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A Study on Ways to Improve the Smell of Pig Barn

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Abstract

Purpose: In this study, we would like to make a technical proposal to solve the odor problem in pig houses. Through this, we would like to suggest an effective way to reduce the odor generated in the pig house as a solution to civil complaints. **Research design, data and methodology:** Conduct direct visits to pig farms where many civil complaints about bad odor occur, and identify the problems of each farm. Identify elements related to odor control, such as structure, facility, equipment, odor management method, and ventilation type. Through this, the technology to be applied to reduce odor and the solution to the odor problem are presented. **Results:** The results of major improvements are as follows: 1. Improvement of the structure of the barn or composting shed to an airtight type 2. Improvement of the pig manure treatment structure using the slope inside the barn 3. Establishment of ventilation and cooling systems 4. Automation of the mist spray system. **Conclusions**: As a result, as practical measures, sealing of facilities using winch curtains, construction of air conditioning systems using negative pressure ventilation, and management systems using AIoT systems were presented. It is judged that this study can be helpful in determining the grievances caused by civil complaints of tenant livestock farms and the direction of facility improvement in the future.

Keywords : Pig barn, Odor, Facility Improvement, Management Plan

JEL Classification Code : I00, I10, I19, I30

1. Introduction

Odor complaints in Korea increased every year from 2,381 in 2003 to 22,851 in 2017. Due to the meat consumption-oriented diet, livestock breeding increased and livestock farms became larger. In particular, in the case of pig farming households, it has increased by 132% since 1990. Among all civil complaints about odor in Korea, complaints about odor caused by livestock facilities account for the largest proportion (27%) (MOE, 2018).

Due to the population density in the metropolitan area, living areas were formed around livestock farms in Gyeonggi-do. As a result, civil complaints due to odors from livestock farms increased (Lee, 2019). Therefore, in this study, we would like to make a technical proposal to solve

the odor problem in pig houses. Through this, we would like to suggest an effective way to reduce the odor generated in the pig house as a solution to civil complaints.

2. Literature Review

Research results of selecting large, medium, and small-scale breeding farms by livestock species and evaluating the differences in relative odor intensity according to the breeding status of each livestock species, what are the main odor substances and their contribution rate through chemical analysis by odor substance was as follows.

Hydrogen sulfide, methyl mercaptan, dimethyl sulfide, dimethyl disulfide, 4 S-type substances, ammonia, methylamine, dimethylamine, trimethylamine, N-type substances, 3 fatty acids, butyric acid, valeric acid, and isovaleric acid A total of 11 materials were measured. In the case of ammonia, concentrations in broiler and laying chickens were as high as 9.5 ~ 15.0 ppm. Hydrogen sulfide showed the highest concentration at 857.7 ppb in the pig breeding facility, and methyl mercaptan showed the highest concentration at the broiler house at 11 ~ 13 ppb. As a result of odor intensity analysis on individual odor substances by livestock species, it was found that substances with odor intensity exceeding 3 degrees were ammonia, hydrogen sulfide, and methyl mercaptan. In the case of cattle, the relative odor was lower than that of other livestock species, and chickens had ammonia, and pigs had a high odor due to ammonia, hydrogen sulfide, and methyl mercaptan. As a result of comparing the overall odor intensity by livestock species, the odor contribution of hydrogen sulfide and dimethyl sulfide was high in pigs and chickens, and the odor contribution of hydrogen sulfide was evaluated to be absolute in pigs. In order to manage odor, continuous investigation and research on odor generation characteristics and reduction measures of livestock facilities for each livestock type are required (Jang, 2009).

The result of a study analyzing the trend of the current livestock industry, where the efficiency of agriculture is emphasized, and the application cases and necessity of mechanization, automation, and expert systems, etc. The current trends of the livestock industry in the fields of livestock environment management, breeding management, disease management, and excreta treatment, which are the main areas of the smart livestock farming system, were investigated, and the application cases of the expert system were analyzed. In Korea, where the agricultural labor force is declining, it is necessary to create high efficiency with a small labor force, and smart livestock farming is attracting attention as a solution. Through the application of the expert system, real-time monitoring of the barn environment, automatic feeding device, disease management through deep learning, and resource utilization of livestock manure could be made possible. There are still technical and cost limitations in generalizing the expert system-based technology. In addition, the technical aspects of expert systems in the field of livestock productivity management include the ability to integrate data from multiple sources, analyze complex data sets, and provide real-time decision support. Using machine learning algorithms and natural language processing, expert systems can adapt to changing conditions based on past learning experiences, yielding more accurate and reliable results over time. Additionally, expert systems can be customized to meet the specific needs of a particular livestock production system, allowing for a more tailored and effective management strategy. However, the development and implementation of expert systems requires careful consideration of ethical and legal implications, as well as potential impacts on stakeholders such as farmers, consumers and the environment. It was concluded that further research is needed to address these challenges and optimize the use of expert systems in smart livestock productivity management (Lee, 2023).

The summary of the analysis results based on the evaluation results of livestock manure treatment facilities and related technologies conducted over 6 years from 2008 to 2014 for domestic livestock manure treatment facilities is summarized as follows. 1) Among the types of facilities supplied to livestock manure treatment facilities in Korea, there were many livestock manure composting facilities. Next, purification and liquefaction facilities showed similar levels. 2) Common treatment facilities or large-scale farmhouses installed and operated compost agitation facilities, and the type of agitation facility was mainly an escalator type. 3) The main shapes of domestic liquefaction facilities are circular and rectangular. The main materials are concrete, enamel-coated steel, and stainless steel. 4) Since the problem of removing sediment from the liquid fertilizer storage tank is directly related to the operational efficiency of the liquid fertilizer storage facility, it was found that it was necessary to secure a method for removing sediment. 5) Livestock manure purification and treatment facilities were used in farms where liquid manure was discharged, as in the case of pig farming, and tended to be supplied mainly to large-scale pig farms rather than small-scale farms. 6) For livestock manure anaerobic digestion facilities, wet anaerobic digestion facilities using pig manure as a raw material are widely used, and the digester type is mixed with single-phase and abnormal. 7) The odor control problem generated during the livestock manure treatment process is an important factor to consider in the operation of livestock manure treatment facilities (Jeong, 2014).

As a result of these preceding studies, it was found that there were many studies on odor control in domestic livestock farms. It was found that these management is

important. In particular, since there are many conventional pig houses in Korea, it is difficult to control odor, so it is necessary to prepare a plan to solve this problem.

3. Research Methods and Materials

The purpose of this study is to derive improvements to reduce the odor of pig farms. Conduct direct visits to pig farms where many civil complaints about bad odor occur, and identify the problems of each farm. Identify elements related to odor control, such as structure, facility, equipment, odor management method, and ventilation type. Through this, the technology to be applied to reduce odor and the solution to the odor problem are presented.

4. Results and Discussion

4.1. Major Problems of Pig Farms

Among the pig farms located in Yongin, Gyeonggi-do, 10 pig farms with many civil complaints about odor were visited and checked, and the main problems found are as follows.

1. Odor control itself is difficult due to the open pig house structure
2. Since it is mainly a rental farm, there are limitations in remodeling and facility improvement.
3. Since the composting facility is an open structure, a lot of bad smell occurs.
4. We are trying to reduce odor through mist spraying facilities, but the efficiency is low when high concentration odor is generated.
5. Absence of reduction measures in case of occurrence of odors during times when it is difficult to control directly, such as at night.

Figure 1 presents the scene where such a problem was revealed.

Figure 1: Pig Farm Problems

In general, odor generation characteristics in pig houses are summarized and presented in Table 1. In the case of the barn, the intensity of the odor was the strongest in the floor and manure of the barn. Hydrogen sulfide, ammonia, methyl mercaptan, trimethylamine, and dimethyl sulfide are the main sources of odor on the floor of barns, and dimethylamine, trimethylamine, and lactic acid are known to be the causative substances in manure. In the case of manure treatment facilities, the odor intensity was the strongest in the compost storage facility. The main odor-causing substances generated from compost storage facilities are known to be hydrogen sulfide, ammonia, methyl mercaptan, trimethylamine, dimethyl sulfide, and dimethyl disulfide.

Table 1: Characteristics of Odor Generation in Pig Houses

Odor source		Odor intensity	Main causes of odor
Barn	Livestock	Weak	Hydrogen sulfide, Ammonia, methyl mercaptan, Trimethylamine, Dimethyl sulfide
	Barn floor	Strong	
	Feed	Weak	
	Excretions	Strong	Dimethylamine, Trimethylamine, Lactic acid
	Outlet	Medium	
Excreta treatment facility	Carrier	Medium	Hydrogen sulfide, Ammonia, Methyl mercaptan, Trimethylamine, dimethyl sulfide, dimethyl disulfide
	Drying facility	Weak~ Medium	
	Compost storage facility	Strong	
	Wastewater treatment facility	Weak	Hydrogen sulfide, Ammonia, Methyl mercaptan
	Manure, sludge treatment plant	Medium	Hydrogen sulfide, Ammonia
	Manure dryer	Medium	Ammonia, dimethylamine, Lactic acid, Methyl mercaptan, Trimethylamine
	Manure incineration	Weak~ Strong	Ammonia, Dimethylamine, Methyl mercaptan

4.2. General Solution

The main odor-causing substances generated from compost storage facilities are known to be hydrogen sulfide, ammonia, methyl mercaptan, trimethylamine, dimethyl

sulfide, and dimethyl disulfide. The most common solutions include.

1. Improving the structure of a barn or composting shed into an airtight type
2. Improving the pig manure treatment structure using the slope inside the barn
3. Ventilation and cooling system establishment
4. Automation of fog spray system

For the third application of the above general solution, first sealing should be preceded. Therefore, the most important solution is to change the structure to a closed structure. The advantage of the sealed structure is that it is possible to control the spreading odor. If an air conditioning system is installed and a prevention facility is installed at the outlet, it is effective in reducing civil complaints by processing and expelling odors. However, in the case of pigs for this study, since they are tenants, they cannot improve the facilities at will and are reluctant to invest in facilities. Therefore, we suggest improvement measures that can be taken instead of extensive remodeling and construction in an airtight structure.

4.3. The Solution Proposed in this Study

The first problem to be solved is the sealing problem. This is because once the sealing problem is solved, the spreading odor can be controlled, and the rest of the problems can be solved through air conditioning and facilities. However, due to the above reasons, the construction of remodeling and changing to an airtight structure is not realistically suitable. Therefore, in this study, it is proposed to use a method of sealing using a winch curtain. The winch curtain can open and close depending on the inside and outside temperature. Due to this feature, it is easy to control the internal temperature. In addition, if installed meticulously, it can have a sealing effect that blocks the inside and outside. Figure 2 shows the appearance of a pig pen with a winch curtain applied.

Figure 2: Winch Curtain Applied to the Pig Pen

If the sealing problem is solved, the next problem is how to manage the temperature inside the pig house. Temperature control inside the pig house is directly related to production and must be managed with great importance. If the temperature is higher than 28℃, artificial temperature control is required. In the case of newborn piglets, the optimum temperature is high, but for the rest of the pigs, the temperature should be maintained at 22℃~28℃. The optimal temperature according to the growth level of pigs is presented in Table 2.

Table 2: Optimum Temperature According to Pig Growth

Growth level	Minimum temperature	Optimum temperature	Maximum temperature
Lactating sow	10	16	21
Newborn piglets	32	35	38
Breeding pigs	10	16	21
Pregnant sow	10	16	21

In order to manage this temperature, an air conditioning system must be well equipped. There are a total of three ventilation methods that can be selected in the pig house: natural ventilation using the natural phenomenon of air flow, forced ventilation using mechanical power, and a compromise method using the above two methods complementary to each other. For good temperature management efficiency, mechanical ventilation should be adopted. This method is divided into positive pressure method and negative pressure method. The negative pressure method is used in closed pig houses, and it has the advantage of being able to install ducts for air distribution at low cost, saving space, and having relatively low pressure loss. A schematic diagram of the negative pressure ventilation system is shown in Figure 3.

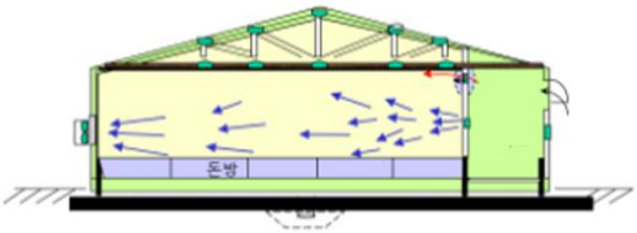

Figure 3: Schematic Diagram of Negative Pressure Ventilation System

Management is necessary after the air conditioning system adopting negative pressure ventilation among mechanical ventilation and sealing of facilities using winch curtains is established. In order to facilitate this, there is a need to apply and manage AIoT technology. The AIoT system monitors the level of odor generated through the

odor sensor and enables to check the amount and time of high concentration. Prevents odor generation by automatically operating the fog spraying device at the time of high concentration. In addition, the temperature sensor, winch curtain opening and closing device, ventilation fan, etc. are configured to be automatically controlled according to the situation so that the optimal temperature of the pig house can be automatically managed. Through this, it is easy to manage odor at night and at vulnerable times, and it is possible to increase economic feasibility by reducing labor costs and improving productivity.

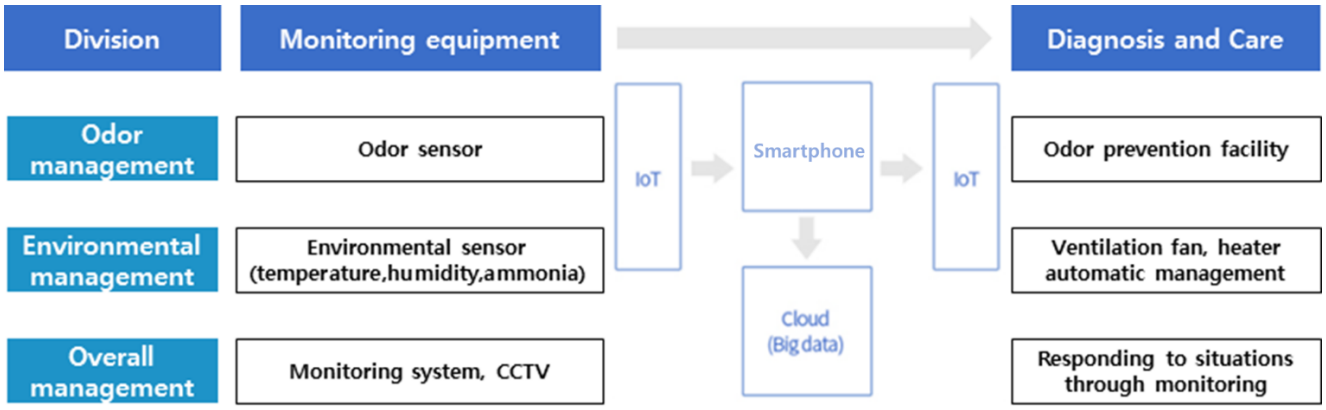

Figure 4: Application Example of AIot Technology

5. Conclusions

The purpose of this study is to suggest odor reduction measures for tenant pig houses, which are practically difficult to change the structure of pig houses. As a result, as practical measures, sealing of facilities using winch curtains, construction of air conditioning systems using negative pressure ventilation, and management systems using AIoT systems were presented. This study aimed to present a general solution considering the current status of tenant pig housing, and additional research is needed to demonstrate the proposed technology. If the methods presented in this study are applied, it is expected that it will be possible to promote complaints of bad odor and increase efficient production in pig farms in the future. However, for this to happen, policy support from local governments and the will and active cooperation of related operators are required. In addition, there is a need to consider additional odor reduction measures and efficient structural improvement measures in consideration of the structure and breeding capacity of each farmhouse. It is judged that this study can be helpful in determining the grievances caused by civil complaints of tenant livestock farms and the direction of facility improvement in the future.

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