ORIGINAL ARTICLE

Investigating the Indoor and Outdoor Respirable Suspended Particulates of Coarse (PM_{10}), Fine ($PM_{2.5}$) and Ultrafine (PM_1)

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ABSTRACT

Introduction: Respirable Suspended Particulate (RSP) is a particularly serious indoor air pollution since at least a portion of particles ingested by humans can be permanently deposited in the respiratory tract. Analysis of indoor air quality in school classrooms is essential because the air quality can have a significant impact on the health and performance of children. **Methods:** The site selections were based on the surrounding activities of commercial and industrial areas. Instruments used for measuring parameters are Dust TraxTM DRX Aerosol II 8532 and Kanomax IAQ Monitor. **Results:** The study shows that the commercial area has a higher concentration of RSP compared to the industrial area. The I/O ratio value is higher at commercial area compared to industrial area with the value of PM_{10} = 3.065, $PM_{2.5}$ = 3.222, PM_1 = 3.261, CO_2 =1.242, RH = 1.212, temperature = 0.891, and air movement = 1.072 for commercial area, and PM_{10} = 1.482, $PM_{2.5}$ = 1.456, PM_1 = 1.449, CO_2 =1.116, RH = 1.134, temperature = 1.040, and air movement = 1.008 for the industrial area. For a commercial area, the indoor RSP is strongly correlated to all meteorological parameters with the value exceeding 0.5 except for CO_2 has moderately correlated with the value is between 0.4 to 0.49, and wind speed has weak correlate with the value is less than 0.39 . **Conclusion:** : In conclusion, the classroom located in commercial is more polluted compared to the industrial area and the RSP is significantly influenced by meteorological factors.
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INTRODUCTION

People nowadays are only concerned with economic development and neglected the air pollution impacts on the environment. According to a recent assessment, indoor air pollution is the ninth most significant global risk factor for disease (1). Rapid economic development and urban population growth result in environmental deterioration and the creation of large volumes of air pollution (2). Furthermore, the oxygen concentration of the air in high-altitude metropolitan areas is substantially lower than at sea level. As a result, combustion is less efficient and pollutant emissions are higher (3). Analysis of indoor air quality in school classrooms is essential because the air quality can have a significant impact on the health and academic performance of students. They are more sensitive because their organ is still in the developmental stage (5, 6). Moreover, children are the new generation for future development that is very important to be protected. Air quality concerns have been raised about cities in Southeast Asia, particularly Malaysia, which have been identified as being surrounded by particulate matter (PM10) (6). Particulate matter with an aerodynamic diameter of less than or equal to 10 micrometers is known as Respirable Suspended Particulate (RSP) (7). RSP can be hazardous because of the inherent properties of hazardous constituents (8). They are produced from combustion processes, vehicles, and industrial sources.

Few factors, such as the rate of air exchange, outside

PM levels, and anthropogenic sources, affected RSP (9). Several studies have discovered that traffic-related air pollution and particulate matter (PM) in urban aerosols play a significant role in the development of cardiovascular disease (4). The study had reported that school indoor microenvironments are among the most highly contaminated sites, finding high levels of particulates, gases, and microorganisms associated with acute and chronic health problems (10). According to estimates, 600 million urban residents globally are now exposed to high levels of the respirable suspended particle (RSP) and other air pollutants (11). Several studies have been carried out over the last two decades to investigate the impact of RSP emissions on children's respiratory and other health consequences, including asthma (12, 13). Because children spend 90 percent of their time indoors, RSP may have a greater impact than outdoor air pollution on children. Children under the age of five have not fully developed respiratory systems, and their immune systems have not fully matured either (14). It appears that children are more vulnerable to the negative health effects of RSP and other air pollutants than adults, owing to their smaller airways and lung sizes, increased baseline ventilation rates, proclivity to mouth breathe, and increased time spent running, jumping, and participating in other aerobic play activities that expose them to higher pollutant loads that penetrate deeper into lung tissues (11). Indoor environmental quality has a significant impact on and influences student attendance and performance, and this influence can be significant (15).

Based on (4), the study was about $PM_{2.5}$ in an indoor and outdoor school classroom. The study was held in Kuala Lumpur from September 2017 until 2018. Researchers found that the lungs hold the bulk of the particle deposition fraction in children's respiratory tracts, with indoor deposition fractions being significantly higher than those found in outdoor settings. Based on their findings, the concentration of RSP in urban areas was found to be higher than that in industrial or rural areas (16). There is a correlation between RSP concentration and meteorological variables such as wind speed temperature and humidity. It was found that the I/O (Indoor/Outdoor) ratio for PM_{10} was greater than one, which indicates that there are significant indoor sources of these particulates. PM_{10} I/O and composition ratios in the schools studied show that the building characteristics such as ventilation, orientation, street morphology, cleaning, and the number of students are more important than the type of environment in which the building is situated. In densely populated urban and suburban areas with a high concentration of buildings and significant traffic activity, air pollution levels in indoor environments are increased by the outside air (17). Local winds can affect the movement of air pollutants from the outside environment into the indoor environment in buildings with open windows. Previously, (18) stated that efforts to improve the quality of city air would result in an improvement in the quality of indoor air. People in high-risk categories should limit their outdoor activities, especially when the city's air quality has been severely reduced because the air inside is cleaner in terms of particle matter than the air outside. A wide range of I/O ratios can be observed across a variety of building characteristics such as interior particle sources, building crack geometry, external wind settings, ventilation patterns, and filtering use among others (19). This study filled the gap of concurrently focusing on the measurement of the indoor and outdoor RSP to investigate the trend, ratio, and relationship between parameters in the industrial and commercial settings.

MATERIALS AND METHODS

Study area and sampling campaign

The site was chosen because of the nearby commercial and industrial activities. The commercial area chosen was TBK Batu Enam (5°21'04.4"N 103°05'34.6"E) and TBK Perumahan Gong Badak (5°23'28.7"N 103°04'44.8"E) was chosen because of its proximity to the Gong Badak industrial area as shown in Fig.1. Dust TraxTM DRX Aerosol Monitor 8534, Kanomax IAQ Model 22b11, and TSI Climomaster Model 9545 were used to collect the data which these instruments were shown in Fig. 2. The sampling technique for RSP, CO, and CO_2 was guided by the Industrial Code of Practice on Indoor Air Quality (ICOP, 2010) (20). Real-time measurements were used as a sampling method. The detection of contaminant sources and the variation in contaminant levels throughout the day can both be assisted by real-time measurements (20). The RSP was measured with a DustTraxTM DRX Aerosol II 8532. Mass and size fractions can be measured simultaneously. The optics chamber was kept clean with a sheath air system, which isolates the aerosol for better reliability and lower maintenance costs. 0.001 to 150 mg/m3 in the range of aerosol concentration. IAQ monitors such as the Kanomax Kanomax monitor simultaneously measured CO, CO_2, temperature, and humidity. The advanced electronics can also calculate dew point, wet bulb temperature, absolute humidity, humidity ratio, and the percentage of outside air in the room. At a glance, a large LCD displayed a wide range of information. For carbon monoxide, it has an accuracy of 3 parts per million (ppm) and for carbon dioxide, it has an accuracy of 50 parts per million (ppm), both of which are 3 percent. The meter's built-in memory or the RS232C terminal can be used to send results to a computer for continuous monitoring. The instruments were placed between 75 and 120 centimeters above the floor following the previous study (16).

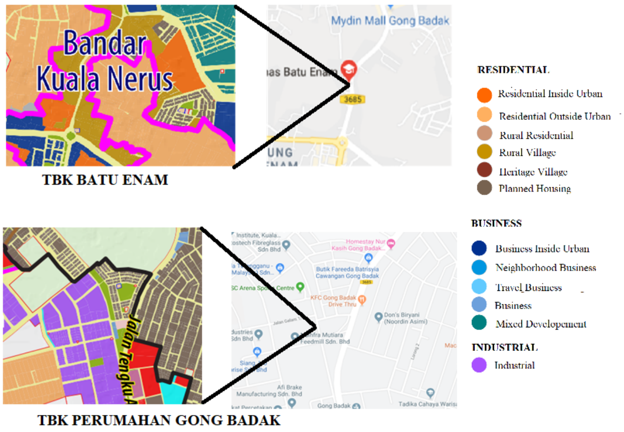

Figure 1: Study areas. Two study areas were selected based on commercial and industrial area.

Figure 2: Instruments used for data collection. Instruments used to include Dust TraxTM DRX Aerosol Monitor 8534, Kanomax IAQ Model 22b11, and TSI Climomaster Model 9545.

Data analysis

The Box and Whisker plot, also known as the box plot, represents both the summary statistics and the distribution of the primary data (21). The box plot is one of a diverse family of statistical techniques, called exploratory data analysis, used to visually identify patterns that may otherwise be hidden in a data set. In boxplot, it displays the five-number summary of a set of data. The five-number summary is the minimum, first quartile, median, third quartile, and maximum. The maximum and minimum values are the highest and the lowest value of the data, respectively. It is advantageous to use the median to determine the center of a set of observations. This is the midpoint of a distribution, the point where half of the information falls at or below it and a half above it. The median, on the other hand, does not provide a satisfactory description of a set of data. This represents one-quarter of the data points or one-fourth of the data values that are at or below the first quartile and three-quarters that are above it. 75 percent of the data falls within or below this quartile, which is called the three-quarters point (or the seventy-five percent point) in the data distribution. The middle half of the data between the two quartiles are represented by the two quartiles. As a result, the distances between the median and the quartiles, as well as the distances between the quartiles, indicate how to spread out the data is, or at the very least how to spread out the middle 50% of the data is. The interquartile range, abbreviated as IQR, is the difference between the first and third quartiles (Q3 – Q1) of a distribution.

This I/O ratio is measured using a relatively simple method. The most commonly employed method is to install two-particle sample monitors, one inside and one outside of the testing facility, and then to achieve the desired I/O ratio. The design of an experiment on the I/O ratio is the most important aspect of the experiment. Researchers selected specific sample buildings following their various research objectives to measure the I/O ratio under various states for comparative purposes (22). It is common practice to investigate the fraction of outdoor air pollution that infiltrates the indoor environment by using the I/O ratio (23). The I/O ratio is used to provide information on the relationship between indoor and outdoor particulate matter (22).

Relationship analysis is a statistical subject that studies linear relationships between variables as well as the strength of those linear relationships between variables. A borderless measure of covariance, this coefficient is scaled so that it ranges from –1 to +1, and it is expressed as a percentage. It is possible to measure the degree of association between two variables using the Spearman rank correlation test, which is a non-parametric test that is used. In contrast to other correlation tests, the Spearman rank correlation test does not make any assumptions about the distribution of the data and is, therefore, the appropriate correlation analysis when the variables are measured on a scale that is at least ordinal. Equation (1) is used to calculate the Spearman rank correlation.

$$\rho = 1 - \frac{6 \Sigma d_i^2}{n(n^2-1)}$$

Where;

ρ = Spearman rank correlation
d_i = Difference between the ranks of corresponding variables
n = Number of observations.

RESULT

Fig. 3 shows the concentration of indoor and outdoor RSP in commercial areas and Fig. 4 shows the concentration of indoor and outdoor RSP in the industrial area. The maximum value of the RSP concentration was PM_{10} with 0.403 mg/m^3 at the outdoor commercial area. The minimum value of RSP concentration was PM_1 with 0.19 mg/m^3 at an indoor commercial area. Previously, (24) stated that the level of indoor RSP concentration may be due to the ventilation rate as a result of closed doors, windows, and ventilators. Overall, the indoor RSP concentration was in between 0.19 – 0.299 mg/

m^3 and outdoor RSP concentration was in between 0.193 – 0.403 mg/m^3. The indoor-outdoor ratio is applied to evaluate the difference indoor concentration and the corresponding outdoor levels (25). I/O ratios greater than or equal to 1.2 indicate that the indoor concentration exceeds that of the outdoors and may be due to indoor sources, 0.8-1.2 or greater indicate that the indoor concentration is equal to that of the outdoors and I/O less than or equal to 0.8 indicate that the indoor concentration is less than that of the outdoors, illustrating the possibility of outdoor influence. The presence of RSP indoors is dependent on the amount of outdoor pollution and the amount of pollution transported indoors, as well as the presence of indoor sources (26). When the influence of natural ventilation rate on deposition velocity is taken into consideration, the I/O ratio will be elevated, and natural ventilation was not preferred, the I/O ratio will be elevated (27). Table I shows the summary of indoor-outdoor ratio RSP. I/O ratio values were observed to be lower which implies that buildings existing were being protected from outdoor pollutants.

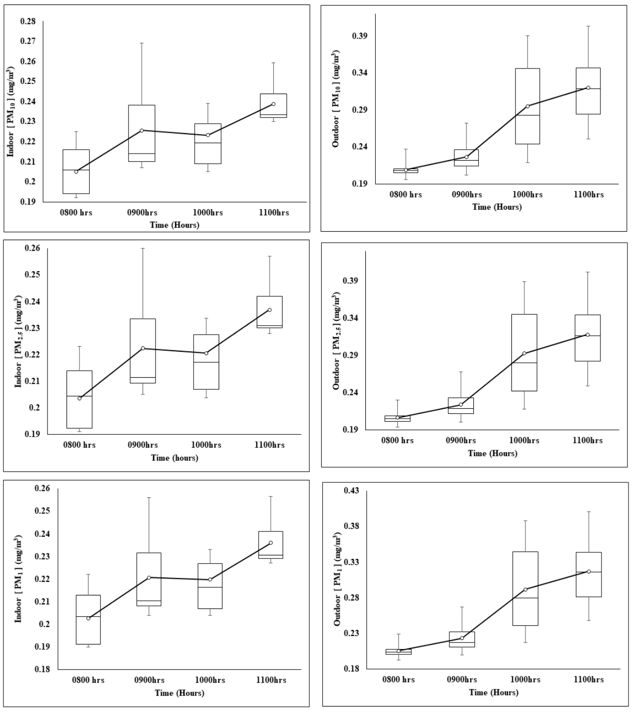

Figure 3: Concentration of indoor and outdoor RSP at commercial area. Concentrations of pollutant are fluctuated over time.

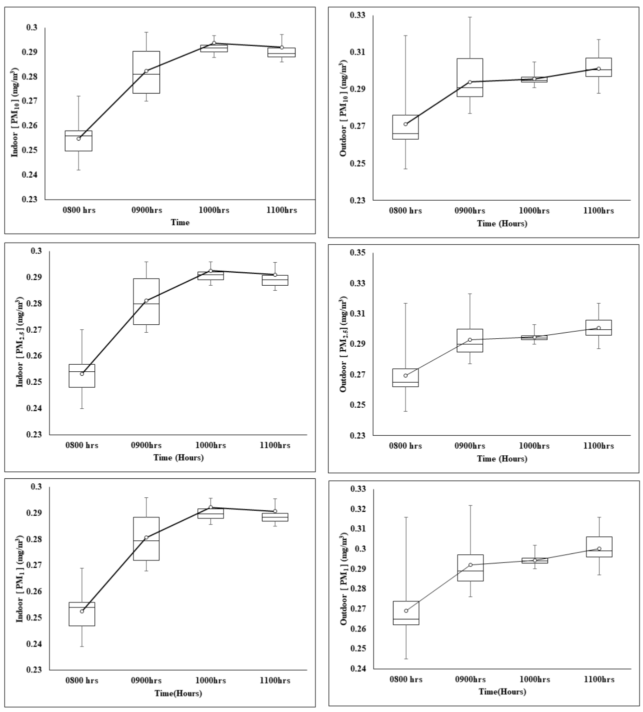

Figure 4: Concentration of indoor and outdoor RSP at industrial area. Concentrations of pollutant are fluctuated over time.

Table I Summary of indoor-outdoor ratio RSP

Sampling Site	Parameters	I/O ratio
Commercial (TBK Batu Enam)	PM_{10}	3.06
	$PM_{2.5}$	3.22
	PM_1	3.26
Industrial (TBK Gong Badak)	PM_{10}	1.44
	$PM_{2.5}$	1.45
	PM_1	1.48

At commercial area, there were no intrusion of outdoor into indoor with the ratio of PM_{10} = 3.065, $PM_{2.5}$ = 3.222, and PM_1 = 3.261. For the industrial area, the intrusion also does not occur due to the I/O ratio value were not in between 0.8 and 1.2 with the ratio of PM_{10} = 1.482, $PM_{2.5}$ = 1.456, PM_1 = 1.449. If the I/O ratio value were more than 1.2, meaning only indoor sources. If less than 0.8, then there will be the influence of outdoor sources. In a previous study, (29) mentioned that the I/O ratio value may reach 1 which is there exists intrusion from outdoor RSP into indoor RSP with a range 1.06 – 1.33 when the doors and windows were open while when the doors and windows were closed, the I/O ratio value will about less 0.6 which means that there was no intrusion. The finer particulate matters show higher concentrations compared to coarse ones. According to a few studies, the I/O ratios were higher for higher fractions of PM_{10} in the air (29). The effect of particle size on deposition rate was investigated, and it was discovered that ultrafine (0.1 m) and coarse (> 1 m) particles deposition rates were significantly higher than those of accumulation mode particles (0.1–1 m) (27).

The Spearman correlation test was used to determine the relationship between RSP and other variables such as CO_2, relative humidity, temperature, and wind speed. The results of the Spearman correlation test were presented in Table II and Table III. According to a previous study, the range of more than 0.50 is considered a strong correlation, the range of 0.4 to 0.49 is considered moderate correlation, and the range of less than 0.39 is considered a weak correlation (30). An inverse relationship between chemical IAQ parameters

Table II: Correlation between indoor RSP with indoor meteorological parameters (A) and outdoor RSP with outdoor meteorological parameters (B) at commercial area

		CO_2	RH	TEMP	WS	PM_{10}	$PM_{2.5}$	PM_1
(A)	**CO_2**	1						
	RH	0.8166**	1					
	TEMP	-0.845**	-0.958**	1				
	WS	-0.21679	-0.0273	0.023023	1			
	PM_{10}	-0.4376*	-0.744**	0.7581**	-0.00335	1		
	$PM_{2.5}$	-0.4692*	-0.760**	0.7729**	0.02 4885	0.9979**	1	
	CO_2	1						
(B)	**RH**	0.79035**	1					
	TEMP	-0.8794**	-0.9187**	1				
	WS	-0.4247*	-0.2913	0.29122	1			
	PM_{10}	-0.6723**	-0.6452**	0.75438**	0.27276	1		
	$PM_{2.5}$	-0.6734**	-0.6456**	0.75552**	0.27526	0.9998**	1	
	PM_1	-0.6749**	-0.6461**	0.75642**	0.27622	0.9998**	0.9999**	1

**Correlation is significant at 0.01 level at (2-tailed)

* Correlation is significant at 0.05 level at (2-tailed)

Table III: Correlation between indoor RSP with indoor meteorological parameters (A) and outdoor RSP with outdoor meteorological parameters (B) at industrial area

		CO_2	RH	TEMP	WS	PM_{10}	$PM_{2.5}$	PM_1
(A)	**CO_2**	1						
	RH	0.6904**	1					
	TEMP	-0.6619**	-0.9889**	1				
	WS	-0.04094	-0.2528	0.26816	1			
	PM_{10}	-0.4656*	-0.7664**	0.8007**	0.2875	1		
	$PM_{2.5}$	-0.4652*	-0.7708**	0.8055**	0.2844	0.9995**	1	
	PM_1	-0.4711*	-0.7723**	0.8071**	0.2845	0.9994**	0.9996**	1
(B)	**CO_2**	1						
	RH	0.2765	1					
	TEMP	-0.2162	-0.9803**	1				
	WS	0.01990	-0.5929**	0.5842	1			
	PM_{10}	0.06416	-0.2711	0.2802	0.1505	1		
	$PM_{2.5}$	0.06106	-0.2838	0.2929	0.1589	0.9995**	1	
	PM_1	0.06199	-0.2869	0.2964	0.1623	0.9993**	0.9998**	1

**Correlation is significant at 0.01 level at (2-tailed)

* Correlation is significant at 0.05 level at (2-tailed)

and thermal comfort parameters such as temperature and relative humidity was discovered (16). To describe indoor and outdoor particle correlation, it is necessary to consider physical factors such as air exchange rate, infiltration and particle deposition, geographical location, weather conditions, and building types. These variables will also have a direct impact on people's exposure levels to particulate matter in both the indoor and outdoor environments, as well as on their health (31).

For the commercial area (Table II), there are positively correlated between RSP with PM_{10} (r = 0.997973 (I), r = 0.999794 (O), $p < 0.01$), $PM_{2.5}$ (r = 0.999158 (I), r = 0.999983 (O), $p < 0.01$), PM_1 (r = 0.995784 (I), r = 0.999793 (O), $p < 0.01$). 50% - 70% of PM_{10} mainly from PM_1 and $PM_{2.5}$ (WHO, 2014). Furthermore, there are a strong correlation between temperature and RSP with PM_{10} (r = 0.758138 (I), r = 0.754385, $p < 0.01$), $PM_{2.5}$ (r = 0.772904 (I), r = 0.755526 (O), $p < 0.01$), PM_1 (r = 0.787807 (I), r = 0.756427 (O), $p < 0.01$). When the indoor temperature is higher than the outdoor temperature, the air forced out of the room will dilute the indoor concentration because the indoor temperature is higher than the outdoor temperature (31). Other than that, correlation between RH with RSP also strong with PM_{10} (r = -0.7448 (I), r = -0.64512 (O), $p < 0.01$), $PM_{2.5}$ (r = -0.76009 (I), r = -0.64563 (O), $p < 0.01$), PM_1 (r =

-0.77496 (I), r = -0.64615 (O), $p < 0.01$), temperature (r = -0.95812 (I), r = -0.91877 (O), $p < 0.01$). Both temperature and relative humidity affects the RSP concentration (32). According to (27), temperature and relative humidity, which are important factors affecting indoor and outdoor correlation, should be taken into consideration and investigated further.

According to research, inadequate fresh air ventilation in classrooms, as evidenced by elevated CO_2 levels, has been shown to negatively impact student performance in both numerical and language-based tasks (33). Next, CO_2 are strongly correlate with outdoor RSP, RH, and temperature, PM_{10} (r = -0.67236 (O), $p < 0.01$), $PM_{2.5}$ (r = -0.67348 (O), $p < 0.01$), PM1 (r = -0.67496 (O), $p < 0.01$), RH (r = 0.816613 (I), r = 0.79035 (O), $p < 0.01$), temperature (r = -0.84541 (I), r = -0.87938 (O), $p < 0.01$), but moderately correlate with indoor RSP, PM_{10} (r = -0.43767 (I), $p < 0.05$), $PM_{2.5}$ (r = -0.46922 (I), $p < 0.05$), PM_1 (r = -0.49551 (I), $p < 0.05$). According to one study, there is a statistically significant positive relationship between indoor CO_2 and indoor PM_{10} concentration (34). This lends credence to the notion that occupied rooms and related activities are a significant source of particles indoors (2013). The processes of accumulation and decay are merely special cases of the general relationship between CO_2 generation rate, outdoor (dilution) air supply rate, CO_2 concentration, and room size that has been established (36). Because of insufficient ventilation, CO_2 concentrations in schools frequently do not meet minimum building standards (37).

Inverse relationships between wind speed and indoor exposure to pollutants are due to the dispersion of these pollutants and, as a result, their diminished contribution to the indoor air quality (38). Wind speed is the weakest correlate to other parameters with PM_{10} (r = -0.00335 (I), r = 0.272769 (O), $p < 0.05$), $PM_{2.5}$ (r = 0.024885 (I), r = 0.275268 (O), $p < 0.05$), PM1 (r = 0.036212 (I), r = 0.276228 (O), $p < 0.05$), CO_2 (r = -0.21679 (I), r = -0.24247 (O), $p < 0.05$), RH (r = -0.0273 (I), r = -0.29134 (O), $p < 0.05$), temperature (r = 0.02302 (I), r = 0.29123 (O), $p < 0.05$). Lower wind speeds in the outdoor environment may also result in higher RSP concentrations both inside and outside the classroom, according to research (32).

Next, at the industrial area (Table III), there are positively correlated between RSP with PM_{10} (r = 0.99952 (I), r = 0.99952 (O), $p < 0.01$), $PM_{2.5}$ (r = 0.99962 (I), r = 0.9998 (O), $p < 0.01$), PM_1 (r = 0.99945 (I), r = 0.99939 (O), $p < 0.01$). The indoor RSP mass concentrations in the coarse mode were lower than outdoor probably due to reduced penetration efficiency and faster settling times (39). Besides, there are more strong correlation to indoor parameters at industrial area but very weak correlation to outdoor. The strong correlate with RH with PM_{10} (r = -0.76635 (I), $p < 0.01$), $PM_{2.5}$ (r = -0.77075 (I), $p < 0.01$), PM_1 (r = -0.77229 (I), $p < 0.01$), CO_2 (r = 0.69038 (I), $p < 0.01$) and temperature (r = -0.98894 (I), $p < 0.01$). Other than that, indoor temperature at industrial also strongly correlate to PM_{10} (r = 0.8007 (I), $p < 0.01$), $PM_{2.5}$ (r = 0.80554 (I), $p < 0.01$), PM_1 (r = 0.80712 (I), $p < 0.01$) and CO_2 (r = -0.66197 (I), $p < 0.01$). Next, CO_2 are moderately correlate with indoor RSP, PM_{10} (r = -0.46561 (I), $p < 0.05$), $PM_{2.5}$ (r = -0.46523 (I), $p < 0.05$), PM_1 (r = -0.47109 (I), $p < 0.05$). Temperature and relative humidity in naturally ventilated indoor environments are influenced by the weather conditions outside the building (32). In addition, (40) reported that increased ventilation rate resulted in a decrease in RSP concentration.

DISCUSSION

The indoor RSP concentrations at commercial facilities are higher than those at industrial facilities. Studies have shown that classroom occupancy can affect RSP levels (especially PM_{10}), because of the resuspension of particles that have been deposited in classrooms (38). Coarse particulate matter was found in high concentrations due to both student activities and the high number of people in the building (32). Indoor and outdoor RSP concentrations can be affected by the air quality in densely populated commercial areas with a high volume of traffic and many buildings (34). At 8:00 a.m., industrial areas have higher outdoor RSP concentrations than commercial areas. The movement of outdoor RSP concentrations at industrial areas increases as the day progresses into the afternoon. The situation in the commercial area was quite different, with the figures increasing significantly between the hours of 0900 and 1000, and peaking and peaking at 1100 hours. Resuspension of RSP from a student's body causes RSP concentration to rise at the end of the school day (34).

Next, RSP levels in the commercial area, which included PM_{10}, $PM_{2.5}$, and PM_1, were higher than those found in the industrial area. According to (16), the commercial sector has a higher concentration of RSP than the industrial sector. Temperature, relative humidity, and wind speed all affect the concentration of RSP in commercial areas, which is higher than the concentration in residential areas. This study's findings confirmed that the majority of environmental factors implicated RSP sources of pollutants, either directly (such as the population density or the length of nearby roads or the speed of nearby winds) or indirectly (such as the type of structure and physical defects at the structure-level) (38). RSP concentration can be traced back to sources of emissions, penetration into the atmosphere and the surface of the earth, resuspension, and coagulation (32). To keep up with human activity, RSP concentrations in commercial areas are increasing. Many studies have shown that the larger RSP is typically generated by human activities, such as resuspension of dust, while finer RSP sources have been identified as infiltration of PM from outside the indoor environment if there are no active sources of cooking or smoking (32). The amount of people living in a given area has a significant effect on the quality of the air inside educational institutions (39).

CONCLUSION

This study aims to assess indoor-outdoor RSP at kindergartens. The study shows that the commercial area has a higher concentration of RSP compared to the industrial area. The highest concentration was at 1100 hours in commercial area due to the meteorological parameters that affect the concentration of RSP. The study also shows the outdoor RSP concentration was higher than indoor RSP concentration. Generally, the commercial area is highly polluted rather than an industrial area. The study shows that the intrusion was not occurred due to the I/O ratio is not in the range of 0.8 – 1.2. For a commercial area, the indoor RSP is strongly correlated to all meteorological parameters with the value exceeding 0.5 except for CO_2 has moderately correlated with the value is between 0.4 to 0.49, and wind speed has weak correlate with the value is less than 0.39. The outdoor RSP also has a strongly correlation with other parameters but the wind speed still has a weak correlation. Then, for industrial areas, the indoor and outdoor RSP shows a strong correlation while for temperature only indoor temperature shows a strong correlation while outdoor temperature shows a weak correlation to other parameters. It is recommended to relocate the location of kindergartens. The building of kindergartens should be placed in an area that is far from busy traffic roads. By relocating the building of kindergartens, it may result in significantly improved air quality and healthier environments in schools. Besides, the safety of the children also can be secured. Other than that, it is a good suggestion to plant trees around the kindergartens. This will also expose the children to be more careful about environment and nature besides the environment of the kindergartens will look more beautiful and harmonious. An effective education program for all teachers about indoor air quality knowledge needs to be exposed. Thus, they will aware that daily activities can contribute the poor IAQ. For the appropriate protection of the health of children, it is important to reduce their exposure to aerosol particles. For example, instead of carpets, smooth panels can be installed. Besides, everyday wet cleaning of the floor is strongly recommended.

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