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Original Article

Health Risks from PM2.5, PM10, and TSP Exposure Among Market Workers Around the 16 Ilir Market in Palembang City

Jhon Wesly Sitanggang
Department of Enviromental Health, Faculty of Public Health, Universitas Sriwijaya, South Sumatra, Indonesia
Corresponding author: jhonwesly@fkm.unsri.ac.id

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ABSTRACT

Background: The air quality index of an area can be evaluated by looking at environmental parameters that serve as air quality monitoring standards, including PM2.5, PM10, and TSP. Exposure to these particulates can cause respiratory issues such as coughing, reduced lung function, lung cancer, asthma, difficulty breathing, and even death. The aim of this study is to analyze the environmental health risks of PM2.5, PM10, and TSP on market workers who are directly exposed to ambient air pollution around Pasar 16 Ilir in Palembang City.
Method: The level of acceptable health risk or to estimate the health risk from exposure to PM2.5, PM10, and TSP can be calculated using Environmental Health Risk Analysis (EHRA). The human population taken in this study consisted of market workers working around Pasar 16 Ilir in Palembang City, with a total of 102 respondents selected purposively from 5 measurement points, which were points with higher human activity. PM2.5, PM10, and TSP measurements were taken every morning, afternoon, and evening for 5 working days using a Met One E-Sampler device.
Result: The research results indicate that the PM10 variable has a health risk impact on market workers with a value of 1.732 or RQ>1, whereas PM2.5 and TSP have RQ values <1.
Conclusion: Exposure to PM10 has health risk impacts on market workers, whereas exposure to PM2.5 and TSP does not have health impacts on market workers.

INTRODUCTION

Air pollution in urban areas constitutes a highly critical environmental issue, as it can affect millions of people on a daily basis (Rosatul Umah & Eva Gusmira, 2024). It represents one aspect of physical environmental degradation. Air is the most fundamental necessity for the survival of all living beings on Earth (Elsa Sulistiani & Ageng Saepudin Kanda S, 2024). In line with increasing urbanization and various deliberate human activities—such as open waste burning, industrialization, motor vehicle emissions, improper waste disposal, and changes in residential land use—air quality has significantly declined in many major cities (Syukri & Ekaria, 2025). According to the World Health Organization (WHO), more than 90% of the global population resides in areas where air quality fails to meet WHO standards, placing the health of millions at serious risk (Rosatul Umah & Eva Gusmira, 2024).

Motor vehicles are the primary source of air pollution in urban areas (Alisain, Rosdiana, & Assiddieq, 2024). Emissions from these vehicles contain various types of pollutants, including carbon monoxide (CO), hydrocarbons, nitrogen oxides (NOx), sulfur oxides (SOx), and lead-containing particulate matter (Pb) (Muslim, Dahliati, Irfan, Lestari Adriyanti, & Sugriarta, 2024). Emissions from motor vehicles that use fossil fuels are the main cause of pollution in major cities and have increased alongside vehicle growth. Road transportation in Indonesia dominates the mobility of people and goods, serving 85% of passengers and 90% of freight transport. The large number of vehicles, coupled with inadequate infrastructure, results in severe traffic congestion, which further contributes to high levels of air pollutant emissions, significantly impacting public health (Humami, Julianti, & Rusmandani, 2024). The air quality index of an area is assessed by monitoring environmental parameters that serve as standards for air quality, namely PM2.5, PM10, O3, NO2, SO2, and CO (Hartono, Fitria, & B.M, 2025). Diseases such as respiratory tract disorders, heart disease, cancer, reproductive disorders, and hypertension (high blood pressure) are adverse effects caused by poor air pollution. Indonesia ranks 61st with one of the worst air quality indices in the world (Rinaldi et al., 2025).

Air pollution has emerged as a significant concern due to its potential health hazards. Coarse dust particles, known as Particulate Matter (PM), represent a dangerous category of air pollutants that can lead to various health problems. The composition of PM in the atmosphere includes a diverse mix of chemical substances (Farhan, Islam, & Chairani H, 2025). PM is a complex blend of solid particles and aerosols, which include dry solid fragments, minute liquid droplets, and solid cores coated with liquid layers. These particles vary widely in terms of their shape, size, and chemical makeup, potentially containing metals, inorganic ions, organic materials, carbon-based substances, metallic compounds, and elements derived from the Earth's crust (Dian Pertiwi, Puji Lestari, & Afandi, 2024). Both PM2.5 and PM10 are capable of being inhaled, with some particles depositing within the respiratory tract. The specific areas of particle deposition in the lungs depend on the size of the particles. PM2.5 particles are more likely to penetrate and settle on the deeper lung surfaces, while PM10 particles are more likely to settle on the larger airway surfaces, for example in the upper parts of the lungs. Tissue damage and lung inflammation are caused by particles that settle on the lung surfaces. Respiratory disorders resulting from PM10 and PM2.5 particles include coughing, decreased lung function, lung cancer, asthma, difficulty breathing, and even death (Dian Pertiwi et al., 2024).

Palembang City has experienced a significant increase in transportation activities in recent years. This increase has led to traffic congestion and air pollution caused by transportation activities. The rise in transportation is accompanied by growing trade activities in Palembang City, which has become one of the pressing issues in the area. Markets serve as places where buying and selling activities of goods and services occur. In addition to economic activities, markets also facilitate social interactions (Fairuz Naila, Bukhari, & Phonna Nurdin, 2024). The narrowing of roads around the 16 Ilir Market area in Palembang City triggers the accumulation of exhaust gases due to the slow movement of vehicles, as many vehicles are parked improperly. According to the 2024 report from the Palembang City Environmental and Sanitation Agency, the Air Pollution Standard Index (ISPU) shows that the average annual concentrations of PM2.5 and PM10 are 6.91 $\mu g/m^3$ and 8.78 $\mu g/m^3$, respectively (DLHK Palembang City, 2024). Market workers are among the community members at risk of health problems due to particulate exposure, as they work close to pollution sources.

Currently, there is no research available on the effects of air pollutant exposure on the health of market workers. Based on this background, this study aims to assess the health risks of exposure to PM2.5, PM10, and TSP among market workrs working around the 16 Ilir Market in Palembang City.

METHODS

This research employs a descriptive design with a quantitative approach. The research method utilized in this study is the Environmental Health Risk Assessment (EHRA) method. EHRA is a systematic evaluation or estimation of potential health risks that may occur within an at-risk population over a specific period. The EHRA framework consists of four main stages: hazard identification, dose-response assessment, exposure assessment, and risk characterization. This method is particularly well-suited for analyzing the impact of environmental factors on public health. The calculation formula used is as follows:

$$\text{Ink} = \frac{C\ x\ R\ x\ tE\ x\ fE\ x\ Dt}{Wb\ x\ tavg}$$

description:

Ink : Intake (mg/kg/day)
C : Consentration $PM_{2,5}$, PM_{10}, dan TSP mg/m^3
R : Amount of Air Inhaled (0,83 m^3/hour)
tE : Exposure Time (hour/day)
fE : Exposure Frequency (day/year)
dE : Exposure Duration (year)
Wb : Body Weight (Kg)
Tavg : Average Time Period

As well as the calculation of risk characterization: RQ:$\frac{I}{RfC}$

Description:

RQ : Risk Quotient; RQ ≤ 1: Not likely to cause health problems, RQ > 1 potentially causes health problems
I : *The intake that has been calculated*
RfC : Reference concentration (RfC) of the risk agent for inhalation exposure

This study involves two types of samples: human samples and ambient air samples. The research was conducted around the 16 Ilir Market in Palembang City, with a total of 102 workers as respondents, selected based on the following inclusion criteria: (1) willingness to participate in the study, (2) having worked as a porter for at least one year, (3) working 8 hours per day or 40 hours per week, and (4) being between 20 and 55 years of age. The exclusion criterion was having a history of lung disease. The ambient air samples included measurements of PM2.5, PM10, and TSP concentrations in the vicinity of the 16 Ilir Market. Air samples were collected at five different locations, with measurements taken three times a day—morning, noon, and afternoon—during peak hours. The instrument used for air sampling was the Met One E-Sampler..

The Met One E-Sampler is designed to comply with EPA standards (Class I and Class III) for particulate samplers and monitors, and has been certified by relevant agencies such as the Environmental Protection Agency (EPA). The E-Sampler provides real-time particulate measurements using near-forward light scattering. The device features an internal rotary vane pump that draws air at a flow rate of 2 L/min into the sensing chamber, where the air passes through a visible laser beam. The operating principle of this instrument is that airborne aerosols scatter light in proportion to the particulate load in the air. As a result, the concentration of particulates being measured is immediately detected and displayed on the monitor integrated into the E-Sampler. This study has obtained ethical approval from the Faculty Of Public Health Sriwijaya University, as stated in decree number: 240/UN9.FKM/TU.KKE/2023.

RESULTS

PM2.5, PM10, and TSP are air pollutants that can cause adverse health effects. The risk analysis of exposure to PM2.5, PM10, and TSP in ambient air indicates a very high health risk. The steps involved in the Environmental Health Risk Analysis (EHRA) method include Hazard Identification, Dose-Response Analysis, Exposure Assessment, and Risk Characterization.

1. Air Pollutant Parameters

Table 1. Measurement Results of PM2.5, PM10, and TSP Concentrations around 16 Ilir Market, Palembang City

Air sampling points	Types of pollutants (mg/m³)								
	$PM_{2,5}$			PM_{10}			TSP		
	Morning	Noon	Afternoon	Morning	Noon	Afternoon	Morning	Noon	Afternoon
Point 1	0.0421	0.0237	0.0325	0.2514	0.3549	0.4485	0.4535	0.7055	0.9467
Point 2	0.0357	0.0168	0.0172	0.0759	0.2231	0.2894	0.0945	0.4428	0.5941
Point 3	0.0108	0.0193	0.0114	0.0254	0.0254	0.0686	0.0612	0.0656	0.1172
Point 4	0.0258	0.0316	0.0237	0.1000	0.3446	0.5752	0.1522	0.6618	1.1676
Point 5	0.0277	0.0112	0.0970	0.0961	0.0761	0.0680	0.1368	0.1214	0.1082

Source: Primary Data, 2024

The study results for PM2.5 concentration showed considerable variability across different areas, with the highest measurement being 0.0970 mg/m^3 recorded at point 5. The PM10 concentration also varied across areas, with the highest value of 0.5752 mg/m^3 measured at point 4. Similarly, TSP concentrations varied, with the highest measurement of 1.1676 mg/m^3 recorded at point 4. The concentrations of air pollutants at the study site during morning, afternoon, and evening measurements exceeded the safe limits stipulated by Government Regulation Number 22 of 2021. The maximum allowable limits for each pollutant are 0.015 mg/m^3 (1-hour measurement) for PM2.5 and 0.04 mg/m^3 (1-hour measurement) for PM10. There is currently no regulation governing the 1-hour threshold limit value (TLV) for TSP; however, the daily standard for TSP is 0.23 mg/m^3. Variations in pollutant concentrations across different locations can be attributed to factors such as meteorological conditions, building heights, and road conditions affecting vehicle traffic.

Based on the field measurements, temperature and humidity data are presented in the following table:

Table 2. Overview of Temperature and Humidity around 16 Ilir Market, Palembang City

Locations	Temperature	Humidity
Location 1	32.03°C	51.73%
Location 2	32.43°C	54.13%
Location 3	33.06°C	57.6%
Location 4	31.46°C	54.67%
Location 5	33.1°C	49.3%

Source: Primary Data, 2024

2. Respondent Characteristics

Table 3. Overview of Market Workers' Age around 16 Ilir Market, Palembang City

Characteristics	Mean	Median	Min-Max
Age	39.05	40	6-51

Source: Primary Data, 2024

Table 3 shows that the respondents' ages ranged from 26 to 51 years, with an average age of 39.05 years. Based on the inclusion criteria, all respondents in this study were male.

3. Risk Analysis

Exposure Analysis

The exposure pattern of the respondents includes anthropometric data such as body weight, intake rate, exposure duration, exposure frequency, and exposure period.

Table 4 Distribution of Body Weight (Wb), Exposure Frequency (Fe), Exposure Time (tE), and Exposure Duration (Dt),

Characteristics	Mean	Median	Standard Deviation	Min-Max	Units
Body Weight	56.68	56.35	4.31	44.2-69.1	Kg
Exposure Frequency	322.33	322	17.524	297-349	day/year
Exposure Time	8.36	8	0.503	7-9	hour/day
Exposure Duration	11.73	12	5.062	3-23	Year

Source: Primary Data, 2024

Table 4 shows that market workers around Pasar 16 Ilir in Palembang experienced an average exposure frequency of 322.33 days/year and an average exposure duration of 11.73 years, indicating long-term exposure to air pollutants. The mean exposure time was 8.36 hours/day, while the average body weight of respondents was 56.68 kg, used to adjust the intake dose. The average air intake rate for adults was 20 m^3/day (0.83 m^3/hour), where higher intake rates increase exposure risk. Workers with longer and more frequent exposure are therefore at greater risk of chronic health effects, especially from PM2.5, PM10, and TSP.

Table 5. Intake Values of PM2.5, PM10, and TSP Exposure

Pollutants	Intake Values (mg/kg/day)
$PM_{2.5}$	0.000934613
PM_{10}	0.008522139
TSP	0.016506711

Source: Primary Data, 2024

The intake variable is calculated by multiplying the concentrations of PM2.5, PM10, and TSP, while incorporating anthropometric characteristics and activity patterns, which include intake rate, exposure time (tE), exposure frequency (fE), exposure duration (Dt), body weight (Wb), and average period (tavg). A higher intake value indicates that the area is more at risk compared to others. The longer the daily exposure duration, annual exposure frequency, and the time the respondent is exposed to the risk agent, the greater the intake value received by that individual, thereby increasing the risk of health disorders caused by exposure to that agent. Additionally, the intake value is inversely proportional to body weight, meaning that the greater a person's body weight, the lower the intake received by the respondent.

4. Dose-Response Analysis

Dose-response assessment is used to estimate the adverse effects of risk agents on the exposed population. The dose-response is expressed as the Reference Concentration (RfC). In this study, the RfC values are based on inhalation reference doses obtained from the Integrated Risk Information System (IRIS) database by the US EPA. The risk level is expressed as a unitless decimal number. The risk is considered Safe when the intake to RfC ratio, expressed as the Risk Quotient (RQ), is **≤** 1. Conversely, the risk is considered Unsafe when the RQ is **>** 1. Below are the RfC values for the three concentrations and their calculations.:

RfC $PM_{2,5}$

$$\mathrm{RfC} = \frac{\mathrm{RfC}\left(\frac{\mathrm{mg}}{\mathrm{m}^3}\right) \mathrm{x\ Inhalation\ rate}\ \left(\frac{\mathrm{m}^3}{\mathrm{day}}\right)}{\mathrm{Wb\ (kg)}}$$

$$\mathrm{RfC} = \frac{0{,}01\left(\frac{\mathrm{mg}}{\mathrm{m}^3}\right) \mathrm{x}\ 20\ \left(\frac{\mathrm{m}^3}{\mathrm{day}}\right)}{56{,}68\ \mathrm{(kg)}} \quad \mathrm{RFC} = 0{,}0035$$

RfC PM_{10}

$$\mathrm{RfC} = \frac{\mathrm{RfC}\left(\frac{\mathrm{mg}}{\mathrm{m}^3}\right) \mathrm{x\ Inhalation\ Rate}\left(\frac{\mathrm{m}^3}{\mathrm{day}}\right)}{\mathrm{Wb\ (kg)}}$$

$$\mathrm{RfC} = \frac{0{,}014\left(\frac{\mathrm{mg}}{\mathrm{m}^3}\right) \mathrm{x}\ 20\ \left(\frac{\mathrm{m}^3}{\mathrm{day}}\right)}{56{,}68\ \mathrm{(kg)}} \quad \mathrm{RFC} = 0{,}0049$$

RfC TSP

$$RfC = \frac{RfC\left(\frac{mg}{m^3}\right) x Inhalation\ rate\ \left(\frac{m^3}{day}\right)}{Wb\ (kg)}$$

$$RfC = \frac{0,26\left(\frac{mg}{m^3}\right) x\ 20\ \left(\frac{m^3}{day}\right)}{56,68\ (kg)} \quad RFC = 0,092$$

5. **Risk Characteristics**

Population Risk Quotient (RQ)

Risk Quotients (RQ), or risk characterization, represent the final step in the Environmental Health Risk Assessment (EHRA). The calculation process in risk characterization involves comparing the intake with the Reference Concentration (RfC) or the safe concentration value. The risk level is considered safe if the RQ value is ≤ 1, and unsafe if the RQ value is ≥ 1.

Table 6. Risk Quotient (RQ) Values for Market Workers

Pollutants	Concentration (mg/m^3)	Intake (mg/kg/day)	RfC	RQ
PM2.5	0.0224 mg/m^3	0.000934613	0.0035	0.267
PM10	0.198 mg/m^3	0.008522139	0.0049	1.732
TSP	0.383 mg/m^3	0.016506711	0.092	0.179

Source: Primary Data, 2024

Table 6 presents the estimated Risk Quotient (RQ) for market workers around Pasar 16 Ilir, Palembang, based on exposure duration to PM2.5, PM10, and TSP. Under real-time conditions, the intake values for PM2.5, PM10, and TSP were calculated as 0.000934613 mg/kg/day, 0.008522139 mg/kg/day, and 0.016506711 mg/kg/day, respectively. The corresponding RQ values were 0.267 for PM2.5, 1.732 for PM10, and 0.179 for TSP. The RQ value for PM10 exceeds the safe threshold (RQ > 1), indicating a potential health risk. These results suggest that long-term exposure to PM10 in the Pasar 16 Ilir area poses a significant health hazard. Therefore, it is necessary to implement traffic flow control to prevent vehicle congestion in the area and to provide education to the community to minimize long-term health risks.

6. **Risk Management**

Estimated Risk Quotient (RQ)

The estimated non-carcinogenic risk quotient (RQ) from exposure to airborne pollutant concentrations of PM2.5, PM10, and TSP around Pasar 16 Ilir, Palembang City, is presented in the table below for projected exposure durations of 5, 10, 15, 20, 25, and 30 years. This projection aims to assess the increase in risk magnitude over exposure periods ranging from 5 to 30 years. Below are the estimated risk quotient values for PM2.5, PM10, and TSP.

Table 7. Estimated Risk Quotient (RQ) at 5, 10, 15, 20, 25, and 30 Years in the Future for Market Workers at 16 Ilir Market

RQ	Dt + 5	Dt + 10	Dt + 15	Dt + 20	Dt + 25	Dt + 30
$PM_{2.5}$	0.38	0.50	0.61	0.73	0.84	0.96
PM_{10}	2.4	3.1	3.8	4.6	5.3	6.07
TSP	0.25	0.32	0.40	0.47	0.55	0.62

Source: Primary Data, 2024

Based on Table 7, it is known that the estimated risk quotient (RQ) values for airborne pollutant concentrations from Dt+5 to Dt+30 years ahead show that the RQ value for PM10 is greater than 1, indicating that exposure during the next 5 to 30 years is considered unsafe and may cause health problems, thus requiring continuation to the risk management stage. However, for pollutants such as PM2.5 and TSP, the estimated RQ values from Dt+5 to Dt+30 are less than 1, meaning that exposure during the next 5 to 30 years is considered safe and unlikely to cause health problems.

DISCUSSION

Environmental Health Risk Analysis of PM2.5, PM10, and TSP Exposure on Market Workers around 16 Ilir Market, Palembang City

Pollutant Concentration

The measurement results of PM2.5, PM10, and TSP concentrations around Pasar 16 Ilir, Palembang City, indicate levels exceeding the Threshold Limit Values (TLVs) set by Government Regulation Number 22 of 2021 concerning Environmental Protection and Management. This situation may be influenced by factors such as temperature, humidity, wind speed, and building height at the sampling locations. The high volume of vehicles, both two-wheelers and four-wheelers, combined with narrow roads, facilitates the accumulation of pollutants.

Based on the measurements, the highest PM2.5 concentration was found at point 5, reaching 0.0970 mg/m^3. This point is located at the vehicle exit route from the market area, and measurements were taken during peak hours when people were finishing their activities and starting to leave the location. The congestion of motor vehicles at this time is the main source of PM2.5 emissions, primarily from fossil fuel combustion. PM2.5 particles typically originate from vehicle exhaust emissions and incomplete combustion processes. Due to their very small size (less than 2.5 micrometers), these particles can penetrate deep into the alveoli of the lungs, causing various health issues such as asthma, chronic bronchitis, and cardiovascular diseases (Nongphromma, 2024; Thangavel, Park, & Lee, 2022). Additionally, high human activity and air stagnation caused by minimal wind flow further contribute to the accumulation of fine particles in the atmosphere.

Meanwhile, the highest concentration of PM10 was recorded at point 4 in the afternoon, reaching 0.5752 mg/m^3. This location is characterized by tightly packed rows of shophouses and narrow roads. This phenomenon creates a structure resembling a street canyon, where tall buildings on both sides of the road restrict horizontal air movement, thereby hindering the mixing and dispersal of pollutants into the open atmosphere. As a result, PM10 particles originating from road dust, vehicle brakes, and other motor vehicle activities become trapped in the area. The lack of vegetation and low wind speeds further reduce atmospheric ventilation efficiency, worsening the accumulation of pollutants in the ambient air. Although PM10 particles are relatively larger than PM2.5 and thus may have more limited systemic penetration, exposure can still impact blood vessels through inflammation pathways and oxidative stress, potentially causing hypertension and endothelial dysfunction (Seihei et al., 2024).

The highest concentration of TSP (Total Suspended Particulates) was also recorded at point 4, measuring 1.1676 mg/m^3. TSP includes all suspended particles in the air with varying sizes, both fine and coarse. The sources of TSP at this location are estimated to be a combination of vehicle emissions, road dust, and human activities around the shophouses. Similar to PM10, the configuration of tall and closely packed buildings, along with the narrow roads, creates physical barriers to wind flow that hinder the dispersion process of these particles (Huo et al., 2023). In the afternoon, traffic intensity tends to increase, which raises the emission rate of particles from vehicles and strengthens the accumulation of pollutants in the area. As a result of TSP exposure, the community is at risk of experiencing respiratory health problems such as acute respiratory infections (ARI), asthma, emphysema, heart disease, and chronic obstructive pulmonary disease (COPD) (Nurfadillah & Petasule, 2022).

High humidity at the surface causes a large amount of water vapor to react with gases in the air, resulting in a reduction of PM10 levels (Muhaniroh & Syech, 2021). The increase in temperature at the research site will raise pollutant levels because temperature affects humidity, which impacts the concentration of PM10 in the air. Higher temperatures reduce humidity, leading to an increase in PM10 concentration due to the decreased reaction between water vapor and gases (Setyowati, Annisa, Riduan, & Prasetia, 2020).

Exposure Frequency in One Year (fE)

Exposure frequency is the number of days per year that respondents are exposed to PM2.5, PM10, and TSP, minus the days they are absent from the study location. The average exposure frequency ranges from 297 days/year to 349 days/year.

The exposure frequency in this study is quite high, with 349 days/year approaching the total number of days in a year. This can increase the risk of health problems for respondents because they are continuously exposed to air containing PM2.5, PM10, and TSP. This aligns with Li et al (2024) study, which showed that the greater the frequency of exposure to harmful substances in ambient air within a year, the higher the health risk. The longer the exposure to air pollutants, the higher the risk of respiratory disorders; however, respondents did not report experiencing respiratory problems. As shown by Harjanti et al (2016), the more frequent the exposure to atmospheric toxins throughout the year, the higher the associated health risks.

The study results indicate that the average exposure frequency of the respondents exceeds the default value set by the United States Environmental Protection Agency (EPA) for industrial work environments, which is 250 days per year. This is related to the socio-economic characteristics of most market workers, who follow a daily work principle where absence from work means no income. Therefore, the exposure frequency tends to be high and may vary depending on individual activities outside of national holidays. Hoppin et al (2002) stated that exposure frequency is a key parameter in risk assessment, as it plays a crucial role in estimating cumulative exposure dose over the long term. The higher the work attendance intensity, the greater the potential accumulation of exposure to hazardous substances, which ultimately increases lifetime health risks (Hoppin, Umbach, London, Alavanja, & Sandler, 2002). Longer exposure duration to air pollutants is also positively correlated with an increased risk of respiratory disorders. However, most respondents did not report experiencing respiratory complaints. This finding aligns with the study by Harjanti et al (2016), which showed that increased frequency of exposure to ambient air pollutants within a year significantly contributes to a higher risk of health problems.

Exposure Duration (Dt)

Based on Table 4, the shortest exposure duration is 3 years, the longest exposure duration is 23 years, and the average exposure duration is 11.73 years. Exposure duration is divided into two categories: real-time exposure and lifetime exposure (30-year lifetime risk). The actual exposure duration was obtained through direct interviews with respondents, while the lifetime exposure (30 years) uses the default value set by the US EPA.

Exposure duration refers to the total time respondents have been exposed to air pollutants PM2.5, PM10, and TSP at the study site over the years. Exposure duration affects an individual's intake value. The amount or intake is directly proportional to the exposure duration. The length of work indicates how long respondents are at risk, and the concentration of air pollution shows that the longer the exposure to air pollution, the higher the likelihood of health risks for the respondents. Continuous exposure to PM2.5, PM10, and TSP can cause health problems. The parts of the body most likely to come into contact are the respiratory tract, eyes, skin, mouth, and airways. Working hours can significantly influence the level of exposure and intake, thus increasing health risks (Fikri, Dewi, & Juariah, 2025). For example, PM2.5 has the ability to enter the respiratory tract, such as the lungs, where exposure to these fine particles can cause short-term effects like irritation (in the eyes, nose, and throat), coughing, sneezing, runny nose, and shortness of breath. Meanwhile, long-term exposure to these pollutants can increase the risk of chronic bronchitis, decreased lung function, and higher mortality rates from lung cancer and heart disease (Hartono et al., 2025). A study showed a correlation between PM10 exposure and cancer incidence in China over a 12-year period. Exposure to PM10 is also associated with occurrences of cardiovascular, cerebrovascular, and respiratory disorders. Eye irritation can also occur due to airborne dust particles, which can affect visual acuity (Putri et al., 2022). This aligns with previous research which found a relationship between PM10 exposure and the occurrence of eye complaints among production workers in Sidoarjo.

Body Weight (Wb)

The anthropometric data of market workers around Pasar 16 Ilir Kota Palembang include body weight (Wb) and inhalation rate (R). Body weight is an anthropometric measure used to calculate intake values aimed at assessing the resulting health risks. The study results showed that the workers' body weight ranged from 44.2 kg to 69.1 kg, with an average body weight of 56.68 kg. Body weight measurement can be a determining factor in calculating risk agents in environmental health risk assessment methods. Body weight is an important variable in estimating exposure to pollutants, as it serves as the denominator in the intake calculation. Mathematically, there is an inverse relationship between body weight and intake value. Individuals with higher body weight tend to have lower intake values, while individuals with lower body weight tend to have higher intake values, assuming other parameters remain constant. This aligns with toxicology principles that the dose relative to body weight influences the extent of harmful substance effects on the body (Bolon et al., 2020).

Furthermore, lung capacity also plays a role in determining the amount of air a person can inhale. Although physiologically, individuals with larger body sizes tend to have greater lung volumes, the workload on the respiratory system is also heavier. Pratiwi et al (2023) explains that the greater the volume of air entering the lungs, the higher the likelihood of pollutant intake, which increases the risk of health problems due to long-term exposure. The variation in body weight among subjects in this study also reflects differences in background factors such as nutritional status, consumption patterns, hormonal influences, culture, and living environment. In the context of national anthropometry, Lee et al (2021) stated that a body weight of 55 kg can be used as a standard for Indonesian adults, until more comprehensive and representative anthropometric data become available. Additionally, it was found that the majority of respondents did not pay attention to their diet or rest management during work, which could worsen their physiological condition over the long term. These findings indicate that besides body weight and exposure duration, lifestyle and work habits are also important factors in determining the level of risk from exposure to air pollutants.

Risk Analysis

Exposure Analysis

Based on the study results, the intake values of PM2.5, PM10, and TSP by market workers around Pasar 16 Ilir in Palembang City are 0.000934613 mg/kg/day, 0.008522139 mg/kg/day, and 0.016506711 mg/kg/day, respectively. The magnitude of these intake values is influenced by several key variables, including pollutant concentration (C), daily intake rate (R), annual exposure frequency (fE), exposure duration in years (Dt), and individual body weight (Wb). The combination of these variables determines the amount of particulate matter or pollutants potentially entering the body and contributing to non-carcinogenic health risks.

A notable study by Kanjanasiranont revealed ambient concentrations of PM10 and PM2.5 within workplaces in Thailand, where averages were reported at 67.32 µg/m^3 for PM10 and 40.21 µg/m^3 for PM2.5, indicating significant exposure risks for security guards and employees (Kanjanasiranont, 2025). Furthermore, Pham et al. assessed similar pollutants in indoor environments (particularly within furniture manufacturing settings) and found TSP levels ranging from 194 to 493 µg/m^3, with PM10 and PM2.5 concentrations at 106.7 to 153.8 µg/m^3 and 72.8 to 95.6 µg/m^3, respectively (Pham, Nguyen, & Vu, 2024). These findings emphasize that market workers, often in close contact with dust-generating activities, could be exposed to dangerously high levels of particulate matter that exceed health guidelines.

Risk Characteristics

Health risk characterization represents the final stage of risk assessment, aiming to determine whether risk management actions are required. Health risks are classified into two categories: carcinogenic and non-carcinogenic, assessed using the Risk Quotient (RQ). If $RQ < 1$, the condition is considered safe, whereas $RQ > 1$ indicates an unsafe condition requiring intervention.

In this study, the RQ value for PM10 exceeded 1, indicating a potential health impact on respondents. Conversely, the RQ values for PM2.5 and TSP were ≤ 1, suggesting that the exposure levels remain within the safe range. The difference between real-time exposure and lifetime exposure arises from variations in exposure duration—real-time exposure reflects the respondents' actual working years, while lifetime exposure assumes a standard period of 30 years.

Lifetime RQ calculations use a default exposure duration of 30 years, with projections between 10 to 30 years based on pollutant concentrations. Air pollutant levels are used to calculate intake and RQ, while other variables such as body weight, exposure duration, and exposure frequency employ average values. The inhalation rate of 0.83 m^3/hour is adopted from US EPA standards. Risk levels are determined by comparing the calculated intake to the Reference Concentration (RfC). When RQ > 1, exposure to PM2.5, PM10, or TSP may cause health problems (Alimin & Wahyuni, 2021).

According to Pangestika & Ridha Wilti (2021), health risk characterization is obtained by dividing exposure values by reference doses. This study focuses on non-carcinogenic risk, where the RQ is significantly influenced by body weight, exposure duration, frequency, and total exposure time. In general, the longer an individual works in a high-risk environment, the higher their RQ value and potential for health deterioration.

Apart from industrial and vehicular emissions, several personal factors—such as poor diet, lack of rest, and fluctuations in body weight—can alter intake levels and potentially raise the RQ above the safe threshold (Prasetyo, Mallongi, & Amqam, 2020). RQ projections over 5 to 30 years show an upward trend, suggesting that prolonged exposure increases risk. However, being in the "safe" category does not guarantee immunity from other health issues. Factors such as smoking habits and medical history can also increase individual vulnerability (Bujawati, A.I. Sadarang, & Syarfaini, 2024).

Age plays an important role as well; with increasing age, immune function tends to decline, making individuals more susceptible to diseases related to air pollution. Pradana et al (2024) found that lung function decreases after the age of 35, consistent with physiological changes such as reduced elasticity, muscle strength, and antioxidant levels . Long-term exposure to cigarette smoke and ambient air pollution can further accelerate respiratory decline (Hambali, Jusuf, & Abudi, 2024; Ridwan, Nurcandra, Simanjorang, Utari, & Bahasoan, 2024).

The use of masks serves as an effective preventive measure against airborne particles and aerosols, especially for individuals who do not consistently wear personal protective equipment (Nidianti & Lukiyono, 2022).

Study Limitations

In conducting this research, several obstacles and challenges emerged as limitations to the study. Nevertheless, the researcher made every effort to obtain the best possible data and information to ensure the smooth progress of the research. One of the limitations of this study was related to the ambient air measurements, which ideally should have been carried out simultaneously at all measurement locations. This means that measurements at 08:00, 12:00, and 16:00 WIB should have been conducted at all five locations at the same time over five working days. However, due to limited equipment and the availability of trained operators, the measurements were instead carried out by assessing one location per day, with three repeated measurements taken at 08:00, 12:00, and 16:00 WIB. Furthermore, wind speed measurements were not conducted at the study sites, making it impossible to determine the factors that influence the dispersion of pollutant concentrations.

CONCLUSION

Based on the results of the study, it can be concluded that the PM10 parameter poses a health risk to market workers around the 16 Ilir Market area in Palembang City. This is indicated by a Risk Quotient (RQ) value greater than 1, which signifies an unsafe condition. In contrast, PM2.5 and TSP were found not to pose significant health risks to the market workers, as shown by RQ values less than 1, indicating a safe condition.

Given the potential health risks associated with exposure to air pollutants, it is recommended that the government conduct regular air quality monitoring in areas with high traffic density. Additionally, effective traffic management measures should be implemented to reduce vehicle emission accumulation and allow air pollutants to be diluted by wind flow. On the other hand, workers—especially market workers—are advised to wear masks that meet respiratory protection standards, rather than relying on cloth masks, which are less effective in filtering harmful particulates.

Author's Contribution Statement: This study was conducted independently by the researcher, beginning with the identification of the research problem, the conceptual development of the study idea, and the formulation of the research methodology. The researcher subsequently carried out the data analysis, prepared the manuscript draft, and completed the final editing before the article was submitted to the journal.

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