Risk Analysis of H_2S Gas Exposure at Benowo Landfill Surabaya

Herman Bagus Dwicahyo[1], Lilis Sulistyorini[2], Abdul Rohim Tualeka[1]

[1]Department of Occupational Health and Safety, Faculty of Public Health, Airlangga University, Indonesia,
[2]Department of Environmental Health, Faculty of Public Health, Airlangga University, Indonesia

Abstract

Air pollution can be caused by the number of dangerous gases that arise due to the process of accumulating decaying waste which has acute and chronic effects for people who are exposed. Judging from the data collection method, this study is observational. The study design used in this study was a cross-sectional study design. Risk agent toxicity is expressed in reference doses. For non-carcinogenic inhalation exposures expressed by the Reference Concentration (RfC). Based on primary data derived from the results of measurements of ambient air quality at the loading terminal IIB TPA Garbage Surabaya, the results showed that H2S gas levels of 0.04 where the levels are still below the ambient air quality standards based on East Java Governor Regulation No. 10 of 2009 concerning Quality Standards Air Ambient. From the calculation above, the researcher took the safe value by choosing the cancer risk safe value from the calculation data most likely to be applied by scavengers in the TPA Sampoerna Benowo Surabaya, namely C safe at 3 mg / m3, safe for 3 hours/day and safe for 2 years. Preventive efforts that can be carried out are by controlling the source such as not doing landfill with the open dumping method using the sanitary system. Routinely monitor and control emissions, so that the air quality around the waste picker environment is maintained. Reducing the number of exposures by using personal protective equipment (PPE) in the form of respirators (masks). Perform administrative control by reducing the time and frequency of exposure to H2S dangerous gases. It is better for the Surabaya government and PT X to socialize the hazards and impacts of H2S exposure to workers.

Keywords: *Risk Analys, Gas H2S, Risk Management*

Introduction

The Waste Management Site is a place where waste reaches the last stage in its management since it starts to rise at the source, collection, transfer or transportation, processing to disposal. Landfill can have an impact on environmental quality such as air pollution from dust and gas resulting from the anaerobic decomposition process, especially if waste disposal uses an open dumping system[1].

Correspondence Author:
Abdul Rohim Tualeka,
Department of Occupational Health and Safety, Faculty of Public Health, Airlangga University, 60115 Surabaya, East Java, Indonesia. e-mail: inzut.tualeka@gmail.com or abdu-r-t@fkm.unair; Handphone: +6281333519732.

Direct exposure to environmental pollution, especially gas to health, is more dangerous than indirect exposure. This can be seen from the health problems that occur in landfill waste such as complaints of respiratory problems that occur more on scavengers in TPA garbage, compared to people who are far from pollutant sources.

Air pollution can be caused by the number of dangerous gases that arise due to the process of accumulating decaying waste which has acute and chronic effects for people who are exposed. According to Soemirat (2005) that the decay of waste will produce Methane gas (CH4), Ammonia gas (N3), and Hydrogen Sulphide (H2S) gas which is toxic to the body.

States that the gas formation from TPA consists of several types of gas, the gas found from TPA consists mainly of Ammonia(NH3), Carbon dioxide(CO2), Carbon monoxide (CO), Hydrogen(H2), Hydrogen sulphide (H2S), Methane (CH4), Nitrogen (N2), and Oxide (O2)[2].

H2S gas is included in the type of chemical asphyxiants, namely chemicals that can cause breathing difficulties because the mechanism of toxicity is through chemical reactions or inhibits oxygen transport [3].

Material and Method

Judging from the data collection method, this study is observational. The study design used in this study was a cross-sectional study design. namely, research conducted by collecting exposure and outcome data simultaneously. In a cross-sectional study, researchers only observe phenomena at a certain point in[4].

The research design uses a risk analysis paradigm design by taking one of its components, namely risk assessment/risk assessment [5]. Risk assessment is used to calculate the estimated level of health risk and determine the control in the form of safe exposure time (Dt). The steps taken in the risk assessment are hazard identification, exposure analysis, dose-response analysis, and risk characteristics.

This research was conducted in 1 (one) work location, precisely at the South IIB waste point in Benowo Surabaya landfill, with the subjects of the study being 37 female respondents aged 15-64 years. The way to determine the sample will be done using Simple Random Sampling. H2S concentration measurements were carried out in the work environment, precisely in the active terminal of the loading and unloading truck using a laboratory test using the Gravimetric method.

The calculation of non-carcinogen intake with sources of exposure through the air can be formulated as follows[6] :

I	: Intake , the amount of risk agent that enters (mg / kg / day)
C	: Concentration risk agent, (mg / m3) for air medium, (mg / L) for drinking water, (mg / kg) for food / food
R	: Rate for air intake (adult: 20 m3 / day or 0.83 m3 / hour, children: 12 m3 / day or 0.5 m3 / hour
tE	: daily exposure time (24 hours/day for residential exposure, 8 hours/day for exposure to the workplace
fE	: Frequency of annual exposure (Exposure to settlements: 350 days/year) and (Exposure to the work environment: 250 days/year)
Dt	: Duration of exposure, real-time or projections for residential (residential/occupational age), adults: 30 years, children: 6 years
Wb	: Body weight, adult 70 kg / 55 kg (70 kg for Europe from US-EPA 1990, 55 kg for Asia from Nukman, et al. 2005)
Tavg	: Average time period, 30 years x 365 days / year (non carcinogens) or 70 years x 365 days / year (carcinogens)

The risk characteristics of non-cancer effects can be known by dividing the value of Non-cancerous Intake with the value of RfD or RfC with the following formula[7]:

RQ	: Risk Quotient
Ik	: Intake of carcinogenic
RFC	: Reference of Concentration

After the RQ value is obtained, then the assumption is used. If the value of RQ ≤ 1 indicates no possibility of the risk of noncarcinogenic health effects, it needs to be maintained so that the numerical value of RQ does not exceed 1. While RQ> 1 indicates an indication of the possibility of risk of non-carcinogenic health effects control efforts[8].

After conducting a risk assessment and obtaining results that are beyond the threshold value, the next thing that can be done is risk management. This is done to minimize and even eliminate the risk of danger arising from the source of danger in the right work. The non-carcinogenic risk management used is the RQ value. In reducing the risk agent concentration value, the value of RQ = 1 so that the intake value = RfC is obtained.

In non-carcinogenic risk management to obtain a safe value is calculated using the following formula[9]:

Based on the calculation formula for non-carcinogenic effects above, it can be derived to find safe values of C, tE, and Dt as follows:

Findings

a. **Risk Analysis and Hazard Identification**

H2S is produced due to the process of decomposition of waste by anaerobic bacteria, in this process, the role of microbial activity is very important. The microorganisms that live at this stage are nonmethanogenic types which consist of facultative anaerobic bacteria. H2S which is a byproduct of the decomposition of organic matter, the percentage of H2S gas produced from TPA ranges from 0-0.2%[10].

H2S gas is quickly absorbed by the lungs, at low concentrations, it can cause eye, nose and throat irritation, at high concentrations it can cause loss of consciousness and even death [10].

b. **Dose Response Analysis**

Dose-response analysis is the stage used to determine the relationship between the size of the dose or the level of exposure to chemicals with the occurrence of adverse effects on human health. Where this stage is a stage to determine the quality of risk agent toxicity has the potential to have an effect that can be detrimental to health in at-risk populations.

The risk agent toxicity is expressed in reference doses. For non-carcinogenic inhalation exposures expressed by the Reference Concentration (RfC). The reference dose is used to estimate the amount of exposure each day in the human population that can be accepted without causing harmful effects during their lifetime. The H2S gas RfC value in this study uses the reference dose value of dust RfC (TSP) in the IRIS list, which is 2.10-3 mg / m3.

c. **Exposure Analysis**

Based on primary data derived from the results of measurements of ambient air quality at the loading terminal IIB At Benowo Landfill Surabaya, the results showed that H2S gas levels of 0.04 where the levels are still below the ambient air quality standards based on East Java Governor Regulation No. 10 of 2009 concerning Quality Standards Air Ambient.

Table 1. Results of Measurement of H2S Levels in Benowo Landfill in Surabaya

No	Parameter	Measured Level	Quality standards	Unit
1.	Hydrogen Sulfide (H2S)	0,01	0,10	µg/Nm3
2.	Air temperature	34,6	-	℃
3.	Humidity Nisbi (RH)	62	-	%
4	Wind velocity	1,8-6,7	-	m/dt

Table 2. The interview table characteristics of individual female scavengers at the Benowo Landfill Surabaya

Variable	Average Results	Unit
tE (Daily exposure time)	9	Hours/ day
fE (Frequency of annual exposure)	336	Day/Year
Dt (Exposure Duration)	6	Year
Wb (Weight)	56	kg

In air pollution, the general impact of continuous exposure to air pollution can cause lung, heart, and other diseases which are risk factors for death[11].

The calculation of carcinogen intake with sources of exposure through the air can be formulated as follows:

The results obtained through interviews revealed that the average respondent had a body weight of 56 kg (Wb), every day worked 9 hours/day (tie), the number of workdays for one year was 336 days (Fe), and had worked on an average for 6 years (Dt). With the rate of inhalation (R) of 20 m3 / HR and tag for non-carcinogenic substances is 30x365 days/yr. With the results of air measurements that have H2S (C) concentrations of 0.01 mg / m3, so the amount of noncarcinogenic intake is 5,9 mg/kg.

d. **Risk Characteristics**

Risk characteristics for non-cancer effects can be known by dividing the value of Non-cancerous Intake with the value of RfD or RfC with the following calculations:

Based on the above calculations, it is known that the Ink is 5,9 and the RFC is 0, 002. The results of the RQ calculation are 2,95 where the RQ value >1.

According to experts, around the year 2000 the deaths caused by air pollution reached 57,000 people per year. During the 20 years the death rate caused by air pollution rose to close to 14% or up close to 0.7% per year. In addition, material losses caused by air pollution are very large[12].

e. **Risk Management**

After conducting a risk assessment and obtaining the results that RQ> 1, the next thing that can be done is risk management by carrying out the following calculations:

From the calculation of the figures above, it can be seen that the concentration of H2S gas at the garbage loading and unloading location even though it is still below the predetermined NAB standard. However, the concentration must be reduced to a maximum concentration of H2S gas of 3 mg / m3 for the duration of exposure for the next 30 years, assuming that the frequency of workday exposure is 336 days per year and the exposure time is also 9 hours per day.

From the calculation using an average H2S concentration of 10 mg / m3, we get 3 hours of results, which means that a 56 kg scavenger who is exposed to H2S gas will be safe for the next 30 years if the daily exposure time is 3 hours/day or around 16 minutes.

From the above calculations, it can be seen that a person weighing 56 kg has been exposed to H2S gas every day for 9 hours with a dust concentration of 10 mg / m3 so the duration of safe exposure is 2 years.

From the calculation above, the researcher took the safe value by choosing the cancer risk safe value from the calculation data most likely to be applied by scavengers in the At Benowo Landfill Surabaya, namely C safe at 3 mg / m3, safe for 3 hours/day and safe for 2 years.

Conflicts Of Interest: All authors have no conflicts of interest to declare

Source of Funding: The source of this research costs from self.

Ethical Clearance: The study was approved by Health Research Ethics Committee Faculty of Publich Health Airlangga University No: 154-KEPK

All subjects were fully informed about the procedures and objectives of this study each subject prior to the study signed an informed consent form.

Conclusion

According to Minister of Manpower Regulation number 5 of 2018, it is explained that H2S gas exposure can cause upper and eye respiratory irritation, and Nausea. The intake calculation results are 5,9 mg/ kg.hari. The results of the current RQ calculation are 2,95 where the RQ value >1, so we have to Safe C calculation results of 3,37mg/m3, the calculation results are safe for 3 hours/day and the Dt results are safe for 2 years. Risk management has been carried out, but additional control is needed so that the risk of illness and occupational accidents can be reduced.

Suggestion:

Preventive measures that can be taken, namely by controlling sources such as not carrying out landfill with the open dumping method using the sanitary system. Carry out regular monitoring and emission control tools so that the air quality around the waste picker environment is maintained. Reducing the number of exposures by using personal protective equipment (PPE) in the form of respirators (masks).

Perform administrative control by reducing the time and frequency of exposure to H2S dangerous gases. It is better for the Surabaya government to socialize the hazards and impacts of H2S exposure to workers.

References

1. Soemirat J. Toksikologi Lingkungan. Gadjah Mada University Press; 2005.

2. Martono D. Teknologi Pemanfaatan Gas Dari

TPA. 2006.

3. Lestari F. Chemical Hazards, Sampling, and Measurement of Chemical Contaminants in the Air. Jakarta: Medical Book Publishers EGC; 2010.
4. Notoatmodjo S. Metode Penelitian Kesehatan. Jakarta: PT Rineka Cipta; 2010.
5. NRC. Risk Assessment in the federal government health. NRC. 1983;volume 63:pp 377-381.
6. Tualeka AR. Toksikologi Industri dan Risk Assesment. Graha Ilmu Mulia; 2013.
7. Siswati. Dust (Total Suspended Particulate) Exposure Risk Assessment in Packer Units PT. X. J Heal Environ. 2017;9:100–10.
8. Rahman A. Basic principles, methods, techniques and procedures for environmental health risk analysis. Depok: University of Indonesia's; 2005.
9. Fahrudi H. Risiko Menderita Kanker dan Non Kanker Pada Pekerja Terpapar Benzena di Home Industry Sepatu Kelurahan Tambak Oso Wilangun Surabaya. Indones J Occup Saf Heal. 2017;vol.6:68–77.
10. Mardia E. Analisis Konsentrasi Gas Hidrogen Sulfida (H2S) di Udara Ambien Kawasan Lokasi Pembuangan Akhir (LPA) Sampah Air Dingin Kota Padang. UNAND; 2011.
11. Handoyo E dan BW. Bambang Wispriyono. Risiko Kesehatan Pajanan Benzena, Toluena, Dan Xylena Petugas Pintu Tol. J KESMAS. 2016;V0l. 11:xx–xx.
12. Huboyo H. dan S. Analisis Resiko Konsentrasi Debu (Tsp) Dan Timbal (Pb) Di Pinggir Jalan Terhadap Kesehatan Manusia Studi Kasus Kota Yogyakarta. J Tek. 2007;Vol. 28.