JURNAL KESEHATAN LINGKUNGAN
JURNAL DAN APLIKASI TEKNIK KESEHATAN LINGKUNGAN

ISSN 1829-9407 (Print)
ISSN 2581-0898 (Online)

Volume 20, No. 2, Juli 2023; Page: 235-242; *DOI: https://doi.org/10.31964/jkl.v20i2.682*

IMPACT OF RISKS DUE TO EXPOSURE TO HYDROGEN SULFIDE (H_2S) ON COMMUNITIES AROUND THE MEDANG PRABUMULIH RIVER TPA

Qonita Rizqina Firdaus, Dini Arista Putri, Elvi Sunarsih, Rafika Oktivaningrum
Universitas Sriwijaya Fakultas Kesehatan Masyarakat Prodi Kesehatan Lingkungan
Jl. Palembang-Prabumulih KM. 32 Indralaya, Ogan Ilir, Sumatera Selatan 30662
Koresponding E-mail: qonitarizqinaf06@gmail.com

Article Info

Article history:

Received March 23, 2023
Revised March 24, 2023
Accepted July 01, 2023

Keywords:

Health Risks
Hydrogen Sulfide
Landfill

ABSTRACT

Impact of Risks Due to Exposure to Hydrogen Sulfide (H_2S) on Communities Around the Medang Prabumulih River TPA. Sungai Medang Landfill in Prabumulih City manages waste through the sanitary landfill method, though not optimally. Waste undergoes anaerobic decay by microorganisms, producing hydrogen sulfide (H2S) gas. Low concentrations of H2S can irritate the eyes, nose, or throat. This study aimed to analyze the environmental health risks of H2S exposure to communities around the Medang Prabumulih River landfill. The Environmental Health Risk Analysis (EHRA) method with a deterministic approach was used. The study sampled 92 people living within a radius of 250 meters and ±500 meters, using purposive sampling techniques. Results showed the highest concentration of H2S at 0.0015 µg/m3 and the lowest at 0.0001 µg/m3. The average intake value (real time) was 0.00053 µg/m3, with a risk level of 0.267 RQ (<1). These results indicate that the current risk level due to H2S exposure is safe and does not pose non-carcinogenic health risks. However, future increases in H2S concentrations may occur due to the rising amount of waste from increased population and urbanization. It is recommended to install air purifiers in homes and plant barrier plants like Liriope spicata (lilyturf/monkey grass) around residences to reduce odors from the landfill.

INTRODUCTION

Air pollution is the only environmental problem that directly correlates with people's standards of living around the world [1]. Air pollution is the world's leading cause of death, affecting 7 million people every year, and the largest contributor to global health problems.[2]. According to estimates, the world will produce 2.24 million tons of solid waste in 2020, at a rate of 0.79 kg per person every day. Annual waste generation is expected to increase by almost 73% from its 2020 level to 3.88 million metric tons in 2050, thanks to rapid population growth and urbanization [2].

Statistically, waste production has increased from year to year due to the rapid growth of cities, from high population to economic growth. In addition, waste transfer to other cities or regions can increase waste in a city or region. The Ministry of Environment and Forestry of the Republic of Indonesia states that cities in Indonesia produce 30.9 million tons of waste per year, and South Sumatra Province can produce 872.8 thousand tons of waste every year. [3].

Prabumulih City is one of South Sumatra Province's cities with only one final disposal site, the Sungai Medang Landfill. The Medang River Landfill's waste management services continue to expand annually, utilizing sanitary landfill management methods. However, the landfill's insufficient area has hindered its optimal operation. Microorganisms can aid in the natural decomposition of waste without oxygen, leading to the release of sulfides such as H2S by anaerobic sulfate-reducing bacteria. (4). The vulnerability of exposure to H2S gas from decomposing waste in landfills mixed with ambient air can result in a decrease in air quality, which has an impact on the health of the surrounding community. (5).

Hydrogen sulfide gas (H2S) is colorless, highly toxic, flammable, and smells like rotten eggs. The scientific name for this sulfidic acid is dihydrogen sulfide, sometimes referred to as swamp gas or sulfidic acid (8). Humans can often detect the aroma of H2S at concentrations of 0.0005 to 0.3 ppm. A person will lose the ability to smell if exposed to H2S at too high a concentration. H2S concentrations above 500 ppm can cause shortness of breath, pulmonary edema, and death (6).

MATERIALS AND RESEARCH METHODS

This is a quantitative descriptive study using the Environmental Health Risk Analysis (ARKL) method with a deterministic approach. Purposive sampling, based on the Lameshow calculation formula, selected 92 people living around the TPA, meeting the criteria of having lived for at least 3 years and not working as scavengers. We took air samples at six measurement points within a radius of 250 meters and less than 500 meters, and analyzed them using the methylene blue method with a spectrophotometer.

This research employs univariate analysis and risk analysis. We carried out a univariate analysis to analyze several variables, such as the concentration of H2S gas in the air, exposure time, exposure frequency, and exposure duration. In the meantime, we conducted an environmental health risk analysis to determine the intake value and risk characteristic (RQ) value of the respondent.

Based on US-EPA 2009 (7), the following formula calculates respondents' intake values due to exposure to H2S gas via the inhalation route:

$$EC = \sum_{i=1}^{n} \frac{CA_i \; X \; ET_i \; X \; EF_i \; X \; ED_j}{AT_j}$$

Information :

EC : Exposure/intake concentration (µg/m3)

C.A : Concentration of risk agents in the air (µg/m3)

ET : Exposure time (hours/day)

E.F : Frequency of exposure (days/year)

ED : Duration of exposure (years) or real time

tavg : Average time period (ED x 24 hours/day x 365 days/year)

The formula used to calculate the risk characteristic (RQ) value of respondents due to exposure to H2S gas is as follows:

$$RQ = \frac{Ink}{RfD \; atau \; RfC}$$

Information :

RQ : Risk characteristics (µg/m3)

EC : Exposure concentration/intake(µg/m3)

RFC : Reference concentration (µg/m3)

RESULTS OF RESEARCH AND DISCUSSION

Hydrogen Sulfide (H2S) Concentration

The results of measuring H2S concentrations at 6 measurement points in the Medang River landfill area within a radius of 250 and ± 500 meters can be seen in table 1 below:

Table 1. Results of measuring H2S concentrations around the Medang River landfill

Distance	Point	Measurement Location	H2S (µg/m3)
Radius 250 meters	1	In front of the house of the guard of the Sungai Medang landfill	0.002
	2	In front of the houses of residents of the Amri plot area	0.002
	3	In front of a resident's house on Jalan Prabu Indah	0.002
Radius ±500 meters	4	In front of residents' houses on Jl. Estuary	0.001
	5	In front of empty land on the Sukajadi-Prabujaya Border road	0.001
	6	In front of the Miftahul Hidayah mosque in the Bumi Sako Damai Housing area	0.003
		Average	0.00065

According to the results of the univariate analysis, the highest concentration of hydrogen sulfide is at point 1, namely in front of the house of the TPA guard at Sungai Medang, amounting to 0.0015 g/m3, while the lowest concentration is at point 4, namely in front of the house of residents on Jalan Muara Sungai, amounting to 0.0001 g/m3. The H2S concentration is still below the quality standards set by the Decree of the Minister of Environment of the Republic of Indonesia No. 50 of 1996, which is 0.028 mg/m3. Observations revealed that despite the concentration values being below environmental quality standards, people continued to complain about the waste's smell. Humans are able to smell H2S at concentrations between 0.0005 and 0.3 ppm, which explains how this can happen [(8)].

Air sampling in residential communities around the Sungai Medang Prabumulih landfill was carried out at six points using two different distances, namely 250 meters and ± 500 meters. At each distance, there were three measurement points. Based on the results of measuring the H2S concentration at the six points, it was found that the average H2S concentration was 0.00065 µg/m3. The measurement results for the highest concentration of hydrogen sulfide were at point 1, namely in front of the house of the guard of the Sungai Medang TPA, amounting to 0.0015 µg/m3, while the lowest concentration was at point 4, namely in front of residents' houses on Jalan Muara Sungai, amounting to 0.0001 µg/m3.

According to Haryoto [(9)], the closer the ambient air sampling distance is to the emission source, the greater the concentration of gas produced.

Findings from Faisya's research [(10)], which found that the point of measurement was closer to the landfill than others, still hold true for the highest average H2S levels in smelly air samples from neighborhoods near the landfill. However, the average concentration levels were 0.002 µg/m3, which is lower than what Hidayatullah's research [(11)] found to be the case. This indicates that the significant difference in concentration between this research and previous studies can be attributed to the variation in waste production from each landfill and the specific waste processing method used at the Sungai Medang landfill, specifically the sanitary landfill, which has a relatively smaller impact on the surrounding environment. This is in contrast to both open dumping and controlled landfill systems.

The H2S concentration in the measurement at point 1 was higher than the other points because the measurement took place during the day at 11.33 WIB, with a measurement time of ±30 minutes at each measurement point. Measurements taken during the day in bright conditions and close to sources of pollution can have an effect on increasing the concentration levels of the gas produced. During the day, the temperature tends to be high. Higher temperatures cause pollutant materials to tend to increase in concentration. In addition, the time difference during measurement and the meteorological conditions at the research site, such as temperature, wind speed, wind direction, and weather, influence the results, which differ from those at point one (12).

Anthropometric Characteristics

Table 2. Results of Statistical Analysis of Body Weight of Living Respondents in the Settlements Around the Medang River Landfill

Variable	Mean	Median	elementary school	Min	Max
Body Weight (kg)	58.9	58.5	9.9886	37	85

According to the univariate analysis results in Table 2, the average body weight of respondents living in settlements around the Medang River TPA is 58.9 kg.
Body weight is a denumerator variable in the intake formula calculation, so the results will be inversely proportional to the intake value (13). This aligns with Amaliana's research (14), which demonstrates an inverse relationship between intake, body weight, and average time period. Specifically, a higher body weight figure corresponds to a lower intake value. The greater the respondent's weight, the smaller the intake value they will receive, and vice versa. Theoretically, the greater the body weight, the smaller the chance of health problems. Vice versa, the lower a person's weight, the greater the risk of health problems (15).
The analysis revealed that the average body weight of the respondents was 58.9 kg, with the heaviest being 85 kg and the lightest being 37 kg. The average body weight in this study is relatively small when compared to the standard adult body weight set by the US-EPA, namely 70 kg. In contrast, the average body weight in this study exceeded the default Indonesian adult weight, namely 50 kg (16).

Exposure Patterns in Communities Around the Medang Prabumulih River Landfill

Activity patterns consist of exposure time (tE), exposure frequency (fE), and exposure duration (Dt). We obtain the exposure time (tE) value by counting the number of hours people spend at the research location in a single day. We obtain the exposure frequency value by subtracting the number of days the community spent in the exposed area in a year (365 days) from the number of days they were not at the research location. The exposure duration value (Dt) represents the duration in years that the community experiences exposure to the research location. The distribution results of the analysis of activity patterns in the Medang River TPA community can be seen in the following table:

Table 3. Results of Statistical Analysis of Exposure Patterns of Respondents Living in Settlements Around the Medang River Landfill

Variable	Mean	Median	elementary school	Min	Max
Exposure Time (hours/day)	20.52	24	4,134	12	24

Frequency of Exposure (days/year)	346.77	365	54,827	104	365
Duration of Exposure (years)	5.85	6	2.1107	3	10

Based on the results of the univariate analysis in Table 3, it is known that the average exposure time of respondents exposed to H2S is 20.52 hours per day, the average frequency of exposure for respondents exposed to H2S during a year is 346.77 days per year, and the average duration of exposure for respondents exposed to H2S is 5.85 years.

The duration of exposure refers to the number of hours the respondent spends in contact with H2SThe questionnaire results yielded an average daily exposure time of 20.52 hours for the respondents. hours per day. In this study, respondents' average exposure time is the maximum exposure time in hours per day. The exposure time is directly proportional to the intake value, meaning that the longer the exposure time, the greater the intake value a person receives. This is in accordance with Rahman (17), who states that the longer a person's exposure time, the greater the intake of gas inhaled into a person's body, and if exposed for the maximum time, the greater the chance that a person will have a greater risk of being unsafe. Additionally, researchPrime (18) also stated that exposure for the maximum time will increase the respondent's chance of having an unsafe risk level.

Frequency of exposure is the number of days of exposure to H2S gas that respondents receive in residential locations within one year, minus the length of time the respondent leaves the research location in days. We obtained the exposure frequency range for respondents living around the landfill by distributing questionnaires, which ranged from 104 to 365 days per year, with an average exposure frequency of 346.77 days per year. Several respondents reported an extremely high average frequency of exposure. This happens because the majority of people living around the landfill are indigenous, so they rarely travel far for long periods of time each year.

The frequency of exposure will be directly proportional to the intake value. The longer the respondent is exposed to H2S in ambient air, the higher the intake value they receive. Study Rahman (17) states that the longer a person lives in a polluted place, the greater the possibility of contact with risk agents, and the greater the impact or risk they will receive. This is in line with research by Wardani (19), which states that the greater the frequency of exposure of respondents to air pollutants in one year, the greater the risk they will receive.

The duration of exposure refers to the number of years the respondent spent exposed to H2S gas at the research site. According to the research results, respondents who live around the landfill have an average real-time exposure duration of 5.85 years. The duration of exposure affects a person's intake value. The value of intake is directly proportional to the duration of exposure, which means that the greater the value of the duration of exposure, the greater the intake and risk level of a person. (17).

Realtime Intake Exposure Analysis in Communities Around the Medang River Landfill

Calculation of intake uses the variables concentration, exposure time, exposure frequency, and exposure duration. The results of statistical analysis of Exposure Concentration (EC) calculations for real-time inhalation exposure in people living in settlements around the Sungai Medang Prabumulih landfill can be seen in the table below:

Table 4. Results of Real-time Intake Statistical Analysis for Communities Living Around the Medang River Landfill

Variable (μg/m3)	**Mean**	**Median**	**elementary school**	**Min**	**Max**
Realtime Intake	0.00053	0.00064	0.000146162	0.000137	0.000650

Based on the results of the risk analysis in Table 4, it is known that the average real-time intake of respondents is 0.00053 μg/m3. The minimum and maximum values are 0.00013 μg/m3 and 0.000650 μg/m3, respectively.

Real-time time periods inform the calculation of H2S exposure intakLater, we will use this intake value to calculate the amount of non-carcinogenic risk and determine whether the respondent is safe or unsafe from the risk. k. According to the research results, the average real-time intake of respondents was 0.00053 μg/m3.

Gas concentration, inhalation rate, exposure time, exposure frequency, and exposure duration all influence the intake value, meaning that the higher this value, the more risk agent enters the body. This is in line with research by Djafri (20), which states that the intake value is directly proportional to the value of hydrogen sulfide concentration, inhalation rate, exposure time, exposure frequency, and exposure duration. This means that the higher the value for this variable, the higher the intake value received.

Low concentrations of H2S gas will cause nausea, dizziness, a feeling of floating, coughing, pain in the nose, throat, and chest, and can paralyze the sense of smell. Exposure to low levels of H2S gas over a long period of time can increase the risk of respiratory tract inflammation and pathological respiratory tract symptoms [(21)].

Risk Characteristics

Risk characteristics are carried out to compare the results of intake exposure analysis with the reference dose value (RfC), which is known as the risk quotient (RQ). The results of the statistical analysis of RQ calculations for real-time exposure in communities living in settlements around the Sungai Medang Prabumulih landfill can be seen in the table below:

Table 5. Results of Real Time Statistical Analysis of Risk Characteristics (RQ) in Communities Living Around the Medang River Landfill

Variable	Mean	Median	elementary school	Min	Max
Realtime RQ	0.267	0.320	0.0730	0.069	0.325

We can see from Table 5 that the non-carcinogenic risk characteristics (RQ) are still safe for health at an average H2S concentration of 0.00065 μg/m3 for real-time exposure. This is because the real-time average RQ is less than one (<1), or 0.26 μg/m3.

Risk characteristics (RQ) are values obtained from calculation results, namely by dividing the intake value by RfC. This research uses hydrogen sulfide as a non-carcinogenic health risk, as it does not have any implications for cancer cases. The calculation of the average real-time RQ for all respondents yielded an RQ value of less than 1.

The interpretation of risk characteristics (RQ) for inhalation exposure routes is that if the RQ value is > 1, then the health risk is declared unsafe and requires control, while RQ ≤ 1 means it is said to be safe, and the risk does not need to be controlled but needs to be maintained so that the RQ numerical value does not exceed 1 [(17)].

From the results of the risk level in this study, there is no need to carry out risk management because the RQ value obtained from the average RQ results of the entire population and the average between measurement points is not more than one (RQ<1), which means it is still said to be safe. There is no risk of non-carcinogenic health problems due to H2S exposure.

CONCLUSIONS AND RECOMMENDATIONS

According to research about the effects of hydrogen sulfide (H2S) exposure on communities near the Medang Prabumulih River landfill, the average amount of H2S in the air in these areas is 0.00065 μg/m2. The real-time intake value of H2S in the community living around the

Sungai Medang TPA obtained an average value of 0.00053 μg/m3, and the real-time RQ for H2S concentration in the air of residential communities living around the Sungai Medang TPA obtained an RQ value <1, meaning the location in this study is still said to be safe and does not have the potential to pose a non-carcinogenic risk due to exposure to hydrogen sulfide (H2S) gas. The suggestions given by researchers are as follows: The community should increase the number of barrier plants that can reduce H2S pollutants in the air, such as the Liriope spicata (lilyturf/monkey grass) plant, around the home environment to minimize the smell caused by piles of rubbish coming from the landfill. And the TPA can optimize the waste management system using the sanitary landfill method, as well as periodically monitoring the air quality around the TPA.

REFERENCES

1. Kahfi A. Tinjauan terhadap pengelolaan sampah. Jurisprudentie: Jurusan Ilmu Hukum Fakultas Syariah dan Hukum. 2017;4(1):12-25.
2. WHO. Principles for modelling dose-response for the risk assessment of chemicals: World Health Organization; 2004.
3. KLHK. Sistem Informasi Pengelolaan Sampah Nasional: SIPSN; 2022 [Available from: https://sipsn.menlhk.go.id/sipsn/.
4. Fang Y, Zhong Z, Shen D, Du Y, Xu J, Long Y. Endogenous mitigation of H2S inside of the landfills. Environmental Science and Pollution Research. 2016;23(3):2505-12.
5. Dwicahyo HB. Analisis kadar NH3, karakteristik individu dan keluhan pernapasan pemulung di TPA sampah benowo dan bukan pemulung di sekitar TPA sampah benowo surabaya. Jurnal Kesehatan Lingkungan. 2017;9(2):135-44.
6. Putri G. Kadar hidrogen sulfida dan keluhan pernapasan pada petugas di pengolahan sampah super depo sutorejo surabaya. Jurnal Kesehatan Lingkungan. 2018;10(2):211-9.
7. US-EPA. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment)2009.
8. ATSDR. *Toxicological Profile for Hydrogen Sulfide and Carbonyl Sulfide*. 2016.
9. Haryoto H, Setyono P, Masykuri M. Fate Gas Amoniak Terhadap Besarnya Resiko Gangguan Kesehatan Pada Masyarakat Di Sekitar Tempat Pembuangan Akhir (TPA) Sampah Putri Cempo Surakarta. Ekosains. 2014;6(2).
10. Faisya AF, Putri DA, Ardillah Y. Analisis risiko kesehatan lingkungan paparan hidrogen sulfida (H2S) dan ammonia (NH3) pada masyarakat wilayah TPA Sukawinatan Kota Palembang Tahun 2018. J Kesehat Lingkung Indones. 2019;18(2):126-34.
11. Hidayatullah F, Mulasari SA, Handayani L. Analisis Risiko Kesehatan Lingkungan Paparan Hidrogen Sulfida (H_2S) Dan Amonia (NH_3) Pada Masyarakat di TPA Piyungan. Jurnal Kesehatan Lingkungan: Jurnal dan Aplikasi Teknik Kesehatan Lingkungan. 2021;18(2):155-62.
12. Rufaedah AA, Sriagustini I, Irma A. Paparan Hidrogen Sulfida Terhadap Risiko Kesehatan Masyarakat Di Sekitar Area TPA Cibereum Di Kota Banjar. Jurnal Kesehatan Lingkungan. 2019;11(4):309-18.
13. Nukman A, Udara SPDP, Ditjen PM, Rahman A. Analisis dan manajemen risiko kesehatan pencemaran udara: studi kasus di sembilan kota besar padat transportasi. 2012.
14. Amaliana A, Darundiati YH, Dewanti NAY. Analisis Risiko Kesehatan Lingkungan Paparan Nitrogen Dioksida (No2) Pada Pedagang Kaki Lima Di Terminal Pulogadung Jakarta Timur. Jurnal Kesehatan Masyarakat (Undip). 2016;4(4):801-9.
15. Almunjiat E. Analisis Risiko Kesehatan Akibat Pajanan Timbal (Pb) melalui Jalur Inhalaspada Operator di Stasiun Pengisian Bahan Bakar Umum (SPBU) di Kota Kendari Tahun 2016 (Studi di SPBU Tipulu, Wua-wua, Anduonohu dan SPBU Lepo-lepo): Haluoleo University; 2016.

16. Kemenkes R. Pedoman Analisis Risiko Kesehatan Lingkungan (ARKL). Jakarta: Dirjen PP-PL. 2012.
17. Rahman A. Model Kajian Prediktif Dampak Lingkungan Dan Aplikasi Untuk Manajemenrisiko Kesehatan. Pusat Kajian Kesehatan Lingkungan dan Industri FKM-UI: Depok. 2007.
18. Perdana C. Gambaran asupan amonia (NH3) pada masyarakat dewasa di kawasan sekitar pemukiman PT. Pusri Palembang Tahun 2015: UIN Syarif Hidayatullah Jakarta: Fakultas Kedokteran dan Ilmu Kesehatan, 2015; 2015.
19. Wardani T. Perbedaan Tingkat Risiko Kesehatan oleh Pajanan PM10, SO2 dan NO2 pada Hari Kerja, Hari Libur dan Hari Bebas Kendaraan Bermotor di Bundaran HI Jakarta. Depok: Universitas Indonesia. 2012.
20. Djafri D. Prinsip dan metode analisis risiko kesehatan lingkungan. Jurnal Kesehatan Masyarakat Andalas. 2014;8(2):100-4.
21. Rifai B, Joko T, Darundiati YH. Analisis risiko kesehatan lingkungan pajanan gas hidrogen sulfida (H2S) pada pemulung akibat timbulan sampah di TPA Jatibarang Kota Semarang. Jurnal Kesehatan Masyarakat (Undip). 2016;4(3):692-701.