

SAFE CONCENTRATION OF HYDROGEN SULFIDE (H₂S) FOR PEOPLE LIVING CLOSE TO LANDFILL (CASE STUDY IN CIPAYUNG LANDFILL, DEPOK, WEST JAVA)

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ABSTRACT

Cipayung landfill operating with open dumping system which accepts waste from 11 subdistricts in Depok City, West Java has exceeded its capacity. The height of the waste heap reaches 30 meters. This study aims to analyze potential health risk caused by H₂S in people living around the landfill. This study uses descriptive quantitative method with analysis health risk approach by calculating the Risk Quotient value. The samples number in the study is 90 people who are living in ≤ 500 meters radius from Cipayung landfill. Data collected by questionnaire and measuring H₂S ambient concentration at 9 points around the residential areas which have ≤ 500 meters distances to Cipayung landfill. The highest measurement result of H₂S is 0.0042 mg/m³ with highest RQ value calculation is 2.4. Out of 90 respondents, 90% had respiratory symptoms during living near the landfill and the most frequent symptom of respiratory symptoms was coughing (87,8%). It needs cross-sectoral cooperation in monitoring and controlling H₂S concentrations originating from the Cipayung landfill to reduce the health risk of people living close to the Cipayung Landfill.

KEYWORDS: *Safe Concentration, Hydrogen Sulfide, Landfill, Risk Quotient, Health Risk*

INTRODUCTION

The waste problem is still the unsolved problem in Indonesia. In 2017 it is known that the amount of waste reaches 65,2 million ton per year (Statistic of Indonesia, 2018). The amount of waste has increased to 67 million tons in 2019 (Anadolu Agency, 2019). The problem of waste becomes even more complicated caused by the management system in Indonesia's landfill that still uses open dumping. Even though the Law No. 18 of 2008 has been issued requires local governments to close landfill in Indonesia which still uses open dumping for 5 years after this regulation came into force. Based on Indonesia Ministry of Environment and Forestry in 2019, amounting to 80,6% of 378 landfills in Indonesia still uses open dumping system in waste management (Ministry of Environment and Forestry, 2019).

Waste management using open dumping has many negative impacts. The accumulation of waste that is only piled up in sunken land and not given any action will cause air quality changes around the landfill (Depok City Environmental Agency, 2010). There are various hazardous gases that are the result of landfill activity. One of them is hydrogen sulfide which comes from the waste decomposition process. Hydrogen sulfide (H₂S) is a colorless, flammable, highly toxic gas that has a characteristic odor like rotten egg. Hydrogen sulfide can be smelled by humans at low concentrations between 0.0005 to 0.3 ppm. Humans can be exposed to H₂S mainly through inhalation and quickly absorbed by the lungs (OSHA, 2013). H₂S is irritant to the respiratory tract and mucous membranes. Acute exposure to H₂S will cause symptoms such as headaches, nausea, delirium, tremors, skin, and eye irritation. H₂S exposure with high concentrations can cause a

decrease in consciousness to death (ATSDR, 2014). People living close to the landfill can be directly exposed to H₂S compounds. Potential health risks can arise, such as irritation respiratory, cancer, and even central nervous system for long-term exposure of H₂S (Wu *et al.*, 2018).

Cipayung Landfill receives and manages waste from 11 sub-districts in the city of Depok. The amount of trash that enters every day is around 900 tons. High garbage heap is in overcapacity category now, which is 30 meters from the ground surface. The waste management system used is the open dumping method. There is no specific management of H₂S gas produced by the decay of garbage in the Cipayung Landfill (Cipayung landfill, 2018). Cipayung Landfill is located very close to the residential area. So the smell of H₂S is felt by the people who live around the Cipayung Landfill. Based on a preliminary study by measuring ambient H₂S concentrations at 2 points in the Cipayung landfill site, were found 0,015 ppm and 0,012 ppm. A preliminary study was conducted by interviewing 10 people who had lived more than 15 years mentioned having experienced respiratory complaints such as coughing, chest pain, and most often was a sore throat due to the foul odor of the landfill. The smell like rotten eggs smelled quite strong even from a distance of 1 km and smelled even stronger when the wind blew.

MATERIALS AND METHODS

Data sources and Study Population

This study uses primary data derived from data collected using a questionnaire. This study aims to identify and analyze potential health risks based on Risk Quotient values. The population in this study were all residents living ≤ 500 meters from the landfill. Based on the sample size, 90 people became the study samples. the inclusion criteria determined are people aged ≥ 18 years based on anthropometric uniformity and duration of living close to the landfill ≥ 4 years.

Measurements

Measurement was carried out by measuring environmental samples in the form of ambient H₂S concentrations at 9 points and analyzed using a spectrophotometer with the methylene blue method. All H₂S measurement points are in the community settlement area with the closest distance to the

landfill is 120 meters and the furthest distance from the landfill is 500 meters. H₂S measurements was carried out in 2 days where the length of measurement at one point is 1 hour. Anthropometric measurements were performed as one of the data used to calculate the RQ value. Measurement was also performed by being made using a questionnaire divided into 2 parts, consisting of the characteristics of respondents (age, gender, nutritional status, length of stay, and distance of the house from the landfill as measured by researchers using the Google Maps) and respiratory symptoms refer to the American Thoracic Society Questionnaire (American Thoracic Society, 1976).

Data Analysis

Descriptive statistics generated for the questionnaire and the results of ambient H₂S concentration measurements using SPSS Software Version 20.0. Continuous variables are described by means, minimum-maximum and categorical variables by frequencies and percentage. The RQ value of all respondents was calculated using the Louvar formula and then averaged. RQ value was categorized (If the RQ value ≤ 1 then the exposure is still safe or not at risk of causing non-carcinogenic health effects. But if the RQ value > 1 then the exposure is unsafe or risk of causing health effects non-carcinogenic).

RESULTS AND DISCUSSION

General Characteristic of People Living Close Cipayung Landfill

Table 1 show that there were more female than male respondents (71.1%) and the most dominant respondent in 18-44 years old range (56,7%). Respondents nutrition status based on Body Mass Index (BMI) were in normal category (47.8%). Most of the respondents live with a distance of > 298 meters from the landfill (51,1%). The majority of duration of time living close the landfill was ≤ 28 years (51,1%).

People living near landfills have the risk of exposure to several hazardous pollutants originating from landfills (Palmiotto *et al.*, 2014). Cipayung Landfill is located very close to community settlements. Even the closest distance between the landfill and the community house is only about 110 meters. This distance is not following Minister of Public Works Regulation No. 03/2013 that the

Table 1. General Characteristic of Respondents

No	Variable	Number (n)	Percentage (%)
1	Age:		
	18-44 Years Old	51	56.7
	> 44 Tears Old	39	43.3
	Total	90	100
2	Gender:		
	Male	26	28.9
	Female	64	71.1
	Total	90	100
3	Nutrition Status:		
	Normal	43	47.8
	Underweight	5	5.6
	Overweight	11	12.2
	Obese	31	34.4
	Total	90	100
4	Distances from Landfill:		
	≤ 298 meters	44	48.9
	> 298 meters	46	51.1
	Total	90	100
5	Duration of Time Living Close to The Landfill:		
	≤ 28 years	46	51.1
	> 28 years	44	48.9
	Total	18	20

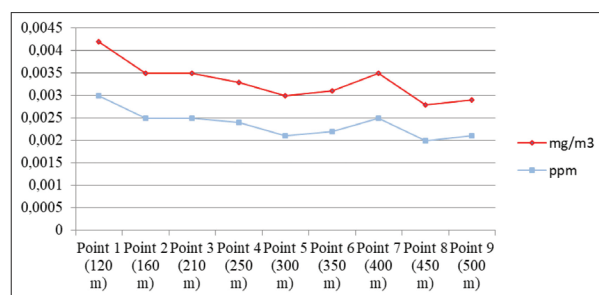
minimum distance between the landfill and the settlement area should be 1 km. The distance between a landfill and community settlements is crucial because it is related to the emergence of health and environmental problems due to air pollution, pollution from leachate, odor pollution and vector-borne diseases from landfill operations (Minister of Public Works Regulation, 2013). Research conducted by Njoku in 2019 found that 78% of respondents living closer to the landfill (100-500 meters) showed more serious contamination. It was also found that there were health problems complained of by respondents who lived closer to the landfill than those who lived far from the landfill, such as eye irritation and body weakness (Njoku, 2019).

Respondents who live around Cipayung Landfill have lived for an average of 28 years. The duration of residence can represent the length of H₂S exposure through inhalation to respondents in the study. The duration of residence can affect the

amount of exposure intake and ultimately will also affect the value of Risk Quotient (RQ). RQ values can indicate the risk of health problems in humans exposed to a pollutant. If the RQ value is ≤ 1, then the exposure is still safe or not at risk of causing health effects. However, if the RQ value > 1, then the exposure can be declared unsafe or risk causing health effects (Rahman, 2017).

H₂S Concentration Around Residents Area That Closed to Cipayung Landfill

Ambient H₂S concentrations were measured at 9 points located in community settlements living around the Cipayung landfill within a radius of ≤ 500 m. The results of H₂S concentration measurements in Figure 1 and Table 2.

**Fig. 1.** Ambient Concentration of H₂S

It is known from 9 measurement points the highest H₂S concentration is 0.0042 mg/m³ (0.003 ppm) at Point 1 that is 120 meters from the landfill. The lowest H₂S concentration is 0.0028 mg/m³ (0.0020 ppm) at Point 8 that is 450 meters from the landfill. The average concentration of H₂S ambient air is 0.0033 mg/m³. If compared with normal H₂S concentrations originating from natural sources in the range 0.00011-0.00033 ppm. So that H₂S concentrations at all points have exceeded their limits (ATSDR, 2016).

Based on Table 2 we know that H₂S concentration decreases at the measurement point with a longer distance. Distance from pollutant sources can influence H₂S concentration in ambient air. In general, the concentration of a pollutant will decrease at a greater distance from the source (Fitri and Retnowaty, 2015). H₂S concentrations in ambient air can be influenced by environmental (meteorological) factors such as temperature,

Table 2. Statistic of Ambient Concentration of H₂S

Variables	n	Mean	Median	SD	Min-Maks	95% CI
Concentration of H ₂ S (mg/m ³)	90	0.0033	0.0033	0.00041	0.0028-0.0042	0.0032-0.0034

humidity, and wind speed. The air temperature greatly affects the humidity conditions of landfill waste in the landfill which will have an impact on the production of gas produced. Wind speed and direction can affect the distribution of pollutants and the direction of their distribution (Pongtuluran, 2015).

Risk Quotient of People Living Close to Cipayung Landfill

The risk characteristics of exposure to non-carcinogenic health effects can be showed by value of Risk Quotient (RQ). If the RQ value is ≤ 1 , then the exposure is still safe or not at risk of causing non-carcinogenic health effects. However, if the RQ value > 1 then exposure may be declared unsafe or risk of causing non-carcinogenic health effects.

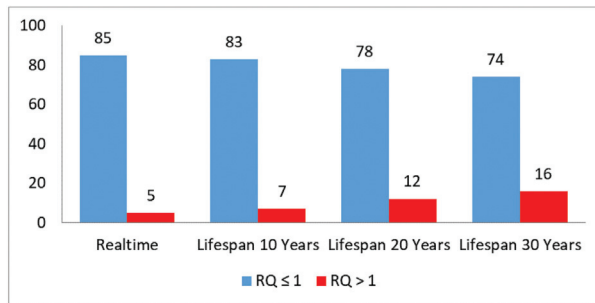


Fig. 2. RQ realtime, lifespan 10, 20, and 30 years

Based on this result study, the average RQ realtime value is 0.27 or the exposure is still ≤ 1 . Even so, there are already 5 respondents who have a realtime RQ realtime > 1 , which means the respondent has non-carcinogenic health risks at present (realtime) due to H₂S exposure. The RQ score of the respondent is getting higher in line with the duration of the stay, 10, 20, and 30 years.

The majority of respondents in this study had settled near the Cipayung landfill > 28 years (the longest duration of residence is 72 years). Long-term exposure to H₂S can pose potential health risks to humans, such as respiratory irritation, and can even cause nerve damage (Wu *et al.*, 2018). H₂S that enters the body through inhalation will inhibit the cytochrome oxidase enzyme that acts as a cell producing oxygen. Inhibition of this enzyme causes the tissue to lack oxygen levels and the respiratory tract becomes irritable (Njoku, 2019).

Previous research conducted around the Cibereum Landfill in Banjar City obtained an average data measurement of H₂S concentrations at 2 points was 0.004 ppm. Calculation of risk

estimation or realtime RQ value of 0.42 which means that there is no non-carcinogenic risk due to H₂S exposure originating from landfill (Rufaedah, Sriagustini and Nurwahidah, 2019). Other studies at Sukawinatan Landfill showed that the average RQ value was still ≤ 1 , which was 0.96. But once found respondents who have an RQ value > 1 , more respondents who live 300 meters from the landfill have an RQ > 1 (Faisya, *et al.*, 2019).

H₂S Safe Concentration of People Living Close Cipayung Landfill

The calculation is performed to determine the amount of safe concentration of H₂S received by respondents through the inhalation route. H₂S safe concentration value calculation is done using data from respondents who have the highest realtime RQ values, 2.4. Weight data (Wb = 35 kg), average non-carcinogenic period (tavg = 30 years x 365 days/years, duration of exposure in years illustrated by the length of residence (Dt = 69 years), length of exposure in hours/days which is depicted by the duration of activities around outside the home and the length of work in the landfill (tE = 5 hours), the frequency of exposure in days/years described by the number of days not leaving the house in 1 year (fE = 365 days), and the rate of adult inhalation intake (R=0.83 m³/hours).

$$C_{\text{safe}} = \frac{RfC \times Wb \times t_{\text{avg}}}{R \times tE \times fE \times Dt}$$

$$= \frac{0,000571 \times 35 \times 30 \times 365}{0,83 \times 5 \times 365 \times 69}$$

$$= 0.0021$$

Based on the above calculations it was found that the recommended safe concentration of H₂S in this study was 0.0021 mg/m³ or 0.0015 ppm. This result is lower than the entire measurement results in this study. Safe calculation aims to reduce the value of the intake which will reduce the RQ value and reduce the occurrence of non-carcinogenic health risk (Rahman, 2017).

Respiratory Symptoms of People Living Close to Cipayung

As many as 81 people (90%) of study respondents experienced symptoms of respiratory disorders. Meanwhile, as many as 9 people (10%) of study respondents did not experience symptoms of respiratory disorders. The following will illustrate the distribution of respiratory distress symptoms experienced by study respondents:

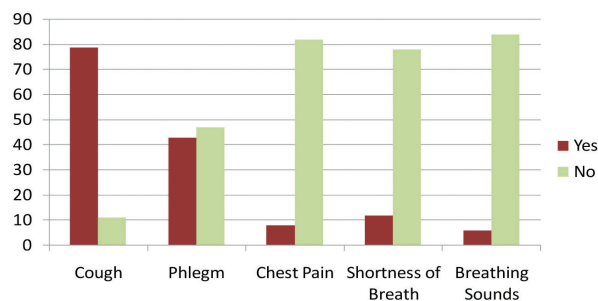


Fig. 3. Respiratory Symptoms on Peoples Living close the Cipayung landfill

Based on the results of the study found as many as 81 people (90%) of respondents who experienced symptoms of respiratory disorders. The most common respiratory symptoms experienced by respondents were coughing up to 80 people (90%), followed by phlegm of 42 people (46.7%), then shortness of breath of 12 people (13.3%), then chest pain as many as 9 people (10%), and the least experienced is sound breathing/wheezing as many as 6 people (6.7%).

In previous studies, people living close to landfill are concerned with H_2S odor that rise health problem on them. Breathing H_2S at low to moderate level can cause irritation of nose, throat, and eye, sometimes cause headaches, balanced problem, and tiredness (Florida Health, 2016). People who are acutely exposed to H_2S will cause symptoms including respiratory tract irritation, headaches, loss of balance and memory, nausea, smell paralysis, and tremor (ATSDR, 2006). In another study, 37 workers were accidentally exposed to H_2S at unspecified concentrations while working at the municipal sewage pumping station, with symptoms including headaches, shortness of breath, coughing, irritation of throat and eye, nausea, and vomiting (Synder *et al.*, 1995).

Previous research conducted by Mothiba, Moja, and Loans (2017) found that the majority of health problems experienced in the past 6 months were respiratory problems more than any other illnesses. The most common respiratory symptoms complained of are coughing and some are chest pains. Previous research conducted at the Delhi Okhla landfill found that 89% of landfill workers experienced 1 or more respiratory symptoms with the most symptoms of respiratory distress namely sneezing of 58.3% (Ray *et al.*, 2005).

The respiratory tract is the most sensitive organ when exposed to H_2S exposure. Humans can be

exposed to H_2S mainly through inhalation and quickly absorbed by the lungs. H_2S exposure at low concentration can cause irritation of the throat and eyes, coughing, dizziness, and symptoms of neurological disorders such as incoordination, hallucinations, and memory (ATSDR, 2014). H_2S at high concentrations can cause a person to lose the ability to smell, so mistakenly think that H_2S is no longer available even though it still exists. This can increase the risk of exposure to air levels which can cause serious health effects (ATSDR, 2016).

CONCLUSION

Based on this result study, recommended safe concentration (C_{safe}) of H_2S was 0.0021 mg/m^3 or 0.0015 ppm . The calculated C_{safe} value is expected to reduce the exposure intake of H_2S thereby reducing the RQ value for people living close to Cipayung Landfill. The number of respondents who are at risk of experiencing non-carcinogenic health problems increases with the duration of exposure (lifespan of 10, 20, and 30 years). Almost all respondents have complaints of respiratory distress symptoms with the most is cough. This shows that there was a risk of health problems in the people living around the Cipayung Landfill. Appropriate steps are needed by stakeholders related to cross-sectoral collaboration in managing and monitoring the ambient H_2S concentrations produced by the Cipayung Landfill and consider the safe concentration of H_2S that has been calculated in this study.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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