Hydrogen Sulfide Exposure Coverage for Residents’ Health Risk at Sukawinata Landfill

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Abstract. This study aims was to assess environmental health risk of hydrogen sulfide gases exposure for residents living around Sukawinatan Landfill. Methods: This study was descriptive research and used quantitative analysis method. The approach used was Environmental Health and Risk Assessment. Sample in this research was 100 respondents who were divided two radiuses, 300 meters and 600 meters away from the landfills, 50 respondents for each radius. Purposive Sampling was conducted to select respondents. Air sampling was conducted to assess hydrogen sulfide concentration around landfill. Data was collected through interview using questionnaires, weighing weight and assessment of hydrogen sulfide concentration used impinger. Data analysis was conducted using univariate and risk analysis. Result: The study found that the average of hydrogen sulfide concentration in radius 300 and 600 meters were 0.0017 mg/m$^3$ and 0.0023 mg/m$^3$ which were not exceed the threshold based on State Minister of The Environment decision Number 50 in 1996. Then, we still found that the residents remained at risk with RQ ≥ 1. The risk analysis resulted that there were 38% residents in 300 meters and 30% residents in 600 meter radius had RQ ≥ 1. Discussion and Conclusion: Though, the concentration of Hydrogen sulfide was still below the threshold but the residents living around Sukawinata landfill would be at risk to be exposed by Hydrogen sulfide which is dangerous for their health. Relocation of sukawinata landfill should be conducted since it is not eligible for landfill area anymore.

1. Introduction
Landfill is one source of air pollution. This happens due to the process of decomposition of waste which will form various types of gases such as Hydrogen Sulfide (H2S), Carbon Monoxide (CO), Ammonia (NH3), Phosphorus (PO4) and Sulfur Oxide (SO4), and Methane (CH4) The quantity of waste that increases every day because human activities will cause foul odor which results in a decrease in air quality in the landfill environment$^1$.

Exposure to Hydrogen Sulfide and ammonia, which is a gas from decomposition of waste, can cause respiratory system disorders even to paralyze the respiratory center because these substances are classified into assertion. The survey results in the Supiturang TPA revealed that 65% of scavengers in TPA experienced respiratory system disorders. Symptoms of a disorder often experienced by
scavengers include coughing, headaches, respiratory system disorders, bronchitis. People who are exposed to large and long amounts can even cause death².

Sukawinatan Landfill is a waste disposal site in the city of Palembang and began operations since 1994. Data from the Palembang City Sanitation Office that the waste produced by the residents of Palembang City in 2013 to 2016 has increased by 50% and that daily waste is transported to the landfill it reaches 1200 tons. The stockpiling process carried out by TPA has the potential to produce H2S and NH3 gas from anaerobic increase in decomposition activity that occurs after the stockpiling process³.

Health risk analysis is an approach to look at the potential magnitude of risk that begins by describing known environmental problems and involves determining risks to human health related to the relevant environmental problems, so that it can identify any hazards that are harmful, understanding the relationship between agent doses body risks and responses are known from various studies, measuring how much exposure to these risk agents, and determining the level of risk and its effects on the population⁴.

Previous Research carried out at Landfill in several cities carried out an analysis of H2S exposure in scavenger groups. Whereas around the Sukawinata landfill there were many houses that inhabit there, so that the surrounding population is also a population that is at risk for exposure to H2S for 24 hours per day, seven days per week or even 30 days per month.⁵ ⁶. This study was aim to analyze the risk of exposure to H2S in two different radius of 300 meters and 600 meters, so that it can measure the minimum risk distance from the landfill.

2. Method
This research was descriptive survey research using quantitative analysis methods. The approach used was the method of Environmental Health Risk Analysis in the form of measuring and observing the concentration of hydrogen sulfide gas and the characteristics of anthropometric parameters and patterns of community activity to be able to calculate the level of risk of the community around Sukawinata landfill.

This research was conducted in a residential area around the Sukawinata landfill. Data is collected from July to October 2018. This study had two types of sample. They were objects and subject samples. The object samples were hydrogen sulfide air concentration, which were at a radius of 300 meters and 600 meters from the Sukawinata landfill. A total of 12 measurements were conducted, 6 points at a radius of 300 meters and 6 points at a radius of 600 meters. Hydrogen sulfide concentration were measured by impinger. Then, we recruited one hundreds residents to participated in this study. They live between 300 meters and 600 meters away from the landfill. Each radius were represented by 50 respondents.

Interviews and anthropometric measurements were performed to see body weight, intake rate, exposure duration and frequency of exposure. In addition, interviews were also conducted on symptoms of exposure to hydrogen sulfide that had been experienced by residents.

Data analysis was conducted with univariate and environmental health risk analysis aproachment. The calculation used this following formula:

\[
\text{Risk Quotients (RQ)} = \frac{\text{Intake} (\text{mg/kg/day})}{(Rfc)}
\]

RQ (Risk Quotients) showed risk level for hydrogen sulfide exposed. When \( RQ \geq 1 \), it meant the exposure exceed threshold and it become at risk for people living in that area to have non carcinogenic risk.

\[
I = \frac{C \times R \times f_E \times D_t}{W_b \times t_{avg}}
\]

Note:
I : Intake (mg/kg/days)
C : Concentration of risk agent (mg/kg)
R : Intake Rate (m³/hours)
\( f_E \) : Exposure Frequency (day/years)
D : Exposure Duration, real time or 30 years for residence exposure
\( W_b \) : Weight (kg)
\( t_{avg} \) : Average time period (30 years x 365 days/year for non carcinogenic effect)

3. Result and Discussion

3.1. Residents Demography Characteristic
Female dominated in this survey since we conducted this survey in week day and from morning until afternoon. Most of female did not have a job. They were wives therefore they spent their time in the area of landfill a long day. More than a half of residents had low education since they only graduated junior high school, elementary school even they never graduated from school at all.

Working man participated in this study only 49%, one third of them were traders and others were employee and porters. Working man did not possibility to stay longer in the home. Moreover distance between their house and and their working place were far away.

| Characteristics              | n  | %   |
|------------------------------|----|-----|
| **Sex**                      |    |     |
| Male                         | 35 | 35.0|
| Female                       | 65 | 65.0|
| **Occupation**               |    |     |
| Working                      | 49 | 49.0|
| Not working                  | 51 | 51.0|
| **Occupation type**          |    |     |
| Trader                       | 27 | 55.1|
| Employee                     | 11 | 22.4|
| Porter                       |  5 | 10.2|
| Others                       |  6 | 12.2|
| **Education background**     |    |     |
| Without education            |  2 |  2.0|
| Elementary                   | 32 | 32.0|
| Junior High School           | 20 | 20.0|
| Senior High School           | 36 | 36.0|
| University                   | 10 | 10.0|

3.2. Residents’ Health Complaints
Toxic effect of H₂S was greatly based on level, route and duration of the exposure. They would determined symptom felt for every one since it depended on some one metabolism. We conducted health complaints through symptoms of health problems experienced by respondents as a result of exposure to H₂S, there were 10 symptoms that were identified. Distribution of respondents based on symptoms of health problems experienced by the community can be seen in the following table

| Type of Health Complaints   | Total (n) | Percentage (%) |
|-----------------------------|-----------|----------------|
|                            | Ever | Never | Ever | Never |
| Cough                       | 39   | 61    | 39.0 | 6.0   |
| Nasal irritation and itchy  | 11   | 89    | 11.0 | 89.0  |
| Breathless                  | 14   | 86    | 14.0 | 86.0  |
| Throat irritation           | 15   | 85    | 15.0 | 85.0  |
| Dry and hot airway          | 15   | 85    | 15.0 | 85.0  |
Cough and fatigue were symptoms that residents had a long living in surrounding landfill area. More than one third residents felt the same symptoms. Eventhough, not all residents felt all of symptoms but all symptoms ever appeared for people surrounding. We found dizziness as majority symptoms that was ever felt. Hydrogen sulfide just need low concentration to make people feel dizzy. It resulted an acute effect for people exposed.

3.3. Hydrogen Sulfide Concentration

Hydrogen Sulfide measurement was conducted in 12 spots based on the radius. To avoid the bias caused by weather and temperature. We measured in the same range of time, in the afternoon.

| Radius | Spot | Time      | H$_2$S (mg/m$^3$) | Note          |
|-------|------|-----------|--------------------|---------------|
| 300 m | 1    | 12.03-12.33 | 0.0022            | < Threshold   |
|       | 2    | 11.27-11.57 | 0.0017            | < Threshold   |
|       | 3    | 11.26-11.56 | 0.0021            | < Threshold   |
|       | 4    | 10.38-11.08 | 0.0011            | < Threshold   |
|       | 5    | 10.30-11.08 | 0.0011            | < Threshold   |
|       | 6    | 10.23-10.33 | 0.0025            | < Threshold   |
| 600 m | 7    | 10.33-11.03 | 0.0022            | < Threshold   |
|       | 8    | 11.15-11.45 | 0.0021            | < Threshold   |
|       | 9    | 11.10-11.40 | 0.0025            | < Threshold   |
|       | 10   | 09.45-10.15 | 0.0025            | < Threshold   |
|       | 11   | 09.50-10.20 | 0.0024            | < Threshold   |
|       | 12   | 10.43-11.13 | 0.0026            | < Threshold   |

*p-value ≥ 0.05 (Two Independent Test, Man Whitney)

Threshold of H$_2$S in air based on decision of environment minister number 50 in year 1996 is 0.02 ppm or 20 mg/m$^3$. Comparing to that decision all the measurement of H$_2$S did not exceed the threshold. Concentration of H$_2$S in the two types of radius away from landfill were not different statistically. Therefore, distance between 300 meters and 600 meters from landfill did not influence exposure of hydrogen sulfide. People living in that distance had the same risk if they had the same duration. This study found that differences 300 meters did not significantly decrease concentration H$_2$S.

3.4. Exposure Pattern and Anthropometery

Anthropometric characteristics consisted of age, weight (Wb) and intake rate (R). Body weight is one of the influential characteristics of anthropometry in calculating the intake rate.

| Characteristics | Mean | Median | Min | Max |
|-----------------|------|--------|-----|-----|
| Age (year)      | 42   | 39.5   | 19  | 80  |
| Weight (kg)     | 57.76| 58.0   | 37  | 83  |
Intake rate (m$^3$/hours) & 0.607 & 0.609 & 0.51 & 0.83 \\
Exposure time (hour/day) & 21.94 & 24 & 7 & 24 \\
Exposure frequency (day/year) & 363.71 & 365 & 288 & 365 \\
Exposure duration (year) & 16.01 & 12 & 3 & 50 \\

Among a hundred participants, we found the average age were 42 years old. The youngest participants was nineteen years old and the oldest participant was eighty years old. Besides that, weight which would determined intake rate in this population were categorized weigh. The weightiest participant was eighty kilogram. Malone Rubright, Pearce stated intake rate would be influenced by duration and type of inhalation. This study found participants of this study exposed more than 20 hours in a day by Hydrogen sulfide.

The activity pattern consisted of exposure time ($t_e$), exposure frequency ($f_e$) and duration of exposure ($D_t$). The length of exposure ($t_e$) was obtained based on the number of hours the community was in the research location in one day. The frequency of exposure was obtained from the number of days the community received in one year (365 days) in the exposed area minus the number of days the community was not at the study location. The value of duration of exposure ($D_t$) was the value of the length of time in the year of the exposed community at the study site. it could be seen that the average exposure time was 21.94 hours / day, the frequency of exposure is 363.71 days / year and duration of exposure was 16.01 years.

Calculation of intake used variables of concentration, weight, rate of intake, daily exposure, frequency of exposure, and duration of exposure with a value of the average time period of 10,950 days. Intake of H$_2$S obtained was 0.00026 mg / kg / day.

We found that statistically, comparison intake rate in two difference radius were significantly not different with $p$-value ≥ 0.05 which people living in the radius 0 until 600 meters had the same risk.

| Radius     | Mean      | Median     | Min   | Max      | *p-value |
|------------|-----------|------------|-------|----------|----------|
| 300 meters | 0.00024   | 0.00022    | 0.0004| 0.00084  | 0.267    |
| 600 meters | 0.00027   | 0.00015    | 0.0001| 0.00093  |          |

* 2 independent T-Test (Man Whitney)

### Table 5. Comparison intake in 2 radius

3.5. **Environmental Health Risk Analysis**

Risk quotient would determind the resident’s health risk for non cancersinogenic risk. We found that the number of female had RQ ≥ 1 more than male. Female stayed in house longer than male since they did not go to work.
This study compare the RQ between two radius. Eventhough we found no difference of intake rate (table 4) between both radius, residents living in 300 meters away from the landfill had RQ ≥ 1 much more than another. Other factors would determind someone’s intake rate. Time of exposure was the amount of time the respondent in one day was in a location that allows H2S exposure. The results showed that the average exposure time was around 21 hours / day (table 3). A longer exposure time would cause effects in the human body. If someone breathes air containing hydrogen sulfide for a long time, it will reduce the composition of oxygen into the body, so that the brain’s performance will be disrupted and result in paralysis of the olfactory nerve and loss of control function of the brain and lungs. Respondents with longer exposure times will influence the risk that will be accepted. the longer the exposure time, the greater the health risk received\textsuperscript{8,10,11}.

![Figure 2. Comparison of Risk Quotients in two radius](image)

The duration of exposure calculated was divided into two, namely realtime (actual exposure time) and lifetime (20-year lifetime exposure). The actual length of exposure obtained from direct interviews with respondents and long lifetime exposure (20 years) was obtained from the default value of the US EPA. The results of the study’s average duration of exposure of respondents have lived for 16 years. The length of stay shows the length of exposure of respondents to H2S risk, the longer the duration of H2S exposure the greater the likelihood of respondents getting large health risks. The results showed that respondents with longer duration of exposure had a higher risk (RQ). Continuous exposure to hydrogen sulfide can cause health problems. The parts of the body that are most likely to come into contact and have an impact are the respiratory, eye, skin, mouth and respiratory tracts. Exposure to hydrogen sulfide with low concentrations for long periods of time can cause permanent effects such as respiratory problems, headaches, and chronic cough\textsuperscript{8}.

![Figure 3. Non Carcinogenic Risk Prediction](image)
Health risk characteristics values were obtained from the results of calculation. They were intake rate and dose of irritant response. The health risk in this study used is the risk of non-carcinogens. This was because hydrogen sulfide gas has no implications for cancer cases so that the effects to be used in the analysis are systemic effects or non-carcinogenic effects. The average of RQ value obtained was still below 1 (RQ <1) which is 0.96 so that it was concluded that the risks received by the community around the Sukawinatan Landfill were currently safe. This was caused by the low \( \text{H}_2\text{S} \) concentration which was still below the quality standard. However, even though the concentration of risk agents was still below the quality standard, it did not relieve the entire population of the risk of health problems.

We still found RQ > 1 in some respondents. This showed that although \( \text{H}_2\text{S} \) concentrations were still below the quality standard, the level of unsafe risk was still found in some respondents. Characteristics of health risks in the future, a time period of up to 10 years and 20 years (life time) based on US-EPA. The results of the study showed that the exposure duration of the next 10 and 20 years respondents would have a non-cancer risk (RQ > 1) with an average of 1.48. This showed that there would be non-carcinogenic health risks that must be avoided. This RQ value > 1 indicated that the intake of hydrogen sulfide in the respondent’s body had exceeded the daily exposure dose limit which was not expected to cause adverse health effects.

We found that RQ in life time (20 years) for all respondents were more than one. It means that for hydrogen sulfide gas exposure to respondents at Sukawinatan landfill did not indicate a current health risk. But, the calculation of intake lifetime exceeded intake rate prescribed since, intake lifetime used an average time period of 20 years. It means that exposure to hydrogen sulfide to residents will pose health risks in the next 20 years. The results showed that respondents with higher intake values had a higher risk.

The principle of Environmental Health Risk Analysis states that risk management is a must if RQ > 1. In order for the intake value to be equal to the RfC value it can be done by reducing the risk agent concentration (C), exposure time (\( t_E \)) and exposure frequency (\( f_E \)) to get a safe limit from the risk of health problems. The safe limit of \( \text{H}_2\text{S} \) concentration from this study is 0.002 mg / m3, so management efforts must be made by increasing green open space in the Sukawinatan landfill area. The safe limit for \( \text{H}_2\text{S} \) exposure at the time of this study was 7.4 hours / day and the safe limit for the frequency of exposure to \( \text{H}_2\text{S} \) was 115, 2 days / year.

The community is expected to increase the number of barrier plants which can reduce the level of air pollution and tree plants to minimize odors produced from \( \text{H}_2\text{S} \) such as trembesi trees, cassia, and cananga. Relocation of Sukawinata could be conducted to prevent greater risk effect.

4. Conclusion

People living surrounding landfill area had at risk to have non-carcinogenic effect from hydrogen sulfide. No differences between both radius away from landfill. People living in 600 meters away from the landfill have the same risk to living in 300 meters away. Hydrogen sulfide could cover until 600 meter away from the landfill. In twenty years coming, residents living in sukawinata landfill would have non-carcinogenic effect as the result of being exposed continuously. Relocation of landfill should be conducted to prevent people had greater risky effect of \( \text{H}_2\text{S} \).

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