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(RESEARCH ARTICLE)

Environmental health risk analysis of Hydrogen Sulfide (H2S) exposure to Jabon Sidoarjo landfill scavengers

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Abstract

Scavengers work every day by interacting with waste in landfill making them a group with a high risk of contracting diseases due to unhealthy working conditions and exposure to air pollutant gases, one of which is hydrogen sulfide gas (H2S). H2S gas can cause respiratory problems for scavengers such as coughing, flu, fever, headache, shortness of breath, sore throat, and sore nose. This study aims to analyze the environmental health risks analysis of hydrogen sulfide gas (H2S) exposure in Jabon Sidoarjo landfill scavengers. This research is a descriptive study with cross sectional design. The approach used is Environmental Health Risk Analysis. Measurement of H2S gas concentration was carried out in the scavenger work area. The research respondents were 46 scavengers who worked in old landfill. Data analysis using univariate analysis and risk analysis. The results for the concentration of H2S in the scavenger work area point 1 and point 2 were 0.00242 ppm and 0.00081 ppm. Analysis of the risk quotient (RQ) in real time, the next 10 years, and in real life, the result is 0.13; 0.25; 0.37. The results showed that the measurement of H2S gas concentrations in the scavenger work area was still below the provincial government's environmental quality standards. Risk quotient analysis (RQ) shows results below 1. This shows that scavengers are still safe from non-carcinogenic risks or the H2S gas produced is not at risk of causing health problems.

Keywords: Hydrogen Sulfide; Landfill; Risk Analysis; Scavenger

1. Introduction

The problem of waste is something that requires special attention, apart from the strong smell and disturbing environment, it also endangers the health of people around it because waste is a source of disease [1]. Increasing population growth will result in increased human activity thereby affecting the rate of high consumption needs. High consumption rates also have a negative impact on the environment, one of which is the increased volume of waste produced [2].

Landfill is one of the places used for waste disposal which has reached the final stage of waste management. The pungent smell of garbage from the landfill arises due to the process of decomposition of waste by bacteria. The impact of air pollution can pose a health hazard to humans, especially those related to respiratory problems [3].

Waste processing at landfill Jabon is carried out in four main places, namely sorting plant, composting plant, new landfill, and old landfill. Waste management in the new landfill uses a sanitary landfill system, but according to the results of observations the management system is still a controlled landfill where when the landfill is full it will be compacted. Garbage cover with a layer of soil is not carried out every day, but a certain number of days or a longer period [4]. Meanwhile, the waste management system in the old landfill still uses the open dumping method, namely disposing and piling up waste without covering it with soil and further management [5]. The volume of waste that entered the Jabon

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landfill in April 2023 reached 15,974 tons of waste and 159 tons of waste were handled from the composting plant, sorting plant, and new landfill processes, leaving 15,814 tons of waste residue that was stockpiled in the old landfill.

The process of decomposing waste in landfills was originally carried out by aerobic bacteria which consume oxygen by breaking down the long molecular chains of complex carbohydrates, proteins and lipids which consist of organic waste. The longer it takes, the oxygen will run out and then it will enter anaerobic decay [6]. One of the anaerobic bacteria, namely sulfate reducing bacteria (SRB) reduces sulfur compounds to produce sulfides which are released in the air as hydrogen sulfide (H2S) [7].

Hydrogen sulfide (H2S) is a colorless, toxic, flammable gas with a rotten egg odor. Exposure to H2S gas can have a negative impact on health because it is irritating to the lungs and has an impact on paralyzing the respiratory center [8]. H2S gas enters the human body through the air when inhaled, at low concentrations of 0.13 to 100ppm, this gas can cause irritation to the eyes, nose and throat, and even respiratory problems in asthma sufferers. At concentrations of 500ppm it can cause death, pulmonary edema and asphyxiant which can paralyze the respiratory center [9,10].

Scavengers who work every day at the Waste Final Processing Site as collectors of unused goods which can be recycled to be sold to collectors. The habit of scavengers interacting with waste makes them a group with a high risk of contracting disease due to the type of work and unhealthy working conditions [11]. Of the 7 scavengers in the Sanggrahan landfill, Temanggung Regency, some of them experienced respiratory complaints including cough, flu, fever, headache, shortness of breath, sore throat, and sore nose [12]. Meanwhile, several scavengers who work at Ganet Landfill Tanjungpinang City have respiratory complaints including shortness of breath, sore throat, fever, cough, and headaches that come and go. This complaint is experienced after 1-3 years of working as a scavenger [13]. Scavengers at the Jabon landfill work in the old landfill area where the waste treatment system still uses open dumping. From the statement above, the authors are interested in conducting research with the title "Environmental Health Risk Analysis of Hydrogen Sulfide (H2S) Exposure to Jabon Sidoarjo Landfill Scavengers."

2. Material and methods

2.1. Material

This research is a descriptive study with a cross-sectional study design using the Environmental Health Risk Analysis approach with the stages of hazard identification, dose response analysis, exposure analysis, and risk characteristics. Measurement of hydrogen sulfide gas (H2S) levels in the scavenger work area, namely the old landfill in the morning at 9.50 West Indonesian Time. Measurements were carried out by experts using the spectrophotometer methylene blue method which refers to the Indonesian National Standard. The sample in this study were 46 scavengers at Jabon Sidoarjo Landfill.

2.2. Methods

This study aims to calculate the level of environmental health risk due to exposure to H2S gas to the respiratory health of scavengers. The dependent variable is the level of risk or risk quotient (RQ). The independent variables were body weight, H2S gas concentration, duration of exposure, frequency of exposure, daily exposure time. For the calculation of Environmental Health Risk Analysis using the following formula:

$$\text{Risk Quotient (RQ)} = \text{Intake} : \text{RfC}$$

Information:

I: Intake from the results of the calculation of the exposure assessment (mg/kg day)

RfC: Dose or reference concentration by inhalation (mg/kg day)

The RQ value indicates the level of health risk from exposure to inhaled H2S gas. RQ value < 1 means exposure is still below normal limits and safe from non-carcinogenic risks. The calculation of non-carcinogenic H2S intake values uses the following formula:

$$Ink = (C \times R \times tE \times fE \times Dt) : (Wb \times Tavg)$$

Information:

Ink : Intake (mg/kg day)
C : Gas exposure concentration (mg/m^3)
R : Rate of inhalation (m^3/hour). The US-EPA default value for adults is 0,83 m^3/hour.
tE : Daily exposure time (hours/day)
fE : Exposure frequency (day/year)
Dt : Exposure duration (real time, 30 years for lifetime)
Wb : Respondent's body weight (kg)
Tavg : Mean time period for non-carcinogenic (30 years × 365 days/year)

3. Results

3.1. H2S Gas Concentration

Based on table 1, it shows that the results of measuring the concentration of H2S gas at point 1 and point 2 are 0.00242 ppm and 0.00081 ppm. If the unit is changed to mg/m^3, the concentration of H2S gas at point 1 and point 2 is 0.00337 mg/m^3 and 0.00112 mg/m^3. Environmental quality standard for ambient air H2S gas according to East Java Governor Regulation No. 10 of 2009 is 0.03 ppm [14]. Based on the measurement results, concentration of H2S gas has not exceeded the quality standards that have been determined. Meteorological factors that affect the concentration of H2S gas include temperature, humidity, and wind velocity. Temperature measurements at point 1 and point 2 reached 37.1^{o}C and 38.1^{o}C. While the results of air humidity measurements at point 1 and point 2 are 44% and 40%. The wind velocity at point 1 and point 2 reaches 3.81 m/sec and 7.52 m/sec with the wind heading west.

Table 1 H2S Gas Concentration Measurement Results

	Variable	Point 1	Point 2
1	H2S concentration	0.00242 ppm	0.00081 ppm
2	Temperature	37.1^{o}C	38.1^{o}C
3	Humidity	44%	40%
4	Wind Velocity	3.81 m/sec	7.52 m/sec

3.2. Characteristics of Scavengers

Based on table 2, it shows that of the 46 respondents, the average weight of scavengers was 56.41 kg with a minimum value of 39 kg and a maximum of 79 kg. While the daily exposure time is calculated based on the daily working hours of scavengers with an average of 7.57 hours working with the minimum working time of 4 hours/day and the most 9 hours/day. While the duration of exposure was obtained from the scavengers' work period with an average working period of 10.4 years with the smallest exposure duration being 0.5 years and the largest being 25 years. Based on the results of interviews with respondents, it was found that their daily work frequency was erratic, but most of them worked 6 days a week. If the respondent's exposure frequency is calculated, it is 6 days multiplied by 52 weeks, which is 312 days/year. Calculation of the inhalation rate uses the US-EPA default value of 0.83 m^3/hour for adults [15].

Table 2 Characteristics of Scavengers

	Characteristics	Mean	Median	Min-Max
1	Weight	56.41 kg	55.0 kg	39 kg - 79 kg
2	Daily exposure time	7,57 (hours/day)	8.00 (hours/day)	4 – 9 (hours/day)
3	Exposure duration	10.4 years	10 years	0.5– 25 years
4	Exposure frequency			312 (day/year)
5	Rate of inhalation			0.83 (m^3/hari)

4. Discussion

4.1. Hazard Identification

The hazard analyzed in this study is exposure to hydrogen sulfide gas (H2S) in the work area of scavengers in the Jabon Sidoarjo old landfill. The source of exposure to H2S gas comes from the decomposition of waste by bacteria. Scavengers work in landfills every day and interact with waste during work which makes scavengers a group at high risk of experiencing respiratory problems due to exposure to gases, one of which is H2S during their working time. Based on the results of observations, the scavengers' work and rest areas are in the same area, the old landfill. This also makes scavengers exposed to H2S gas for a longer time because some scavengers choose to take a break by setting up a small hut on the outskirts of their work area to rest during the day. In addition, most scavengers do not use masks during working hours on the grounds that it is more difficult to breathe during work activities.

Exposure to H2S gas with a concentration of 50 ppm can cause symptoms of drowsiness and headaches. Concentrations of 50-100 ppm can cause dizziness, concentrations over 200 ppm can cause symptoms of motion sickness (severe dizziness), numbness, and feeling nauseous. Exposure to H2S gas that exceeds 500 ppm can cause mental disorders and impaired coordination. Short-term exposure to H2S gas at high concentrations (600 ppm) can cause fatigue, dizziness, headaches, loss of balance, nausea, and fainting. Meanwhile exposure to H2S gas at a concentration of 1000 ppm can cause death due to respiratory failure [16].

Based on the table 1, the concentration of H2S gas at point 1 and point 2 are 0.00242 ppm and 0.00081 ppm. These results indicate that the concentration of H2S gas is still below the quality standard. H2S gas concentration is affected by temperature, humidity, and wind velocity. High temperatures cause the air to become more tenuous so that pollutant concentrations are lower, conversely at low temperatures the concentrations of pollutant gases are higher. Low air humidity has a small water vapor content, so that air dispersion is faster and the concentration of pollutant gases is lower. High wind velocityalso causes the concentration of pollutant gases to decrease, conversely if the wind velocity is low, the gas concentration will be higher [17].

4.2. Dose Response Analysis

Exposure to H2S gas enters the human body through the inhalation route. Analysis of dose response was not measured directly by the researcher. In this study, the dose response analysis used the RfC value (inhalation concentration reference) from the Integrated Risk Information System (IRIS) according to the US-EPA [18]. The RfC value according to the US-EPA is 2E-3 mg/m^3 or 0.002 mg/m^3 or 0.00057 mg/kg day.

4.3. Exposure Analysis

Exposure analysis is carried out to calculate intake or the amount of concentration of risk agents that enter the human body every day. Analysis of exposure to scavengers at Jabon landfill shows that the average value of the respondent's body weight (Wb) is 56.41 kg with an average daily exposure time (tE) of 7.57 hours/day. Respondents' average duration of exposure (Dt) was 10.4 years with an exposure frequency (fE) of 312 days/year. Inhalation rate (R) uses the adult default value of 0.83 m^3/day. The average concentration of H2S gas in the scavenger work area (C) is 0.002245 mg/m^3. Calculation of the average time period for non-carcinogenic (tavg) is 30 years × 365 days/year or equal to 10,950 days. Calculation of the intake value using the formula:

Ink = (C × R ×tE ×fE × Dt) : (Wb ×tavg) = (0.002245 × 0.83 × 7.57 ×312 ×10.4) : (56.41 × 10950)

Then the results of the calculation of exposure analysis through non-carcinogenic inhalation in real time are 0.0000741 mg/kg day.

4.4. Risk Characteristics

Based on the calculation of the intake results obtained, it is equal to 0.0000741 mg/kg day and the inhalation concentration reference value (RfC) is 0.00057 mg/kg day. Then the risk quotient calculation can be done by calculating the formula:

RQ = Intake : RfC = 0.0000741 : 0.00057

Then the calculation of the risk quotient for non-carcinogenic effects results in a risk quotient of 0.13.

Table 3 Estimation of the Risk Characteristics of Jabon Sidoarjo landfill scavengers

	Projection	Intake (mg/kg day)	RQ	Information
1	Real Time (Dt = 10,4 years)	0.0000741	0.13	RQ < 1
2	Next 10 Years (Dt = 20 years)	0.000142	0.25	RQ < 1
3	Life Time (Dt = 30 years)	0.000213	0.37	RQ < 1

The value of the risk quotient (RQ) can indicate that the level of health risk is due to the parameter of hydrogen sulfide (H2S) pollutant gas. The results of the RQ value < 1, indicate that the level of risk with an average concentration of exposure to H2S gas in the scavenger work area point 1 and point 2 of 0.001615 ppm or 0.002245 mg/m^3 is still below the normal limit and safe from non-carcinogenic risks in real time, the next 10 year or life time. The low RQ value is influenced by variables in the intake calculation, one of which is the concentration of H2S gas in the scavenger work area. Therefore, the risk quotient of scavengers is still said to be safe.

5. Conclusion

The results of measuring the concentration of H2S gas in the scavenger work area are still below the environmental quality standards. Meteorological factors that affect the concentration of H2S gas include temperature, humidity, and wind velocity at point 1 and point 2. The risk level of exposure to H2S gas with an average H2S concentration value of 0.00323 ppm at present (real time), the next 10 years, and life time (next 30 years) obtained a value of 0.13; 0.25; 0.37 which states that the RQ value < 1. This indicates that scavengers are still safe from non-carcinogenic risks or the H2S gas produced is not at risk of causing health problems. The results of this RQ calculation are influenced by individual characteristics which include weight, daily exposure time, exposure duration, exposure frequency, inhalation rate from scavengers.

Compliance with ethical standards

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Disclosure of Conflict of interest

The Authors proclaim no conflict of interest.

Statement of informed consent

All informants/respondents involved in this study have stated their consent to provide information/data according to the research needs.

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