

Original Research

Environmental Health Risk Analysis of NH₃ Exposure Around a Laying Chicken Farm in Darsono, Jember

Febriyanti Ayuningtyas, Khoiron Khoiron*, Rahayu Sri Pujiati and Prehatin Trirahayu Ningrum

Faculty of Public Health, University of Jember, Jember, East Java 68121, Indonesia

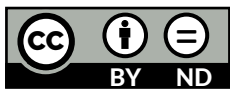
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*Correspondence:

Khoiron Khoiron
Address: Perum Pondok Bambu M12
Kebonsari, Jember Regency, Indonesia.
Email: khoiron@unej.ac.id

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ABSTRACT

Introduction: Laying hen farming constitutes a vital agricultural subsector that plays a significant role in meeting the demand for animal-based food products. However, livestock production is also recognized as a major source of atmospheric ammonia emissions. Ammonia has a negative impact on public health and the environment. This study aims to analyze the environmental health risks of exposure to ammonia gas around laying hens farms. **Methods:** The research was carried out using a descriptive design method of environmental health risk analysis (EHRA). The population in this study was the community around the laying hen farm with a sample of 95 respondents. Measurement of ammonia gas was carried out using a spectrophotometer using the Indophenol method based on SNI 19-7119.6-2005. Air samples were taken at three points. **Results:** The results of this study showed that the largest concentration was 0.00807 mg/Nm³ and the lowest was 0.00711 mg/Nm³. Based on an analysis of environmental health risks, the RQ value at the highest concentration was 0.00466 for the adult population and 0.00618 for the child population. **Conclusion:** The conclusion of this study is that exposure to ammonia gas in the adult population weighing 55kg and the child population weighing 25kg around the laying hen farm in Darsono Village is still within safe limits for a frequency of 350 days/year for the next 9 years. The advice that can be given is that the farm concerned needs to carry out livestock waste management as a source of ammonia emissions in laying hen farms.

Keywords: Laying hen farm; ammonia exposure; environmental health risk

1. INTRODUCTION

Livestock is one of the agricultural sub-sectors which play a very important role in fulfilling food needs, especially animal protein. Based on data from BPS-Statistics Indonesia, shows that one of the livestock products with high demand is eggs, reaching 5 million tons in 2021. Eggs are a product that is relatively cheap and easy to obtain, so that people with lower middle income consume more eggs. This encourages the high development of laying hen farms. According to BPS, the population of laying hens in Indonesia has reached 281 million, in East Java Province it has reached 96 million, and Jember Regency has reached 1 million. Based on the preliminary study, the Department of Food Security and Livestock of Jember Regency recorded that the population of laying hens in Arjasa District reached 31.550 heads, and Darsono Village is the village with the highest population of laying hens, reaching 19.250 heads.

Laying hen farming represents a vital subsector of agriculture that plays a significant role in meeting the demand for animal-based food products. However, intensive production systems are often associated with environmental and animal welfare challenges. High stocking density, defined as a greater number of birds per unit area, has been widely reported to negatively affect animal welfare and housing conditions. Although regulatory standards in Europe vary,

there is a growing emphasis on reducing stocking density to improve the health and comfort of poultry. In addition to welfare concerns, livestock production is recognized as a major source of atmospheric ammonia emissions. Elevated concentrations of ammonia in poultry housing environments can adversely affect both animals and workers, leading to irritation of the mucous membranes and respiratory tract, as well as conjunctivitis and dermatitis. These conditions highlight the importance of managing stocking density and environmental quality in poultry farming systems to ensure sustainable production and protect health. Ammonia is released into the atmosphere through the process of evaporation in the air. The more chickens there are, the more manure they produce, resulting in higher levels of ammonia gas. This gas often causes odors in the cage environment.⁽¹⁾ Individual, environmental, and peak occupational ammonia exposures were 0.23, 0.16, and 65.50 mg/m³ in the exposed group, respectively. Calcium and BUN, although within the normal range, were significantly higher in the exposed group compared with the control group.⁽²⁾

The extent of injury from ammonia exposure depends on the duration of exposure, gas concentration, and rate of inhalation. Ammonia reacts with mucous membranes in the skin, eyes, oral cavities, and respiratory hydroxide. Most inhaled ammonia reacts with the upper respiratory system, causing immediate irritation.⁽²⁾ Ammonia is a nitrogen gas compound that can be found in poultry droppings.⁽³⁾ Exposure to ammonia gas can occur in people who live near the construction of poultry cages. One of the laying hen farms in Darsono Village is an independently managed operation that has been active for nine years, housing approximately 2,000 birds.

2. METHODS

2.1 Study Design

This study employed a descriptive research design using the Environmental Health Risk Assessment (EHRA) approach. The EHRA method was applied to estimate health risks associated with environmental exposure by systematically collecting data on both environmental parameters and individual exposure characteristics. This field-based EHRA focused on quantifying exposure and assessing potential non-carcinogenic health risks among populations residing near emission sources. The study was conducted in residential areas surrounding a laying hen farm located

in Darsono Village, Arjasa District, Jember Regency, Indonesia. Data collection was carried out in December 2022. The selected area represents a community exposed to ammonia emissions originating from poultry farming activities.

2.2 Population and Sample Size

The study population consisted of 6,185 individuals residing in the study area. A total of 95 respondents were included in this study. The sample size was determined based on field feasibility and representativeness of populations exposed to ammonia emissions.

2.3 Sampling Technique

Sampling was conducted using a purposive sampling method, with respondents selected based on their proximity to the emission source. Inclusion was limited to individuals residing within a 100-meter radius of the laying hen farm, as this distance is considered to have a higher potential exposure to ammonia gas.

2.4 Inclusion and Exclusion Criteria

Respondents included in this study were selected based on specific inclusion criteria to ensure relevance to the exposure assessment. Eligible participants were residents living within a 100-meter radius of the laying hen farm, as this distance represents a population with a higher potential for exposure to ammonia emissions. In addition, participants were required to have resided in the area for at least one year to ensure sufficient exposure duration. All respondents were also required to provide informed consent and demonstrate a willingness to participate in the study.

Exclusion criteria were applied to maintain data quality and validity. Individuals with incomplete or missing data were excluded from the analysis. Furthermore, residents who were unwilling to participate or did not provide consent were not included in the study.

2.5 Study Variables

Individual Variables: Data on individual exposure characteristics were collected through structured interviews, including: Age (years), Body weight (kg), Exposure time (hours/day), Exposure frequency (days/year), Exposure duration (years). Environmental Variables: Environmental parameters measured in this study included: Temperature (°C), Humidity (%), Wind direction, Ambient ammonia (NH₃) concentration.

2.6 Data Collection

Primary data were collected through direct field measurements and interviews. Ambient air samples were collected at three sampling points: Point A: Settlement located near the emission source, Point B: Settlement located east of the farm, Point C: Settlement located west of the farm. Ammonia (NH₃) concentrations were measured using a spectrophotometric method with the indophenol technique, following the Indonesian National Standard SNI 19-7119.6-2005. Meteorological data, including temperature, humidity, and wind direction, were measured simultaneously during air sampling to support interpretation of pollutant dispersion.

2.7 Data Analysis

Descriptive statistical analysis was performed to summarize the characteristics of respondents and environmental measurements. Data were presented using mean and median values, depending on the distribution pattern. Normality of data distribution was assessed using the Shapiro–Wilk test and Kolmogorov–Smirnov test. If the data were normally distributed, the mean value was used as a measure of central tendency.

Conversely, if the data were not normally distributed (skewed), the median value was used to better represent the distribution. The EHRA method was applied to estimate exposure and calculate risk levels based on respondent characteristics and measured ammonia concentrations.

2.8 Ethical Considerations

This study was conducted in accordance with ethical research standards and approved by the Health Research Ethics Committee of the Faculty of Dentistry, Universitas Jember, with ethical clearance number 1803/UN25.8/KEPK/DL/2022. All respondents were informed about the study objectives and provided consent prior to participation.

3. RESULTS

3.1 Respondent Characteristics

The characteristics of respondents are categorized into several aspects including age, body weight, time of exposure, frequency of exposure, and duration time. Age groups are categorized into two based on EHRA guidelines, namely children (6-12 years) and adults (≥12 years). The results showed that 91,6% of respondents were ≥12 years old (adult age). The weight variable based

on Table 1, shows that the child's weight is 22 kg and 25 kg, respectively 2 respondents (25%).

Table 1. Respondent characteristics

Variable	Frequency	%
Age (year)		
Children (6-12 years)	8	8.4
Adult (≥12 years)	87	91.6
Children's weight (kilogram)		
22	2	25.0
22.50	1	12.5
25	2	25.0
27	1	12.5
34.90	1	12.5
35.40	1	12.5
Adult body weight (kilogram)		
<55	8	8.4
≥55	87	91.6
Time of exposure (t_e) (hour/day)		
8	1	1.1
9	1	1.1
13	1	1.1
14	5	5.3
15	6	6.3
16	14	14.7
17	3	3.2
18	8	8.4
19	6	6.3
20	4	4.2
21	38	40
22	4	4.2
23	4	4.2
Frequency of exposure (f_e) (day/year)		
278	2	2.1
290	1	1.1
296	1	1.1
314	1	1.1
326	1	1.1
345	1	1.1
348	9	9.5
350	79	83.2
Duration time (D_i) (year)		
2	1	1.1
3	1	1.1
4	1	1.1
5	2	2.1
7	2	2.1
8	1	1.1
9	87	91.6

Source: Primary data, 2022

The majority of adult respondents' weigh ≥ 55 kilograms, 50.6% of respondents. Adult respondents in this study are categorized based on the default values in the 2012 Ministry of Health's ARKL guidelines, where for inhalation pathway exposure calculations, the default value for Asian or Indonesian adult body weight is 55 kg. The majority of respondents had an exposure time of 21 hours/day (40%). Respondents with exposure < 21 hours/day also had activities outside. The results showed that 83.2% of respondents had an exposure frequency of 350 days/year.

The results show the duration time, as many as 91.6% of respondents were exposed to ammonia gas for 9 years. The duration time is determined based on the

respondent's length of stay since 2013 when the laying hen farm X as built (source of exposure) until. 2022 when the interview was conducted with the respondent.

Ammonia concentration measurements (Table 2) were carried out for 60 minutes for each point so that measurements for three points were carried out for 180 minutes starting from 10.50 WIB (Western Indonesia Time) to 14.05 WIB. The location for measuring ammonia concentration, point A (S:08°7'6.452" E:113°43'58.093") is in a residential area 50 meters from the emission source, point B (S:08°7'5.259" E:113°44'4.669") is in a residential area to the east of the chicken farm, and point C (S:08°7'7.078" E:113°43'56.097") is to the west of the laying hen farm (Figure 1).

Table 2. Hazard identification

Identification	Description
Risk agent	Ammonia (NH ₃)
Environmental media	Ambient air
Concentration of risk agents	Measurements of Ammonia (NH ₃) around laying hen farms were carried out at 3 points. The results of measuring the concentration of Ammonia (NH ₃) at point A was 7.11 µg/Nm ³ , point B was 8.07 µg/Nm ³ , and point C was 7.15 µg/Nm ³ . The three ammonia (NH ₃) measurement points produced ammonia (NH ₃) concentrations which were still below the ambient air quality standards for ammonia (NH ₃) parameters set according to East Java Governor Regulation No 10 of 2009, namely 2.00 ppm (1360 µg/Nm ³)
Characteristic of risk agent	Non-carcinogenic
Effects of risk agent on human health	Inhalation of ammonia gas is associated with acute clinical effects, including irritation of the respiratory system, coughing, wheezing, chest tightness, and decreased pulmonary function

Source: Primary data, 2022

3.2 Dose Response

Reference concentration (RfC) is a reference value for a safe value for the non-carcinogenic risk of ammonia exposure.⁽⁶⁾ The safe value of a risk agent with non-carcinogenic effects in environmental health risk analysis using the inhalation exposure route. The reference concentration for ammonia is derived from the Integrated Risk System (IRIS) quality standard value of 0.5 mg/m³.⁽⁸⁾

3.3 Exposure Intake

Intake is calculated by the amount of ammonia received and entering the body using the intake formula.⁽⁶⁾ Intake calculation uses primary data from interview results to obtain values as in the Table 3.

Calculation of non-carcinogenic intake uses the intake formula as below.⁽⁵⁾

$$I_{nk} = \frac{C \times R \times t_E \times f_E \times D_t}{W_b \times t_{avg}}$$

Table 3. Formula description

Notation	Value
Ammonia concentration (C)	a. C _{max} = 8.07 µg/Nm ³ b. C _{min} = 7.11 µg/Nm ³ c. C _{avg} = 7.44 µg/Nm ³
Rate (R)	a. Adult = 0.83 m ³ /hari b. Children = 0.5 m ³ /hari
Time of exposure (t _E)	20 hour/day
Frequency of exposure (f _E)	350 days/year
Duration time (D _t)	9 years
Weight	a. Adult = 55 kilogram b. Children = 25 kilogram

Source: Primary data, 2022

Based on the Table 4, the intake value was obtained using a formula and resulted in adult respondent's inhale ammonia between 0.00205 mg/kg/day to 0.00233

mg/kg/day in one day. And child respondents inhale ammonia between 0.00272 mg/kg/day to 0.00309 mg/kg/day in one day.

Table 4. The calculation result

The calculation result	Value
Intake of the adult population	
Maximum intake	0.00233 mg/kg/day
Minimum intake	0.00205 mg/kg/day
Average intake	0.00215 mg/kg/day
Intake of the child population	
Maximum intake	0.00309 mg/kg/day
Minimum intake	0.00272 mg/kg/day
Average intake	0.00285 mg/kg/day
Risk Quotient adult population	
RQ Maximum	0.00466
RQ Minimum	0.0041
RQ Average	0.0043
Risk Quotient child population	
RQ Maximum	0.00618
RQ Minimum	0.00544
RQ Average	0.0057
Safe concentration	
Adult	1.7276 mg/Nm ³
Children	1.3035 mg/Nm ³
Safe duration time	
Adult	232.2 years
Children	175.2 years

Source: Primary data, 2022

3.4 Risk Characterization

Risk characterization determines the risk level of a risk agent. The level of risk for non-carcinogenic effects is called the Risk Quotient (RQ). The risk level is safe if the RQ value is ≤ 1 , while the risk level is unsafe if the RQ value is > 1 . Risk characterization is calculated using a formula.⁽⁶⁾

$$RQ = \frac{I \left(\frac{mg}{kg \cdot hr} \right)}{RfC \left(\frac{mg}{kg \cdot hr} \right)}$$

The results of the risk quotient calculation in Table 4 are less than 1, so that exposure to ammonia at the minimum concentration to maximum concentration in the adult and child population living around the X laying hen farm in Darsono Village is still safe for a frequency of exposure for the next 9 years.

3.5 Risk Management

Risk management is used to reduce health risks due to exposure to risk agents. Risk management is

divided into risk management strategies and risk management methods.⁽⁸⁾ The risk management strategy determines safe value for the risk agent concentration (C) and duration time (D_t) using a formula.⁽⁶⁾

$$C_{nk(safe)} = \frac{RfC \times W_b \times t_{avg}}{R \times t_E \times f_E \times D_t}$$

and

$$D_{tnk(safe)} = \frac{RfC \times W_b \times t_{avg}}{C \times R \times t_E \times f_E \times D_t}$$

Based on the Table 4, the results of calculation safe concentration value and safe duration time show that the population can live around the laying hen farm for up to 232.2 years for adult with an ammonia concentration of 1.7276 mg/Nm³ and 175.2 years for children it an ammonia concentration of 1.3035 mg/Nm³. Because that is a safe value for duration time and ammonia concentration.

4. DISCUSSION

Respondent characteristics are characteristics inherent in the respondent such as age and weight. Adult age is dominated in the data results because based on population data in Darsono village by Darsono Village Hall it is dominated by people aged 15-64 years, so that more adult age respondents are obtained. Age is a characteristic factor that has the potential to have a risk of decreasing lung function.⁽⁵⁾ Body weight's function in environmental health risk analysis will influence a person's risk value due to exposure to certain risk agent.⁽⁴⁾ The greater the body weight value, the smaller the risk that appears.

Duration time is determined based on the the length of exposure. Exposure has existed since the laying hen farm was built. High intake is caused by high exposure to ammonia, so the risk of health problems is also higher. Exposure to ammonia occurs 24 hours/day, but exposure decreases if the respondent has activities outside the research location such as work and education. Frequency of exposure is exposure to ammonia in the number of days each year. The results show varying values because people have outside activities such as work, visiting family, and education in other cities so that the frequency of exposure is < 350 days/year.

The present study evaluates ammonia gas as a key environmental hazard in the ambient air surrounding the X laying hen farm in Darsono Village, Arjasa District, Jember Regency. The main source of exposure is attributed to emissions from the laying hen production system.

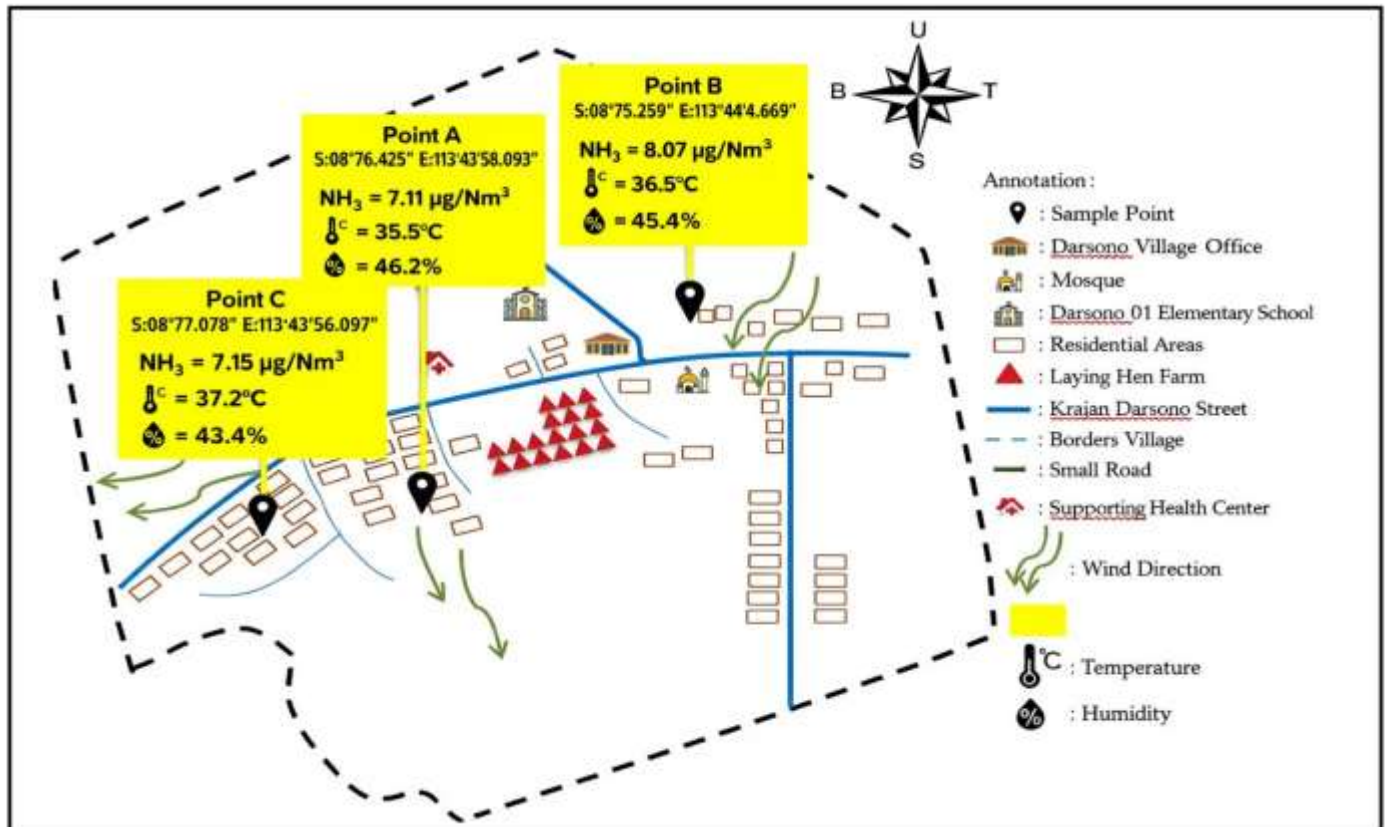


Figure 1. Sample map (Source: Primary data, 2022)

Meteorological parameters are measured together with ammonia gas concentrations such as temperature, humidity, wind direction, and wind speed. This is because meteorological conditions also affect the results of ammonia gas concentration. Meteorology has an influence on the results of measuring ammonia concentrations. This parameter has a major influence on the dispersion and removal of natural air pollutants.⁽⁶⁾

Ammonia concentration will increase when the air temperature is high and conversely the concentration decreases at low air temperature.⁽⁷⁾ The increased risk of ammonia exposure and health injury events in broiler chicken production is due to the management of ammonia levels for poultry welfare.⁽⁸⁾ The results of temperature measurements at points B and C produce higher values than point A so that concentration of ammonia gas is higher at point B and C. NH₃ concentrations showed an increase, it can be said that the probability of exceeding the acute toxicity threshold for 5% of species (exposed to AN or NH₃) is less than 13.3%.⁽⁹⁾ The result of low humidity measurements at point C and B produce a higher concentration of ammonia gas.

Emissions in the air can also be affected by wind speed. Low wind speeds will increase PM₁₀ particle levels in the air. Furthermore, wind speed also indicates

the movement of pollutants according to the current wind direction or their local persistence over a longer period of time in an area.⁽¹⁰⁾ This is contrary to the results of wind speed measurements in this study, point B produces the highest wind speed and the highest concentration of ammonia gas.

The results of measuring the concentration of ammonia gas show that it is still below environmental quality standards. In Indonesia, three types of broiler chicken housing systems are commonly used: open, semi-closed, and closed systems. Among these, the closed housing system is considered more promising and environmentally friendly compared to the others. However, studies that comprehensively compare these housing types remain limited. This study evaluated air quality parameters, including temperature (°C), relative humidity (RH), particulate matter (PM₁₀, mg/m³), ammonia (NH₃), and total airborne bacteria (CFU/m³), in 30 broiler houses located in close proximity in Banyumas Regency, Central Java. The sampled facilities consisted of 11 open houses, 9 semi-closed houses, and 10 closed houses. The results showed that the average values of temperature, relative humidity, and total airborne bacteria exceeded the standards established by the Indonesian government. In contrast, PM₁₀ and NH₃

concentrations across all observed housing systems remained below the permissible limits.⁽¹¹⁾ However, ammonia gas was proven to be present around the X laying hen farm. Low concentration of ammonia gas can be caused by the chicken population on X farm.

The farm reduced chickens on a large scale by 1,400 out of 2,000 before measuring the concentration of ammonia gas. This affects the ammonia in the air because the quantity of chicken manure is reduced. Chicken population affects the amount of chicken manure produced. Research by Setiawan et al., 2021 regarding solid waste in chicken farms shows that a farm with a population of 8,700 chickens produces 3,297.3 kg of chicken manure and 27,000 chickens produce 10,241 kg of chicken manure. This shows that the increasing population of laying hens will result in an increasing quantity of manure.⁽¹²⁾

Exposure to ammonia gas can affect human health. The main target of ammonia toxicity in the inhalation route is the respiratory system. Ammonia can irritate the upper respiratory tract in humans. Ammonia concentration has a significant relationship with cough, phlegm, wheezing (with and without shortness of breath) and asthma. Chronic exposure to ammonia in ambient air can increase the risk of respiratory irritation, coughing, wheezing, chest tightness, and impaired lung function in humans.⁽⁸⁾ Severe exposure to ammonia gas results in upper respiratory tract irritation syndrome, acute toxic lobar consolidation, and irritant conjunctivitis.⁽¹³⁾ Clinical effect due to exposure to low concentrations ammonia gas over a long period of time which have negative impacts on health such as irritation of the eyes, nose and throat, headaches, nausea, diarrhea, hoarseness, sore throat, cough, stuffy nose, palpitations, shortness of breath, stress, drowsiness, and changes in mood.⁽¹⁴⁾

Reference Concentration (RfC) for risk agents for the inhalation exposure pathways ammonia parameter is derived from the Integrated Risk System (IRIS) quality standard value of 0.5 mg/m³.⁽¹⁵⁾ Exposure intake in this study was carried out on non-carcinogenic risk agents. Real-time exposure intake uses intake formula calculations with primary data. Intake calculations result in the adult population producing lower intakes compared to the intake values for the child population. Basically, lung capacity and volume are affected by age. However, body weight also affects lung capacity and volume. This is because a person with a large body will have a large lung capacity and lung volume is also

determined by the body's surface area for exchange, especially the chest cavity.⁽¹⁶⁾ When the resulting intake value is compared with the reference concentration value of 0.5 mg/kg/day, the intake in the adult and child population in maximum, minimum, and average concentrations is still within the safe limit where the value does not exceed the safe limit value.

According to the results, the risk quotient (RQ) values for both adult and child populations were below the threshold of 1, suggesting that the exposure does not pose a significant health risk. The risk agents remain safe for an exposure frequency of 350 days per year for the next 9 years. The 9-year value is based on the analogy of RQ calculation, indicating that the intake or exposure that has occurred for 9 years is not significant or harmful to health. Therefore, it is assumed that exposure to ammonia for both adult and child populations will still be safe for the next 9 years as long as the level of exposure and exposure characteristics of the risk agent remain consistent (unchanged).⁽¹⁷⁾ However, this projection is not absolute and depends on whether there are changes in the risk agents or the exposed population.^(18,19) Hence, the fact that the community still faces potential health issues due to exposure to ammonia gas originating from poultry farms. Supported by other research, residential areas near livestock are associated with an increased risk of airway obstruction and there is a significant relationship between air pollutant emissions (NH₃ and PM₁₀) from livestock with decreased lung function in vulnerable groups such as children, the elderly and people with respiratory diseases.

Exposure to high concentrations of ammonia gas is known to cause fatal injuries in humans. This case series reports five deaths and one case of injury caused by acute ammonia exposure in the rubber industry.⁽²⁰⁾ The value of the concentration of ammonia gas from the three points of measurement of ammonia gas at point A (0.00711 mg/Nm³), point B (0.00807 mg/Nm³), dan point C (0.00715 mg/Nm³) does not exceed safe limits for safe concentrations. Based on the study results, the calculated safe exposure durations were 232.2 years for adults and 175.2 years for children.

The method of risk management uses technological, socio-economic and institutional approaches. Risk management for laying hen farms uses technological approaches such as reducing ammonia production from animal feed. Ammonia levels can be reduced by reducing dietary protein levels accompanied by amino acid supplementation. Supplement the ration

with non-starch polysaccharide degrading enzymes such as *manam* (palm kernel cake) or add probiotics to the ration. This can reduce ammonia levels.⁽²¹⁾ Another way is to plant pollutant absorbers. *Rhapis excelsa* (Finger palm) and *Liriope spicata* (Monkey grass) plants can absorb ammonia gas and are optimal with the number of plants that suit environmental conditions so that the plants can be used as recommendations for plants that can absorb pollutants such as ammonia in the air.⁽²²⁾

Risk management with a socio-economic approach in laying hens can be carried out using the reduce, re-use and recycle principles. That is the process of making and utilizing waste into a product of use value such as chicken manure which is used as compost through certain stages. Compost is useful for farmers in increasing income and reducing environmental pollution.⁽²³⁾

Institutional risk management is management using institutional mechanisms.⁽¹²⁾ Institutional mechanisms for livestock businesses can cooperate with several agencies such as the Animal Husbandry Service and the Environmental Service. Based on the Changes to the Strategic Plan for 2016-2021, the Livestock Service is tasked with supervising and coaching livestock businesses, especially chicken farming. Based on the Changes to the Strategic Plan for 2016-2021 the Environmental Service has the function of controlling environmental pollution and damage, managing and monitoring environmental quality, as well as fostering countermeasures and restoration of environmental pollution and damage. So that the ammonia gas produced from livestock can be controlled.

5. CONCLUSION

Darsono Village, Arjasa District, Jember Regency were dominated has the characteristics of an adult population with a body weight ≥ 55 kg more than a child population with a body weight of 25 kg and the time of exposure is 20 hours/day, the frequency of exposure is 350 days/year and the duration time for 9 years. The results of research on the concentration of ammonia gas at three location points produced different value and were still below ambient air quality standards. Intake values for the non-carcinogenic effects of ammonia at the adult and child populations at maximum, minimum and average concentrations produce below the reference value so that intake values can be said to be safe. The risk quotient value for the adult and child population is < 1 ,

which means it is still safe for an exposure frequency of 350 days/year for the next 9 years. Risk management to reduce health risks due to exposure to ammonia. Risk management strategies determine safe values for ammonia concentration and duration time. The safe concentration results for the adult population is 1.7276 mg/Nm³ and the safe limit exposure for adult population is 232.2 years.

Suggestions that can be given as consideration for related agencies are to carry out inspections of ambient air levels for ammonia content in laying hen farms, counseling and training related to livestock rearing management to breeders, development of open-source technology to monitor air quality and microclimate conditions inside the barn. Inhalation uses primary data to get more accurate results, especially on chicken farms in Jember Regency.

Ethical Approval

This study was conducted in accordance with ethical research standards and approved by the Health Research Ethics Committee of the Faculty of Dentistry, Universitas Jember, with ethical clearance number 1803/UN25.8/KEPK/DL/2022.

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Competing Interests

All the authors declare that there are no conflicts of interest.

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Underlying Data

Derived data supporting the findings of this study are available from the corresponding author on request.

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