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by Novrikasari Novrikasari

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Analysis of Environmental Health Risks of Cement Dust in Cement Grinding and Packing

Widia Eka Susanti[1*]; Achmad Fickry Faisya[2]; Novrikasari[3]

[1*] Program Magister Ilmu Kesehatan Masyarakat Universitas Sriwijaya
[2] Kesehatan Lingkungan (KL) Fakultas Kesehatan Masyarakat Universitas Sriwijaya
[3] Keselamatan Kesehatan Kerja (K3) Fakultas Kesehatan Masyarakat Universitas Sriwijaya

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A B S T R A C T

Cement industry has the potential to cause dust as contamination or pollution in the air. Dust generated from the cement production process can be a health threat to cement industry workers. This study aims to assess the magnitude of the environmental health risk of cement dust exposure in the Cement Grinding and Packing section of PT X.This research is a quantitative descriptive study with the approach used is the Environmental Health Risk Analysis (ARKL). The number of sampling points in this study were 20 sampling points with a sample of 62 workers with a sample selection technique using a purposive sampling method with the criteria that workers have worked for at least 1 year. The results showed that the highest dust concentration was 0.84 mg/m3 and the lowest was 0.04 mg/m3. The dust concentration is still below the Threshold Limit Values (TLVs) which is 1 mg/m3. The results of the Environmental Health Risk Analysis (ARKL) indicate that more than a portion of the dust RQ value showed below 1 (RQ <1) and there are still RQ values showed above 1 (RQ>1) in some workers. The risk of a lifetime with a calculation of a work period of 30 years results in the majority of dust RQ value showed above 1 (RQ>1).

Analisis Risiko Kesehatan Lingkungan Debu Semen di Cement Grinding and Packing

Kata kunci:

Debu
Semen
Penggilingan
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Risiko Kesehatan Lingkungan

**) corresponding author*

Program Magister Ilmu Kesehatan Masyarakat Universitas Sriwijaya

Email: widiaeka11@gmail.com

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A B S T R A K

Industri semen memiliki potensi menimbulkan debu sebagai kontaminasi atau pencemaran di udara. Debu yang dihasilkan dari proses produksi semen dapat menjadi ancaman kesehatan bagi pekerja industri semen. Penelitian ini bertujuan untuk menilai besaran risiko kesehatan lingkungan paparan debu semen di bagian Cement Grinding and Packing PT X.Penelitian ini merupakan penelitian deskriptif kuantitatif dengan pendekatan yang digunakan adalah Analisis Risiko Kesehatan Lingkungan (ARKL). Jumlah titik sampling pada penelitian ini sebanyak 20 titik sampling dengan sampel pekerja sebanyak 62 pekerja dengan teknik pemilihan sampel menggunakan metode purposive sampling dengan kriteria pekerja telah bekerja minimal 1 tahun.Hasil penelitian menunjukkan bahwa konsentrasi debu tertinggi yaitu 0,84 mg/m3 dan terendah yaitu 0,04 mg/m3. Konsentrasi debu tersebut masih dibawah Nilai Ambang Batas (NAB) yaitu 1 mg/m3. Hasil Analisis Risiko Kesehatan Lingkungan (ARKL) menunjukkan bahwa lebih dari sebagian nilai RQ debu masih berada di bawah 1 (RQ<1) dan masih terdapat nilai RQ lebih dari 1 (RQ>1) pada beberapa pekerja. Besar risiko lifetime dengan perhitungan masa kerja 30 tahun didapatkan hasil sebagian besar RQ debu berada di atas 1 (RQ>1).

INTRODUCTION

One of the most important factors for increasing the productivity of the workforce as a human resource is a health. Good health conditions have the potential in achieving good work productivity. Jobs that require high productivity can only be done by workers with excellent health conditions (Sima'mur, 2013).

Cement was one of the most important building materials in the world (Zeleke, Moen, & Bråtveit, 2011). Based on OSHA data, more than 250,000 people work in the manufacture of concrete (Rafeemanesh, Alizadeh, Saleh, & Zakeri, 2015). The negative effect of the cement production process was the emergence of dust which has the potential to cause contamination or pollution in the air. The dust generated from the cement industry activities was the result of the production process starting from the raw materials procurement to the transportation of the finished product outside the factory (Siswati & Diyanah, 2017).

Cement industrial workers were exposed to dust during the production process, such as extracting and handling raw materials, during clinker grinding, mixing, packaging and shipping of finished products (Meo, 2004). The workers who were exposed to dust continuously for 8 hours/day can reduce pulmonary function in the form of obstructions in workers (Mukono, 2000).

Dust exposure in workers who were inhaled such as cement dust can have acute and chronic health effects, especially on the respiratory system and lung function performance (Zeleke, Moen, & Bråtveit, 2010). One study in France proved that there was a positive correlation with the increase in the prevalence of asthma and rhinitis due to exposure to particulate matter (Annesi-Maesano et al., 2012). Epidemiological studies proved that exposure to cement dust on workers can cause health problems (Mwaiselage, Bråtveit, Moen, & Mashalla, 2005; Nordby et al., 2011)

Risk analysis was one of the preventive steps in preventing health impacts that have been carried out in previous studies using residential populations (Rahman et al., 2008; Suryaman & Rahman, 2011). Centers of Disease Control and Prevention (CDC) stated that 30 percent of people with COPD and asthma were caused by workplace exposure (Kurniawidjaja, Safety, & UIDepok, 2010), so it was necessary to carry out a risk analysis using the working population (Nukman A, Rahman A, Warouw S, Setiadi MI, & CR., 2005).

Based on this description, it is necessary to carry out an Environmental Health Risk Analysis (ARKL) of cement dust at X's factory of Cement Grinding and Packing with the aim for knowing the amount of risk of exposure to cement dust so, it can be taken into consideration in intervening to minimize the impact and risk of exposure to cement dust on respiratory health X's factory of cement grinding and packing.

METHOD

This research is descriptive quantitative research with the approach used is Environmental Health Risk Analysis. This research was conducted in the Cement Grinding and Packing section of X's factory and the research time was from February to March 2020. Measurement of the dust area (respirable) used a cyclone dust sampler using the SKC 2000 standard and weight measurement by using a standard (portable) stamping scale with WHO standards.

The number of sampling points in this research was 20 sampling points based on SNI 7230 of 2009 concerning techniques for determining air sampling points in the workplace. The number determination of samples used a computer software Sample Size 2.0 and it was obtained a total sample of 62 workers with the sample selection technique using purposive sampling method with the criteria that workers have worked at least 1 year.

The data collection technique was carried out by direct interviews with workers by using a questionnaire to determine the characteristics and activity patterns of workers and followed by measuring body weight and measuring the area's dust concentration (respirable) using a cyclone dust sampler measuring instrument.

The data analysis used was univariate analysis to determine the frequency distribution of each variable. In the next step, the researchers calculated the risk of exposure to area dust (respirable) using the Environmental Health Risk Analysis Louvar & Louvar 1998 method (Indonesian Ministry of Health, 2012), it was carried out in 4 steps starting from hazard identification to identifying risk agents, dose-response analysis, exposure analysis and determining risk characteristics.

In this research used Environmental Health Risk Analysis with non-carcinogenic calculations because cement dust has non-carcinogenic effects such as lung function disorders, respiratory disease symptoms, and asthma (ACGIH, 2019) with the following calculation formula (Indonesian Ministry of Health, 2012).

$$RQ = \frac{I}{RfC}$$

$$I = \frac{CxRxt_Exf_ExD_t}{W_bxt_{avg}}$$

Where, RQ = risk level, *RfC* = risk agent reference value (mg/kg/day), Ik = intake (mg/kg/day), C = risk agent concentration (mg/m3), R = inhalation rate (m3/hour), tE = exposure time (hours/day) fE = frequency of exposure (days/years) Dt = duration of exposure (years) Wb = body weight (kg) tavg = average time period (days)

RESULT AND DISCUSSION

Anthropometric characteristics, activity patterns and cement dust concentration

Anthropometric characteristics data, activity patterns and cement dust concentration in the cement grinding and packing section of X's factory (table 1). Based on table 1, the average respirable area dust concentration was 0.33 mg/m^3, with the highest measurement of dust concentration as many as 0.84 mg / m^3 and the lowest was 0.04 mg / m^3. The respirable concentration of dust was still under the Threshold Value (TLV) of 1 mg/m^3 (ACGIH, 2019). The results of this measurement can be influenced by temperature, wind direction and speed because these parameters can affect dust dispersion (Verma & Desai, 2008).

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Table 1
Frequency Distribution of Cement Dust Concentration, Activity Patterns, Anthropometric Characteristics of Workers in the Cement Grinding and Packing Section of X's factory in 2020

Variable	n	Mean	Median	SD	Min-Max
Respirable Area Dust Concentration(mg/m^3)	62	0,33	0,29	0,21	0,04 – 0,84
Exposure Time (hour/day)	62	8,00	8,00	0,00	8,00 – 8,00
Exposure Frequency (days/year)	62	250	250	0,00	250 – 250
Duration of Exposure (years)	62	4,94	3,00	4,63	1,00 – 26,00
Inhalation Rate (m^3/jam)	62	0,83	0,83	0,00	0,83 – 0,83
Weight (kg)	62	63,06	62,95	11,58	47,00 – 97,00

The activity pattern consisted of exposure time (tE), exposure frequency (fE), and exposure duration (Dt). Exposure time was the number of working hours of workers in one day, in this research the average working hours is 8 hours/day. The exposure frequency value used the exposure default value in the work environment, which is 250 days/year. The frequency of exposure was the most important part in calculating the risk assessment because this variable will be used to determine the cumulative dose over time (Hoppin et al., 2011).

The exposure duration value is the value obtained from the length of time the worker was exposed to the research site with an average duration of exposure for the worker of 4.94 years. The length of work will affect the amount of dust exposure received by workers. The longer the working period, the higher the risk of diseases due to dust exposure such as COPD, chronic bronchitis, emphysema, cough, and asthma (Kurnia, 2013).

In this study, the duration of exposure was divided into 2, namely real-time exposure duration and lifetime exposure duration. Real-time exposure duration was the result of direct interviews with respondents, while lifetime exposure duration was the default value for non-carcinogenic risk, which is 30 years.

Anthropometric characteristics consist of inhalation rate (m^3 / hour) and body weight (kg). In this research, the value of the inhalation rate used the default value of the inhalation rate in adults, which is 0.83 m3 / hour, while the value of bodyweight was obtained from the worker weight with an average bodyweight that is 63.06 kg.

Bodyweight and inhalation rate greatly influence the dose of a risk agent received by individuals (Nukman A et al., 2005). In this research, the inhalation rate used the US EPA default value so, the value of the inhalation rate for all workers is the same, while the worker's body weight is the measurement result of each worker. This is different from previous studies, which used inhalation rate calculations which used the logarithmic formula for body weight (Tualeka & Cahya Rose, 2014). In this calculation, bodyweight will affect the rate of inhalation (Azni, Wispriyono, & Sari, 2016). A person's weight will be influenced by various factors including consumption patterns, nutrition, culture, hormones, and the environment (Nasution, 2016). However, bodyweight remains one of the variables that will influence the dose of a risk agent. The greater the person's body weight, the smaller the internal dose that will be received (Nukman A et al., 2005; Rahmadani & Tualeka, 2016).

Dose Analysis - respond

The reference dose/concentration *(RfC)* of cement dust (Respirable) is not yet available in the IRIS (EPA) list. Respirable dust was the most dangerous dust and can be trapped, starting from the terminal bronchioles to the alveoli, which is included in the PM2.5 category (Azizah, 2019). The reference dose/concentration *(RfC)* of PM2.5 used a derivative of the National Ambient Air Quality Standards (NAAQS), which is 35 µg/m3 so that the value *(RfC)* that can be used to determine the exposure risk to PM2.5 is 0.01. mg/kg/day (Novirsa & Achmadi, 2012).

Exposure Analysis (Intake)

The calculation of Respirable Area Dust Intake used variable dust concentration (C), inhalation rate (R), exposure time (tE), exposure frequency (fE), duration of exposure (Dt), body weight (Wb) and average time period (tavg). The lifetime exposure duration value is 30 years and the average time period value is 10,950 days.

Table 2
Realtime and Lifetime Respirable Area Dust Intake of Workers at PT X's Factory Cement Grinding and Packing in 2020

Exposure Group	Respirable Area Dust Intake (mg/kg /day)		
	C Min (0,04)	C Average (0,33)	C Max (0,84)
Realtime	0,0002	0,0042	0,0298
Lifetime	0,0027	0,0248	0,0808

Note: CMin (Minimum Concentration), Average C (Average Concentration), C Max (Maximum Concentration)

Based on table 2, it showed that the average realtime intake value on workers at X's Factory Cement Grinding and Packing was 0.0042 mg/kg/day with a minimum intake of 0.0002 mg/kg/day and a maximum intake of 0.0298 mg/kg /day, while the average intake lifetime value on workers at X's Factory Cement Grinding and Packing was 0.0248 mg kg/day with a minimum intake of 0.0027 mg/kg/day and a maximum intake of 0.0808 mg/kg /day.

Respirable area dust intake was directly proportional to the exposure duration. The longer the duration of exposure to workers, the greater the intake received by workers (Rosalia, Wispriyono, & Kusnoputranto, 2018). The exposure duration is the number of years of service for the worker which will be in line with the age of the worker. The increasing age of workers will be followed by increased susceptibility to disease (Anes, 2015). This will affect the tissue in a person's body, the elasticity function of the lung

tissue decreases so, it weakens the power of breathing which causes the volume of air when breathing will decrease (Nego, 2011).

Risk Characteristics

The risk characteristic is a calculation to determine the risk level by comparing the results of the exposure analysis (intake) with the risk agent reference value (*RfC*). The level of risk for non-carcinogenic effects is expressed by the Risk Quotient (RQ).

Based on table 3, it showed that more than part of the RQ value of the dust in the respirable area was still under 1 (RQ <1) with an average RQ of 0.42, which means that the risk of cement dust on workers at X's Factory Cement Grinding and Packing can still be said to be safe. This is because the dust concentration in the respirable area is under the threshold value. On the other side, with dust concentrations in the respirable area below the threshold value, it cannot be said that workers are free from health impacts due to cement dust, because there is still an RQ value which more than 1 (RQ> 1) for some workers, it can be seen that the maximum RQ is 2.98. Based on the research results, there are 8 workers with RQ> 1, which means that the risk level is not safe. The amount of lifetime risk with the calculation of a working period of 30 years showed that the work period of 30 years for workers at X's Factory Cement Grinding and Packing will have a non-carcinogenic health risk (RQ> 1) with an average RQ of 2.48. This showed that the exposure to cement dust into the worker's body has exceeded the daily exposure dose value which has no impact on the health of the worker. The dust that is inhaled by the worker can cause abnormalities in lung function, causing damage to lung tissue and will affect work productivity and quality. (Harrington, 2005). Previous research stated that workers exposed to high concentrations of dust have a risk of developing pneumoconiosis compared to workers exposed to low concentrations of dust (Simanjuntak, 2015).

Risk management

Risk management aims to reduce risk to the point where it does not have an impact on health. The following is a risk forecast for the next 30 years of exposure.

Table 3
Health Risk Frequency Distribution of Realtime Respirable Area Dust Exposure and Lifetime on workers at X's Factory Cement Grinding and Packing in 2020

Exposure Group	RQ of Respirable Area Dust (mg/kg /day)		
	C Min (0,04)	C Average (0,33)	C Max (0,84)
Realtime	0,02	0,42	2,98
Lifetime	0,27	2,48	8,08

Note: C Min (Minimum Concentration), C Average (Average Concentration), C Max (Maximum Concentration)

Table 4
Health Risks of Respirable Area Dust Exposure at Years 5, 10, 15, 20, 25, and 30

	Risk Level in Exposure Duration (Years)					
	Dt +5	Dt +10	Dt +15	Dt +20	Dt +25	Dt +30
Risk Level (RQ)	0,40	0,79	1,19	1,58	1,98	2,38

Based on table 4, it can be seen that the RQ value for the exposure length of 5 years and 10 years was under 1 (RQ <1) with a risk level 0.40 and 0.79 respectively, which means there was no risk to the health of workers, while for long exposure in15 to 30 years obtained RQ> 1, which means that it has a risk of being unsafe for the health of workers and indicates a non-carcinogenic risk in that time span.

The amount of risk every 5 years has increased, and it can be concluded that the prediction of health risks to workers can occur from 15 to 30 years of service.

Based on Environmental Health Risk Analysis principles, risk management was carried out if RQ> 1. Risk management was carried out in order to the intake value is the same as the *RfC* value. To equalize the two values, there are two scenarios that can be done, namely reducing the concentration of the risk agent (C) and reducing the exposure time (tE) and the length of exposure (fE) (Nukman A et al., 2005).

In this research, only the first scenario could be carried out because in the second scenario, the exposure time (tE) and exposure time (fE) of all workers were the same, namely 8 hours/day and 250 days/year.

The magnitude of the decrease in the concentration of risk agents for each worker will be different so, in the study, the duration of exposure used is 30 years (lifetime) and the safe limit for the concentration of risk agents used the lowest risk agent concentration value. Based on the calculation results, the safe limit for the concentration of cement dust is 0.1033 mg / m^3.

CONCLUSION AND SUGGESTION

The concentration of cement dust at X's Factory Cement Grinding and Packing showed an average concentration of 0.33 mg / m^3. The dust concentration was still under the TLV set by the American Conference of Governmental Industrial Hygienists, which is 1 mg / m^3. The result of real-time risk calculation showed the highest value of 2.98 or RQ> 1 which means the risk was not safe.

The suggestion for further research is to conduct an Environmental Health Risk Analysis (ARKL) of cement dust in the community at the X's Factory area to see the level of the spread of cement dust and make a comparison of cement dust concentration in the X's Factory area and the area around of X's factory.

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