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Risk Analysis of Exposure to NH_3 And H_2S Gas to Workers in The Small Industrial Environment of Magetan Regency in 2021

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ABSTRACT Decomposition of fur, meat, and skin residues produces NH_3 and H_2S gases that may pose a risk to worker health. NH_3 gas is a gas that has a characteristic pungent odor, is corrosive, and is highly toxic even in low concentrations. Exposure to H_2S gas can cause bad effects on health because it is quickly absorbed by the lungs. This study aims to analyze and determine the risk of exposure to NH_3 and H_2S gases to workers' health in the Magetan Regency Small Industrial Environment (LIK). The design of this study is descriptive-quantitative, that is, a study that aims to describe or characterize an event that occurs in numerical and narrative form. The study used a cross-sectional temporal approach and an environmental health risk analysis (ARKL) approach. The sample consisted of 13 workers. Air samples were collected from a site where the leather tanning process was conducted in the unbundling phase. The data analysis method used is the risk analysis to determine the risk characterization of workers in the small industrial environment (LIK) Magetan. Based on ARKL guidelines, the level of risk is called "safe" when the RQ value is 1, and the level of risk is called "unsafe" when the RQ value is > 1. The results show that the NH3 and H_2S gas concentration is still below the NAV value based on the Minister of Manpower and Transmigration Order No. PER .05/MEN/X/2018, which is 25 ppm and 1 ppm, respectively. The ARKL calculation uses the minimum and maximum values for measuring NH_3 and H_2S gas concentrations with reference concentration (RfC) values of 0.5 mg/kg/day and 0.002 mg/kg/day. The RQ value for workers for NH_3 and H_2S gas concentrations RQ < 1 is safe for workers.

INDEX TERMS Risk analysis, NH_3, H_2S, workers in the tanning industry.

I. INTRODUCTION

Article 28 H of the Second Amendment in paragraph (1) of the 1945 Constitution states that "everyone has the right to live in physical and mental well-being, to have a place to live, to have a good and healthy environment, and to have the right to health services."). This mandate is the government's commitment to the Sustainable Development Goals (SDGs) in Goal 3. Healthy and Prosperous Living, explicitly states, "Ensure healthy lives and improve the well-being of all people at all ages [1].

The development of the health sector towards the SDGs is highly dependent on the active role of all stakeholders, both central and local governments, parliament, the business community, mass media, social institutions, professional and scientific organizations, development partners, and the United Nations (UN). The program being implemented to achieve the SDGs in the health sector is the Healthy Indonesia Program with three pillars, namely 1) a healthy paradigm, 2) health services, and 3) national health insurance. It is clear that the development of the health sector towards the SDGs requires the role of each component, and one of them is the role of the business community in creating a healthy and productive industry.

The role of the business world is reflected in the development of modern science and technology, which today makes the industrial world compete to increase labor productivity with a larger scale of enterprises, making the industrial development factor better and superior. Therefore, it is necessary to increase the awareness, willingness, and ability of each worker to lead a healthy life to achieve the highest level of health as part of the investment in the development of healthy and productive human resources.

Article 3, subparagraph (b) [2]on the protection and management of the environment states that the protection and management of the environment aim to ensure safety, health, and human life. This statement is consistent with Article 1, paragraph (1) [3] on occupational safety and health: "Occupational safety and health mean all activities to ensure and protect the safety and health of workers through efforts to prevent occupational accidents and diseases.

Data from the Central Statistics Agency of the Ministry of Health of the Republic of Indonesia show that in 2016, 26.74% of the population aged 15 years and older were employed and had health complaints or problems. Work-related health problems are mostly caused by exposure to substances generated at work, especially chemicals, physical agents, and biological agents, which are health risk factors.

Health risks due to human activities occur because basically every activity always has environmental and health impacts. Health risks are negative effects that can only be controlled, but not completely eliminated. Emerging environmental health problems raise questions about, among other things, the extent of health risks due to exposure to environmental hazards, how to control risks without stopping the activities of risk sources, and the effectiveness of legal instruments and available technologies to protect the health of people exposed to adverse health effects called Environmental Health Risk Analysis [4].

Air is an important life factor that must be protected for survival. Wind speed, air temperature, and humidity are among the meteorological parameters that can affect the concentration of harmful gases in the air [5]. Air pollutants are generally in the form of gases that can affect health and particles of solid and liquid substances that are toxic. These toxic gases come from mobile sources such as vehicle fuel combustion, stationary sources such as households, and industry [6].

One of the gases that play a role in air pollution is $NH_3$and H_2S gases. NH_3 is a gas that has a characteristic pungent odor, is corrosive, and is highly toxic even at low concentrations. This compound usually appears as a gas with a pungent odor at concentrations of 50 ppm, which can cause eye and nose irritation, throat irritation, coughing, chest pain, and shortness of breath. At even higher concentrations (2500 ppm-5000 ppm), ammonia gas can cause severe eye irritation (keratitis), shortness of breath (dyspnea), chest pain, lung swelling, hemoptysis, bronchitis, and pneumonia [7].

According to [8] H_2S gas enters the human body through the air, mainly through inhaled air. Exposure to H_2S gas can have adverse health effects because it is rapidly absorbed by the lungs. At low concentrations of 0.13 to 100 ppm, this gas can cause irritation of the eyes, nose, and throat, and even respiratory problems in asthmatics. At high concentrations of 2000 ppm, it can cause unconsciousness and even death [9].

In the small-scale industry (LIK) environment, there are 35 small and medium industries (ICMs), consisting of 4 ICM units for production processes, 23 ICM units for production, and 23 ICM units for services. magnet. Approximately 8,200,000 feet/year of leather products are produced. Leather production in Magetan is dominated by tanning, where the raw material is fresh leather, so the main components are protein, carbohydrates, fats and minerals. The skin content is a very good breeding ground for spoilage microbes such as Bacillus sp., Micrococcus sp. and Staphylococcus sp. These microbes can convert the protein in salt peels and fresh hides into soluble and volatile nitrogen compounds. The conversion of proteins produces H_2S, NH_3, indole, skatole, and mercaptan compounds, which disperse into the air, causing the air to smell foul, unpleasant, and very pungent [10].

Previous research on Healt Risk Analysis of Hydrogen Sulfide H_2S and Ammonia NH_3 Exposure at Piyungan Landfill by [11] improving the object used in previous research, namely the community in the Piyungan TPA environment, while in the current study the Small Industrial Environment (LIK) workers and the location of the research which took place at the TPA in Ngablak, Sitimulyo, Piyungan, Bantul. While the current research location used for research is the Small Industrial Environment (LIK).

Based on the background of the problem, it is interesting to know more. The purpose of this study was to analyze the environmental health risks of exposure to NH_3 and H_2S gases in workers as a result of the decomposition process of the rest of the fur, meat and skin scraps in the Small Industrial Environment (LIK).

II. METHODHOLOGY

In this research, a quantitative-descriptive type of research is used, that is, a study that aims to describe or describe an event in the numerical and narrative form. This type of research is used to describe or measure the concentration of NH_3 and H_2S gases in the small-scale industrial environment (LIK). This study uses an environmental health risk analysis (ARKL) approach [12]. Risk analysis is used to estimate and evaluate the risks to human health caused by exposure to environmental hazards.

Hazard is an inherent characteristic of a risk agent or situation that has the potential to cause adverse effects when an organism, system, or subpopulation is exposed to the risk agent [13]. The temporal approach in this study is cross-sectional because it is conducted in a period of time and observations are made only during the observation. Data analysis was carried out using univariate analysis and environmental health risk analysis (ARKL) was calculated using the following equation:

$$I = \frac{(C.R.t\ .f\ .D\ )}{W\ .t}$$

Description :

I : Intake (mg/kg/hari)
C : Gas concentration NH_3 dan gas H_2S
R : Intake volume (m^3/jam)
tE : Exposure time (day/hour)
fE : Exposure frequency (hari/tahun)
Wb : Respondent's weight (kg)

Dt : Exposure duration
ta_{vg} : Average time (tavg)

III. RESULTS

From Table 1, it can be seen that the results of the measurement of the air temperature during fleshing in the small-scale industry (LIK) of the Magetan regency gave an average of 29.6ºC, with the lowest air temperature of 27.8ºC and the highest air temperature of 31.8ºC. Humidity measurements gave an average of 64%, with the lowest humidity at 54% and the highest at 72%. For wind speed, the average value was 1.25 m/s, with the lowest wind speed being 0.95 m/s and the highest wind speed being 1.51 m/s. The wind direction at the time of sampling was blowing from the west and south.

TABLE 1

Results of temperature, humidity, wind speed, and wind direction measurements in the Magetan Regency small industrial environment (LIK) in 2021.

Location	Time	Temp. (ºC)	Humidity (%)	Wind speed (m/s)	Wind direction
Fleshing Unit	07.30	27,8	72	0,95	From the West
	11.30	31,8	54	1,51	From the West
	14.30	29,3	65	1,31	From the South
Average		29,6	64	1,25	-
Lowest value		27,8	54	0,95	-
Highest value		31,8	72	1,51	-

Source: Primary Data 2021

TABLE 2

Results of the measurement of NH_3 and H_2S gas concentrations in a small industry (LIK) in Magetan Regency in 2021

Parameter	Pick-up time	Gas concentration	
		ppm	mg/m^3
	07.30	0,0078	0,0054
	11.30	0,0075	0,0052
NH_3	14.30	0,0070	0,0048
Overall average		0,0074	0,0052
	07.30	0,000027	0,000037
H_2S	11.30	0,000026	0,000036
	14.30	0,000025	0,000034
Overall average		0,000026	0,000036

Source: Primary Data 2021

Table 2 shows the average measurement results in the tannery during fleshing in the small industrial environment (LIK) Magetan Regency. Conversion from ppm to mg/m^3 according to the following formula:

$$\frac{M \qquad w \quad ht}{2 \quad ,5} \text{ x } Co \qquad \text{tion } Pi \quad =$$

Information:

Molecular weight: gas NH_3: 17,0 g/mol
Molecular weight: gas H_2S : 34.1 g/mol

The average NH_3 gas content was 0.0074 ppm (0.0052 mg/m^3). The lowest afternoon NH_3 gas reading was 0.0070 ppm (0.0048 mg/m^3), and the highest morning NH_3 gas reading was 0.0078 ppm (0.0054 mg/m^3). The average H_2S gas readings are 0.000026 ppm (0.000036 mg/m^3). The lowest H_2S gas reading in the afternoon is 0.000025 ppm (0.000034 mg/m^3), and the highest H_2S gas reading in the morning is 0.000027 ppm (0.00037 mg/m^3).

From Table 3, the NH_3 and H_2S gases that may cause health problems for workers during the fleshing process in the Magetan Regency small industrial area (LIK) are NH_3 and H_2S gases generated by the decomposition process of the remaining fur, meat, and skin pieces, resulting in mixed gases with the ambient air that may pollute the air at this site.

The average, minimum and maximum concentrations of NH_3 and H_2S gases are used to calculate the intake value in the exposure assessment phase. The minimum concentration of NH_3 gas is 0.000076 mg/ m^3, the maximum concentration is 0.000085 mg/ m^3, and the average concentration is 0.000082 mg/m^3. The minimum concentration of H_2S is 0.00000054 mg/m^3, the maximum concentration is 0.00000057 mg/m^3, and the average concentration is 0.00000059 mg/m^3.

TABLE 3

Identification of NH_3 and H_2S gas hazards in small-scale industries (LIK) in Magetan Regency in 2021

Environmental media Potential	Risk Agent	Measured concentration (mg/m^3)		
		Min	Average	Max
Ambient Air	NH_3	0,0048	0,0052	0,0054
	H_2S	0,000034	0,000036	0,000037

Source: Primary Data 2021

TABLE 4

Dose sensitivity and critical effects of NH_3 and H_2S

No.	Agent	Response Dose	Critical effects
1.	Ammonia (NH_3)	0,5 mg/m^3	Decreased lung function and respiratory symptoms
2.	Hidrogen Sulfida (H_2S)	0,002 mg/m^3	Decreased olfactory function in the nose

Source: www.epa.gov/iris, accessed 20 October 2021

The reference concentration value (RfC) for NH_3 and H_2S is based on the literature according to EPA 2016 and is listed on the website www.epa.gov/iris accessed on October 20, 2021. The dose-response value for NH_3 gas is 0.5 mg/m^3 with the effect of decreased lung function and respiratory symptoms, and the dose-response value for H_2S gas is 0.002 mg/m^3 with the effect of decreased olfactory function in the nose.

TABLE 5
Calculation of NH_3 and H_2S gas intake variables for small industry workers (LIK) in Magetan County in 2021

No.	Variable	Result
1.	Gas concentration NH_3	Cminimal = 0,0048 mg/m^3 Caverage = 0,0052 mg/ m^3 Cmaximal = 0,0054 mg/ m^3
	Gas concentration H_2S	Cminimal = 0,000034 mg/m^3 Caverage = 0,000036 mg/ m^3 Cmaximal = 0,000037 mg/ m^3
2.	Intake volume (R)	Adult = 0,83 m^3/jam
3.	Exposure time (tE)	8 hours/day
4.	Exposure frequency (fE)	192 days/year
5.	Exposure duration (Dt)	5 years
6.	Weight (Wb)	Average 55 kg
7.	Average time (tavg)	30 years x 365 days/year

Source: Primary data 2021

The calculation of NH_3 and H_2S gas is done by entering each required variable into the formula and calculating them individually. The results of the calculation of the uptake value are given in the appendix. For fleshing, the highest uptake value of NH_3 gas has a maximum concentration of 0.000085 mg/kg/day and the lowest uptake value of NH_3 gas has a minimum concentration of 0.000076 mg/kg/day. The highest uptake value of H_2S gas has a maximum concentration of 0.00000059 mg/kg/day, and the lowest uptake value of H_2S gas has a minimum concentration of 0.00000054 mg/kg/day.

The RQ value can be calculated by interpreting the level of risk that occurs at the research site, regardless of whether it is classified in the safe or unsafe category. If the RQ value is 1, the risk level can be designated as safe for humans, while an RQ value > 1 means that the risk level can be designated as unsafe. In fleshing, the highest RQ value of NH_3 gas has a maximum concentration of 0.00017 and the smallest RQ value of NH_3 gas has a minimum concentration of 0.00015. The highest RQ value of H_2S gas with a maximum concentration of 0.00029 and the smallest RQ value of H_2S gas with a minimum concentration of 0.00027 means that the value of exposure to NH_3 and H_2S gases RQ < 1 is safe for workers weighing 55 kg, 8 hours/day with an exposure frequency of 288 days/year over 30 years."

IV. DISCUSSION

In this study, the average age of the respondents was 20-35 years. Body weight also affects the magnitude of the health risk value. Weighing was obtained using manual/analog scales with an average weight of 55 kg. In the research [14] the average value of the respondent's body weight is 58 kg so that the results of the calculation of NH_3 gas are obtained. The average RQ value both at the minimum, maximum, and average concentrations is still below 1 (RQ < 1).

Inhalation rate is the volume of air contaminated with NH_3 and H_2S gases that enter the body of adult category workers using the US-EPA default value of 0.83 m^3/hour. Based on observations about the habits of workers in wearing masks, it can be seen that all workers have a habit of not wearing masks, this can affect the amount of NH_3 and H_2S gases that enter the respiratory tract and cause respiratory problems [15].

Temperature, humidity, and wind speed are air physical environmental factors that can affect the high and low values of NH_3 and H_2S gas concentrations. [16] states that a high air temperature of 30ºC will cause the air to become more tenuous, so that the concentration of contaminants will be low. Conversely, when the air temperature is cold, the air becomes denser so that the concentration of pollutants is high.

Air humidity also plays a role in the concentration of NH_3 and H_2S gases. Moist air will help the process of deposition of pollutants because it will cause particles to bind to water in the air so that the concentration will be lower [17]. According to [18] Air conditions in the morning and evening are cooler than in the afternoon so that hydrogen sulfide and ammonia gas are retained in the earth's surface layer coupled with high air humidity which can accelerate the process of decomposition of waste by microorganisms.

In addition, wind speed also affects the height of NH_3 and H_2S gases. In the research of [19] stated that high wind speeds can cause low pollutant concentrations, and vice versa. The low wind speed causes the spread of air over a wider space to be slow and accumulate.

According to [20] the influence of temperature, humidity, and wind speed factors on the increase/decrease in the concentration of NH_3 and H_2S gas concentrations. The expansion in the air will dilute the concentration of polluting gases including NH_3 and H_2S gases. Temperature affects air pressure and humidity which will then affect wind speed.

Based on direct measurements of NH_3 and H_2S gases, they still meet the environmental quality standards specified in the Regulation of the Minister of Manpower and Transmigration No. PER.05/MEN/X/2018 on Occupational Safety and Health as shown in Table 3, although different results may also be affected by differences in temperature, humidity, wind speed, and the process of skin tanning at the time of measurements. From the three sampling times, it is evident that measurements in the morning yielded higher NH_3 and H_2S gases than in the afternoon and evening during the fleshing phase of the tannery.

NH_3 and H_2S gases in the air from the rotting process of a feather, meat, and leather residues pose a risk to the health of workers in the Magetan Regency small-scale industrial (LIK) environment. This process produces NH_3 and H_2S

gases that can pollute the environment. According to [21] NH_3 and H_2S have water-soluble properties and cause poisoning in the upper respiratory tract, including damage to ciliated cells, inflammation, and hypertrophy or hyperplasia of mucous cells.

According to [22] The impact of exposure to NH_3 gas causes disturbances in lung function and sensitivity to the sense of smell, if in high concentrations it can cause effects such as burning on the skin, eyes, throat, or lungs. While the impact of repeated or long-term exposure to H_2S gas can cause symptoms of red eyes, headaches, fatigue, irritability, insomnia, digestive disorders, and weight loss.

The minimum, average, and maximum concentrations of NH_3 and H_2S gases are used in the calculation of intake in this study. The amount of intake value is also directly proportional to the value of exposure frequency, exposure duration, and inhalation rate, so it can be said that the greater the intake value, the greater the intake of a person. The intake level is inversely proportional to the body weight, so the greater the weight of a person, the lower the intake level [23].

Risk characterization (RQ) for NH_3 gas with minimum concentration of 0.00090 < 1, average concentration of 0.00098 < 1, and RQ value of 0.000102 < 1. Risk characterization (RQ) for H_2S gas with minimum concentration gives RQ value of 0.00160 < 1, average concentration gives RQ value of 0.00170 < 1, and maximum concentration gives RQ value of 0.00175 < 1. Based on the calculation results of the gas RQ values for NH_3 and H_2S concentrations, the exposure risk to small industry workers (LIK) Magetan Regency is safe.

Health risk management/control is carried out through 3 approaches, namely a technological approach, a socio-economic approach, and an institutional approach. 8 Control can be done by determining the safe limit / lowest risk that occurs by reducing contact with exposure in the form of minimizing existing activity patterns [24][25].

V. CONCLUSION

The results of environmental physical measurements at the fleshing stage tannery at an average temperature of 29.6ºC, average humidity of 64%, and an average wind speed of 1.25 m/s, with the wind blowing from the west and south. The concentration of NH_3 and H_2S gases in the fleshing stage tannery still meets the quality standards set in the Order of the Minister of Labor and Transmigration No. PER.05/MEN/X/2018, namely 25 ppm and 1 ppm respectively. Environmental health hazards in the tannery in the fleshing stage are NH_3 and H_2S gases in the tanning process. Dose-response (RfC) values for NH_3 and H_2S gas pollutants are 0.5 mg/kg/day and 0.002 mg/kg/day, respectively, with effects on respiratory system disorders. The highest intake level for exposure to NH_3 and H_2S gases in the fleshing phase of tanneries is 0.00085 mg/kg/day and 0.00000059 mg/kg/day, respectively. The risk level of exposure to NH_3 and H_2S gases for workers in a leather tannery in the fleshing phase is still safe at a maximum concentration of 0.000017 mg/m^3 and 0.00029 mg/kg/day. Some suggestions that need to be considered in research For Agencies: the Department of Environment (DLH) of East Java Province and Magetan Regency should carry out supervision to assess the compliance of the Small Industry Environment (LIK) of Magetan Regency to environmental documents that have been agreed upon. Conduct air quality regularly and continuously so that the concentration of pollutant gases in the ambient air, especially in the Small Industrial Environment (LIK) of Magetan Regency. For Small Industry Environment (LIK): conducting socialization about the dangers of exposure to NH_3 and H_2S gases and managing the disposal site for the rest of the meat, fur and fresh skin so as not to cause excessive gas. Carry out routine environmental inspections at the tannery unit at the fleshing stage to measure and monitor the gas content of NH_3 and H_2S in the air. For Other Researchers: other researchers need to do the same research, namely analyzing the risk of exposure to NH_3 and H_2S gases, but with different locations or target populations in order to know the comparison between this study and the research conducted. Other researchers can also conduct further research on the risk of exposure to NH_3 and H_2S gases in people living around the Small Industrial Environment (LIK) Magetan Regency.

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