



UNIVERSITI PUTRA MALAYSIA

***ASSOCIATION OF TRAFFIC-RELATED AIR POLLUTION (TRAP)
EXPOSURE AND RESPIRATORY SYMPTOMS AMONG PEDESTRIAN
DURING COMMUTING AROUND CAMPUS AREA***

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FPSK4 2018 30**

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EXPOSURE AND RESPIRATORY SYMPTOMS AMONG PEDESTRIAN
COMMUTING AROUND CAMPUS AREA**

BY

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**Thesis submitted in fulfilment of the requirement for the degree of Bachelor
Science (Environmental and Occupational Health) from the Faculty of Medicine
and Health Sciences, Universiti Putra Malaysia**

ACKNOWLEDGEMENTS

In the name of Allah, the Most Gracious and the Most Merciful.

Alhamdulillah, all praises to Allah for granting me good health and opportunity in completing my Bachelor journey and this research. I would like to express my endless gratitude to people who had been there with me during whole process of this research and during this four years of study.

First and foremost, I would like to express my deepest appreciation to my supervisor, Dr Nor Eliani bt Ezani for giving me a chance to learn under her supervision. Her endless support, advice, time and continuous encouragement to guide me find the right way in completing this research. Without her guidance and persistent help, this research would not have been possible.

I would like to express sincere gratitude towards my research partner, Mohd Fadhil b Zakaria for his endless support and time to help me in completing this research. My sincere gratitude also goes to my classmates who have been making my research journey much easier with their support. Furthermore, all thanks to all dear respondents for their willingness to engage in this research.

Last but not least, all credit goes to my beloved family members who have been very compassionate and lenient with my commitments as a final year student, praying for my success, endless encouragement and not to forget with every financial support that I need; my mom Mrs Jamilah Ibrahim, my dad Mr Abdul Hisham and siblings. Lastly, to those individuals who contributed either directly or indirectly in my research, may Allah shower all of you with eternal blessings. Thank You.

ABSTRACT

ASSOCIATION OF TRAFFIC-RELATED AIR POLLUTION (TRAP) EXPOSURE AND RESPIRATORY SYMPTOMS AMONG PEDESTRIAN DURING COMMUTING AROUND CAMPUS AREA

NUR AFIFAH BINTI ABDUL HISHAM

Directly inhaled pollutants may cause people to have highest exposure to air pollution. This situation occurred among people who commute by active traveling. Exposed to high levels of pollution could cause disruption of the normal functioning of respiratory system by affecting not only the lungs, but also include larynx, trachea, pharynx and respiratory muscles. **Objective:** To determine the association of traffic-related air pollution (TRAP) exposure and respiratory symptoms among pedestrian around campus area. **Method:** A cross-sectional study was conducted by measuring three main traffic-related air pollutants (TRAP); PM_{2.5}, PM₁₀ and ozone during walking along designated sampling routes around Universiti Putra Malaysia (UPM) at different rush periods (morning, afternoon and evening) (n=32). A set of questionnaires was distributed among students who were actively commute around the campus. Measurements of PM_{2.5}, PM₁₀ and ozone (O₃) were taken using SidePak, DustTrak and Aeroqual Series 500 and carried by the researcher. Motor vehicles traffic count were conducted simultaneously with the measurement. A set of standardized questionnaires adopted from International Union Against Tuberculosis and Lung Disease) were distributed among pedestrian (n=45) to obtain respondents' background information and their respiratory symptoms. **Result:** There was significant association of TRAP exposure and some of the respiratory symptoms among pedestrian in UPM campus. PM_{2.5} and PM₁₀ were statistically significant with symptoms of wheezing with p-value 0.017 and 0.019 while shortness of breath with p-value of 0.040 and 0.039. While O₃ concentration did not showed significant difference with any of the respiratory symptoms studied. Traffic count result showed the highest number of vehicles using Road 1 and 2 were during morning rush hour. **Conclusion:** In conclusion, pedestrian were exposed to high levels of TRAP and it was associated with symptoms of respiratory problems.

Keywords: *Traffic-Related Air Pollution (TRAP), Respiratory Symptoms, Pedestrian*

ABSTRAK

HUBUNGKAIT PENDEDAHAN PENCEMARAN UDARA BERKAITAN LALU LINTAS DAN GEJALA-GEJALA PERNAFASAN DALAM KALANGAN PEJALAN KAKI DI SEKITAR KAWASAN KAMPUS

NUR AFIFAH BINTI ABDUL HISHAM

Menghirup pencemar secara langsung boleh menyebabkan orang mengalami pendedahan yang paling tinggi terhadap pencemaran udara. Keadaan ini berlaku di kalangan rakyat yang berulang-alik dengan perjalanan aktif. Terdedah kepada tahap pencemaran yang tinggi boleh menyebabkan gangguan fungsi normal sistem pernafasan dengan memberi kesan bukan sahaja pada paru-paru, tetapi juga termasuk tekak, trakea, rongga kerongkong dan otot pernafasan. **Objektif:** Untuk menentukan persekitaran pendedahan pencemaran udara yang berkaitan dengan lalu lintas (TRAP) dan gejala pernafasan di kalangan pejalan kaki di sekitar kawasan kampus. **Kaedah:** Kajian keratan rentas dilakukan dengan mengukur tiga pencemar udara yang berkaitan dengan trafik (TRAP); $PM_{2.5}$, PM_{10} dan ozon (O_3) semasa berjalan di sepanjang laluan pensampelan yang ditetapkan di sekitar Universiti Putra Malaysia (UPM) pada waktu puncak yang berbeza (pagi, petang dan petang) ($n = 32$). Satu set soal selidik telah diedarkan di kalangan pelajar yang aktif berkunjung ke kampus. Pengukuran $PM_{2.5}$, PM_{10} dan O_3 diambil menggunakan SidePak, DustTrak dan Siri Aeroqual 500 dan dibawa oleh penyelidik. Kiraan trafik kenderaan bermotor telah dijalankan serentak dengan pengukuran. Satu set soal selidik standard yang diterima pakai dari Kesatuan Antarabangsa terhadap Tuberkulosis dan Penyakit Paru-paru (IUATLD) diedarkan di kalangan pejalan kaki ($n = 45$) untuk mendapatkan latar belakang responden dan gejala pernafasan mereka. **Keputusan:** Terdapat persamaan penting pendedahan TRAP dan beberapa gejala pernafasan di kalangan pejalan kaki di kampus UPM. $PM_{2.5}$ dan PM_{10} yang signifikan secara statistik dengan gejala menghidu dengan p-nilai 0.017 dan 0.019 sementara sesak nafas dengan p-nilai 0.040 dan 0.039. Sedangkan kepekatan O_3 tidak menunjukkan perbezaan yang signifikan dengan mana-mana gejala pernafasan yang dikaji. Hasil kiraan lalu lintas menunjukkan jumlah kenderaan yang paling banyak menggunakan Jalan 1 dan 2 adalah semasa waktu puncak pagi. **Kesimpulan:** Sebagai kesimpulan, pejalan kaki terdedah kepada kadar TRAP yang tinggi dan dikaitkan dengan gejala masalah pernafasan.

Kata kunci: *Pencemaran Udara Berkaitan Trafik (TRAP), Gejala Pernafasan, Pejalan kaki*

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LIST OF ABBREVIATIONS

$\mu\text{g}/\text{m}^3$	Microgram per meter cube
BMI	Body Mass Index
CDC	Centre for Disease Control
CI	Confidence Interval
CO	Carbon Monoxide
CO ₂	Carbon Dioxide
COPD	Chronic Obstructive Pulmonary Disease
DOSH	Department of Occupational Safety and Health
IUATLD	International Union Against Tuberculosis and Lung Disease
IQR	Interquartile Range
km	Kilometer
m	Meter
MAAQS	Malaysian Ambient Air Quality Standard
MAA	Malaysia Automotive Association
NO ₂	Nitrogen Dioxide
O ₃	Ozone
PM _{2.5}	Particulate matter with up to 2.5 micrometers aerodynamic diameter
PM ₁₀	Particulate matter with up to 10 micrometers aerodynamic diameter
SD	Standard Deviation
SPSS	Statistical Package for Social Science
SO ₂	Sulphur Dioxide
TRAP	Traffic-Related Air Pollution
TSP	Total Suspended Particles
UPM	Universiti Putra Malaysia
USA	United States
UV	Ultraviolet
VOC	Volatile Organic Compound
WHO	World Health Organization

CHAPTER 1

INTRODUCTION

1.1 Background

Air pollution is one of the major environmental issues today and it lead to the increasing of morbidity and mortality of population (Ai, Mak, & Lee, 2016). Globally, it was reported that the exposure to outdoor pollution had caused the mortality of population ranged from 200 000 to 570 000. However, in Malaysia, there were no establish report on the number of morbidity and mortality due to air pollution exposure.

Statistics shown that urban population in 2015 achieved about 54% percent of total population in the world. By 2030, the number of population who lived in urban areas are expected to increase by 60% (“WHO | Ambient air pollution,” 2016). Increasing of population may cause the population density to growth and it may affect pollution exposure in urban areas. In 2014 there was about 90% of urban population exposed to particulate matter that exceed WHO air quality guidelines. In addition, “WHO | Ambient air pollution” 2016) stated that exposure to particulate matter has caused about three million deaths every year. In 2017, Malaysia population has increased to 32.0 million with average annual

population for about two percent. Of all that, about 75.5% has moved to urban areas such as Selangor, Putrajaya and Kuala Lumpur. For example, in Kuala Lumpur there was about 6891 persons per square kilometer in the country (Department of Statistics Malaysia, 2015). This situation could show that more and more people are exposing to the pollutants in their daily life.

Exposing to high pollutants in the environment may affect the population health. Samoli et al. (2016) found that long-term exposure to pollutants might cause to have higher tendency to be admitted due to respiratory and cardiovascular problem. According to Sylla, Faye, Fall, & Tal-dia (2017), about 4.2 million deaths occurred in low or middle income countries in a year due to the chronic respiratory disease such as asthma and chronic obstructive pulmonary disease (COPD) and it were caused by rapid urbanization in the country which leads to production of air pollution. In the study, they found out that children mostly experienced increased risk of wheezing while adult had chronic bronchitis from exposure to traffic pollution (Sylla et al., 2017).

1.2 Problem Statement

As developing countries, Malaysia is one of the countries that undergoes rapid development from agriculture based into industrial economy. This economic growth lead to the development of towns into urban areas. This causes the population to shift to from rural areas to urban areas in increasing their quality of life (Hasan & Nair, 2014).

Therefore, with the increasing of population, the number of vehicles might also increasing. For example, statistics shown that the number of vehicles sold are increasing from 1990 to 2017 worldwide. There are 77.25 million cars were sold in 2016 and the number are increasing in 2017 which are 79.02 million (Statista, 2017). MMA (2018) reported that there were about 576,635 vehicles were registered in 2017 and most of it were from urban areas. Those vehicles could gave huge impact on air pollution as it is the major source of pollution in urban areas. Study conducted by Rahman et al. (2015) found out that Port Klang contained highest PM₁₀ concentration as it is the areas that have heavy traffic congestion due to the industrial activities there. This would eventually cause people in urban areas to exposed to high pollution levels due to vehicles emission.

The pollutants that being emitted by the vehicles such as carbon monoxide (CO), nitrogen dioxide (NO₂), ozone (O₃) and particulate matter. Each of the pollutants might impacts the health of population in different ways depending on the size, feature of system of body and breathing pattern. Pollutants might go

deeper into the body and deposited there with the smaller size pollutants, reduce breathing airway and higher diffusion rate (Kesavachandran, Kamal, Bihari, Pathak, & Singh, 2015).

According to Rebekka (2016), active transport could be generalized as any forms of movement that was based on human energy including walking, cycling, scootering, skateboarding, rollerblading and also the use public transport. Promoting this activities in the community may increase their physical activity, decrease pollution level and the impacts, and change the number of accidents (Davis, 2012). However, active travel may cause people having the highest exposure to air pollution as they are directly inhaled the pollutants. As Hankey, Lindsey, & Marshall (2017) stated that active travel have significant association with particulate concentrations especially on major roads as pedestrian mostly used passages around activity centre such as along main transportation roads which caused them to have high exposure to the pollutants. However, no such studies yet on active travellers' exposure being conducted in Malaysia.

Moreover, study conducted by Samoli et al. (2016) found that exposed to pollutants for a long time could result in higher hospital admission of paediatric respiratory disease. Long term exposure could cause permanent damage to the lungs such as aging of the lungs, decreased lung function, shortened life span and development of many disease ("Spare The Air: Health Effects of Air Pollution," 2017). However, less study has been carried out to assess short-term exposure to pollutants and their health effects on population.

1.3 Study Justification

The purpose of this study is to determine the association between traffic-related air pollution with respiratory symptoms during active commute around campus area. This study will add to the knowledge and benefits to the topic. This study become concern matters as it is affecting individuals as pedestrian who commute actively near roadside and may disintegrate their health outcomes. Traffic-related air pollutants that will be measured are including $PM_{2.5}$, PM_{10} , and O_3 .

Besides, there is less studies that had been carried out for exposure during active travel in Malaysia. Active travel is another way of moving from one place to another by a means of method that involves physical activity such as walking, bicycling and other non-motorized vehicles including public transport ("Information Sheet on Active Transport and Walking," 2016).

Active travel could benefit in various way such as it could lead to the reducing number of vehicles on the road which at the same time increase the quality of the air. Therefore, the number of patients with any traffic-related symptoms such as respiratory could decreased and eventually decrease the cost for the treatment (Rebekka, 2016). However, people commuting by active traveling might having the highest exposure to air pollution as compared to vehicle users (Hankey et al., 2017).

This can be seen that pedestrian walking with short distance is highly exposed to the traffic-related air pollutions and it may impacts the health of the population such as chronic and acute respiratory disease including asthma, lung cancer, heart disease and stroke (Davies & Whyatt, 2014).

1.4 Conceptual framework

The aim of this study is to determine the association of traffic-related air pollution (TRAP) exposure and respiratory symptoms among pedestrian who are walking around UPM campus. From the conceptual framework, the studied pollutants are PM_{10} , $PM_{2.5}$ and O_3 . The dependent variables of the study is respiratory symptoms experienced by pedestrian. The confounder that may arise from the study are socio-demographic information, medical history and smoking practices

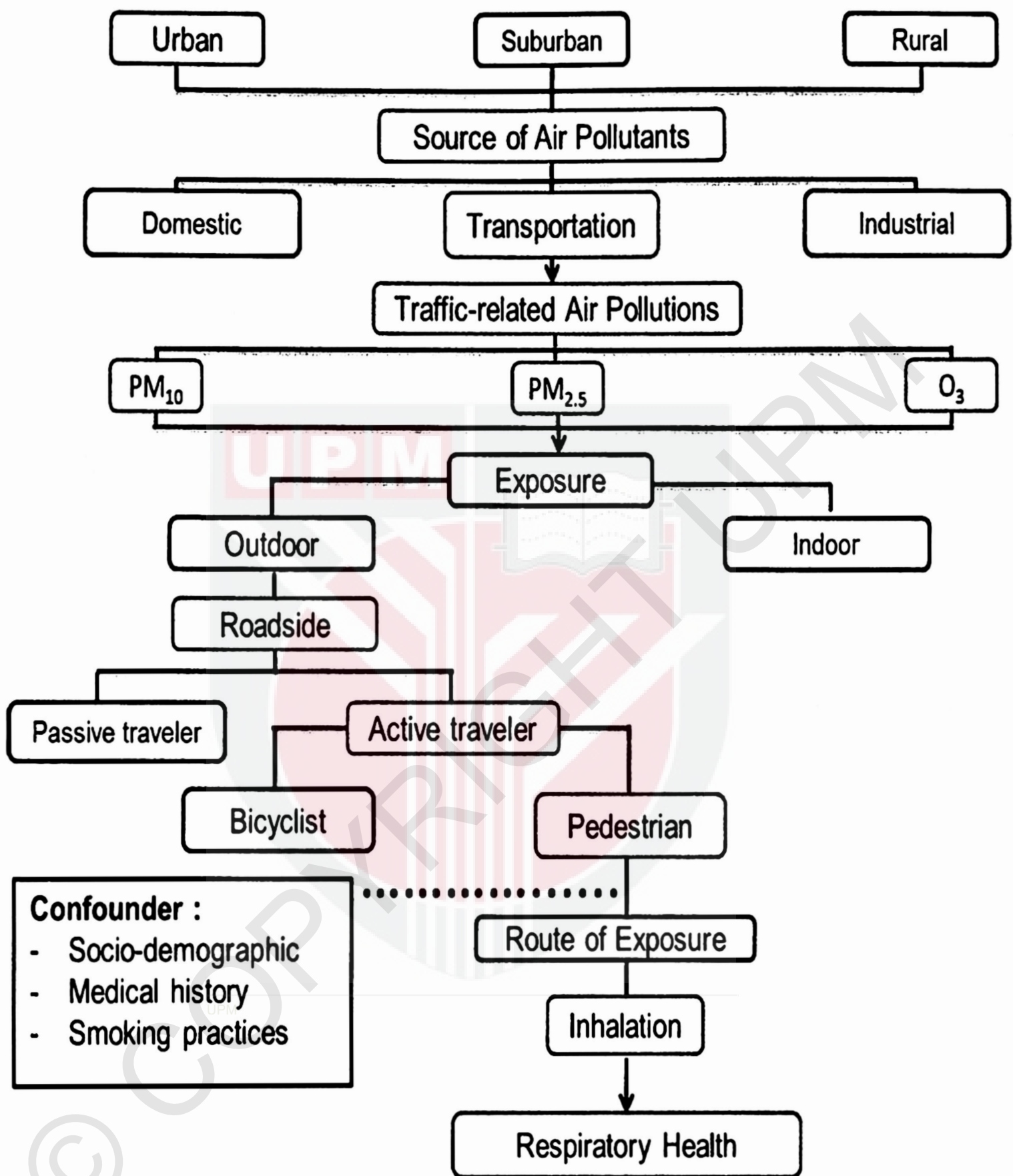
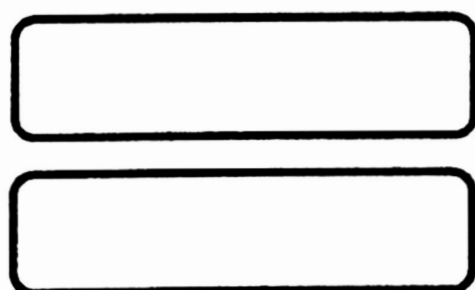


Figure1: Conceptual Framework



Independent variable

Dependent variable

1.4 Objectives

1.4.1 General Objective

To determine association of traffic-related air pollution (TRAP) exposure and respiratory symptoms among pedestrian during commuting around UPM campus.

1.4.2 Specific objectives

- i. To determine health symptoms reported by pedestrian during commuting around campus area.
- ii. To determine the levels of air pollutants such as O₃, PM₁₀ and PM_{2.5} in the campus area along designated route.
- iii. To compare background and roadside measurement of traffic-related air pollution (TRAP).
- iv. To determine relationship of traffic-related air pollution (TRAP) exposure with respiratory symptoms reported.
- v. To determine association between sociodemographic factors and health symptoms reported.
- vi. To determine the association between motor-vehicle traffic count and traffic-related air pollution (TRAP).

1.5 Hypothesis

- i. There is significant comparison of background and roadside measurement of traffic-related air pollution (TRAP)
- ii. There is significant relationship of traffic-related air pollution (TRAP) exposure and respiratory symptoms reported.
- iii. There is significant association between sociodemographic factors and health symptoms.
- iv. There is significant association of motor-vehicle traffic count and traffic-related air pollution (TRAP).

1.7 Definition of Variables

1.7.1 Conceptual Definition

Traffic-Related Air Pollution (TRAP)

Activities such as walking, standing in busy street, in a vehicles and at home are exposing Canadians to traffic air pollution. Cars, buses and vehicle trucks are the main sources that emitting traffic pollutants which could result in asthmatic symptoms, development of cancer, heart disease and others (Government of Canada, 2016). Lived in 500 m buffer from highways or either 100 m from major roads are exposing about one third of Canadian population to traffic-related air pollution (TRAP) (Brauer, Reynolds, & Hystad, 2013).

Active Transport

The used of physical activity such as walking, bicycling and other non-motorized transport relates to active transport when it is used as transport to move except for recreation. Public transport also called as active transport because it involves the activity of pick-up and drop-off (“Information Sheet on Active Transport and Walking,” 2016). This activities giving a lot of benefits to people and environment including increase physical activity, reduce greenhouse gases, and others (“Active Transport - Healthy Spaces & Places,” 2016).

Pedestrian

If any person is walking as part of his or her journey, it is called pedestrian. Besides, hiking, running, jogging, sitting or lying down in the roadway also called as pedestrian. He or she may at the same time carrying any items whether held in hands, strapped on the back, pushed or pulled, or even placed on the head (Biehl, Older, & Griep, 2013). While travelling by foot, wheelchair or small wheeled device that contribute to personal mobility to a person also called as pedestrian (Bassil, Rilkoff, Belmont, Banaszewska, & Campbell, 2015).

Respiratory Diseases

When human respiration was affected by the disorder of the airways and the lungs, respiratory disease was being diagnosed (Hansen-Flaschen & Bates, 2017). When a person is exposed to outdoor environment that is polluted, the lungs need to have a series of defences of inhaled material to protect themselves. The malfunction of the lungs cause a person to have tendency to develop the disease (Hansen-Flaschen & Bates, 2017).

1.7.2 Operational Definition

Traffic-Related Air Pollution (TRAP)

Traffic-related air pollution is the pollution caused by the emission of pollutants such as particulate matter, nitrogen dioxide, ozone and black carbon. The increasing number of vehicles the main contributor of the pollutions. Road users such as pedestrian, cyclist, motorcyclist, and vehicle users are exposed to those pollution.

Active Transport

Active transport is any kind of activities that being used to move from one place to another such as walking and bicycling either for a short period of time of longer. The encouraging of this activities may help the environment to reduce the pollution levels.

Pedestrian

Pedestrian in this study referring to the students population who are walking using pedestrian route to the campus. In average, students aged from 18 to 24 years old are the most user of pedestrian route. They spend short or long time to walk to campus and exposed to the traffic-related air pollution along the route.

Respiratory Diseases

Respiratory disease is a disease that occurred due to many factors. One of it is due to the environment. Inhaled polluted air may cause disruption of any part of respiratory system thus causing dysfunction of the organ. This may lead to the incidences of respiratory disease.

CHAPTER 2

LITERATURE REVIEW

2.1 Traffic Related Air Pollution (TRAP)

Human activities such as transportation and industrialization activities including mining, manufacturing, agriculture and construction has being the most environmental concern nowadays. It is main contribution of the declination of air quality results in occurrence of air pollution cases. In addition, natural activities also could cause the air pollution however, it is not commonly occur and it does not produce huge impacts as human did (Petrisor, 2017).

There is little gap in finding the most harmful pollutants and their sources even though many literature reported on the air pollution (Samoli et al., 2016). Nitrogen dioxide (NO₂), particulate matters (PM), carbon monoxide (CO), sulphur dioxide (SO₂) and ozone (O₃) have been linked as the main pollutants that comes from transportation such as exhaust emission of the car, motorcycles, and buses (Ai, Mak, & Lee, 2016). Apart from the pollutants mentioned before, other studies also included other types of pollutants that seems to be one of pollutants emitted from the vehicles such as carbon dioxide (CO₂) and formaldehyde (Shields et al., 2013) and also metals and hydrocarbons (Cosselman, Navas-Acien, & Kaufman, 2015). In the cities, it has become major sources of environmental problems (Huang et al., 2013).

This problem encountered when motor vehicles emitted exhaust, road abrasion, tyre and brake wear has been associated with the disease (Samoli et al., 2016b).

Traffic-related air pollution may contain various types of components and every component of TRAP could target different organ in the human body. Particulate matter (PM) and ozone(O_3) are some of the components of TRAP. Particulate matter comprised of particles and droplets in the air. They have different in size and composition. PM_{10} are particles that size less than 10 microns (Fung, 2016). As for smaller PM, it is being called respirable particulates which have aerodynamics of less than 2.5 microns. It usually was produced from construction activities, smokestacks, fire or from roads abrasion. This kind of particles may have great impacts on the organ as it may reach lungs and bloodstream. Exposure to this pollutants could cause asthma attack, disruption of lung function, variability in the heart rate and also caused respiratory problems (Fung, 2016).

Ozone (O_3) is secondary pollutants that formed from chemical reaction of nitrogen dioxide (NO_2), volatile organic compounds (VOCs) and also presence of UV light. O_3 usually higher in suburban areas compared to busy city and it has abilities to traveled far. O_3 concentration will also increase during summer and in the noon time in which it shown that the concentration of the pollutants could varied based on season, time and location. A study found out that long term exposure to O_3 lead to lung damaged in which affects people health such as asthmatic incidence, cancer, and development of lung being prevented (WHO, 2003). Table below shown

the air quality guidelines from WHO and Malaysia New Ambient Air Quality Guidelines from DOE.

Table 1 : Air Quality Guidelines from WHO and DOE Malaysia

Pollutants	Averaging Time	Ambient Air Quality Standard (µg/m ³)	WHO Air Quality Standard (µg/m ³)
PM ₁₀	1 Year	45	20
	24 Hour	120	50
PM _{2.5}	1 Year	25	10
	24 Hour	50	25
SO ₂	1 Hour	300	-
	24 Hour	90	20
	10 Minute	-	500
NO ₂	1 Year	-	40
	1 Hour	300	200
	24 Hour	75	-
O ₃	1 Hour	200	-
	8 Hour	120	100

2.2 Respiratory Symptoms

Any disruption in the normal functioning of respiratory system such as the lungs or the airways are called respiratory disease. It may affect not only the lungs, but also the larynx, trachea, pharynx and respiratory muscles (Hansen-Flaschen & Bates, 2017). There are some risk factors that could contribute to the disease such as

tobacco smoke, air pollution, occupational exposure to smoke dust and chemicals and also infection on lower respiratory during childhood (World Health Organization, 2016). Statistics shown that approximately 6% of all death worldwide are caused by chronic obstructive pulmonary disease (COPD). This shown that disease due to respiratory problems could contribute to the increase number of death in the world. However, this disease can be prevented by reducing the exposure to tobacco smoke, air pollution and also avoid having infections (“Chronic Obstructive Pulmonary Disease (COPD),” 2017).

Air pollution might affect respiratory system by inducing the airway muscles to contract, thus narrowing the airways which cause air hypersensitivity. Only short term exposure to high level of pollution might lead to condition of having difficulties of breathing, chest pain and airway inflammation of the person exposed. Therefore, it is not possible that long term exposure could result in permanent damage of the lungs which may cause reduced lung function, shortened life span and development of other diseases (“Spare The Air: Health Effects of Air Pollution,” 2017).

2.3 Traffic-Related Air Pollution (TRAP) and Respiratory Symptoms

A study conducted by Alnawaiseh, Hashim, Isa, & Salahat (2014), they found out that live in high polluted area (HPA) increased their exposure to air pollution compared to low polluted areas (LPA). Besides, they also found that congested area with high density of vehicles has the association with respiratory symptoms. Live

near heavy traffic roads also increase the chance of developing respiratory allergy, shortness of breath, and dry cough. In addition, old and being smokers proved that it could help in developing frequent phlegm or sputum. Alnawaiseh et al. (2014) said that the prevalence of respiratory symptoms could increase due to people perception of exposing to high levels of pollution which could cause them to be high risk group of developing respiratory illness. Another study also proved that exposure to traffic pollution have higher risk of having respiratory tract diseases than exposure to other types of pollution (Q. Liu et al., 2017).

Other than that, development of these respiratory cases' also may come from other causes such as number of total population, number of vehicles and current land use at certain places. Increase number of population, vehicles and changes of current land use would cause the decreasing of air quality and eventually increase number of respiratory cases' at the place (Tarhan, Sinem, & Pelin, 2016).

However, every person might having different response to those pollution as there are differences of gender, socio-economic status and others. People with lower income might having adverse effect to their health when exposed to pollution such as PM_{2.5} compared with living in high socio-economic status (Brugha & Grigg, 2014). According to Yoshizaki et al. (2017), there was a difference of response to the same level of pollution among male and female. They found out that male would experience more acute effects to the same pollution compared to female.

2.4

Exposure to Pedestrian

Pedestrian's exposures to air pollution are of particular concern for several reason. Compared to other road users, pedestrian are highly exposed to this pollution. Since most of pedestrian are young and healthy adult, they are considered as active population which spend most of their time outdoors. Being college students, most of people aged 18 to 24 spend about 9 hours in a day only for sleeping and the rest for other activities including 3.9 hours comprised of time in and outside of the class such as doing research and assignment. Another 3.9 hours usually was spent on sports or recreation such as entertainment, social activities and relaxing (Wilk, 2011).

Pedestrians were found that they were exposed about 4.7-fold PM_{10} and 2.2-fold $PM_{2.5}$ during commuting instead of people in driving mode (W.-T. Liu et al., 2015). This support of their findings that walking exposed people to higher pollution than bus, car and subway users (W.-T. Liu et al., 2015). As study by Ai et al. (2016), roadside air quality is being measured and compared with air quality objectives to determine people's exposure to the pollutants. After considered that people did not spend more than one hour at roadside, concentration of NO_2 were determined to be safe for passenger and pedestrian. On the other hand, $PM_{2.5}$ and PM_{10} concentrations measured during rush hour were high which would increase risk of short-term exposure to road users and pedestrian.

Nyhan, McNabola, & Misstear (2013) investigated that pedestrians and cyclists had the highest particulate matter inhaled and deposited in the lungs when

compared to bus and train passengers. However, this situation was being neglected since people did not exactly had the same response to the environmental condition around them. This could be seen when people from aged 18 to 34 years old commonly would report the dusty environment around them compared to people more than 55 years old. Their response could be different because of their attitude, behaviour and physical activity Pantavou, Lykoudis, & Psiloglou (2017).

Regulations for air quality implemented in United States seems unsuccessful due to the high number of vehicles and traffic congestion which result in the increased concentration of pollutants being inhaled by people especially commuters, pedestrians and people living nearby the road (Cosselman et al., 2015).

2.5 Other Factors Affecting Traffic-Related Air Pollution

Previous study has indicated that there are also other factors that contributed to the increased of pollution level rather than only traffic volume. Route chosen, presence of trees (Amorim et al., 2013), volume of vehicles that emitted diesels, prevention of the process of diluting the exhaust emission from on-road to roadside, street canyon, and effects of high-rise building are the contributors for the higher pollution levels. For example, buildings near the roadways could prevent the mixing of air while street canyon may cause the dispersion of traffic pollutants being interrupted thus increasing pollutants concentration at the place (Rakowska et al., 2014).

Apart from that, meteorological components also may give effects on the particles concentration on the road. Wind speed, temperature and relative humidity were some of the influencers that are not so obvious (Qiu et al., 2017). Brugha & Grigg (2014) stated that the level of particulate matter (PM) could vary due to the fact that differences of sources, wind speed and weather conditions. Samoli et al. (2016) found that the temperature might affect the number of pollutants being inhaled as the study proved that warm period affecting the increase number of respiratory admissions.

Exposure to the pollution can be reduced in certain circumstances. According to Hankey et al. (2017) exposure to pollutants could be decreased as the distance of person and major road further away. However, the best solution in reducing the pollution is through modifying source and position of the source of pollutions (Qiu & Peng, 2015).

CHAPTER 3

METHODOLOGY

3.1 Study Design

This research is a cross sectional study design to determine the association of traffic-related air pollution and respiratory symptoms experienced by pedestrian during commuting around Universiti Putra Malaysia (UPM) campus.

3.2 Study location

This study was conducted around UPM campus such as around residential college and faculty area. UPM campus was chosen as this area usually become congested during rush hour. Apart from that, many of the students spend their time outdoors especially during walking. Thus, the exposure during rush hour may be high and affecting the health of the pedestrian.

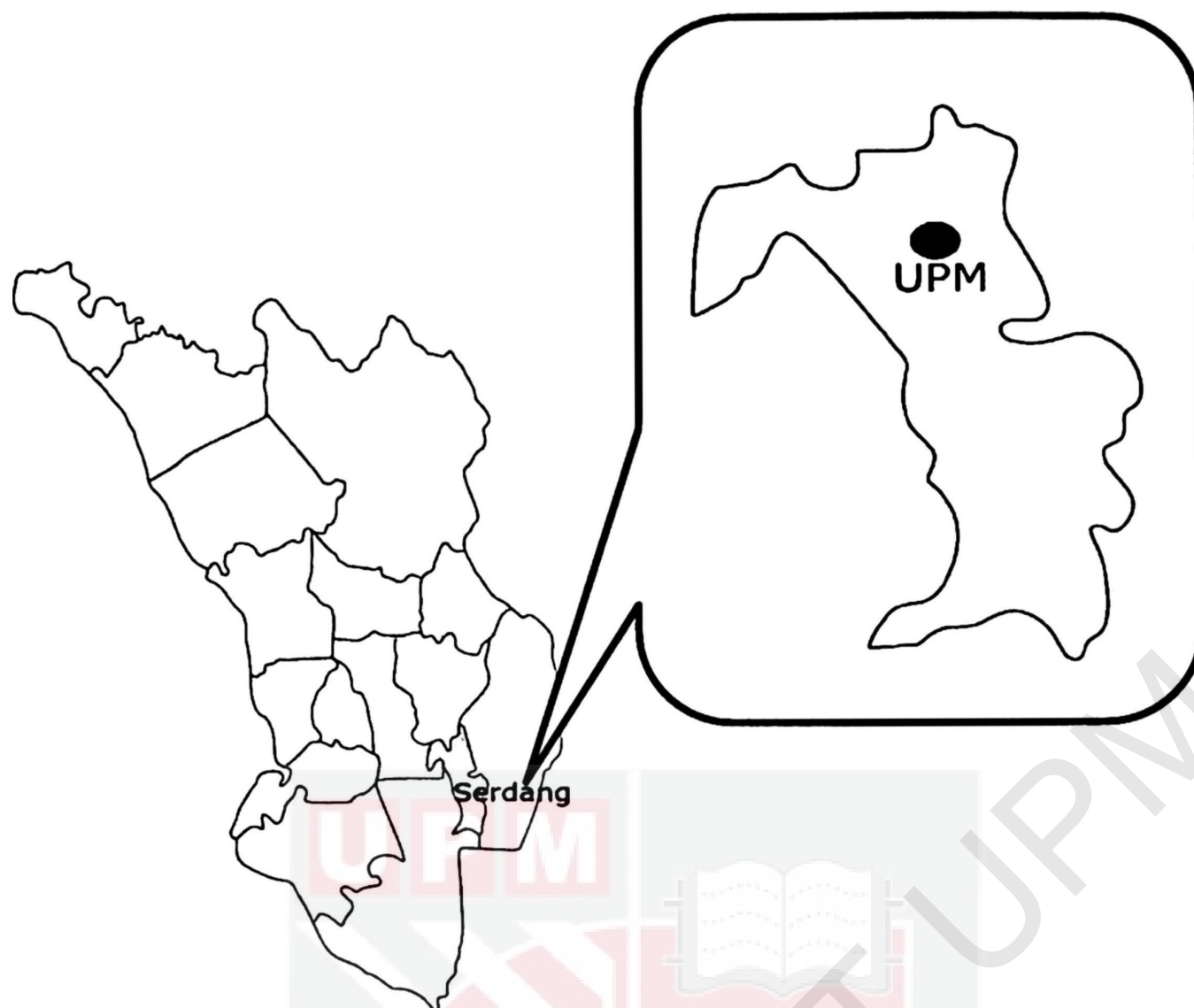
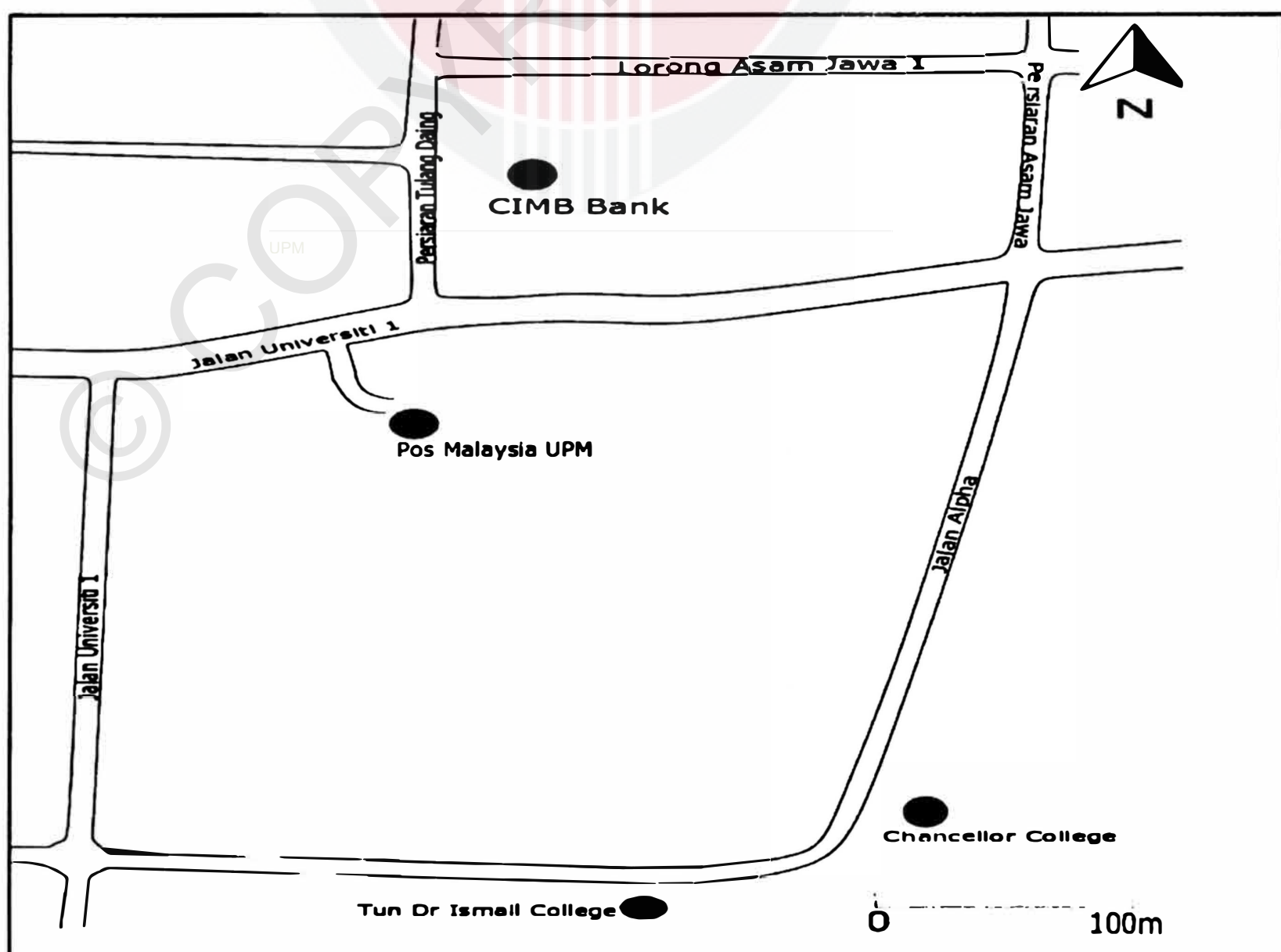


Figure 2 : Map of Study Location

ROAD 1



ROAD 2

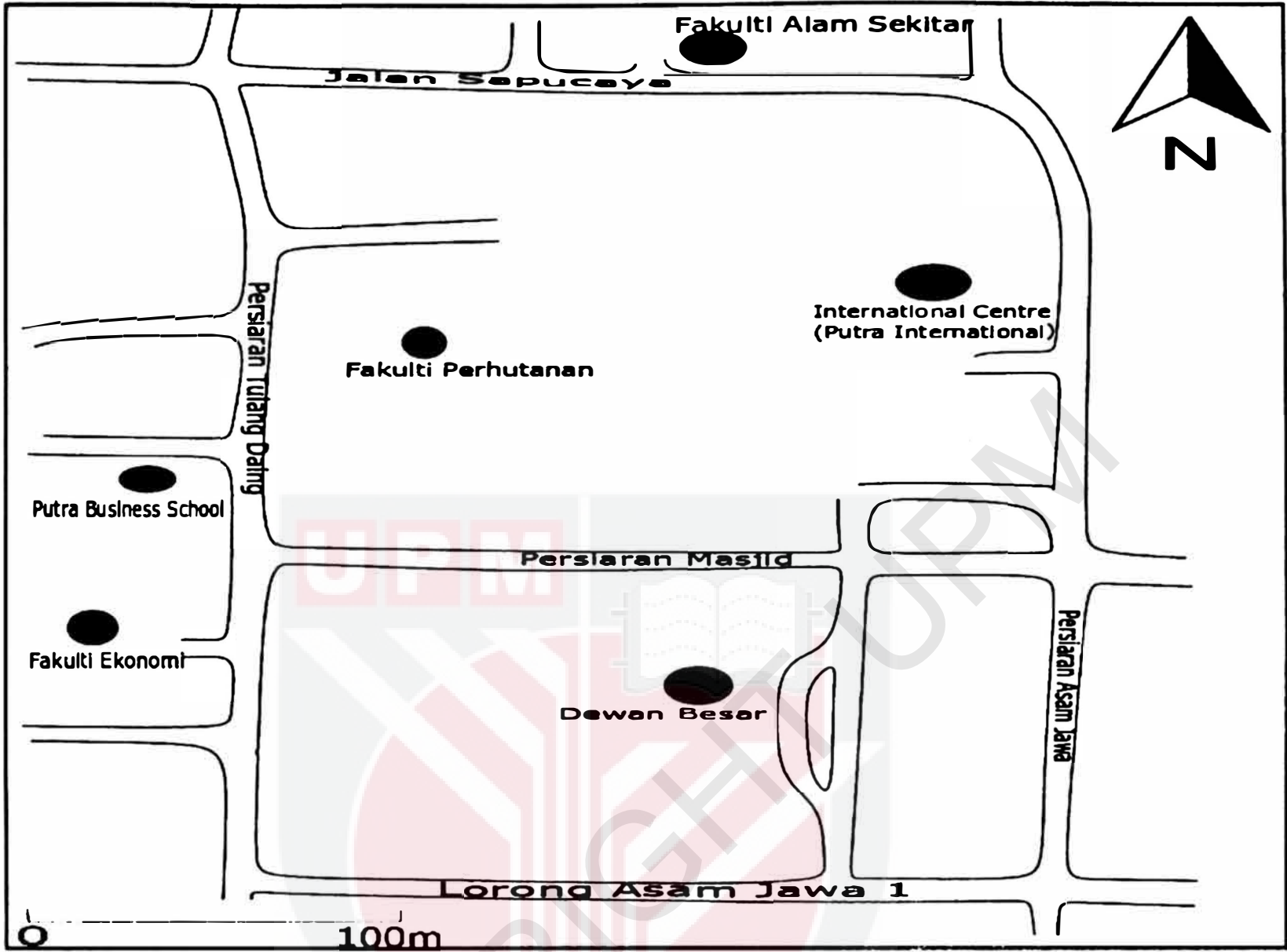


Figure 3 : The Map of Sampling Route (Road 1 and 2)

3.3 Sampling

3.3.1 Study Population

This study was conducted among students of Canselor College, Tun Dr Ismail College, Second College, Sultan Alaeddin Suleiman Shah College, and Fifth College who are walking around college and campus area every day. Students who are pedestrian that chose to walk along the designated route such as Jalan Alpha, Jalan Universiti 1, Persiaran Tulang Daing, Lorong Asam Jawa and Persiaran Asam

Jawa. While another route including Persiaran Tulang Daing, Jalan Sapucaya, Persiaran Asam Jawa and Lorong Asam Jawa 1 (Figure 2).

3.3.2 Sample Size

Sample size is determined by using formula made by Kirkwood and Sterne (2003) :

$$N = p (1-p) / e^2$$

Where,

N = sample size

p = prevalence of respiratory symptoms (Noomnual & Shendell, 2017)

e = sampling error

$$N = 0.87 (1-0.87) / (0.05)^2$$

$$= 45 \text{ respondents}$$

3.3.3 Sampling Method

3.3.3.1 Questionnaires on Respiratory Symptoms

Convenience sampling was used in this study. The samples were collected by distributing the questionnaires to the students who are walking to and from the college to faculty in the main campus. The respondents were selected based on

inclusion and exclusion criteria in which the students that chose were from Canselor College, Tun Dr Ismail College, Second College, Sultan Alaeddin Suleiman Shah College, and Fifth College. The students from the selected colleges were randomly chosen as respondents. This method was chosen with the expectation that the respondents will provide valuable information to the study.

In order to minimize any bias, the respondents shall be the person that used to walk everyday around the campus and college area especially going to and from college to faculty along the chosen route such as Jalan Alpha, Jalan Universiti, Persiaran Tulang Daing, Lorong Asam Jawa and Persiaran Asam Jawa. Another route chosen was around faculty area including Persiaran Tulang Daing, Jalan Sapucaya, Persiaran Asam Jawa and Lorong Asam Jawa 1.

3.3.3.2 TRAP Measurement

TRAP measurement was conducted along designated route (Figure 3) in measuring pedestrian exposure during walking in which the researcher will bring along the instruments during commuting to represent the pedestrian exposure. The researcher carried handheld instruments such as Dust Trak II and Aeroqual S500 while SidePak was put in the researcher's backpack to measure the pollution levels (Steinle, Reis, & Sabel, 2013). The levels of pollution along the route were presented in the result. Measurement was conducted in a good weather condition in which the rainy days will be excluded as sampling days as it may affect the measurement. Road traffic count, pollutant measurement and meteorological parameters were done simultaneously at the study location. Before roadside measurement, background

measurement was conducted for 30 minutes at different location. Background measurement was conducted at the location far from the source of traffic pollution.



Figure 4 : Researcher conducted TRAP measurement

3.3.4 Inclusion and Exclusion Criteria

Inclusion criteria :

- a. Students of Canselor College, Tun Dr Ismail College, Second College, Sultan Alaeddin Suleiman Shah College, and Fifth College
- b. Students who are walking to and from college to faculty along designated route
- c. Students who do not have medical history which may act as confounder
- d. Male and female
- e. Age of respondents shall be less than 26 years old (Undergraduate students)

Exclusion criteria :

- a. Students from other than selected colleges such as Pendeta Za'ba College, Tun Perak College, Mohamad Rashid College, Sixth College, 12th College, 13th College, 14th College, 15th and 16th College
- b. Students who are commuting to and from college to faculty using any type of vehicles such as cars, motorcycles, bicycles or buses
- c. Students aged more than 27 years old (Did not include postgraduate students)
- d. Students who take medications during research done

3.4 Study Instrumentation

Questionnaires

Questionnaires were used in this study to gather information on the respondents' socio-demographic characteristics, health status and respiratory-related symptoms they ever experienced along the route around the campus. Questionnaires are divided into two sections which Section A is a self-developed and Section B is adapted from Standardized Questionnaires from International Union Against Tuberculosis and Lung Disease (IUATLD) on Respiratory Symptoms. Questionnaires were randomly distributed to the people who mainly walking around the colleges and faculty area. The respondents also were chosen based on inclusion and exclusion criteria stated by the researcher.

Dust Trak II 8532

Particulate matter such as PM_{10} are measured using Dust Trak II (TSI Incorporated). The characteristics of the device are handheld battery-operated, data-logging, light-scattering laser photometer that allow real-time measurements. It is suitable to be used for measurement in office, industrial workplace, construction and environmental sites. The instrument was bring along with the researcher during measurement. Researcher walked through the route chosen with the instrument. All the data measured by the instrument were being logged for every one minute interval. Measurement was conducted from January till March 2018 and during clear and sunny days. Rainy and bad weather day were excluded from measurement because it could affect distribution of pollutants by diluting it.

SidePak AM520

SidePak AM520 (TSI Incorporated) is an equipment used as personel aerosol monitor which is portable, battery-operated, data logging and light-scattering laser photometer. The equipment can measured particulate matter varied in size such as PM_1 , $PM_{2.5}$, PM_4 , PM_5 and PM_{10} by changing the impactor. It can be used to conduct real-time measurement and produce the data instantly. The instrument was bring along with the researcher during measurement. Researcher walked through the route chosen with the instrument and data measured by the instrument were being logged for every one minute interval. Measurement was conducted from January till March and during clear and sunny days. Rainy and bad weather day were excluded from

measurement. Different instruments were used to measure particulate matter because the particulate matter need to be measured at the same time.

Aeroqual S500

Aeroqual S500 (Aeroqual Limited) is a handheld device. It is measuring device for ozone (O_3) to measure accurate ambient gas in the environment. The device consists of monitor base, sensor head, rechargeable battery and also additional temperature and relative humidity sensor. It is interchangeable sensor head. It can be used up to four to six hours when it is fully charged. Aeroqual S500 also consists of alarm that will appear in certain condition. While walking, researcher brought along the instruments and collected the data for one minute interval. The instrument was being put on the backpack carried by the researcher during walking to represent the exposure of pedestrian to ozone while walking. Measurement was conducted from January till March 2018 and during clear and sunny days. Rainy and bad weather day were excluded from measurement.

Traffic count form

Traffic count survey is the survey conducted to count number of vehicles that are using the specified road. In this study we conducted traffic count survey during the measurement of traffic-related air pollution. The type of vehicles were classified into six different group such as bicycle, motorcycle, cars and taxis, buses, light good vehicles and heavy good vehicles. Traffic count survey was conducted at the same time while measuring all the parameters during walking. Research assistant did the

traffic count survey along the route where researcher used. This method was being done to know the number of vehicles used the road with the levels of pollutants at the road.

3.5 Data Collection Technique

Background measurements were taken for 30 minutes before measurement of traffic-related air pollution were conducted. Then, measurement of traffic-related air pollution were conducted at sampling site. Then, consent form and questionnaires were distributed. The respondents who fulfil the inclusion and exclusion criteria and agreed to participate in the study were recruited. Finally, data from measurement of traffic-related air pollution and questionnaires answered were analyzed.

3.6 Data analysis

All data were analysed by using SPSS version 22. Descriptive study was used to measure the mean, median, percentage, mode and standard deviation. Kolmogorov Smirnov and skewness test were used to determine the normality of the data collected. Appropriate test for further analysis were determined after that. Below are the statistical analysis used to analyse every objective of this study:

Table 2 : Statistical Analysis of Research Objectives

Objectives	Type of Analysis
To compare background and roadside measurement of traffic-related air pollution (TRAP)	Mann-Whitney U test
To determine relationship of traffic-related air pollution (TRAP) exposure and respiratory symptoms	Independent T-test
To determine association of sociodemographic factors and respiratory symptoms	Chi square
To determine association of motor vehicle traffic counts and traffic-related air pollution (TRAP)	Pearson correlation/Spearman rho

3.7 Quality Control

Questionnaires

The modified questionnaires were used in this research was pre tested on 10% of total respondents to ensure its reliability and validity. Cronbach's Alpha Test was used to tested the result in which value of 0.7 and above shows that the reliability and validity of the questionnaires were acceptable.

Traffic-Related Air Pollution (TRAP) Assessment

All equipment used in this research were calibrated first according to manufacturer's standard to avoid any error of the equipment. Before conducting the measurement at the study location, background measurement were conducted at location away from sampling site to monitor daily background concentration of pollutants. Background measurement were conducted 30 minutes before real measurement so that day-to-day differences of background concentration can be adjusted.

3.8 Ethical Approval

Ethical approval for this research was obtained from the Research Ethic Committee of Universiti Putra Malaysia. All data and information collected were kept confidential between the researcher and respondents and only used for research and scientific publication purposes only.

3.9 Health and Safety

Before conducting the measurement, researcher did risk assessment to identify any risk that may occur during measurement. Then, mitigation measure were taken to ensure the safety of researcher and researcher's assistant. During measurement, researcher wore protective clothing to ensure other road users aware the presence of researcher conducting the research.

CHAPTER 4

RESULTS

4.1 Socio – Demographic, Medical History and Respiratory Symptoms of Respondents

Socio-demographics, medical history and respiratory symptoms of respondents

Questionnaires used were self-administered and adapted from American Thoracic Society, Division of Lung Disease 1978. It consists of Section A on socio-demographic information and medical history while Section B on respiratory symptoms. For the data analysis, descriptive statistics were used to determine the distribution of data from respondents such as socio-demographics, medical history and respiratory symptoms.

Socio-demographics of respondents

From the questionnaires distributed among students of UPM Serdang campus, there were total of 45 respondents recruited in this study. Socio-demographic data on age, gender, BMI, ethnic and smoking status were being asked. From the questionnaires distributed, it can be concluded that most of the respondents aged more than 20 years old which comprised of 33 out of 45 respondents. For the

gender, female were the highest participated in the study 33 people (73.3%). Distribution of BMI shown that 29 respondents (64.4%) are normal, followed by overweight category 12 respondents (26.7%), underweight 3 (6.7%) and obese 1 (2.2%). The randomly distributed questionnaires shown that the respondents comprised of Malay (84.4%), Others (6.7%), Indian (4.4%) and Chinese (2.2%). All of the respondents are pedestrian who commute the faculty and they usually spend about 10 – 20 minutes per trip. The respondents collected were also did not taken any medication 6 months prior the study.

All the data collected were being presented in the table as follows :

Table 3 : Socio-demographic Data of Respondents (N=45)

Socio-demographics	Frequency (%)
Age	
Under 20	12 (26.6)
21 – 25	33 (73.4)
Gender	
Male	12 (26.7)
Female	33 (73.3)
BMI	
Underweight	3 (6.7)
Normal	29 (64.4)
Overweight	12 (26.7)
Obese	1 (2.2)
Ethnic	
Malay	38 (84.4)
Indian	2 (4.4)
Chinese	1 (2.2)

Others	3 (6.7)
Smoking status	
Yes	0 (0)
No	45 (100)

Medical history of respondents

Medical history information of respondents being included such as an injury or operation affecting the chest, heart trouble, bronchitis, pneumonia, pulmonary tuberculosis, bronchial asthma, hay fever and other chest trouble. Descriptive statistics were used to determine the frequency and percentage of the distribution.

Medical history of the respondents were also obtained in this study. The data were collected on their health history such as had injury or operation affecting their chest, heart trouble, bronchitis, pneumonia, pulmonary tuberculosis, hay fever and other chest trouble. Data collected shown that only one person had injury or operation affecting their chest while no respondents were having heart trouble and bronchitis. Other medical problems such as pneumonia, pulmonary tuberculosis and other chest trouble resulted in one person had each of the health problems which means that three of respondents ever had pneumonia, pulmonary tuberculosis and other chest trouble. Moreover, there were three out of 45 respondents who had hay fever before.

Table 4 : Medical History Information of Respondents

Medical History	Frequency (%)
An injury or operation affecting your chest	
Yes	1 (2.2)
No	44 (97.8)
Heart trouble	
Yes	0
No	45 (100)
Bronchitis	
Yes	0
No	45 (100)
Pneumonia	
Yes	1 (2.2)
No	44 (97.8)
Pulmonary tuberculosis	
Yes	1 (2.2)
No	44 (97.8)
Hay fever	
Yes	3 (6.7)
No	42 (93.3)
Other chest trouble	
Yes	1 (2.2)
No	44 (97.8)

Respiratory symptoms reported by respondents

Descriptive statistics were used in determining the number of respondents having the symptoms of respiratory-related problems. Frequency and percentage of the symptoms were analysed from 45 respondents who answered the questionnaires.

Respiratory symptoms were another variables being collected from the questionnaires. Questions being asked were on wheezing and tightness in the chest, shortness of breath, cough and phlegm, breathing and illness on asthma. Results shown that there were five (11.1%) ever had the wheezing and tightness related problem in the last 12 months. About 40 person (88.9%) never had any wheezing or whistling in the chest. Respondents reported that some of the condition persist for 2 months and some of respondents with symptoms only had the problem sometimes only.

For symptoms shortness of breath, there were 8 respondents (17.8%) had attack of shortness of breath when not doing anything strenuous, 5 respondents (11.1%) had attack of shortness of breath after stopped exercise and 3 respondents had an attack of shortness of breath at night. Out of 45 respondents, 18 of them were having an attack of coughing at night, 10 were usually would coughing in the morning and 12 usually bring up phlegm in the morning.

Breathing problems shown that most of the respondents did not have much problems with the breathing. 15 respondents never or rarely get trouble with

breathing, 10 respondents get regular trouble with breathing but it usually get completely better and 3 respondents had uncomfortable feeling with their breathing. Less respondents also having sensitivity with any allergen as 39 (86.7%) did not have any feeling of tightness of chest and only 9 (20.0%) feel short of breath with the existing of allergen.

Table 5 : Respiratory Symptoms of Respondents

Respiratory Symptoms	Frequency (%)
Wheezing and Tightness in the Chest	
Had wheezing or whistling in the chest last 12 months	
Yes	5 (11.1)
No	40 (88.9)
Woken up with feeling of tightness in the chest first thing in the morning last 12 months	
Yes	5 (11.1)
No	40 (88.9)
Shortness of Breath	
Attack of shortness of breath when not doing anything strenuous	
Yes	8 (17.8)
No	37 (82.2)
Attack of shortness of breath after stopped exercise	
Yes	5 (11.1)
No	40 (88.9)
Woken up at night by an attack of shortness of breath	
Yes	3 (6.7)
No	42 (93.3)
Cough and Phlegm	
Woken up at night by an attack of coughing	
Yes	18 (40.0)
No	27 (60.0)

Cough first thing in morning	
Yes	10 (22.2)
No	35 (77.8)
Bring up phlegm first thing in morning	
Yes	12 (26.7)
No	33 (73.3)
Breathing	
Never or rarely get trouble with breathing	
Yes	15 (33.3)
No	30 (66.7)
Regular trouble with breathing	
Yes	10 (22.2)
No	35 (77.8)
Breathing never quite right	
Yes	3 (6.7)
No	42 (93.3)
Animal, dust, feathers	
When you are in dusty house or with the animals :	
Tightness in the chest	
Yes	6 (13.3)
No	39 (86.7)
Short of breath	
Yes	9 (20.0)
No	36 (80.0)
Illness	
Ever had attack of asthma	
Yes	6 (13.3)
No	39 (86.7)
Attack of asthma last 12 months	
Yes	3 (6.7)
No	42 (93.3)

Taking medicines, pills or inhalers for asthma

Yes	2 (4.4)
No	43 (95.6)

4.2 Air Pollutants Concentrations of Study Location

Air pollutants concentration were being measured at two different location. The measurement used real-time monitoring by using DustTrak II, SidePak AM 520 and Aeroqual S500. Mobile measurement were conducted in this study at Road 1 and Road 2 (Figure 2).

Road 1: Jalan Alpha, Jalan Universiti, Persiaran Tulang Daing, Lorong Asam Jawa and Persiaran Asam Jawa

Road 2 : Persiaran Tulang Daing, Jalan Sapucaya, Persiaran Asam Jawa and Lorong Asam Jawa 1.

4.2.1 Air Pollutants Concentration

The pollutants concentrations were measured in both locations which nearby residential college and faculty area. Data obtained from all measurements were averaged to know the mean concentration of the pollutants during each rush hour.

The result of the analysis were below :

Road 1 showed the highest number of vehicles using the road was during morning rush hour. Therefore, the pollutants level such as $PM_{2.5}$ and PM_{10} were highest which mean and standard deviation of $PM_{2.5}$ was 51.16 ± 12.13 while PM_{10} 94.69 ± 27.70 . However, O_3 levels were the lowest as compared to afternoon and evening rush hour with concentration of $30.91 \mu g/m^3$ and standard deviation, 7.89.

**Table 6 : Pollutants Concentrations of $PM_{2.5}$, PM_{10} and O_3 with Motor Vehicles
Traffic Count (TC) at Road 1 During Peak Hour (am, noon and pm)**

	n	TC	$PM_{2.5} (\mu g/m^3)$	$PM_{10}(\mu g/m^3)$	$O_3(\mu g/m^3)$
AM	7	235	51.16 ± 12.13	94.69 ± 27.70	30.91 ± 7.89
NOON	6	166	31.12 ± 8.00	53.48 ± 16.61	200.29 ± 124.15
PM	5	182	26.11 ± 13.92	48.62 ± 21.06	134.23 ± 51.17

Based on bar chart below, data were divided into different rush hour and month. Bar chart below showed the lowest concentration of O_3 during morning in all months research being conducted (January till March 2018). O_3 levels reach highest peak during afternoon and slightly decreased in the evening. Result obtained showed concentration of $PM_{2.5}$ were lower compared to PM_{10} at all rush hour.

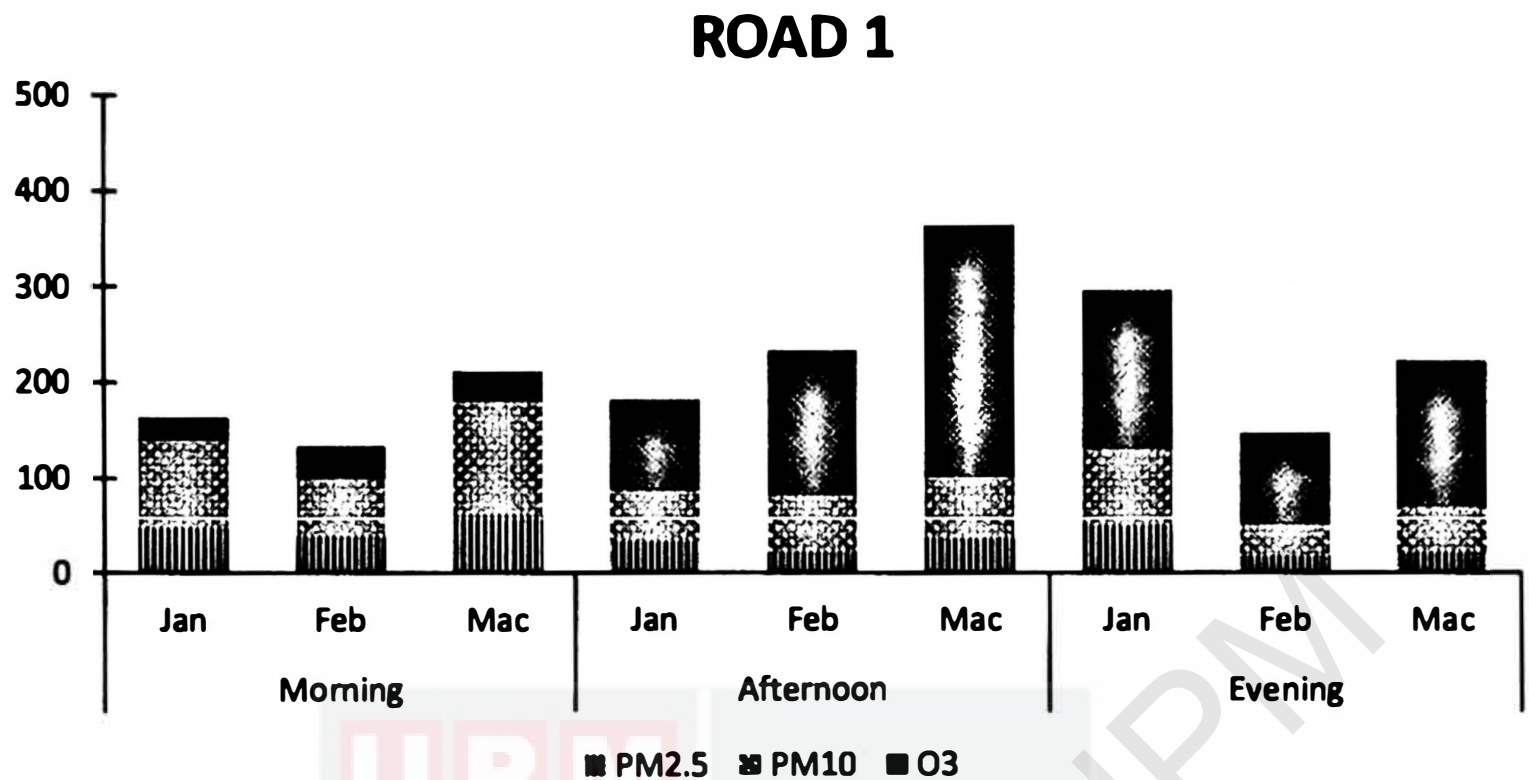


Figure 5 : Bar Chart of Pollutants Concentration of PM_{2.5}, PM₁₀ and O₃ at Road 1 During Different Peak Hour Observation and Month

Measurement of TRAP at Road 2 showed that evening rush hour pollutants levels was the highest among three rush hour. Mean and standard deviation of PM_{2.5} was 58.69 ± 9.68 , PM₁₀ 103.51 ± 13.78 and O₃ was 203.60 ± 63.36 . However, the highest number of vehicles counted was during morning rush hour with slightly difference with evening rush hour. O₃ levels at Road 2 also showed the lowest values in the morning time.

Table 7 : Pollutants Concentrations of PM_{2.5}, PM₁₀ and O₃ with Motor Vehicles Traffic Count (TC) at Road 2 During Peak Hour (am, noon and pm)

	n	TC	PM _{2.5} ($\mu\text{g}/\text{m}^3$)	PM ₁₀ ($\mu\text{g}/\text{m}^3$)	O ₃ ($\mu\text{g}/\text{m}^3$)
AM	6	166	49.45 ± 11.84	88.48 ± 20.62	34.48 ± 4.35
NOON	6	143	36.53 ± 9.09	71.50 ± 16.40	157.62 ± 52.35
PM	5	164	58.69 ± 9.68	103.51 ± 13.78	203.60 ± 63.36

Bar chart below showed the pollutants level in different rush hour and month. Road 2 showed highest concentration of pollutants ($PM_{2.5}$, PM_{10} and O_3) were during evening rush hour. There was huge differences of pollutants levels between morning and evening rush hour.

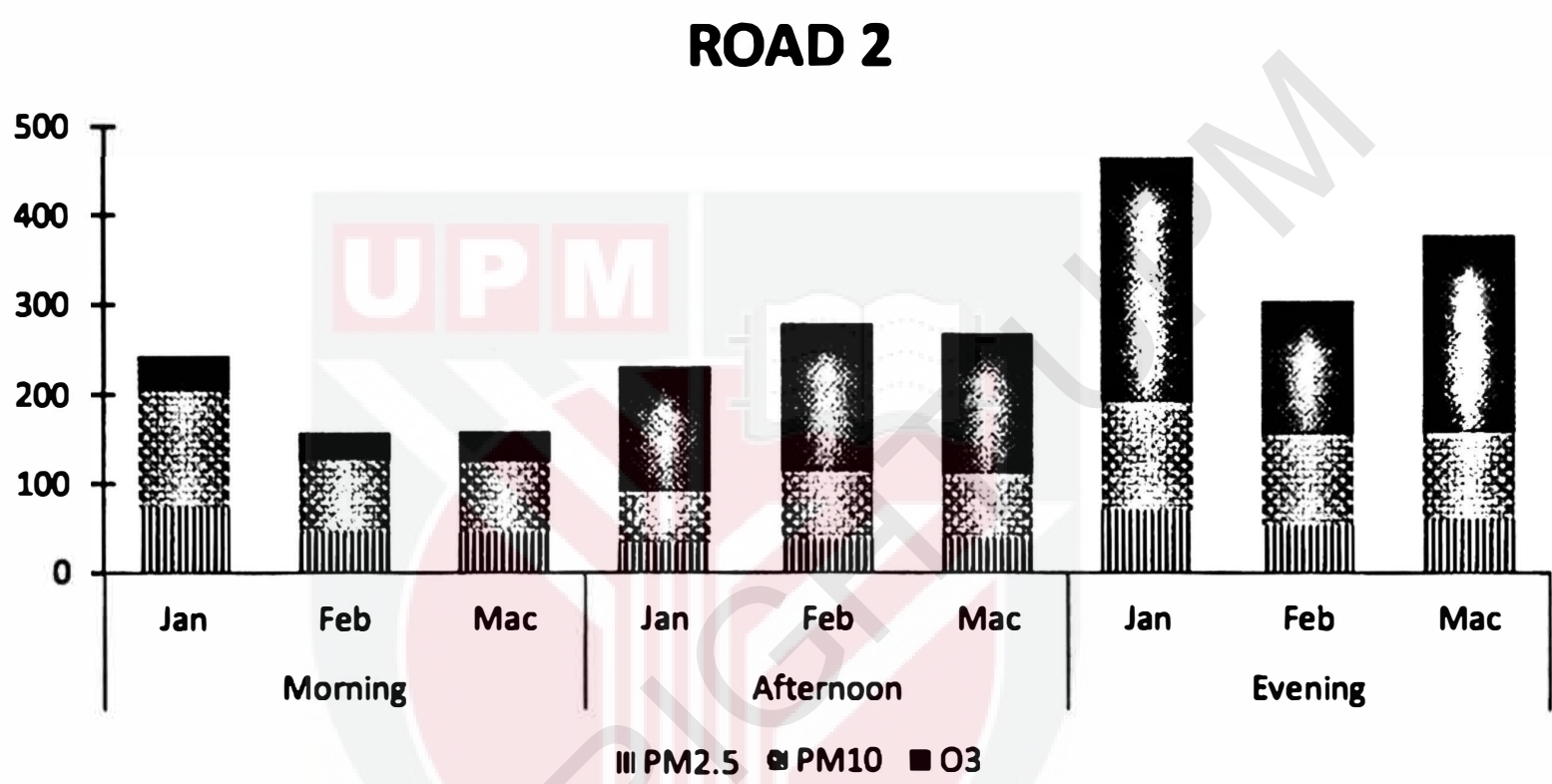


Figure 6 :Bar Chart of Pollutants Concentration of $PM_{2.5}$, PM_{10} and O_3 at Road 2 During Different Peak Hour Observation and Month

Average concentration of pollutants during measurement were being compared to the standard from WHO guidelines and Malaysia Ambient Air Quality Standard (MAAQS). Measurement of pollutants were only conducted for one hour during rush hour. Bar chart below shown the concentration of pollutants compared to MAAQS and WHO.

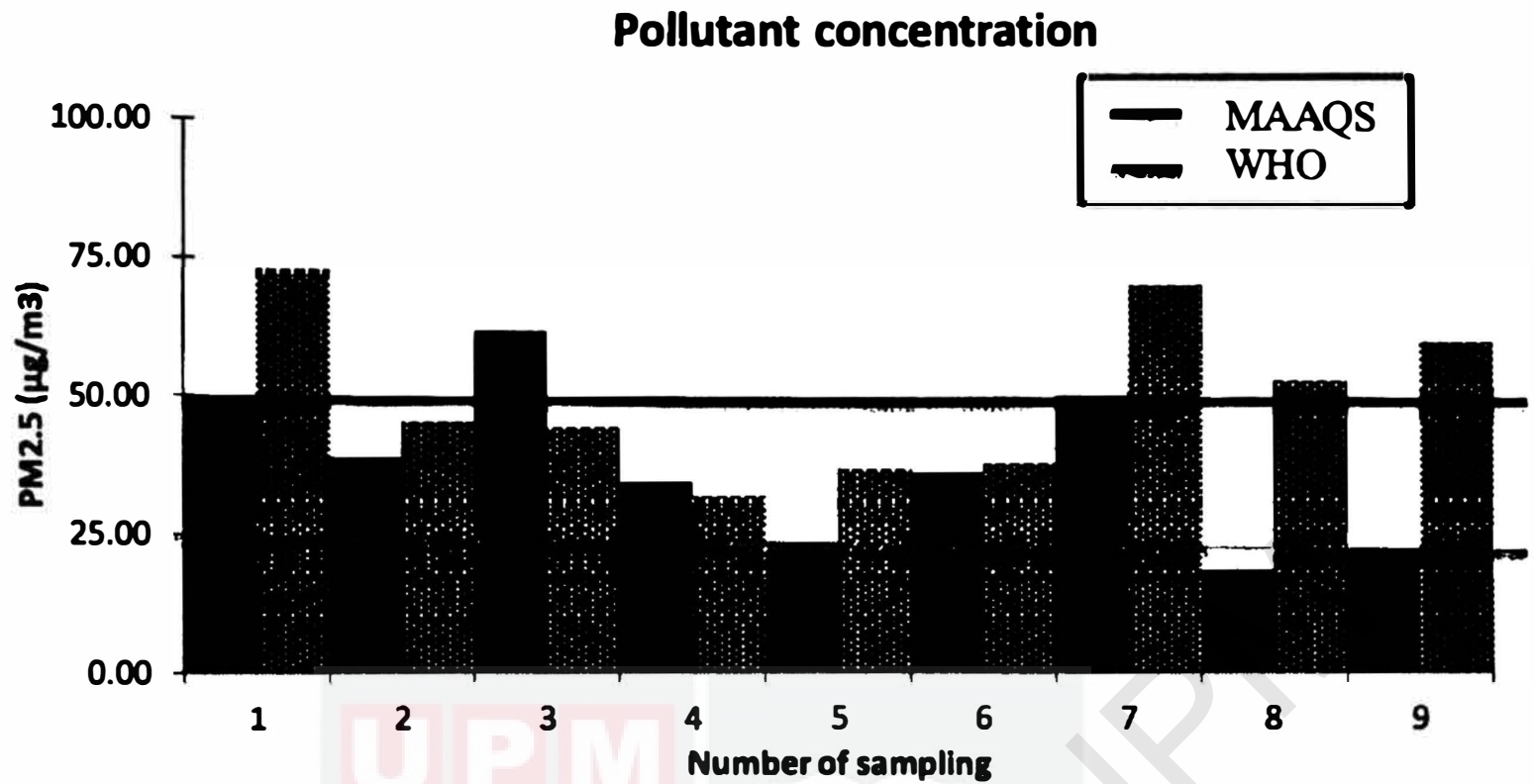


Figure 7 : Concentration PM_{2.5} with WHO and Malaysia Air Quality Standard

18 sampling were conducted for both road. The data collected were compared with standard of PM_{2.5} for 24 hour since the data only available for 24 hour and one year. WHO and MAAQS guidelines are being used in this study because they have different value for air quality standard. WHO stated that standard for 24 hour exposure shall not be more than 25µg/m³ while MAAQS standard higher which is 50µg/m³.

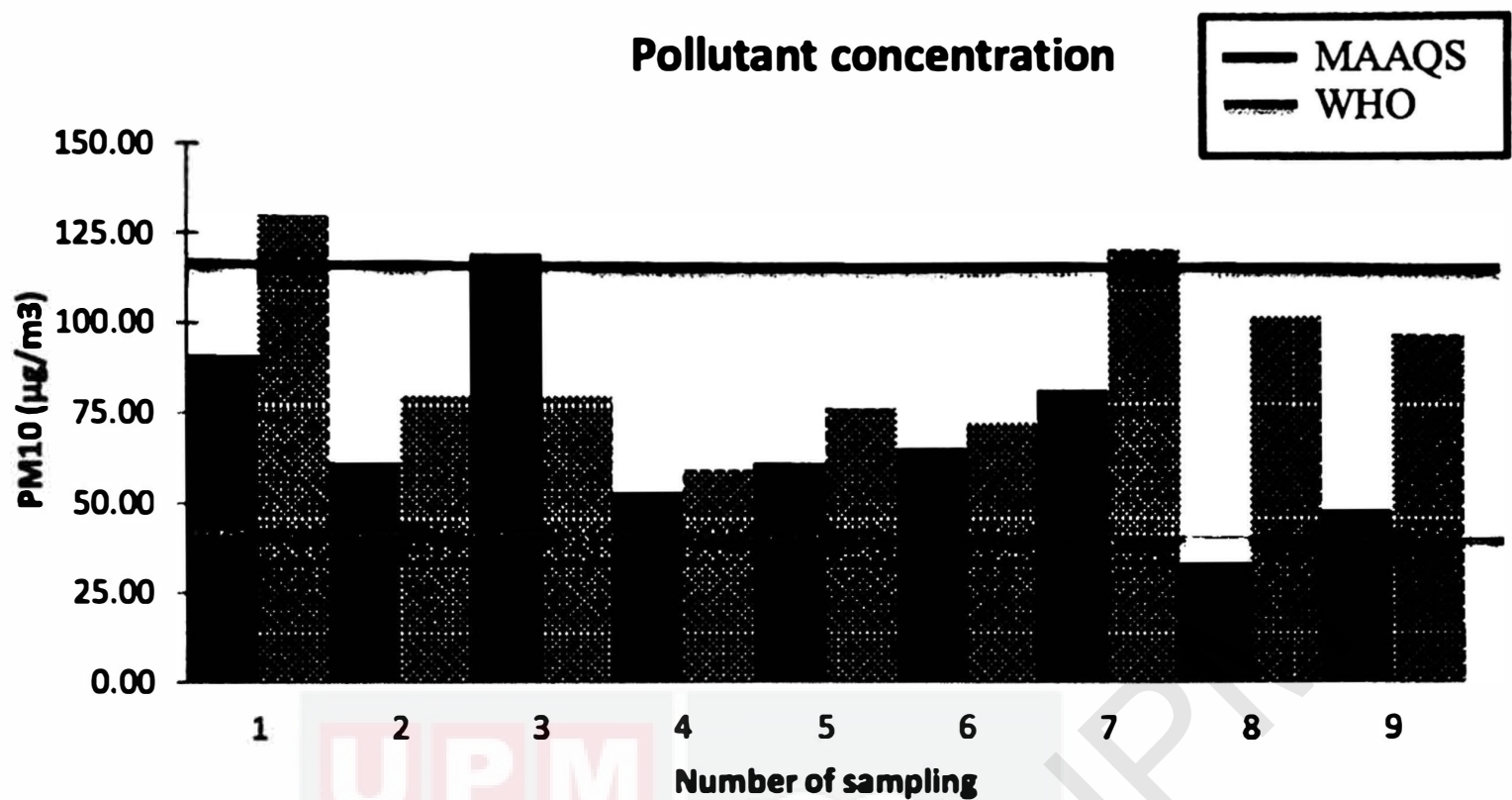


Figure 8 : Concentration PM_{10} with WHO and Malaysia Air Quality Standard

Standard limit for PM_{10} exposure set by WHO was $50 \mu\text{g}/\text{m}^3$ for 24 hour exposure while MAAQS limit was $120 \mu\text{g}/\text{m}^3$ for 24 hour. The data obtained from both road shown that pedestrian who used Road 2 during rush hour were highly exposed to TRAP. This can be seen from Figure 8 above. Although 24 hour standard are being used as comparison, we can see that one hour exposure during rush hour has exceeded the standard limit by WHO and MAAQS. PM_{10} concentration were very high at Road 2 which exceeded MAAQS limit, $120 \mu\text{g}/\text{m}^3$. Moreover, most of the concentration during rush hour were exceeded standard limit by WHO. One hour concentration could posed high risk for pedestrian having high exposure to those pollutants.

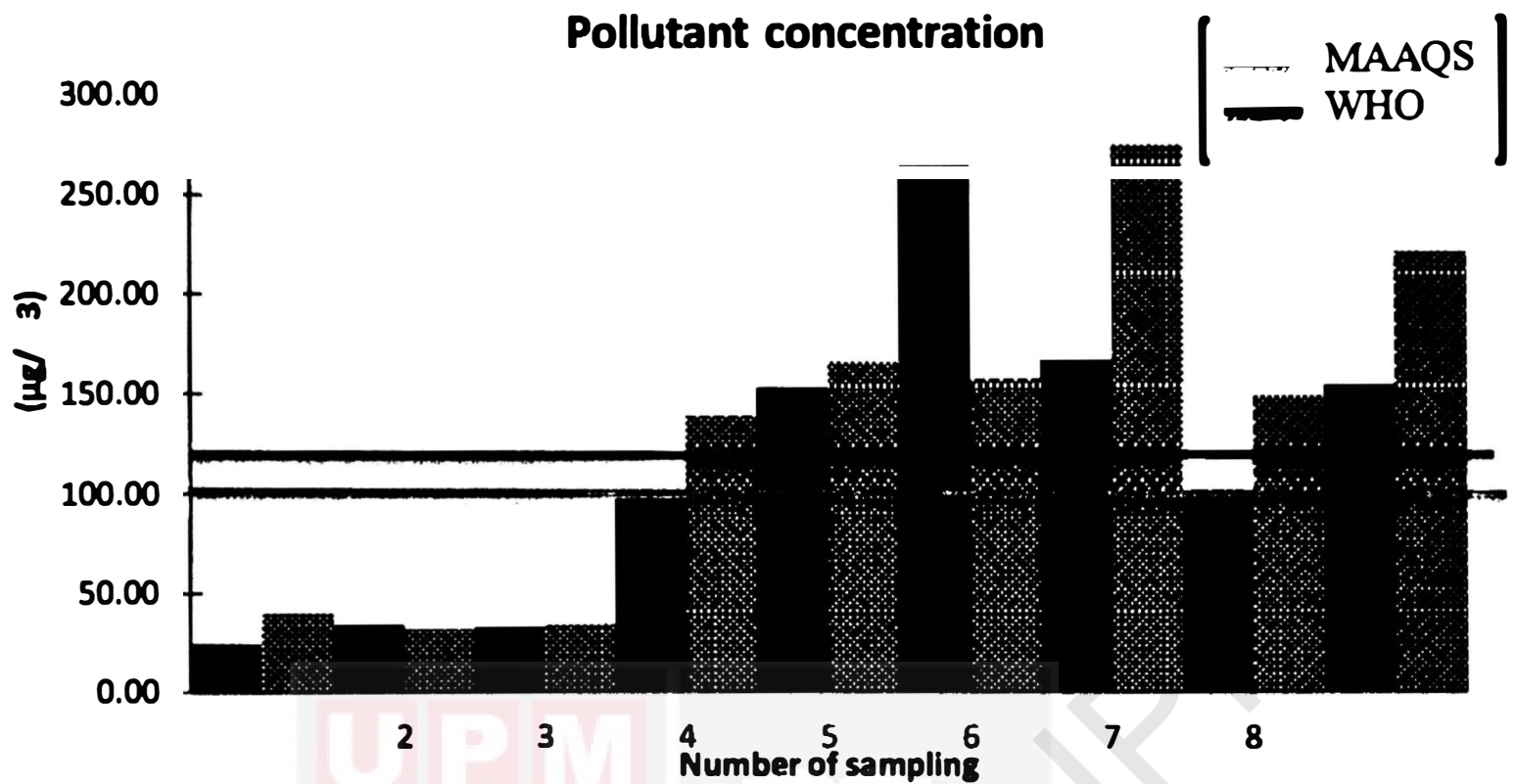


Figure 9 : Concentration O₃ with WHO and Malaysia Air Quality Standard

O₃ concentration for MAAQS is available for 1 hour and 8 hour while WHO standard only stated guidelines for 8 hour. Therefore, 8 hour concentration are being used as standard to be compared with the data collected. WHO stated 100 µg/m³ for 8-hour exposure while MAAQS stated higher guidelines which is 120 µg/m³. Based on average sampling for each day, the highest concentration of O₃ was 275.75 µg/m³ which has exceeded 8-hour standard limit by WHO and MAAQS. MAAQS stated that limit of O₃ in 1 hour shall not exceed 200 µg/m³, however, the concentration measured were exceeded the limit set by MAAQS.

4.2.2 Pedestrian Exposure to TRAP and Motor Vehicles Traffic Count

Traffic count were conducted to determine the number of vehicles using the road that were used in this study. During rush hour, the number of vehicles were counted simultaneously with the measurement of pollutants. The type of vehicles were grouped in three categories such as light, medium and heavy type of vehicles. Light vehicles consist of motorcycle, medium for cars and taxis while heavy category comprised of buses and good vehicles. Average traffic count calculated during measurement for Road 1 and Road 2 can be seen in the bar charts below.

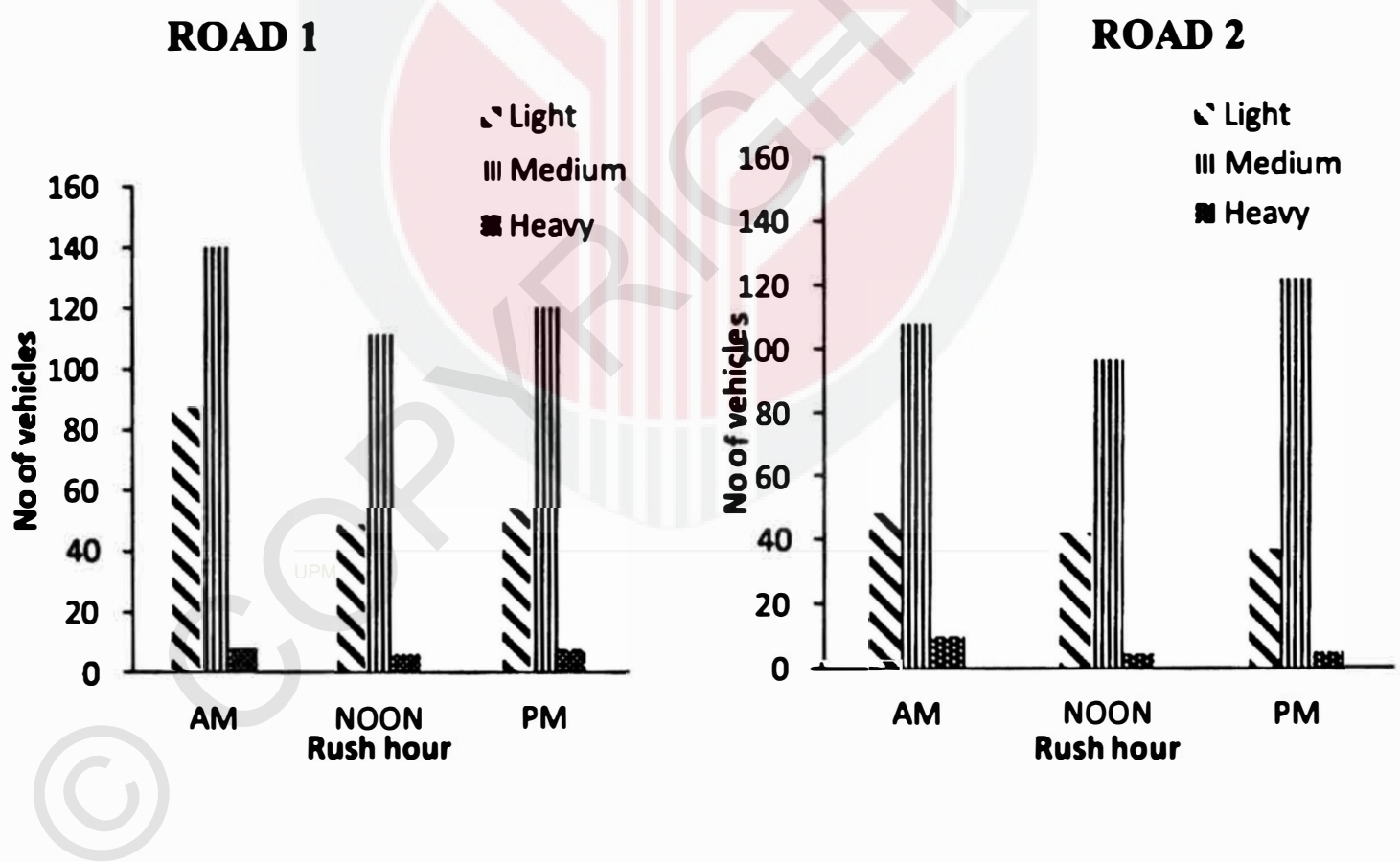


Figure 10 : Comparison of Vehicles Number during Different Rush Hour

The number of vehicles that used Road 1 and Road 2 also were being recorded based on the type of vehicles which were light, medium and heavy. Both road recorded the highest number of vehicles were medium type which comprised of

cars and taxis. At Road 1, the highest number of vehicles on the road were during morning, followed by evening and afternoon rush hour. While for Road 2, the highest number of vehicles were during evening. Afternoon rush hours seems to be lowest number of vehicles on both road, Road 1 and Road 2. At morning, afternoon and evening rush hour, most of the vehicles counted were cars and taxis.

ROAD 1

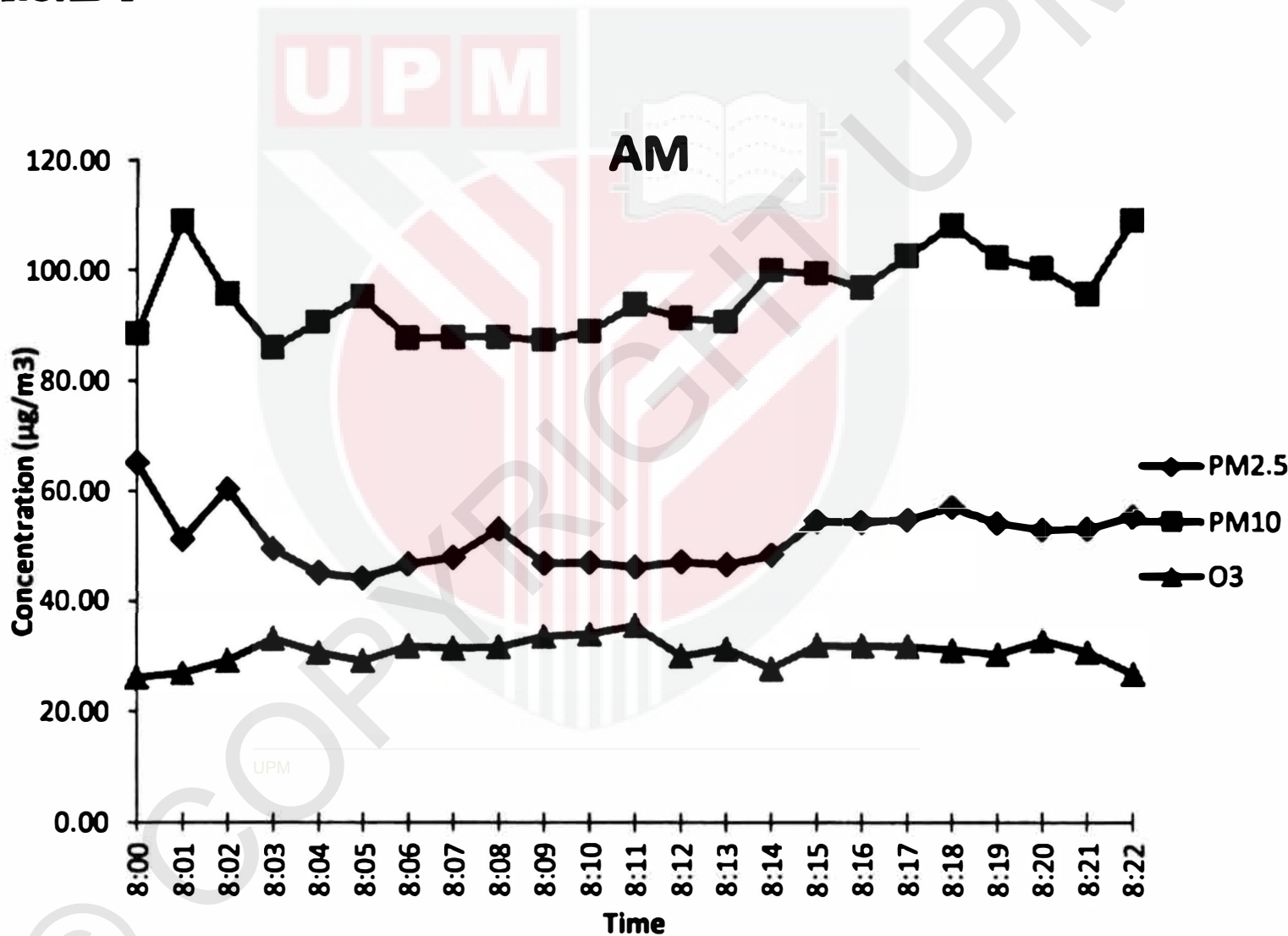


Figure 11 : Concentration of pollutants during morning rush hour (1-minute interval)

Figure 11 above shown the averaged concentration of pollutants measured at Road 1. Morning measurement were conducted along the route from 08:00 until 08:22.Total time was 22 minutes. As seen at figure above, highest pollutants measured were PM₁₀ as compared to PM_{2.5} and O₃. At 08:02, PM₁₀ achieved the

highest peak while $PM_{2.5}$ reduced and O_3 remained at low levels. Table shown the trend of pollutants concentration along the route which researcher used. O_3 and $PM_{2.5}$ did not have huge differences of concentration. PM_{10} was the only pollutants that keep on having changes of trend that varies each minute of measurement.

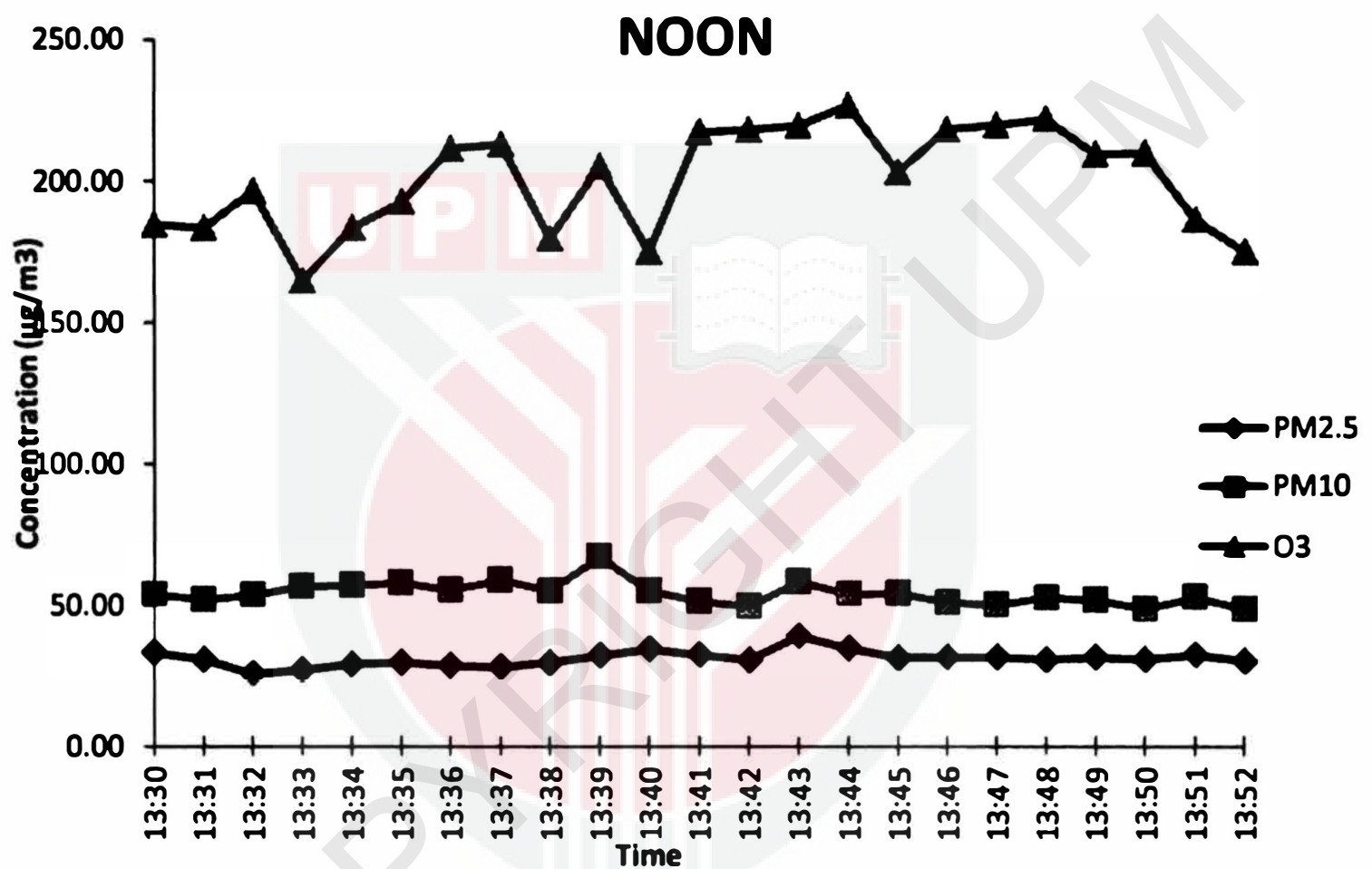


Figure 12 : Concentration of pollutants during afternoon rush hour (1-minute interval)

In the afternoon, the concentration pattern seems to change a lot. Figure 12 shown that the highest pollutants measured at the time was O_3 . O_3 have the highest concentration compared during morning rush hour. PM_{10} and PM_{10} remained steady at the baseline without having a lot of concentration differences between each minute. Averaged concentration of O_3 abruptly increased and decreased between each minute. Lowest O_3 levels was at 13:33 where the concentration suddenly drop while the highest could reach $227.00 \mu\text{g}/\text{m}^3$.

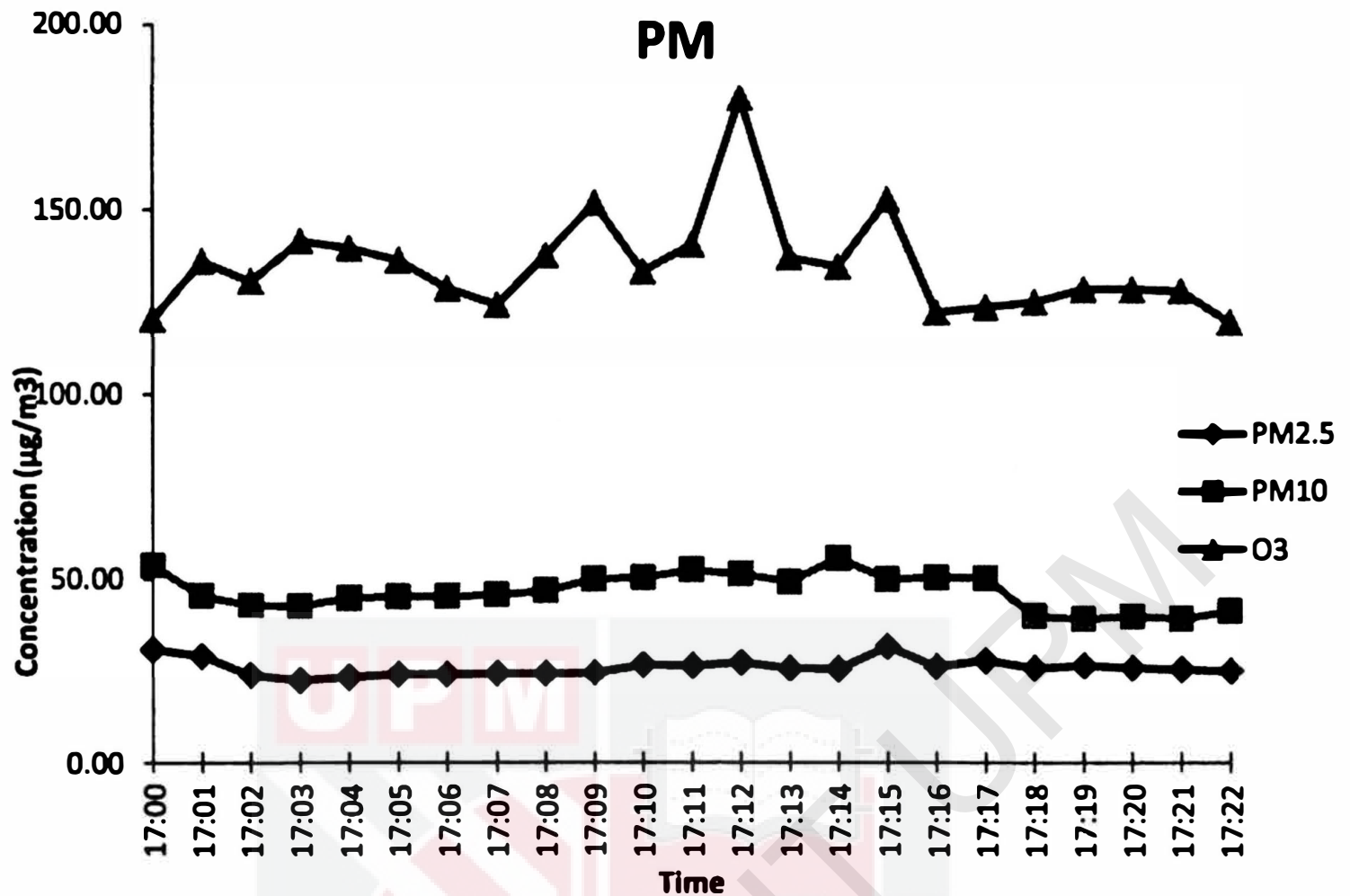


Figure 13 : Concentration of pollutants during evening rush hour (1-minute interval)

Evening rush hour also shown the highest concentration of O₃. PM_{2.5} and PM₁₀ concentration only having slightly changes of pattern throughout 22 minutes of measurement. Although the number of vehicles seems quite high, the levels of pollutants emitted did not increased as much as the vehicles were passing by the researcher during measurement. Only O₃ undergoes unexpected peak at 17:09, 17:12 and 17:15. The highest peak could reach 181.20 µg/m³ from 141.40 µg/m³ a minute before. However, at the same time PM₁₀ and PM_{2.5} levels did not increased and only at 51.60 µg/m³ for PM₁₀ and 27.40 µg/m³ for PM_{2.5}.

ROAD 2

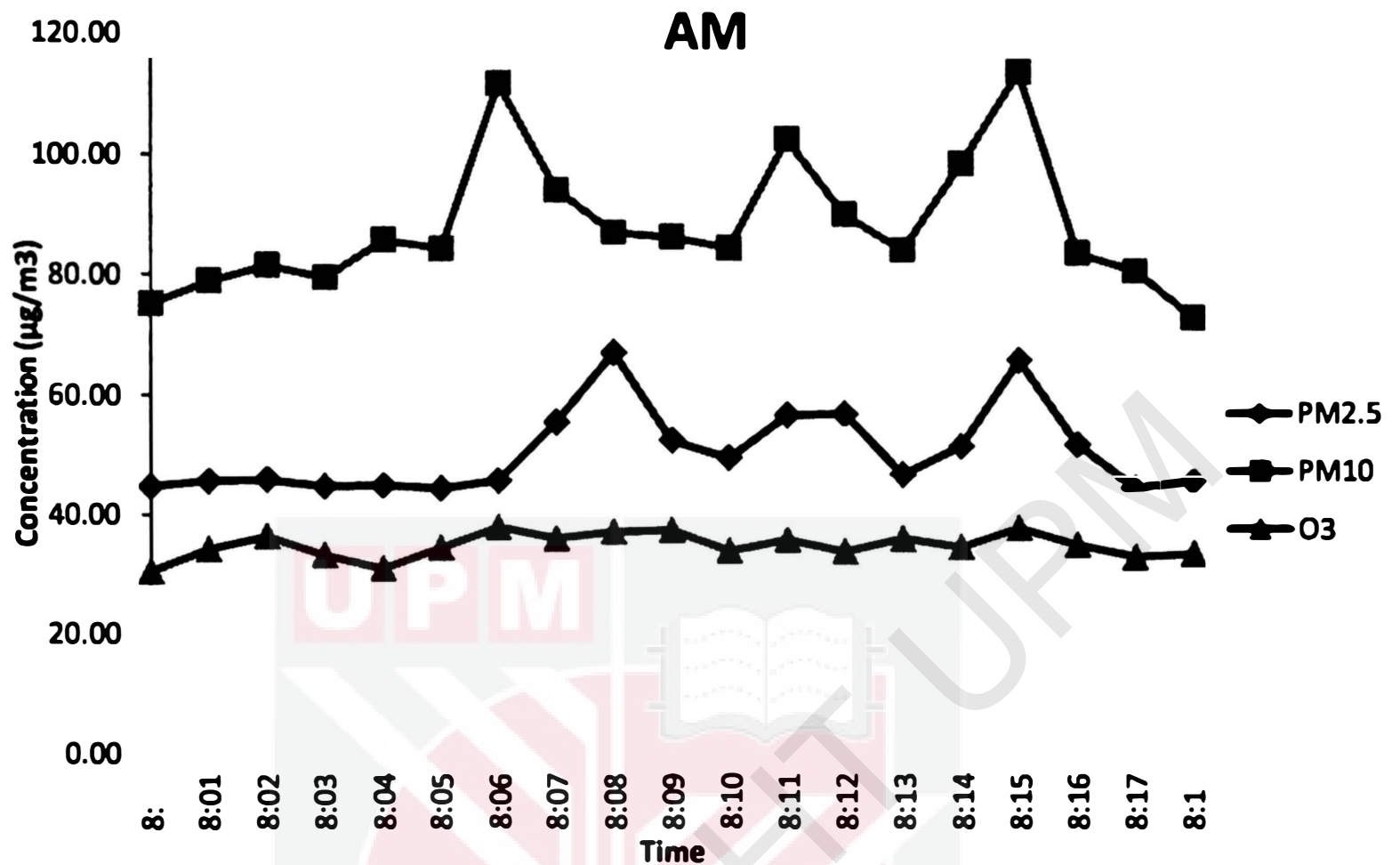


Figure 14 : Concentration of pollutants during morning rush hour (1-minute interval)

Road 2 in this study including Persiaran Tulang Daing, Jalan Sapucaya, Persiaran Asam Jawa and Lorong Asam Jawa 1. This is the main road used by students and staff to move around the campus area. All of the road except Lorong Asam Jawa 1 were one way road. Only Lorong Asam Jawa 1 was two-way road. Figure 14 above shown that during this time, PM_{10} levels were high as compared to $PM_{2.5}$ and O_3 . The first five minutes of measurements, all of the pollutants levels increased gradually. However, at 08:06 sudden peak of PM_{10} were observed while $PM_{2.5}$ and O_3 levels only increased slightly. Another peak of PM_{10} occurred at 08:15 which during this time, $PM_{2.5}$ also reached the highest levels. O_3 levels also increased at this point. However, after that point the pollutants levels gradually decreased.

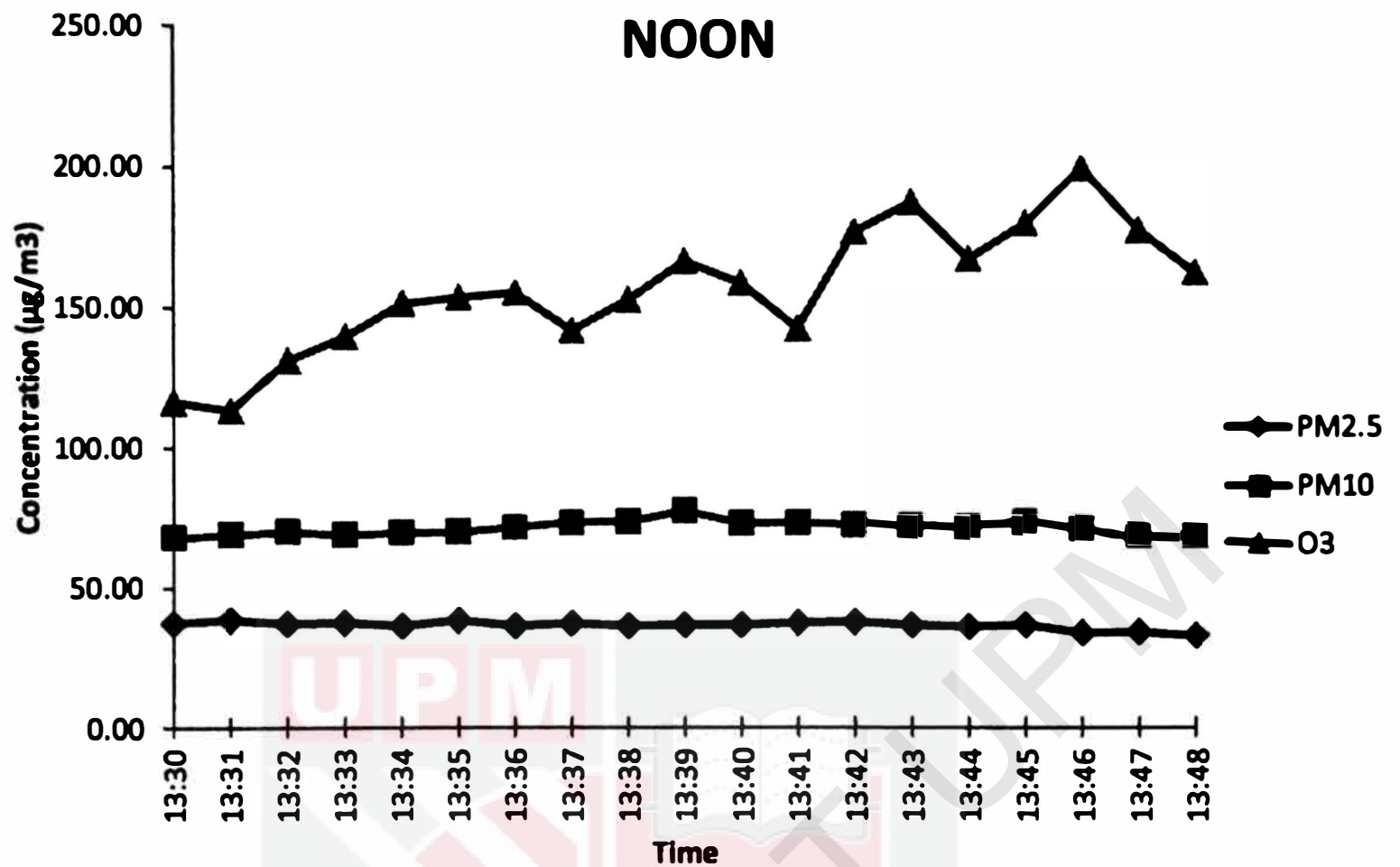


Figure 15 : Concentration of pollutants during afternoon rush hour (1-minute interval)

Measurement during afternoon shown uniform pattern of $PM_{2.5}$ and PM_{10} levels while O_3 abruptly increasing throughout 18 minutes of sampling. Graph pattern for O_3 were very different as compared to other pollutants. As seen in the figure above (Figure 15), O_3 reach the highest peak at 13:46 where the concentration was $200 \mu g/m^3$. O_3 concentration pattern keep on changed as it went through sudden peak and sudden drop in only one minute.

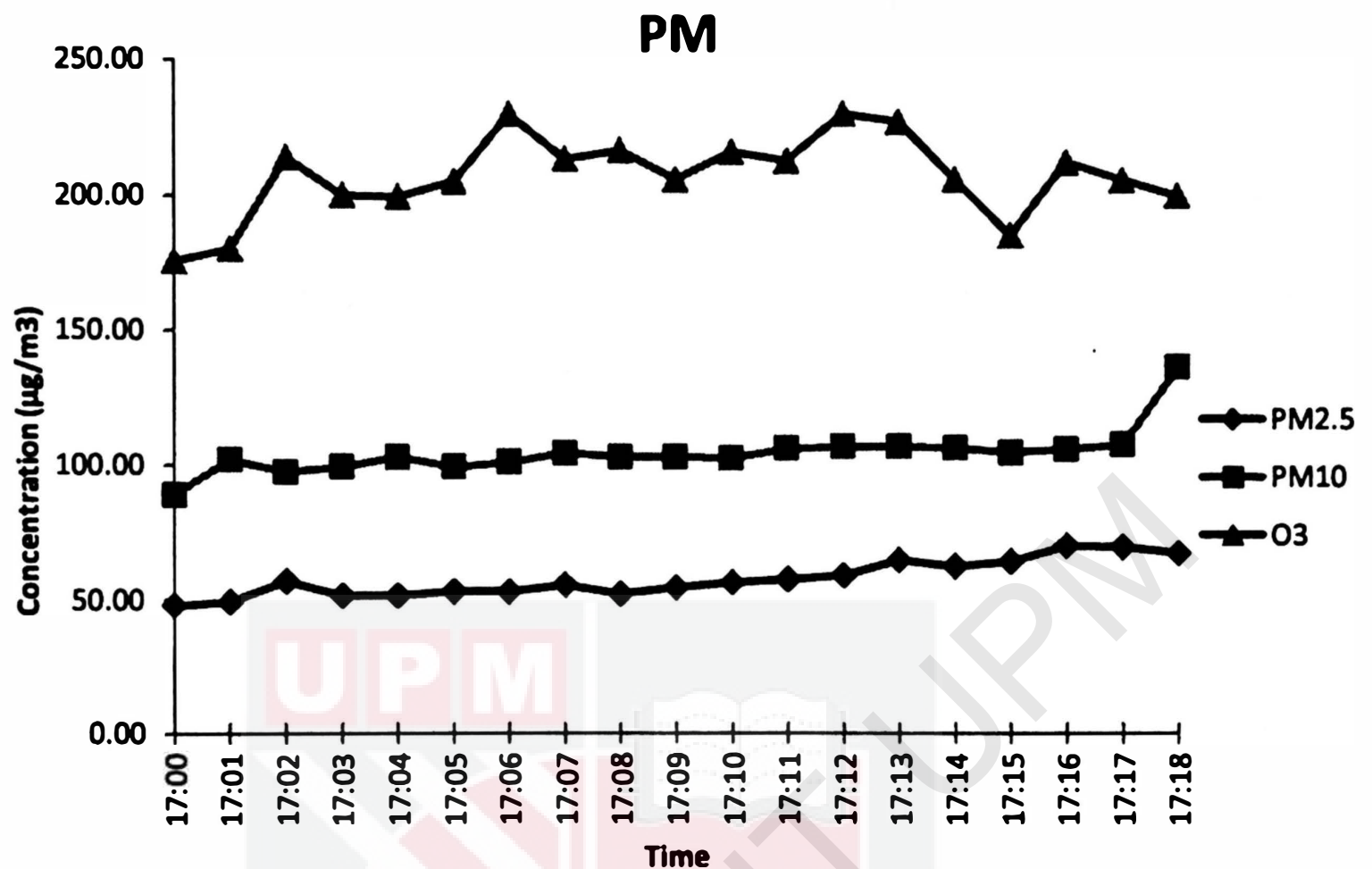


Figure 16 : Concentration of pollutants during evening rush hour (1-minute interval)

In the evening, O₃ has the highest levels followed by PM₁₀ and PM_{2.5}. At the first minute, O₃ levels was 175.40 µg/m³, while PM₁₀, 89.00 µg/m³ and PM_{2.5}, 47.80 µg/m³. Pattern of PM_{2.5} remained at the levels around 50.00 µg/m³ without any huge differences in each minute. PM₁₀ pattern also having the same condition as they did not undergo big concentration differences except at the last minute there was a peak levels which increased up to 136.00 µg/m³. However, O₃ levels at some point become high such as at 17:02 where the levels increased up to 214.40 µg/m³, 17:06 up to 230.80 µg/m³. There was also sudden drop of O₃ to 185.20 µg/m³ which occurred at 17:15. At the same time, PM levels seems do not changed although there was a high number of vehicles using the road.

4.3 Comparison Background and Roadside Measurement of TRAP

Before conducting measurement at both study location, background measurement were being conducted at the location far from the main source which was away from roadside. Background concentration were being measured by using the same instruments and used static measurement before conduct for both study location. DustTrak, SidePak and Aeroqual were being used.

The tables below (Table 8 and 9) were the result of averaged pollutants measured during background and roadside measurement. At Road 1, there were no pollutants that significantly differed between background and roadside measurement. All p-value of pollutants were more than 0.05 level. This means that no difference of pollutants distribution between background and roadside measurement. Although all the pollutants did not significantly different, the result reported that roadside concentration is higher than background as expected.

While Road 2 shown significant association of $PM_{2.5}$ and PM_{10} between background and roadside. P-value for $PM_{2.5}$ was 0.008 while PM_{10} was 0.009. Only O_3 did not have association of pollutants distribution between background and roadside. In the table 9 below, $PM_{2.5}$ averaged concentration at background were $36.17 \mu\text{g}/\text{m}^3$ while roadside $47.60 \mu\text{g}/\text{m}^3$. PM_{10} also have higher concentration of pollutants at roadside which is $84.44 \mu\text{g}/\text{m}^3$ compared to background which only $68.17 \mu\text{g}/\text{m}^3$. On the other hand, O_3 at background were higher when compared to roadside. This could be due to other factors involved.

Table 8 : Comparison Pollutants during Background and Roadside Measurement at Road 1

	Median (IQR)		Z	p-value*
	Background	Roadside		
PM2.5	29.34 (18.67, 38.59)	37.26 (23.10, 48.66)	-0.775	0.483
PM10	56.09 (36.63, 82.96)	60.38 (44.03, 87.64)	-0.696	0.486
O3	70.25 (24.38, 110.38)	96.29 (31.04, 176.21)	-1.044	0.296

^aMann-Whitney U test
p-value significant < 0.05 level

Table 9 : Comparison Pollutants during Background and Roadside Measurement at Road 2

	Median (IQR)		Z	p-value
	Background	Roadside		
PM2.5	36.17 (31.59, 39.42)	47.60 (36.38, 52.41)	-2.670	0.008*
PM10	68.17 (59.92, 74.67)	84.44 (68.55, 101.47)	-2.601	0.009*
O3	132.00 (26.25,241.75)	122.19 (36.88, 220.30)	-0.086	0.931

^aMann-Whitney U test
*p-value significant < 0.05 level

4.4 Relationship between TRAP Exposure and Respiratory Symptoms

Traffic-related air pollution (TRAP) exposure could result differently to individuals. People might have different symptoms of respiratory related problems due to the exposure. Respiratory symptoms being studied such as wheezing, tightness in the chest, shortness of breath, cough, phlegm, allergic sensitization and asthma. In determining the significant difference of TRAP exposure and respiratory symptoms among respondents, Independent T-test analysis were used.

The result shown that pollutant $PM_{2.5}$ and PM_{10} concentrations have significant difference with symptoms of wheezing and shortness of breath. $PM_{2.5}$ and PM_{10} were significant difference with respiratory symptoms with p-value 0.017 and 0.019, which less than 0.05. Shortness of breath also associated with both PM with p-value, 0.040 and 0.039. O_3 did not shown any significant difference with any symptoms studied. All other symptoms such as tightness of chest, cough, phlegm, allergic sensitization and asthma were more than 0.05. There were no significant difference found between variables studied.

The result of the analysis were as below:

Table 10 : Mean difference of PM_{2.5} Concentration and Respiratory Symptoms

Respiratory Symptoms	PM _{2.5}	Mean	t-value	p-value
	Mean ± SD	difference (95% CI)		
Wheezing				
Yes	27.57 ± 8.96	-20.39 (-36.59, - 4.18)	-2.667	0.017*
No	47.96 ± 14.33			
Tightness in the Chest				
Yes	36.57 ± 13.79	-8.24 (-29.52, 13.05)	-0.820	0.424
No	44.80 ± 16.15			
Shortness of Breath				
Yes	30.94 ± 12.83	-16.06 (-33.58, 1.46)	-1.944	0.040*
No	47.00 ± 14.95			
Cough				
Yes	42.02 ± 17.91	-2.82 (-18.95, 13.31)	-0.371	0.716
No	44.84 ± 14.15			
Phlegm				
Yes	38.82 ± 15.98	-6.37 (-24.14, 11.38)	-0.761	0.458
No	45.20 ± 15.91			
Allergic Sensitization				
Yes	42.34 ± 26.92	-1.30 (-23.02, 20.42)	-0.127	0.900
No	43.65 ± 14.01			
Asthma				
Yes	22.17 ± 0.00	-22.51 (-55.79, 10.77)	-1.434	0.171
No	44.68 ± 15.26			

^aIndependent T test

^{*}p-value is significant < 0.05 level

Table 11 : Mean difference of PM₁₀ Concentration and Respiratory Symptoms

Respiratory Symptoms	PM ₁₀	Mean	t-value	p-value
	Mean ± SD	difference (95% CI)		
Wheezing				
Yes	53.09 ± 16.70	-33 (-61.44, -	-2.614	0.019*
No	87.03 ± 24.10	6.41)		
Tightness in the Chest				
Yes	67.15 ± 17.31	-14.80 (-50.62,	-0.876	0.394
No	81.95 ± 27.80	21.02)		
Shortness of Breath				
Yes	58.33 ± 21.76	-27.21 (-	-1.952	0.039*
No	85.53 ± 25.18	56.75,2.33)		
Cough				
Yes	81.52 ± 30.80	4.06 (-23.18,	0.316	0.756
No	77.45 ± 23.21	31.32)		
Phlegm				
Yes	72.84 ± 31.63	-9.20 (-39.32,	-0.648	0.526
No	82.04 ± 25.26	20.91)		
Allergic Sensitization				
Yes	79.05 ± 44.54	-0.52 (-	-0.030	0.976
No	79.57 ± 23.90	37.19,36.15)		
Asthma				
Yes	47.86 ± 0.000	-33.49 (-90.44,	-1.246	0.231
No	81.35 ± 26.11	23.47)		

^aIndependent T test

*p-value is significant < 0.05 level

Table 12 : Mean difference of O₃ Concentration and Respiratory Symptoms

Respiratory Symptoms	O ₃ Mean ± SD	Mean difference (95% CI)	t-value	p-value
Wheezing				
Yes	137.31 ± 27.77	28.07 (-43.38,	0.578	0.571
No	121.08 ± 91.28	75.84)		
Tightness in the Chest				
Yes	159.81 ± 6.53	42.15 (-6.69,	1.842	0.086
No	117.66 ± 87.39	90.99)		
Shortness of Breath				
Yes	110.45 ± 59.13	-18.31 (-118.15,	-0.389	0.703
No	128.76 ± 87.67	81.52)		
Cough				
Yes	107.92 ± 57.57	-33.53 (-115.02,	-0.872	0.396
No	141.46 ± 99.92	47.95)		
Phlegm				
Yes	92.30 ± 58.01	-44.84 (-134.86,	-1.056	0.307
No	137.14 ± 86.95	45.18)		
Allergic Sensitization				
Yes	111.46 ± 62.17	-15.87 (-127.45,	-0.302	0.767
No	127.33 ± 85.81	95.71)		
Asthma				
Yes	154.62 ± 0.00	31.69 (-149.59,	0.371	0.716
No	122.93 ± 83.10	212.97)		

^a Independent T test

^{*} p-value is significant < 0.05 level

4.5 Socio-demographics and Respiratory Symptoms

Socio-demographic of respondents might affect the risk of them getting respiratory-related symptoms. Therefore, statistical analysis were conducted to determine their relationship. Chi-square and Fisher exact test were being used for the analysis.

Gender and Respiratory Symptoms

Gender of respondents was one of socio-demographic information being collected from respondents. Respondents are divided into 12 male and 33 female with total of 45 respondents for this study. In the analysis, it was found that there were no evidence of difference of respiratory symptoms among male and female respondents. All of the respiratory symptoms p-value were more than 0.05.

Table 13 : Respiratory Symptoms of Respondents between Male and Female

Respiratory Symptoms	Gender		X ²	p-value
	Male	Female		
Wheezing				
Yes	2	3	-	0.598**
No	10	30		
Tightness in the Chest				
Yes	2	3	-	0.598**
No	10	30		
Shortness of Breath				
Yes	5	9	-	0.470**
No	7	24		

Cough				
Yes	6	16	-	1.000**
No	6	17	-	
Phlegm				
Yes	4	8	-	0.705**
No	8	25	-	
Breathing				
Yes	10	17	-	0.086**
No	2	16	-	
Allergic Sensitization				
Yes	2	10	-	0.466**
No	10	23	-	
Asthma				
Yes	2	5	-	1.000**
No	10	28	-	
Chi-square test				
*p-value significant < 0.05 level				
**Fisher exact test				

Age and Respiratory Symptoms

Age of the respondents were being grouped into under 20 and for 21 until 25 years old. This could determine whether age have the association with respiratory symptoms. In this study, we found out an association of age with coughing symptoms. People aged 21-25 have higher tendency of developing cough symptoms than aged under 20. Besides, younger people have higher risk of developing asthma as this study found an association of age with symptoms of asthma. Other symptoms did not significantly correlated with age.

Table 14 : Respiratory Symptoms of Respondents based on Age

Respiratory Symptoms	Age		X ²	P-value
	Under 20	21-25		
Wheezing				
Yes	1	4	-	1.000**
No	11	29		
Tightness in the Chest				
Yes	1	4	-	1.000**
No	11	29		
Shortness of Breath				
Yes	2	12	-	0.287**
No	10	21		
Cough				
Yes	2	20	6.799	0.009*
No	10	13		
Phlegm				
Yes	2	10	-	0.466**
No	10	23		
Breathing				
Yes	10	17	-	0.086**
No	2	16		
Allergic Sensitization				
Yes	2	10	-	0.466**
No	10	23		
Asthma				
Yes	4	3	3.937	0.047*
No	8	30		

Chi-square test

*p-value significant < 0.05 level

**Fisher exact test

BMI and Respiratory Symptoms

Body Mass Index (BMI) was another information being gathered. By doing this, researcher might determine whether respiratory symptoms experienced by the respondents was due to their BMI. BMI were divided into underweight, normal, overweight and obese group. Result obtained shown that no association were found between the difference of BMI with any of respiratory symptoms studied. All of the symptoms have p-value more than 0.05.

Table 15 : Respiratory Symptoms of Respondents based on BMI

Respiratory Symptoms	BMI				X ²	P-value
	Under - weight	Normal	Over - weight	Obese		
Wheezing						
Yes	1	2	2	0	2.522	0.471
No	2	27	10	1		
Tightness in the Chest						
Yes	0	2	3	0	3.365	0.339
No	3	27	9	1		
Shortness of Breath						
Yes	2	9	3	0	2.430	0.488
No	1	20	9	1		
Cough						
Yes	1	17	3	1	5.176	0.159
No	2	12	9	0		
Phlegm						
Yes	2	8	2	0	3.444	0.328
No	1	21	10	1		
Breathing						
Yes	1	19	7	0	2.771	0.428

No	2	10	5	1		
Allergic Sensitization						
Yes	1	7	4	0	0.799	0.850
No	2	22	8	1		
Asthma						
Yes	0	3	4	0	4.223	0.238
No	3	26	8	1		

Chi-square test

• p-value significant < 0.05 level

Ethnic and Respiratory Symptoms

Different ethnic also affect risk of getting respiratory problems. Since Malaysia consist of variety of ethnic, therefore some ethnic might have higher risk of getting respiratory diseases. Main ethnic were being selected which were Malay, Indian, Chinese and Others. Difference of ethnic also did not show significant association with respiratory symptoms. This may be because of the small sample size used in this study.

Table 16 : Respiratory Symptoms of Respondents based on Ethnicity

Respiratory Symptoms	Ethnic				X ²	P-value
	Malay	Indian	Chinese	Others		
Wheezing and Tightness in the Chest						
Yes	5	0	0	0	0.865	0.834
No	34	2	1	3		
Tightness in the Chest						

Yes	5	0	0	0	0.865	0.834
No	34	2	1	3		
Shortness of Breath						
Yes	13	0	0	1	1.452	0.693
No	26	2	2	2		
Cough						
Yes	19	0	1	2	3.338	0.342
No	20	2	0	1		
Phlegm						
Yes	10	0	1	1	3.566	0.312
No	29	2	0	2		
Breathing						
Yes	24	1	0	2	1.677	0.642
No	15	1	1	1		
Allergic Sensitization						
Yes	11	0	1	0	4.615	0.202
No	28	2	0	3		
Asthma						
Yes	6	1	0	0	2.544	0.467
No	33	1	1	3		

Chi-square test

*p-value significant < 0.05 level

4.6 Motor Vehicle Traffic Count and TRAP Concentrations

Traffic count of vehicles and TRAP concentration were being analysed in determining the relationship of those variables. The data were being analysed by using Pearson correlation analysis for Road 1 and Spearman rho correlation for Road 2.

The result shown that $PM_{2.5}$ did have significant correlation with number of motor vehicles using the road. This can be seen in the Table 15 and 16 shown that p-value were less than 0.05. This means that increased motor vehicles number contribute to the increasing concentration of $PM_{2.5}$. However, PM_{10} and O_3 did not have significant correlation with motor vehicles number. This may be due to other factors such as wind speed and temperature during measurement.

Although PM_{10} did not have significant relationship with traffic count, r-value showed that both of the variables have high relationship with each other. This means that increasing number of traffic count may lead to the increased levels of PM_{10} . Table 15 and 16 below showed that traffic count were positively correlated with $PM_{2.5}$ and PM_{10} levels at both route. However, O_3 have negative correlation with traffic count and no significant association was found.

The result of relationship of motor vehicles number and pollutants concentration at both road were shown in the tables below:

**Table 17 : Relationship of Motor Vehicles Traffic Count and Pollutants
Concentration at Road 1**

ROAD 1		
	Traffic counts	
	Coefficient (r)^a	p-value[*]
PM _{2.5}	0.669	0.049[*]
PM ₁₀	0.613	0.079
O ₃	-0.459	0.213
^a Pearson correlation [*] p-value is significant < 0.05 level		

**Table 18 : Relationship of Motor Vehicles Traffic Count and Pollutants
Concentration at Road 2**

ROAD 2		
	Traffic counts	
	Coefficient (r)^a	p-value[*]
PM _{2.5}	0.683	0.042[*]
PM ₁₀	0.633	0.067
O ₃	-0.250	0.526
^a Spearman rank correlation [*] p-value is significant < 0.05 level		

CHAPTER 5

DISCUSSION

5.1 Air Pollutants Concentration ($PM_{2.5}$, PM_{10} and O_3) of Study Location

Pollutants concentration were measured at two different location which were Road 1 and Road 2 (Figure 2).

Road 1: Jalan Alpha, Jalan Universiti, Persiaran Tulang Daing, Lorong Asam Jawa and Persiaran Asam Jawa (Residential College)

Road 2 : Persiaran Tulang Daing, Jalan Sapucaya, Persiaran Asam Jawa and Lorong Asam Jawa 1 (Faculty area)

5.1.1 Air Pollutants Concentration

Distribution of the pollutants concentration might be affected by many factors. Since meteorological parameters may affect distribution of the pollutants, the time of conducting the measurement matters. Since the study was conducted during rush hours, there were three different rush hours which were morning (0700-0800), afternoon (1300-1400) and evening (1700-1800). The data analysis also were separated into Road 1 and Road 2 as different road would have different characteristics and concentrations. Road 1 consist of Jalan Alpha, Jalan Universiti,

Persiaran Tulang Daing, Lorong Asam Jawa 1 and Persiaran Asam Jawa and the result shown that most of vehicles using this road in the morning as compared to afternoon and evening rush hour. This is because morning rush hour is the time people going to work and class as explained in study by Rahman et al. (2015) said that morning was the peak time of people went to work and sending off their children to school which would increase traffic volume and eventually higher pollutants level were emitted. Mostly, they used this road (Road 1) as it is the main road to colleges and out from colleges.

The highest concentration for morning measurements of $PM_{2.5}$ and PM_{10} were recorded with mean and standard deviation 51.16 ± 12.13 and 94.69 ± 27.70 while O_3 , 30.91 ± 7.89 . Data were collected from 0730 until 0830 am and it was the peak time when people going to work, school or class which would results in increased traffic volume. Study by Bereitschaft (2015) explained that pollutants concentration were peak in the morning was due to increased traffic volume and atmospheric conditions that were conducive in preventing dispersion of pollutants. The concentration of $PM_{2.5}$ and PM_{10} reduced in the afternoon may be because people did not go out during lunch break. Concentration eventually increased in the evening due to the fact that they went back from work or class as Rahman et al. (2015) stated that pollutants level increased after 1700 because people were went back to home from workplace.

Another route comprised of Persiaran Tulang Daing, Jalan Sapucaya, Persiaran Asam Jawa and Lorong Asam Jawa 1. This route was grouped as Road 2 in

the analysis. Road 2 did not have much difference on the traffic count between morning, afternoon and evening rush hours. During evening rush hours which is from 1700 until 1800, the mean and standard deviation of pollutants were $PM_{2.5}$ 58.69 ± 9.68 , PM_{10} 103.51 ± 13.78 and O_3 203.60 ± 63.36 . However, the number of vehicles counts did not show high results as only 164 vehicles used the road at that time. Road 2 showed highest concentration of pollutants were high in the evening, followed by morning and afternoon rush hour. This result was in line with result obtained in study by Ai et al. (2016) which they found that evening rush hour was recorded the highest level pollutants as compared to morning and afternoon rush hour.

Averaged concentration of TRAP were being compared to existing standard by WHO and Malaysia Ambient Air Quality Standard (MAAQS). Although the measurement were conducted for one hour only, the data were found to be higher than 24 hour standard. In a study Leong, Muttamara, & Laortanakul (2002), they found that averaged PM during rush hour varied between $78.53 - 157.18 \mu g/m^3$ which sometimes it exceeded 24 hour average limit set by in Thailand. This means that pedestrian that used the roads were pose to higher risk of developing health-related problem. The result were explained to be higher in study conducted by Hankey, Lindsey, & Marshall (2017) stated that pedestrian and cyclist have significant association with particulate concentrations especially on major roads as pedestrian mostly used passages around activity centre such as along main transportation roads which caused them to have high exposure to the pollutants.

5.1.2 Pedestrian Exposure to TRAP

High concentration of pollutants might affect the population nearby. Study by Q. Liu et al. (2017) said that exposed to high concentration of PM_{2.5} could increase risk of health-related problems such as respiratory tract related problems. This is because particles ranged 0.25 – 0.59 $\mu\text{g}/\text{m}^3$ have highest contribution as they existed in the air as much as 98% (Qiu et al., 2017). This means that smaller pollutants existed in our air and highly exposed to this pollutants could increase the risk of pedestrian to develop respiratory tract related problems.

In this study, pedestrian were exposed to high level of PM₁₀ almost during morning, afternoon and evening rush hour. This in line with study by Leong, Muttamara, & Laortanakul (2002) which they found that PM₁₀ were high throughout monitoring period and posed high risk of developing health-related problems such as lung capacity become reduced, respiratory disease, breathing problems and premature death. PM₁₀ concentration also could be an indicator for the health status of population.

Exposure to averaged O₃ was as high as 200 $\mu\text{g}/\text{m}^3$ during afternoon and up to 203 $\mu\text{g}/\text{m}^3$ in the evening. O₃ have the characteristics to change the patterns of breathing by increasing the frequency and reduce the volume of air being breathe in because the physical activity being done cause breathing mode to changes from nasal to oral which increase pollutants uptake into breathing system (Kesavachandran, Kamal, Bihari, Pathak, & Singh, 2015). Other study from Altu et al. (2014) proved

that O_3 were statistically significant with some upper respiratory tract complaints. This study found out that O_3 concentration were lower in the morning and eventually higher during afternoon and evening. This in line with study conducted by Leong, Muttamara, & Laortanakul (2002) as they stated that O_3 were the lowest in the morning, It would increase in the afternoon as the UV light intensity increased. This was because it needs light for O_3 formation. Therefore, it can be concluded that pedestrian commuting during afternoon and evening time were highly exposed to high levels of O_3 .

5.2 Comparison background and roadside measurement

The importance of conducting background measurement before sampling for roadside location is because we could control the variations of air pollution during sampling days. Air pollution concentration could varies from day-to-day due to spatial variation which could cause unreliable data collected (Hankey, 2014).

Background measurement were conducted at location away from traffic sources while measurement at the roadside were conducted along pedestrian route. From statistical analysis, both background and roadside measurement are being compared. Results obtained from Road 1 shown that there are no significant difference of background and roadside measurement. All pollutants shown result of $PM_{2.5}$ (p-value = 0.483), PM_{10} (p-value = 0.486) and O_3 (p-value = 0.296). This means that background and Road 1 pollutants concentration does not have positive

association. No difference between both measurement may be because of the location of background and roadside were near to each other and have same topographic characteristics. However, Road 2 shown result significant difference of background and roadside measurement for $PM_{2.5}$ and PM_{10} with p-value, 0.008 and 0.009. No significant difference were found on O_3 concentration between background and roadside measurement. This being explained as O_3 did not primarily due to pollution but also due to other factor such as sunlight.

Hankey (2014) also conduct background measurement 30 minutes before and after roadside measurement. He found out that afternoon measurement shown lower background concentration compared to morning measurement. Fewer number of sampling could cause in such result as it cause uncertainty to estimate spatial distribution in the morning.

5.3 TRAP Exposure and Respiratory Symptoms

Respiratory health might decreased due to the effect of exposure to the traffic pollution such as nitrogen dioxide (NO_2), particulate matter (PM) and carbon monoxide (CO) (Sylla, Faye, Diaw, Fall, & Tal-dia, 2018). The result of data analysis found that air pollutants measured such as $PM_{2.5}$, PM_{10} and O_3 only correlated with some of the respiratory symptoms. $PM_{2.5}$ and PM_{10} were significantly correlated with symptoms of wheezing or whistling in the chest with p-value of 0.017 and 0.019 and also with symptoms of shortness of breath especially after

exercise with p-value 0.040 for $PM_{2.5}$ and 0.039 for PM_{10} . Review from Q. Liu et al. (2017) also found $PM_{2.5}$ correlated with respiratory symptoms such as wheezing, cough and lower respiratory infections. This is because $PM_{2.5}$ can enter and deposited deeply into the respiratory tract and they consist of contaminants that might cause inflammation of the lungs.

Besides, O_3 concentration were shown no significant difference with any respiratory symptoms studied. This result in contrast with previous study that found increased concentration of the O_3 affect the condition of the lungs. O_3 significantly correlated with respiratory symptoms which being explained due to the characteristics of ozone which it could cause irritation and inflammation of the lung (Leong et al., 2002).

In study by Tao, Mi, Zhou, Wang, & Xie (2014) found out that PM_{10} were statistically significant with hospital admission for respiratory disease. An increased of concentration by $10 \mu g/m^3$ could cause about 0.2 – 1.1% higher admission to hospital due to respiratory disease while Arbex et al. (2012) said that only $10 \mu g/m^3$ increased of PM with one day lag could result in 11.6% increased of patients being hospitalized. This showed that short-term exposure to higher pollutants concentration lead to higher hospital admission or emergency visits (Q. Liu et al., 2017; Tao et al., 2014).

However, most of the respiratory symptoms mostly conducted among children rather than adults which cause it remains unclear on adults (Q. Liu et al., 2017; Sylla et al., 2018). A study by Sylla, Faye, Fall, & Tal-dia (2017) reported that risk of diseases such as asthma, difficult breathing, rhino-conjunctivitis and eczema among children were associated with road traffic.

Other symptoms such as cough, phlegm, allergic sensitization and asthma did not have significant correlation with the pollutants. Anyhow, PM_{2.5} were found to be associated with incidences of asthma as number of emergency visited for asthma increased with the increased of the pollutants concentration as several studies conducted in USA, Canada, Finland and Taiwan (Requia, Adams, & Koutrakis, 2017). Arbex et al. (2012) reported positive relationship between exposure to air pollution with asthma attack. It was being explained as the pollution has correlation with the increasing of emergency visit and patient being hospitalized due to asthma. Emergency visit due to COPD – related symptoms also correlated with PM₁₀ and SO₂ (Arbex et al., 2012).

Short-term exposure to TRAP also could lead to other health effects such as changes of autonomic regulation of heart. Study conducted by Brook et al. (2016) stated that pollutants could trigger the elevation of blood pressure. They found that PM_{2.5} and black carbon were associated with increased of blood pressure and heart rate after exposed for few hours. This showed that only short-term exposure could affect other system in the body including cardiovascular system. Cardiovascular health has become one of the indicator in determining short-term exposure to TRAP

due to immediate changes of biological system. Exposed 3-hour to O₃ were found to increase systolic and diastolic blood pressure and reduced heart rate variability (Weichenthal, Hatzopoulou, & Goldberg, 2014).

5.4 Socio-demographics and Respiratory Symptoms

Socio-demographic being included in this study were gender, age, BMI and ethnic. Based on the result negative association were found between gender and respiratory symptoms. However, there was a study stated that female have higher risk to develop respiratory symptoms as they were more susceptible for pollutants to enter and remain in pulmonary region (Yin et al., 2017). Female also have higher risk of developing COPD compared to male group (Tao et al., 2014).

Based on the age of respondents, it has been found that there was positive association of age and risk of asthma with p-value, 0.047. Younger people have higher tendency to get the disease as compared to older ones. In this study, we found that people aged under 20 have higher risk of getting asthma attack. This may be because of the susceptibility of younger people are higher (Yin et al., 2017). Age also have an association with symptoms of coughing with p-value, 0.009. Respondents who aged 21-25 have higher number of developing symptoms of coughing which in line with study by Alnawaiseh et al. (2014) in their study reported that older people have higher tendency to develop coughing. They found that people with aged more than 51 have higher risk of developing cough which 3.3 times higher. In this study,

age was found that it did not have an association with other respiratory symptoms such as wheezing, tightness in the chest, shortness of breath, phlegm, breathing, allergic sensitization and asthma. People aged more than 65 years old also have higher risk of being hospitalized due to respiratory disease (Tao et al., 2014).

Apart from that, we also tested BMI and ethnic comparison group with respiratory symptoms. However, we found out that BMI also did not have any positive association with any respiratory symptoms studied. Another socio-demographic such as ethnic also did not have any positive results. The results might be unable to be correlated with any respiratory symptoms because the number of respondents were too small.

5.5 Motor Vehicle Traffic Count and TRAP Concentration

Traffic count is one of the variables that affect the distribution of TRAP. As it was conducted together with the measurement, this study aims to find the correlation between traffic count and TRAP concentration at study location. At Road 1, the result found out that traffic count were significantly correlated with $PM_{2.5}$ concentration (p value = 0.049). Traffic count also has correlation with $PM_{2.5}$ concentration with p-value, 0.042 at Road 2. This is in line with the result by Buonanno, Fuoco, & Stabile (2011) which concentration of pollutants increased with the increased number of vehicles.

Buonanno et al. (2011) stated that emission of pollutants such as $PM_{2.5}$ and PM_{10} from vehicles would increase when the vehicles move in higher speed which made the particles to easily re-suspended from road surface. This is line with study by Qiu & Peng (2015) also said that speed of the vehicles could cause in significant result of $PM_{2.5}$. When the vehicles keep on stop and start like in congested traffic, all of the pollutants would be emitted from exhaust in high numbers. Another study by Ai et al. (2016) also found significant association pollutants concentration and traffic volume. This in contrast with study conducted by Lung et al. (2014) as they found negative correlation between traffic count and pollutants concentration.

Nonetheless, no significant correlation were found between traffic count with PM_{10} and O_3 at both study location. Unlike this study, Alnawaiseh et al. (2014) however, found that vehicle count were significantly correlated with TSP and PM_{10} since they only studied those parameters. Other study by Gül et al. (2011) also found significant association of traffic volume with prevalence of asthma. While study conducted by Tarhan et al. (2016) found that high number of vehicles and density population could result in lung cancer cases among population in Izmir, Turkey.

On the other hand, there were also other factors that affecting pollutants concentrations such as season. Seasonal changes seems to affect the pollution in which warm period increased the sources and dispersion of pollutants while at the same time increased the number of health-related incidences (Samoli et al., 2016). This happens because it have different direction of the wind and temperature in different seasons (Ai et al., 2016).

Apart from that, width of the road and presence of high buildings also contribute to dispersion of pollutants. Ai et al. (2016) stated that width of the road would be one of the factor that caused traffic congestion at certain road while high buildings may influenced dispersion of pollutants by interrupting wind speed, air temperature and humidity above the road. Therefore, it was stated that road width and presence of high buildings could have relationship with TRAP concentration.



Study Limitation

During research, there are few limitation being identified. First of all, the study design used in the study. This study is a cross-sectional study in which exposure and outcome were being assessed concurrently. Although some of the data show certain relationships between the exposure and outcome, there were still insufficient evidences to prove them such as if there is other exposure that could contribute to the outcome and whether other person who does not exposed to this pollution are having the same outcome. Apart from that, this study was only conducted among students of Universiti Putra Malaysia (UPM) campus only. Students who choose to walk as their main transportation to commute from college to faculty were selected as respondents not including cyclists. Respondents were restricted as students of certain colleges only. More studies can be conducted among pedestrian, cyclists and vehicles users to determine their health risk with TRAP exposure.

Apart from that, this study also limited on few parameters only such as $PM_{2.5}$, PM_{10} and O_3 . No other factors being measured such as meteorological factors that might affect the pollution since limited time and instruments to conduct the measurement. This study only limited on certain road around UPM campus which the results obtained might not represent TRAP exposure around whole campus. Sample size of this study only comprised of 45 respondents which fulfil the inclusion and exclusion criteria. Larger sample size could help the researcher in identifying the

population health status due to exposure to traffic-related air pollution (TRAP) more accurate.

Limited available instrument also cause limitation in this study. We conduct background and roadside measurement at two different times as only one instrument were available. Therefore, background and roadside measurement cannot be conducted at the same time which may cause error in the data collected. Same time of measurement could help the researcher to determine the differences of those locations. Apart from that, there was also some problems with the instrument used as the concentration being measured did not consistent.

In this study, limited data available also cause limitation to the study. The example of it such as data from nearest monitoring station could not be retrieved as the data were not available. Data from meteorological department also could not be obtained due to some problems. Lack of data may cause the underestimation or overestimation occurred in this study.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Findings from this study indicated that exposed to high levels of air pollution might increase the risk of getting respiratory symptoms. Only short-term of exposure could increase the risk of getting those symptoms.

All pollutants that were being measured such as $PM_{2.5}$, PM_{10} and O_3 are some of pollutants that were being emitted from vehicles engines. Association was found between the exposure to $PM_{2.5}$ and PM_{10} with symptoms of wheezing (p-value = 0.017, 0.019) and shortness of breath with $PM_{2.5}$ (p-value=0.040) and PM_{10} (p-value=0.039) among respondents. Although they only spend about 20-30 minutes per journey every day, they might be developing the disease after sometimes. Result shown that age was correlated with respiratory symptoms reported due to the fact that students aged 21-25 have exposed to those pollutants for quite a long time.

Meanwhile, the number of vehicles (maximum number counted in one rush hour = 274) using the road during rush hours might be high that cause the concentration to be high at that time. Although there was limited data on certain parameters, it has been proven that pedestrian which refers as students in this study are actually exposed to quite high levels of traffic pollution and some of them already developed some respiratory symptoms.

The hypothesis being set in the early stage of this study had been tested statistically and those proven to be true although not all variables were significant. The hypothesis being met as follows:

- i. There is significant comparison of background and roadside measurement of traffic-related air pollution (TRAP).
- ii. There is significant relationship of traffic-related air pollution (TRAP) exposure and respiratory symptoms reported.
- iii. There is significant association between sociodemographic factors and health symptoms.
- iv. There is significant association of motor-vehicle traffic count and traffic-related air pollution (TRAP).

6.2 Recommendations

First of all, it is important to educate people on environmental risk they may pose as they are walking around campus area. People shall be informed on the level of risk they might be facing and the health associated with it. Ministry of Health can collaborate with Ministry of Higher Education to arrange a campaign on creating awareness among students or staff around the campus so that they alert on health risk they may experience. By educating the communities around, strong awareness can be shaped, therefore pollutants exposure may be controlled and health risk can be minimized.

Besides, management of the university can introduce any activities or program that can encourage the communities in the campus to participate in reducing the pollution. Programs such as Carpooling Day, A Day Without Vehicles or Walking Day can be planned and done regularly every month. For example, Stockholm created program called Electronic Road Pricing by charges vehicles that enter the city during peak time which on 06.30 and 18.30 except buses, taxis, eco-fuel cars and emergency vehicles (Wong, 2014). It could encourage people to reduce the use of vehicles around campus area. Even with the development of cleaner vehicles engines could not reduce the pollutants levels. Therefore, it is encouraged for people to get together and participate to reduce pollution levels especially around campus area.

Future studies are recommended to conduct more research on pedestrian and cyclists as they are directly exposed to the TRAP. Since their exposure and health effects remains unclear therefore more study shall focus on those group as more countries are promoting active travel activities in their country.

This study was conducted on few parameter such as $PM_{2.5}$, PM_{10} and O_3 , therefore it is recommended for future study to assess more parameters such as nitrogen dioxide (NO_2), black carbon (BC), total suspended solid (TSP), carbon monoxide (CO), and sulfur dioxide (SO_2) on finding the effect of those pollutants on human health. Having more parameter included in the study could provide more information on the volume and pathways of the pollutants exposed.

Besides, it is recommended for future studies to use Geographical Information Systems (GIS) as a tool in identifying polluted zones and population at risk in certain area for detailed understanding of pollution dispersion. Site-specific activity patterns also were recommended so that researcher could identify the differences of pedestrian exposure at certain location. A GPS device could be used to track the movement of pedestrian while measuring the pollutants.

Since this study did not take into account other factors that may affect the pollution such as meteorological factors, future researcher shall look further into this matter. Wind speed, wind direction, temperature and relative humidity may give much impact on the pollutants distribution. Future research also shall considered on

having large sample size in order to generalize the sample to population exposure and health risk.

Furthermore, it was recommended to conduct more detailed calibration of the instruments used so that the instruments could measure the pollutants correctly at the location of study. Last but not least, it is recommended for future studies conduct more studies on the health effects of TRAP. Other test that can be conducted to determine the health effects such as taking into account lung function test for respiratory disease or blood pressure and heart rate variability (HRV) for cardiovascular disease. Toxicology studies also can be conducted in determining their health condition.

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APPENDIX



**JAWATANKUASA ETIKA UNIVERSITI UNTUK
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UNIVERSITI PUTRA MALAYSIA, 43400 UPM SERDANG,
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FORM 2.4: RESPONDENT'S INFORMATION SHEET AND INFORMED CONSENT FORM

Please read the following information carefully and do not hesitate to discuss any questions you may have with the researcher.

1. STUDY TITLE :

Association of traffic-related air pollution (TRAP) exposure and respiratory symptoms among pedestrian commuting around campus area.

2. INTRODUCTION:

Air quality plays an important role in the quality of life, affecting humans' health and also welfare. Poor air quality is closely related to adverse health effects or even premature death. Although pedestrian enjoy the health benefits of increased physical activity, but at the same time increased the uptake of traffic-related air pollutants which have been linked to adverse health effects and associated mortality. Therefore, it is important to carry out this study to explore traffic-related air pollution exposure among pedestrian and their respiratory symptoms from the exposure.

3. WHAT WILL YOU HAVE TO DO?

As a respondent, your are needed to sign the consent form which indicated you are interested and willing to cooperate with this study. Then, you are asked to complete the questionnaire. This research is voluntary participation and participant able to withdraw from participation at anytime without any penalty. Result of this research will be given after the research is done if participant likely to know about it.

4. WHO SHOULD NOT PARTICIPATE IN THE STUDY?

Respondent who are not travel by walking around the campus.

5. WHAT WILL BE THE BENEFITS OF THE STUDY:

(a) TO YOU AS THE SUBJECT?

Participant will be able to know the air pollution levels at the campus along the route chosen. Participant also will be able to know the air pollution levels and correlated it with respiratory symptoms they experienced.

(b) TO THE INVESTIGATOR?

The researcher hope that the finding of this study will provide data to know the respiratory health effects of pedestrian when they are commuting by walking around the campus area.

6. WHAT ARE THE POSSIBLE RISKS?

There are no possible risk known for joining this study.

7. WILL THE INFORMATION THAT YOU PROVIDE AND YOUR IDENTITY REMAIN CONFIDENTIAL?

All the information and identity that are provided by the respondents will remain confidential.

8. WHO SHOULD YOU CONTACT IF YOU HAVE ADDITIONAL QUESTIONS DURING THE COURSE OF THE RESEARCH?

If you have any inquiries you can contact the researcher responsible for the study or the project leader of the researcher.

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Please initial here if you have read and understood the contents of this page_____

9. CONSENT

I Identity Card No.
address.....
... hereby voluntarily agree to take part in the
research stated above *(clinical /drug trial/video recording/ focus group/interview-based/
questionnaire-based).

I have been informed about the nature of the research in terms of methodology, possible
adverse
effects and complications (as written in the Respondent's Information Sheet). I understand that
I have the right to withdraw from this research at any time without giving any reason
whatsoever. I also understand that this study is confidential and all information provided with
regard to my identity will remain private and confidential.

I* wish / do not wish to know the results related to my participation in the research

I agree/do not agree that the images/photos/video recordings/voice recordings related to me be
used in any form of publication or presentation (if applicable)

* delete where necessary

Signature Signature
(Respondent) (Witness)
Date : Name :
I/C No. :

I confirm that I have explained to the respondent the nature and purpose of the above-
mentioned research.

Date Signature
(Researcher)

ID

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UPM
UNIVERSITI PUTRA MALAYSIA
BERILMU BERAKTI

Department of Environmental and Occupational Health

Faculty of Medicine and Health Sciences

Universiti Putra Malaysia

Title :

**Association between Traffic-Related Air Pollution (TRAP) Exposure with
Respiratory Symptoms Among Pedestrian During Commuting Around Campus
Area**

Questionnaire Instruction :

This questionnaire contains two sections

Section A : Socio-demographic information

Section B : Respiratory Symptoms

**Respondent required to answer all questions in this book and please mark your answer on the boxes provided.
Answer will be private and confidential, only for study purpose.**

Please return this questionnaire booklet to researcher upon completion.

cm

Year	1999	2000	2001	2002
1999	100	100	100	100
2000	100	100	100	100
2001	100	100	100	100
2002	100	100	100	100

Figure 6

100

Kesihatan

Yes

No

chest / Kecelakaan atau operasi yang menjejaskan dada anda

b) Heart trouble / Masalah Jantung

c) Bronchitis / *Bronkitis*

d) Pneumonia / *Pneumonia*

e) Pulmonary tuberculosis / Tuberkulosis pulmonari

f) Bronchial Asthma / Asma bronkial

g) Other chest trouble / *masalah dada yang lain*

h) Hay Fever / Radang hidung

9 Have you taken any medications for the past 6 month? *Pernahkah anda mengambil apa-apa ubat selama 6 bulan yang lalu?*

Yes ☐ No ☐

10 What is your current residence? *Apakah kediaman anda sekarang?*

Canselor ☐
Tun Dr Ismail ☐
Second ☐
Fifth ☐
KOSASS ☐

11 What is your main travel modes around the campus? *Apakah mod perjalanan utama anda di sekitar kampus?*

Walking ☐ Cycling ☐ Car/Motorcycles/Bus ☐

12 How long do you usually spend during commuting around campus in a day? *Berapa lama anda biasanya menghabiskan waktu berangkat di kampus dalam sehari?*

Less than 10 minutes ☐
10 - 20 minutes ☐
20 - 30 minutes ☐
More than 30 minutes ☐

13 In your opinion, do you think that your environment (air) is in good condition? *Pada pendapat anda, adakah anda berfikir bahawa persekitaran anda (udara) dalam keadaan baik?*

Yes ☐ No ☐

14 What do you think of the traffic / number of vehicles around the campus? *Apakah yang anda fikirkan lalu lintas / bilangan kenderaan di sekitar kampus?*

Few ☐
Considerable ☐
Many ☐

15 Did you ever think / feel any of those problems due to the traffic in the campus *Adakah anda pernah berfikir / merasakan apa-apa masalah yang disebabkan oleh lalu lintas di kampus:*

Dizziness ☐
Headache ☐
Sore throat ☐
Fever ☐

Section B : Respiratory Symptoms / Gejala Pernafasan

To answer the questions, please tick the appropriate box. If you are unsure of the answer please tick "No"

Wheezing and Tightness in the Chest / Dada berbunyi dan Sesak dada

1 Have you had wheezing or whistling in your chest, at any time in the last 12 months?
Adakah anda terasa dada anda berbunyi pada bila-bila masa dalam jangka masa setahun yang lepas?

Yes	No

2 If yes, how long this condition occurred? *Jika ya, sudah berapa lama keadaan ini berlaku?*

3 Have you woken up with the feeling of tightness in your chest first thing in the morning, at any time in the last 12 month?
Adakah anda terasa dada anda sesak setelah bangun pagi pada bila-bila masa dalam jangka masa setahun yang lepas?

--	--

4 If yes, how long this condition occurred? *Jika ya, sudah berapa lama keaaan ini berlaku?*

Shortness of Breath / Kesukaran Bernafas

5 Have you at any time in the last 12 months, had an attack of shortness of breath that came on during the day when you were not doing anything strenous?
Adakah anda pernah diserang kesukaran bernafas semasa hari yang anda tidak berbuat apa-apa?

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6 Have you had an attack of shortness of breath that came after you stopped exercising, at any time in the last 12 months?
Adakah anda pernah diserang kesukaran bernafas selepas berhenti melakukan senaman pada bila-bila masa dalam jangka masa 12 bulan yang lepas?

--	--

7 Have you, at any time in the last 12 months, been woken up at night by an attack of shortness of breath?
Dalam jangka masa 12 bulan lepas, adakah anda pernah terjaga malam kerana diserang kesukaran bernafas?

--	--

Cough and Phlegm / Batuk dan Kahak

8 Have you , at any time in the last 12 months, been woken at night by an attack of coughing?
Dalam jangka masa 12 bulan lepas, adakah anda pernah terjaga malam kerana diserang batuk?

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9 Do you usually cough first thing in the morning? *Adakah anda kerap batuk di permulaan pagi anda?*

Yes	No

10 Do you usually bring up phlegm from your chest first thing in the morning? *Adakah anda kerap mengeluarkan kahak di permulaan pagi anda?*

--	--

Breathing / Pernafasan

11 Which of the following statement best describe your breathing? *Manakah pernyataan yang menerangkan keadaan pernafasan anda?*

a) I never or rarely get trouble with my breathing. *Saya tidak pernah atau jarang mempunyai masalah pernafasan.*

--	--

b) I get regular trouble with my breathing, but it always gets completely better. *Saya biasa mendapat masalah dengan pernafasan , tetapi ia sentiasa mendapat lebih baik*

--	--

c) My breathing is never quite right. *Pernafasan saya tidak pernah rasa selesa.*

--	--

|Animal, dust, feathers / Haiwan, debu, bulu

When you are in a dusty part of the house or with the animals (for instances dogs, cats or horses) or near feathers (including pillows, quilts and eiderdowns) do you ever: *Apabila anda berada di bahagian rumah yang berdebu atau dengan haiwan (untuk contoh anjing, kucing atau kuda) atau berhampiran bulu (termasuk bantal, selimut dan eiderdowns) adakah anda pernah :*

12

a) Get a feeling of tightness in your chest? *Rasa sesak di dada?*

--	--

b) Start to feel short of breath? *Mula berasa nafas pendek?*

--	--

Illness / Penyakit

13 Have you ever had an attack of asthma? *Adakah anda pernah mengalami serangan asma?*

--	--

14 Have you had an attack of asthma at any time in the last 12 months? *Adakah anda pernah mengalami serangan asma dalam 12 bulan lepas?*

--	--

15 Are you currently taking medicines, pills or inhalers for asthma? *Adakah anda sedang mengambil ubat, pil atau inhaler untuk asma?*

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Smoking / Merokok

16 Have you ever smoked for as long as a year? *Pernahkah anda merokok selama setahun?*

Yes	No

(This means at least one or more cigarettes a day (or one or more cigars a week or one or more ounces of pipe tobacco a month) for as long as a year) *(Ini bermakna sekurang-kurangnya satu atau lebih rokok sehari (atau satu atau lebih cerutu seminggu atau satu atau lebih auns tembakau sebulan) selama setahun)*

17 Do you now smoke *Adakah anda merokok sekarang :*

Not all all / *Tidak langsung*

Occasionally / *Kadang-kadang*

Daily / *Setiap hari*

If you have given up smoking altogether, how long is it since you last gave up smoking?

18 *Sekiranya anda telah berhenti merokok sepenuhnya, berapa lama sejak lepas anda berhenti merokok?*

Less than a month ago / *Kurang sebulan yang lepas*

More than a month ago / *Lebih sebulan yang lepas*

UPM

Thank you for your cooperation in completing the questionnaire

Terima kasih di atas kerjasama anda menyiapkan soal selidik ini.