



Characteristics of Ammonia Gas Emission in the Laying Hen Farming Industry in Indonesia

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Abstract | The huge number of laying hens impacts the output of livestock waste, especially manure. Ammonia (NH₃) and other volatile compounds are the main culprits behind manure odor. High ammonia emissions will harm laying hens' health and decrease their egg-producing efficiency. This study aims to determine the factors that influence NH₃ emissions in the agricultural sector of laying hens, specifically in Sidrap Regency. This study uses quantitative techniques to ascertain how the independent variable (X) affects the dependent variable (Y) in the four sub-districts of Sidrap Regency, Maritengngae, Pitu Riawa, Kulo, and Watang Pulu. Data was gathered from 96 units on laying hen farms. Ammonia (NH₃) emissions (variable Y) were measured, and data was instantly collected using the Ammonia Gas Detector Smart Sensor AR8500 device. The 11 X variables are divided into three-factor categories: feed factors (feed consumption, feed protein content, seasonal factors (temperature, humidity, wind speed, and THI); cage systems and management factors (Population, cage density, cage area height, cage height, and length of time manure accumulate). Multiple linear regression analysis was used to determine which factors had the most influence on the farm's manure ammonia levels, and correlation analysis was used to find interactions between groupings of factors. Ammonia emissions surrounding the cage are partially and simultaneously reduced by higher wind speed values, population, and cage height, as indicated by the regression equation $NH_3 = 12.343 - 0.771 \text{ Wind Speed} - 0.0001 \text{ Population} - 0.552 \text{ Cage Height}$. Information on the factors that influence air ammonia levels may be used to suggest ways that laying hen farms may reduce the effects of ammonia gas emissions. The findings of this study can also serve as a guide for the government, affiliated businesses, and other relevant stakeholders to establish guidelines or criteria for safe and high-quality laying hen farm construction complexes and control the spread of ammonia gas emissions.

Keywords | Ammonia (NH₃) gas, Emissions, Laying hens, Industry, Livestock

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INTRODUCTION

The population of laying hens is growing annually due to rising consumer demand for animal protein, par-

ticularly for commodities like eggs. According to information gathered by the Directorate General of Animal Husbandry and Animal Health, there were 308.6 million laying hens in Indonesia in 2022. This information is in

line with the 6.2 million tons of eggs produced in 2022, of which laying hens account for 88.89%, or roughly 5.6 million tons (Ditnakkeswan, 2023). In the production phase, laying hens create around 150 grams of manure per head per day, according to Tańczuk *et al.* (2019). Assuming the population, laying hens may produce 46.3 thousand tons of manure daily in Indonesia. Considering the huge emissions from poultry manure, this amount is extremely substantial.

South Sulawesi Province, which is primarily in Sidrap Regency, is one of the regions in Indonesia that produces the largest quantity of eggs. According to BPS Kabupaten Sidenreng Rappang (2023), there were 3.98 million laying hens in Sidrap Regency in 2022, spread across 11 sub-districts. Increased output of livestock waste, particularly manure, is a result of this large population. A daily total of 59.7 tons of manure can be produced. According to Wyer *et al.* (2022), this relatively high manure production has the potential to produce emissions at levels high enough to pollute the environment, harm workers and livestock, and, at even higher levels, contribute to the thinning of the ozone layer through the greenhouse effect these emissions produce (Heriyanti *et al.*, 2022). The cage system used by the majority of laying hen farms in Sidrap Regency is still an open-house style; therefore, this negative impact has a very high potential there. Uncontrolled manure emissions and odor spread are impacted by this cage model.

Since ammonia can have detrimental effects on the health of both humans and animals, it is one of the basic chemicals found in manure that is most extensively studied. Both the hydrolysis of uric acid and the microbial decomposition of organic compounds in excrement that contain nitrogen can produce NH_3 . Evaporation of liquid ammonia results in the creation of NH_3 , a soluble and reactive gas (Kacprzak *et al.*, 2023; Pohl *et al.*, 2022).

NH_3 readily dissolves in water and reacts chemically with other chemicals to generate molecules that include ammonium. The largest concentration of NH_3 in the atmosphere is caused by intensive livestock production (Gerber *et al.*, 2015). Inappropriate feed composition that contains too much protein and amino acids can cause poultry feces to smell strong. Only one-third of the necessary nitrogen reaches the tissues and eggs; the other two-thirds are ejected (Nowak *et al.*, 2016).

Most of the dung that birds excrete will either mineralize into ammonium (NH_4^+) or transform into NH_3 . If poultry dung falls on a solid surface without being covered with litter, it will turn into sludge since it is a mixture of solid manure and pee. Manure sludge can release gases such as nitrogen gas (N_2), nitrogen dioxide (N_2O), and NH_3 through enzymatic and bacterial breakdown (Mendes *et al.*, 2017). Numerous factors, including livestock (genetics, feeding

management, behavior, activity, and behavior); waste (handling, pH, temperature, and surface area); environment (temperature inside and outside the cage, ventilation flow, and wind speed above the surface manure); location; and cage floor type, all contribute to the formation and release of NH_3 (Mažeikienė and Bleizgys, 2022; Swelum *et al.*, 2021).

One important aspect impacting NH_3 gas release is climate; high temperatures and humidity in the cage environment will cause ammonia gas emissions to increase (Bist *et al.*, 2022; Jiang *et al.*, 2021). Since air flows around the cage in open-house cage systems, wind speed also significantly impacts how ammonia gas spreads (Brouček and Čermák, 2015). The amount of protein in the feed is another determinant, while undigested protein is still the precursor to ammonia production (Vilela *et al.*, 2020). Cage management, including how feces are handled and cage models that are made to reduce the effects of ammonia gas on animals, is an additional factor (Alberdi *et al.*, 2016; Chai, 2023).

Both humans and livestock are negatively impacted by ammonia (NH_3). Ammonia (NH_3) may lead to skin, eye, nose, throat, and upper respiratory tract infections and irritations in laying hens. Furthermore, elevated levels of NH_3 may cause respiratory system injury (air sac inflammation) and lower feed intake, which in turn lowers live weight, egg production, and quality (Mohammad Al-Kerwi *et al.*, 2022; Pratiwi *et al.*, 2018). Another consequence is that chickens are more vulnerable to infection by the Newcastle Disease virus and the bacterium *Mycoplasma gallisepticum* (Ulupi *et al.*, 2015). Ammonium hydroxide (NH_4OH), which is created when NH_3 dissolves in water and enters the eyes, can result in red eyes, keratoconjunctivitis, swelling of the eyelids, a corneal injury that makes it difficult for the chicken to open its eyes, and trouble reaching food and water (Padappayil and Berger, 2023). Body weight, feed intake, and feed conversion ratio (FCR) will all decrease as a result (Huda *et al.*, 2021). Based on the number of laying hens in the district, Sidrap Regency has a high potential for ammonia gas emissions to spread. However, a comprehensive study has yet to be conducted to determine the extent of emissions and the factors that contribute to their spread. By this, the study was carried out as foundational research to ascertain how various parameters, including climate, diet, and cage system, relate to ammonia gas levels and to identify the most significant factors.

MATERIALS AND METHODS

DATA COLLECTION

This study uses a quantitative approach to determine how independent and dependent variables affect each other. The study was conducted in May 2024. The study was con-

ducted in four districts of Sidrap Regency—Maritengngae, Pitu Riawa, Kulo, and Watang Pulu—that had the greatest concentration of laying hen farms. Since the population can generate a significant amount of fecal waste, which can result in emissions that have an effect, the study's population consisted of laying hen farms with 500–20,000 laying chickens. The study had 127 farms as its population. Using the Slovin formula, the number of samples collected was calculated (Ismail *et al.*, 2022). The study's sample size consisted of 96 farm units, or 75.59% of the total number of farms in Sidrap Regency, based on a total of 127 populations. Potential biases or limitations in the data collection process may be experienced by sudden changes in wind speed and direction. This can happen because the object being measured is a gaseous object. Therefore, researchers need to be careful when reading the values of the measuring instrument used. Reading the values always uses a stable condition basis, such as relatively stable wind speed and direction.

INDEPENDENT VARIABLE (X)

CLIMATE FACTORS (X1): Climate-related factors (X1). Temperature (°C), humidity (g/m³), wind speed (m/s), and temperature humidity index (THI) are climate parameters. An Elitech DT-3 Thermohygrometer measured the farms' temperature and humidity. A digital anemometer was used to measure the wind speed around the fields. The formula $THI = 0.8 \times T + ((RH \times T)/500)$ is used to determine THI (Nieuwolt, 1977).

DIETARY FACTORS (X2): The feed consumption (g/h/day) and diet protein content (%) are two components that make up the dietary factor. The difference between the amount of food provided and consumed in a single day is used to calculate daily feed consumption.

MANAGEMENT AND HOUSING SYSTEM FACTORS (X3): Population (head), stocking density (head/cage), farm area height (masl), cage height (m), and the length of time manure accumulates in the cage (times/year) are management parameters and housing systems. The number of hens per cage unit is a measure of stocking density. The number of times manure is retrieved from the cage floor in a year determines the manure collecting time.

DEPENDENT VARIABLE (Y)

Ammonia emissions (ppm) (Y1). Ammonia (NH₃) emissions in the cage are measured using an Ammonia Gas Detector Smart Sensor AR8500 system.

STATISTICAL ANALYSIS

PEARSON CORRELATION ANALYSIS: An appropriate statistical method for determining the linear correlation between two variables is Pearson's correlation coefficient. This investigation demonstrates the degree of their relationship.

For variables X and Y, the experiment yielded two sets of data: $X = [X_1, X_2, X_3, X_n]$ and $Y = [Y_1, Y_2, Y_3, Y_n]$. The symbol "r" represents the correlation coefficient. The Pearson correlation range describes the degree of direct association or component connectedness between two variables, which runs from +1 to -1. According to Zhi *et al.* (2018), a relationship denotes a strong positive correlation between the variables or that the samples essentially have the same structure. In contrast, a relationship of -1 denotes a strong negative correlation or that the sample structures differ. This study's analysis aimed to determine how each variable in the climate factor group, feed, management, and cage system (X) related to the ammonia gas level variable (Y).

MULTIPLE LINEAR REGRESSION ANALYSIS

To ascertain the degree to which models including multiple independent variables influenced the dependent variable, multiple linear regression analysis was performed on the models (Sugiyono, 2013). The following is the multiple linear regression equation utilized in this study:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + e$$

Where:

Y= Ammonia (NH₃) emissions (Y)

a= Constant numbers

b₁= Regression coefficients of climate

X₁= Climate factors

b₂= Regression coefficients of diet

X₂= Dietary factors

b₃= Regression coefficients of management and housing system

X₃= Management and housing system factors

e = Error factor

F-TEST (SIMULTANEOUS TEST): The impact of the independent factors on the dependent variable is examined using the F-test. Simultaneous hypothesis testing is used in this study to gauge how much each independent variable affects NH₃ emissions. Comparing the F_{count} value with the F_{table} at a 5% error degree (α = 0.05) was how the test was conducted. The independent variable concurrently significantly impacts the dependent variable if F_{count} > F_{table} value (Sugiyono, 2013).

T-TEST (PARTIAL TEST): To determine whether variable X independently affects the dependent variable Y, the t-test is utilized. By examining the t values of each independent variable, this test can also determine the degree to which each one influences the dependent variable. The t value indicates which independent variable influences the dependent variable most (Sugiyono, 2013).

COEFFICIENT OF DETERMINATION (R²): The percentage contribution of the independent variables' influence on the

dependent variable is determined using the coefficient of determination (R^2). The following is the formula for the coefficient of determination (Sugiyono, 2013).

$$CD = R^2 \times 100\%$$

Where;

CD = coefficient of determination

R^2 = correlation coefficient squared

RESULTS AND DISCUSSION

AMMONIA (NH_3) EMISSIONS, CLIMATE, DIETARY, MANAGEMENT AND HOUSING SYSTEMS FACTORS

Many factors influence ammonia (NH_3) emissions. Studying these factors in more depth is important, especially when they relate to the correlation and interaction that may arise and influence each other. Climate, dietary, management, and housing systems play important roles that may influence each other. Ammonia emissions, climate conditions, dietary, management, and housing systems are among the variables included in the research results. The average, standard deviation, maximum value, and minimum value of the data are displayed in Table 1.

Table 1: Mean, standard deviation, maximum value, and minimum value of research variables.

Variables	Mean	Std. Deviation	Maximum	Minimum
Ammonia (NH_3) emissions (ppm)	0.09	1.093	5.4	0
Temperature ($^{\circ}\text{C}$)	33.47	2.203	37	29
Humidity (%)	55.91	15.763	90	30
Wind speed (m/s)	0.78	0.481	1.9	0
Temperature Humidity Index (THI)	30.46	1.282	32.9	27.94
Feed consumption (g/h/day)	116.09	4.768	120	110
Protein content %	17.28	0.451	18	17
Population (head)	10975.0	4461.330	15000	5000
Height of the Farm Area (masl)	63.03	34.883	122	19
Stocking density (h/cages)	2.01	0.827	4	1
Cage height (m)	1.25	0.554	2.5	0.5
Duration of manure accumulation (times/year)	3.47	1.809	6	0.5

Note: masl (meter above sea level).

Perdanasari *et al.* (2023), Table 1 shows that average NH_3 emissions stay between 0.08 and 3.82 parts per million. This quantity, however, is lower than the results of research

conducted by Kilic and Yaslioglu (2014), which discovered that the concentration was 1.012 ppm in laying hen farms during the summer. Temperature, humidity, wind speed, and temperature humidity index (THI) are the climate elements included in this study. The laying hens' cage temperature in this study was more significant than the 19–22 $^{\circ}\text{C}$ range recommended by Kim *et al.* (2021).

Dietary parameters in this study include feed consumption and protein levels. The average feed consumption under high-efficiency conditions is about 120 g/h/day (Clark *et al.*, 2019). The recommended daily dietary intake for laying hens in the layer phase is 110 g/h, per Feedmaster (2020). Within the recommended range, the feed consumption in this observation is 116.09 g/e/day. Ribeiro *et al.* (2016) recommend that laying hens consume 17.2% of their diet protein in the layer phase. This Figure corresponds to the protein composition of the food under study.

This finding includes the following management and housing system factors: population, farm elevation above sea level, stocking density, cage height, and length of dung buildup. The average number of laying hens per farm in this observation was 10,975. According to data on the number of households raising laying hens in Sidrap Regency in 2020, the number of farmers keeping laying hens with a population of 1000–5000 is more significant than the number of people above or below that Figure. However, the focus of this study is restricted to farmers that have between 5001 and 20,000 laying hens, which means that 10,000 laying hens are on average. The average elevation of the cage area in this investigation was 63.03 meters above sea level. According to Pemkab Sidrap (2014), the Sidrap region lies between 10 and 3000 above sea level meter (aslm), with Mount of Botto Tallu (3086 meters above sea level) being the highest point. The average laying hen stocking density is two birds per cage. According to Wan *et al.* (2023), laying hens should be stocked at a density of two birds per cage to produce the most eggs possible.

In this observation, the average height of the laying hen cage above the ground was 1.25 meters. This cage is shorter than the 2.03 m Hilal (2020) recommended height. In this study, the average amount of time that manure accumulated from the cage was 3.47 times per year. Weaver recommends cleaning dung in laying hen cages twice yearly (2024). This indicates that the laying hen cage's average manure accumulation occurred more frequently than recommended during this observation.

AMMONIA (NH_3) EMISSIONS IN LAYING HENS AND THEIR CORRELATION WITH CLIMATE, DIETARY, MANAGEMENT AND HOUSING FACTORS

Temperature, humidity, wind speed, and temperature humidity index (THI) are examples of climate factors. Die-

tary considerations include the amount and consumption of protein. Housing and management parameters include population, stocking density, cage height, cage area, and manure accumulation duration. The study's findings indicate the significance, p-value, and correlation between NH_3 emissions and climate, dietary, management, and housing factors in laying hens (Table 2).

Table 2: Correlation of ammonia (NH_3) emissions with climate, dietary, management and housing factors in laying hens.

Variables correlation	Correlation coefficient	p-Value	Correlation Level
NH_3 - Temperature	0.155	0.066	Weak
NH_3 - Humidity	-0.090	0.191	Weak
NH_3 - Wind speed	-0.613	0.000	Strong
NH_3 - THI	0.189	0.032	Weak
NH_3 - Feed consumption	0.080	0.219	Weak
NH_3 - Protein content	0.137	0.092	Weak
NH_3 - Population	-0.294	0.002	Moderate
NH_3 - Height of the farm area	-0.367	0.000	Moderate
NH_3 - Stocking density	-0.158	0.062	Weak
NH_3 - Cage height	-0.578	0.000	Moderate
NH_3 - Duration of manure accumulation	0.133	0.099	Weak

Sugiyono (2013) states that correlation coefficient values of 0.60 to 0.79 are classified as strong, 0.46 to 0.59 as medium, and less than 0.46 as weak. In this category, the climate parameter that most significantly corresponds with NH_3 emissions is wind speed ($r=-0.613$), and the correlation is statistically significant ($P<0.05$). The findings show that THI and other climate parameters are slightly correlated ($r=0.155$; $r=-0.090$; $r=0.189$). For THI, the association is substantial ($P<0.05$), but not for the temperature and humidity components ($P>0.05$).

Consumption and diet protein content had weak correlations ($r=0.080$ and 0.137 , respectively) and were considered dietary factors with an insignificant relationship ($P>0.05$). Population, cage height, and cage area were significantly ($P<0.05$) somewhat associated with housing systems and management parameters ($r=-0.294$, $r=-0.367$, and $r=-0.578$, respectively). A weak correlation ($r=-0.158$ and $r=0.133$, respectively) was found between the two additional parameters, the stocking density and the length of manure buildup, with no statistically significant difference ($P>0.05$).

Illustrates the connection between air ammonia levels and moderately correlated variables (population, cage height, and cage area) and strongly correlated (wind speed) pre-

sented in Figure 1. There are high and moderate associations between NH_3 emissions and wind speed and cage height, respectively, as shown in Figure 1a and Figure 1d. The height of the farmland (Figure 1c) and the population (Figure 1b) have a moderate association. The fact that the r value is less than 0.50, however, suggests that factors other than the farm area's height and population account for more than 50% of the air ammonia levels. Air ammonia levels and wind speed are strongly correlated. This illustrates that the air ammonia levels in the cage decrease with increasing wind speed. Cage ventilation plays a major role in NH_3 dispersion, especially in open-house dwelling systems. Wind speed significantly affects the NH_3 surrounding the cage because nearly all observation farms employ open-house systems. since some NH_3 was released into the farm environment's atmosphere. Konapathri and Azimov (2024) found that the NH_3 levels in the air around the cage decreased with increasing wind speed. $\text{NH}_3 = -1.391$ wind speed $+2.097$ is the regression equation for this connection, which shows that wind speed influences NH_3 emissions fluctuations (Figure 1a).

Another factor to consider is that the increased elevation of the cages from the ground lowers the NH_3 content and simplifies managing manure. Saunders (2022) recommends utilizing "high-rise" cages for laying hens to make managing chicken waste easier. These cages are situated significantly higher above the coop floor. Based on this study, the regression equation $\text{NH}_3 = -1.139$ cage height $+2.425$ (Figure 1d) shows that the NH_3 levels are lower when the cages are positioned about two meters above the cage floor.

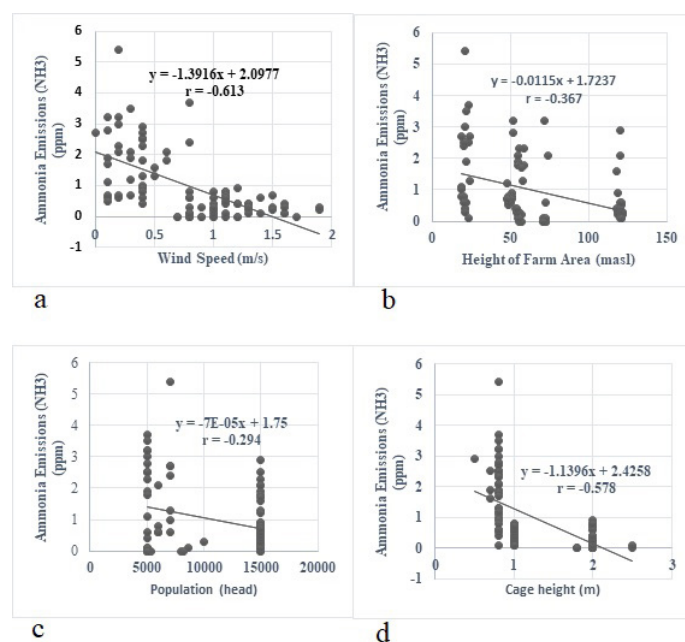


Figure 1: Correlation of ammonia (NH_3) emissions with population, wind speed, height of the farm area, and height of the cage.

REGRESSION OF AMMONIA (NH₃) EMISSIONS IN LAYING HEN FARMS WITH CLIMATE, DIETARY, MANAGEMENT AND HOUSING FACTORS

Statistical analysis to determine the relationship between factors affecting ammonia emission conditions needs to be studied more deeply. This will certainly provide an overview of these factors' positive or negative correlation. An overview of the statistical analysis results related to the factors that influence (climate, dietary, and housing management) the amount of NH₃ emissions is presented in Table 3.

Table 3: Influence of climate, dietary, management and housing factors on ammonia (NH₃) emissions.

Variables	coefficient	t-value	p-value	R ²
Constant	12.343	1.500	0.137	
Temperature (°C)	-2.766	-1.479	0.143	
Humidity (%)	-0.203	-1.500	0.137	
Wind Speed (m/s)	-0.771	-3.381	0.001	
Temperature Humidity Index (THI)	2.911	1.404	0.164	
Feed consumption (g/h/day)	0.036	1.806	0.074	
Protein content (%)	0.102	0.512	0.610	
Population (head)	-0.0001	-2.847	0.006	
Height of the farm area (masl)	-0.004	-1.108	0.271	
Stocking density (h/cages)	-0.009	-0.031	0.976	
Cage height (m)	-0.552	-2.101	0.039	
Duration of manure accumulation (times/year)	0.132	1.181	0.241	
Simultaneous			0.000	0.616

Note: masl (meter above sea level).

The investigation results show that wind speed has a significant ($P < 0.05$) impact on NH₃ emissions from farms, at least partially. This is because wind speed, especially in open-house housing systems, greatly affects NH₃ concentration since the wind quickly disperses it. This is in line with the results of Wyrer *et al.* (2022), who found that wind quickly deposits NH₃ into the atmosphere and is highly reactive.

Population is another element that has a partial ($P < 0.05$) impact on the cage's NH₃ emissions. This aligns with the results of Perdanasari *et al.* (2023), who found that larger chicken populations lead to higher levels of NH₃ in the cage and more dung output. Furthermore, the cage height component had a partial effect ($P < 0.05$) on the NH₃ levels. RSPCA Assured (2017) states that the ideal cage height for laying hens is between 0.8 and 2.0 meters. This distance is calculated such that the hen is situated within the manure disposal space beneath the cage. Lower-quality

eggs were produced by laying hens with health problems brought on by exposure to NH₃ at concentrations higher than 50 parts per million (Bist *et al.*, 2022).

The multiple linear regression analysis results show how housing, management, and climate factors affect the NH₃ emissions around the cage in Table 3. The NH₃=12.343-0.771; Wind Speed -0.0001; Population -0.552 Cage Height is the result of this. At the same time, 61.6% of climate parameters (wind speed) and management and housing factors (population and cage height) significantly ($P < 0.05$) affect NH₃ emissions around the farm, according to the coefficient of determination (R²) of 0.616. This formula demonstrates that the wind speed factor surrounding the cages significantly affects NH₃ emissions compared to other variables.

Based on several factors contributing to the concentration of ammonia gas in cage air, farmers can implement some practical strategies to prevent the gas from spreading and minimize its negative impacts on workers and livestock. Ammonia is a chemical compound that can cause damage or inflammation. Ammonia can be contaminated by breathing and then circulate throughout the surface of the human body. Eventually, it will go to certain organs of the body. Several body organs, including the liver, lungs and blood, liver, and kidneys, can be affected. By managing the population in each cage unit according to the manure storage capacity, ammonia levels surrounding the cage can be decreased. To reduce the chance of hens becoming contaminated with manure, the cages' height from the cage floor must also be between 0.8 and 2.0 meters. An anemometer mounted within the cage can regularly measure wind speed.

CONCLUSIONS AND RECOMMENDATIONS

Wind speed and air ammonia levels are strongly correlated, while population, cage height, and cage area are moderately correlated. Low air ammonia levels are partially and simultaneously present in layer chicken farms with high wind speed, population, and cage position conditions.

Farmers may implement this action to control the ammonia gas concentration surrounding the cage and prevent it from lowering the productivity of laying chickens. To reduce the impact of ammonia gas emissions on livestock, employees, and the surrounding community, laying chicken farms can use information related to the results of various factors that affect air ammonia levels to guide their cage building's location, position, and direction as well as the design of the best cage model. The government, partner businesses, and other relevant parties can use the study's

findings as a guide to establish regulations or implement policies for safe and good laying hen farm construction complexes, which would help stop the spread of ammonia gas emissions. Because this study is limited and focuses on identifying the factors that play the most role in increasing ammonia gas emissions in laying hen farms, more research can be done by identifying workable solutions to maximize the reduction of ammonia gas emissions based on the recommendations of the results presented in this study.

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NOVELTY STATEMENT

The results of previous research studies show that data related to the characteristics and distribution patterns of ammonia gas emissions in the industrial area of laying hen farming has not been found in published data and articles. The data is still limited to notes that have never been published or published in a book.

AUTHOR'S CONTRIBUTIONS

Conceptualization, Urfiana Sara, Muhammad Irfan Said, Wempie Pakiding and Sri Purwanti; investigation, Urfiana Sara; analysis and interpretation of data, Urfiana Sara, Muhammad Irfan Said, Wempie Pakiding; original draft preparation, Urfiana Sara and Sri Purwanti; review and editing, Muhammad Irfan Said, Wempie Pakiding, Sri Purwanti. project administration, Urfiana Sara; funding acquisition, Urfiana Sara, Muhammad Irfan Said, Wempie Pakiding, Sri Purwanti, authors have read and agreed to the published version of the manuscript.

CONFLICT OF INTEREST

There is no conflict of interest between researchers and authors in the article preparation and publication process for this article.

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