Environmental Health Risk Analysis Of PM2.5 Exposure To Market Traders In Duri, Indonesia

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Abstract:
Background: The Market occupants, especially traders, are at high risk of being exposed to pollutants in the ambient air of the market environment, one of which is exposure to PM2.5. The purpose of this study was to determine the level of health risk due to PM2.5 exposure to traders in Duri, Indonesia
Materials and Methods: This study uses environmental health risk analysis (EHRA) method that aims to calculate the level of risk received by a population due to environmental exposure. The number of sample were 67 respondents. The sampling technique used was accidental sampling. PM2.5 concentration measurements by CE (Conformite Europeenne) and RoHS (Restriction of Hazardous Substances) certified Air Quality Detector.
Results: The average concentration of PM2.5 is 25.6 µg/m3. Respondents had an average body weight of 64.01 kg, an average length of exposure was 9.25 hours/day, an average frequency of exposure was 348.4 days/year, and an average duration of exposure was 10.84 years. The real-time exposure risk level at all air sampling locations is in the safe category, but lifetime exposure has an unsafe category at two sampling locations at maximum concentrations.
Conclusion: The average concentration of PM2.5 is below the standard. The lifetime risk level at the maximum concentration at the two sampling locations indicates that traders will experience respiratory problems in the next 30 years. Therefore, the Government is advised to rearrange the market and monitor air quality regularly.
Key Word: pm2.5, exposure, health risk assessment.

I. Introduction

Ambient air pollution results in the deaths of around 3 million people each year. About 90% of people breathe air that does not comply with WHO Air Quality Guidelines. (1) Based on a study in London, more than 80% of particulate matter comes from road traffic. Another study in Athens, Greece, found that traffic contributes around 66.5% to total PM2.5 emissions. (2)

Particulate matter 2.5 (PM2.5) is particulate matter measuring ≤ 2.5 micrometers and consists of dust, liquid, smoke, and dirt so that it becomes a complex mixture of particles. (3) PM2.5 is so small that it can enter the lungs' deepest part of the alveoli. In addition, the metal content in PM2.5 can spread in the bloodstream. PM2.5 has severe impacts, including respiratory tract disorders, decreased heart and blood vessel work, lung function, and COPD (Chronic Obstructive Pulmonary Disease). (4,5)

The type of particulate widely studied at this time is PM2.5 because it is so tiny that it can enter the alveoli, the deepest part of the lungs. In addition, the metal content in PM2.5 can spread in the bloodstream. PM2.5 has severe impacts, including respiratory tract disorders, one of which is ARI (Acute Respiratory Infection), decreased work of the heart and blood vessels, decreased lung function, lung cancer, and COPD (Chronic Obstructive Pulmonary Disease). In addition, PM2.5 can cause impaired mental and motor development and cognitive impairment in children or adolescents (1,12,13). (1,6,7)

Based on the world's highest PM2.5 rating in 2020, Indonesia is ranked 9th with a PM2.5 concentration of 40.7µg/m^3. This concentration is classified as unhealthy for sensitive groups. Meanwhile, in Southeast Asia, Indonesia is ranked first as a country polluted by PM2.5. This is due to rapid urbanization and population growth, increasing new construction, and energy demand. Indonesia's energy is mainly supplied by polluting fossil fuels, with oil and coal being significant contributors. Indonesia's primary sources of air pollution include burning agricultural land and forest fires (14). (8)

The Minister of Environment and Forestry of the Republic of Indonesia said that several big cities in Indonesia tend to experience a decrease in air quality; this has been seen in the last ten years. Monitoring data proves an increase, especially in the concentration of particulate matter (PM10 and PM2.5) and oxidant/ozone (O3). (9) Particulate Matter (PM) has a more significant effect on health than other pollutant substances. PM10 and PM2.5 are hazardous forms of SPM (Suspended Particulate Material). (10)

The capital of Riau Province, Pekanbaru, is included in the six cities with the highest concentrations of PM2.5 in Indonesia in 2020. According to BPS, the number of motorized vehicles in Riau Province in 2021 was relatively high, namely 4,066,211 units, in 2nd place. 8 with the highest number of motorized vehicles. This can have a significant effect on decreasing air quality in Riau Province. (11)

Based on Latifah's research in 2020 regarding PM2.5 exposure ARKL in students at SDN 28 Mandau Duri Riau, it was found that PM2.5 concentrations at several points exceeded the quality standard values set by WHO, with the highest concentration of 11.53 µg/m3. The school where the research was conducted was right on the side of the road with heavy traffic conditions. (12)

According to the initial survey, Pasar Mandau Raya is located on the edge of the Jendral Sudirman highway, and 6 out of 10 traders interviewed had experienced respiratory problems while trading in that environment. One of the six traders has been diagnosed with bronchitis. Then, 1,917 motorized vehicles passed in front of Pasar Mandau Raya for one hour, consisting of 1,584 motorbikes, 271 private cars, 43 public transport units, and 19 trucks.

Air quality in Duri is in an unhealthy category for sensitive groups with an AQI (Air Quality Index) value of 141, and the primary pollutant is PM2.5, with a concentration of 51.9µg/m^3. Duri is in the second place, after Cirebon, with Indonesia's highest air quality index value. (IQAir, 2022)

Based on this background, the researcher encouraged to conduct research related to the level of environmental health risk of PM2.5 exposure to the traders in Duri. The results of this study are not only useful in risk control, but also can be used as a scientific framework in decision making and Policies to address health and environmental issues

II. Material And Methods

This research is a quantitative research in the form of descriptive method of environmental health risk analysis (EHRA) which aims to calculate the level of risk received by a population due to the exposure of PM2.5 in the environment. This study was conducted from 26 June 2022 to 28 June 2022, with a total sample of 67 respondents. Sampling technique is accidental sampling. Anthropometric data collection and activity pattern by interview using questionnaire and PM2.5 concentration measurement using CE (Conformite Europeenne) and RoHS (Restriction of Hazardous Substances) certified Air Quality Detector.

Some of the procedures involved include hazard identification and risk sources, dose-response analysis, exposure assessment, and risk characterization. The risk level is expressed in the Risk Quotion (RQ) expressed as the ratio between the value of the intake and the reference dose (RfC). Intake is the amount of inhaled concentration per kilogram of body weight, while RfC is an approximate daily exposure dose that has no health effects in lifetime exposure. A situation is considered risky and management of control is required if RQ> 1.

III. Result

The anthropometric characteristics of the respondents according to the average age were 45.19 years. The average body weight was 64.01 kg. Then, the average length of exposure is 9.25 hours a day. In addition, the average exposure frequency was 348.42 days/year, and the average exposure duration was 10.84 years. The distribution of the frequency of respondents according to gender was obtained by male respondents as many as 34 traders (50.7%) and female respondents as many as 33 traders (49.3%). In addition, most of the trader respondents had a high school education, as many as 45 traders (67.2%).

As many as 21 respondents (31.3%) experienced respiratory problems while trading at Pasar Mandau Raya, with 2 respondents (3%) having been diagnosed with bronchitis in the last 1 year. Then, there were 45 respondents (67.2%) who rarely even ever used masks while trading and as many as 25 respondents (37.3%) had smoking habits.

The highest temperature during the measurement of PM2.5 concentration on the first day was at point 5, 34.72°C, and the lowest temperature was at point 1, which was 30°C. The highest humidity was at point 1, 79.27%, and the lowest humidity at point 5, 64.48%. Then, the highest temperature on the second day was at point 3, 32.42°C, and the lowest temperature at point 1, which was 30.97°C. Then, the highest humidity is measured at point 5, 74.8%, and the lowest humidity at point 5, which is 65.80%.

The results of measuring PM2.5 concentrations in Table 1 obtained an average concentration of PM2.5 at all sampling points of 25.6 µg/m3. The highest PM2.5 concentration is at point 1 on the average maximum concentration, 65 µg/m3, while the lowest concentration is at point 3 on the average minimum concentration, which is 13 µg/m3 at both points.

Table 1: PM2.5 Concentration in Mandau Raya Market, Duri

No.	Location	Time	consentration	TLV 31 mg/m^3
1	Point 1	10.00-11.00	31 mg/m^3	not exceed

2	Point 2	11.05-12.05	30 mg/m^3	not exceed
3	Point 3	12.10-13.10	18 mg/m^3	not exceed
4	Point 4	13.15-14.15	26 mg/m^3	not exceed
5	*Point 5*	15.20-14.20	33 mg/m^3	exceed

The RfC value for PM2.5 is not yet known, so the RfC value for PM2.5 can be determined using the formula derived from intake. The results obtained were 0.00637 mg/kg/day. The highest PM2.5 real-time and lifetime average intake values in Table 2 are at the maximum concentration at point 1, with a real-time intake value of 0.00265 mg/kg/day and an intake lifetime of 0.00732 mg/kg/day. The lowest PM2.5 real-time and lifetime average intake values were at the minimum concentration point 3, with a real-time intake value of 0.00051 mg/kg/day and an intake lifetime of 0.00142 mg/kg/day.

Table 2: Anthropometric characteristics and Activity Patterns Respondents

No.	Element	Mean	Median	Mode	Min	Max	SD
1	Body Weight (w) (Kg)	64,01	65	65	40	89	11.05
2	Lenght of Exposure (t_E) (hour/day)	9.05	9	9	5	15	2.05
3	Frequency of Exposure (f_E) (day/year)	348	355	353	254	365	21.8
4	Duration of Exposure (D_t) (year)	10.84	10	12	0.5	30	6.9

The risk level for real-time intake in Table 3 at each sampling point is in the safe category (RQ ≤ 1). The highest RQ value is found at the maximum concentration at point 1 of 0.41601, and the lowest RQ value is at the minimum concentration at point 3 with a value of 0.08006. Meanwhile, the risk level for intake lifetime in Table 4 shows that two sampling points are in the unsafe category (RQ > 1). The unsafe risk level is at point 1 at the maximum concentration of 1.14914 and point five at the maximum concentration of 1,06907.

Table 3: Lifetime and Realtime Intake of TSP Exposure to Employees

No.	Point of Sample	Realtime Intake	Lifetime Intake
1	Point 1	0,00127 mg/Kg/day	0,00352 mg/Kg/day
2	Point 2	0,00123 mg/Kg/day	0,00340 mg/Kg/day
3	Point 3	0,00074 mg/Kg/day	0,00204 mg/Kg/day
4	Point 4	0,00107 mg/Kg/day	0,00295 mg/Kg/day
5	*Point 5*	0,00135 mg/Kg/day	0,00375 mg/Kg/day

Based on the results of calculating the level of unsafe risk, risk management is carried out by calculating safe limits and obtaining safe concentrations acceptable to traders of <56 μg/m3, with safe exposure times of <8.1 hours in a day and safe exposure frequencies <318 .77 days a year. Then, determine how to manage risk using technological, socio-economic, and institutional approaches

IV. Discussion

The average weight of traders at Pasar Mandau Raya is 64.01 kg, higher than the default Asian adult weight of 55 kg. (14) The more significant the body weight, the lower the intake received, and the higher the risk owned by individuals are also safer. (15) The median value of the duration of exposure is 9 hours/day. This is in line with Falahdina's research in 2017, where the daily duration of exposure to Kampung Rambutan Terminal traders is more than 8 hours/day, which is 12 hours/day. (16) The median value of exposure frequency is 355 days/year, which is lower when compared to Sembiring's research (2020) on traders under Pasar Pagi Asemka Jakarta Flyover, which is 364 days/year. (6) The average value is 10.84 years and higher compared to the average duration of exposure from the 2021 Saver research on traders at the Anduring-Andalas T-junction, Padang City, which is 7.21 years. (15) The high daily exposure duration and duration of exposure to traders at Pasar Mandau Raya can increase the intake value of traders.

Twenty-one traders (31.3%) experienced respiratory problems while trading at Pasar Mandau Raya. This is in line with Saver's research in 2021, in which 28 respondents had experienced respiratory problems when trading in the T-junction area. (15) Most traders rarely, even never, use masks when trading. Using masks can minimize the amount of particulates inhaled into the lungs. Lung. (15) 25 traders (37.3%) had a smoking habit. Smoking makes it harder for the lungs to get clean air, so humans are prone to respiratory problems. (7)

Point 5 is the point that has the highest average concentration of PM2.5, amounting to 32 μg/m3. The distance from point 5 to the Jendral Sudirman highway is quite close, about 30 meters, and this point is a place

for selling heavy food where there is a lot of burning, such as burning satay with charcoal or burning cartons to drive away insects, this burning activity can affect PM2.5 concentrations in air. According to the EPA, smoke is a complex mixture of gases and fine particles such as PM2.5 produced when wood and other organic materials are burned. (8) The temperature at the time of measurement at point 5 tends to be higher than other points with the lowest percentage of humidity among other points, in line with Cahyadi's research (2016), which states that an increase in air temperature can increase the concentration of particulates. Low humidity will also increase the concentration of particulates. (9)

PM2.5 concentrations on weekends are higher than on weekdays. Vehicles because many people use vehicles to go to work. (10)

The RfC value used in this study was 0.00637 mg/kg/day, lower than the RfC value in the 2017 study by Falahdina, which was 0.0177 mg/kg/day, this difference in RfC values occurred due to the PM2.5 concentration value. The method used is different. In Falahdina's study, the quality standard was used according to Government Regulation No. 41 of 1999, namely 65 μg/m3. Then, the default value of the length of daily exposure and body weight are also different. (16)

The intake value was different at each sampling point, this was due to the different PM2.5 concentration values at each point. However, the real-time value and lifetime intake are higher when compared to Latifah's research in 2021 in Mandau, with the highest real-time intake value of 0.00074 mg/kg/day and the lowest real-time intake value of 0.00037 mg/day. kg/day. while the highest lifetime intake value was 0.00089 mg/kg/day and the lowest intake lifetime value was 0.00044 mg/kg/day. (12)

The RQ value for real-time intake has a safe category or RQ ≤ 1. Then, the highest real-time RQ value is obtained at point 1 with a maximum concentration of 0.41601. At the same time, the lowest real-time RQ value is at measurement at point 3 with a minimum concentration of 0.08006. This value is higher when compared to research by Maksum in 2022 regarding ARKL of PM2.5 exposure from transportation activities in Gorontalo, which obtained the highest real-time RQ value of 0.09487 and the lowest real-time RQ value of 0.014251. (17) The RQ value for intake lifetime indicates that the two sampling points are in the unsafe category or RQ > 1, namely at point 1 and point 5 at the maximum concentration of 1.14914 and 1.06907. The highest RQ lifetime value is found at point 1 at the maximum concentration of 1 .14914, and the lowest RQ lifetime value at point 3 with a minimum concentration of 0.22292 at these two points. The higher the intake value received, the higher the risk of health problems.

Risk management can be done to reduce PM2.5 concentrations at Mandau Raya Market by planting trees or other plants that can absorb pollutants around Mandau Raya Market. According to research by Latifah in 2021, the results of lower PM2.5 concentrations are in vegetated areas, where low PM2.5 concentrations are due to the absorption of particulates carried out by green plants. (12) Then, educate Mandau Raya Market traders about the dangers of exposure to PM2.5 on traders' health and socialization to adopt a healthy lifestyle because this can reduce the impact of PM2.5 exposure on traders, where if a trader's weight is ideal then the intake value of PM2.5 will be low, besides that if traders have a lifestyle unhealthy habits such as smoking, this will further exacerbate the impact of PM2.5. This socialization and education activity will be more effective if it is carried out by stakeholders such as the Head of the Market, the Health Service, the Environment Service, and the Industry and Trade Service

V. Conclusion

The average concentration of PM2.5 does not exceed the quality standard value based on the Republic of Indonesia Government Regulation Number 22 of 2021 for an average measurement of 24 hours, which is 55 μg/m3. However, it has exceeded the WHO quality standard value for an average of 24 hours by 25 μg/m3 at several sampling points.

PM2.5 exposure risk management for traders in Mandau Raya Market is carried out by calculating the safe limit with the result that a safe concentration acceptable to traders is <56 μg/m3, with a safe exposure time of <8.1 hours in a day, and a safe exposure frequency of < 318.77 days in a year.

The Environmental Service is expected to routinely monitor PM2.5 concentrations in the Mandau Raya Market area and plant trees in the Mandau Raya Market area to help reduce PM2.5 concentrations. Then, it is hoped that the Department of Transportation can conduct exhaust gas emission tests regularly and periodically. It is hoped that the Health Office can conduct outreach and education regarding the impact of PM2.5 exposure and how to prevent it. In addition, it is hoped that the Industry and Trade Service will be able to rearrange the Mandau Raya Market so that the distance between traders and the road is not too close.

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