, Africa, Middle East and South America.

b) Epidemic status

In 2019, the epidemic occurred at 468 communes, 127 districts, 42 provinces and cities. The number of diseased livestock was 28,011 (including 23,862 pigs and

4,149 buffalos and cows). The number of dead and disposed of livestock was 18,623 (including 18,512 pigs and 111 buffaloes and cows).

As at December 24, 2019, the epidemic occurred at 53 communes in 24 districts of 12 provinces: Lang Son, Bac Kan, Quang Tri, Quang Binh, Nghe An, Tra Vinh, Vinh Long, Quang Ninh, Cao Bang, Son La, Ben Tre and Dong Thap for less than 21 days; the total number of infected buffaloes and cows was 1,251; 86 dead and disposed of ones and 122 ones not yet been clinically cured (accounting for about 10%).

Poultry were diseased due to not being vaccinated or protection period was expired.

FMD virus causing disease in most outbreaks is of serotype O, SEA/Mya-98, ME-SA/Pan Asia and Cathay strains.

Monitoring after vaccination shows that 1,803 of 2,214 samples of livestock were positive, accounting for 81% with foot and mouth virus antibody.

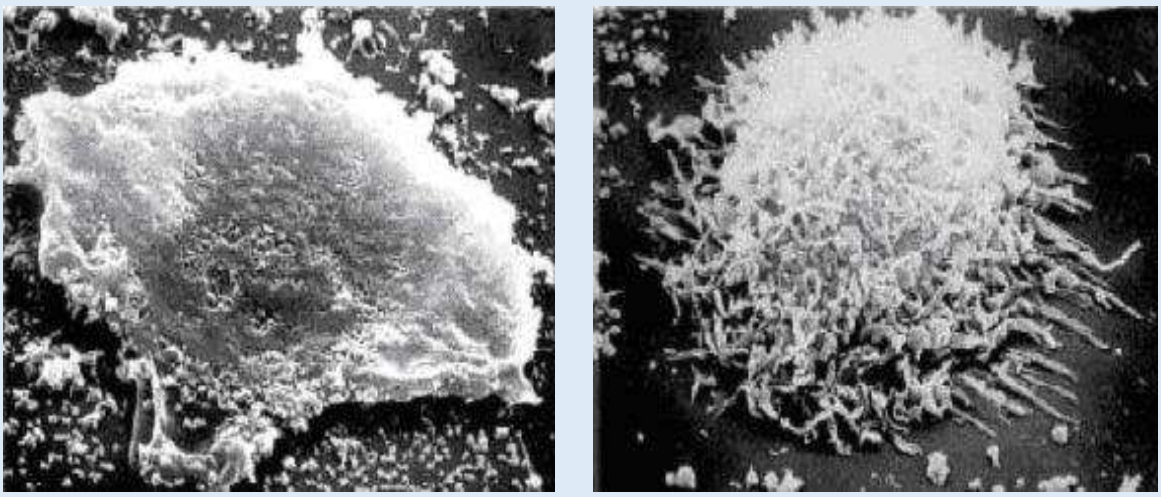
Recently, the National Program on FMD Control for period 2016 - 2020 has been being performed by relevant authorities, in which the following solutions are focused: (i) Husbandry with biosecurity and proactive sanitation for disease prevention are a highly effective solution; (ii) Vaccination is the most important and effective measure in the condition of small-scale animal husbandry and pathogens circulating in many places. Currently, there are sufficient amount of foot and mouth vaccine to vaccinate livestock in Vietnam; (iii) It is to proactively monitor, detect and treat diseased livestock thoroughly; not to trade transport and slaughter diseased pigs.

2.2.1.3. Porcine Reproductive Respiratory Syndrome (PRRS)

a) Epidemiological characteristics

PRRS is a disease of pigs with miscarriage in sows and respiratory disorders in newborn and growing pigs. The disease first occurred in the United States around 1987, which was later found in Europe and appeared in Asia in the early 1990s. Till now, it has spread worldwide with different regional characteristics, causing serious economic losses.

PRRS is caused by Arterivirus, which was isolated and classified in 1991. It is an envelope virus, of the viral RNA type, about 45 - 80mm in size, resistant to low temperatures (it can survive 4 months under the temperature of -70°C). Disease-carrying animals are vectors of pathogens dangerous to the environment; and the air also disperses the virus effectively, especially in high humidity, low temperatures and strong wind. Husbandry devices, tools and means of transport, etc. are also sources of this virus dispersion. In addition, insects like mosquitos (Aedes vexans) and flies (Musca domestica); wild duck, etc. may be a disease transmission medium. One of Arteriviruses' characteristics are the method and location of the primary copy, which reproduce in the cytoplasm around the nucleus of host cells.



(a) *(b)*

Figure 17: Macrophages infected by PRRS (a) and before being infected by PRRS (b)

New virions are released by exocytosis from the cell's surface. The primary target cell of the virus is pig's embryonic macrophages. The virus is very suitable for the lung. Normally, macrophages will kill all bacteria and viruses that enter the body, especially PRRS virus can multiply in macrophages, then destroy and kill macrophages.

b) Epidemic status

In Vietnam, the disease was detected in 1997 on the pigs imported from the US (10/51 pigs with seropositive result). Relevant studies on the disease at breeding pig farms in the Southern provinces show that the percentage of pigs seropositive for disease varies significantly, from 1.3% to 68.29%. However, until the beginning of 2007, the disease became an epidemic in 7 Northern provinces, then spread rapidly to a number of Central and Southern provinces, causing serious economic losses. Currently, PRRS has been identified with two main genotypes: genotypes originating from Europe and genotypes originating from North America. The comparison of the gene sequence reveals an important genetic difference between these two groups. In North America the NA genotype is found only, although there is also a report isolating the EU genotype. In Europe, the EU genotype dominates and so far no strain of the NA genotype has been recorded in Western Europe. In Asia and South America both genotypes as mentioned above are recorded, however there are differences between strains in each genotype.

In outbreaks, apart from PRRS virus identified as the main cause, a series of other pathogens such as classical swine fever, PCV2, *pasteurellosis, paratyphoid, streptococci* (caused by *Streptocuccus spp.*), pig asthma, etc. is also present and causing of death of many infected pigs. The emergence of a highly virulent PRRS virus strain spreads it rapidly, causing a higher mortality rate than the classical strain.

There is not any PRRS epidemic on pigs nationwide in 2019.

2.2.1.4. African Swine Fever (ASF)

a) Epidemiological characteristics

ASF is a dangerous infectious virus-caused disease. The disease is characterized by rapid spreading and occurring in pigs (including domestic pigs and wild boars). The disease is not spread to humans but causes serious damage to pigs with high mortality rate up to 100%.

ASFV's features

ASFV is a virus with a genetic genotype of ADN, highly resistant, possible for surviving for a long time in secretions, carcasses, pork and pork products such as sausages, ham, salami is a trait that makes this virus dangerous for pigs. The virus is able to withstand low temperatures for 3 to 6 months, especially in raw or undercooked pork products, the virus can be killed at 56^{0}C in 70 minutes or at 60^{0}C for 20 minutes.

The virus can live in decomposed blood for 15 weeks; in dry blood for 70 days; in feces at room temperature for 11 days, in pig blood at 4^{0}C for 18 months; in bone meat at a temperature of 39^{0}C for 150 days; in ham for 140 days.

The process of diseasing and spreading ASFV

ASF incubation period is 3 - 15 days, in acute form the incubation period is only 3 - 4 days. The disease is spread by respiratory and digestive tract, through direct or indirect contact with objects contaminated with the viruses, such as barns, vehicles, tools, utensils, clothing and uneaten food containing infected pork or pork bit by soft tick.

(Soure: GreenFeed)

Figure 18: Risk of ASF transmission through fomites

ASF symptoms and pathology

Pigs infected with ASF show many symptoms, depending on the severity of the disease. Diseased pigs have symptoms not different from the symptoms of classical swine fever. In the acute form due to the highly virulent virus, the diseased pig will die quickly without symptoms or it will lie down and have a high fever before it dies.

The acute form is caused by a highly virulent virus, with symptom of high fever (40.5 - 42^0C). During the first 2 - 3 days, leukopenia and thrombocytopenia are reduced. Pigs do not eat, being lazy for movement, moody; preferring to lie in a shade or near water. Some areas of white skin turn red, especially in the ears, tail, lower legs, skin below the chest and abdomen, and may be dark purple-green. In 1 - 2 days before the pig dies, it shows neurological symptoms, unstable movement, tachycardia, rapid breathing, shortness of breath or foamy blood in the nose, eye inflammation, vomiting, diarrhea sometimes mixed with blood or maybe constipation, hard stools that are small in size, with mucus and blood. The pig will die within 6 - 13 or 20 days. Pregnant pigs can have an abortion in any stage. The mortality rate is up to 100%. Pigs recovering from the disease or infecting chronic virus often have no symptoms, but they will be the vector of the ASFV throughout their lives.

Subacute type caused by viruses of moderate toxicity, which is primarily found in Europe; pigs show less severe symptoms. Pigs have mild fever or increased and decreased fever, losing weight, reducing appetite, moodiness, inflammation of the whole lung, making it difficult to breathe, coughing with phlegm; and lungs may be infected with secondary bacteria; arthritis and difficult movement. The disease lasts 5 - 30 days, if there is a blood stasis in the heart (acute or heart failure), pigs may die; pregnant pigs will miscarry; pigs die within 15 - 45 days; the mortality rate is about 30 - 70%. Pigs can recover or suffer from chronic diseases.

The chronic type is caused by low or medium pathogenicity viruses. Pigs have different symptoms, for example weight losses, unstable fever, respiratory symptoms, skin necrosis or chronic skins inflammation and ulcer, arthritis, myocarditis, rib stick inflammation, arthritis at different joints during development stages. The symptoms last for 2 - 15 months with low mortality. Pigs recover after being infected by viruses and become chronic.

b) Epidemic status

- On 19 February 2019, the Department of Animal Health (DAH) of MARD informed the discovery of the first ASF outbreaks in Hung Yen and Thai Binh Provinces. On 03 September 2019 the disease appeared in all 63 provinces and cities in Vietnam (Ninh Thuan was the last province to declare disease outbreak).
- As accumulation from the beginning of February 2019 to 24 December 2019, ASF occurred in 8,532 communes of 667 districts in 63 provinces with the total disposed of pigs of 5,965,173 heads, total weight of 341,000 tons *(accounting for 9% of total pig weight of the whole nation)*, including:
- 6,315 communes (accounting for 74% total epidemic communes) of 412 districts 56 provinces and cities experienced the epidemic for 30 days. At present in 3 provinces (Hung Yen, Hai Duong and Thai Binh) epidemics

ended; 25 provinces and cities have 85% of communes are experiencing the epidemic for 30 days, viz Lang Son, Bac Giang, Bac Ninh, Quang Ninh, Cao Bang, Hai Phong, An Giang, Can Tho City, Gia Lai, Binh Phuoc, Ho Chi Minh city, Thai Nguyen, Dong Nai, Binh Duong, Hau Giang, Tay Ninh, Ha Noi, Long An, Bac Kan, Son La, Dien Bien, Yen Bai, Vinh Long, Bac Lieu and Dong Thap.

- At the end of 24 December 2019, the nation saw ASF occurrence in 23 more communes with 34,715 pigs disposed of, a decrease of nearly 74% compared with November 2019 and 97% compared with June 2019 (the peak month in the country with 1.27 million pigs disposed of).

Table 6: Epidemic situation by months of the year 2019 in the whole country

Period of time	Number of locations that ASF occurred	Number of pigs disposed of (head)	Note
February 2019	ASF occurred in 11 communes, 08 districts and 6 provinces	2,142	
March 2019	ASF appeared in 598 other communes, 90 districts, 19 provinces	103,107	
April 2019	ASF occurred in other 1,144 communes, 92 districts, 2 provinces	717,020	
May 2019	ASF were seen in other 1,713 communes, 120 districts, 23 provinces	1,270,718	
June 2019	ASF emerged in other 1,565 communes, 165 districts, 12 provinces	957,102	
July 2019	ASF visited other 1,353 communes, 102 districts, 2 provinces	883,670	
August 2019	ASF spread out to other 856 communes, 60 districts, 01 province	724,735	
September 2019	ASF was seen in other 692 communes, 14 districts	678,696	The number of pigs disposed of decreased by 6% compared with August and 47% compared with May
October 2019	ASF occurred in other 301 communes, 03	432,790	The number of pigs disposed of dropped by 36%

Period of time	Number of locations that ASF occurred	Number of pigs disposed of (head)	Note
	districts		compared with September and by 66% compared with May
November 2019	ASF was seen in other 164 communes, 05 districts	151,380	The number of pigs disposed of dropped by 65% compared with October and 66% compared with May
December 2019	ASF occurred in other 23 communes	29,627	The number of pigs disposed of decreased by 74% compared with November and 97% compared with May

2.2.2. Epidemic situation in 10 surveyed provinces

a) Livestock production scale

In 2019, the livestock production sector in Vietnam developed in a context with both advantages and disadvantages, especially in the complicated epidemic situation nationwide. The 10 surveyed localities were also affected by ASF and livestock production in December 2019 saw a drop of 11.5% over the same period of 2018. Repopulation has been progressing slowly due to farmers' worries about epidemic outbreak re-occurrence risks.

Table 7: Current situation of livestock production in provinces

No	Province	Pig (head)	Livestock (head)	Poultry (head)
1	Ha Noi	1,060,000	159,900	26,500,000
2	Hung Yen	450,000	41,800	9,400,000
3	Hai Duong	568,193	-	-
4	Thai Binh	750,000	61,000	14,500,000
5	Nam Dinh	717,270	36,501	8,461,680
6	Thua Thien Hue	137,830	50,000	3,985,000
7	Quang Nam	-	-	-
8	Dong Nai	2,100,000	89,800	26,500,000
9	Vinh Long	369,788	-	-
10	Can Tho	131,162	4,840	1,872

(-) No data

b) Diseases occurred in the localities

In Vietnam, small and fragmented livestock production is in commune with high density. Disease prevention measures have not been regularly and continuously implemented. Trade, slaughtering and distribution of animals and animal products have been on the increased illegal trade and movement of animals and animal products among countries via road, air and sea ways pose the risks of transmitting dangerous infectious diseases from abroad into Vietnam. In 2019 besides the complicated ASF, there also appeared other diseases among livestock and poultry, specifically:

Table 8: Diseases in 10 provinces

No	Province	ASF	AI	FMD	PRRS	Note
1	Ha Noi	x	x	-	-	
2	Hung Yen	x	-	-	-	
3	Hai Duong	x	-	-	-	
4	Thai Binh	x	-	-	-	
5	Nam Dinh	x	-	-	-	
6	Thua Thien Hue	x	-		-	
7	Quang Nam	x	x	x	-	
8	Dong Nai	x	x	x	-	
9	Vinh Long	x	x	-	-	
10	Can Tho	x	-	-	-	

(-) No disease

c) ASF in 10 provinces

Hung Yen and Thai Binh were the first two provinces with ASF in Vietnam. After these two provinces, ASF spread out to 63 provinces and cities, causing severe damages to the pig farming sector in all localities. Hanoi was the one that had highest number of disposed of pigs.

Table 9: ASF situation in 10 surveyed provinces

No	Province	Eco-region	Date of detection	Cumulative number of districts	Cumulative number of communes	At 30 September 2019		At 31 December 2019		Declaration of epidemics ended, at 31 December 2019
						Cumulative number of pigs disposed of	*Cumulative weight of pigs (kg)*	*Cumulative number of pig heads*	*Cumulative weight of pigs (kg)*	
1	Ha Noi	Red River	23/02/2019	24	449	525,231	35,875,167	543,752	37,160,739	Epidemics not ended
2	Hung Yen	Red River	01/02/2019	10	156	196,888	11,150,624	203,080	11,484,500	Epidemics ended
3	Hai Duong	Red River	01/03/2019	12	254	391,059	23,201,814	-	-	Epidemics ended
4	Thai Binh	Red River	12/02/2019	8	281	376,567	18,758,637	377,498	18,817,568	Epidemics ended
5	Nam Dinh	Red River	12/03/2019	10	214	258,252	14,072,657	265,959	17,507,176	Epidemics not ended
6	Thua Thien Hue	North Central	18/03/2019	9	113	65,183	3,724,457	73,743	4,459,000	Epidemics not ended
7	Quang Nam	South Central	10/05/2019	16	189	119,165	6,695,638	149,961	8,911,651	Epidemics not ended
8	Dong Nai	Southeast	17/04/2019	11	130	396,634	20,755,657	450,000	24,000,000	Epidemics not ended
9	Vinh Long	Mekong River Delta	11/05/2019	8	104	32,910	1,980,495	-	-	Epidemics not ended
10	Can Tho	Mekong River Delta	15/05/2019	9	76	57,974	3,295,606	-	-	Epidemics not ended
Country total				**647**	**7,804**	**5,237,049**	**301,284,995**			

(Source: Nguyen Gia Entech, cumulative data in 10 surveyed provinces; DAH, Report on livestock epidemic prevention and control, Dec. 2019; (-) No data)

2.2.3. Existing legal documents, regulations on safe-environment collection, transport and disposals of infected animals/animal carcass due to epidemic outbreak

2.2.3.1. Assessment of current situation of existing legal documents and regulations

In Vietnam, the legal documents and regulations on environmentally-sound collection, transport and disposal of infected animal carcasses are quite complete and in effect upon epidemic outbreak.

Table 10: Related existing legal documents, regulations

No	Type of legal documents	No. of legal documents	Name of legal documents	Date of issue
1	Law	55/2014/QH13	Law on Environment protection	23 June 2014
2	Law	79/2015/QH13	Law on Animal Health	19 June 2015
3	Law	32/2018/QH14	Law on Livestock Production	19 November 2018
4	Resolution	42/NQ-CP	Implement some urgent solutions in ASF control	18 June 2019
5	Decree	38/2015/ND-CP	Waste and scrap management	24 April 2015
6	Decree	35/2016/ND-CP	Detailed regulations on some articles of Law on Animal Health	15 May 2016
7	Decree	155/2016/ND-CP	Regulating on handling of administrative sanctions in the environmental protection sector	18 November 2016
8	Decree	90/2017/ND-CP	Regulating on handling of administrative sanctions in the veterinary sector	31 July 2017
9	Circular	33/2011/TT-BNNPTNT	Promulgating national technical regulation on veterinary hygiene conditions (QCVN 01-41:2011/BNNPTNT -	6 May 2011

No	Type of legal documents	No. of legal documents	Name of legal documents	Date of issue
			National technical regulation for treatment requirements on veterinary hygiene of disposal of animals and animal products)	
10	Circular	36/2015/TT-BTNMT	Management of hazardous waste	30 June 2015
11	Circular	07/2016/TT-BNNPTNT	Regulations on disease prevention and control among terrestrial animals	31 May 2016
12	Document	1025/BTNMT-TCMT	Enhancing environmental protection in ASF control	11 March 2019
13	Guidelines	4178/HD-BNN-TY	Specific guidance on ASF infected pig handling & disposal by burning method	14 June 2019

The Law on Environment Protection No. 55/2014/QH13 on environment protection in agricultural production (Article 69) clearly stipulates that infected livestock carcasses must be managed in accordance with regulations on management of hazardous waste and sanitation for disease prevention (Item d, Article 69).

Decree No. 38/2015/ND-CP dated 24 April 2015 provides regulations on management of hazardous waste and scraps, including conditions for granting license for hazardous waste handling, including health facilities (Article 9) and management of waste discharged from health activities (Article 49).

Decree No. 155/2016/ND-CP dated 18 November 2016 of Government provides for administrative sanctions in the environmental protection sector. This Decree stipulates administrative sanctions and corrective measures against behaviors like:

- Not having sufficient vehicles and equipment for collection, storage and classification of solid waste at source (Article 11);
- Violations against regulations on public sanitation; collection, transport, landfill of domestic waste and normal industrial solid waste; transport of raw materials, materials and goods that cause environmental pollution (Article 20);
- Violations against regulations on environmental protection for hazardous waste (Article 21).

According to Circular No. 36/2015/TT-BTNMT dated 30 June 2015 of MONRE on management of hazardous waste, dead livestock, livestock and poultry (due to epidemics) are hazardous waste and must be treated according to regulations on management of hazardous waste.

Document No. 1025/BTNMT-TCMT dated 11 March 2019 of MONRE provides for strengthening environmental protection in ASF prevention and control (issued attached with environmental protection guidelines on handling infected animals).

Law on Animal Health No. 79/2015/QH13 provides for state administration responsibilities of the Government, Ministries, Agencies and localities as follows:

- The Government uniformly perform state administration at national scale;
- MARD is responsible to the Government in carrying out state administration functions in animal health sector and be accountable for directing, guiding and organizing for disease prevention and treatment, epidemic control among animals as well as disposal of infected animals;
- MONRE is responsible for taking lead and work with MARD to enact regulations on environmental protection and national technical regulations related to animal health. People's Committees at levels are responsible for allocating, managing, utilizing budgets and mobilizing local resources in accordance with laws and regulations on prevention, control and conduct surveillance on animal diseases and for allocating budgets for handling and disposal of infected animals and animal products.

Disposing acts that are against the regulations and do not meet environmental sanitation standards (free waste discharge, illegal disposal, etc.) are prohibited behaviors according to Article 13 of Law on Animal Health 2015, and Decree No. 90/2017/ND-CP dated 31 July 2017 of the Government, which provide for administrative sanctions in animal health sector, clearly defines violations, administrative sanctions and corrective measures (from non-implementation acts to announcement, transport or discharge of infected animals and poultry into the environment or disposal against regulations, etc.)

In order to ensure uniformed implementation nationwide, MARD developed and enacted:

- Circular No. 33/2011/TT-BNNPTNT dated 6 May 2011, which provided QCVN 01-41:2011/BNNPTNT - National technical regulation on sanitary handling in disposal of animals and animal products;
- Circular No. 07/2016/TT-BNNPTNT dated 31 May 2016, which provided regulations on diseases prevention and control among terrestrial animals;
- Guidance No. 4178/HD-BNN-TY dated 14 June 2019, applied for Vietnamese organizations and individuals, and foreign organizations and individuals operating in activities related to production, trading, slaughtering, transport and doing business on animals and animal products in Vietnam.

Methods for disposal include burial and burning. There are requirements involved in these methods, including the following:

- Animals and animal products must not be buried in under water areas or areas with shallow groundwaters;
- Animal carcass burial areas must be far away from residential areas, cultural structures, tourism spots, pagodas, hospitals, commune health centers;
- The burial pit must be at least 30m from local residents' houses, wells, animal cages and must have enough space. It is advisable to select burial sites areas in fruit-tree gardens/horticulture gardens or timber areas to enable quick transformation of organic matter into inorganic matter and limit environmental pollution;
- In sandy soils areas, the bottom and surrounding walls should have waterproof materials to protect groundwater sources. If the total weight is more than 10 tons/pit, the location must not be near a groundwater extracting site, river or lake. The pit should have waterproof lining at the bottom and surrounding walls;
- After burial, the pit surface and surrounding areas must be sprayed with lime powder and disinfectants to kill pathogens that may spread out during the process;
- Regular management and examination should be performed. Subsidence, erosion, leakage of smell must be handled in a timely manner by filling another layer of soil, refilling or spraying disinfectant;
- For burning methods, it is necessary to choose an appropriate location for the burning frame so that heat, dust and smell generated in the burning process do not affect surrounding ground or high aerial structures, roads and residential areas;
- It is necessary to strengthen communication, education and to persuade local people to handle and bury animal carcasses in accordance with regulations and not to throw animal carcasses anywhere. Strict sanctions should be taken in handling the act of careless discharge of animal carcasses into the environment causing pollution and adverse impacts on the life of the community.

The Law on Livestock Production No. 32/2018/QH14 contain provisions on dealing with of livestock waste at breeding households and farms, including the following: (i) Measures must be taken to treat manure, livestock waste water and associated gases to ensure environmental sanitation and to prevent negative effects on people in the surrounding area; (ii) livestock dying of epidemics and other hazardous waste must be treated in accordance with existing laws and regulations on animal health and environmental protection (Item 2, Article 59 and Article 60).

Under Resolution No. 42/NQ-CP dated 18 June 2019 of the Government on implementing some urgent measures in ASF prevention and control in alignment with the instructions under Directive No. 34-CT/TW dated 20 May 2019 of the Central Party Secretariat on some urgent duties and solutions on epidemic prevention and

control, MONRE is tasked to steer, conduct inspection, and provide guidelines on overall solutions on pig disposal that are relevant for the different scopes, levels and locations to ensure that epidemics do not spread and no environmental pollution results from disposal.

As such, it can be said that Vietnam has a relatively comprehensive and complete set of legal documents and regulations on environmentally-sound collection, transportation, and disposal of epidemic-infected animals and animal carcasses. The participation by the Government, Ministries, Agencies, localities, and each citizen has been legally instituted in laws. Ministries and agencies have issued epidemic scenarios, as well as guidelines on prevention, control and disposal of epidemic-infected animal carcasses and national technical regulations on disposal of epidemic-infected animal carcasses and products. Provinces have developed plans on prevention and control, disposal and handling of epidemic-infected animal carcasses. Scenarios to respond to possible epidemic situations have been prepared. In reality, when epidemics outbreak on a large scale, all the political system and existing legal documents are put into operation with possible results. However, provinces and eco-regions have different socio-economic and geo-climate conditions which lead to certain constraints and bottlenects in implementation of the above-mentioned documents. Further studies to are needed to support the amendment/revision of such legal documents to ensure uniformity in implementation.

2.2.3.2. Constraints in existing legal documents, regulations and causes

a) Selection of burial sites

For large-scale livestock farms that are large in terms of land areas and are located far from residential areas, dead pigs can be buried within the farm, at the designated sites as per the farm development plan that have been approved. Small-scale farms and households have smaller areas and are often close to residential areas. When there are large quantities of dead pigs due to epidemics and on-site disposal is not possible, dead pig carcasses must be transported to designated areas for centralized disposal.

The facts of 2019 ASF show that most large-scale pig farms did not have infections. ASF mainly occurred in small-scale farm and breeding households where biosafety did not receive due attention. Dead pig carcasses were mainly disposed of in centralized waste disposal areas, cemeteries or local public land lots, which were far from residential areas.

However it is quite challenging to comply with the regulations in the Vietnamese standards QCVN 01-41:2011/BNNPTNT, Circular No. 2016/TT-BNNPTNT and Document No. 1025/BTNMT-TCMT, on the distance from the burial sites to urban areas, cultural structures, tourism spots, hospitals, commune health centers, ground and surface water exploitation places, roads and water sources for agricultural irrigation, and aquaculture production areas due to rapid economic development and urbanization in provinces. Revisions to the current regulations on distance from burial sites to other places should be made to be relevant for the real context based on improvements in dead animal carcass burial technologies.

b) Burial technology

The dimensions of a burial pit should be based on the quantity of ASF carcasses to be disposed of. The regulatory specification that a burial pit must be 1.2 - 1.5m deep is not relevant for areas with strong soil texture and difficult to conform to in high-level groundwater areas (like the Mekong River Delta).

Waterproofing and anti-permeation measures for burial pit: to ensure biosafety and environmental sanitation, there must be compulsory regulatory requirements for waterproofing and anti-permeation measures to be taken to prevent substances at risks of causing pollution to leak from the burial pit into the environment. This can be done by improving burial technologies and using waterproof materials.

For explosion, subsidence and large cracks at burial pits: It is necessary to add technical guidelines on dealing with gases generated in the initial stage of decomposition of dead animals.

Monitoring environment quality at burial areas: it is necessary to include in regulations with high legal standing compulsory indicators or parameters that have great impacts on environment and epidemic safety. There should be specifications on the frequency and timing of monitoring that are relevant for the actual situation with regards to decomposition of animal carcass in burial pits.

The list of materials and chemicals for handing and disposal of epidemic-infected animal carcasses should be developed. The increased use of lime, disinfectants, de-odourizer and bio yeast to enhance intra-pit decomposition to reduce environmental pollution and improve biosafety for epidemic areas has been proven effective by many studies. Nevertheless, when epidemics outbreak, these supplies are always scarce and so it is difficult to follow the guidelines, leading to many potential pollution risks. A list of materials and chemicals to be stocked for use during the epidemic season should be proposed.

There should be warning signs at animal carcass burial pit for passers-by. The Commune People's Committees have the responsibilities to manage, regularly check and deal with, in a timely manner, incidents such as subsidence, sink-hole, leakage, bad smell incidents at the pit. Burial sites should be marked on the commune's map, data should be recorded and stored at the Commune People's Committees.

c) Burning method

With complicated evolution of the ASF epidemics and the high risks of floods, landslides, high-level groundwater faced by many localities at, MARD enacted the regulations on burning methods. However, there remain some shortcomings as follows:

- As burning remains manual, and land filing is still required after burning, there are challenges in selection of sites, similar to the direct burial method.
- Manual burning poses many risks of causing environmental pollution. For example, air pollution caused by gases emitted during the burning process; only a small quantity of animals can be burnt; and burning is not complete. Therefore, there are similar effects on the environment as the direct burial method.
- There have yet to be guidelines on how and where incineration in modern incinerators should be done. If this is the optimal method in areas where

direct burial is not possible, it is necessary that specific guidelines should be provided so that localities can make investments and employ the method. For example, the Shanghai University of Environmental Science and Techniques (China) has turned the “cabinet for urgent treatment of medical waste” into “solid waste and animal carcass treatment cabinet”. This cabinet has a standard container dimension of 6m long with a volume of about 30m^3, divided into parts: a solid waste grinding compartment, a burning/incinerating compartment and a smoke filtering compartment. This mobile cabinet allows urgent treatment of domestic waste, medical waste and animal carcasses. The cabinet can operate continuously with high efficiency. Each day, it can burn 5 tons of animal carcasses and medical waste.

2.2.4. Regulations on infected animal carcass disposal and environmental protection

In the context of complicated evolution of epidemics among animals in the past period, MARD issued Circular No. 07/2016/TT-BNNPTNT dated 31 May 2016 which provides for prevention and control of diseases among terrestrial animals, including technical guidelines on compulsory disposal and slaughtering of infected animal and animal products, specifically as follows:

a) Principles for disposal

Animals should be made dead by electricity or other methods (if any);

Disposal sites must be selected in accordance with guidelines issued by competent authorities. Priority must be given to sites in the livestock production areas where there are infected animals or other suitable sites near the epidemic cluster.

b) Methods for disposal

Burial;

Burning by specialized incinerator or manual burning that involves digging a pit, then putting the bags containing animal carcasses and products into the pit, and burning those with firewood, coal, straw, gasoline, and diesel. After that the pit should be backfilled with soil and the soil must be compacted.

c) Transportation of animal carcasses and animal products to disposal sites

If the disposal sites are outside the epidemic clusters, animal carcasses and products must be put in bags, tightly closed and gathered in one place for spraying and disinfection before transportation. In case the animals are too big to put into bags, plastic sheets or other waterproofing materials must be used inside (bottom and around) containers of transport vehicles;

Vehicles used to transport animal carcasses and animal products must have sealed floors to prevent leakages of wastes on the way;

Vehicles used to transport animal carcasses and animal products must be cleaned and disinfected according to the instructions by technical bodies in charge of animal health before transporting and after unloading bags onto disposal sites or leaving such places.

2.2.4.1. Burning methods

a) Burial pit specifications

Location: burial pits must be at least 30m away from local residents' homes, wells, animal cages and have sufficient areas. Places inside gardens should be selected (ideally fruit tree/horticulture or timber gardens);

Dimension: burial pit must be wide enough to be relevant to the weight of animals, animal products and waste to be buried. For example, if there is one ton of animals, the burial pit should have dimension of 1.5m - 2.0m depth x 1.5m - 2.0 width x 1.5m - 2.0m length.

b) Steps involved in burial

After the pit is dug, put a lime powder layer on the pit bottom in accordance based on the ratio of 1kg of lime/m^2, then place bags into the pit, spray disinfectant or lime powder on surface, backfill the pit with soil and compact the pit. The distance from the surface of the bag to the ground should be at least 0.5m. The soil layer on top of the bags must be at least 1m thick and must be on a higher elevation than the level of the ground area around to prevent water from running into the pit and causing subsidence. Disinfect the burial areas to complete disposal process.

c) Burial pit management

There should be warning signs at the burial pit to warn passers-by;

Commune People's Committees are to be responsible for management, conducting regular checks, and taking actions to fix the issues such as subsidence, erosion, leakage and smell from burial pit;

Burial sites must be marked on the commune's map, recorded and stored at Commune People's Committees.

d) In case other entities or individuals are contracted to carry out disposal, the technical bodies in charge of animal health in the locality must conduct supervision to ensure compliance with technical regulations stated under items a), b), c)

However, the burial method has certain disadvantages. For example, the time taken is long and it is difficult to control the elements inside the pits. Animal carcass burial pits, especially those that are not buried in accordance with technical specifications can easily cause local area pollution and be the source of infection for areas around the burial sites. Particularly, the currently spontaneous and improper burial of pigs can easily cause pollution to the living environment because the burial sites are within residential areas and close to farming places and burial pits are not in accordance with design. This improper handling cannot prevent epidemics from spread but cause reverse pollution to the burial sites for several years.

2.2.4.2. Burning methods

In the past period, ASF occurred in the Mekong River Delta provinces where there are many canals. It was challenging to bury infected pigs. Therefore, the MARD issued Document No. 4178/HD-BNN-TY dated 14 June 2019 to provide detailed instructions on handling and disposal of ASF pigs by burning, with details as follows:

a) Principles for disposal

Animals should be made dead by electricity or other methods before disposal;

Disposal sites must be selected in accordance with guidelines issued by competent authorities. Priority must be given to sites in the livestock production areas where there are infected animals or other suitable sites near the epidemic cluster. Sites near commercial scale pig farms without any ASF-infected pigs must not be selected.

Vehicles used to transport pig, pig products and waste to disposal places must have closed floors that are cleaned, disinfected before and after transporting pigs to disposal places;

People taking part in disposal of pig carcasses must have personal protective equipment (PPE) and perform hygiene and disinfection to prevent pathogen transmission.

b) Transporting animals, animal products to disposal sites

If the disposal sites are outside epidemic clusters, animal carcasses and products must be put in bags, tightly closed and gathered in one place for spraying and disinfection before transportation. In case the animals are too big to put into bags, plastic sheets or other waterproofing materials must be used inside (bottom and around) containers of transport vehicles.

Vehicles used to transport animals and animal product must be cleaned, disinfected according to the instructions by animal health technical bodies before transporting and after unloading bags onto disposal sites or leaving such places.

c) Handling of pig carcasses, disposal by burning method

(i) The burning method involves the following steps:

- Dig a pit with dimension relevant to the quantity and weight of pig carcasses to be burned (for example, to dispose 1 ton of pig carcasses, it is necessary to dig a pit that is 1.5m deep x 1.0m wide x 1.0m long, equivalent to 1.5 m^3);
- Put burning materials (firewood, coal, etc.) into the pit first, then use steel bar and concrete panels to make a holding frame on top of the pit and put pig carcasses on (including bags and floor covering sheets), then pour diesel on the pig carcasses to burn. If the pit is under water, put burning materials and the pig carcasses on the steel and concrete panel frame, then pour diesel on the pig carcasses to burn or use water pump to take out all water inside the hole to ensure successful pig burning;
- An example of calculating materials to burn 1 ton of pig carcasses is as follows: 50kg of dry fire woods, 200kg of coal and 10 liters of diesel. The ratio of burning materials can be adjusted to be suitable with what is required in practice;
- Use appropriate materials to surround the pit before burning pig carcasses;
- Arrange pig carcasses on top of burning materials from big to small (pigs must be made totally dead before burning);

- Burn pig carcasses and bury the remains in the hole with the following requirements: the distance from the remains to land surface must be at least 0.5m; disinfectant and lime powder must be sprayed on the burial pit; the burial pit under this method must be managed in the same way as a burial pit under the direct burial method; the burning duration must be long enough to ensure that pig carcasses are fully burned.

(ii) If localities have sufficient conditions, they may use specialized incinerators to handle pig carcasses

Besides, to proactively carry out environmental protection requirements in disease and epidemic prevention and control, on 11 March 2019, MONRE issued Document No. 1025/BTNMT-TCMT on environmental protection in strengthening ASF prevention and control. Accordingly, MONRE requested the People's Committees of provinces and cities to direct provincial DONRE to organize for implementation.

2.3. Environmental pollution risks caused by infected animal disposal

2.3.1. For burial methods

2.3.1.1. Elements impacting decomposition in burial pits

The animal carcass burial pit has protein, fiber, sugar powder, fat, minerals and some micro-organisms and pathogens. After the animals die, animal carcasses will decompose, similar to the process of transformation of organic matter into inorganic matter in nature. The speed and time of decomposition depend on environmental factors like:

- Temperature, humidity. The environmental temperature lower than 4^0C is also a factor that hinders decomposition;
- Oxygen volume in soil;
- pH level of substances after decomposition;
- Microbial systems in the environment. The microbial systems involved in decomposing animal carcasses are plentiful, including micro-organism, fungi, yeast, protozoa, insects and other animals living in soils;
- If carcasses have many chemicals, antibiotics and disinfectants, the process shall slow down. Strong antiseptic substances, acids, and base substances will hinder decomposition.

a) Effects caused by environmental factors around burial pit

Effects caused by temperature: Temperature has profound effects on chemical reaction process and bio-chemical reaction process in cell, thus exerting effects on the speed of growth of micro-organisms. Based on the ranges of favorite temperatures, micro-organisms are divided into 4 main groups: psychrophiles, mesophile, thermophile and hyperthermophile. Most micro-organisms have typical temperature range of maximum, optimal and minimum temperature. Optimal temperature means the ones that helps them have most powerful growth. At maximum and minimum temperatures micro-organisms still grow but at much lower speed.

Effects caused by pH: pH levels exert effects on permeation via membrane, material metabolism in cell, enzyme activity and ATP formation. Micro-organisms respond to pH in similar ways to temperature. Based on appropriate pH, they are divided into 3 main groups:

- Most bacteria and protozoa favour neutrality and grow best at pH level range of 6 - 8 and stop growing when pH level is <4 or >9. The reason is that ions suppress enzyme activity in cell.
- Few bacteria and most fungi are pH acid tolerant, in the range of 4 - 6. Ions only make their membrane firm but do not accumulate inside cells. Therefore, intracellular pH still maintains neutral.

Effects caused by humidity: To grow and metabolize materials, micro-organisms need water. Water is needed to dilute enzymes and nutrients, and also takes part in many important metabolic reactions. When growing in a water environment with dissolvent contents higher than intracellular contents, intracellular water shall be drawn out, leading to protozoa contraction and growth suppression. On the contrary, if the environment has too low dissolvent contents (e.g, pure water), water from outside shall penetrate into the cells.

b) Effects caused by using disinfectants, antiseptic substances during epidemic elimination on inner pit decomposition process

The use of disinfections and antiseptic substances like chloramine B, calcium hypochlorite during epidemic elimination has huge effects on decomposition process inside the burial pit. These disinfectants will limit the quantities of micro-organisms inside the pit and hinder the animal carcass decomposition process. In burial pits without disinfectant sprayed, the decomposition process is faster than in those that have. Therefore, the disinfection must be carried out 2 - 3 days before burial or right after the pit formation completes. Disinfection and antiseptic application should be done for the pit surface and surrounding areas.

c) Effects caused by local/indigenous microbial systems on animal carcass decomposition inside burial pits

As mentioned above, there are rich microbial systems taking part in animal carcass decomposition like micro-organisms, fungi, yeast, protozoa, insects and animals living in soil. The animal carcass decomposition process is the process of transformation of organic substances, via many stages, into inorganic products like Natrium Nitrate, Ammonium Nitrate and sulfur. This process is mainly undertaken by decomposing micro-organisms (decomposing organisms). Other organism groups just play supportive roles so that the decomposing micro-organism can do the job in a faster and easier manner.

2.3.1.2. Post-burial animal carcass decomposition process

Decomposition process is divided into two stages:

- *Decay stage*: Depending on environmental temperature, decay starts 2 - 8 hours after the animals die. Anaerobic micro-organisms in the digestive tract

increase in quantity to decompose organic substances in colon, stomach and small intestine. After that the membrane and muscles of digestive tract expand due to pressure from gases generated during the decomposition process, leading to rupture of the digestive tract. From here, micro-organisms shall quickly spread out to all abdominal compartment, chest and then attack the muscles and bone marrow. If there are plenty of chemicals, antibiotics and disinfectants in animal carcasses, the process will slow down. Environmental temperature below 4°C is also another factor hindering decomposition. Products of this stage include diamine, amine, peptide, minerals, hydrogen sulfide, ammonia, mercaptan, organic sulphite and pathogenic micro-organisms. Bacteria like E. Coli, Salmonella may exist in animal carcasses for a rather long time, especially those having blastema such as *B.anthrasis, Clostridium tetani*, which can stay alive for many years in carcasses and soil.

- *Mineralization stage*: The mineralization stage occurs immediately after the decay stage. Microbial systems participate in the process of turning organic into inorganic substances that plants can absorb. Nitrogen-containing products are turned into ammonia, nitrite and nitrate. Organic phosphoric substances in animal cells are turned into sodium phosphate or potassium phosphate. Amino acids containing sulfur like *Methionin, Systein* shall become sodium sulphate, potassium sulphate. Whether the mineralization process is fast or slow depends on temperature, humidity, pH level, and other factors such as microbial systems and flora systems.

2.3.1.3. Environmental pollution and biosafety risk caused by infected animal carcass burial pit

The severity of impacts caused by burial pits depends on the following factors:

- Number of livestock, poultry buried/unit of area. Higher number suggests higher pollution;
- Soil conditions of burial areas: properties of soil (humus, clay, sand, etc.), low or high level ground water;
- Burial site/location: close or far from water sources, residential areas;
- Bio-systems (micro-organisms, plants) at the burial site;
- Animal carcasses burial techniques.

a) Air pollution

Air pollution only occurs in the initial stage after burial, i.e. within 10 days to 1 month after burial. During this stage, the carcass decaying process takes place under anaerobic or aerobic conditions, creating highly toxic products. Toxic gases can easily spread into the environment, generating bad smell and pollute the air.

b) Soil environment contamination

In the first stage, soil respiration in the burial area increases until organic substance oxidization process reaches the peak. However, a large quantity of organic substances accumulating underground will create an imbalance, retarding plant growth, hindering air circulation in soil, quickly reducing water absorption speed and oxygen dilution. In these areas, anaerobic decomposition creates many highly toxic immediate products. Oxygen volume may drop to minimum level and affect the

nutrient mineralization cycle. Oxygen deficiency will turn CH_4, NO_3^-products from the aerobic decomposition process into N_2O and N_2, and SO_4^{2-} into H_2S. Most of the products generated in the anaerobic decomposition process cannot be absorbed and are highly toxic to plants.

The finer the soil, the greater the capacity for the soild to hold microorganisms and vice versa, coarse soil granules will increase farther movement of pathogens. Soil composition include cation, minerals that create different pH, iron, and aluminum ions. Low soil pH level increases the absorption of surface micro-organisms. Cation increases soil absorption because it limits the pushing force between micro-organisms and soil granules. Organic substances, humic and fulvic acids reduce adhesion of viruses on the ground surface. Pathogens are killed more quickly in areas with more direct light than in areas without light. If there is no re-infection, pathogens can stay alive on soil surface for shorter periods than in deep underground layers.

Soil samples with high water retaining capacities means longer pathogen survival time. Pathogens stay alive for shorter periods in sand compared with argillaceous soil and humus. Low-level groundwater and wet areas have higher risks of quicker and broader pathogen transmission into surrounding environment.

Some micro-organisms in the environment can compete for survival with underground pathogens. Many bacteriophage and protozoa can kill pathogens or limit their existence underground. In soil samples with rich microbial systems and quick transformation of organic into inorganic matter, pathogens' ability to survive is undermined. Bacteria containing blastema like *B.anthrasis, Clostridium tetani, Clostridium perfringens,* etc. are able to survive longer than those not containing blastema. Digestive tract bacteria exist longer underground than others.

c) Water pollution

According to professional analysts, groundwater around infected pig carcass burial area is polluted mainly by wastewater/leachate discharged from the decomposition process into the environment due to improper bottom lining or absence of lining.

The content of pollutants in this leachate is very high. Such leachate can be discharged from the burial pit into the environment in up to several years. In some localities like Thang Binh, Quang Nam province, it is possible to find a place far from water source. However, the soil foundation is mainly composed of sand and so water can easily flow into the pit and spread out very far away.

Pollutants from decomposed animal carcasses will spread along groundwater flowpath and contaminate groundwater in the area. Besides if the burial pit has large quantities of pigs, the decomposition process will generate large volume of methane, causing cracks on pit surface. Rainwater will bring pollutants from the pit to surface water.

Organic, inorganic substances and pathogens will follow the horizontal groundwater flowpaths to penetrate into water source. Human beings, livestock and poultry may contract diseases due to *Salmonella, E.coli, Shigella, Proteus, Arizona,* etc. from poor quality water sources.

d) Biosafety threats

Besides micro-organisms causing 4 diseases among livestock and poultry as mentioned above, animal carcasses have many digestive tract bacteria, viruses and parasite eggs like *E. coli, Salmonella, Shigella, Proteus, Arizona. Brucella* may survive 74 - 108 days, *Salmonella* 3 - 6 months, and *Leptospira* 3 - 5 months. Other blastema bacteria like *Bacillus anthracis* exist for nearly 10 years (recent literature suggests it can live for 20 years). *B.tetani* exists and causes diseases in 3 - 4 years. Underground protozoa, insect, worms and crickets can carry pathogens onto the surface and spread out very far. Human being, livestock and poultry may be infected due to direct contact with pathogens.

2.3.2. Burning method

The main type of gas emitted during the process of burning animal carcasses is sulfur dioxide (SO_2), which is a colorless gas with very unpleasant smell and is one of the main pollutants in the air. When SO_2 is dissolved in rainwater, it will create acid rain. This compound can also be created from burning petroleum, coal, natural gas, and bio-organic compounds.

The increase of SO_2 content in the air often has to do with animal carcass burning besides dust, mercury, heavy metals and other substances. Additionally, the burning of animal carcasses also generates other gases like dusts, CO, HCl, NOx, etc.

According to regulations, after burning animal carcasses, the remains must also be buried and monitored in the same ways as for direct carcass burial method. Thus, it is possible to say that there is a great risk of environmental pollution due to open and incomplete burning, similar to what is mentioned under item 2.3.1 above.

2.3.3. Environmental pollution from epidemic control activities

In the recent past, large scale ASF occurrence has caused numerous challenges to disposal. In many places, the disposing techniques remain poor. Infected pigs are transported from farming households to disposal sites by rudimentary vehicles without cover and bottom lining, leading to discharge of waste, excreta, body fluids, and even pig blood into the environment. People involved in disposal have not been adequately trained to minimize pathogen transmission and spread-out during the disposal process. Equipment and personal protective clothes of personnel involved in disposal do not meet the requirements of hygiene and disinfection to kill pathogens, causing disease transmission. Many burial pits had dimensions that were not commensurate with the quantities of animals to be disposed of.

The detection and disposal of diseased and dead pigs in the recent past have not been timely and thorough. Many localities have not been following the regulations and technical guidelines by MARD and MONRE properly. In many places, only diseased and dead pigs are disposed of. Others in the same cage are retained and monitored. As a result, all of the remaining pigs die, leading to repeated disposals in same households. Selection of disposal is challenging due to unavailability of land area. Many large livestock production farms have to dig pit rights in their gardens and farms. Although the minimum distance is more than 30m away from farming areas to houses,

there will be considerable adverse impacts on production, especially future restocking/ repopulation. An example was the Phu Nhuan commune (Bao Thang district, Lao Cai province). The commune authorities and competent bodies of Bao Thang District disposed of dead pigs by burying them in a wet rice field along a local road and in front of two houses. Three days after disposal, the burial pit discharged unpleasant smell, causing much discomfort to the life of people in surrounding areas.

Besides, according to the Department of Animal Health, the prevailing regulation is that local vets will examine and provide confirmation about diseased pigs and pigs suspected of infection. However, as the epidemic occurs in many households in the same commune while there are only 1 - 2 local vets, examination and verification cannot be done in a timely manner. Sometimes, commune authorities leave all the work to local vets, including examination, lime powder scattering, disinfection and disposal. Allowances for local vet re low and there are delays in payment. Moreover, epidemics last long and personnel involved in disposal re overloaded with work for a prolonged period and fall short of personal protective equipment, leading to some failure in disposal of the carcasses in accordance with technical requirements. Bac Giang province could be an example. For some day, 20 - 30 households in a commune had dead pigs at the same time and there was only one local vet. Besides local farmers dropped dead pigs into canals and rice fields. It was so alarming because of environmental pollution and disease transmission risks.

2.4. Assessment of direction, guidance, implementation and multi-sectoral collaboration in disposing infected animals

Surveys in localities show that the direction for implementing ASF prevention and control activities have been done at all levels and in all sectors. Firstly, the Central Level has established the National Steering Committee on ASF Prevention and Control under Decision No. 302/QD-TTG dated 21 March 2019 of Government.

The Steering Committee is tasked to assist the Prime Minister to direct and coordinate ASF activities nationwide and work with Ministries, agencies and mass organizations to mobilize resources and support the implementation of the urgent plans on epidemic control; organize for implementation and urge Ministries, agencies and localities to carry out epidemic control plans.

Besides the Central Party, the Government and Prime Minister have paid special attention, provided close and specific direction. There have been more than 80 documents providing guidance and instructions on ASF prevention and control. The most important ones include: (i) Directive No. 34-CT/TW dated 20 May 2019 of the Central Party Secretariat on enhancing leadership and guidance to effectively implement ASF prevention and control, (ii) Resolution No. 100/2019/QH14 dated 27 November 2019 of the National Assembly. Besides 10 documents issued by the Government and Prime Minister, 60 documents by the National Steering Committee, MARD, Department of Animal Health of MARD and 3 documents issued by MONRE, Vietnam Environment Administration of MONRE to providing timely guidance and instructions on epidemic control activities, including environment protection activities.

At local level, most provinces and cities have established their ASF Steering

Committees to assist the Provincial People's Committees in providing instructions and directions, work with Departments and related agencies in ASF control, assign specific tasks to each member according to their relevant functions and areas of responsibilities, issue dispatches/documents and provide guidance and instructions for epidemic control, issue urgent ASF response plan, regularly put forth solutions on ASF control to improve the effectiveness of epidemic control and prevention, mobilize resources to participate and support the implementation of epidemic control plan, make field visits to provide instructions and urge localities to take measures for epidemic control, establish task missions to supervise the epidemic control activities and monitor activities at animal quarantine checkpoints set up at important nodes in the province's transport network.

Box 1. Hai Duong Province is one of the localities who have developed cost norms for disposal support activities (including cost norms for labour in pit digging, transport and disposal; lime, gasoline, diesel cost, etc.) applied within the locality according to Decision No. 602/QD-UBND dated 05 March 2014 by Provincial People's Committee with 90,000 VND/head.

Guidance and instructions for ASF prevention and control has been provided by provincial People's Committees, DARDs, DONREs and local authorities in a systematic and serious manner, in accordance with legal documents enacted by upper levels such as Directive No. 34-CT/TW dated 20 May 2019 of the Central Party Secretariat, Directive No. 04/CT-TTg dated 20 February 2019 of the Prime Minister, Resolution No. 42/NQ-CP dated 18 June 2019 of the Government, Circular No. 07/2016/TT-BNNPTNT dated 31 May 2016 of MARD, Decision No. 4527/QD-BNN-TY dated 15 November 2018 of MARD, and Document No. 1025/BTNMT-TCMT dated 11 March 2019 of MONRE.

Provincial DARDs played the key role in epidemic prevention and control in localities, for example: (i) issuing many official documents and guides in the epidemic prevention and control activities, sanitation, disinfection at farm and cages; (ii) performing proactively and working closely with localities to implement the epidemic prevention and control; (iii) strengthening surveillance, disease detection, timely handling and preventing the epidemics from spreading; (iv) supplying chemicals and disinfectants in a prompt manner for cleaning and disinfection; (v) establishing a working group to inspect, urge and assist in resolving the difficulties and challenges of localities in the implementation process. DARDs have also been undertaking communication and education activities to raise awareness among local vet and people on prevention and control measures to prevent epidemic spread-out and assuming the role of the lead provincial departments to consolidate report on epidemic situation and implementation results of ASF prevention and control activities to provincial People's Committees.

Besides, provincial DONREs have also acted in a timely manner to provide many guidance documents on environmental protection, supervising sanitation and environmental quality observation at ASF-infected-pig carcass disposal places for districts, communes, wards and towns to implement. They also actively participate in and work with DARDs and People's Committees of districts and communes on issues related to their functions and duties on environmental protection. DONREs guide the

People's Committees of districts and communes to select disposal sites in advance and develop disposal plans to ensure readiness for response actions to be taken when epidemics occur. DONREs send staff to join the provincial steering committees to ensure timely cooperation in environmental protection, epidemic control and disposal of ASF- infected pigs. At the same time DONREs regularly monitor and capture information about environmental protection and current status of environmental quality by sensory perceptions (such as subsidence, bad smell) at disposal sites. Other tasks include checking upon burial and disposal of infected-pig carcasses for timely detection of issues and incidents and adoption of remedial measures for burial pits failing to meet technical requirements. DONREs also work with DARDs to communicate and advocate for epidemic control and environmental sanitation.

Some provinces have enacted joint documents by both DONREs and DARDs to provide guidelines on disposal procedures and ensure that environmental protection requirements are met. Examples included Thai Binh[1] and HCM City.

In order to cooperate in epidemic prevention and control at local level, District People's Committees have established endemic emergency response plan, strengthen the steering committees on animal epidemic control with focus on directing the implementation of urgent epidemic control measures and direct communes/towns to establish responsible teams for handling of infected pig carcasses with supervision by communal environmental staffs and vet. The District People's Committees also provided vehicles to transport infected pigs from sources to disposal sites, guided local people on disinfection and sanitation to avoid disease spread, and provide instructions on disposal and burial according to technical agencies' guidance.

Besides the Commune People's Committees also fulfill their roles as the first line responder to reach and take part in outbreak management, spray disinfectants, supervise the pig disposal process, direct local para vets to check and verify information about the current situation, list disposal sites in local areas, monitor bad smell leakage and subsidence at burial pit to report to upper levels. They are also responsible for management and storage of information on infected pig carcass disposal sites.

The whole political system has been mobilized. However, in some places the cooperation has not been closely maintained. Departments only issued official documents to guide localities (districts and communes) to implement. They do not organize field missions or if yes, with limited effectiveness. Part of the reason is limited human resources while epidemics occurred at large scale in most districts and communes. Another reason is that a principle in epidemic prevention and control is to restrict access by people into endemic outbreak areas.

Besides, in some places, local authorities and vet system has not been doing a good job in communication, especially on compulsory animal disposal. As result, when epidemic outbreaks occur, people do not report.

[1] Document No. 921/UBND-NNTNMT dated 15 March 2019 of Thai Binh People's Committee on strengthening environmental protection in ASF prevention and control.

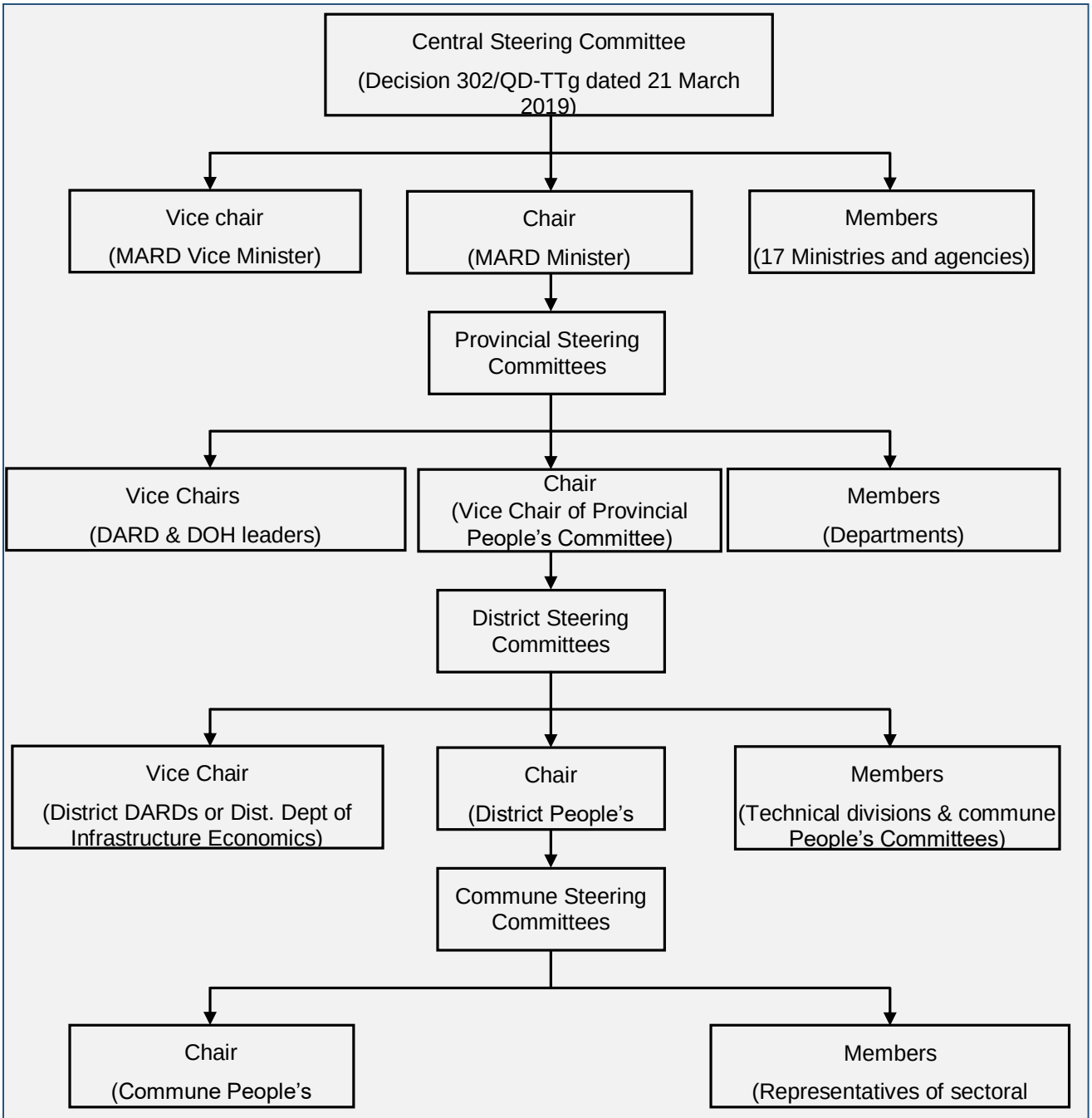


Figure 19: Organization chart of Steering Committees on ASF prevention and control at levels

2.5. Assessment of current practice in disposal of epidemic-infected animal carcasses in localities

The field surveys in 10 provinces shows that in terms of the current practice in disposal and burial of pigs dying of ASF infection in 10 provinces and cities, either off-farm centralized burial site or on-farm burial is practised. Basically, the localities followed burial procedures as provided for under Circular No. 07/2016/TT-BNNPTNT,

Document No. 1025/BTNMT-TCMT and guiding documents issued by the DARDs and DONREs.

2.5.1. Burial methods that have been applied

As per the guidelines under Circular No. 07/2016/TT-BNNPTNT, currently, there are two methods for disposal of epidemic-infected animal carcasses: burial and burning. Almost all localities have opted for the direct burial as it does not require high technology while the epidemic outbreak location can be handled quickly within 24-hours. In the Mekong Delta Region, after Guidance Document No. 4178/HD-BNN-TY was issued by MARD providing specific measures/methods for handling and disposal of ASF-infected pigs by burning method, the provinces issued written instructions to lower levels to apply the burning method in areas with high ground water level and prone to inundation (with a quantity of about 5 - 10 pigs).

In HCM city, almost all districts could not practise on-farm burial due to unavailability of land areas for burial; the conditions of burial sites are not up to requirements as per technical guidelines in animal health sector or requirements to be met in the event of a large-scale outbreak. The City People's Committee instructed district-level People's Committees to work with the DARD, DONRE, and the Urban Environment Company (URENCO) to treat and dispose carcasses at the medical waste treatment plant (Dong Thanh waste treatment plant) or buried at Phuoc Hiep waste treatment complex.

Table 11: Burial methods applied in localities

Name of province	Burial	Burning	Other measures
Ha Noi	Burial	None	None
Nam Dinh	Burial	None	None
Thai Binh	Burial	None	None
Hung Yen	Burial	None	None
Hai Duong	Burial	None	None
Quang Nam	Burial	None	None
Thua Thien Hue	Burial	None	None
Dong Nai	Burial	Burning	Boiled then landfilled (with 1 - 2 infected pigs)
Vinh Long	Burial	Burning	None
Can Tho	Burial	Burning	None

2.5.2. Handling (killing) of livestock, poultry prior to disposal

Under the regulations issued by MARD, livestock and poultry must be killed prior to disposal. In the past, under MARD's guidelines (Decision No. 3400/BNN-TY dated 5 December, 2005), poultries - before taken away for disposal - had to be killed by dislocating of the neck joints, then put into nylon bags; livestock had to be killed by slamming sledge hammers onto the head. However, humane treatment of animals

has been recommended globally, and in Vietnam, poultries are to be put into CO_2 kilns to faint/be suffocated before being disposed of; while livestock are to be killed by electrical stunning, which reduce the sufferings for the animals.

Hanoi was the first place to apply the electrical stunning method - the optimal method. With regards to pig disposal, right from the beginning, Hanoi used pig electrical stunning machine to ensure humane disposal of pigs. During the process, many appropriate measures were studied and applied by the local staff.

Most localities employ the electrical stunning method for ASF-infected pigs prior to disposal. However, in reality, due to the large quantities of infected pigs to be disposed, many localities do not follow the regulated procedures prior to disposal but just dump live pigs into burial pits.

In addition, due to the huge quantities of dead pigs in the piggery, it was difficult for burial, and burial workers had to use saws and knives to chop up the pigs before transportation, causing fluids and blood to scatter onto the floor of the piggery, which poses the potential risks of infection and outbreak re-occurrence (in Vinh Cuu district of Dong Nai province).

2.5.3. Collection and transportation

In some localities, vehicles used to transport dead pigs do not meet the requirements as set in regulatory documents; dead pigs are transported to burial sites in trucks without sealed compartment. But when dead pigs are transported to the burial sites, the local animal health workers follow the vehicles, disinfect, and scatter lime powder (calcium oxide) along for disinfection.

In case the disposal site is outside the epidemic outbreak location, animal carcasses and animal products must be contained in bags with tightened mouth, and the bags must be put together in one place for disinfection before transportation. In case the animals are too big to fit in a bag, use nylon sheets or other leakproof materials to lay inside (bottom and walls) the transportation vehicles. In practice, this regulation is not fully observed in localities and failure to perform cleaning and disinfection prior to transportation of infected pigs is also a cause of wider spread and transmission of epidemics.

2.5.4. Locations for burial/burning

Burial sites are located far from households, water source and farming areas, and are large in terms of land area occupied. Burial pits are large in size and commensurate with the quantity of infected pigs to be disposed.

With the “4 on-the-spot” approach (on-the-spot directions/instructions, mobilization of resources, human and equipment) and exercise of “5 NOs” (no cover-up of epidemic, no sale and purchase of infected and dead pigs, no slaughter of infected and dead pigs, no throw-away of dead pigs to environment, no use of unprocessed and left-over food), localities have been proactive in surveying and propose possible options and reach consensus on disposal sites to avoid widespread transmission of diseases and epidemics. Usually, localities opt to dispose the carcasses at households, local public cemeteries, dump sites and public land areas (local agricultural land or bought from the locals).

However, presently, local communes cannot bring pig carcasses to pagoda, or local communal houses for burial in the gardens and they also refrain from taking the carcasses to local public cemeteries to bury close to deceased human beings for spiritual reasons. Meanwhile, local cultural houses, school gardens, stadium, markets, etc. are places where the locals have their activities so pig carcasses cannot be buried there. The public land areas are used up while the communal and district land use plans do not set aside/earmark land areas for addressing consequences of natural disasters or epidemics, and therefore a number of challenges can be observed.

Table 12: Selection of burial sites

Location	In household garden	Waste treatment area	Cemetery	Public land
Ha Noi	Yes	Yes	Yes	Yes
Nam Dinh	No	Yes	Yes	Yes
Thai Binh	No	Yes	Yes	Yes
Hung Yen	No	Yes	Yes	Yes
Hai Duong	No	Yes	Yes	Yes
Quang Nam	No	Yes	Yes	Yes
Thua Thien Hue	No	Yes	Yes	Yes
Dong Nai	Yes	Yes	Yes	Yes
Vinh Long	Yes	Yes	Yes	Yes
Can Tho	Yes	Yes	Yes	Yes

Ha Noi and other provinces and cities practised the '4 on-the-spots" approach, including restrictions on transportation of infected pigs out of isolation areas so they usually opt for burial at household (6%), burial in local public cemeteries, designated area as planned, agricultural land bought from local people (60%) and the rest are landfilled in centralized landfill site (34%) with adequate distance to residential areas. Large-sized burial pits in Dong Anh and Soc Son (over 1,000 pigs per pit) posed some difficulties in terms of finding available land area, management of burial pits and risk of environmental pollution.

In Vinh Long, Can Tho provinces, the survey team surveyed the burial sites in gardens of households and all were found to meet the requirements in terms of distance.

Site visits to and physical examination of environment protection practices at disposal sites of 02 central provinces (Quang Nam and Thua Thien Hue) shows that the burial sites for infected pigs are located far from residential areas and livestock farming areas; not close to household water source; with warning signage put up at the burial site; and sprayed with calcium hydroxide on the surface.

2.5.5. Burial procedures

In general, parameters of burial pits for infected pigs in surveyed sites are up to requirements set under Circular No. 07/2016/TT-BNNPTNT dated 31 May 2016 of

the MARD. The pit size is large and is appropriate for the quantities infected pigs to be disposed of. The burial procedures followed in those sites are consistent with those specified under Circular No. 07/2016/TT-BNNPTNT dated 31 May 2016 of MARD. After the pit is dug, lime (calcium oxide) is scattered onto the bottom surface, sprayed with disinfectants and lined with HDPE film. After soil filling, lime powder is to be scattered on top, disinfectants is sprayed around the site and then deodorization liquid is sprayed.

In Thai Binh, the site visits to 3 burial pits of infected pigs show that: infected pigs are disposed of right in the endemic area (at communal scale), the burial sites are local domestic waste dump sites; all burial pits have HDPE film sheet laid at the bottom; pig carcasses are disinfected prior to burial, and the sites are disinfected with chemicals, scattered with lime, and backfilled, warning signages are in place; the burial site did not show any sign of subsidence and no unpleasant odour was emitted.

In Can Tho city, the survey team checked all burial pits and found all of them to meet the requirements on minimum distance, with the bottom of the pits covered with leakproof HDPE geomembrane. The pits were disinfected and discontaminated prior to disposal, fenced with warning string around, and no subsidence was found. At the first pit, earth was put on top and compacted, and the earth mounding was elevated at 0.3m higher than the elevation of the ground area around, with a nylon sheet on top. However, the burial pit did not have a ventilation pipe, and no unpleasant odour was smelled. At the second pit, earth was put on top and compacted but on the same elevation as the ground area around so it cannot prevent raining water from running over the burial pit. The top of the pit was covered with nylon sheet, no ventilation pipe was seen, and no unpleasant odour was smelled. These two burial pits were routinely checked by local authority and animal health agency when they had just been put in place.

In Vinh Long, all the burial pits were lined with HDPE geomembrane at the bottom, and were disinfected and decontaminated prior to disposal. One pit was found located at about 20m away from the household (the household was using tap water (nước máy thủy cục) rather than groundwater), which means it failed to meet the requirement on ensuring a distance of 30m at a minimum as specified in Annex 6 of Circular No. 07/2016/TT-BNNPTNT. The top of the pit was covered with compacted earth but with on the same elevation as the ground area around so it cannot prevent rain water from running over the burial pit; the pit was fenced with warning string around but no warning signages and ventilation pipe were in place. The second pit actually met the requirement on distance to households as stipulated. At the time of the site visit, unpleasant odour was smelled because the burial had taken place only 11 days before. However, there were no warning signages and ventilation tube, and subsidence was found at the pit. These two burial pits were routinely checked by local authority and animal health agency during the period after the burial took place.

As the Mekong Delta Region is the low-lying, and the amount of soil available for burial is less than needed, the elevated soil cover layer on top of the burial pit is not adequate. No warning signage was put up at the burial pits in the gardens of local households.

There are no specific technical guidelines for the installation of ventilation and gas

release system for burial pits. Belows are some findings:

Site check in Vinh Long and Can Tho city found that there was no ventilation pipe and gas release system for burial pits. With this type of burial pit, when odour is emitted, deodorization liquid is sprayed. However, as no ventilation pipe and gas release system were in place, the decomposing process of pig carcasses generated noxious biogases, which tore off HDPE geomembrane at the bottom liner, and caused the pit surface to subside.

If a ventilation pipe and gas release system had been put in place, it would have minimized the risk of tearing off the HDPE geomembrane used as bottom liner. However, technical guidelines to help minimize and treat unpleasant odour from these ventilation pipes are yet to be in place.

Some small-sized pig carcass burial pits were not lined with HDPE geomembrane at the bottom. Monitoring and supervision of pig carcass burial sites are not conducted on a sufficiently frequent basis, leading to untimely actions for dealing with burial pits that affect the environment.

2.5.6. Monitoring, supervision

Some localities have already developed plans and conducted supervision of environmental quality at burial pits as per the requirements specified in Document No. 1025/BTNMT-TCMT. However, due to limited resources (focused on epidemic control work), supervision of burial pits is predominantly qualitative (monitoring and checks are performed within the first 2 weeks after burial, and sampling if subsidence is noticed).

Because pig production in most southern provinces, especially those in the Mekong Delta region, is small-scale, there are numerous small-sized burial pits, which are located here and there in households. As a result, most provinces have not taken samples and conducted analysis of environment quality of burial pits. Besides, burial pit monitoring costs are relatively high (about VND 90 million per pit), and therefore, monitoring of small-sized burial pits will be very costly. In terms of guidelines for environment protection related to disposal and burial of ASF-infected pigs, a number of issues are faced in implementation of the monitoring program in practice, as follows:

- Unpleasant odour and air pollution only arise during the early days after burial of epidemic-infected pigs. Therefore, it is necessary to issue detailed guidelines on monitoring and assessment of air pollution during this phase. The NH_3 level is high right after the disposal but will diminish thereafter. Thirty days after the burial, all air environment parameters will meet the standards for ambient air. Therefore, the requirement on taking samples and conducting analysis of ambient air samples on the 30th day, 60th day and 90th day after burial should be revisited, i.e., it is necessary to consider reducing the frequency to be relevant for the actual situation of air pollution at burial pits, and to reduce the costs of monitoring for the localities.
- At each burial pit, the fact is that when soil samples are taken in 4 directions, with 3 distances and 4 different depths, the number of soil samples to be analyzed is high, as there are 04 x 03 x 04 = 48 samples/pit, which is costly for soil environment analysis. Besides, there are no technical standards and specifications specifying the parameters for soil environment monitoring (total

Nitrogen, total Phosphorus, total Carbon, etc.), and thus, when the results of soil sample analysis are available, it is not possible to assess the level of pollution and performance of the pits.

2.5.7. Information, database of infected-pig carcass disposal sites

With regards to preparation and management of records and storage of information at local levels (decisions on disposal, minutes of disposal, serial-numbering of disposal sites on the commune administrative maps, logbooks of burial pits, etc.): When dead pigs are found in the piggery, local people will report to the commune government, who will dispatch staff to come to the site to check, weigh and prepare minutes of disposal. For each and every disposal, the quantity and weight of pigs will be recorded in the logbook. At the same time, the sub-Department of Animal Health and local Animal Health Agency/staff prepare an ad-hoc report and updates on ASFS situation in the province.

Although localities have statistics on infected-pig carcass disposal sites (i.e., location, number of pigs buried and time of disposal), there is missing other information and data needed for environmental management, monitoring and surveillance purposes, such as: altitude, disposal methods (e.g., whether or not the pit bottom is lined with HDPE geomembrane, or whether disinfection is done).

2.5.8. Other epidemic control related issues

a) Epidemic prevention and control

There is yet to be any vaccine against ASF so far. The transmission route of the pathogens is quite complicated, and the virus can survive for a long time in the external environment and is highly resistant while pig production is on a smallholder basis, commonly scattering in residential areas and households. Biosafety in livestock production is not strictly observed in households and livestock production farms, bio-safe animal husbandry protocol is not fully followed even though communication and training are provided.

Most smallholder pig producers are not well aware of the importance of adopting the full range of measures for environment protection and sanitary measures for epidemic prevention and control, and therefore, these households are usually the sites where the epidemic is detected in the provinces.

At times, when there is an epidemic outbreak, the commune authorities fail to collect and dispose of the pigs dying of the epidemic in households with a small number of pigs, and as a consequence, there are cases where households just carry the pig carcasses to the rivers and in-field roads for dumping.

The control of pathogens in pig farms with epidemic infections is challenging, especially in the rainy season and when pathogens are transmitted via surface water as there are yet to be detailed guidelines on procedures for disinfection and de-contamination of surface water contaminated with pathogens.

State budget allocation for environment protection in localities is usually small and therefore, procurement, distribution and use of supplies, and chemicals (HDPE

geomembrane, lime, de-odourizing chemicals) for disinfection and containment of environmental pollution at disposal sites are not in line with regulatory requirements.

Localities are still struggling in planning, inspection, supervision and sampling for assessment and monitoring of environmental quality at these disposal sites.

Finding the sites for burying infected pig is a challenge. Besides the large quantities of dead pigs, leading to burial sites being overloaded, many localities still do not have designated burial sites due to the limited availability of land areas and cannot find any appropriate sites that meet the requirements on minimum distance to residential areas, traffic route, water source, etc. In reality, some disposal sites for epidemic-infected pigs do not meet the requirements on distance because these sites are located close to areas with water source for irrigation or located in fruit gardens with water flow path connected to canals and rivers. In some localities, there is no land available for burial of epidemic-infected pigs.

As guidelines from the central level change over time, a number of challenges are faced in epidemic prevention and control: According to the regulations, pigs that show signs of infection must be examined prior to disposal. If the entire herd of pigs are disposed of without being tested, it is both against the regulations and also likely to lead to gaming of policies for personal gains. However, in order to ensure strict compliance with the regulations, the authorities and responsible people must work very hard. The workload is already too much to handle for the epidemic control workforce whereas the number of dead pigs is rising. Therefore, epidemic-infected pigs must be “left to lie” in the piggery for a long time, which leads to higher risks of transmission pf pathogens to other households. After Guideline Document No. 5169/BNN-TY dated 22 July 2019 of MARD came into force, there have arisen a number of challenges in disposal, because disposal has to be done in a scattered manner and repeatedly in one household while the workforce is inadequate.

b) Human resource

Human resource in charge of environmental and animal health affairs at provincial, district, and especially commune levels remain inadequate, and so it is hard for them to be on top of the situation and stay in control of environment protection work in districts, towns and cities where ASFS epidemic occurs and in locations where epidemic-infected pigs are disposed of, especially at the sites that are far from residential areas. Staff are mainly deployed during the disposal phase and mobilized to fix the issues of burial pits with unpleasant odour and subsidence.

2.6. Assessment of current environment at burial sites and environmental protection measures

2.6.1. Monitoring of assessment of current environment is performed by the localities

Localities predominantly perform examination and assessment of current environment of burial pits based on visual and smell perceptions (unpleasant odour, subsidence). At some disposal sites, when the local residents complained about unpleasant odour, local authorities take swift action to spray biological de-odourizing

liquids, put soil covering at the sites where subsidence is found, and make efforts in communication and advocacy, and therefore, local residents generally accept.

Currently, four provinces/cities (Thai Binh, Hai Duong, Hung Yen, Thua Thien Hue, and Ha Noi) have already conducted site visits to the burial sites for ASF epidemic infected-pig carcass disposal. They took measurements and sampling for environmental examination analysis. The purpose is to assess environmental impacts on ASF-infected-pig carcass disposal in burial pits (soil, air, surface water, groundwater) then synthesize results and report to competent authorities. However, at present, Ha Noi is still waiting for final budget approval for the field assessment; tentatively about 60% of burial sites with volumes of 5 tons of dead pigs will be monitored and samples will be taken for environmental examination. In localities where monitoring and supervision had been already conducted, the team was not provided with data to compare and cross-check with the assessment results of this study - due to the sensitive nature of the data.

Southern provinces, especially the Mekong River Delta, is characterized by small-scale pig farming, which results in enormous number of small-scale burial pits scattered in households. These provinces do not know how to monitor and assess the current environment in the context where there are far too many burial pits. Most of them have not yet taken samples and analyzed environment quality at the burial sites.

2.6.2. Monitoring results from burial pits carried out by assessment team

In order to assess the impacts of disposal of ASF-infected pigs on the soil environment, air environment, surface water environment, and ground water environment to serve the purpose of consolidating findings and recommending appropriate methods for disposal, the consultants conducted the field surveys, site visits and assessment as well as taking samples for environment analysis in 10 provinces and cities. The results are as follows:

- Surface water environment: The monitoring and analysis results show that the micro-organism index (E.coli) in all the monitored sites were high; the parameters of some surface water samples exceeded the permissible limits under QCVN 08-MT:2015/BTNMT - National technical regulation on quality of surface water (column B1 shows the quality of water to be used for irrigation or other uses requiring similar quality). In some provinces/cities, such as Ha Noi, 8/13 parameters exceeded those specified under QCVN 08-MT:2015/BTNMT - column B1, in which: DO ranged from 1.9 - 2.58 mg/L; BOD_5 ranged from 103.2 - 199.8 mg/L (6.88 - 13.3 times higher), COD was 1.36 - 1.46 times higher, E.Coli was 180 times higher, etc.; Thai Binh has 3/13 parameters exceeding QCVN 08-MT:2015/BTNMT - column B1, in which: BOD_5 was 1.26 - 1.53 times higher, COD was 1.36 - 1.46 times higher, E.Coli was 1.04 - 3.2 times higher.

Assessment: The site visits show that most burial pits were lined with geomembrane and there was no leakage causing effects on surface water. Remedial measures have been taken to solve the issue of subsidence in some landfill pits (spraying disinfectants, elevating, compacting the soil, scattering lime powder). Therefore, in

some monitoring sites, there are signs of surface water contamination, but it has been due a combination of many factors, such as geological characteristics/processes, farming activities, and daily activities of households residing around the burial sites (irrigation canals are to drain 60 - 70% of domestic wastewater discharged in rural areas). Besides, as the burial sites are located in landfill sites and cemeteries, the quality of the environment in the pig disposal sites located within waste treatment areas or landfill areas may be affected by leachate.

- Underground water environment: Most burial sites shows 1 parameter that exceeded QCVN, namely (NH_4^+-N), and micro-organisms (E.Coli) were found to exist in groundwater. Some sites have excessive contents. For example, the burial site in Ms. Thuy's residence in Dong Thuan commune, Thoi Lai Dist. shows that NH_4^+-N= 1.83 mg/L (1.83 times higher); the burial pit at the dump site of Vu Quy commune, Kien Xuong Dist., shows NH_4^+-N= 1.83 mg/L (1.91 times higher). As pigs were buried in the dump site/landfill site and cemeteries, the quality of groundwater in this area may be affected by carcass decomposition but can also be affected by leachate from the dump sites/landfill sites.
- Ambient air environment: The parameters about the air environment were all within permissible limits as per QCVN 06:2009/BTNMT - National technical regulation on some toxic substances in ambient air environment.NH_3 was high right after the burial (153.8 µg/m^3), and this is consistent with the fact that the emission of unpleasant odour was found during the site visit to a burial pit in Vinh Long. At the burial pit in all the 10 provinces, 30 days after the burial, all the monitored parameters about the ambient air environment were conforming to QCVN.
- Soil environment: The results of analyzing ASFV shows that in most burial sites, no existence of pathogens were found; but the pathogens were found to exist in some soil samples taken at the locations of 5m from the burial pits (for example, the burial pit in ward 8, Vinh Long city, Vinh Long province the burial pit at Vinh An district township, Vinh Cuu district, Dong Nai province). The reason is that the burial had just taken place shortly before the site visit, bottom lining and disinfection were not done properly, or the quantities of infected pigs were far too large, leading to subsidence of the surface of the burial pit, causing leakage of pollutants into the environment (with the pathogens carried along).

(Detailed results for each locality are enclosed to Annex 02).

PART 3. PROPOSED SOLUTIONS

3.1. Policy and legislative solutions and multi-sectorial coordination

3.1.1. Propose to amend and supplement a number of documents related to the disposal of diseased animals

On the basis of above-mentioned analyses and field assessment results, the team of consultants proposes the following:

For prevention and control of animal epidemic: It is imperative to review and revise guiding procedures for environment protection on disposal of epidemic-infected animals to ensure practical implementability and timely response to urgent tasks in epidemic prevention and control and disposal. To be specific, it is necessary to:

- Make considerations and issue guidelines on the timing of sampling for monitoring purpose and the endpoint of environmental monitoring program at the livestock and poultry burial sites as appropriate given the characteristics of the ASFV;
- Issue guidelines on sampling in the burial pit to determine the time to release the burial pit and options for using the biologicially decomposed or not fully decomposed (bones) products in the pits; guidelines on rehabilitation and restoration of sites used for burying infected animals;
- Set clear regulations on the number of samples, locations and frequency of sampling, and environmental parameters and components to be monitored. Specifications are to be issued to allow for benchmarking/comparison and assessment. Guidelines on burial pit selection (size) are to be issued;
- Issue technical guidelines on the gas release system and on leachate collection and treatment system for burial pits;
- Issue guidelines on disclosure of information about environment quality at epidemic-infected animal disposal sites;
- Issue detailed guidelines on handling of ASFV epidemic-infected pigs in particular and handling of livestock and poultry in general in centralized landfill sites (such as solid waste landfill sites, centralized burning sites) to ensure strict compliance with specialised regulations on animal health and environment. Besides, it is also necessary to issue guidelines on calculating the unit costs for centralized disposal and specific guidelines on the sources of funding to be tapped on for examination and monitoring of burial pits;
- Issue guidelines to localities on how to implement measures to disinfect surface water in rivers and streams to minimize the spread of epidemics without affecting the quality of surface water and the ecosystem and aquatic system in rivers and streams. It is necesary to conduct further studies on the survival time of the pathogens in the external environment, the transmittability and susceptibility of the virus to disinfectants to enhance effectiveness of biological decomposition process to minimize the transmission of pathogens, contamination of the living around and the direct impacts on human health.

With regards to Circular No. 07/2016/TT-BNNPTNT dated 31 May 2016 of the MARD on epidemic prevention and control in terrestrial animals and QCVN 01-41:2011/BNNPTNT - National technical regulation on requirements for sanitary handling in disposal of

animals and animal products: It is necessary to revise/amend the regulations on transportation and disposal because at present, epidemic-infected animals are considered hazardous wastes under the Law on Environment Protection 2014.

With regards to QCVN 01-41:2011/BNNPTNT: It is necessary to specify the types of waterproof materials to be used to ensure uniformity.

MONRE and MARD jointly consider to submit the Prime Minister for issuance of document providing unified guidelines to local levels on handling/disposal (burial and burning) in ways that meet the specialized requirements on animal health and environment.

3.1.2. Multi-sectorial collaboration mechanisms/solutions/actions to improve the performance of relevant sectors before, during and after disposal

During the epidemics prevention and control process, it is necessary to minimize the risk of disease intrude into Vietnam, simultaneously, proactively monitor and promptly detect infected animals in Vietnam to handle thoroughly, not to spread epidemics widely; mitigate negative impacts to economic, social and environmental issues caused by epidemics.

To effectively prevent and control animal epidemics in Vietnam (including epidemics that have ever occurred or new epidemics), the promulgation of an Urgent Action Plan on epidemic control and response is very necessary. At the same time, it would be established the Steering Committees on epidemic control from central to local level to mobilize the implementation of all relevant Ministries, industries to direct, coordinate and promulgate specific regulations, documents and guidelines consistent to epidemic status and situation. Simultaneously, it should be promulgated working regulations of the Steering Committee, of which assign specific tasks to each member according to their relevant functions and responsible areas. The Steering Committee at all levels should meet weekly, irregular or online to update epidemic situation and direct the implementation. The Steering Committee members at all levels should make field visits epidemic areas of suspected-epidemic areas to provide instructions and urge localities to take measures for epidemic control.

a) Epidemic has not occurred

MARD works with MONRE in developing technical guidelines for compulsory disposal of diseased animals and diseased animal products.

MONRE works with MARD provide guidance on environmental treatment measures in prevention and control activities of animal epidemic. The team propose MARD and MONRE to jointly develop and submit to the Prime Minister to issue a guiding document on compulsory disposal of diseased animals and diseased animal products and environmental treatment measures in prevention and control activities of animal epidemic.

The relevant ministries who are in charge of their responsibilities proactively direct the related agencies to coordinate closely in implementing strong measures to prevent the infection and spread of epidemic coming into Vietnam.

People's Committees of provinces and cities are in charge of:

- Directing DARD to coordinate with local and central agencies and industries, based on the Urgent Action Plan on epidemic control and response, to

develop the local Plan to submit to the competent authorities for approval; promulgating documents on guiding the compulsory disposal of diseased animals, diseased animal products and environmental treatment measures in prevention and control activities of animal epidemic.

- Organizing the month of cleaning and disinfecting in livestock areas, markets, trading and slaughtering places for animals and animal products with powdered lime or chemicals; after the month, it is necessary to periodically clean and disinfect in high-risk areas.
- Guiding the animal husbandry and animal health personnel to enhance the monitoring and applying biosecure measures in animal husbandry (daily cleaning of animal livestock facilities; hygiene and disinfection of human and vehicles entering and exiting the livestock areas; periodically spraying disinfecting chemicals to entire livestock areas; minimizing the access to and visit of livestock areas, especially at breeding production facilities, etc.).
- Preparing funds, materials, chemicals and vehicles to promptly implement prevention and combat measures when an epidemic occurs, including reviewing and making ready plans on disposal, burial or burning sites if infected or suspected to be infected animals with viruses detected, especially in case of mass disposal (hundreds, thousands or even tens of thousands of livestock and poultry).

b) Epidemic occurred and disposal implemented

MARD is in charge of:

- Directing the provincial People's Committee where the epidemic has occurred to mobilize local resources to promptly implement measures to encircle, control, stamp out epidemics and prevent from spreading; examining, supervising and urging the provincial People's Committee to implement animal disease control.
- Assigning quick response teams directly to make field visits to localities to support epidemic prevention and control (with the participation of Steering Committee members).

MONRE is in charge of Joining the mission as assigned by the Steering Committee; proactively organizing internal delegations to guide and support localities in epidemic prevention and control.

People's Committees of provinces and cities are in charge of:

- Organizing the treatment and prevention of outbreaks under the Law on Animal Health, of which disposal of infected pigs within 24 hours after receiving the test results confirming the infection of virus.
- Organizing zoning of epidemics, threatened epidemics and surveillance areas; simultaneously setting up control stations and points for transporting pigs and pig products; as well as traffic stops to carry out the cleaning and disinfection of vehicles coming from epidemics, threatened epidemics and surveillance areas.
- Organizing the cleaning, disinfection continuously 01 times/day within the first 1 week; 03 times/week for the next 2 weeks in a threatened area; cleaning and disinfection continuously 1 time per week within 1 month in the surveillance area.

- Reporting to the Department of Animal Health under the requirements of Circular No. 07/2016/TT-BNNPTNT; updating daily information about the disease situation on the local media.

c) After disposing epidemic

Inspect and supervise of animal disposal areas, of which the main role is at the provincial level (DONRE; DARD, People's Committee of district and commune), of which:

- DONRE cooperates with DARD, People's Committee of district, and People's Committee of commune to review the list of disposal sites, develop and implement a plan for environmental quality monitoring.
- DARD coordinates with DONRE, People's Committee of district, People's Committee of commune to select disposal sites.
- Communal People's Committee appoints staff to supervise the animal disposal areas within 2 weeks after destroying (daily performing).

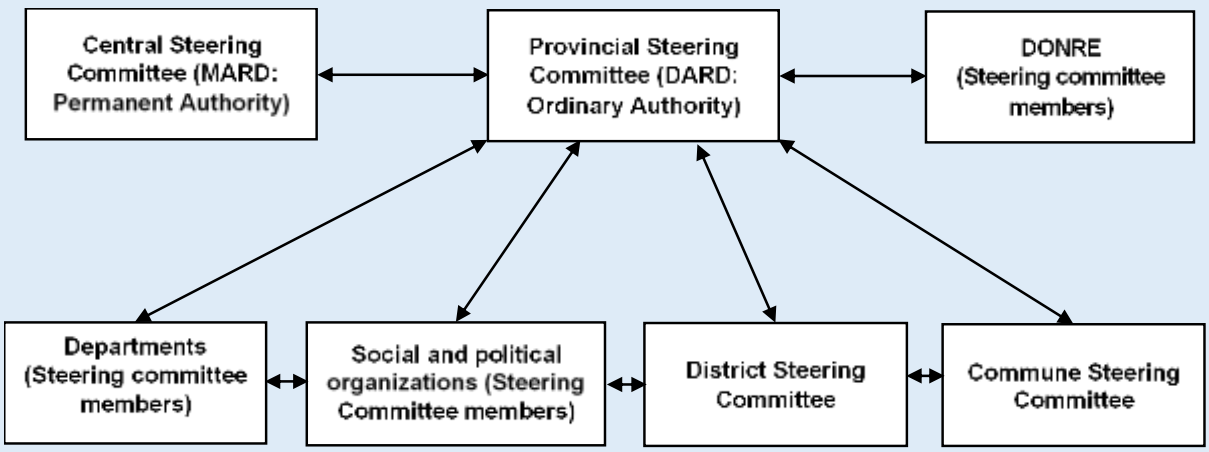


Figure 20: Multi-sectorial coordination in epidemic prevention and control

In addition, in order to improve the effectiveness of related sectors/industries in animal disease prevention and control, it is necessary to:

- Communicate and provide adequate and truthful information to avoid excessive worries about the epidemic situation;
- Make stronger efforts to disseminate information and provide training to improve the awareness and knowledge of relevant target groups (officials, businesses, people, etc.) on animal epidemics and encourage community members, agencies and organizations to actively participate in the prevention and control of epidemics;
- Invest in the construction and upgrading of laboratories for virus analysis to serve the purpose of doing research, testing and putting into use safe and highly protective vaccines for animals;
- Actively share information on the epidemic situation and disease and epidemic prevention and control among relevant agencies via meetings of the Steering Committees and media;
- Develop a national database on epidemics and epidemic prevention and

control, as well as on disposal of epidemic-infected animals;

- Allocating and mobilizing contingency resources (contingency fund) for animal epidemic prevention and control.

3.2. Technical solutions

3.2.1. Guidance for biosecure collection, transportation and environmental sanitation of diseased animals

3.2.1.1. Measures

(i) Humane killing: Epidemic-infected animals to be disposed must be killed by electrical stunning or other measures (if any) prior to disposal to ensure humane slaughtering. Electrical stunning must be done properly and correctly, for example, how the stunning should be done for the animals to faint, where to clamp on the animal and how strong the electrical current should be, etc. to ensure that the animals experience a painless death in a fastest manner, and induces no fear for the people involved in disposal.

(ii) Classification and treatment: Epidemic-infected animal carcasses and products are regarded as hazardous waste. Waste must be segregated where it is generated and must be contained in bulk bags or specialized bags. It can be mixed with a certain proportion of domestic waste but the mixture must be treated and disposed of in the same ways as for hazardous waste.

(iii) Collection and transportation: The collection and transportation of such hazardous waste to centralized disposal site must be done within 12 hours. Waste containing bags or bulk bags must be coated with waterproof material, have high force-bearing capacity, with well-tied mouths, labelled as “hazardous waste”, and have warning signs in conformity to TCVN 6707:2009 on Bio waste - hazard warning symbol before being handed over to the entities engaged in transportation and disposal. The waste bags that contain animal carcasses are to be preliminarily disinfected with disinfectants.

- Animal health agencies are to specify the routes and hours for transportation of animal carcasses. No transportation of animal carcasses should be allowed on routes going through densely populated residential areas, farms, and plantations to prevent pathogens from spreading.
- The DONREs are to take lead and work with the DARDs to provide technical advice to the provincial People’s Committee to issue guidance on collection, transportation, and handling of epidemic-infected animal carcasses and products.

3.2.1.2. Vehicles

Vehicles used to transport the carcasses to disposal sites are available vehicles on farms and family-scale farms or hired by the commune-level People's Committee such as improved vehicles, trucks, forklift trucks. Vehicles for transporting animal carcasses and products must have sealed floors to prevent waste from dropping on the way to the disposal site and must be cleaned and disinfected prior to and after transportation to the disposal sites People involved in the process of infected or suspect pigs disposal need to undertake personal hygiene and sterilization to avoid spreading pathogens.

The use of mechanized equipment during loading and unloading in livestock production sites and disposal sites is encouraged.

3.2.1.3. Human resource

The commune-level People's Committee should establish a taskforce in charge of infected animals handling, including disposal of epidemic-infected animal carcasses and products with members including commune cadastral and environment officers and animal health workers. Human resource should be made available for transportation of infected animals from the source of the endemic to the disposal site and guidance should be provided to local people on how to clean and disinfect to prevent the disease from spreading.

3.2.1.4. Protective equipment

The composition of animal carcasses and products from epidemic-infected animals might have a large quantity of microorganisms that penetrate into human body through the following ways:

- Via skin (puncture, abrasion or cuts in the skin);
- Via the mucus membranes (membranes);
- Via respiratory ducts (due to passive inhalation);
- Via the digestive tracks.

Therefore, protective equipment such as: gloves, facemasks, gowns, rubber boots and other necessary devices and supplies (spray devices, disinfectants, etc.) must be provided to workers involved in the collection and transportation of animal carcasses as regulated.

Figure 21: Illustration of labour protective equipment and devices

3.2.2. Selection of appropriate disposal methods

In dealing with animal epidemics, there are various methods for handling and disposal of epidemic-infected animal carcasses and products available as mentioned earlier. The most common methods for disposal of epidemic-infected animal carcasses and other materials are burial (in licensed burial/landfill site), burning (pyre burning, open-air burning or in incinerators), extracting, composting and alkaline hydrolysis-based disposal.

So far, there is no method that is absolutely safe and feasible to be applied in Vietnam. The method of using heat is relatively safe, but it involves a large initial investment in incinerators, much fuel consumption and possibly causing air pollution in the burning process.

Applying of burning method with available fuel such as wood and similar materials is not safe for environment, in addition it is difficult to implement when large epidemic would been occurred in the localities. And landfill methods have caused major concern for water pollution, effecting adjacent areas and spread of disease through the air. Its advantages are easy to carry out and handle timely with a large number of carcasses during an outbreak. However the landfill methods have been currently applied in localities under the guidance of competent authorities still have shortcomings in implementation such as: Not safe due to low isolation capacity of materials; many localities could not find the location of the burial pit to meet the requirements of being far away from residential areas, far from water sources, in dry places, large distances to the undergroundwater layer; and the transportation of dead animals to the burial sites is at risk of spreading pathogens, etc.

Therefore, the most appropriate methods must be in line with the regulations of each country and requirements for biosafety and environment set by sectoral authorities,be well-suited to the geographical locations, climatic and socio-economic conditions of region and locality where the epidemics occur, and match the financial capacity/affordability for employing the selected disposal method.

The selected methods for handling and disposal of epidemic-infected animal carcasses and products during the outbreak must be based on science and prior consultation with the authorities is necessary in order to determine the appropriate sites and minimum basic requirements for employing the selected methods. Four methods for disposal of epidemic-infected animal carcasses and animal products recommended for use Vietnam in the near future are burial (safe burial pits and Jumbo bags), burning/incineration, composting and autoclaving to kill pathogens (the autoclaved animals are to be buried thereafter or used for animal feed production). However, for methods that have not been used in Vietnam (composting, autoclaving for animal feed production), studies and piloting are required before they are put into use on a wider scale.

Table 13: Some methods for disposal of epidemic-infected animals recommended for application in Vietnam

Methods	Type of epidemic	Number of animals disposed of	Localities	The necessary (basic) conditions for applying the method
Burial	AI, FMD, PRRS, ASF	Various number (from 1 to thousands head)	The localities are not in low-lying, landslide and flood areas	Having required land fund.
Burning	AI, FMD, PRRS, ASF	A few number (<50 heads)	The localities are in low-lying, landslide and flood areas (the Mekong River Delta)	There are specialized vehicles for transporting to factories (possibly outside the affected areas); Having incinerators met technical requirements on hazardous waste treatment, such as medical waste incinerators, hazardous industrial waste incinerators, cement kilns, etc.
Composting	AI, FMD, PRRS, ASF	Various number (from 1 to thousands head)	All localities	Having required land fund; Having factory or facility to composting waste and requiring testing and evaluation of quality as well as without pathogen.
Autoclaving to process into animal feed	AI, FMD, PRRS, ASF	A few number (<50 heads/batch)	All localities	Having factory for processing animal feed and necessary facilities (cold warehouse, etc.) while waiting for veterinary agencies to take samples for testing; Must be tested and certified that there is no pathogens in animal carcasses by a veterinary agency

3.2.2.1. Landfill

For a long time, landfilling technology has been employed for treatment of household and hazardous waste in most countries throughout the world. The main isolation materials used are HDPE geomembrane, bentonite and Enviromat filter.

a) Requirements for landfill site

The location of the selected landfill pits must meet the specifications/ standards under TCXDVN 261:2001 Landfill site for solid wastes - Standards for designing landfill pits for hazardous waste.

b) Technical requirements for landfill pits

The landfill pits must meet the following requirements: The size must be appropriate in order to economize on land area and treatment costs. The pit may have multiple layers and compartments depending on the volume to be treated; it must have a long-lasting structure and is well-isolated from the surrounding environment; there must be wells to allow samples to be taken for examination, monitoring and supervision over technical aspects of the pit; there must be trenches to prevent overflowing water and walls where necessary; demarcation markers, signages, warning signs, and information sign boards about the pit must be in place. The landfill pit is to have the following structural layers:

- *Reinforcement layer:* This layer is made up of sand and soil mixture to which 4 - 10% of bentonite mineral is added, with a thickness of 25 - 40cm to replace the clay layer as stipulated under Decision No. 60/2002/QD-BKHCNMT dated 7 August 2002 of the Minister for Science, Technology and Environment promulgating the "technical guidelines on landfilling of hazardous waste" as there is no natural clay layer as part of the geological structure at the site where the pit is located as required.
- *Geotextile layer:* This is a base fabric canvas to reinforce the load-bearing capacity of soil to prevent washout and erosion.
- *Geomembrane layer:* HDPE film with a thickness of 0,252 - 2,0mm thickness is to be used. This type of film is highly environmentally durable, highly waterproof (~5.10 - 11m/s), with good physio-mechanical properties and chemical resistance.
- *Adsorbent material layer:* The material is made from polymer fabric and bentonite minerals (trade name: Environmat, Bentofix, Betomat, etc.), is alkaline, adsorbate and capable of decomposing some toxics; highly expandable, and serves to seal off other structural layers, preventing leakage of pollutants into the environment during the life time of the pit.
- *Water-absorbing layer:* Sand or gravel of reasonable size.
- *Topsoil layer:* Apart from the geotextile layer, isolation film, and adsorbent layer to cover the contaminated soil, there is also a clean soil and topsoil layer with a thickness of 0.5 - 1.0m thick on which grass is planted for protection. The order of layers of landfill pit to dispose of hazardous waste is presented in following table.

Table 14: Sequence of structure layers for a landfill pit

Sequence	Sequence of layer from bottom up
Landfill pit	Depth of the pits for disposal: 2.35m. Slope around the pit
Layer 1	The bottom layer is evenly flattened and tightly rolled as required, then

	filled with sand-soil mixture with 10% bentonite
Layer 2	Coarse yellow sand or macadam layer (between Layer 2, a PVC pipe with a D100 diameter - the type used for leachate collection according to TCXDVN 320:2004) - is to be placed to collect leachate that leads to probe well for examination) is to be placed.
Layer 3	Geotextile 250 PP layer for reinforcement
Layer 4	Layer of special use HDPE film (Geomembrane) at the pit bottom
Layer 5	Absorbent layer Environmat at the bottom of the pit
Layer 6	Contaminated soil layer
Layer 7	Intermediate soil layer
Layer 8	Geotextile layer
Layer 9	Adsorbent layer Environmat at the top of the pit
Layer 10	Geomembrane HDPE layer for insulation at the top of the pit
Layer 11	Vegetative topsoil layer

The advantage of the landfill method is that it does not require high technology, is easy to employed with low treatment cost, and can handle a large quantity of hazardous waste at the same time. The isolation landfilling technology requires prolonged isolation period and monitoring is required for quality control of the landfill pit. The model for hazardous waste under isolation landfill technology is presented in the following figure.

Figure 22: Isolation landfill model

3.2.2.2. Burning

Burning method includes open-air burning and off-farm incineration as presented in Part 1 of this report. This is an effective and safe method for treatment of infectious waste, especially carcass and products of infected animals. This method is recommended for low-lying areas where a natural water fountain appears as soon

as the depth of more than 1m is reached during digging. If the burial method is employed, infected animal carcasses will expand, rise to the surface, stink and pollute environment when they are in contact with water. In addition, there should have incinerators that meet technical requirements for treating hazardous waste such as: Medical waste incinerators, hazardous industrial waste incinerators, cement kilns, etc.

Another direction of research that needs to be considered in the coming time is the use of mobile incinerators to meet full requirements of environmental protection as prescribed to adhere to one of the principles combating epidemic, which is “on-the-spot epidemic control" (refer to and study the model of “medical waste and animal carcass treatment cabinet” of Shanghai University of Environmental Science and Technology (China).

As the burning method involves using lots of fuel, labour, and other input factors than other methods, it may not be the appropriate option when a huge quantity of epidemic-infected animal carcasses have to be disposed of.

3.2.2.3. Autoclave

The application of non-burning technologies in the disposal of diseased animals to replace the burning technology in our country is very necessary and is aligned with the current trend of the world, contributing to the implementation of Vietnam's commitment when participating in the Stockholm Convention on reduction of unintentional emissions of persistent organic pollutants from the burning technology. Autoclave method is one of the recommended options in Vietnam in the near future. There are many methods of autoclave applied in the world as presented in Part I. After autoclaving, the pathogens are inactivated, which is one of advantages of this method; then the animal carcasses can be processed to become animal feed (after the animal health agency takes samples, conduct a test, and confirm that there are no pathogens in the autoclaved animal carcasses).

A direction for research for localities in Vietnam is that each locality should provide funding to have a specialized vehicle built to transport animal carcasses and internal organs of animals confiscated. This vehicle can use a boiler with high heat to treat animal carcasses on-site. After a certain period of time, the competent authorities can test samples after heat treatment. If it is completely sterile, they can allow the animal carcasses to be crushed and used as animal feed, which is to avoid wasting resources and saving money.

3.2.2.4. Composting

Composting is a natural biological process that transforms organic materials, in a predominantly aerobic environment, into a useful and biologically stable end product. Compared to burial, composting takes less space. This method can also reduce carbon emissions comparing to incineration activities. Composting can be carried out on-site or at another appropriate location. Localities and facilities can choose one of three composting methods as presented in Part I. However, it is essential to ensure the necessary conditions for useful microorganisms to work, to collect leachate, and to prevent the disease/epidemic from spreading.

3.2.3. Guidance on safe burial method

From the actual implementation of measures to disposal diseased animals in Vietnam recently, especially in the 10 provinces and cities selected for the survey, most localities have chosen the burial method for disposal of epidemic-infected animals. This method will be still used by localities in the coming time for epidemic prevention activities. However, this method also has some shortcomings due to existing regulations and actual implementation. The team proposes a safe burial process for epidemic-infected animals (to overcoming the shortcomings mentioned above) and propose MONRE and MARD jointly submit to the Prime Minister for promulgation of guidance document on the treatment/disposal process (burial, burning) to ensure alignment with requirements related to animal health and environment.

3.2.3.1. Selection of treatment location and appropriate burial method

To maintain environmental sanitation and contribute to the timely prevention of disease sources in localities, basing on scientific research findings and experience from the practical treatment and disposal of epidemic-infected animal carcasses in many years, taking into account the on-site material, human and financial resources availability, it has been seen that safe burial is an affordable solution in case of the disease outbreak in the locality. Below are issues that must be taken into consideration to select a suitable location for this method:

a) Safe distance

(i) General requirements

Solutions for dead animal treatment and disposal must meet the following safety distance requirements:

- Care must be taken so that pathogens and pollutants are not spread into the soil, water and air environment during transportation to the treatment sites and during treatment and disposal.
- The solution can be implemented in all localities in the country, in locations which are near residential areas and have different natural conditions.
- This method can be deployed in the burial pits that are not necessarily far from residential areas or groundwater sources; theoretically it can be applied for location meeting the above requirements.
- It is feasible in terms of technical materials, funding and operation after the handling and disposal.
- Remaining products of animal burial pits upon the completion of the disposal can be reused.

(ii) On-farm burial of epidemic-infected pigs

This solution limits the spread of pathogens during transportation of dead pigs. The designated farms are typically large in size and far away from the residential areas and can be a location for burying dead pigs. Burial pits in the farm must be at least 15 - 50m from the breeding area, well water and workers' dormitories, depending on the number of dead pigs to be buried. Pigs should be buried in areas with many

green trees to mitigate environmental pollution.

- With the quantity is about 10 tons of dead pigs/pit, the required distance is more than 15m in case isolating, waterproof materials are used;
- With the quantity is about 20 tons of dead pigs/pit, the required distance is more than 25m in case isolating and waterproof materials are used;
- For larger sized pits, the required distance may be more than 50m in case isolating and waterproof materials are used;
- Onsite treatment and disposal at the epidemic cluster is suitable for large-scale farms as they are located far from residential areas and are large in terms of land area, which makes them suitable for burial.

(iii) Burial in the planned area

In the event of an epidemic which causes a huge number of pigs to die making it impossible to opt for on-site burial, dead pigs are transported to centralized disposal sites in the designated areas. The requirements for centralized burial sites in the designated area are as follows:

- The distance from a centralized burial site to urban areas, cities, towns, townships, cultural facilities, tourism sites, pagodas, hospitals and health care centers must be at least 1,000m;
- The distance from a centralized burial site to a residential cluster must be over 100m;
- The distance from a centralized burial site to groundwater and surface water extraction facilities/works providing domestic water must be 200m;
- Distance from a centralized burial site to roads:
  - ✓ Distance to national highways, inter-provincial or district roads: at least 100m;
  - ✓ Distance to inter-communal roads: at least 50m.
- The distance from a centralized burial site to surrounding water sources (water for agriculture, aquaculture) must be at least 20m.
- The size of the burial pit must be determined based on the quantity of dead pigs to be buried. Typically:
  - ✓ The width is no more than 3m;
  - ✓ The depth in the range of 2.0 - 3.0m (depending on the groundwater level);
  - ✓ The length is not fixed;
  - ✓ Burial pit volume: 1.2 - 1.5 times of the volume of dead pigs to be buried.

b) Topographic and geomorphological conditions

In the carcass burial pit, the main components include protein, fiber, sugar, fat, minerals, some micro-organisms and pathogenic viruses. Animal carcasses will decompose in a way that is similar to the natural process of transforming inorganic matter into organic matter. Due to the rapid decomposition, the time needed for complete decomposition of dead animals does not last as long as other types of waste, in order to select location for the dead pig burial site, it is necessary to pay attention to topographic and geomorphological conditions as follows:

(i) Suitable terrain

For elevation: To avoid water pollution and to limit the possibility of erosion of concentrated burial sites, it is necessary to keep away from low-lying areas where surface water flows and flood water accrue, and at the watershed area of rivers' and streams' basin, stream. Terrain elevation is also a major factor affecting the spread of pathogens and pollutants from the leachate to the surrounding environment.

For slope: The burial site should not be located in a place with a high gradient because it is difficult to prevent the water flows on the slope to the burial site, increasing the risk of pollution when the burial pit would have an incident. Moreover, when the gradient is too high, construction of burial site will be difficult.

(ii) Soil suitability

The mechanical and physical composition of the soil in the centralized disposal area is extremely important for the ability to minimize contaminants to penetrate into the aquifer. Therefore, permeability is the basic parameter to evaluate the suitability of the soil at the disposal site. Among the soils, clay has the lowest permeability, and sand, sandy soil, gravel is high permeability. Therefore, the clay area is often chosen to locate the centralized disposal site. The thicker the clay layer, the harder it is for contaminants to penetrate into the aquifer. The most suitable clay thickness is 3.0m.

(iii) Appropriate climatic characteristics

Climate is an extremely important factor that affects the spread of pollutants from burial pit into the surrounding environment.

Wind direction and speed: The direction and wind speed affect the ability to emit odors from a burial site. When planning for centralized disposal sites, attention should be paid to the direction and speed of wind in each month of the year. It is necessary to avoid choosing the disposal site located at the beginning of the wind direction near residential areas.

Precipitation and evaporation: Rain is a factor that causes inundation in the burial sites, causing pollution/contamination to spread to the surrounding area When planning the centralized disposal site, attention should be paid to rainfall and evaporation characteristics in the locality.

Air temperature: The higher the air temperature (June, July, August in North, Central), the higher possibility of evaporating pollutants such as methane (CH_4), hydrosulfide (H_2S), and mercaptans results in the spread of air pollutants from the disposal areas into the surrounding environment.

(iv) Suitability in terms of hydrogeological conditions

If centralized disposal sites are located in flooded areas, it will be easy for contaminants/pollutants and viruses from leachate of animal carcass burial pits to spread to the surrounding surface and groundwater sources.

Hydrogeological factors such as aquifers, depth of water tables, etc. are important factors in the planned location of centralized disposal sites.

Distribution of aquifers: The location of the burial sites must not be located in areas with good aquifers with value for food and drink and for daily activities. If it is compulsory or not possible to arrange the above places, the burial sites must necessarily have waterproof layer to meet the requirements of ensuring safety of aquifers.

Depth of water table: The burial sites should be selected in locations where the water table is located as deep as possible. The deeper the water table, the longer the time for leachate to groundwater. On the other hand, where the water table is located near the ground, it is difficult to carry out the works of the landfill because the groundwater flows into the foundation pit when construction.

Water permeability of soil and rock: The better the permeability of the soil, the better the leachate permeability from the landfill to the groundwater. It is advisable to choose locations where the top soil layer is not less than 3m thick and the permeability coefficient of the soil is smaller than 10^{-7}cm/s.

c) Other biological conditions and ecosystems

(i) Impacts of the organism system in the burial pit

As mentioned above, the organism system involved in the decomposition of carcasses in the soil is rich, including microorganisms, molds, yeasts, protozoa, insects and soil-dwelling animals. The decomposition of animal carcasses is the transformation of a substance in organic form through many stages into inorganic products such as nitrate, ammonia, sulfur. These processes are mainly carried out by decomposing microorganisms (decomposing organisms), and other groups of organisms only facilitate the decomposing microorganisms in the process. The group of microorganisms that decompose animals is classified into the following main categories:

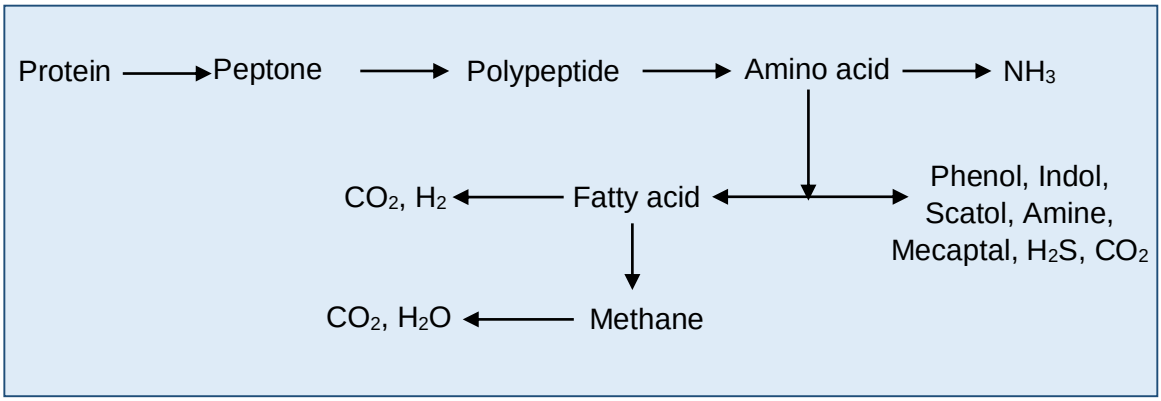
- *Sulfur decomposing microorganism group*

The main microorganisms are *Thiobacillus thioparus, Thirodaceae* family, *Chlorobacteria ceae*family. This group's final product of animal carcass decomposition is sulfur compounds such as H_2S, H_2SO_4.

- *Phosphorus decomposing microorganism group*
  - ✓ Phosphorus decomposing microorganisms: Mainly under *Bacillus and Pseudomonas genus*. Species with strong decomposing capacity are *Bacillus.megaterium, Serratia, B.subtilis, Serratia, Proteus, Arthrobster*, etc.
  - ✓ Bacteria: *Pseudomonas, Alcaligenes, Achromobacter, Agrobacterium, Aerobacter, Brevibacterium, Micrococcus, Flavobacterium*, etc.
  - ✓ Actinomycetes: *Streptomyces*, etc.
  - ✓ Fungi: *Aspergillus, Penicillium, Rhizopus, Sclerotium*, etc.
  - ✓ This group's product is H_3PO_4, formed in the decomposition process.
- *Nitrogen decomposing microorganism group*
  - ✓ Protein decomposing microorganisms are various, including many species of bacteria and fungi, and the bacteria possess different respiratory

properties. Aerobic bacteria are also the most common soil-dwelling ones, and H_2S is not formed in their decomposition process. *Bacillus mezentericus* and *Bacillus megathericum* are Bacillus with flagella and H_2S is not formed in their decomposition process. Other species can be found such as *Bacillus substilis, Pseudomonas fluorescens, Cromobacterium prodigiosum*. Respiratory bacteria include *Proteus vulgaris, Bacterium coli; Anaerobic bacteria include Bacillus putrificum, Bacillus sporogenes*.

- ✓ In addition to the above bacteria, there are also actinomycete species, including *Penicillium, Aspergillus, Mucor, Tricoderma*, etc. that can decompose proteins quickly.
- ✓ The products are organic compounds that will be fully oxidized and inorganized into the basic constituents of proteins such as NH_3, CO_2, H_2O, H_2S, H_3PO_4 (in aerobic condition). In anaerobic condition, as the products are not fully oxidized, the environment will accumulate a huge amount of organic acids, alcohols, amines, among which, some are smelly and very toxic.



(ii) Impacts of disinfectants used to quench the epidemic on the decomposition process in the burial pit

The use of disinfectants such as chloramine B, calcium hypochlorite in the epidemic control process has significant impacts on the decomposition process in the pit. These disinfectants will limit the number of microorganisms in the pit, restraining the decomposition of carcasses. Experimental results show that, in burial pits without disinfectants, the decomposition process takes place faster than those in which disinfectants are sprayed on infected pigs. Therefore, the disinfection and sterilization must be conducted 2 - 3 days before burial or immediately after the burial pit has been completed. Sterilization and disinfection shall be carried out on the surface of the burial pit and the pit's surrounding area.

3.2.3.2. Material selection requirements

High isolation capacity, minimum thickness of the isolation layer, best use of the volume of burial pits; prevention against spread of pathogens and harmful agents to the surrounding environment in many years.

Waterproofing feature of several common isolating materials is provided in technical documents, specifically:

Table 15: Waterproofing feature of several materials

Materials	Unit	Waterproofing feature
Sandy soil	m/s	10^{-3}
Clay	m/s	10^{-4}
Rammed clay	m/s	10^{-7}
Bentonite, nylon	m/s	10^{-9}
Geotextile	m/s	10^{-10} - 10^{-11}
HDPE	m/s	10^{-11}

The above data shows that, geotextile, HDPE, PE have an isolation capacity which is hundreds to thousands of times higher than that of other materials. Thus, the safe distance from the burial pit to the water source and environmental factors to be protected will be reduced proportionally. On the other hand, these materials also have some characteristics as follows: Geotextile can be self-welding so with this material, construction errors can be addressed, and it's easier to use geotextile than HDPE while HDPE is more durable in terms of withstanding stronger mechanical impacts such as earthquakes and landslides. If the strong impacts are not taken into account, geotextile and PE are more relevant and it can be produced and supplied locally or on-site for the bed and the surface layers while HDPE is imported and the construction using HDPE requires specialized welding machines.

Local supply or commercial supply is available with a reasonable price.

Needs can be met in a timely manner in the event of disease outbreak.

3.2.3.3. Application of a safe burial procedure

a) Safely isolated burial pit technology

(i) Scientific basis for a safely isolated burial pit design

- Regarding the scientific basis for a safe isolated burial pit design, an isolated burial pit must be designed to ensure biological safety and environmental sanitation in the burial area. The structure of a burial pit includes the following layers:
- Buffer layer: is a layer of rammed clay or soil mixed with bentonite at an appropriate ratio. This layer protects the main isolating layers and reduces the waste inflow or outflow and has a permeability coefficient of more than 10^{-}

^{7}m/s. The buffer layer is usually made of sand or onsite soil and its typical thickness is 10 - 20cm;

- Insolating layer: The main insolating layer is made of imported HDPE film with a thickness of 0.25 - 0.8mm or local PE with a thickness of 2 - 2.5mm; its permeability coefficient is more than 10^{-11}m/s;
- The layer of animal carcass bag, stable/shed bed lining materials, animal manure, carriers used for fertilizer production and carbon balancing substances in the burial pits facilitate the process of decomposition;
- The collection and treatment system of gases generated from the decomposition in the burial pit, located in the isolating layer and the covering soil layer of the burial pit;
- The thickness of topsoil is not less than 1m.

Burial pits must be protected against the impact of dry - wet, hot - cold conditions, mechanical vibration caused by construction drilling in the surrounding areas, earthquakes, etc. Traditional materials (rammed clay, reinforced concrete) cannot meet these requirements. Due to the dangerous nature of epidemics, burial pits are structured like landfill pit for other hazardous wastes. Safe burial pit structure and technological process diagram are presented in the following figure.

- A waterproofing material layer is used for bed lining and surrounding the pit wall. The thickness of the bottom layer is about 10cm, made of soil (or sand mixed with 3 - 4% of bentonite BT-1 (BT-1 can be used directly with a required apparent thickness of 1 - 2cm).
- The one-piece HDPE isolating layer is used for bed lining and the wall (if HDPE is not available, one-piece PE can be used instead).
- HDPE (0.8mm) or PE layer with a thickness of 2.5mm. The area of the isolating sheet must be sufficient to cover all the animals to be buried and the topsoil of the pit (plus 5 - 10% for contingency).
- Animal carcasses: Carcasses are placed in Jumbo bags neatly placed in rows and layers in the pit, starting from the center to the edge of the pit; Jumbo bags can be placed with additional effective microorganisms.
- Fill the BT-1 layer in the bag gaps and pit walls, put the soil above the surface of the bag containing carcasses and compact thoroughly, the thickness of this layer must be in the range of 0.8 - 1.0m; install gas collecting and releasing pipes (made of PVC).
- Wrap the HDPE (PE) sheet into a bag and seal the seam.
- Cover the waterproofing layer and the whole pit with an indigenous soil layer with a thickness of 50 - 80cm, reinforcing and compacting they layer to form a grave shape (trapezoid shape).
- Cover the pit with a layer of indigenous grass to prevent erosion caused by floods.

(ii) Safe isolated burial process

Step 1 - Select the location of burial pits;

Step 2 - Calculate and determine the quantity and volume of animals to be buried;

calculate the size of burial pits, make drawings of burial pits; calculate the amount of supplies, material consumed and manpower required;

Step 3 - Prepare supplies, materials and chemicals, and transport the needed supplies to the gathering place;

Step 4 - Construct burial pits according to the drawings, set the order of the structural layers; handle arising technical issues;

Step 5 - Transport, check and count the number of carcasses and products of infected animals to be disposed, carry out disinfection of items and areas that may cause pollution during transportation;

Step 6 - Carry out the burial, check the technical requirements of structure and composition of the burial pit;

Step 7 - Complete the burial pit; conduct environmental cleansing and disinfection for people and objects used; disinfection of peripheral areas in the direction of possible dispersion of water and dust; install warning signs on burial pits as prescribed;

Step 8 - Monitor burial pits, check and carry out maintenance of the pits in accordance with regulations.

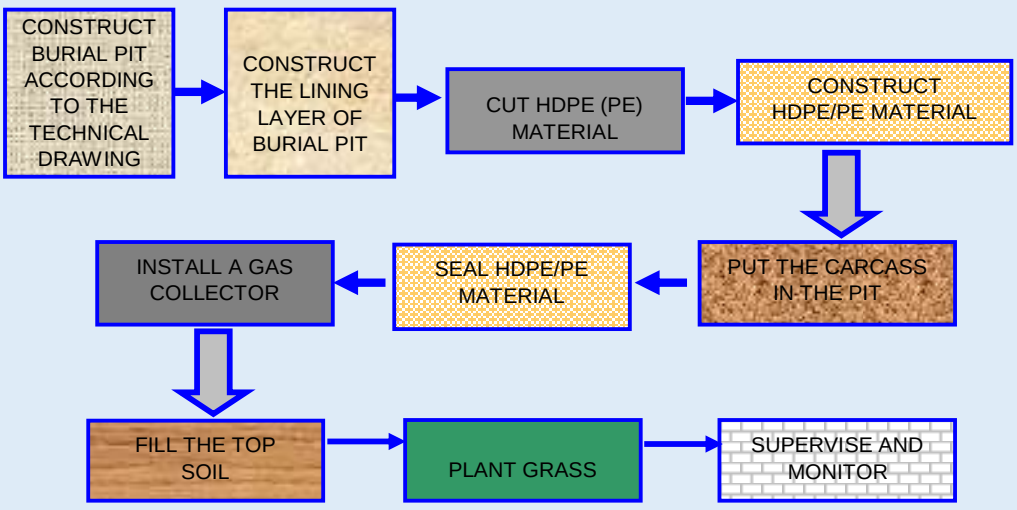


Figure 23: Process diagram of the safe isolated pit

(iii) Construction of the safely isolated burial pit

Below are construction activities of isolated burial pits.

- *Activity 1*: Select the burial pit location

Select the location of burial pits in the breeding farm, household's garden or the planned centralized treatment area of the locality. The site should be in an area with low traffic, a lot of trees, and relocation is not required for at least 6 - 8 months. The pit should be protected against other impacts during the decomposition of animal carcasses.

- *Activity 2:* Calculate and determine the burial pit volume and size

Calculate and determine the quantity of the dead animals and the necessary volume of burial pits. Volume of substances to be put into a burial pit includes: animal carcasses; barn bedding materials + manure collected during barn cleaning; carbon balancing substance in burial pits (straw, leaves, husks, etc.); porous carriers to with high level of water absorbance (diatomite, non-metallic mineral, etc.) and effective microorganisms.

- *Activity 3:* Construct burial pits according to the sample design

Figure 24: Construction of the safe burial pit for dead pigs with a size of 1,000 kg/pit

A trapezoidal burial pit is dug manually or by a trencher to easily place construction materials and animal carcasses into the pit. The size of the pit is calculated by multiplying its width by length by height.

Technical requirements for the pit:

- ✓ Choose the location where the ground is not too soft and groundwater level is low, to ensure low impacts on the lining material of the pit;
- ✓ After being dug, a burial pit must have a relatively flat bed and walls, with no pool of water and solid ground so that construction materials can be laid;
- ✓ The pit's bed must be treated and filled with lining material according to technical requirements.

- *Activity 4:* Build a 10cm-thick lining layer (soil + 10% bentonite)

Put bentonite into the bed of the pit, use hoe and shovel to mix bentonite with soil; this layer must be 5 - 10cm thick. Then use a compactor to compact the bed of the pit. This lining layer protects the isolating layers, reduces the load of waste inflow or outflow and has a permeability coefficient of less than 10^{-7}m/s.

- *Activity 5:* Cut the HDPE/PE isolating sheet in accordance with the design

Use tape measure (metric system), chalk and scissors to cut the sheet according to the design; Use a welding machine to weld the basic welding lines on the isolating

sheet in accordance with the instructions in the design.

Adjacent sheets are bonded by welding to create isolating and waterproofing films. The applicable welding methods are fusion and extrusion welding. Each welding equipment must have a welding temperature meter to maintain the required welding temperature.

Place filter tube, PVC pipe ϕ48mm; length of 4m to create wells to monitor and assess the safety of burial pits.

- *Activity 6:* Construct isolating, waterproofing layers

Install HDPE (PE) that consist of 1 bed layer and 4 wall layers on top of the layer. The isolating layer must be placed so that its edge is parallel to the direction of the slope. These sheets should be flat, not wavy, especially at the edges. The joint of the two adjacent sheets must be 10cm. Clean the joint to remove the soil.

- *Activity 7:* Transport the pig carcasses containers to the pit

The carcasses are to be collected in bags. Excavators and cranes should be used and the bags are to be put into the pits as compactly as possible, in rows and layers, starting from the center of the pit to the edge of the pit; placing additional combinations of probiotics. Add a clean soil layer to the pit with a height of about 20 cm to the ground, compact layers. Place a 2 x 3cm layer of rock with a thickness of 15cm and a size of 0.45m × 0.45m on the surface of the burial pit to install a gas collector for gas generated during the decomposition in the burial pit.

- *Activity 8:* Install a gas collector in the burial pit

Figure 25: Gas collector and treatment or the burial pit

Preparation of materials and supplies:

- ✓ PVC filter pipe ϕ48 with a length of 0.4m: 02 sections;
- ✓ PVC filter pipe ϕ48 with a length of 0.20m: 04 sections;
- ✓ PVC elbow ϕ48: 04 pieces;

- ✓ Tee ϕ48/21: 02 pieces;
- ✓ Tee ϕ21: 02 pieces;
- ✓ Pipe ϕ21: 01m;
- ✓ Construction rock size (2 × 3cm)

Install the gas collector as described. Place the gas collector on the rock layer and then sequentially filled with Enviromat, HDPE layers and weld to close the pit.

- ➢ *Activity 9:* Install the gas collector for the collection and treatment of generated gas in the pit.

Use HDPE sheets, cut and weld them to create a gas treatment box. The HDPE sheets should be cut as follows:

- ✓ Cut 2 square bedding sheets of 0.5m x 0.5m, cut a hole of ϕ21mm in the middle of the bedding sheet to insert the gas treatment pipe;
- ✓ Cut 1 HDPE sheet of 0.6m x 1.5m. Fold the cut sheet a long its length so that the two layers have a 15cm overlap and use a dual welding machine to weld. Then fold a 10cm-edge on each end. Create a square box of 0.45 x 0.45m using a fusion and extrusion welding machine to weld the bedding sheet;
- ✓ Insert the pipe to collect the gas in the burial pit, install a tee ϕ21, fill rock with a dimension of 3 x 2 to fill the plastic tee. Fill 1.5 - 2.0kg of $Ca(ClO)_2$ in the form of granules or lumps of lime before sealing the sheet on the surface of the box and welding the gas collector to fix it.

Figure 26: Gas treatment for the burial pit

- ➢ *Activity 10:* Complete the burial pit, disinfect the burial site

Disinfect the site upon the carcass burial. Use lime chloride, chloramine, lime, etc. to disinfect and prevent the spread of harmful microorganisms. Install warning signs to

prevent people's access to the site. The burial location must be marked on the commune's map and registered in the records/files of the commune People's Committee.

Figure 27: Pictures of large-sized safe burial pit construction

b) Burying pig carcasses in Jumbo bags

The method of burying pig carcasses in Jumbo bags can be used for small-sized breeding households, in case the number of dead pigs is not large (from 5 to 10), and when pigs die at different points in time. This method has the following advantages:

- Disposal of pig carcasses can be carried out quickly to ensure biosecurity.
- It is possible to bury the pig carcasses caused by ASFV to ensure biosecurity in the breeding farm while preventing negative impacts on the environment during handling and disposal.
- Onsite disposal involves low costs. Particularly, each farm can carry out the burial and disposal themselves in case of epidemic.
- Supplies and chemicals used by this method may be stored for a long time before an outbreak.

Scientific basis and procedure for burying animal carcasses in Jumbo bags:

(i) General requirements

Collect the pig carcasses and items to be disposed of into the Jumbo bags and complete the disposal as soon as possible.

The burial should be carried out immediately onsite to minimize the risk of pathogen spread and avoid difficulties in burying when the carcasses decay. Bags must be sprayed with disinfectant and closely monitored. Animals and insects must be controlled because they pose a risk of infecting other nearby susceptible species.

These requirements are aimed at mitigating the spread of pathogens, in compliance with the regulations in disease prevention, zoning of outbreaks and epidemic control, and facilitate the application of disinfection measures.

(ii) Technical requirements for the Jumbo burial bag

The Jumbo bag contains 5 - 10 pigs with an average weight of 300 - 500kg/bag, is suitable for households and small farms.

Calculation of bag size: The bag volume is equal to one third of the actual volume of livestock to be disposed.

It is necessary to decompose wastes and barn bedding materials in burial pits to ensure biosecurity and shorten isolation time in post epidemic period.

Gases generated during the decay process must be well treated to ensure environmental safety and sanitation in disease prevention (biosecurity).

Decomposed matter/products can be used as a source of fertilizer in agriculture.

Inventories can be stored to be available when epidemic occurs. Jumbo bags are easy to use and safe and the costs are reasonable.

(iii) Design of the Jumbo bags used for animal carcass burial

Jumbo bag is a kind of large-sized bag used to store and transport all kinds of products in bulk such as soil, sand, cement, wood loam, plastic particles, agricultural products. It is made from woven PP with a typical containing weight of 500 - 2,000kg. Common types of Jumbo bags are as follows:

- Spout top jumbo bag;
- Baffle jumbo bag;
- Skirt top jumbo bag;
- Spout bottom jumbo bag;
- Plain bottom jumbo bag.

The size of the bag depends on the carrying weight and requirements. Specifications and ability to contain pig carcasses of Jumbo bags:

- Type 300kg; bag size: 0.9 × 0.9 × 1.2m;
- Type 400kg: bag size: 1.2 × 1.2 × 1.4m;
- Type 500kg: bag size: 1.4 × 1.4 × 1.6m.

Jumbo bags are mostly used in the construction and agriculture (FIBC). Jumbo bags are made of woven Polypropylene by various technology meeting different needs and purposes. As jumbo bags can be recycled and are environmentally friendly, they are preferred.

Jumbo bags used for collecting, transporting and disposing of animal carcasses are made of 0.5 - 1mm thick PP, sealed by PE tightly around. On top, a vapor and biogas collector are installed to collect the gas and vapor formed in the decomposition. Jumbo bags are used in on-site burial pits or transferred to centralized disposal sites, with a net volume of 0.9 - 2.0m^3. The effective volume of the bag is 0.6 - 1.4m^3. A vapor and biogas collector are installed to collect the gas and vapor formed in the decomposition. There are load-bearing straps on the bag, which makes it convenient

for using lifting equipment, cranes, and excavators to facilitate transportation or put to burial sites.

Figure 28: Jumbo bag model

(iv) Diagram for disposal of epidemic-infected pig carcasses using Jumbo bags

Process diagram for the pig carcass burial using jumbo bags:

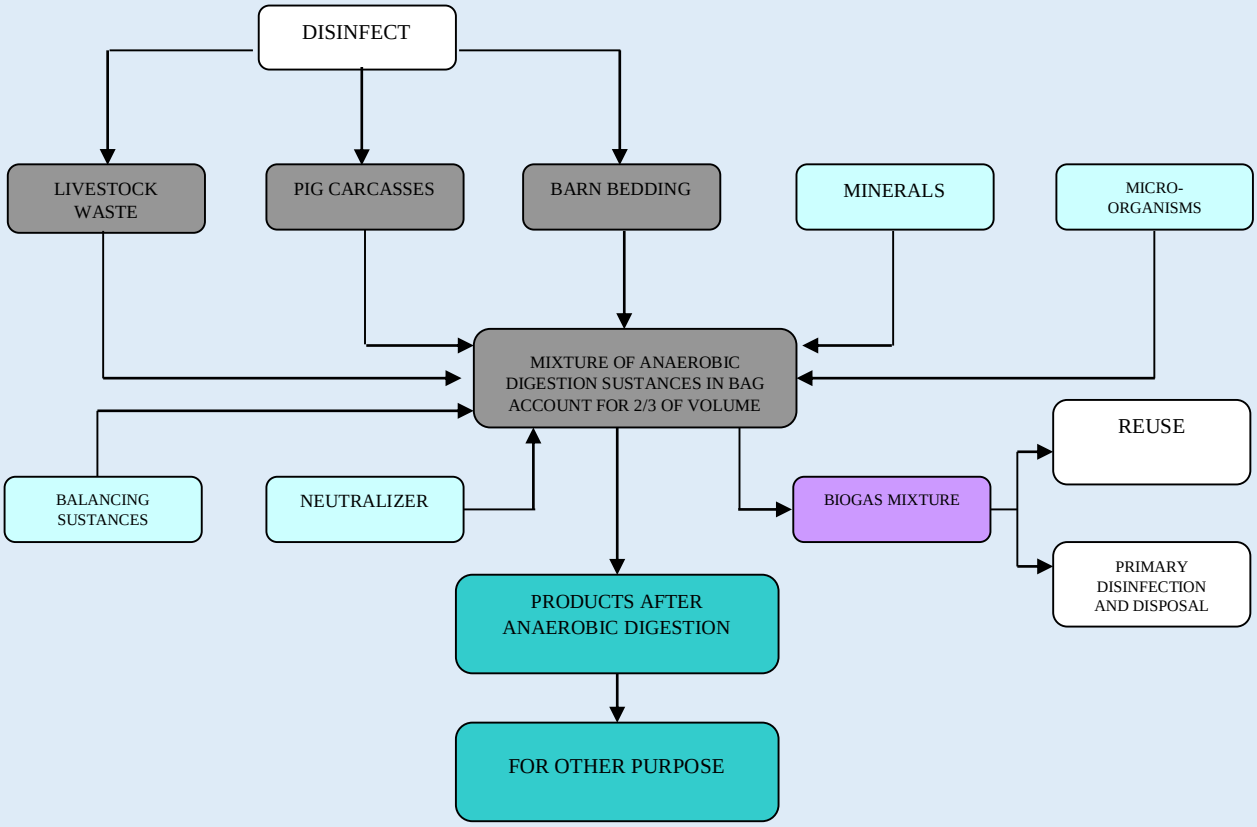


Figure 29: Process diagram for pig carcass burial using jumbo bags

Process steps:

- *Activity 1* - Choose a location for the bags.

Bags are placed in burial pits in the garden or on the ground, where the traffic is low and there is no requirement for relocation for at least 6 - 8 months. Depending on the number of Jumbo bags to be buried, determine the sizes of burial pits accordingly.

- *Activity 2* - Calculate, determine the weight and volume of the bag.

Prepare necessary materials and chemicals for the pig carcasses disposal; put into the bag according to the proportion of pig carcasses weight + 10% barn bedding material (manure collected in the barn cleaning, carbon balancing substance in the bag such as straw, leaves, husks, etc.) and some effective microorganisms to enhance decomposition and deodorize decomposition. Substances put into the bag related to the disease should be disinfected with the disinfectants prescribed.

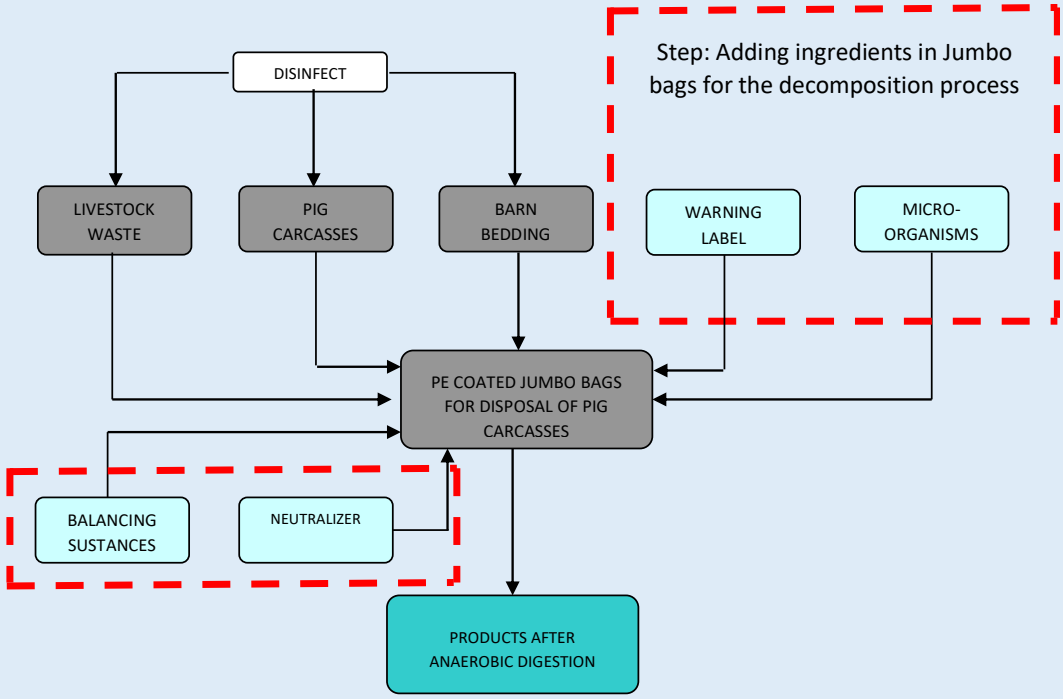


Figure 30: Deploying and preparation of substances for adjusting the composition of Jumbo bag

- *Activity 3* - Deploying the allocated Jumbo bag

Depending on the size of Jumbo bags, place pig carcasses and barn bedding material into Jumbo bag for disposal. The bags are designed for household's disposal that can decompose from 200 - 500 kg/bag; preliminary disinfection with chemical as prescribed. Prepare substances and adjust the composition of the bag following the instructions.

- *Activity 4* - Install the biogas collector in the bag, seal the bag by fastening

the mouth at the available places on the surface of the bag. Put the bag in to the burial pit, cover with a layer of soil at least 60 - 80cm thick on the surface of the pit.

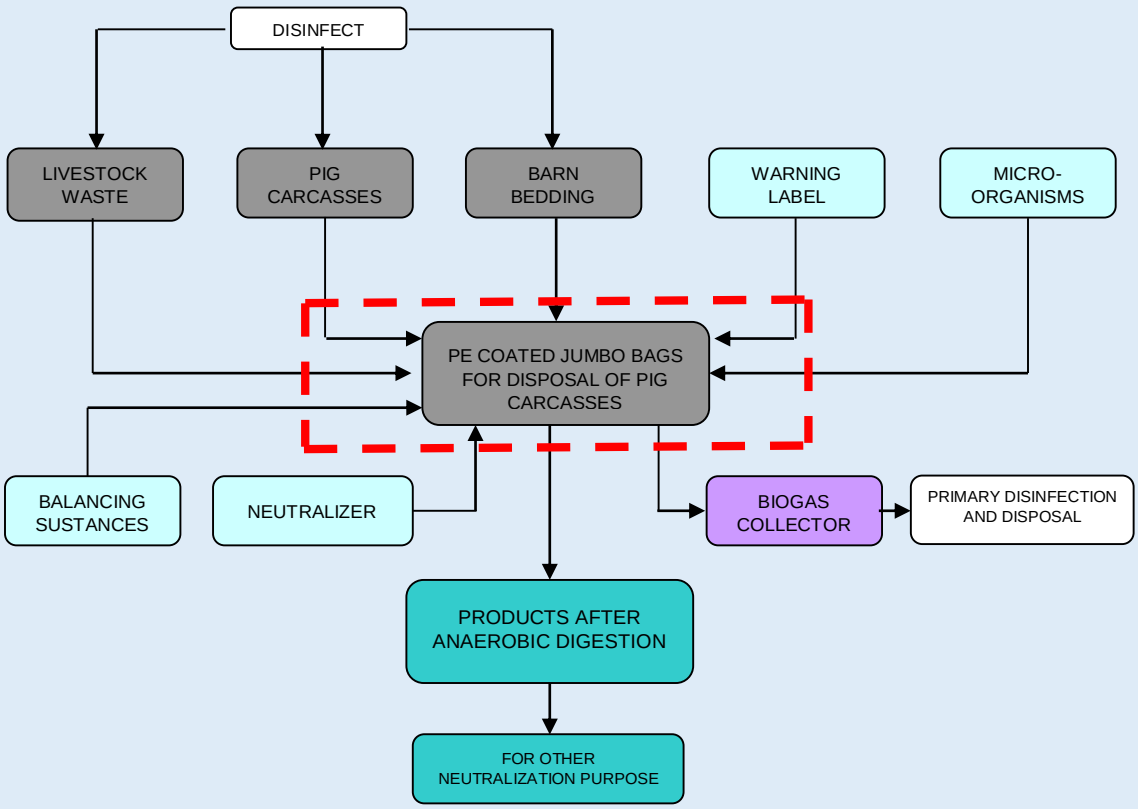


Figure 31: Filling the Jumbo bag with substances and waste to be disposed of

- *Activity 5* - Seal the bag by tightening its knots, install the biogas collector in the top of the bag, then seal the bag with glue.
- *Activity 6* - Discharge the biogas produced in the decomposition to the gas treatment system (tank containing lime water and chlorine solution).

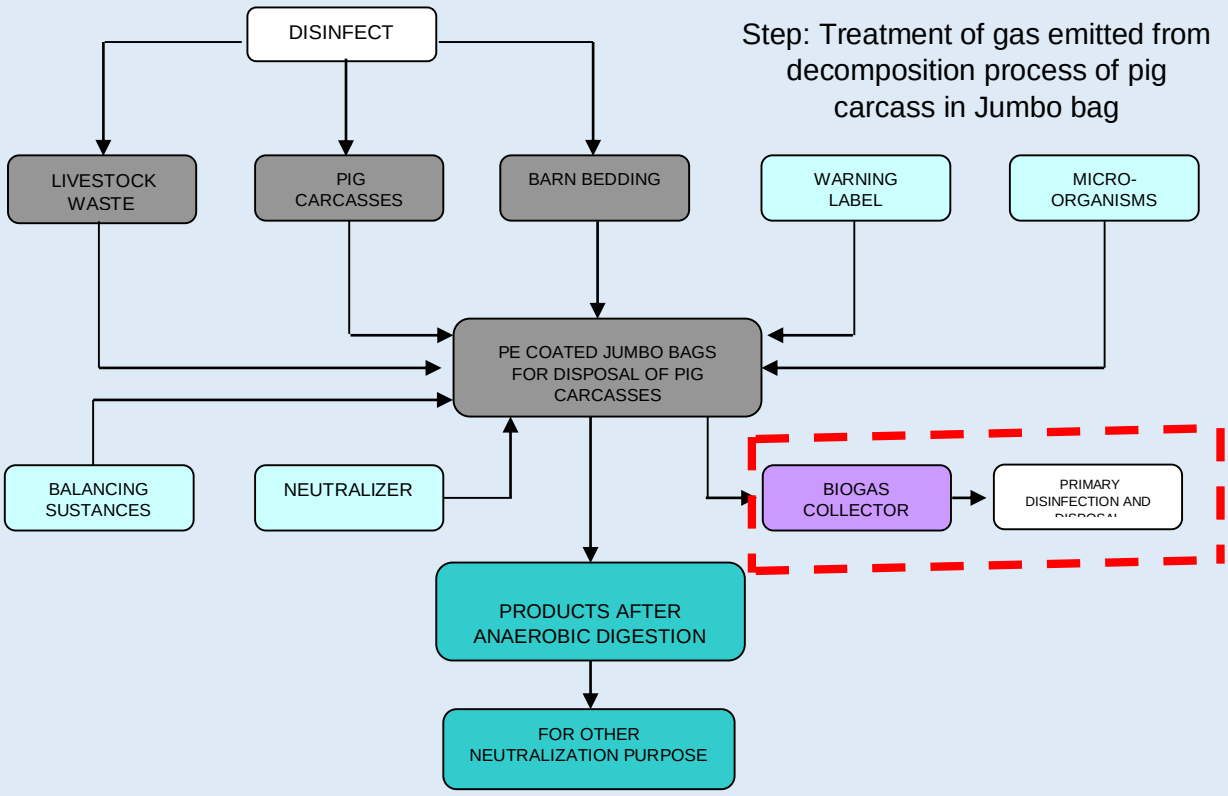


Figure 32: Treatment of biogas formed in the decay of animal carcasses

- *Activity 7* - Carry out environmental disinfection, disinfection for people, processing items.
- *Activity 8* - Monitor the bags during the disposal process.
- *Activity 9* - Use the decomposition products as fertilizer for agriculture. After a period of time, decomposition products will be formed, which can be easily absorbed by plants and exist in the soil in the form of humus.

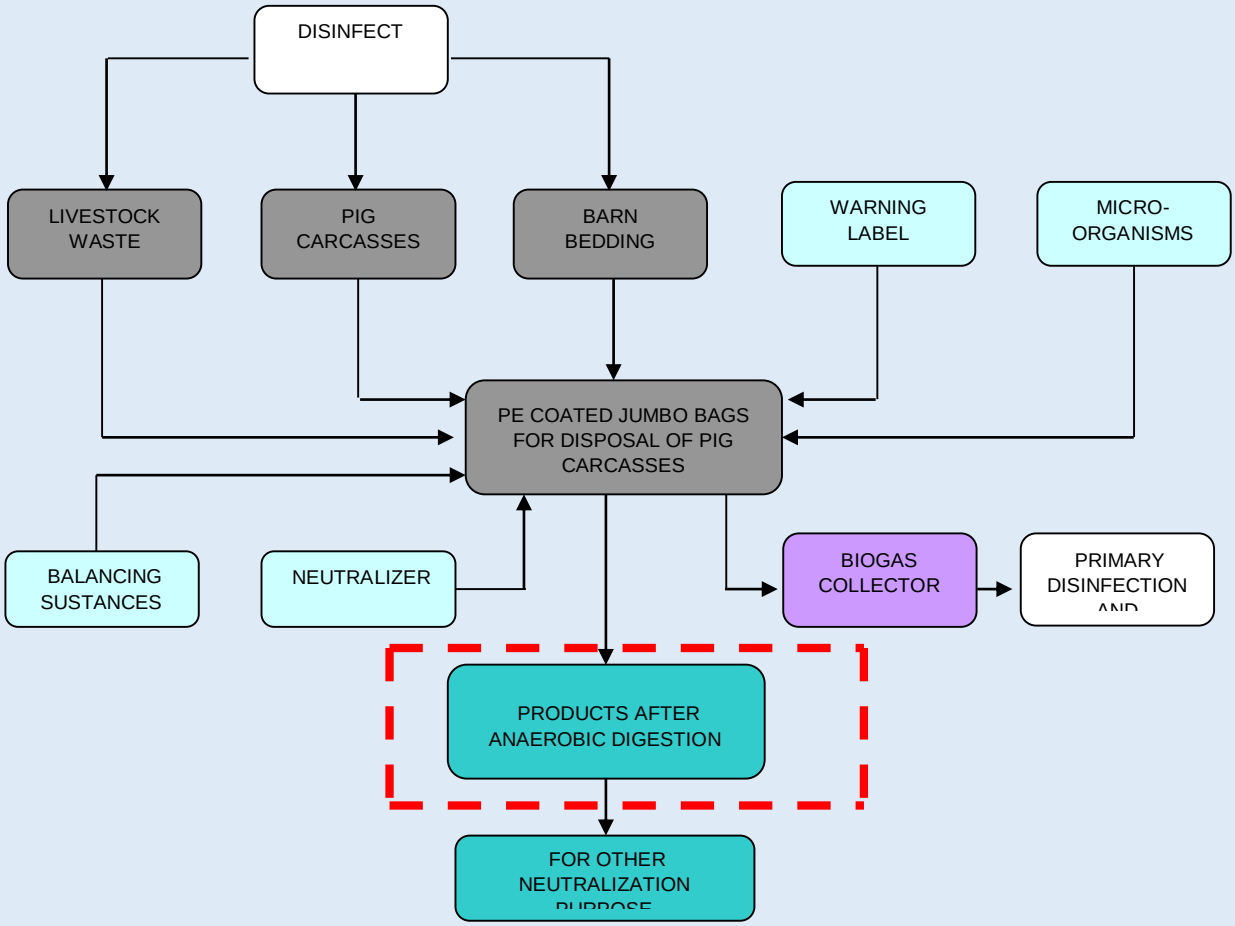


Figure 33: Using decomposition products of pig carcasses pits

Strong chemical disinfectants are typically used to limit the spread of pathogens into the environment during the burial of pig carcasses caused by the epidemic. Chemicals used such as formaldehyde, chloramine, lime chloride can hinder the decay of carcasses by inhibiting the growth of beneficial microorganisms. However, these disinfectants only be active for a certain period of time, so it is necessary to calculate specific parameters to ensure that the decomposition is still taking place while disease spread to the environment can be prevented.

3.2.3.4. Chemical disinfectants and effective microorganism use in burial process

a) Chemical disinfectants

Sodium hypochlorite (NaOCl) or chlorine dioxide $Ca(ClO_2)$ are chemicals which are often used for disinfection in epidemic prevention and control. They are very efficient in inactivating bacteria, fungi, viruses and controlling odors.

b) Effective microorganism (EM) use to accelerate the organic substance decomposition and deodorization

In order to enhance the decomposition, shorten the time, it is necessary to supplement an amount of diversified and strong microorganisms. The presence and dominance of

the number of pathogenic microorganisms in the diseased animal carcasses will be largely eliminated after a period of bio-heat decomposition, thanks to the addition of EMs and substrate to inhibit the growth by nutrient-competing microorganisms and promote the production of target antibiotics, contained in the EMs.

The most common EMs are mainly microorganisms with powerful organic substance decomposing capability, can survive and thrive in soil and water environments. DW 97, EM, and EMC are among these. They participate in both decay and mineralization stages. DW97 and EMC are combinations of dozens of isolated and selected microorganisms with strong biological activities such as the ability to produce strong extracellular hydrolytic enzymes such as proteaza, xellulaza, amylaza and resistance to some pathogenic microorganisms. They can also grow in anaerobic, aerobic or arbitrary conditions. These include bacteria, fungi, actinomycetes, etc. Because of their dominant quantity, growth rate and nutritional competitiveness, bacteria play a leading role, followed by fungi and actinomycetes. In addition to the above-mentioned microorganisms, there are a number of other microorganisms that play a role in supporting the development of beneficial microorganisms, inhibiting the growth of harmful microorganisms, and accelerating mineralization process and causing no odour, etc.

Figure 34: Effective microorganism DW 97 and EMC

3.2.3.5. Safety measures in diseased animal landfill process

Disinfection method for the disposal of animal carcasses:

a) Vehicles for the transportation of livestock and poultry carcasses to be disposed of

Collect the manure, waste in the vehicle;

Clean with soap water then clean with water;

Spray disinfectants with a concentration of 80 - 120ml/m^2 of floor area, both on the inside and outside walls of the vehicle.

b) Burial sites

Spray chloramine B disinfectant with a concentration of 2 - 3% on the carcass bags to mitigate the spread of pathogens during transportation;

Upon the burial completion, spread a layer of powdered lime with a volume of 0.8 - 1kg/m^2 on the surface of the burial pit and the carcass gathering area.

c) For people participating in the disposal

Protective clothes, hats, boots, reusable glasses, disinfectant must be disinfected by dipping in grutaraldehyde disinfectant solution with a concentration of 2% or chlorine 2 - 3% for 5 - 10 minutes after being used, washed again with clean water, and dried.

Hand sanitization with alcohol with a concentration of 70%, virkon or soap containing specialized phenol.

Rinse mouth with oral antiseptic solutions of medical facilities.

Burn or bury protective clothing, masks and disposable equipment.

Rinse mouth with oral antiseptic solutions of health facilities.

Burn or bury protective clothing, masks and single-use equipment.

3.2.3.6. Management of activities at burial sites

a) Burial pit check

In order to check the burial pit, a plastic sampling probe ϕ60 with a height equal to the height of the pit will be inserted. The plastic probe will be inserted through the top layers of material of the pit. The tube is closed and checked every 3 months, 6 months, 9 months, 12 months or with another frequency after 12 months from the burial date. Use a water pump to collect sample water in the burial pit to monitor the decomposition. In addition, with the tube, it is possible to check the exhaust gas components in the burial pit.

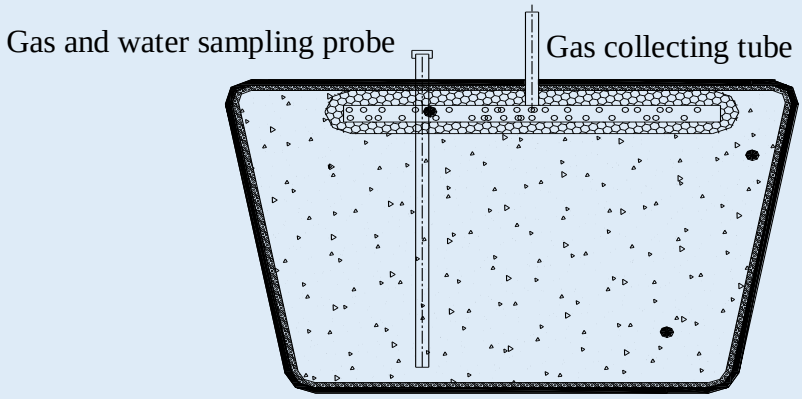


Figure 35: Sampling to check the environment in safe isolated burial pits

b) Zoning and warning

Burial site must be installed with a warning sign for people in and out of the area according to regulations. Burial site must be marked on the commune's map, recorded and filed by the CPC.

c) Burial site environment monitoring

Visually monitor and inspect the treated site (via color and odor) regarding the soil,

water sources (ditch water, field water, domestic water) and ambient air to timely detect and handle incidents; prevent pollutants from being discharged to surface water, aquaculture, agriculture water, and especially domestic water source and water source for husbandry. This task should be done daily within one week and weekly in the period from the 2nd week to the 12th week after burial.

Monitor surface water, dug well, drilling well pollution: Assess the level of pollution, odor, color, foam, monitor the status of living organisms such as fish, shrimp, vegetables, duckweed, algae. Basing on the visual check results, decision of the sampling for analysis may be required. In case of sampling, it is necessary to take samples of soil, water and air for analysis, to evaluate the safety of burial pits and monitor the decomposition in burial pits.

Frequency: Every 3 months, 6 months, 9 months, 12 months and at another frequency depending on the actual situation after 12 months since the burial date.

(i) Surface water sampling

Surface water sampling can be done at some locations around the burial pits (for areas with ditches, canals, ponds, lakes, rivers, streams, etc.) and ideally in the depth of 5 - 25m.

Sampling and parameter analysis: pH; Temperature; DO; Electrical conductivity; Total dissolved solids (TDS); Biochemical oxygen demand (BOD); Chemical oxygen demand (COD); Ammonium (NH_4^+, N-based); Nitrite (NO_3^-, N-based); Nitrate (NO_2^-, N-based), Phosphate (PO_4^{3-} , P-based), Total oil and grease; E.coli.

(ii) Underground water sampling

Groundwater sample is collected in the nearest borewell or dug well.

Sampling and parameter analysis: Temperature; pH; DO; Conductivity (EC); Total dissolved solids (TDS); Permanganate index; Nitrite (NO_2^-, N-based); Nitrate (NO_3^-, N-based); Ammonium (NH_4^+, N-based); E.Coli.

(iii) Ambient air sampling

Monitor ambient air at the gas collector location of the burial pit and another location which is 5 - 10m from the pit towards the wind direction.

Visually monitor air pollution and use the quick monitoring device with specialized sensors to monitor the air pollution.

Sampling and parameter analysis: Temperature; Humidity; Wind speed; Wind direction; Ammoniac (NH_3); Methyl mercaptan (CH_3SH); Hydrosulfide (H_2S).

(iv) Soil sampling

Conduct exploration drilling, soil sampling for analysis. Ideally, take the sample in 4 locations around the pit; in 3 distances (next to the burial pit, 5m from the burial pit and 25m from the burial pit), in different depths of the soil layers (soil surface, depth of 0.5m, depth of 1.0m, depth of 2.0m and may be deeper depending on the soil characteristics at the burial sites, such as heavy soil or sandy soil).

Soil samples are collected in specialized sample containers with a sample weight of about 2kg of soil/sample.

Parameters to be analyzed include: Total Phosphorus, Total Nitrogen, Total Carbon, and pathogenic microorganisms at the time of burial.

3.2.3.7. Pollution treatment at burial sites

Irrelevant burial measures in the event of local outbreak may cause serious environmental pollution. The consequences include:

- Collapse burial pits; explode burial bags due to gas explosion generated during decomposition inside burial pits causing air pollution;
- Contaminated water leakage pollutes surface water, surface aquifer and even groundwater in some localities.
- Cause unpleasant stench, negatively affect the landscape, and spread disease to neighboring localities. The breeding facilities and barns must be isolated, which causes disruption to production and causing considerable economic losses.
- Create concern and panic among local residents.

a) Isolation

To overcome this situation, it is necessary to address the following issues:

- Promptly block air and water pollutants to the surrounding environment.
- Quickly reinforce the burial pit, or construct a new one to bury animal carcasses in the decaying process.

The next section is about steps to handle irrelevant burial pits.

b) Treatment

Step 1 - Ambient environment disinfection

Ambient environment disinfection is done with specialized chemicals such as:

- Volatile disinfectants to disinfect the ambient air (foocmol, ozone, Cl_2, etc.)
- Probiotics, or deodorants to prevent the possibility of odor generation (EM, BIOTIV, ENCHOICE, etc.).
- Durable disinfectants to disinfect and prevent dispersal (lime chloride, chloramine, lime, ash, etc.).

Step 2 - Creating a blockade wall

About 1m away from the edge of the pit, dig a ditch around the pit with 0.5 - 0.6m wide, 1.0 - 1.5m depth, fill with disinfectant such chloramine, lime chloride with a concentration of 0.5 - 1.0 kg/m long (can be replaced with powdered lime, salt). Put gas collector generating from burial pit.

Step 3 - Install the gas collector

Install the gas collector as mentioned above. The materials used to make the gas collector include:

- PVC filter pipeϕ48 with a length of 0,5m: 02 sections;

- PVC cap ϕ48: 04 pieces;
- Tee ϕ48/21: 01 pieces;
- Tee ϕ21: 02 pieces;
- Pipe ϕ21: 1m;
- Rock with the size of 3 x 4cm

(For large unhygienic burial pits, gas collectors are made similar to those used for the pits mentioned above).

Step 4 - Building a waterproof cap

After installing the gas collector on top of the rock layer, create a waterproof cap by sequentially covering the surface of the burial pit with layers of Enviromat, HDPE and sealing the pit from the blockade ditch side, the pit surface and use an on-site soil layer to cover layers of materials with a thickness of 40 - 50cm.

Step 5 - Installation of the gas collector

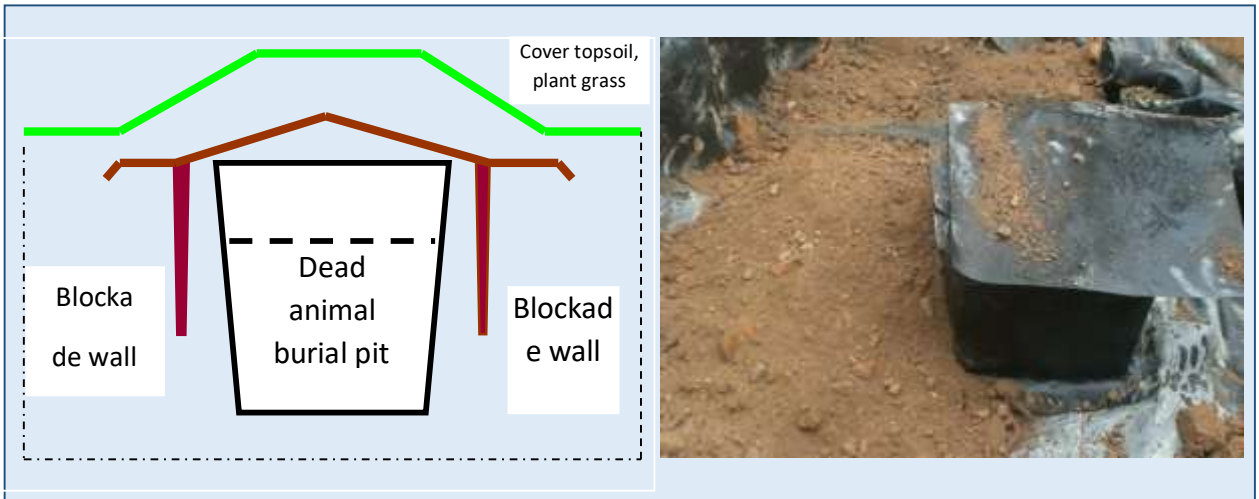


Figure 36: Pollution treatment at burial site

c) Environmental restoration

The following measures should be taken to minimize environmental pollution and disease spread in the community:

- Construct a topsoil covering the surface of the burial pit (tightly compacted with a minimum thickness of 1m);
- Plant grass on newly added soil layer to prevent erosion;
- Disinfect the area after the treatment, use durable disinfectants to disinfect and prevent spread of pathogen (powder two third, lime chloride, chloramine, lime, etc.).

d) Other highlighted issues

Regularly monitor and check the quality (color, odour) of water sources (ditch, field water, rainwater) around the area, timely detect and fix the incidents; prevent contaminated water discharge into surface water, aquaculture and agriculture water and especially domestic and farming water.

ANNEX 1: Field measurement and sampling and analysis method

1. Field measurement and sampling method

- For surface water sample:

+ Field sampling standards: TCVN 6663-6:2018, TCVN 6663-3:2016, TCVN 6663-1:2011, TCVN 5994:1995, TCVN 8880:2011.

- For underground water sample:

+ Field sampling standards: TCVN 6663-11:2011, TCVN 6663-1:2011, TCVN 6663-3:2016, TCVN 8880:2011.

+ Parameters measured promptly on field and measurement method:

No.	Monitoring parameters	Unit	Monitoring method
1	pH	-	TCVN 6492:2011
2	Temperature	^{0}C	SMEWW 2550B:2017
3	Total dissolved solid (TDS)	mg/L	NG.QT.N.01
4	Dissolved oxygen (DO)	mg/L	TCVN 7325:2016
5	Electrical conductivity (EC)	mS/cm	SMEWW 2510B:2017

+ Type of water sample containers:

No.	Items for analysis	Container
1	pH, BOD_5, Nitrite (NO_2^- calculated with N); Nitrate (NO_3^- calculated with N), Phosphate (PO_4^{3-} calculated with P), permanganate index	Plastic bottle
2	Microbiology: E.Coli	Dark glass bottle
3	Ammonium (NH_4^+ calculated with N), COD	Glass bottle
4	Total oil and grease	Wide mount glass bottle

+ Sample preservation on field:

No.	Items for analysis	Preservation technique
1	pH, BOD_5, permanganate index, Nitrate (NO_3^- calculated with N), Phosphate (PO_4^{3-} calculated with P)	In darkness
2	Microbiology: E.Coli	Cold (1 - 5)ºC
3	Ammonium (NH_4^+ calculated with N), COD	Acidification with H_2SO_4 to pH < 2

4	Total oil and grease	pH < 2 H_2SO_4

- *For air sample:*

+ Parameters measured promptly on field and measurement method:

No.	Monitoring parameter	Unit	Monitoring method
1	Temperature	^{0}C	QCVN 46:2017/BTNMT
2	Humidity	%	QCVN 46:2017/BTNMT
3	Wind speed	m/s	QCVN 46:2017/BTNMT
4	Wind direction	0 - 360^0	QCVN 46:2017/BTNMT

+ Field sampling equipment:

There are two equipment depending on actual mud sample:

No.	Sampling devices
1	QC2 machine
2	Staplex High-volume

+ Field measurement equipment: GPS machine

+ Sample preservation on field:

No.	Items of analysis	Type of sample container	Preservation technique
1	Ammoniac (NH_3)	Plastic bottle	Cold < 5^{0}C
2	Methyl mercaptan (CH_3SH)	Adsorption casset	In darkness
3	Hydrogen sulfide (H_2S)	Plastic bottle	Room temperature

- *For soil sample*

+TCVN 5297:1995; TCVN 7538-2:2005; TCVN 6857:2001

+ Sample preservation on field: in specialized sample containers or clean nylon bags (cold preservation at 2 - 5°C).

2. Method of laboratory analysis and test

Items of analysis in sample foundation (surface water, groundwater, air, soil) were quantified in laboratory with physical, chemical, organic, microbiological and grease criteria of wastewater; etc. These techniques must essentially comply with the

national technical regulations for laboratory sample analysis, as following:

No.	Component	Monitoring parameters	Monitoring method
I	**Ambient air**		
1		Amoniac (NH_3)	MASA 401
2		Methyl mercaptan (CH_3SH)	OSHA method 26
3		Hydrogen sulfide (H_2S)	MASA 701
II	**Surface water**		
1		Biochemical oxygen demand (BOD_5)	TCVN 6001:1-2008
2		Chemical oxygen demand (COD)	SMEWW 5220C:2017
3		Nitrite (NO_2^- calculated with N)	TCVN 6178:1996
4		Nitrate (NO_3^- calculated with N)	TCVN 6180:1996
5		Phosphate (PO_4^{3-} calculated with P)	TCVN 6202:2008
6		Ammonium (NH_4^+ calculated with N)	TCVN 6179-1:1996
7		E.Coli	TCVN 6187-2:1996
8		Total oil and grease	SMEWW 5520B:2017
III	**Underground water**		
1		Permanganate index	TCVN 6186:1996
2		Nitrite (NO_2^- calculated with N)	TCVN 6178:1996
3		Nitrate (NO_3^- calculated with N)	TCVN 6180:1996
4		Ammonium (NH_4^+ calculated with N)	TCVN 6179-1:1996
5		E.Coli	TCVN 6187-2:1996
IV	**Soil**		
1		ASFV	Laboratory method (diagnosis engineering on ELISA, Realtime PCR)

ANNEX 2: Results of environmental sample analysis

Nguyen Gia Engineering, Equipment, and Technology Consultancy Co., Ltd conducted field survey and sampling at the burial sites of ASF pigs in 10 provinces throughout the country, including: Ha Noi, Dong Nai, Vinh Long, Can Tho, Quang Nam, Thua Thien Hue, Nam Dinh, Thai Binh, Hai Duong and Hung Yen.

The consultant team surveyed on field, sampled surface water, underground water, ambient air and soil at 27 burial pits (4 pits in Ha Noi city, 3 pits in Dong Nai province, 2 pits in Vinh Long province, 2 pits in Can Tho city, 2 pits in Quang Nam province, 2 pits in Thua Thien Hue province, 3 pits in Nam Dinh province, 3 pits in Thai Binh province, 3 pits in Hai Duong province and 3 pits in Hung Yen province). Parameters for monitoring and analyzing of environmental components include:

- Surface water: Measured promptly on field and analyzed 13 parameters (pH; temperature; Electrical conductivity (EC); Total dissolved solids (TDS); DO; biochemical oxygen demand (BOD_5); Chemical oxygen demand (COD); Ammonium (NH_4^+); Nitrite (NO_2^-); Nitrate (NO_3^-), Phosphate (PO_4^{3-}), Total oil and grease and E.Coli). Monitoring and analyzing results were compared to QCVN 08-MT:2015/BTNMT - column B1.
- Underground water: Measured promptly on field and analyzed 10 parameters (pH; temperature; DO; Electrical conductivity (EC); Total dissolved solids (TDS); permanganate index; Nitrite (NO_2^-); Nitrate (NO_3^-); Ammonium (NH_4^+) and E.Coli). Monitoring and analyzing results were compared to QCVN 09-MT:2015/BTNMT.
- Ambient air: Monitored and analyzed 3 parameters (Ammoniac (NH_3); Methyl mercaptan (CH_3SH); Hydrogen sulfide (H_2S)). Monitoring and analyzing results were compared to QCVN 05:2013/BTNMT and QCVN 06:2009/BTNMT (average one hour).
- Soil: Analyzed ASFV.

(Analysis results are summarized from table 16 to 19)

Table 16. Summarize the results of monitoring and analysis of surface water samples at pits in 10 localities

Local	The sample code	Survey and sampling area	Pit characteristics	pH	Temperature	DO	EC	TDS	BOD_5	COD	NH_4^+	NO_2-	NO_3-	PO_4^{3}-	Total oil, grease	E.Coli
				-	^0C	mg/L	mS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	VK/100 mL
Ha Noi	NM-HN 01	Pits in the cemetery area of Yen Thai village, Dong Yen commune, Quoc Oai district	Divided into 2 pits, buried 632 pigs (from 3 to 6 months)	8.5	26.3	2.48	145	190	199.8	256.7	34.5	4.5	28.7	19.8	9.5	$18x10^3$
	NM-HN 02			7.8	23.1	1.9	122	157	109.2	231.1	20.1	2.7	22.5	13.7	7.2	$11x10^3$
	NM-HN 03	Pits near the landfill site in Phuong Cach commune, Quoc Oai district	Pits for 112 pigs, in the yard (from 3 to 6 months)	8.6	26.7	2.58	148	187	195.8	254.7	35.5	4.7	27.7	19.5	9.5	$19x10^3$
	NM-HN 04			7.4	23.4	1.85	122	151	103.2	241.1	21.1	2.4	23.5	13.2	7.1	$12x10^3$
	NM-HN 05	Pits in cemetery area of Hoa Thach commune, Quoc Oai district	Pits for 425 pigs (from 3 to 6 months)	8.4	26.6	2.54	149	183	191.8	236.7	35.5	4.6	27.7	20.7	9.6	$17x10^3$
	NM-HN 06			7.3	22.5	1.85	120	147	103.2	221.1	21.1	2.4	22.3	13.7	7.0	$12x10^3$
	NM-HN 07	Pits in the rice field of	Divided into 5 pits, buried 926	8.9	28.3	2.58	150	198	196.8	258.7	33.5	4.8	27.7	19.7	9.6	$16x10^3$

Local	The sample code	Survey and sampling area	Pit characteristics	pH	Temperature	DO	EC	TDS	BOD_5	COD	NH_4^+	NO_2-	NO_3-	PO_4^{3-}	Total oil, grease	E.Coli
				-	^0C	mg/L	mS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	VK/100 mL
	NM-HN 08	Ngoc My commune, Quoc Oai district	pigs (>6 months)	7.2	24.1	1.82	123	151	103.2	221.1	18.1	2.4	21.5	12.7	7.1	$10x10^3$
Hung Yen	NM-HY 01	Pits at landfill site of An Vi commune, Khoai Chau district	Pits for 509 pigs, divided into 3 small pits, about 3m depth, covered grass on the surface (>6 months)	8.4	25.5	2.40	36	696	249.2	812.7	156.8	17.5	55.3	67.8	41	$18x10^3$
	NM-HY 02			8.2	25.1	2.36	39	673	256.8	807.5	150.8	18.2	54.7	66.4	44	$16x10^3$
	NM-HY 03	Pits in a rice field near the people's cemetery area in Chi Tan commune, Khoai Chau district	Pits for 838 pigs, about 2m depth, covered HDPE film around and on the surface (>6 months)	8.3	25.8	2.49	33	725	311.3	937.3	125.8	14.4	58.8	67.7	37	$17x10^3$
	NM-HY 04			8.8	26.2	2.54	38	714	322.7	921.8	120.4	15.5	60.1	69.2	33	$16x10^3$
	NM-HY 05	Pits at the landfill site of Yen	Pits for 143 pigs, about 2m depth, covered grass	8.8	25.5	2.86	30	742	286.5	798.6	132.8	16.5	58.9	68.2	44	$16x10^3$

Local	The sample code	Survey and sampling area	Pit characteristics	pH	Temperature	DO	EC	TDS	BOD_5	COD	NH_4^+	NO_2-	NO_3-	PO_4^{3-}	Total oil, grease	E.Coli
				-	^0C	mg/L	mS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	VK/100 mL
	NM-HY 06	Lich village, Dan Tien commune, Khoai Chau district	(>6 months)	8.2	25.1	3.02	34	726	293.7	784.9	127.6	17.8	55.7	66.3	42	$17x10^3$
Hai Duong	NM-HD 01	Pits at the agricultural land area of Phu Lien village, Hong Phong commune, Nam Sach district	Divided into 08 pits with 3,124 pigs, covered with soil and grass on top (>6 months)	7.03	25.8	8.5	38	89	75.5	155.5	15.4	No detection	16.5	10.8	2.2	$9x10^3$
	NM-HD 02			6.99	26.5	8.3	42	87	78.2	148.3	16.5	No detection	14.3	9.7	2.8	$10x10^3$
	NM-HD 03	Pits outside the landfill site of Nam Trung commune, Nam Sach district	Pits for 496 pigs, about 2m depth, covered with HDPE film around and on the surface (>6 months)	6.98	25.8	7.9	39	85	73.6	135.5	16.1	No detection	15.5	9.8	2.4	$11x10^3$
	NM-HD 04			7.02	26.5	8.1	41	86	74.7	138.6	15.8	No detection	16.3	9.2	2.3	$12x10^3$
	NM-HD 05	Pits at landfill site of Hiep Cat	Divided into 04 pits with 2,012 pigs, about 2m depth, covered	6.92	24.8	7.8	42	81	78.6	133.8	17.5	No detection	16.6	9.3	1.8	$8x10^3$

Local	The sample code	Survey and sampling area	Pit characteristics	pH	Temperature	DO	EC	TDS	BOD_5	COD	NH_4^+	NO_2-	NO_3-	PO_4^{3-}	Total oil, grease	E.Coli
				-	^0C	mg/L	mS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	VK/100 mL
	NM-HD 06	commune, Nam Sach District	with HDPE film around and on the surface (>6 months)	6.88	25.5	7.9	45	82	77.8	138.2	16.8	No detection	15.8	9.0	1.9	$9x10^3$
Thai Binh	NM-TB 01	Pits at the landfill site of Vu Quy commune, Kien Xuong district	Pits for 746 pigs (>6 months)	8.3	28.9	2.8	123	160	18.9	43.8	0.82	2.5	28.7	19.8	8.3	$16x10^3$
	NM-TB 02			8.0	29.2	3.2	118	165	19.2	41.2	0.75	3.2	29.5	17.4	5.6	$15x10^3$
	NM-TB 03	Pits at the landfill site of Doan Ket village, Binh Dinh commune, Kien Xuong district	Pits for 412 pigs (from 6 April to 20 July 2020)	7.2	29.0	3.1	119	145	22.3	40.9	0.7	2.8	18.4	16.3	5.2	$14x10^3$
	NM-TB 04			6.8	30.2	2.9	126	137	20.1	42.6	0.64	3.3	18.9	17.2	4.7	$13x10^3$
	NM-TB 05	Pits at the landfill site of Binh Minh commune, Kien Xuong district	Divided into 05 pits with a total of 1,083 pigs (from 23 March to 08 July 2020)	6.72	28.7	4.3	108	139	19.2	42.8	0.53	2.7	18.2	8.9	5.6	$12x10^3$
	NM-TB 06			7.32	27.5	4.4	112	132	22.95	40.8	0.45	3.0	17.9	7.9	4.7	$15x10^3$

Local	The sample code	Survey and sampling area	Pit characteristics	pH	Temperature	DO	EC	TDS	BOD_5	COD	NH_4^+	NO_2-	NO_3-	PO_4^{3-}	Total oil, grease	E.Coli
				-	^0C	mg/L	mS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	VK/100 mL
Nam Dinh	NM-ND 01	Public land area of Hong Thuan commune, Giao Thuy district	Pits for 85 pigs, 3m depth (>6 months)	8.5	26.3	2.48	35	210	141.3	216.7	27.2	2.4	31.7	19.8	8.2	$18x10^3$
	NM-ND 02			8.8	27.6	2.88	41	220	145.6	228.2	28.5	2.8	30.3	17.2	8.1	$17x10^3$
	NM-ND03	Pits at the field of Giao Nhan commune, Giao Thuy district	Pits for 97 pigs (from 3 to 6 months)	7.5	25.3	2.32	32	230	135.2	206.7	25.2	3.1	28.7	20.2	7.4	$16x10^3$
	NM-ND04			8.1	26.6	2.52	37	210	133.8	212.2	24.5	2.9	29.3	19.8	7.6	$14x10^3$
	NM-ND05	Pit at the disposal area of Ngo Dong town, Giao Thuy district	Pits for 103 pigs, 3m depth (from 3 to 6 months)	7.2	27.7	2.54	28	180	127.7	254.2	28.2	4.1	32.2	23.2	7.9	$15x10^3$
	NM-ND06			7.6	26.8	2.65	32	175	130.2	264.2	27.4	3.9	33.4	24.8	8.2	$16x10^3$
Thua Thien Hue	NM-TTH 01	Pits at Phong Son commune, Phong Dien district	Pits for 2,105 pigs, 3m depth; in high ground, sprinkled with lime powder (from 6 July to 09 August 2019)	8.1	25.6	2.41	34	644	286.5	803.4	179.4	20.1	57.9	66.6	38	$15x10^3$
	NM-TTH 02			8.6	25.2	2.24	37	657	289.8	815.8	188.5	19.8	60.6	68.5	40	$17x10^3$

Local	The sample code	Survey and sampling area	Pit characteristics	pH	Temperature	DO	EC	TDS	BOD_5	COD	NH_4^+	NO_2-	NO_3-	PO_4^{3-}	Total oil, grease	E.Coli
				-	^0C	mg/L	mS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	VK/100 mL
	NM-TTH 03	Pits at Mr. Thang's household, Phong Thu commune, Phong Dien district	Pits for 111 pigs (from 3 to 6 months)	9.5	26.4	2.66	37	739	329.1	957.8	157.6	18.9	66.6	70.3	39	$18x10^3$
	NM-TTH 04			8.7	27.6	2.72	39	744	338.4	963.5	144.3	20.2	70.4	65.7	42	$19x10^3$
Quang Nam	NM-QN 01	Pits at Duy Nghia commune, Duy Xuyen district	Divided into 3 pits for 814 pigs, 3m depth (from 6 July 2019 to 9 August 2019)	8.2	26.7	2.51	135	180	189.8	266.7	44.5	4.3	29.7	19.8	9.4	$19x10^3$
	NM-QN 02			6.8	22.5	1.87	123	152	108.7	221.4	22.1	2.1	22.8	12.7	7.3	$12x10^3$
	NM-QN 03	Pits at Duy Thanh commune, Duy Xuyen district	Pits for 45 pigs, 3m depth; in the garden, 1 side is garden; household using well water (from 3 to 6 months)	8.5	27.7	2.71	143	184	184.8	261.7	44.3	4.8	29.6	19.4	9.6	$18x10^3$
	NM-QN 04			6.5	21.5	1.67	126	152	107.7	221.0	22.0	2.3	22.3	12.2	7.2	$10x10^3$
Dong Nai	NM-DN 01	Pit at Mr. Hoc's household in Vinh An town, Vinh	Divided into 5 pits for 2,118 pigs; within the farm, there is a pond 5m from the	8.2	26.3	2.48	135	180	135.8	289.7	25.5	3.3	28.3	16.8	8.5	$18x10^3$

Local	The sample code	Survey and sampling area	Pit characteristics	pH	Temperature	DO	EC	TDS	BOD_5	COD	NH_4^+	NO_2-	NO_3-	PO_4^{3-}	Total oil, grease	E.Coli
				-	^0C	mg/L	mS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	VK/100 mL
	NM- DN 02	Cuu district	pits; pits have a phenomenon of lower settlement than buried ground (from September to October 2019)	7.6	24.5	1.8	112	168	108.2	235.5	19.8	2.5	24.5	14.8	7.5	$12x10^3$
	NM- DN 03	Pit at Mr. Long's household, Tan Binh commune, Vinh Cuu district	Pits for 520 pigs (from 3 to 6 months)	6.9	28.8	2.3	88	145	89	135	18.6	2.6	18.5	15.4	4.3	$12x10^3$
	NM- DN 04			7.2	29.3	2.5	92	136	76	143.2	17.8	2.4	16.7	13.7	4.9	$13x10^3$
	NM- DN 05	Pits at Mrs. Ut Tam's household, Tan An commune, Vinh Cuu district	Pits for 362 pigs, in the garden, one side is the barn, the other 3 sides are fruit trees (from 3 to 6 months)	6.82	27.6	3.2	99	145	76	136.5	21.5	3.4	17.4	8.8	5.3	$14x10^3$
	NM- DN 06			6.89	28.2	3.1	102	158	82	142.8	19.8	3.9	16.9	9.2	4.6	$15x10^3$
Vinh Long	NM-VL 01	Pits at household 62/59, hamlet 6, ward 5,	Pits for 68 pigs (buried on 21 May 2019), in gardens - the area used to be a	7.05	29.0	2.48	85	450	109.8	235.7	14.5	No detection	No detection	7.5	3.5	$11x10^3$

Local	The sample code	Survey and sampling area	Pit characteristics	pH	Temperature	DO	EC	TDS	BOD_5	COD	NH_4^+	NO_2-	NO_3-	PO_4^{3-}	Total oil, grease	E.Coli
				-	^0C	mg/L	mS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	VK/100 mL
	NM-VL 02	Vinh Long city	canal to irrigate in the garden, to grow fruit trees surrounding and breeding many ducks freely; using tap water (<3 months)	6.98	30.0	2.51	81	428	126.2	245.8	13.6	No detection	No detection	6.8	3.8	$12x10^3$
	NM-VL 03	Pits at Mrs. Lan's household, ward 8, Vinh Long city	Pits for 394 pigs, in the garden, planting fruit trees, close to the breeding area; there is odors at monitoring duration; using clean water (burial period <30 days)	7.08	29.7	3.29	88	389	16	183.2	1.11	0.04	1.68	0.4	3.1	$2,4x10^3$
	NM-VL 04			6.95	30.2	2.7	92	375	16	185.1	1.02	No detection	No detection	6.3	3.0	$2,4x10^3$
Can Tho	NM-CT 01	Pits at Mr. Tha's household, Dinh Mon commune, Thoi Lai district	Pits for 106 pigs (buried on 16 June 2019), in the garden, one side is a rice field, one side is a tomb of the family, the two other sides are gardens with pepper and fruit trees	6.97	29.5	1.04	32	686	11	22	1.11	No detection	No detection	0.14	0.7	$1,1 x10^3$
	NM-CT 02			8.1	30.0	2.27	37	672	13	28	1.23	No detection	No detection	0.22	0.75	$17x10^3$

Local	The sample code	Survey and sampling area	Pit characteristics	pH	Temperature	DO	EC	TDS	BOD_5	COD	NH_4^+	NO_2-	NO_3-	PO_4^{3-}	Total oil, grease	E.Coli
				-	^0C	mg/L	mS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	VK/100 mL
	NM-CT 03	Pits at Mrs Thuy's household, Dong Thuan commune, Thoi Lai district	Pits for 64 pigs (buried on 27 May 2019); in the garden, one side close to the barn, the other three sides are gardens with fruit trees; households use well water (depth of wells is over 100m, 100m from burial pits)	7.36	32.7	7.19	33	203	4.6	42	0.17	No detection	No detection	0.02	0.6	4,6 x10^3
	NM-CT 04			8.9	32.3	2.83	35	667	234.5	477	24.62	No detection	No detection	2.78	0.7	1,6 x10^3
	QCVN 08-MT:2015/BTNMT			**5.5-9**	**-**	**≥4**	**-**	**-**	**15**	**30**	**0.9**	**0.05**	**10**	**0.3**	**1**	**100**

Table 17. Summarize the results of monitoring and analysis of underground water samples at pits in 10 localities

Local	The sample code	Survey and sampling area	Pit characteristics	pH	Temperature	DO	EC	TDS	Permanganate index	NH_4^+	NO_2-	NO_3-	E.coli
				-	^{0}C	mg/L	mS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	VK/100 mL
Ha Noi	NN-HN 01	Pits in the cemetery area of Yen Thai village, Dong Yen commune, Quoc Oai district	Divided into 2 pits, buried 632 pigs (from 3 to 6 months)	7.6	30.2	6.9	50	56	No detection	1.82	No detection	No detection	No detection
	NN-HN 02			6.65	29.7	7.5	45	48	No detection	1.63	No detection	No detection	No detection
	NN-HN 03	Pits near the landfill site in Phuong Cach commune, Quoc Oai district	Pits for 112 pigs, in the yard (from 3 to 6 months)	7.8	29.6	6.9	49	50	No detection	1.82	No detection	No detection	No detection
	NN-HN 04			6.4	27.7	7.1	42	45	No detection	1.58	No detection	No detection	No detection
	NN-HN 05	Pits in cemetery area of Hoa Thach commune, Quoc Oai district	Pits for 425 pigs (from 3 to 6 months)	7.5	30.2	6.6	48	55	No detection	1.62	No detection	No detection	No detection
	NN-HN 06			6.35	29.7	7.4	42	43	No detection	1.58	No detection	No detection	No detection
	NN-HN 07	Pits in the rice field of Ngoc My commune, Quoc Oai district	Divided into 5 pits, buried 926 pigs (>6 months)	7.7	29.7	6.9	50	55	No detection	1.67	No detection	No detection	No detection
	NN-HN 08			6.65	28.1	7.4	45	44	No detection	1.50	No detection	No detection	No detection
	NN-HY 01	Pits at landfill site of An Vi	Pits for 509 pigs, divided into 3 small	6.65	26.4	7.6	42	52	No detection	1.52	No detection	No detection	No detection

Local	The sample code	Survey and sampling area	Pit characteristics	pH	Temperature	DO	EC	TDS	Permanganate index	NH_4^+	NO_2-	NO_3-	E.coli
				-	^{0}C	mg/L	mS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	VK/100 mL
Hung Yen	NN-HY 02	commune, Khoai Chau district	pits, about 3m depth, covered grass on the surface (>6 months)	6.72	27.1	7.8	45	55	No detection	1.63	No detection	No detection	No detection
	NN-HY 03	Pits in a rice field near the people's cemetery area in Chi Tan commune, Khoai Chau district	Pits for 838 pigs, about 2m depth, covered HDPE film around and on the surface (>6 months)	6.68	27.9	8.3	39	48	No detection	1.38	No detection	No detection	No detection
	NN-HY 04			6.73	28.2	8.6	41	51	No detection	1.41	No detection	No detection	No detection
	NN-HY 05	Pits at the landfill site of Yen Lich village, Dan Tien commune, Khoai Chau district	Pits for 143 pigs, about 2m depth, covered grass (>6 months)	6.77	26.1	8.6	35	39	No detection	1.49	No detection	No detection	No detection
	NN-HY 06			6.89	25.5	8.8	38	40	No detection	1.55	No detection	No detection	No detection
Hai Duong	NN-HD 01	Pits at the agricultural land area of Phu Lien village, Hong Phong commune, Nam Sach district	Divided into 08 pits with 3,124 pigs, covered with soil and grass on top (>6 months)	7.9	30.1	7.3	56	61	No detection	1.75	No detection	No detection	No detection
	NN-HD 02			6.53	29.4	6.9	47	47	No detection	1.64	No detection	No detection	No detection
	NN-HD 03	Pits outside the landfill site of Nam Trung	Pits for 496 pigs, about 2m depth, covered with HDPE	7.9	30.5	7.6	60	61	No detection	1.77	No detection	No detection	No detection

Local	The sample code	Survey and sampling area	Pit characteristics	pH	Temperature	DO	EC	TDS	Permanganate index	NH_4^+	NO_2-	NO_3-	E.coli
				-	^{0}C	mg/L	mS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	VK/100 mL
	NN-HD 04	commune, Nam Sach district	film around and on the surface (>6 months)	6.43	29.7	6.3	46	43	No detection	1.60	No detection	No detection	No detection
	NN-HD 05	Pits at landfill site of Hiep Cat commune, Nam Sach District	Divided into 04 pits with 2,012 pigs, about 2m depth, covered with HDPE film around and on the surface (>6 months)	7.8	30.4	7.0	59	61	No detection	1.79	No detection	No detection	No detection
	NN-HD 06			6.42	29.2	6.8	45	42	No detection	1.54	No detection	No detection	No detection
Thai Binh	NN-TB 01	Pits at the landfill site of Vu Quy commune, Kien Xuong district	Pits for 746 pigs (>6 months)	6.89	29.3	7.4	47	53	No detection	1.82	No detection	No detection	No detection
	NN-TB 02			7.03	28.9	8.3	54	49	No detection	1.91	No detection	No detection	No detection
	NN-TB 03	Pits at the landfill site of Doan Ket village, Binh Dinh commune, Kien Xuong district	Pits for 412 pigs (from 6 April to 20 July 2020)	6.92	28.9	7.5	43	47	No detection	1.79	No detection	No detection	No detection
	NN-TB 04			7.01	29.6	6.9	54	55	No detection	1.82	No detection	No detection	No detection
	NN-TB 05	Pits at the landfill site of Binh Minh commune, Kien Xuong district	Divided into 05 pits with a total of 1,083 pigs (from 23 March to 08 July 2020)	7.03	28.7	7.8	45	39	No detection	1.69	No detection	No detection	No detection
	NN-TB 06			6.83	29.0	8.2	49	42	No detection	1.72	No detection	No detection	No detection

Local	The sample code	Survey and sampling area	Pit characteristics	pH	Temperature	DO	EC	TDS	Permanganate index	NH_4^+	NO_2-	NO_3-	E.coli
				-	^{0}C	mg/L	mS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	VK/100 mL
Nam Dinh	NN-ND 01	Public land area of Hong Thuan commune, Giao Thuy district	Pits for 85 pigs, 3m depth (>6 months)	6.75	27.1	8.1	38	38	No detection	1.63	No detection	No detection	No detection
	NN-ND02			6.85	28.5	8.3	42	44	No detection	1.71	No detection	No detection	No detection
	NN-ND03	Pits at the field of Giao Nhan commune, Giao Thuy district	Pits for 97 pigs (from 3 to 6 months)	6.95	28.2	7.9	41	38	No detection	1.45	No detection	No detection	No detection
	NN-ND04			7.12	28.8	7.3	43	41	No detection	1.55	No detection	No detection	No detection
	NN-ND05	Pit at the disposal area of Ngo Dong town, Giao Thuy district	Pits for 103 pigs, 3m depth (from 3 to 6 months)	7.12	29.6	7.7	45	37	No detection	1.73	No detection	No detection	No detection
	NN-ND06			7.22	28.7	8.4	42	38	No detection	1.81	No detection	No detection	No detection
Thua Thien Hue	NN-TTH 01	Pits at Phong Son commune, Phong Dien district	Pits for 2,105 pigs, 3m depth; in high ground, sprinkled with lime powder (from 6 July to 09 August 2019)	6.94	27.3	6.6	44	45	No detection	1.84	No detection	No detection	No detection
	NN-TTH 02			6.86	26.8	6.3	40	49	No detection	1.77	No detection	No detection	No detection
	NN-TTH 03	Pits at Mr. Thang's household, Phong Thu commune, Phong Dien district	Pits for 111 pigs (from 3 to 6 months)	6.78	27.5	6.4	36	40	No detection	1.55	No detection	No detection	No detection
	NN-TTH 04			6.82	26.6	6.8	38	44	No detection	1.46	No detection	No detection	No detection

Local	The sample code	Survey and sampling area	Pit characteristics	pH	Temperature	DO	EC	TDS	Permanganate index	NH_4^+	NO_2-	NO_3-	E.coli
				-	^{0}C	mg/L	mS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	VK/100 mL
Quang Nam	NN-QN 01	Pits at Duy Nghia commune, Duy Xuyen district	Divided into 3 pits for 814 pigs, 3m depth (from 6 July 2019 to 9 August 2019)	8.1	29.7	7.4	57	63	No detection	1.73	No detection	No detection	No detection
	NN-QN 02			7.2	28.5	7.0	43	49	No detection	1.62	No detection	No detection	No detection
	NN-QN 03	Pits at Duy Thanh commune, Duy Xuyen district	Pits for 45 pigs, 3m depth; in the garden, 1 side is garden; household using well water (from 3 to 6 months)	8.6	30.7	7.7	62	59	No detection	1.77	No detection	No detection	No detection
	NN-QN 04			7.3	30.5	7.3	51	44	No detection	1.65	No detection	No detection	No detection
Dong Nai	NN-DN 01	Pit at Mr. Hoc's household in Vinh An town, Vinh Cuu district	Divided into 5 pits for 2,118 pigs; within the farm, there is a pond 5m from the pits; pits have a phenomenon of lower settlement than buried ground (from September to October 2019)	7.2	29.2	6.8	46	52	No detection	1.72	No detection	No detection	No detection
	NN- DN 02			6.95	28.7	7.9	43	49	No detection	1.68	No detection	No detection	No detection
	NN- DN 03	Pit at Mr. Long's household, Tan Binh commune, Vinh Cuu district	Pits for 520 pigs (from 3 to 6 months)	6.87	28.3	7.4	42	36	No detection	1.58	No detection	No detection	No detection
	NN- DN 04			7.02	27.9	7.8	44	42	No detection	1.62	No detection	No detection	No detection

Local	The sample code	Survey and sampling area	Pit characteristics	pH	Temperature	DO	EC	TDS	Permanganate index	NH_4^+	NO_2-	NO_3-	E.coli
				-	^{0}C	mg/L	mS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	VK/100 mL
	NN- DN 05	Pits at Mrs. Ut Tam's household, Tan An commune, Vinh Cuu district	Pits for 362 pigs, in the garden, one side is the barn, the other 3 sides are fruit trees (from 3 to 6 months)	6.82	27.3	7.8	45	38	No detection	1.68	No detection	No detection	No detection
	NN- DN 06			7.14	27.8	7.9	47	43	No detection	1.71	No detection	No detection	No detection
Vinh Long	NN-VL01	Pits at household 62/59, hamlet 6, ward 5, Vinh Long city	Pits for 68 pigs (buried on 21 May 2019), in gardens - the area used to be a canal to irrigate in the garden, to grow fruit trees surrounding and breeding many ducks freely; using tap water (<3 months)	7.02	26.3	7.4	36	145	No detection	1.35	No detection	No detection	No detection
	NN-VL 02			7.15	25.8	7.2	45	158	No detection	1.42	No detection	No detection	No detection
	NN-VL 03	Pits at Mrs. Lan's household, ward 8, Vinh Long city	Pits for 394 pigs, in the garden, planting fruit trees, close to the breeding area; there is odors at monitoring duration; using clean water (burial period <30 days)	6.95	26.6	7.8	34	133	No detection	1.45	No detection	No detection	No detection
	NN-VL 04			6.88	26.8	7.9	36	138	No detection	1.46	No detection	No detection	No detection

Local	The sample code	Survey and sampling area	Pit characteristics	pH	Temperature	DO	EC	TDS	Permanganate index	NH_4^+	NO_2-	NO_3-	E.coli
				-	^{0}C	mg/L	mS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	VK/100 mL
Can Tho	NN-CT 01	Pits at Mr. Tha's household, Dinh Mon commune, Thoi Lai district	Pits for 106 pigs (buried on 16 June 2019), in the garden, one side is a rice field, one side is a tomb of the family, the two other sides are gardens with pepper and fruit trees	6.77	29.1	8.4	47	50	No detection	1.65	No detection	No detection	No detection
	NN-CT 02			6.89	30.2	8.8	52	55	No detection	1.72	No detection	No detection	No detection
	NN-CT 03	Pits at Mrs Thuy's household, Dong Thuan commune, Thoi Lai district	Pits for 64 pigs (buried on 27 May 2019); in the garden, one side close to the barn, the other three sides are gardens with fruit trees; households use well water (depth of wells is over 100m, 100m from burial pits)	6.92	30.5	7.8	42	50	No detection	1.83	No detection	No detection	No detection
	NN-CT 04			6.94	31.2	8.2	46	52	No detection	1.71	No detection	No detection	No detection
QCVN 09-MT:2015/BTNMT				**5.5-8.5**	**-**		**-**	**-**	**1500**	**1**	**1**	**15**	**No detection**

Table 18. Summarize the results of monitoring and analysis of ambient air samples at pits in 10 localities

Local	The sample code	Survey and sampling area	Pit characteristics	Temperature	Humidity	Wind speed	Wind direction	NH_3	Methyl mercaptan	Hydrosunfua (H_2S)
				^0C	%	m/s	^{0}	µg/m^3	µg/m^3	µg/m^3
Ha Noi	KK-HN 01	Pits in the cemetery area of Yen Thai village, Dong Yen commune, Quoc Oai district	Divided into 2 pits, buried 632 pigs (from 3 to 6 months)	30.1	57	0.54	57	36.5	4.9	26.6
	KK-HN 02			30.2	54	0.59	54	32.6	5.5	23.8
	KK-HN 03	Pits near the landfill site in Phuong Cach commune, Quoc Oai district	Pits for 112 pigs, in the yard (from 3 to 6 months)	30.5	55	0.53	57	31.3	4.6	29.2
	KK-HN 04			31.2	56	0.50	54	32.1	4.8	22.7
	KK-HN 05	Pits in cemetery area of Hoa Thach commune, Quoc Oai district	Pits for 425 pigs (from 3 to 6 months)	30.7	60	0.62	52	33.3	4.7	28.7
	KK-HN 06			31.1	54	0.52	50	33.7	4.9	23.3
	KK-HN 07	Pits in the rice field of Ngoc My commune, Quoc Oai district	Divided into 5 pits, buried 926 pigs (>6 months)	30.3	58	0.61	57	33.3	4.1	29.2
	KK-HN 08			31.1	54	0.52	52	33.9	4.2	26.3
Hung Yen	KK-HY 01	Pits at landfill site of An Vi commune, Khoai Chau district	Pits for 509 pigs, divided into 3 small pits, about 3m depth, covered grass on the surface (>6 months)	27.8	58	0.55	59	39.9	4.4	29.9
	KK-HY 02			28.3	59	0.53	62	38.5	4.8	28.4
	KK-HY 03	Pits in a rice field near the people's cemetery area in Chi Tan commune, Khoai Chau district	Pits for 838 pigs, about 2m depth, covered HDPE film around and on the surface (>6 months)	28.3	58	0.59	63	38.4	3.9	25.8
	KK-HY 04			28.7	56	0.60	61	39.2	4.2	25.1
	KK-HY 05	Pits at the landfill site of Yen Lich village, Dan Tien	Pits for 143 pigs, about 2m depth, covered grass (>6	30.4	58	0.58	60	33.7	4.5	25.5

Local	The sample code	Survey and sampling area	Pit characteristics	Temperature	Humidity	Wind speed	Wind direction	NH_3	Methyl mercaptan	Hydrosunfua (H_2S)
				^0C	%	m/s	^{0}	µg/m^3	µg/m^3	µg/m^3
	KK-HY 06	commune, Khoai Chau district	months)	29.6	54	0.54	62	36.5	4.2	21.5
Hai Duong	KK-HD 01	Pits at the agricultural land area of Phu Lien village, Hong Phong commune, Nam Sach district	Divided into 08 pits with 3,124 pigs, covered with soil and grass on top (>6 months).	29.5	45	0.46	58	19.5	3.2	16.9
	KK-HD 02			28.8	46	0.47	56	18.8	3.5	17.2
	KK-HD 03	Pits outside the landfill site of Nam Trung commune, Nam Sach district	Pits for 496 pigs, about 2m depth, covered with HDPE film around and on the surface (>6 months)	28.5	48	0.48	55	18.5	3.3	17.9
	KK-HD 04			28.1	49	0.46	56	19.2	3.6	17.8
	KK-HD 05	Pits at landfill site of Hiep Cat commune, Nam Sach District	Divided into 04 pits with 2,012 pigs, about 2m depth, covered with HDPE film around and on the surface (>6 months)	29.1	47	0.44	52	19.8	3.6	16.9
	KK-HD 06			28.9	46	0.43	51	18.5	3.9	16.5
Thai Binh	KK-TB 01	Pits at the landfill site of Vu Quy commune, Kien Xuong district	Pits for 746 pigs (>6 months)	29.5	47	0.47	53	32.3	4.4	26.5
	KK-TB 02			29.8	48.7	0.52	56	33.8	4.8	25.8
	KK-TB 03	Pits at the landfill site of Doan Ket village, Binh Dinh commune, Kien Xuong district	Pits for 412 pigs (from 6 April to 20 July 2020)	30.1	49	0.55	51	37.4	4.5	25.6
	KK-TB 04			31.2	47	0.58	49	38.2	4.8	24.7
	KK-TB 05	Pits at the landfill site of Binh Minh commune, Kien Xuong district	Divided into 05 pits with a total of 1,083 pigs (from 23 March to 08 July 2020)	30.5	50	0.48	53	33.8	3.9	21.9
	KK-TB 06			30.8	48	0.46	52	32.7	4.1	22.5

Local	The sample code	Survey and sampling area	Pit characteristics	Temperature	Humidity	Wind speed	Wind direction	NH_3	Methyl mercaptan	Hydrosunfua (H_2S)
				^0C	%	m/s	^{0}	µg/m^3	µg/m^3	µg/m^3
Nam Dinh	KK-ND 01	Public land area of Hong Thuan commune, Giao Thuy district	Pits for 85 pigs, 3m depth (>6 months)	27.5	59	0.74	60	36.5	4.2	28.6
	KK- ND02			28.8	63	0.65	62	34.8	4.7	27.8
	KK- ND03	Pits at the field of Giao Nhan commune, Giao Thuy district	Pits for 97 pigs (from 3 to 6 months)	28.5	57	0.58	54	35.5	4.8	23.6
	KK- ND04			27.2	59	0.62	57	33.6	5.2	25.8
	KK- ND05	Pit at the disposal area of Ngo Dong town, Giao Thuy district	Pits for 103 pigs, 3m depth (from 3 to 6 months)	26.5	63	0.49	57	34.7	4.7	27.6
	KK- ND06			27.2	64	0.45	59	35.6	4.9	26.5
Thua Thien Hue	KK-TTH 01	Pits at Phong Son commune, Phong Dien district	Pits for 2,105 pigs, 3m depth; in high ground, sprinkled with lime powder (from 6 July to 09 August 2019)	29.8	54	0.57	58	37.9	4.1	28.8
	KK-TTH 02			30.6	51	0.52	61	39.4	4.5	26.5
	KK-TTH 03	Pits at Mr. Thang's household, Phong Thu commune, Phong Dien district	Pits for 111 pigs (from 3 to 6 months)	30.4	59	0.55	56	38.2	4.6	25.8
	KK-TTH 04			29.2	56	0.59	52	37.5	4.8	27.3
Quang Nam	KK-QN 01	Pits at Duy Nghia commune, Duy Xuyen district	Divided into 3 pits for 814 pigs, 3m depth (from 6 July 2019 to 9 August 2019)	29.8	64	0.62	59	35.2	5.1	27.8
	KK-QN 02			29.6	60	0.56	60	31.3	5.3	24.1
	KK-QN 03	Pits at Duy Thanh commune, Duy Xuyen district	Pits for 45 pigs, 3m depth; in the garden, 1 side is garden; household using well water (from 3 to 6 months)	29.5	67	0.67	54	36.2	5.5	27.6
	KK-QN 04			28.6	59	0.52	62	32.3	5.0	24.4

Local	The sample code	Survey and sampling area	Pit characteristics	Temperature	Humidity	Wind speed	Wind direction	NH_3	Methyl mercaptan	Hydrosunfua (H_2S)
				^0C	%	m/s	^{0}	µg/m^3	µg/m^3	µg/m^3
Dong Nai	KK-DN 01	Pit at Mr. Hoc's household in Vinh An town, Vinh Cuu district	Divided into 5 pits for 2,118 pigs; within the farm, there is a pond 5m from the pits; pits have a phenomenon of lower settlement than buried ground (from September to October 2019)	30.5	55	0.51	55	35.5	4.8	25.6
	KK- DN 02			31.2	56	0.58	58	33.6	5.2	22.8
	KK- DN 03	Pit at Mr. Long's household, Tan Binh commune, Vinh Cuu district	Pits for 520 pigs (from 3 to 6 months)	29.5	53	0.56	54	36.8	4.3	23.6
	KK- DN 04			29.2	54	0.51	55	37.3	4.7	25.8
	KK- DN 05	Pits at Mrs. Ut Tam's household, Tan An commune, Vinh Cuu district	Pits for 362 pigs, in the garden, one side is the barn, the other 3 sides are fruit trees (from 3 to 6 months)	29.8	58	0.46	52	32.7	3.8	19.5
	KK- DN 06			31.2	59	0.48	54	33.3	4.2	21.4
Vinh Long	KK-VL01	Pits at household 62/59, hamlet 6, ward 5, Vinh Long city	Pits for 68 pigs (buried on 21 May 2019), in gardens - the area used to be a canal to irrigate in the garden, to grow fruit trees surrounding and breeding many ducks freely; using tap water (<3 months)	28.7	55	0.46	54	21.5	4.2	18.5
	KK-VL 02			29.5	58	0.47	57	19.8	4.3	19.2
	KK-VL 03	Pits at Mrs. Lan's household, ward 8, Vinh Long city	Pits for 394 pigs, in the garden, planting fruit trees, close to the breeding area; there is odors at monitoring duration; using clean water (burial period <30 days)	29.9	58	0.49	56	158.3	4.6	16.5
	KK-VL 04			30.1	59	0.51	58	21.8	4.5	18.1

Local	The sample code	Survey and sampling area	Pit characteristics	Temperature	Humidity	Wind speed	Wind direction	NH_3	Methyl mercaptan	Hydrosunfua (H_2S)
				^0C	%	m/s	^{0}	µg/m^3	µg/m^3	µg/m^3
Can Tho	KK-CT 01	Pits at Mr. Tha's household, Dinh Mon commune, Thoi Lai district	Pits for 106 pigs (buried on 16 June 2019), in the garden, one side is a rice field, one side is a tomb of the family, the two other sides are gardens with pepper and fruit trees	29.5	55	0.75	60	21.5	2.8	17.8
	KK-CT 02			28.7	56	0.76	62	22.1	3.2	18.5
	KK-CT 03	Pits at Mrs Thuy's household, Dong Thuan commune, Thoi Lai district	Pits for 64 pigs (buried on 27 May 2019); in the garden, one side close to the barn, the other three sides are gardens with fruit trees; households use well water (depth of wells is over 100m, 100m from burial pits).	30.5	58	0.73	59	19.8	3.2	17.8
	KK-CT 04			31.5	59	0.74	58	18.8	3.5	17.2
QCVN 06:2009/ BTNMT				**-**	**-**	**-**	**-**	**200**	**50**	**42**

Table 19. Summarize the results of monitoring and analysis of soil samples at pits in 10 localities

Local	The sample code	Survey and sampling area	Pit characteristics	ASFV
Ha Noi	Đ-HN 01	Pits in the cemetery area of Yen Thai village, Dong Yen commune, Quoc Oai district	Divided into 2 pits, buried 632 pigs (from 3 to 6 months)	No detection
	Đ-HN 02			No detection
	Đ-HN 03			No detection
	Đ-HN 04			No detection
	Đ-HN 05	Pits near the landfill site in Phuong Cach commune, Quoc Oai district	Pits for 112 pigs, in the yard (from 3 to 6 months)	No detection
	Đ-HN 06			No detection
	Đ-HN 07			No detection
	Đ-HN 08			No detection
	Đ-HN 09	Pits in cemetery area of Hoa Thach commune, Quoc Oai district	Pits for 425 pigs (from 3 to 6 months)	No detection
	Đ-HN 10			No detection
	Đ-HN 11			No detection
	Đ-HN 12			No detection
	Đ-HN 13	Pits in the rice field of Ngoc My commune, Quoc Oai district	Divided into 5 pits, buried 926 pigs (>6 months)	No detection
	Đ-HN 14			No detection
	Đ-HN 15			No detection
	Đ-HN 16			No detection
Hung Yen	Đ-HY 01	Pits at landfill site of An Vi commune, Khoai Chau district	Pits for 509 pigs, divided into 3 small pits, about 3m depth, covered grass on the surface (>6 months)	No detection
	Đ-HY 02			No detection
	Đ-HY 03			No detection
	Đ-HY 04			No detection
	Đ-HY 05	Pits in a rice field near the people's cemetery area in Chi Tan commune, Khoai Chau district	Pits for 838 pigs, about 2m depth, covered HDPE film around and on the surface (>6 months)	No detection
	Đ-HY 06			No detection
	Đ-HY 07			No detection
	Đ-HY 08			No detection
Hai Duong	Đ-HD 01	Pits at the agricultural land area of Phu Lien village, Hong Phong commune, Nam Sach district	Divided into 08 pits with 3,124 pigs, covered with soil and grass on top (>6 months).	No detection
	Đ-HD 02			No detection
	Đ-HD 03			No detection
	Đ-HD 04			No detection
	Đ-HD 05	Pits outside the landfill site of Nam Trung commune, Nam	Pits for 496 pigs, about 2m depth, covered with HDPE film around	No detection
	Đ-HD 06			No detection

Local	The sample code	Survey and sampling area	Pit characteristics	ASFV
	Đ-HD 07	Sach district	and on the surface (>6 months)	No detection
	Đ-HD 08			No detection
Thai Binh	Đ-TB 01	Pits at the landfill site of Vu Quy commune, Kien Xuong district	Pits for 746 pigs (>6 months)	No detection
	Đ-TB 02			No detection
	Đ-TB 03			No detection
	Đ-TB 04			No detection
	Đ-TB 05	Pits at the landfill site of Doan Ket village, Binh Dinh commune, Kien Xuong district	Pits for 412 pigs (from 6 April to 20 July 2020)	No detection
	Đ-TB 06			No detection
	Đ-TB 07			No detection
	Đ-TB 08			No detection
Nam Dinh	Đ-ND 01	Public land area of Hong Thuan commune, Giao Thuy district	Pits for 85 pigs, 3m depth (>6 months)	No detection
	Đ- ND02			No detection
	Đ- ND03			No detection
	Đ- ND04			No detection
	Đ- ND05	Pits at the field of Giao Nhan commune, Giao Thuy district	Pits for 97 pigs (from 3 to 6 months)	No detection
	Đ- ND06			No detection
	Đ- ND07			No detection
	Đ- ND08			No detection
TT - Hue	Đ-TTH 01	Pits at Phong Son commune, Phong Dien district	Pits for 2,105 pigs, 3m depth; in high ground, sprinkled with lime powder (from 6 July to 09 August 2019)	No detection
	Đ-TTH 02			No detection
	Đ-TTH 03			No detection
	Đ-TTH 04			No detection
Quang Nam	Đ-QN 01	Pits at Duy Nghia commune, Duy Xuyen district	Divided into 3 pits for 814 pigs, 3m depth (from 6 July 2019 to 9 August 2019)	No detection
	Đ-QN 02			No detection
	Đ-QN 03			No detection
	Đ-QN 04			No detection
Dong Nai	Đ-DN 01	Pit at Mr. Hoc's household in Vinh An town, Vinh Cuu district	Divided into 5 pits for 2,118 pigs; within the farm, there is a pond 5m from the pits; pits have a phenomenon of lower settlement than buried ground (from September to October 2019)	>1
	Đ- DN 02			No detection
	Đ- DN 03	Pit at Mr. Long's household, Tan Binh commune, Vinh Cuu district		>1
	Đ- DN 04		Pits for 520 pigs (from 3 to 6 months)	No detection

Local	The sample code	Survey and sampling area	Pit characteristics	ASFV
	Đ- DN 05	Pit at Mr. Hoc's household in Vinh An town, Vinh Cuu district	Divided into 5 pits for 2,118 pigs; within the farm, there is a pond 5m from the pits; pits have a phenomenon of lower settlement than buried ground (from September to October 2019)	No detection
	Đ- DN 06			No detection
	Đ- DN 07			No detection
	Đ- DN 08			No detection
Vinh Long	Đ-VL 01	Pits at household 62/59, hamlet 6, ward 5, Vinh Long city	Pits for 68 pigs (buried on 21 May 2019), in gardens - the area used to be a canal to irrigate in the garden, to grow fruit trees surrounding and breeding many ducks freely; using tap water (<3 months)	>1
	Đ-VL 02			No detection
	Đ-VL 03			>1
	Đ-VL 04			No detection
Can Tho	Đ-CT 01	Pits at Mr. Tha's household, Dinh Mon commune, Thoi Lai district	Pits for 106 pigs (buried on 16 June 2019), in the garden, one side is a rice field, one side is a tomb of the family, the two other sides are gardens with pepper and fruit trees	No detection
	Đ-CT 02			No detection
	Đ-CT 03			No detection
	Đ-CT 04			No detection

ANNEX 3: Survey questionnaires

Form No. 01. For provincial agencies
(Department of Natural Resources and Environment,
Department of Agriculture and Rural Development)

SURVEY QUESTIONNAIRE

MANAGEMENT AND DISPOSAL OF ANIMAL CARCASSES CAUSED BY EPIDEMIC DISEASES AT LOCALITIES

In an effort to evaluate actual situation, analyze environmental safe gathering, transporting and disposal of animal carcass caused by epidemic diseases and pollution control at disposal sites recently to address proposal applicable in animal epidemic disease control, please answer the following questions and provide sufficient information about the arisen situation, disposal of animal carcass caused by epidemic diseases recently. We do believe that your information will be useful for animal epidemic diseases in the time to come.

Sincerely thanks!

I. GENERAL INFORMATION

1. Province: .....

Address: .....

2. Director of Department:

Full name: .....

Telephone: ……Fax: .....

Email: .....

3. Interviewee:

Full name: …… Title /position: .....

Telephone: …… Email: .....

4. Situation of livestock production in localities

4.1. Livestock production scale

No	Items	Unit	Year	
			2018	*2019*
I	**Number of herds**			
1	Buffaloes	Unit		
2	Cows	Unit		
3	Dairy cows	Unit		
4	Pigs	Unit		

No	Items	Unit	Year	
			2018	*2019*
5	Poultry	1,000 units		

4.2. Number of farmhouses, farms in localities

No.	Locality	COW			PIG		POULTRY			
		Number of farmhouses of breeding cows ≥ 5 units	*Number of farmhouses of beef cows ≥ 20 units*	*Number of farmhouses of dairy cows ≥ 5 units*	*Number of farmhouses of sows ≥ 20 units*	*Number of farmhouses of porkers ≥ 100 units*	*Number of farms of broiler chickens ≥ 2,000 units*	*Number of farms of laying hens ≥ 1,000 units*	*Number of farms of ducks ≥ 1,000 units*	*Number of farms of gooses ≥ 1,000 units*
1										
2										
3										
	Total									

5. Information about epidemics:

5.1. Diseases outbreak in two last years in localities

- African swine fever (ASF):

Yes ☐ No ☐

If yes, specify at table 1

- Foot-and-mouth disease:

Yes ☐ No ☐

If yes, specify at table 1

- Avian influenza:

Yes ☐ No ☐

If yes, specify at table 1

- Porcine Reproductive Respiratory Syndrome:

Yes ☐ No ☐

If yes, specify at table 1

- Other diseases:

Yes ☐ No ☐

If yes, specify at table 1

Table 1. Summarization of epidemic development

No	Epidemics	2018				2019			
		Epidemic time	*Epidemic-end time*	*Number of suffering animal*	*Number of disposed of animal*	*Epidemic time*	*Epidemic-end time*	*Number of suffering animals*	*Number of disposed of animals*
1	African swine fever								
2	Foot-and-mouth disease								
3	Porcine Reproductive Respiratory Syndrome								
4	Avian influenza								
5	Other disease, specify								
	Total								

II. DIRECTION AND INSTRUCTION FOR EPIDEMIC DISEASE CONTROL

1. Development of province-level instructive documents

Yes ☐ No ☐

If yes, specify at table 2

Table 2. Summarization of instruments regarding epidemic disease control issued by Provincial People's Committee, Department of Natural Resources and Environment, Department of Agriculture and Rural Development

No.	Documents	Number	Name of documents	Date of issue
1				
2				

2. The role in epidemic disease control

Instruct for epidemic disease control

Yes ☐ No ☐

Control the environmental sanitation at the diseased pig disposal sites

Yes ☐ No ☐

Monitor environmental quality at burial pit

Yes ☐ No ☐

Instruct for safe disposal, collection and treatment of diseased pig waste, disinfection

Yes ☐ No ☐

Instruct for zoning, epidemic outbreak treatment, disinfection, restoring animal husbandry environment after the end of epidemic disease

Yes ☐ No ☐

Instruct for handling unsatisfactory burial pit of diseased pigs

Yes ☐ No ☐

Disseminate the risk of harm from infectious diseases in animals

Yes ☐ No ☐

Other roles (Specify).....

.....

.....

3. Detailed activities for performing responsibilities

- Instruct for implementation of regulation:

Disseminate on mass media (newspapers, radio, television of the province)

Yes ☐ No ☐

Train

Yes ☐ No ☐

Other form (specify): .....

.....

.....

- Monitor, supervise the disposal:

Establish a specialized team

Yes ☐ No ☐

Manage and store information of disposal sites that are diseased

Yes ☐ No ☐

Other form (specify): .....

.....

.....

- Supervise environmental quality at disposal sites:

Implemented by a supervision authority appointed by Department of Natural Resources /Department of Agriculture and Rural Development

Yes ☐ No ☐

Supervision program has been approved

Yes ☐ No ☐

Publicize information and supervision results

Yes ☐ No ☐

Other form (specify): .....

.....

.....

4. Multi-sectoral coordination in epidemic disease control

Coordinate with Department of Industry and Trade, Department of Transport, Market Management Bureau, Public Security of the city, District People's Committees, etc. to strengthen quarantine for transportation of animals and animal products; trading, slaughtering and consumption of livestock products, especially in epidemic and contiguous areas

Yes ☐ No ☐

Coordinate with District People's Committee and relevant units to work out specific

plans to handle disposal of diseased pigs and pig products

Yes ☐ No ☐

Coordinate with Department of Finance to propose funding for epidemic disease control; proposing a plan to support pig farmers whose pigs are disposed of; review and propose funding levels for forces involved in disease control

Yes ☐ No ☐

Coordinate with the Department of Finance and relevant units, urgently advise the City People's Committee to implement policies of agricultural production support to restore production in areas affected by natural disasters and epidemics

Yes ☐ No ☐

Coordinate with the force of public security in combating with smuggling of animals and animal products illegally imported, suspected sign of illegal import or transportation; arrest and strictly handle violations according to legislations

Yes ☐ No ☐

Coordinate with the Department of Information and Communications to provide information to the central and local press agencies and district radio stations to propagate the situation of epidemics; the dangerous nature and serious harms of epidemics and measures for epidemic control

Yes ☐ No ☐

Coordinate with the Vietnam Fatherland Front Committee of the city and mass organizations to take the initiative and join the authorities, relevant departments and cities in epidemic control; disseminate and propaganda to raise people's awareness; encourage people of all strata, agencies and units to actively participate in epidemic control; strengthen inspection and supervision of organizing epidemic control at each level

Yes ☐ No ☐

III. ACTUAL SITUATION OF DISEASED ANIMAL DISPOSAL

1. Collecting, transporting diseased animals/animal carcasses

- Selecting disposal sites:

+ Inside the epidemic area:

Yes ☐ No ☐

+ Outside the epidemic area:

Yes ☐ No ☐

- Chemicals used in transport and disposal:

Yes ☐ No ☐

If available, list chemicals in table 3

Table 3. List of chemicals used

No.	Chemicals	Dosage	Time of usage

- Means of transport:

+ Tight floor:

Yes ☐ No ☐

+ Sanitation and disinfection of means of transport:

Yes ☐ No ☐

2. Measures of disposal performed

2.1. Measure of burying

- Selection of burial sites: .....
.....
.....
.....

- Specification of burial pit: .....
.....
.....
.....
.....

2.2. Measure of burning

- Burning with specialized furnace:

Yes ☐ No ☐

- Manual burning by digging holes, putting bags containing animal carcasses and products into the pits and burning with firewood, coal, straw, gasoline, diesel, etc.

Yes ☐ No ☐

2.3. Other measures

Specify other methods for disposal performed:

.....
.....
.....

Table 4. Summarization of disposal measures

No.	**Locality**	**Measure of burying**		**Measure of burning**		
		Quantity of disposal	*Number of burial pits*	*Quantity*	*Burning with specialized furnace*	*Manual burning*
1						
2						
3						
4						

2.4. Environmental quality supervision at diseased animal carcass disposal sites

- Visual inspection and supervision

Yes ☐ No ☐

If so, specify inspection and supervision agency: .....

.....
.....
.....

- Measuring, sampling and environmental analysis

+ Environmental components:

✓ Surrounding atmosphere:

Yes ☐ No ☐

✓ Surface water:

Yes ☐ No ☐

✓ Groundwater:

Yes ☐ No ☐

✓ Soil:

Yes ☐ No ☐

If yes, specify detailed results: .....
.....
.....
.....

2.5. Proposal and recommendation related to amending regulations on epidemic disease control and diseased animal disposal

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IV. RECOMMENDATION

(Other recommendations related to epidemic disease control)

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……., dated …….. 2020

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<u>Form No. 02.</u> For district and commune levels

SURVEY QUESTIONNAIRE

MANAGEMENT AND DISPOSAL OF ANIMAL CARCASSES CAUSED BY EPIDEMIC DISEASES AT LOCALITIES

In an effort to evaluate actual situation, analyze environmental safe gathering, transporting and disposal of animal carcass caused by epidemic diseases and pollution control at disposal sites recently to address proposal applicable in animal epidemic disease control, please answer the following questions and provide sufficient information about the arisen situation, disposal of animal carcass caused by epidemic diseases recently. We do believe that your information will be useful for animal epidemic diseases in the time to come.

Sincerely thanks!

I. GENERAL INFORMATION

1. District/commune: .....

Address: .....

2. Interviewee:

Full name: …… Title /position: .....

Telephone: …… Email: .....

3. Situation of livestock production in localities

3.1. Livestock production scale

No	Items	Unit	Year	
			2018	2019
I	**Number of herds**			
1	Buffaloes	Unit		
2	Cows	Unit		
3	Dairy cows	Unit		
4	Pigs	Unit		
5	Poultry	1,000 units		

3.2. Number of farmhouses, farms in localities

No.	Locality	COW			PIG		POULTRY			
		Number of farmhouses of breeding cows ≥ 5 units	*Number of farmhouses of beef cows ≥ 20 units*	*Number of farmhouses of dairy cows ≥ 5 units*	*Number of farmhouses of sows ≥ 20 units*	*Number of farmhouses of porkers ≥ 100 units*	*Number of farms of broiler chickens ≥ 2,000 units*	*Number of farms of laying hens ≥ 1,000 units*	*Number of farms of ducks ≥ 1,000 units*	*Number of farms of gooses ≥ 1,000 units*

No.	Locality	COW			PIG		POULTRY			
		Number of farmhouses of breeding cows ≥ 5 units	*Number of farmhouses of beef cows ≥ 20 units*	*Number of farmhouses of dairy cows ≥ 5 units*	*Number of farmhouses of sows ≥ 20 units*	*Number of farmhouses of porkers ≥ 100 units*	*Number of farms of broiler chickens ≥ 2,000 units*	*Number of farms of laying hens ≥ 1,000 units*	*Number of farms of ducks ≥ 1,000 units*	*Number of farms of gooses ≥ 1,000 units*
1										
2										
3										
Total										

4. Information about epidemics:

4.1. Diseases outbreak in two last years in localities

- African swine fever (ASF):

Yes ☐ No ☐

If yes, specify at table 1

- Foot-and-mouth disease:

Yes ☐ No ☐

If yes, specify at table 1

- Avian influenza:

Yes ☐ No ☐

If yes, specify at table 1

- Porcine Reproductive Respiratory Syndrome:

Yes ☐ No ☐

If yes, specify at table 1

- Other diseases:

Yes ☐ No ☐

If yes, specify at table 1

Table 1. Summarization of epidemic development

No	Epidemics	2018				2019			
		Epidemic time	*Epidemic-end time*	*Number of suffering animal*	*Number of disposed of animal*	*Epidemic time*	*Epidemic-end time*	*Number of suffering animals*	*Number of disposed of animals*
1	African swine fever								
2	Foot-and-mouth disease								
3	Porcine Reproductive Respiratory Syndrome								
4	Avian influenza								

No	Epidemics	2018				2019			
		Epidemic time	*Epidemic-end time*	*Number of suffering animal*	*Number of disposed of animal*	*Epidemic time*	*Epidemic-end time*	*Number of suffering animals*	*Number of disposed of animals*
5	*Other disease, specify*								
	Total								

II. DIRECTION AND INSTRUCTION FOR EPIDEMIC DISEASE CONTROL

1. Development of instructive documents

Yes ☐ No ☐

If yes, specify at table 2

Table 2. Summarization of local documents regarding epidemic disease control

No.	Documents	Number	Name of documents	Date of issue
1				
2				

2. The role in epidemic disease control

Develop an Action Plan for epidemic response, establish a Steering Committee for epidemic disease control

Yes ☐ No ☐

Arrange burial areas, do landfill and dispose diseased pigs in a proper measure as instructed by competent authorities

Yes ☐ No ☐

Establish multisectoral inspection missions to check slaughtering places, markets, business locations, street traders with meat products; strictly handle breaches according to regulations

Yes ☐ No ☐

Guide breeders to apply biosecurity measures in livestock production; propagandize and encourage breeders and slaughterhouses to commit implementation of "5 No"

Yes ☐ No ☐

Report on situation of epidemic control, inadequacies and risks of environmental pollution caused by unhygienic burying

Yes ☐ No ☐

3. Performance of responsibilities

- Instruct for implementation of regulation:

Disseminate via mass media at communes, wards

Yes ☐ No ☐

Hold meeting

Yes ☐ No ☐

Distribute leaflets

Yes ☐ No ☐

Other form (specify): .....

.....

.....

- Monitoring and supervising the disposal:

Daily inspect and supervise burial pits for pigs in the first week after burying

Yes ☐ No ☐

Method of inspection and supervision:

+ By visual inspection

Yes ☐ No ☐

+ By sampling for analysis

Yes ☐ No ☐

Inspect and detect timely and strictly handle case of throwing dead pigs to public places

Yes ☐ No ☐

- Performance of disposal:

Develop detailed plan for disposal of diseased pigs and their products as instructed by the Ministry of Agriculture and Rural Development, Ministry of Natural Resources and Environment

Yes ☐ No ☐

Burial pits are lined and treated for bad smell, disinfected and sterilized

Yes ☐ No ☐

People involving in such disposal must were personal protection devices, do sterilization and disinfection to avoid epidemic spreading

Yes ☐ No ☐

III. ACTUAL SITUATION OF DISEASED ANIMAL DISPOSAL

1. Collecting, transporting diseased animals/animal carcasses

- Performance of compulsory slaughtering for diseased animals

Yes ☐ No ☐

Specify measures of slaughtering (if any): .....

.....

.....

- Selecting disposal sites:

+ Inside the epidemic area:

Yes ☐ No ☐

+ Outside the epidemic area:

Yes ☐ No ☐

- Chemicals used in transport and disposal:

Yes ☐ No ☐

If available, list chemicals in table 3

Table 3. List of chemicals used

No.	Chemicals	Dosage	Time of usage
1			
2			
3			

- Means of transport:

+ Tight floor:

Yes ☐ No ☐

+ Sanitation and disinfection of means of transport:

Yes ☐ No ☐

2. Measures of disposal performed

2.1. Measure of burying

- Selection of burial sites: .....
.....
.....
.....

- Specification of burial pit: .....
.....
.....
.....

2.2. Measure of burning

- Burning with specialized furnace:

Yes ☐ No ☐

- Manual burning by digging holes, putting bags containing animal carcasses and products into the pits and burning with firewood, coal, straw, gasoline, diesel, etc.

Yes ☐ No ☐

2.3. Other measures

Specify other methods for disposal performed:

.....
.....
.....

Table 4. Summarization of disposal measures

No.	Locality	Measure of burying		Measure of burning		
		Quantity of disposal	*Number of burial pits*	*Quantity*	*Burning with specialized furnace*	*Manual burning*
1.						
2.						

3.						
4.						

2.4. Environmental quality supervision at diseased animal carcass disposal sites

- Visual inspection and supervision

Yes ☐ No ☐

If so, specify inspection and supervision agency: .....

.....

.....

.....

2.5. Proposal and recommendation related to amending regulations on epidemic disease control and diseased animal disposal

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IV. RECOMMENDATION

(Other recommendations related to epidemic disease control)

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……, dated …….. 2020

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