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EVALUATING THE NH_3 AND H_2S DEODORIZING PERFORMANCE OF MICROBIAL PRODUCTS IN LIVESTOCK FACILITIES: A SMALL-SCALE FARM STUDY

Pham Thi Thom,
Doctor, Faculty of Natural Resources and Environment,
Bac Giang Agriculture and Forestry University, Vietnam
Golovin V.
Doctor, Department of Marine Arctic Technologies (Polytechnic Institute),
Far Eastern Federal University (FEFU), Russia
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Abstract

This study evaluates the efficacy of microbial additives in mitigating ammonia (NH_3) and hydrogen sulfide (H_2S) odors in poultry and pig pens on small-scale family farms. The results indicate a significant reduction in odor within the poultry pens following the application of microbial additives. Specifically, the H_2S concentration decreased by 95.22%, while NH_3 decreased by 99.19%, with effects lasting up to 2 days. Conversely, in pig pens, the reductions in NH_3 and H_2S concentrations were less pronounced. After 3 hours of microbial additive spraying, the H_2S and NH_3 concentrations decreased by 51.27% and 53.10%, respectively. Further comprehensive research efforts are needed to facilitate the widespread implementation of odor reduction in livestock operations using microbial additives.

Keywords: Ammonia, hydrogen sulfide, deodorization, microorganisms, animal waste, microbial products.

INTRODUCTION

Air pollution, particularly odor pollution originating from livestock, remains a significant concern and source of complaints in regions with thriving animal husbandry industries (Matusiak et al., 2016; Mariuzza et al., 2022; Conti et al., 2020). Livestock odors arise from a complex mixture of gases, primarily originating from the decomposition of organic matter in animal waste. Studies have identified over 170 odor-causing gases generated during this decomposition process, with hydrogen sulfide (H_2S) and ammonia (NH_3) being the primary offenders (Doan, 2011; Piccardo et al., 2022; Conti et al., 2020).

NH_3, a colorless gas with a pungent odor, readily dissolves in water, causing irritation, tearing, nasal congestion, laryngospasm, and coughing. NH_3 emissions from enclosed pigpens can exceed acceptable levels by 30 to 40 times (Doan, 2011; Chau and Long, 2008). The average NH_3 concentration in cowshed exhaust gases has been measured at 3700 μg/m3, surpassing the odor threshold of 27 μg/m3, leading to persistent odor issues in livestock facilities (Phung et al., 2005).

H_2S, also colorless with a characteristic rotten egg odor, is produced during the reduction of sulfur-containing compounds in waste. Even trace amounts of H_2S, ranging from 0.01 to 0.7 ppm, can produce noticeable odors, while concentrations of 3 to 5 ppm result in a strong odor (Chen et al., 2022; Deng et al., 2023). Additionally, H_2S is toxic, posing health risks to both animals and humans, even at low concentrations (Doan, 2011; Chen et al., 2022; Oesterhelweg and Püschel, 2008). Systemic effects induced by H_2S include the inhibition of respiratory enzymes, leading to suffocation and death at concentrations of 150 ppm. Therefore, NH_3 and H_2S gases have detrimental effects on livestock growth and human health, with prolonged exposure exacerbating their harmful impacts.

In response to these challenges, numerous studies have explored the utilization of microbial products to enhance air quality in livestock operations. These products harness the capabilities of beneficial microorganisms, such as Bacillus spp, Actinomyces spp, Mucor spp, and Pseudomonas spp (Kanagawa et al., 1989; Durka et al., 2010; Hien, 2012; Matusiak et al., 2016; Park, 2006), aimed at reducing the concentration of odorous compounds in livestock waste.

Recent research endeavors have been directed towards microbial consortia possessing deodorizing properties, encompassing purple photosynthetic bacteria, Thiobacillus (sulfur bacteria), lactic acid bacteria, and yeast bacteria. These microorganisms exhibit potential in substantially diminishing hydrogen sulfide H_2S) odors by converting them into elemental sulfur or sulfate compounds. Lactic acid bacteria contribute to odor reduction by creating an acidic environment, thereby inhibiting the proliferation of putrefactive bacteria and diminishing ammonia (NH_3) odors. Additionally, yeast bacteria, in synergy with other microbial species, facilitate decomposition processes and ameliorate odors emanating from livestock waste. Consequently, exploring combinations of these microbial groups holds promise for effective deodorization of livestock waste.

This study focuses on evaluating the efficacy of microbial preparations for mitigating odors in livestock operations. These preparations encompass a consortium of efficacious microorganisms, including photosynthetic bacteria, nitrogen-fixing bacteria, actinomycetes, lactic acid bacteria, and yeast. The primary objective of this research is to assess the deodorizing effectiveness of microbial preparations against livestock odor-causing gases, specifically hydrogen sulfide (H_2S) and ammonia (NH_3), thereby offering insights into enhancing air quality in livestock facilities.

MATERIALS AND METHODS

MATERIALS:

Fecal samples: Swine and poultry excreta were collected from a family-owned livestock farm located in the Kuangminh commune, Viet Yen district, Bac Giang province, Vietnam. Stool samples were obtained in June 2023.

EMRO - Vietnamese probiotics, transferred and produced in Vietnam by EMRO - Japan. EMRO comprises the EM1 product line, in liquid form, with a yellow-brown color, pleasant odor, and sweet-sour taste. The pH is < 3.5. It consists of approximately 80 species of microorganisms belonging to 10 different genera, including photosynthetic bacteria, nitrogen-fixing bacteria, actinomycetes, lactic acid bacteria, and yeast. The microorganisms in the composition form a microbial system, supporting each other, and growing and developing together.

METHOD:

Preparation of working microorganisms:

The preparation of EM2 solution from EM1 involves mixing 0.1 liters of EM1 preparation with 0.1 liters of molasses and 1.8 liters of chlorine-free water, resulting in 2.0 liters of EM2. This solution is then stored in a sealed container, placed in a cool environment devoid of direct sunlight, for a duration of 3-5 days. As gas formation occurs during fermentation, causing expansion of the container, it is imperative to periodically release the gas by opening the lid, followed by resealing. The resultant EM2 secondary fermentation solution exhibits a floating foam and emits a pleasant aroma.

The preparation of EM Bokashi C from EM1 involves combining 20 ml of EM1 preparation solution with 20 ml of molasses, 200 ml of chlorine-free water, and 400 g of carrier material (rice bran, rice husk, ash in a 1:1:1 ratio), yielding EM Bokashi C with a moisture content ranging between 20-30%. This mixture is then incubated in a sealed container for approximately 5-7 days until a sweet fermentation odor develops, accompanied by the appearance of white mold on its surface.

Check the Deodorizing Ability:

For the treatment of cages (such as chicken coops and pigsties), the EM2 solution should be diluted with clean, chlorine-free water at a ratio of 1:10. Subsequently, the working solution is sprayed onto the barn at a rate of 1 L/15 m2.

Regarding experimental samples, swine manure is stored in two round plastic containers with lids, each having dimensions of diameter (d) by height (h) = 0.5 x 0.7 meters. Each container is filled with 3 kg of swine manure. Box 01 is designated as the control batch, while Box 02 serves as the experimental batch, to which EM Bokashi C is added at a dosage of 30 g/kg.

Gas Sampling:

Gas samples are collected both before and after the application of the EM2 inoculant and EM Bokashi C. Sampling intervals include 3 hours post-application in pigsties, 24 hours in chicken coops, and within plastic containers.

The Kimoto HS7 gas sampler is positioned centrally within the chicken coop or adjacent to the pig toilet, approximately 30 cm above ground level. For samples contained within plastic containers, only the suction tube is inserted, with the lid secured, to collect gas samples.

Ammonia (NH_3) and hydrogen sulfide () gases are collected at a rate of 1 L/min for a duration of 10 minutes. The NH_3 gas absorption solution comprises 0.1N H_2SO_4 acid, while the solution for H_2S gas absorption comprises 1% $AgNO_3$.

Gas Concentration Determination:

The concentration of NH_3 gas is assessed in accordance with the Vietnamese standard TCVN 6179-1:1996 (Ministry of Science, Technology, and Environment, 1996).

For the determination of H_2S gas, the methodology relies on the principle of gas absorption by a solution, as outlined by Linh and Nghiem (2019).

RESULTS AND DISCUSSION

Deodorizing capacity of experimental samples

After periodic gas sampling in the experimental and control batches, the concentrations of H_2S and NH_3 gases were determined accordingly. The results are presented in Table 1.

Table 1

Concentrations of H_2S and NH_3 in Experimental and Control Samples (mg/m^3)

Day	Control sample		Experimental sample		Decrease in concentration (%)	
	H_2S	NH_3	H_2S	NH_3	H_2S	NH_3
The first day	15,42	0,19	14,46	0,11	6,23	42,11
The second day	12,90	0,35	2,90	0,18	77,52	48,57
The third day	12,53	0,38	2,11	0,08	83,16	78,95
The fourth day	12,26	0,26	2,04	0,07	83,36	73,08

The obtained results demonstrate a significant reduction in the concentration of gaseous H_2S within the experimental group compared to the H_2S levels observed in the control group after a 4-day period. The deodorizing efficiency of the EM Bokashi C product reached 83.36% after 4 days.

Conversely, the concentration of gaseous NH_3 in the control group exhibited a tendency to increase throughout the experiment, while in the experimental group, a significant decrease in NH_3 concentration was observed on the 3rd and 4th days.

The deodorizing effect of the NH_3 EM Bokashi C preparation reached 78.95% compared to the control group after 3 days and 73.08% on the 4th day. These findings align with the results reported by Pham Bich Hien (2012), who utilized microbial strains including Streptomyces uredospore's, Bacillus licheniformis, Lactobacillus plantarum, and Bacillus subtilis for the treatment of solid livestock waste. In that study, the concentration of gaseous NH_3 decreased by 73.1%, and H_2S decreased by 78% after 3 days (Hien, 2012).

Ability to deodorize air in the cowshed withmicrobial products

The capacity to mitigate odors within the chicken coop was assessed. Gas samples were collected both before and after the periodic application of the EM2 microbial inoculant solution. The findings regarding the concentrations of H_2S and NH_3 gases are detailed in Table 2

Table 2

The concentrations of H_2S and NH_3 in the air of the chicken coop (mg/m^3)

Before treatment		After treatment							
		The first day		The second day		The third day		The fourth day	
H_2S	NH_3	H_2S	NH_3	H_2S	NH_3	H_2S	NH_3	H_2S	NH_3
10,45	24,60	0,5	0,12	0,5	0,20	0,64	0,23	1,12	0,89
Deodorization efficiency (%)		95,22	99,51	95,22	99,19	93,88	99,07	89,28	96,38

The results presented in Table 2 indicate that prior to the application of the inoculant solution, the concentrations of H_2S and NH_3 gases within the chicken coop were relatively elevated, at 10.45 mg/m³ and 24.60 mg/m³, respectively.

Following the spraying of the modifying solution, there was a noticeable decrease in the concentrations of both H_2S and NH_3 gases. Specifically, the concentrations of gaseous H_2S and NH_3 measured after 1 day decreased by 95.22% and 99.51%, respectively.

The deodorizing effect of the modifier solution remained evident for up to 2 days. However, by the 3rd day, gas concentrations within the chicken coop began to rise. Nevertheless, after 4 days, the deodorizing effect of the inoculant solution reached 89.28% and 96.38% for H_2S and NH_3, respectively. Consequently, to mitigate odor within the chicken coop, it is recommended to apply the inoculant solution every 2 days.

Research on the Elimination of Sulfur and NH_3 Volatile Compounds

The potential for odor reduction within the pigsty was investigated. Gas samples were collected both before and after the application of the modifying solution, with measurements taken 3 hours post-application. The outcomes of quantifying the concentrations of H_2S and NH_3 gases are detailed in Table 3.

Table 3

Concentrations of H_2S and NH_3 in the air of a pigsty (mg/m^3)

Before treatment		After treatment		Decrease in concentration (%)	
H_2S	NH_3	H_2S	NH_3	H_2S	NH_3
18,88	1,45	9.20	0,68	51,27	53.10

The findings depicted in Table 3 illustrate a decrease in the concentration of H_2S and NH_3 gases within the pigsty following a 3-hour application of the EM2 microbial inoculant solution, in comparison to the initial concentrations. However, a challenge associated with pig manure management is its high water content, comprising 65-80% of the manure's weight. This elevated water content, coupled with abundant organic matter, fosters an environment conducive to the proliferation of spoilage-causing microorganisms, thereby generating malodorous byproducts [1].

The measured results indicate a reduction in H_2S gas concentration within the pigsty after application of the microbial inoculant solution, by 51.27%, while the NH_3 concentration decreased by 53.10% compared to the initial gas levels. These findings are consistent with observations from numerous studies conducted by various authors (Kanagawa et al., 1989; Gutarowska et al., 2014; Yan et al., 2013; Matusiak et al., 2016; Chen et al., 2022) employing odor-mitigating microorganisms. Specifically, these studies reported reductions in gaseous H_2S concentrations within cowsheds ranging from 47.2% to 70.1%, and decreases in gaseous NH_3 content ranging from 35% to 68.7%.

CONCLUSIONS

The microbial solutions EM2 and EM Bokashi C are derived from the EMRO-Vietnam microbial product (EM1). They exhibit the ability to mitigate both H_2S and NH_3 odors, yielding favorable results in laboratory experiments and household applications.

The concentrations of H_2S and NH_3 gases, known environmental pollutants, were reduced by approximately 50% compared to initial gas concentrations in the absence of microbial products.

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The article includes3 Tables and 18 References.
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