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# Health Risk Analysis of Hydrogen Sulfide ($H_2S$) and Ammonia ($NH_3$) Exposure at Piyungan Landfill

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**ABSTRACT**

Waste processing facilities produce toxic gases to the body. One of which in Piyungan landfill, which produces hydrogen sulfide and ammonia gas. The gas comes from anaerobic decomposition of waste, and risk causing health problems. The purpose of this study is to identify health risks due to hydrogen sulfide and ammonia exposure in the community of Piyungan landfill. This study was descriptive quantitative using an environmental health risk analysis approach. The environmental health risk analysis is an approach to estimate or calculate the risk level of human health due to risk agents exposure. The research design was cross-sectional. The research sample was a community Ngablak hamlet, which lives in a zone of ± 600 meters from Piyungan landfill. The number of respondents was 59 people with the sampling technique used total sampling. The results indicate that RQ hydrogen sulfide is 1.49549 (RQ>1), while ammonia is 0.02501 (RQ≤1). Public health problems among headache, cough, breathlessness, influenza, and sore throat. The risk level due to exposure to hydrogen sulfide indicates risk. However, ammonia indicates no risk of health problems for the community. The findings of this research may serve as improving the waste management system at Piyungan landfill.

## 1. INTRODUCTION

Waste is a residual component that comes from housing and agriculture. These components can have an impact on the environment [1]. The increase in population and activities is directly proportional to the increase in waste volume [2]. As a result, the burden of waste processing sites has increased, one of which is Piyungan landfill. Piyungan landfill is a waste processing facility in Yogyakarta. The landfill ware located at RT 03 Dusun Ngablak, Sitimulyo, Piyungan, Bantul. In March 2020, Piyungan landfill was closed because the volume of waste exceeded the storage limit. That is due to a significant increase in waste volume. Previously, the volume of waste was 17,992,033 Kg to 21,586,307 Kg [3].

Landfill waste can pollute the environment. That is due to the process of decomposing waste [4]. This process produced a gas that smells bad [5]. The process of decomposing waste produces gaseous components such as hydrogen sulfide ($H_2S$) and ammonia ($NH_3$). Based on the D.I.Yogyakarta Governor Regulation Number 43 of 2016, the two gases were indicators of environmental odor levels. The odor level standard for $H_2S$ and $NH_3$ gases is basing on regulations, including hydrogen sulfide ($H_2S$) is 0.010 ppm, while ammonia ($NH_3$) is 1.500 ppm. Feuyit et al. [6] gases that enter the air and pollute the environment can endanger a person's health.

Hydrogen sulfide ($H_2S$) is a byproduct of the waste decomposition process. The process of decomposing garbage produces a pungent odor like rotten eggs [7]. The effects of $H_2S$ can cause environmental damage and endanger one's health [8]. Ammonia gas ($NH_3$) ware produced by the natural odor of animals/plants in the environment. The gas irritates the respiratory tract when it enters the body [9]. If $H_2S$ and $NH_3$ gases had been inhaled continuously, there is a risk of causing public health problems.

The results of research at TPA Sukawinatan indicate that the risk level of H2S has an RQ value of > 1, which is at risk of causing public health problems. However, $NH_3$ has an RQ value < 1, which is not a risk of public health problems [10]. Therefore, people living around the Piyungan landfill are at risk of experiencing health problems. One of them is the Ngablak hamlet.

The people of Ngablak hamlet living and working in the Piyungan landfill area. Most of the people work as scavengers and garbage collectors [11]. The community ware exposed by $H_2S$ and $NH_3$ from Piyungan landfill. Because the community has a place to live beside the Piyungan landfill. As a result, people are at risk of experiencing health problems. Norsa'adah et al. [12] stated that people living near the Sabak landfill have a higher health risk. The landfill environment can have an impact on public health [13]. For example, irritate the nose, eyes, throat, difficulty breathing, and nausea due to exposure to the smell of landfill.

The result of an interview with the people of Ngablak hamlet stated that the smell of waste sometimes disturbs breathing. The smelled causes shortness of breathlessness or headache. However, people are increasingly ignoring these health complaints. To estimate the risk level of public health, this study uses an environmental health risk analysis approach with the aim to identify health risks due to hydrogen sulfide and ammonia exposure in the community of Piyungan landfill.

The findings of this research may serve as improving the waste management system at Piyungan landfill.

## 2. METHODOLOGY

This study was descriptive quantitative using an environmental health risk analysis approach. The environmental health risk analysis is an approach to estimate or calculate the risk level of human health due to risk agents exposure. The research design was cross-sectional. The research sample was a community Ngablak hamlet, which lives in a zone of ± 600 meters from Piyungan landfill. The number of respondents was 59 people with the sampling technique used total sampling.

The research data were collected using interviews and observations. The research instruments used were structured interview guides, observation sheets, and measuring instruments (weight scales, Distance and Area Measurement application, length meter). Data analysis used univariate analysis and risk analysis. Risk analysis ware used to determine the level of public health risk (RQ). First, the calculation of intake/ intake ware carried out with the formula:

$$I_{nk} = \frac{C \; x \; R \; x \; t_E \; x \; f_E \; x \; D_t}{W_b \; x \; t_{avg}} \quad (1)$$

The concentration of $H_2S$ and $NH_3$ risk agents (mg) that enter the body, body weight (kg), exposure time (tE), and duration of exposure (Dt) in the community at Piyungan landfill area can affect the results of the intake value of this study. The intake can be used to calculate the level of risk. The risk level of non-carcinogenic effects is expressed in Risk Quotation (RQ) notation, with the formula:

$$RQ = \frac{I}{RfC} \quad (2)$$

This study has received an ethical approval letter from the Universitas Ahmad Dahlan Research Ethics Committee (KEP UAD) with Number: 012004019 for health research using human subjects.

## 3. RESULTS AND DISCUSSIONS

Piyungan landfill has located in Ngablak, Sitimulyo, Piyungan, Bantul. Piyungan landfill has been operating since 1995 and which only intended for the next ten years. However, so far the Piyungan landfill is still functioning. Even though the land for collecting garbage has exceeded the limit. The situation can endanger public health. Especially the people who live at Piyungan landfill.

There are health impacts due to direct exposure to polluted environments, for example in the environment landfill. Respiratory tract health problems are more common and experienced by scavengers [14]. Because the air is polluted by harmful gases. For example, hydrogen sulfide and ammonia are produced from anaerobic decomposing of waste. As a result, the gas has chronic effects on someone who is exposed. The results analysis of health risks of hydrogen sulfide and ammonia exposure in the community at Piyungan landfill include:

### 3.1 Public health complaints

The results an interview with the people of Ngablak hamlet were that most respondents did not feel health complaints as many as 37 people (62.7%). As many as 22 other people (37.3%) felt health complaints due to gas from the Piyungan landfill. Some of the health complaints felt by the people of Ngablak hamlet in Table 1, among others:

**Table 1.** Distribution of health complaints

| Health Complaints | n | % |
|---|---|---|
| **Cough** | | |
| Cough | 6 | 10.2 |
| Don't Cough | 53 | 89.8 |
| | **59** | **100** |
| **Influenza** | | |
| Influenza | 2 | 3.4 |
| Don't Influenza | 57 | 96.6 |
| | **59** | **100** |
| **Breathlessness** | | |
| Breathlessness | 6 | 10.2 |
| Don't Breathlessness | 53 | 89.8 |
| | **59** | **100** |
| **Headache** | | |
| Headache | 11 | 18.6 |
| Don't Headache | 48 | 81.4 |
| | **59** | **100** |
| **Sore throat** | | |
| Sore throat | 1 | 1.7 |
| Don't Sore throat | 58 | 98.3 |
| | **59** | **100** |

Distribution of respiratory health complaints from the people of Ngablak hamlet, headache (18.6 %), cough (10.2 %), breathlessness (10.2 %), influenza (3.4 %), and sore throat (1.7 %).

A waste disposal environment, a person has a low level of health. For example allergies, asthma, respiratory tract irritation, skin irritation, and other diseases [15]. Therefore, some people in the Piyungan landfill experience health problems due to exposure to hydrogen sulfide and ammonia. The effects of exposure to hidrogen sulfide gas on health can cause several complaints such as chest pain, dry throat, shortness of breath, and coughing [16]. Some of the symptoms or complaints due to poisoning due to ammonia in the respiratory tract include coughing, cough with phlegm, wheezing, shortness of breath, and others [17].

### 3.2 Environmental health risk analysis

Environmental health risk analysis is an approach to estimate public health risks [18]. The steps in risk analysis include:

#### 3.2.1 Hazard identification

Hazard identification is the first step in a risk analysis. This step is to identify specific risk agents that have the potential to cause health problems in a person [18]. The risk agents in this study were hydrogen sulfide and ammonia. Both risk agents have potential respiratory health problems. In this study, concentrations of $H_2S$ and $NH_3$ were not measured directly by the researcher. Because the research was conducted during the Covid-19 pandemic. As a result, $H_2S$ and $NH_3$ concentrations cannot be measured directly at the study site. Therefore, the concentration of $H_2S$ and $NH_3$ uses concentration data from the Yogyakarta Environmental and Forestry Office.

The average concentration of $H_2S$ is 0.011 mg/m$^3$ (0.00805 ppm x 1.394 mg/m$^3$), while $NH_3$ is 0.046 mg/m$^3$ (0.06615 ppm x 0.697 mg/m$^3$). Both risk agents can enter the body through the inhalation route. The concentration of risk agents that enter has the potential to cause health problems. When hydrogen sulfide enters the body can cause eye irritation, nose irritation, throat irritation, difficulty breathing, headaches, and others [7].

Cases of short-term $H_2S$ exposure can cause respiratory tract disease. Long-term effects can cause fatigue, loss of appetite, pain, and fainting. Also, cases in women can cause miscarriage (abortion) [19]. Ammonia gas can react with the upper respiratory system [9]. The health effect felt by the body is irritation of the respiratory tract. Because ammonia gas is irritating and corrosive to the human body.

3.2.2 Dose-response assessment

Dose-response analysis was performed to find the RfD/ RfC or SF values of a risk agent in risk analysis [18]. In this study, dose-response analysis used the RfC (reference concentration) values of hidrogen sulfide and ammonia risk agents. This research uses the RfC value, because the risk agent enters the body from inhalation route, and the effect is non-carcinogenic.

Dose-response analysis was not carried out directly by the investigators. The dose-response analysis of this study used the RfC value (reference concentration). RfC values can be accessed at www.epa.gov/iris. RfC value of hidrogen sulfide risk agent is 0.002 mg/m$^3$, while ammonia is 0.5 mg/m$^3$.

The previous RfC $H_2S$ value was 1x10$^{-3}$ mg/m$^3$. These values were obtained from a study of subchronic inhalation rats by CIIT in 1983. The samples used inflammation of the nasal mucosa. The RfC reduction is based on NOAELHEC 1 mg/m$^3$ and LOAELHEC 2.6 mg/m$^3$, with a combined uncertainty factor of 1,000. The last experimental RfC value obtained was 0.002 mg/m$^3$ [20].

Ammonia exposure studies in the last experiment obtained an RfC value of 0.5 (rounded) mg/m$^3$. The values were obtained by dividing the POD (continuous exposure: NOAELADJ) by the composite uncertainty factor (UF) 10. This is done because there are no data that evaluate the variability of the Ammonia response. The ammonia in question is inhaled by the human population [21].

3.2.3 Exposure assessment

Exposure analysis to quantify intakes of risk agents ($H_2S$ and $NH_3$) in risk analysis. Several components of the results interviews with the community, including the concentration (C) of the average $H_2S$ = 0.011 mg/m$^3$ and $NH_3$ = 0.046 mg/m$^3$; Adult (R = 0.83 m$^3$/hour); tE = 24 hours/day; fE = 350 days/year; Dt = 25 years; Wb = 61.05 kg; $t_{avg}$ = (30 years x 350 days/year) = 10500 days. Based on the data above, the calculation results of the intake $H_2S$ and $NH_3$ gas include:

Intake Hydrogen sulfide

$$I_{nk} = \frac{0.011\ x\ 0.83\ \ x\ 24\ x\ 350\ \ x\ 25}{61.05\ x\ 10500} \quad (3a)$$

= 0.002990991 mg/kg x day

Intake Ammonia

$$I_{nk} = \frac{0.046\ x\ 0.83\ \ x\ 24\ x\ 350\ \ x\ 25}{61.05\ x\ 10500} \quad (3b)$$

= 0.0125077805 mg/kg x day

The intake value of the Ngablak hamlet community obtained is $H_2S$ intake of 0.002990991 mg/kg x day, while $NH_3$ intake was 0.0125077805 mg/kg x day.

Several components in the exposure analysis affect the intake value. Intake value is influenced by time of exposure, duration of exposure, and body weight. ATSDR [9] stated that intake value is influenced by the concentration of risk agents, frequency of exposure, duration of exposure, and the bodyweight of person.

The exposure time of hydrogen sulfide and ammonia in the Ngablak hamlet community shows the exposure for 24 hours/day. Because most of the people of Ngablak hamlet are still working in tthe Piyungan landfill. The community work as scavengers and laborers at Piyungan landfill. As a result, people breathe air containing $H_2S$ and $NH_3$ all the time. Both of these gases can affect the health of the body. Feuyit et al. [6] stated that a longer exposure time in a landfill environment could lead to greater health effects on the body.

The duration of hydrogen sulfide and ammonia exposure from Piyungan landfill in the community shows a duration of 25 years. The majority of the people Ngablak hamlet are natives. The community already have a place to live before the operation of the Piyungan landfill. The duration of exposure can increase the risk of health problems. Health problems experienced by the community are respiratory disorders.

Low concentrations of risk agents may result in the body being unable to tolerate its toxic properties. Because the risk agents that enter the body occur continuously for a long time [2]. The longer person lives in a polluted environment, the greater the risk or impact received by the body.

The measured average body weight of respondents was 61.05 kg. The greater a person's body weight can increase the intake rate [22]. The amount of respondent's body weight affects health risks. Because there is more fat tissue in the body. Fat tissue can dissolve toxic substances such as $H_2S$ and $NH_3$. An underweight person can be more easily exposed to risk agents. Risk agents can directly interact with body cells. As a result, the body experiences health problems faster.

3.2.4 Risk characterization

Risk characterization is the final step in risk analysis. This step is used to determine the risk agent at a certain concentration. This means that the risk agent is at risk of causing health problems in the community or not [18]. The results of the risk level (RQ) $H_2S$ and $NH_3$ include:

RQ Hydrogen sulfide

$$RQ = \frac{0.002990991\ \text{mg/kg x hari}}{0.002\ mg/m^3} \quad (4a)$$

= 1.49549

RQ Ammonia

$$RQ = \frac{0.0125077805\ \text{mg/kg x hari}}{0.05\ mg/m^3} \quad (4b)$$

= 0.02501

The risk level (RQ) of hydrogen sulfide in this study exceeded 1 (RQ>1), namely 1.49549. This means that currently people in the Piyungan landfill are said to be at risk of health problems. However, some respondents still found RQ<1 (22 %).

The prediction of community risk level in Piyungan landfill for the next 10 years obtained RQ>1 of 55 people (93.2%). Lifetime risk level (30 years) obtained RQ>1 by 58 people (98.3 %). This means that almost all respondents are at risk of lifetime exposure. The longer the community is exposed to $H_2S$ from Piyungan landfill, the more people risk.

In the future (30 years of exposure), the health risk characteristics have a greater non-carcinogenic risk (RQ> 1). The possibility of these risks must be avoided. This indicates that the hydrogen sulfide that enters the body has exceeded the concentration limit for daily exposure to non-carcinogenic effects [10].

The risk level (RQ) of ammonia was obtained less than 1 (RQ≤1), namely 0.02501. This means that currently the community in the Piyungan landfill is said to be at no risk of health problems. The community risk level forecast for the next 10 years and exposure to lifetime (30 years) shows an RQ<1. This means that all the people of Ngablak hamlet who are exposed to $NH_3$ either now, in the next 10 years, or a lifetime, not at risk. This means that the community in the research location is safe from the impact of $NH_3$ exposure.

Low RQ value is influenced by the variables in the intake calculation (I). One of them is the concentration variable (C) of NH3. For example, the intake calculation uses the highest NH3 concentration (0.0102 $mg/m^3$). However, the concentrations are still below the quality standard [23]. Therefore, the level of risk obtained is still safe for the community.

## 4. CONCLUSIONS

The risk level due to exposure to hydrogen sulfide was obtained at 1.49549 (RQ>1) or said to be risky. However, the risk level due to exposure of ammonia was obtained 0.02501 (RQ≤1) or said no risk of respiratory tract disorders for people in the Piyungan landfill environment. Public health problems among headache, cough, breathlessness, influenza, and sore throat. The findings of this research may serve as improving the waste management system at Piyungan landfill. Researchers hope that further studies will develop the results of this research. For example, to be measuring hydrogen sulfide ($H_2S$) and ammonia ($NH_3$) gas in the people living around at other landfill. Future studies can also calculate the level of risk due to other harmful gases such as methane ($CH_4$). The results of the research can be an indicator of environmental pollution and health problems for the community around the landfill.

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## NOMENCLATURE

| | |
|---|---|
| C | Risk agent concentration (mg/m$^3$) |
| Dt | Duration of exposure (years) |
| $f_E$ | Duration of exposure each year (settlement = 350 days/year) |
| $I_{nk}$ | The total concentration of risk agents (mg) that enter the body per body weight (kg) per day (mg/kg day) |
| ppm | Parts per million |
| R | Inhalation rate (Adult = 0.83 m$^3$/hour) |
| RfC | The reference value for inhalation exposure risk agents |
| $t_{avg (nk)}$ | Mean time period for non-carcinogenic effect (30 years x 350 days/year) = 10500 days |
| $t_E$ | Duration of exposure per day (hours/day) |
| Wb | Respondent's body weight (kg) |