ISSN: 2586-6036 © 2021 KODISA & JWMAP.
http://www. welfareconvergence.or.kr
doi: http://dx.doi.org/10.13106/jwmap.2022.Vol4.no4.51

Development of Complex Module Device for Odor Reduction in Sewage

Young-Do KIM[1], Tae-Hwan JEONG[2], Su-Hye Kim[3], Woo-Taeg KWON[4]

[1. First Author] Researcher, Department of Environmental Health & Safety, Eulji University, Korea, Email: youngdo31@naver.com
[2. Second Author] Researcher, Unionenv. CO. LTD., Korea, Email: jeongth@naver.com
[3. Third Author] Researcher, Dept. of Environmental Health & Safety, Eulji University, Korea. Email: kagome00@naver.com
[4. Corresponding Author] Professor, Department of Environmental Health & Safety, Eulji University, Korea, Email: awtkw@eulji.ac.kr

Received: December 22, 2022. Revised: December 27, 2022. Accepted: December 27, 2022.

Abstract

Purpose: By applying an ultrasonic mechanical device to the liquid fertilizer storage in the pig dropping treatment plant, the initial odor of the odor source is reduced, and the air dilution drainage of the complex odor is fundamentally recognized to facilitate odor treatment on the mechanical and chemical biological treatment devices at the rear. **Research design, data and methodology:** The odor concentration on the site boundary was measured to confirm the state of reduction. In order to prevent the spread of odor from the collection of the pig dropping treatment plant, it was measured by installing an ultrasonic generator inside the installation wall after installing the sealing wall. **Results:** The average value of the March and April measurement data remained close to neutral at 8.2 after 8.6 treatment before pH treatment, decreased 97.3% from 462 mg/L before SS treatment to 10.5 mg/L after treatment, and the composite odor was reduced by 85% from 20 to 3 before treatment. It was confirmed that ammonia (NH3) was reduced by 99% from 5.8 ppm to 0.09 ppm, and general bacteria were also reduced by 99% from 3,200 CFU/mL to 57 CFU/mL **Conclusion:** Applying the ultrasonic air ejector hybrid system and zigzag air complex module development product to resource circulation centers or sewage treatment facilities is thought to reduce inconvenience to residents due to odors caused.

Keywords : Complex odor, H_2S, NH_3,Water treatment, Complex module device

JEL Classification Code: E44, F31, F37, G15

1. Introduction[1]

Livestock manure is first generated in animal husbandry farms, passes through Resource Recycling Centers(RRC) operated by local governments, private livestock manure treatment facilities, agricultural land, forests, and soil, and is eventually discharged into the waste water system. It can be seen that the number of public civil complaints to the Ministry of Environment in Korea increases every year.

Livestock manure, an organic wastewater, has long been a local problem in conjunction with the NIMBY (Not in My Backyard; NIMBY) phenomenon due to the odor generated

* Acknowledgements: This work was supported by the research grant of the KODISA Scholarship Foundation in 2022.

during the treatment process. Recently, the main causes of public civil complaints due to odors emission from private facilities are barns, pigs, liquid farm manure spraying facilities, and composting sites.

The method of controlling & reducing the odor is divided into various types according to the cause of occurrence and the nature and characteristics of the odor.

Since the odor emission source is narrow and fixed, various odor deodorization methods such as forced inhalation or sealing can be applied. However, if the source of the odor is mobile, such as a RRC, liquid manure spraying facility, composting field, or livestock manure treatment facility, or is widely dispersed and exposed, such as a large-scale barn, pigsty, or compost fermentation facility, forced inhalation treatment is impossible. Accordingly, odor deodorization methods using various additives and spraying agents are mainly applied.

This method has a stable effect on complex odors by using microbial treatment techniques and additive techniques for liquid manure that has completed solid-liquid separation in pig excrement processing companies with a narrow source of odor emission, so users can easily use it without special skills. However, the above method is difficult to select additives that meet the odor emission source conditions, and most additives are effective only for a few kinds of odor compounds, so they are not effective for complex odors caused by a mixture of dozens of odor compounds. That is, the technical difficulty of the above method is that microbial agents are the main species, and it is not easy to spread the storage culture. Therefore, as a technical and economical aspect of the chemical and biological treatment method, a suitable odor deodorization method that considers the user's convenience and the safety and working environment of workers is required.

With a physical preliminary treatment process, it is safer than chemical treatment methods and cavitation by ultrasonic waves (CAVITATION) should be applied in consideration of the convenience of workers. The initial odor of the odor generating source should be reduced by applying an ultrasonic device to the liquid manure storage in the pig manure treatment plant. Therefore, this study intends to fundamentally understand the air dilution factor of complex odors and design odor treatment easily in the mechanical device and chemical and biological treatment device that will be at the rear end.

2. Literature Review

2.1. Characteristics of Odor in a Pigsty

Excreta treatment facilities and methods vary depending on livestock barns, poultry houses, and pig farms because odor emissions differ depending on the storage and treatment of pig manure. Although the proportion of odor emission in the entire pig manure treatment facility may show a large difference, on average, the odor generated during the storage and treatment of pig manure accounts for about 20% of the pig farm odor (Ryu et al., 2003).

According to the concentration distribution characteristics of odorous compounds according to the type of pigsty, ammonia was 17.66 ppm and hydrogen sulfide 66.41 ppb in the sealing without a window (scraper) pigsty, and ammonia was 6.79 ppm and hydrogen sulfide 38.36 ppb in the open (scraper) pigsty (Kim & Choi, 2013). Ammonia was found to be 14.98 ppm and hydrogen sulfide 628.38 ppb in the natural ventilation (slurry) pigsty, and ammonia was found to be 16.35 ppm and hydrogen sulfide 37.73 ppb in the natural ventilation (slurry) pigsty (Kim & Choi, 2013).

In the case of the compost & liquid manure, the manure storage period is relatively longer than that of the inside of the pigsty, and the emission of odorous compounds due to aeration and agitation may appear differently. Therefore, the characteristics of the odor may appear differently depending on the facility characteristics of the pig farm. Concentrations of ammonia, sulfur compounds, fatty acids, and phenols were highest in the order of inside the pigsty, exhaust air fan, compost & liquid manure, and site boundary, while indole compounds showed high concentration in the order of inside the pigsty, exhaust air fan, site boundary, and compost & liquid manure.

It can be seen that the odor diffusion distance is much longer when the wind speed is low than when the wind speed is high, and it is judged that the higher the wind speed, the higher the left-right up-down odor diffusion effect, and the diffusion distance along the ground surface decreases (Kim et al., 2014). In addition, it was found that the concentration of ammonia generated from the slurry increased rapidly as the temperature increased, and it was analyzed that as the pH increased, more ammonia gas was generated.

As a result of the study, it was determined that the odor gas generated from the slurry could be greatly reduced by lowering the temperature or lowering the pH of the slurry.

Livestock odor compounds are decomposed into volatile fatty acids, phenols, indoles, ammonia, and volatile amines as proteins in feed are hydrolyzed into amino acids through metabolic processes, and these decomposition products come out as odor compounds (Jensen & Jorgensen, 1994).

Odor compounds are classified into 22 types designated by the Ministry of Environment in Korea. Major designated odor substances for pig farms include ammonia, trimethylamine, hydrogen sulfide, methyl-mercaptan, propionic acid, butyric acid, iso-valeric acid, and non-designated odor substances such as acetic acid, p-cresol, and indole. (Ministry of Environment, Malodor Prevention Act, 2019).

Common odorous compounds in pig manure are produced and build up during the bacterial degradation of pig manure 10 slurries under anaerobic conditions. These compounds can be divided into several groups. The group of volatile fatty acids consists of acetate, propionate, butyrate, iso-butyric acid, valerate, and iso-valerate. Volatile fatty acids can be produced during the deamination of amino acids produced during the breakdown of proteins and carbohydrates.

In the gastrointestinal tract, neutral pH 6–7 generally predominates, at which deamination is the major pathway of amino acid metabolism, resulting in the production of not only ammonia but also volatile fatty acids, carbon dioxide and hydrogen. Bacteria involved in this process include Eubacteria, Pepto streptococcus, Escherichia, Megasphaera, Propionibacterium, Lactobacilli, and Clostridium.

3. Research Methods and Materials

3.1. Experimental Devices and Operating Conditions

3.1.1. Composition of Ultrasonic Device

It is judged that the prototypes developed so far are bulky and inappropriate for commercialization due to the large number of necessary attached facilities for commercialization. Therefore, in this study as presented in Figure 1, an aluminum case with a width x length of 1,800 mm x 900 mm and a height of 1,000 mm was designed and manufactured. The air ejector in this machine is made with Inlet ø 25 and Outlet ø 30, and the inner diameter of the air injection part is made with 10mm so that the surrounding air can be injected.

The ultrasonic generator of this device is a 700W AC generator and a piezoelectric transducer, which is the most widely used device for chemical reaction devices, increasing its versatility as shown in Figure 2. Four ultrasonic generators and vibrators were designed in the process of setting the release device and vibrator suitable for the amount of pig manure collected per day, 250 tons. Vibrators were arranged in four directions in the solid-liquid separation treatment tank so that the state of vibration was most effectively arranged and investigated.

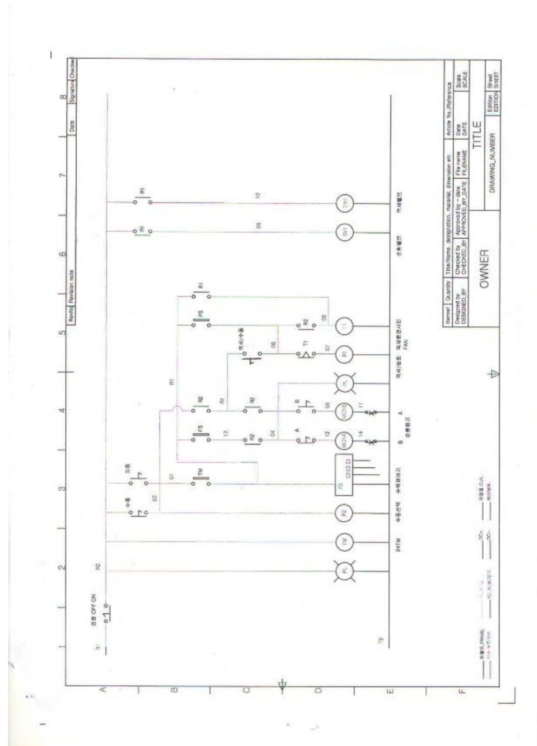

Figure1: PCB control panel design

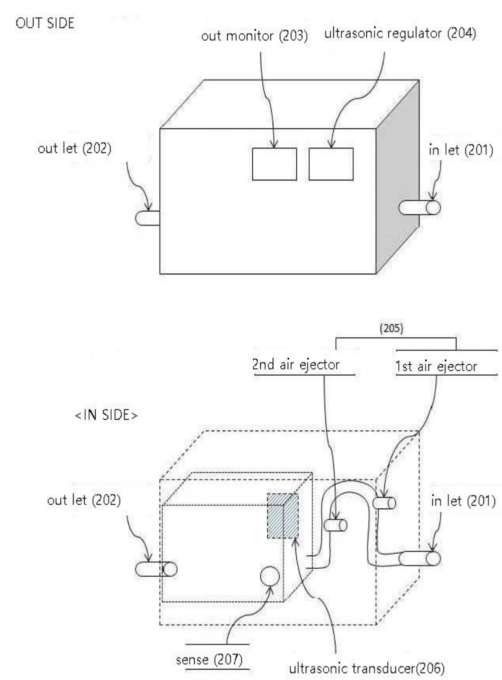

Figure 2: Control unit design diagram

Figure 3: An ultrasonic oscillator

Figure 4: Ultrasonic module generator

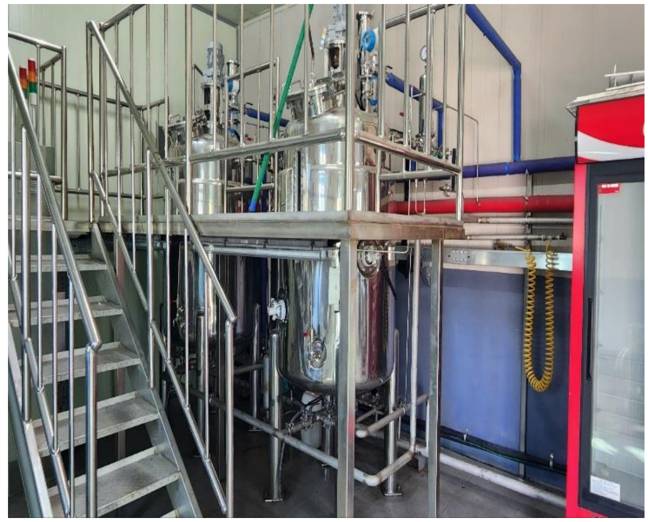

Figure 5: A seed culture device

3.2. Research Methods

From March 10 to May 10, 2022, an ultrasonic processor was installed in the liquid fertilizer storage tank in the solid-liquid separator of the Cheongmiwon Resource Recovery Center(RRC) located in Juwon-ri, Changsu-myeon, Pocheon-si, Gyeonggi-do, Korea, and operated biweekly. The concentration of complex odor before and after operation of this device was measured, and the state of reduction was confirmed by measuring the concentration of odor along the site boundary.

In order to prevent the spread of odors occurring in the collecting well of the pig manure treatment plant, after installing the air sealing wall, an ultrasonic generator was installed in the air sealing wall and measured as shown in Figure 6. The air ejector was installed together with the circulation pump, and it was installed inside the collecting well to be less affected by temperature to improve the survival rate and maximum performance in anticipation of performance degradation due to temperature drop in which microorganisms cannot survive.

Figure 6: An ultrasonic culture device

4. Results and Discussion

4.1. Contaminant Levels Before and After Operation of the Ultrasonic Device

The treatment efficiency before and after the installation of the ultrasonic device showed a difference by season and temperature, but showed data within a range suitable for the level of significance. The average measured value of the data in March and April was maintained at a value close to neutral at 8.6 before pH treatment and 8.2 after treatment, and was reduced by 97.3% from 462 mg/L before SS treatment to 10.5 mg/L after treatment. Complex odor was reduced by 85% from 20 before treatment to 3. Ammonia (NH3) was reduced by 99% from 5.8 ppm to 0.09 ppm, and it was confirmed that general bacteria were also reduced by 99% from 3,200 CFU/mL to 57 CFU/mL.

SUMMARY OF THE RESULT

division	0 HR	48 HR
complex odor	1150	300
hydrogen sulfide (ppm)	1.07	0.25
Turbidity (NTU)	230.26	87.79
Do (ppm)	5.78	7.58
pH	6.29	7.83
NO_2 - N (ppm)	20.15	0.86
NH_3 - N (ppm)	7.25	1.59
common bacteria (c f u)	10^4	TNTC
Escherichia coli (c f u)	10^2	10^3
Bacillus (c f u)	10^3	10^6

pollutant reduction rate

complex odor 75% decrease

hydrogen sulfide 77% decrease

Turbidity 62% decrease

Do 25% increase

pH 20% increase

NO_2 - N 96% decrease

NH_3 - N 79% decrease

Figure 7: Summary of experimental results

Initial concentration of wastewater generated from 48 domestic public sewage treatment facilities (122-6,694 OU/Unit), sewage treatment facilities near Daegu Industrial Complex (3.7-11.8 OU/Unit), and leather manufacturing facilities located in Ansan, Gyeonggi-do (3,000 OU/Unit),

a pig farm in Chungcheongbuk-do (5.5-448.1 OU/Unit), and a pig farm in Canada (818-3,822 OU/Unit), the complex odor concentration at the inlet was 300 OU/Unit, which was not low. It is lower than 500 OU/Unit, which is the minimum value of the standard for complex odor at the outlet, and the research target facility is being managed.

The complex odor concentration at the outlet was 20 OU/Unit, which was lower than the result of applying the ultrasonic-air ejector pretreatment device (120 OU/Unit). This is the average value of the measured data in March and April, and it came out lower than the data value in July and August. For this reason, it is considered that the influence of the season is large.

.

5. Conclusions

Since the environment and components of complex odors are different for each pig manure treatment RRC, the efficiency of the arbitrary deodorization method is different, so it is difficult to cope with and remove the complex odor created by combining chemical components. By applying two methods or technologies rather than one, the odor deodorization method can be applied to the field variably using ultrasonic and air ejector methods.

The cavitation phenomenon (CAVITATION) from the air ejector and the cavitation phenomenon (CAVITATION) of the micro bubbles from the ultrasonic waves must be configured so that two or more coral construction methods can be applied variably to the field. That is, in this study, a field adaptable device for odor deodorization efficiency with a higher oxidation effect was constructed and an oxidation device by two types of microbubbles was installed. Standards, unification of standards, electrical wiring, compatibility of detachable devices, etc. of these parts were made easy to replace.

The performance of the complex odor, H_2S, and NH_3 of the RRC by pig manure to which the oxidation deodorization facility by fine bubbles produced in this study was applied was 75%, 77%, and 79%, respectively, and DO was increased by 25%, resulting in general bacteria was amplified in large amounts with TNTC. The substances generated by existing RRC are complex odor, H_2S, and NH_3, and most RRCs use biological processes to treat them.

The removal performance of the complex odor was higher than that of the deodorization equipment in this study, but the air dilution factor of the complex odor generated in the ultrasonic treatment tank of the collecting well was found to be low. If the ultrasonic air ejector hybrid system and the composite module development product of the zigzag air flow are applied to a RRC or sewage treatment facility, it is expected that residents' discomfort due to odor will be reduced.

References

Jensen, B. B. & Jørgensen. H. 1994. Effect of dietary fiber on microbial activity and microbial gas production in various regions of the gastrointestinal tract of pigs. *Appl. Environ. Microbiol. 60*.6: 1897.

Kim K Y. & Choi. J.H. 2013.Distribution characteristics of odorous compounds concentrations according to type of pig buildings. *J. Kor. Soc. Odor Res. Eng*. *12*(1). DOI: https://doi.org/10.11161/jkosore.2013.12.1.27.

Kim, DooHwan, Ha, Duck Min, Lee, In Bok, Choi, DongYun, Song, Jun Ik. 2014. A Study on Dispersion Characteristics of Odor from Swine Farms. *Journal of animal environmental science, 20*(2). 41-48. DOI:http://dx.doi.org/10.11109/JAES.2014.20.2.41

Lee, SH, Yun, N K, Kim, K w, Lee, I B, Kim, T I, Chang,JT. 2006. Study on Ammonia Emission Characteristic of Pig Slurry. *Journal of animal environmental science. 12*(1): 7–12.

Ministry of Environment, MALODOR PREVENTION ACT 2019. https://www.law.go.kr

Rhu, Hee Wook, Cho, Kyung Suk, Lee, Tae Ho, Huh,Mock. 2003. Management of Offensive Odors in Swine Production Facilities: I. Domestic Status and Offensive Odors in Swine Production. *Journal of Odor and Indoor Environment. 2*(2), 69–77.

Seo, B. R., H. S. Jeon, Y. S. Park, B. R. Yun, T. H. Jang, T. O. Kim. 2013. The emission characteristics and management of odor compounds from public sewage treatment facility. *Kor. J. Odor Res. Eng.*. *12*(3): 97–109. DOI: https://doi.org/10.11161/jkosore.2013.12.3.97