Analysis Of The Risk Of Dust/Particulate Matter ($PM_{2,5}$) On Public Health (Case Studi :Place Of Manufacture Of Bricks In Kaloran Village, Ngronggot Sub-District, Nganjuk District On 2021)

Dzahabiyyah Dwi Putri Ridayanti[1], Khambali[2(CA)], Hadi Suryono[3]
[1]Department of Environmental Health, Health Polytechnic Ministry of Health Surabaya, Indonesia; dzahabiyyahdpr@gmail.com
[2(CA)]Department of Environmental Health,Health Polytechnic Ministry of Health Surabaya, Indonesia; khambali2014@gmail.com (Corresponding Author)
[3]Department of Environtmental Health, Health Polytechnic Ministry of Health Surabaya,Indonesia; hadisur@poltekkesdepkes-sby.ac.id

ABSTRACT

Firewood and corn cobs as the main fuel in the brick burning process can produce $PM_{2.5}$ pollutants which can pose a risk to the health of the surrounding community. The purpose of this study was to analyzed and determined the risk of exposure to $PM_{2.5}$ to the health of the community around the brick-making site of Kaloran Village, Ngronggot District, Nganjuk Regency. This research was a quantitative descriptive using a cross sectional design with the study of Environmental Health Risk Analysis. The sampling technique was used the purposive sampling method based on certain characteristics, with a sample of 306 families. Air sampling was carried out at 4 points where the bricks were burned. The data analysis method used risk analysis to determined the characterization of risk in the surrounding community was said to be "safe" if the RQ value is ≤1, and was said to be "unsafe" if the RQ value is > 1. The results showed that the concentration at the four locations exceeded the NAV based on PP RI No. 41 of 1999 concerning Air Pollution Control was 0.065 mg/m3. The ARKL calculation used the minimum and maximum values for measuring $PM_{2.5}$ concentrations at the four location points with a reference concentration value (RfC) of 0.018 mg/kg/day. RQ value for each resident for a minimum concentration of RQ < 1 and a maximum concentration of RQ > 1. So the level of risk of $PM_{2.5}$ exposure to residents was not safe at the maximum $PM_{2.5}$ concentration while the acceptable safe limit was at the minimum $PM_{2.5}$ concentration.

***Keywords**:Risk assessment; bricks; $PM_{2.5}$.*

INTRODUCTION

Air has a very important role for human life and other living things. Air is very beneficial for the preservation of environmental functions, so air needs to be maintained, maintained, and its quality guaranteed through air pollution control. Along with the increasing development of industrial centers that are not balanced with air pollution control measures, the quality of clean air has undergone changes in the composition of gases in the atmosphere.

According to the Minister of Environment Regulation No. 12 of 2010, air pollution is the process of entering or inserting living things, substances, energy, and/or other components into ambient air by human activities so that they exceed the air quality standards that have been determined. The main air pollutants can be sourced from human activities such as industrial activities as well as from the transportation sector, there are 5 groups of primary air pollutants, namely sulfur oxides (SO2), nitrogen oxides (NO2), carbon monoxide (CO), hydrocarbons (HC), and Particulate(Khambali, 2017). Sources of air pollution can come from various activities such as offices, transportation, housing and industry. One of the industries that can cause air pollution is the brick household industry. Kaloran Village is one of the villages in Ngronggot District, Nganjuk Regency which has the most red brick or precarious industrial businesses (Central Bureau of Statistics, 2019). The existence of this brick industry can produce air pollutants, one of which is Particulate Matter (PM).

Particulate matter (PM) is dust particles that float in the air for long periods of time or dust particles found in the air, including dust, dirt, soot and smoke. Particulate Matter ($PM_{2.5}$) is a dust particle with a diameter of 2.5 m or called fine air particles which generally can come from anthropogenic sources such as motor vehicles, biomass combustion, and fuel combustion (Mukhtar et al, 2013). Combustion of biomass can produce smoke with dust particles in the smoke which is $PM_{2.5}$(EPA, 2016). Exposure to biomass smoke is one of the causes of health problems such as ARI in children, chronic obstructive disease, asthma and lung

cancer. So far, the manufacture of bricks in Kaloran Village uses fuel from corn cobs, rice husks, firewood and the rest of the wood saw to produce smoke.

Several studies have proven that there is a relationship between Particulate Matter ($PM_{2.5}$) with impaired respiratory function. Research conducted on workers in the Citereup Cement Industry showed that there was a significant relationship between impaired lung function and the concentration of particulate matter ($PM_{2.5}$) pollutants with a sample proportion of 50% experiencing restrictive and 10.9% experiencing obstructive (Komariah. 2017). Then research on permanent traders in Kampung Rambutan also showed a risk of decreased respiratory function due to exposure to Particulate Matter ($PM_{2.5}$) in realief exposure and a lifespan of 30 years (Falahdina, 2017). Research conducted in the community area around the cement industry in Lubuk Kilangan District also shows RQ > 1 which means there is a health risk due to particulate matter ($PM_{2.5}$) exposure, especially in areas with a distance of 2.5 km from pollutant sources (Novirsa et al, 2012). In Rohmawati & Andriyani's (2018) research the concentration of particulate matter ($PM_{2.5}$) was measured in each hamlet in Kaloran Village with the results, among others, in Kaloran Hamlet, the concentration of particulate matter ($PM_{2.5}$) was 5.538 mg/m3 then in Nanggungan Hamlet of 5.538 mg/m3. 7,953 mg/m3, Barengan Hamlet is 1,509 mg/m3 and Bulakmiri Hamlet is 2,497 mg/m3. Of the four hamlets, all of them exceeded the ambient air quality standards regulated in PP RI No. 41 of 1999 concerning Air Pollution Control, which is 0.065 mg/m3.

The results of the initial interview conducted on November 13, 2020 to 20 residents who live around the brick-making site, 12 people experienced several complaints such as shortness of breath, sore eyes, and sometimes coughing. People who live in the brick-making area in Kaloran Village, Ngronggot District, Nganjuk Regency are at risk of health problems caused by pollutants from burning bricks. The smoke from burning bricks produces several types of pollutants including dust, CO, SO2, NO2 gas. If the community is continuously exposed to pollutants from burning bricks, especially Particulate Matter ($PM_{2.5}$), it can increase the risk of health problems. $PM_{2.5}$ is a pollutant that has the potential to cause health problems in a number of developing countries and can cause pneumonia, respiratory system disorders, eye irritation, allergies, chronic bronchitis (Istirokhatun et al, 2011). Based on the problems above, this study aims to analyze the risk of exposure to Particulate Matter ($PM_{2.5}$) dust in the people who live around the brick-making area in Kaloran Village, Ngronggot District, Nganjuk Regency.

METHODS

This research is a quantitative descriptive research, which is a study that aims to describe or describe an event that occurs in society in numerical and narrative form (Notoatmodjo, 2018). This study uses a time-based design that is cross sectional with an Environmental Health Risk Analysis (ARKL) approach. The research location is at the brick making site in Kaloran Village, Ngronggot District, Nganjuk Regency, while the research location for laboratory examination is the Department of Environmental Engineering, Sepuluh Nopember Institute of Technology. The time for the research to be carried out is February-June 2021.

The population in this study is all the people who live around the brick making site as many as 1297 families. The sampling technique was carried out by purposive sampling method based on certain characteristics. The sample in this study amounted to 306 families. Air samples were taken at 4 location points with each point sampling 3 times namely in the morning, afternoon and evening. Air sampling locations were carried out at 4 brick kilns.

The independent variables in this study included the concentration of PM2.5 in the air in the brick industrial area, frequency of exposure (fE), exposure time (tE), duration of exposure (dt), inhalation rate (R), habit of wearing masks, smoking habits , RfC, intake / intake, temperature, humidity, wind speed and direction. While the dependent variable is the result of the RQ value on the residents around the brick making place. Data collection techniques were carried out by means of interviews, measurements, and observations. The data analysis method was carried out by univariate analysis which aims to explain or describe the characteristics of each research variable and risk analysis to obtain the RQ value so that it can determine the level of risk.

RESULTS

Based on the research activities that have been carried out, the results can be seen, including the results of measuring air physical quality, concentration of Particulate Matter ($PM_{2.5}$), hazard identification, dose response analysis, public health disorders, exposure analysis, and risk characterization.

Measurement Results of Temperature, Humidity, Wind Speed and Direction

The following are the results of measurements of the physical environment of the air at each brick kiln in Kaloran Village, Ngronggot District, Nganjuk Regency:

Table 1. Results of Measurement of Temperature, Humidity, Wind Speed and Direction at the Burning Site Bricks in Kaloran Village, Ngronggot District, Nganjuk Regency

No	Location	Time (WIB)	Temperature (^oC)	Humidity (%)	Wind Velocity (m/s)	Wind Direction
1.	Bulak Miri Hamlet	07.30	28,4	77,2	0,1-0,5	From the south
		12.37	35,0	49,2	0,2-0,4	From the north
		15.45	33,8	55,5	0,2-0,4	From the north
2.	Barengan Hamlet	07.35	27,1	84,5	0,1-0,2	From the south
		12.15	33,7	50,2	0,1-0,4	From the north
		15.40	33,9	56,9	0,1-0,3	From the north
3.	Kaloran Hamlet	08.10	29,0	76,6	0,1-0,2	From the south
		12.50	34,5	44,2	0,1-0,5	From the south
		16.15	33,7	55,5	0,1-0,2	From the north
4.	Nanggungan Hamlet	08.45	32,6	63,3	0,1-0,4	From the south
		12.05	32,9	61,5	0,2-0,6	From the south
		15.05	33,4	55,3	0,2-0,4	From the north
Average			**32,3**	**60,8**	**-**	**-**
Lowest Value			**27,1**	**44,2**	**0,1**	**-**
Highest Value			**35,0**	**84,5**	**0,6**	**-**

Based on Table 1, it can be seen that the results of air temperature measurements at the brick kiln in Kaloran Village, Ngronggot District, Nganjuk Regency obtained an average of 32.3°C. Then for the results of air humidity measurements obtained an average result of 60.8%. For the results, the lowest wind speed is 0.1 m/s and the highest wind speed is 0.6 m/s. The wind direction at the time of sampling blows from the South and North.

Measurement of Dust/Particulate Matter Concentration (PM2.5)

The following is the result of measuring the level of dust/particulate matter (PM2.5) in each brick kiln in Kaloran Village, Ngronggot District, Nganjuk Regency:

Table 2. Results of Measurement of Dust/Particulate Matter (PM2.5) Concentrations in Combustion Sites Bricks in Kaloran Village, Ngronggot District, Nganjuk Regency

No.	Location Point	Pick-up Time (WIB)	Dust Concent/ $PM_{2,5}$ (mg/m^3)
1.	Bulak Miri Hamlet	07.30	0,0857
		12.37	0,1357
		15.45	0,1500
Overall Average			**0,1238**
2.	Barengan Hamlet	07.35	0,0785
		12.15	0,0500
		15.40	0,1285
Overall Average			**0.0857**

No.	Location Point	Pick-up Time (WIB)	Dust Concent/ $PM_{2,5}$ (mg/m^3)
3.	Kaloran Hamlet	08.10	0,0857
		12.50	0,0500
		16.15	0,1071
Overall Average			**0,0809**
4.	Nanggungan Hamlet	08.45	0,0428
		12.05	0,1071
		15.05	0,1000
Overall Average			**0,0833**

Based on Table 2, it can be seen that the average results of measuring $PM_{2.5}$ levels in each brick kiln are as follows: at location point I in Bulak Miri Hamlet, which is 0.1238 mg/m3, at location point II in Hamlet Barengan which is 0.0857 mg/m3, at location point III in Kaloran hamlet, which is 0.0809 mg/m3, and at location point IV in Nanggungan hamlet it is 0.0833 mg/m3.

Hazard Identification of Exposure to Particulate Matter (PM2.5)

The following is a hazard identification table:

Table 3. Hazard Identification ofParticulate Matter ($PM_{2,5}$) in Combustion Sites Bricks in Kaloran Village, Ngronggot District, Nganjuk Regency

Source	Potential Environmental Media	Risk Agent	Location Point	Measured Concentration (mg/m^3)		
				Min	Average	Max
Emissions from burning bricks in Kaloran Village, Ngronggot District, Nganjuk Regency using wood fuel, corn cobs and rice husks.	Ambient air	Dust / Particulate Matter ($PM_{2,5}$)	Location I	0,0857	0,1238	0,1500
			Location II	0,0500	0,0857	0,1285
			Location III	0,0500	0,0809	0,1071
			Location IV	0,0428	0,0832	0,1071

Based on Table 3, it can be seen that the particulate matter (PM2,5) that can be at risk of causing health problems for residents who live around the brick-making site is particulate matter (PM2.5). This particulate matter (PM2.5) is caused by the burning of bricks that use corncobs and rice husks as fuel, resulting in smoke mixed with ambient air which can pollute the air in the location.

Analysis of Dust Exposure Response Dose / Particulate Matter ($PM_{2.5}$)

The following is a table of dose response analysis:

Table 4. RfC Value and CriticalParticulate Matter ($PM_{2,5}$)

No.	Risk Agent	RfC Value	Critical Effect
1.	Particulate Matter ($PM_{2,5}$)	0,018 mg/kg/day	Respiratory system disorders and lung cancer

Source : Falahdina (2017)

Based on Table 4, it can be seen that the agent that can be at risk of causing health problems in people who live around the brick-making site in Kaloran Village, Ngronggot District, Nganjuk Regency is Particulate Matter (PM2.5). The RfC value for dust/PM2.5 exposure is 0.018 mg/kg/day with critical effects, namely respiratory system disorders and lung cancer.

Table 5. Percentage of Complaints of Health Problems in Residents Around the Brick Making Site in Kaloran Village, Ngronggot District, Nganjuk Regency

No.	Complaints about health problems	N	Percentage (%)
1.	Out of breath	153	25,1
2.	Cough	187	30,6
3.	Eye irritation	214	35,1
4.	Allergy	56	9,2
	Total	**610**	**100**

Based on Table 5, it can be seen that there are health problems felt by residents who live around the brick-making site of Kaloran Village, Ngronggot District, Nganjuk Regency, namely 153 people (25.1%) experienced shortness of breath, 187 people (30 ,6%) often coughed, 214 (35%) had eye irritation and 56 (9,2) had dust allergy.

Exposure Analysis of Particulate Matter ($PM_{2.5}$) Exposure

The following is a table of the results of calculating the intake value for residents who live around the brick-making site in Kaloran Village, Ngronggot District, Nganjuk Regency:

Table 6. Intake Values for Residents Around the Brick Making Site in Kaloran Village, Ngronggot District, Nganjuk Regency

No.	Location Point	Intake$PM_{2,5}$Concentration(mg/kg/day)		
		Minimum	Average	Maximum
1.	Location I	0.030614	0.044224	0.053583
2.	Location II	0.017861	0.030614	0.045903
3.	Location III	0.017861	0.028899	0.038258
4.	Location IV	0.015289	0.029721	0.038258

Based on Table 6, it can be seen that in each brick kiln, the results obtained, among others, at location I, the largest intake value was 0.053583 mg/kg/day and the smallest intake value was 0.030614 mg/kg/day. In location II, the largest intake value was 0.045903 mg/kg/day and the smallest intake value was 0.017861 mg/kg/day. At location III the largest intake value was 0.038258 mg/kg/day and the smallest intake value was 0.017861 mg/kg/day. At location IV the largest intake value was 0.038258 mg/kg/day and the smallest value was 0.015289 mg/kg/day.

Risk Question*(RQ)*of Exposure to Particulate Matter ($PM_{2.5}$)

The following is a table of the results of the calculation of the risk characterization value (RQ) for residents who live around the brick-making site in Kaloran Village, Ngronggot District, Nganjuk Regency:

Table 7. Risk Question (RQ) Value for Residents Around the Brick Making Site in Kaloran Village, Ngronggot District, Nganjuk Regency

No.	Location Point	*Risk Question (RQ)*Concentration		
		Minimum	Average	Maksimum
1.	Location I	1.700766	2.456883	2.976837
2.	Location II	0.992279	1.700766	2.550157
3.	Location III	0.992279	1.605507	2.125462
4.	Location IV	0.849391	1.651152	2.125462

Based on Table 7, it can be seen that the RQ calculation results for residents around the brick making site for a minimum concentration get an RQ value of 0.849391 < 1 and at a maximum concentration an RQ value of 2.976837 > 1. Based on the results of the RQ calculation, it can be concluded that the risk level of exposure to Particulate Matter (PM2.5) in residents living around the brick-making site is not safe at a maximum PM2.5 concentration of 0.1500 mg/m3 while the acceptable safe limit is at a PM2.5 concentration of 0.0428 mg/m3.

DISCUSSION

Measurement of dust/$PM_{2.5}$ concentration was carried out in the morning, afternoon and evening. Measurements were carried out at 4 location points with each location sampling 3 times. Based on these measurements, it was found that all the location points where sample measurements were carried out had exceeded the quality standards set in PP RI No. 41 of 1999. Different measurement results at each point can be influenced by differences in temperature, humidity, wind speed and direction. The lower the temperature, the higher the humidity. At high humidity, dust particles will settle more quickly than at low humidity. High humidity will cause particles to bind to water and form larger particles so that they easily settle to the earth's surface and increase pollutant concentrations. In addition, low wind speeds also cause high concentrations of dust/$PM_{2.5}$, this is because at low wind speeds, pollutants will accumulate and can pollute the air where you live around the pollution location. This is in line with the research of Istantinova et al (2012) which states that the high concentration of pollutants in the air can be influenced by wind speed, humidity and air temperature.

Agents that are at risk of causing health problems in the community around the brick making site are Particulate Matter ($PM_{2.5}$) in the air which is sourced from the process of burning bricks using wood fuel, rice husks, corn cobs and coconut husks. This produces smoke that can pollute the surrounding environment. According to Rohmawati and Andriyani (2018) the smoke from burning bricks can produce several types of pollutants, one of which is dust/$PM_{2.5}$ which can cause respiratory system disorders, eye irritation, allergies and decreased lung function.

The response dose of dust/$PM_{2.5}$ used in this study is based on the reference dose value (RfC) for inhalation from previous studies because the RfC value for Particulate Matter ($PM_{2.5}$) has not been found in the Integrated Risk Information System (IRIS) which is accessed through the website www.epa.gov/iris. The RfC value for Particulate Matter ($PM_{2.5}$) carbon gas is 0.018 mg/kg/day(Falahdina, 2017).

The impact of exposure to dust/$PM_{2.5}$ on human health is the disruption of the respiratory system with respiratory symptoms, especially coughing. Coughing is a reflex carried out by the body's defenses to remove foreign objects from the body. Another effect that occurs on lung function is characterized by disturbances in ventilation which causes a decrease in lung function consisting of lung expansion and obstruction disorders (slow air flow in the airways due to increased mucus production (Azizah, 2019). According to Putri (2017) in addition to disrupting the respiratory system , exposure to $PM_{2.5}$ shortness of breath, to eye irritation. Complaints that are often felt by residents are coughing (30.6%) and eye irritation (35%) when burning. However, residents have never experienced very severe respiratory problems that can cause they can't work.

The results of the intake analysis are used to describe the health risks at the location. The high intake value is directly proportional to the measured dust/$PM_{2.5}$ concentration. The amount of intake value is also

directly proportional to the value of the frequency of exposure, duration of exposure and rate of inhalation, so it can be interpreted that the greater the intake value, the greater a person's intake will be. While the intake is inversely proportional to the value of body weight, the greater a person's weight, the smaller the intake value (Djafri, 2014). However, in this study, no direct weight measurement was carried out because the current condition was still in the pandemic period, so it used the default weight value that had been set for the ARKL calculation, namely for adults 55 kg and children 15 kg (Ministry of Health, 2012). Therefore, the intake value for each respondent at the same location point with the value of dust/$PM_{2.5}$ concentration, then the intake value is the same. For the calculation of the intake rate also uses the default value that has been set in IRIS which is 0.83 m3/hour.

The length of time exposure can also affect the intake value results. In this study, the exposure time for exposure time (tE) was 24 hours/day because the brick burning process lasted for 24-26 hours/day. The frequency of exposure (fE) is 360 days/year and for the duration of exposure to dust/$PM_{2.5}$, the longest duration is 45 years, the smallest duration is 15 years and the average duration is 30 years. Residents who are exposed to dust/$PM_{2.5}$ with time of exposure, long duration of exposure will be at greater risk of experiencing health problems. People exposed to $PM_{2.5}$ for a longer time will have a 1.174-fold risk of developing health problems compared to those exposed for a minimal time (Arba, 2019).

Calculation of risk characterization (RQ) on non-carcinogenic effects is done by comparing the intake value with the reference dose (RfC). The results of the calculation of the risk characterization value (RQ) in each brick kiln for a minimum concentration get an RQ value of 0.849391 < 1 and at a maximum concentration an RQ value of 2.976837 > 1. This indicates that the risk level (RQ) dust/$PM_{2.5}$ exposure to residents living around the brick-making site in Kaloran Village, Ngronggot District, Nganjuk Regency is no longer safe at a maximum $PM_{2.5}$ concentration of 0.1500 mg/m3 while the acceptable safe limit is at a concentration of PM2.5 of 0.0428 mg/m3.

CONCLUSION

Based on the results of the study, it was concluded that the level of risk of exposure to Particulate Matter ($PM_{2.5}$) in residents living around the brick making site is not safe at a maximum $PM_{2.5}$ concentration of 0.1500 mg/m3 while the acceptable safe limit is at a $PM_{2.5}$ concentration of 0 ,0428 mg/m3.

REFERENCES

Khambali. (2017). 'Environmental Pollution'. First Edition. Surabaya: Association of Indonesian Environmental Health Experts.

Central Bureau of Statistics. (2019) 'Ngronggot District in 2019 Figures'. Central Bureau of Statistics.

Mukhtar R, et al. (2013) 'Chemical Components of PM2.5 and PM10 in Ambient Air in Serpong – Tangerang'. *Ecolab Journal*. 7(1):1-7.

EPA. (2016) 'Criteria Air Pollutans'. Accessed via https://www.epa.gov/criteria-air-pollutants on 20 October 2020 at 20.30 WIB. 2016.

Komariah, V. H. (2017). 'Analysis of Risk and Its Impact on Decreased Lung Function of Cement Industry Workers at Plant 06 PT Indocement Citeureup-Bogor 2016'. *Essay*.

Falahdina A. (2017) 'Analysis of Environmental Health Risks of PM2.5 Exposure to Permanent Traders at the Kampung Rambutan Terminal'. *Essay* .

Novirsa R, Achmadi U. and Fahmi. (2012) 'Risk Analysis of PM2.5 Exposure in Ambient Daylight on Communities in Cement Industrial Areas'. *National Journal of Public Health*. 7(4):173-179.

Rohmawati N and Andriyani R. (2018) 'Differences in Pm2,5 Levels in Bricks Burning Sites and the Occurrence of Dry Eye Syndrome'. *The Indonesian Journal of Occupational Safety and Health*. 7(1):112-121.

Istirokhatun T, Wardhana I. W. and Primelya A. (2011) 'In Replication and Household Scale Wood-Fired Kitchens'. *Journal of Precipitation*: Communication and Environmental Engineering Development. 8(1): 8-13.

Notoatmodjo S.(2018) 'Health Research Methodology'. Jakarta : PT. Rineka Cipta.

Istantinova D. B, Hadiwidodo M and Handayani D. S. (2012) 'The Effect of Wind Speed, Humidity and Air Temperature on the Concentration of Sulfur Dioxide (SO2) Pollutant Gas in Ambient Air Around PT. Core General Yaja Steel Semarang'. Undergraduate Thesis, Diponegoro University.

Azizah I. T. N. (2019) 'Analysis of PM2.5 Dust Levels and Lung Function in Organic Fertilizer Industry Workers in Nganju'. *Journal of Environmental Health*. 11(2): 141-149.

Putri N. B. D. (2017) 'Study of PM2.5 Reduction of Ambient Air by Green Open Space in the Industrial Estate of PT. Petrochemical Gresik'. Undergraduate Thesis, Sepuluh Nopember Institute of Technology.

Djafri Defrian. (2014) 'Principles and Methods of Environmental Health Risk Analysis'. *Andalas Journal of Public Health*. Andalas University.

Ministry of Health. (2012). 'Guidelines for Environmental Health Risk Analysis (ARKL)'. Directorate General of PP and PL Ministry of Health in 2012.

Arba S. (2019) 'Concentration of Respirable Dust Particulate Matter (PM2.5) and Health Problems in Communities in Settlements Around PLTU'. *Journal of Public Health*. 9(5): 178-184.