CHARACTERIZATION OF PARTICULATE MATTER (PM_{10}) EXPOSURE IN URBAN AND RURAL AREA

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by:

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DECLARATION

I declare that this thesis entitled "Characterization of Particulate Matter (PM_{10}) Exposure in Urban and Rural Area" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ________________________________

Name : ________________________________

Date : ________________________________

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LIST OF ABBREVIATIONS

Ace	Acenaphthene
Acy	Acenaphtylene
Ant	Anthracene
AQI	Air Quality Index
BaA	Benzo (a) anthracene
BaP	Benzo (a) pyrene
BbF	Benzo (b) fluoranthene
BghiP	Benzo (g, h, i) perylene
BkF	Benzo (k) fluoranthene
Chry	Chrysene
CO_2	Carbon dioxide
DBA	Dibenzo (a, h) anthracene
DCM	Dicholoromethane
DOE	Department of Environment
EPA	Environmental Protection Agency
Flt	Fluoranthene
Flu	Fluorene
GC-MS	Gas Chromatography-Mass Spectrophotometry
H_2O	Water
Ind	Indenol (1, 2, 3 - c, d) pyrene
LVAS	Low Volume Air Sampler
Nap	Naphthalene
NO_x	Nitrogen oxide
O_3	Ozone
PAH	Polycyclic Aromatic Hydrocarbon
Phe	Phenanthrene
PM	Particulate matter
PM_{10}	Particulates with aerodynamic diameters <10 micron
$PM_{2.5}$	Particulates with aerodynamic diameters <2.5 micron
POP	Persistent of Organic Pollutant
Pyr	Pyrene
MAAQG	Malaysia Ambient Air Quality Guidelines

SO_2	Sulphur dioxide
SPE	Solid Phase Extraction
US EPA	United States Environmental Protection Agency
WHO	World Health Organizations

LIST OF SYMBOLS

°C	Degree celcius
cm	Centimetre
m	Metre
min	Minute (s)
mL	Mililiter
mm	Milimetre
ppm	Parts per million
$\mu g/m^3$	Microgrammes per meter cube

Characterization of PM_{10} in Urban and Rural Area

ABSTRACT

Particulate matter (PM_{10}) was major pollutants of the air pollutions which it can easily adsorbed toxic substances such as organic compounds that contribute to Polycyclic Aromatic Hydrocarbons (PAHs) and heavy metals. Urban area has higher concentration of PM_{10} than rural area because of urbanization and industrial activity that resulted to the existence of PAHs that might lead to negative impact neither on society nor for the environment and natural resources. The 3 days sampling was done in Balok (urban area) and Jeli (rural area) from 28th February – 2nd March 2019 and 10th July – 12th July 2019 respectively. The glasswares were baked in furnace for 400 °C and filter paper were baked for 300 °C. The samples extracted through ultrasonification process using ultrasonic bath and continued with solid-phase extraction (SPE) process then centrifuged until 2 mL by using nitrogen evaporater before analysed using GC-MS. The results showed that average concentration of PM_{10} in Balok was 89.120 µg/m^3 (ranging from 41.667 – 114.583 µg/m^3) and Jeli was 17.361 µg/m^3 (ranging from 13.889 – 20.833 µg/m^3). The detected PAHs for Balok and Jeli is 16 PAHs and 2 PAHs (naphthalene and acenaphthene). Meteorological and anthropogenic activity might be as the factors that contribute to higher concentration of PM_{10} and more PAHs compound detected in Balok than Jeli. It can be concluded that the average concentration of PM_{10} for Balok was much higher than Jeli but still under the Malaysia ambient air quality standard.

Pencirian Kepekatan Zarah Terampai PM_{10} daripada Kawasan Bandar dan Luar Bandar

ABSTRAK

Zarah terampai (PM_{10}) adalah bahan pencemar utama bagi pencemaran udara yang dapat menyerap bahan toksik dengan mudah seperti sebatian organik iaitu Polisiklik Hidrokarbon Beraroma (PAH) serta logam berat. Kawasan bandar mempunyai kepekatan PM_{10} lebih tinggi berbanding kawasan pedalaman ekoran daripada kesan urbanisasi dan kegiatan industri yang membawa kesan negatif kepada masyarakat, alam sekitar dan sumber semula jadi. Tiga hari pensampelan dilakukan di Balok (kawasan bandar) dari 28 Februari sehingga 2 Mac 2019 dan Jeli (kawasan luar bandar) dari 10 Julai sehingga 12 Julai 2019. Prosedur dimulakan dengan membakar gelas makmal pada suhu 400 °C dan kertas penapis dibakar pada suhu 300 °C. Sampel mula diekstrak melalui proses ultrasonik menggunakan tab ultrasonik dan diteruskan dengan proses pengekstrakan pepejal sehingga 2 mL dengan menggunakan pengewapan nitrogen sebelum dianalisis dengan menggunakan GC-MS. Keputusan menunjukkan bahawa purata kepekatan PM_{10} di Balok adalah 89.120 $\mu g/m^3$ (dari 41.667 - 114.583 $\mu g/m^3$) dan Jeli adalah 17.361 $\mu g/m^3$ (dari 13.889 - 20.833 $\mu g/m^3$). Jumlah PAH yang dikesan untuk Balok adalah 16 dan Jeli adalah 2 iaitu naftalena dan acenaftena. Aktiviti meteorologi dan antropogenik adalah kemungkinan bagi faktor-faktor yang menyumbang kepada kepekatan PM_{10} yang tinggi dan mempunyai kompaun PAH yang banyak dikesan di Balok berbanding Jeli. Kesimpulannya, purata kepekatan PM_{10} bagi Balok jauh lebih tinggi daripada Jeli tetapi masih di bawah piawaian kualiti udara di Malaysia.

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Air pollution can be defined as the emission of the unwanted things or pollutants in the air that detrimental to life in the planet includes of human, animal and plants. There are two types of pollutants which are primary and secondary pollutants (Kibble & Harrison, 2005). Primary pollutants refer to the air pollutants that directly emit from the sources meanwhile for secondary refer to the indirectly emission from the sources but it is form when the primary pollutants are reacts with the atmosphere.

Based on the WHO (2003) air pollution includes of four which are particulate matter (PM), sulphur dioxide (SO_2), ozone (O_3), nitrogen oxide (NO_x). These are known as hazardous substances that can give negative effect to human health and environment (Bernstein et al., 2004). This study concentrates on the problems of air pollution that can give negative effect to social life because of the existence of particulate matter. Particulate matter is the major indicator of the air pollution that originally due to anthropogenic sources and natural sources. Particulate matter in simple words can be defined as mixture of liquids and solids that cannot be seen with naked eyes that contribute to air ecosystems such as smoke, smog, dirt, soot or haze with diameter of 10 microns known as PM_{10} is inhalable particles and it suspend in the air for long period of time. Stated by US Environment Protection Agency (2013) the sources of the PM_{10} are pollen and combustion activities that includes of smoke from vehicles and also from industrial of the released of gas pollutant. Particulate matter give impact on the climate change through the cooling effect because of the high scattering to the atmosphere as the aerosols is increase. Recorded that 3400 million tonnes of the particulate matter are emitted on the global where includes of anthropogenic factors and natural factors, 85 % and 10 % respectively (Mearns & Hulme, 2001).

Particulate matter (PM_{10}) gave hardcore threat on human health rather than O_3, SO_2 or NO_x (Kim, Kabir, & Kabir, 2015). The observed health effects include of cardiovascular disease, cardiopulmonary disease mortality and respiratory symptoms such as bronchitis (Pope, Bates, & Raizenne, 1995). It can lead to throat sickness and irritation if people expose to PM_{10} in longer time. People that already had history health of the chronic issues of lung problem they tend to have high chance on their health effect in serious way.

PM_{10} generally adsorbed organic and inorganic chemicals that can give harm to the human health. The compound that generally found associated from the PM_{10} was polycyclic aromatic hydrocarbon (PAHs) (Han et al., 2009). One of the factors that contribute to the production of PAHs that underdone by incomplete combustion are from the mobile source which are combustion fuel, aromatic fuel and other compounds that have undergo through vehicles combustion process (Thongsanit et al., 2003). Both PM_{10} and PAHs has their own counter effects to human health which can be categorized as serious problems. The side products of waste from the anthropogenic activities such as construction, agriculture, industries activity and also urbanisation that may lead to negative effect to human and environment.

1.2 Problem Statement

During 1994 and 1997, Malaysia was faced with the under blanket of smoke or haze and also stagnant of the atmospheric situations that occur due to the presence of air pollution (Abas, Oros, & Simoneit, 2004). Air pollution occurs when the gases, dust, smoke, or smog that introduce to the atmosphere or releasing of pollutants that can contribute to the negative impacts on human, plants or animals. The gaseous pollutants from the combustion activities such as open burning or transportation that release prominent atmospheric pollutants which are carbon monoxide (CO), carbon dioxide (CO_2), sulphur dioxide (SO_2), and nitrogen dioxide (NO_2) (WHO, 2003). This has led to the increases rate of respiratory-related health incidents where the impact of health functions used to quantify the relationship between PM_{10} and health issues related to the exposed population (Nordin et al., 2016). Stated that particulate matter can give high risk to the infants of the children to have respiratory problems, asthma, and affects the lung functions (WHO, 2003). Reported that the number of death were increases in Bandra, India due to the construction activities, the build of the flyover near the residential area (Joseph, Sawant, & Srivastava, 2003).

A study by Jamhari et al. (2014) stated that between the area of industrial, urban and sub-urban of Malaysia it showed that the concentration for PM_{10} was higher in industrial and sub-urban area than semi-urban area. This might happen due to human activity such as urbanization, increase in growth population, transportation, industrial activity that actively happened in urban area than rural area. Particulate matter can lead to human health issues since it can be adsorbed by inorganic and organic compound. The particles will deposited in the lungs either undergo experimental animals that induce for mild airway problems or in human patient that has poor lung function, asymptomatic smokers or mild bronchitis with normal spirometry has been shown to be increased and this may put subjects with pre-existing airway obstruction at increased risk for the adverse effects of inhaled particles (WHO, 2003). This was supported by Salam et al., (2011) that proved the suspended PM_{10} was associated from inorganic pollutants such as PAHs that adsorbed within it. The potential of risk health issues due to PAHs is very high. This can be supported by US Environment Protection Agency (2013) that done for animal testing showed that PAHs have caused tumors in mice that undergo experiments exposed to PAHs from breathing in a contaminated air and applied to their skin. A study showed that, when pregnant mice exposed with high doses of benzo (a) pyrene they experienced reproductive problem. PAHs showed effect on human health which mean a research showed the ability of PAHs to cause distruption in human systems such as reproductive developmental and neuro toxicities that works with animal model and human research (Goodale, 2013).

The common problems face by Balok air quality are because it is located near to the industrial area of Gebeng which is 5 km of distance and takes about 5 to 10 minutes from industrial park of Gebeng to Balok. This study aimed to characterize of PM_{10} and determine the presence of PAHs in urban and rural areas. If the concentration of PM_{10} is high, it indicates that the area will have high concentrations of pollutants. The composition of PM_{10} concentration used to identify whether those area is clean or pollute. The identifications of PAHs were studied to determine whether the study area affected by PAHs activity or not.

1.3 Objectives

- To determine the relationship between meteorological factors and particulate matter (PM_{10}).
- To compare the concentration of particulate matter (PM_{10}) in urban and rural areas.
- To identify the type of Polycyclic Aromatic Hydrocarbon (PAHs) in urban and rural areas by using GC-MS.

1.4 Significant of Study

This study focused on the characterization of particulate matter (PM_{10}) on study area of Balok and Jeli. This was done to make sure the air quality recorded from concentration of PM_{10} below the standard guideline of concentration PM_{10} in Malaysia. The data were collected by using low volume air sampler (LVAS) and automatic weather station where the LVAS used to trap the PM_{10} particles in the fibre filter while automatic weather used to obtain the air pressure, air humidity and wind speed that related to spreading of air to atmosphere and the effect if PM_{10} hanging in atmosphere. This study was conducted for 24-hours of 3 days sampling. These parameters are main elements for this study to characterize the PM_{10} in rural and urban area by dilute the samples PM_{10} with internal standards and undergo extraction of PAHs to identify the PAHs compound in each study area. This study compared the concentration of PM_{10} between rural and urban area to analyse which location have the higher concentration of PM_{10} between both area and to identify the causes that lead to the event. It might be happened due to human activity or even natural activity. Due to higher concentration of PM_{10} can lead to human health effect that can be link with the upbringing health effect cases that might affect to the population in study area. This can be categorized between short-term and long-term effect.

Other than that, this study also uses to identify the number of PAHs presence in its atmosphere by using PM_{10} samples through extraction of PAHs solution where the samples were spike with the 100 µL of the six internal standards which are surrogate standard that used as the internal standards were naphthalene-d_8, acenaphtene-d_{10}, anthracene-d_{10}, perylene-d_{12}, chrysene-d_{12} and p-terphenyl-d_{14}.This process continued with sonification and solid phase extraction (SPE) method. Final step is to analyse the PAHs compounds in rural and urban area using Gas Chromatography-Mass Spectrophotometry (GC-MS).

This collected data obtained from this study can be one of future research refer to which can help to understand the relationship between the concentrations of PAHs in PM_{10} and its effect to surroundings which are to environmental and social. This study showed the understanding and relationship between anthropogenic sources and meteorological activities that come up with changes in ambient air quality of PM_{10} that may lead to PAHs in urban and rural area in Balok and Gebeng. The findings of this research will benefit to the society considering that air pollution issues near the selected regions can be a prove that can voice out to the government to manage the issues based on industrial and transportation. Furthermore, it also can mitigate the environment issues that consider more on human health. The acute and chronic issues due to pollution need to look out as serious issues it was unseen and can be as one of the human health factors. It can be proved through the analysis of data from the PM_{10} data and characterization of 16 PAHs.

CHAPTER 2

LITERATURE REVIEW

2.1 Air Pollution

Environmental pollution has been highlighted as the world issues that concern on human's interest. On 2011, it was reported that megacities in the world that faced with air pollution includes New York City, Delhi, Istanbul Tokyo, Mexico City, Sao Paulo, Seoul and other sixteen cities (Drahansky et al., 2016). Air pollution is one of the environmental problems that happened to be as one of major problem happened due to the natural and anthropogenic sources. The natural sources of the air pollutants include fog and mist, ozone, radon, volcanic and salt spray. Anthropogenic sources can be simply defined as the percentage of CO_2 in the atmosphere that produced directly by human such as transportation, open burning, industries and more. Air pollution sources can be categorized into four types of main sources which are natural sources and anthropogenic sources which includes mobile sources, stationary sources, and area sources. The mobile sources were from the transportations activity which is vehicle smoke emission while for the stationary sources includes of industrial activities. Area sources covers for the agricultural sectors while for the natural sources includes of volcanoes emission, wind-blow dust, wildfires and more. In matter of facts, human industrial made and the agricultural sector considered to be as the engines of the economic growth (Environmental Protection Agency (EPA), 2011). Air pollutants can be categorized into gaseous pollutants and particulate matter where gaseous pollutants include of PM_{10} or $PM_{2.5}$, SO_2, NO_x, and O_3.

2.2 Particulate Matter (PM_{10})

Particulate matter are coarse particles that can reach to the upper parts of the airways and lungs (Isa, 2010). Particulate matter was suspended in the air that comes from the mixture of complex of liquid and solid particles then released to the atmosphere (Sierra-Vargas & Teran, 2012). Coal, gasoline, diesel, and burning of wood are the example of the sources that release to the atmosphere. Furthermore, it is chemical reaction production of organic compounds and nitrogen oxides that presence in the environment. In the country or the big cities, the particulate matter originally from the transportation and industries (Sierra-Vargas & Teran, 2012).

The particulates that present in the atmosphere of the air come with different physical, characteristics and sources (Environmental Protection Agency (EPA), 2011). Based on Figure 2.1 that showed the difference of diameter for PM_{10}, fine beach sand and human hair. Particles diameter ranging from the 0.005 to 0.05 μm known as aitken nuclei whereas, those between 0.05 to 2.5 μm are called fine particles ($PM_{2.5}$). Particulate size that are less than 10 μm is known as coarse particles (PM_{10}) (Environmental Protection Agency (EPA), 2011).

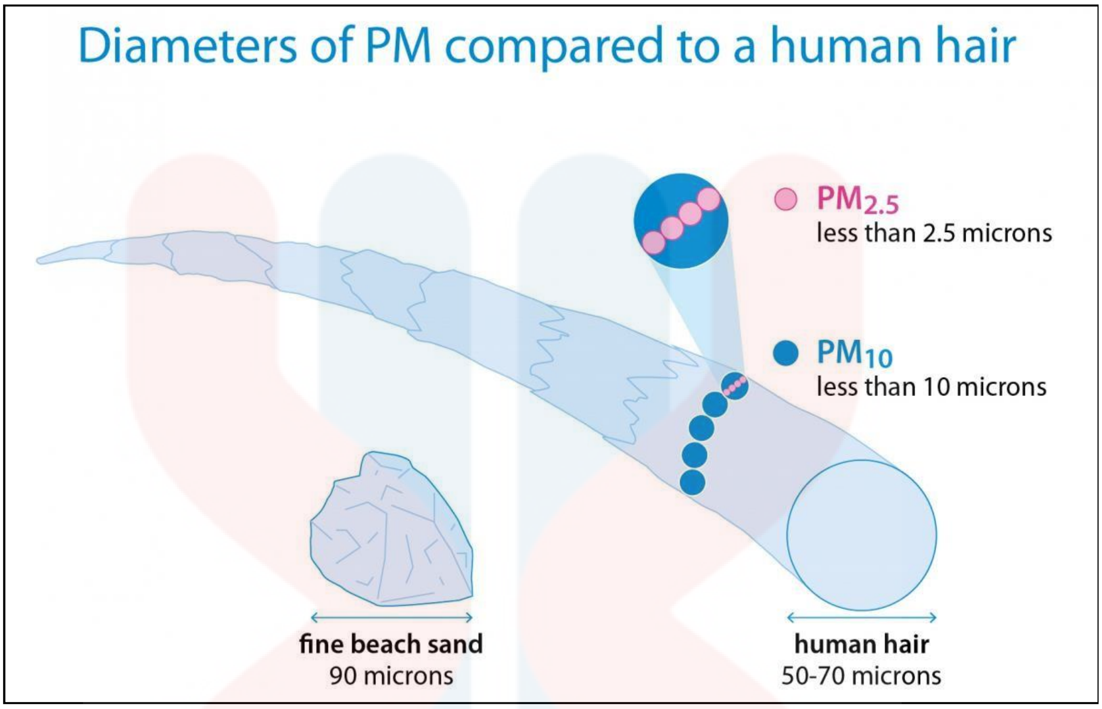


Figure 2.1 showed the particulate matter size comparison with the human hair and fine beach sand, (source Environmental Protection Agency (EPA), 2011).

Normally, coarse particles generate from activities of construction or farming that made up of changes in topography while for fine particles it general comes from the combustion (Lancet, 2006). Those particulate matter were responsible for the human health problems that comes from the air pollution sources. Particles that had larger surface area for same volume and mass will have smaller velocities where they able to stay suspended in air for very long periods meanwhile for very large particles that more than 100 μm cannot remain suspended in the atmosphere for longer time. Particles in the air can be directly or indirectly emission. For instance, directly emission occur when the fuel is burning down or dust is carried through the wind while indirectly emission resulted the gaseous pollutants that release into the atmosphere

2.3 Effects of Particulate Matter (PM_{10}) to Human Health

The classification of the particulate matter was based on the size comparison to identify their penetration into human body. Coarse particles (PM_{10}) can deposit into the anterior nasal region and also the important of thoracic region while for the fine particles ($PM_{2.5}$) can reach easily into the alveoli (Kawanaka et al., 2006). There are several factors from the PM_{10} that lead to negative effects in terms of human health. The epidemiological studies have showed that suspended PM that able to influence human health such as respiratory health (Monn et al., 1995). Schindler et al., (2009) reported that there are few health issues in terms of cough which are chronic and less chronic or phlegm, wheezing and also asthma that contribute from the sources of PM_{10}. Individual health effect from the PM_{10} can be categorize based on few factors which are gender, age, composition and size of the particles, level of duration for the exposure and sensitivity of the exposure.

The symptoms include of persistent cough, burning eyes, sore throat and chest tightness that hard to breath (WHO, 2003). Particulate matter can also lead to asthma, and premature death. Moreover, people that active for outdoors activity will have high risk which means that physical activity can rise up the amounts of particulates that penetrate into their airways since people that doing active activity tends to have higher respiratory time rather than in normal activity. People with health history such as diabetes, mellitus, heart disease or cancer tend to cause severe effect when particulate matter attack on them.

2.4 Polycyclic Aromatic Hydrocarbons (PAHs)

PAHs is the organic compounds that mostly colourless, white or pale-yellow solid that categorized on ubiquitous group of several hundreds of related of the chemicals compounds, plus persistent in environment that come out with differences structure and various toxicity (Abdel-Shafy & Mansour, 2016). Polycyclic aromatic hydrocarbons (PAHs) is the composition of more than 100 chemicals that released from the incomplete combustion from burning coal, oil gasoline, tobacco, trash and wood that lead to negative effect to environment and human plus belonged to groups of persistent of organic pollutants (POPs) (Maliszewska-Kordybach, 1999).

In general, PAHs contaminate within the environment through various of routes and found in mixture of two, three or more compounds such as it comes in terms of soot. PAHs can be categorize into various of sources which are natural sources, domestic sources, agricultural sources, industrial sources and transportation sources (Baldwin et al., 2017). Natural sources of PAHs are released through volcanoes and natural forest fires (Lee & Vu, 2010). PAHs in terms of air was found in second-hand smoke, cigarette, transportation (vehicle smoke), open burning, emission from fossil fuel and volcanoes. PAHs can be exposed to humans from ingestion, breathing and skin contact where are from the consumption of eat grilled food, charcoal broiled, contaminated meats or drinks and touching foods that expose PAHs.

Based on Figure 2.2 shows the chemical structure for 16 PAHs includes naphthalene, acenaphthylene, chrysene, dibenzo (a, h) anthracene, anthracene, fluorene, pyrene, benzo (a) pyrene, phenanthrene, fluoranthene, benzo (b) fluoranthene, indeno (1,2,3-c, d) pyrene, acenaphthene, benzo (a) anthracene, benzo (k) fluoranthene, and benzo (g, h, i) perylene.

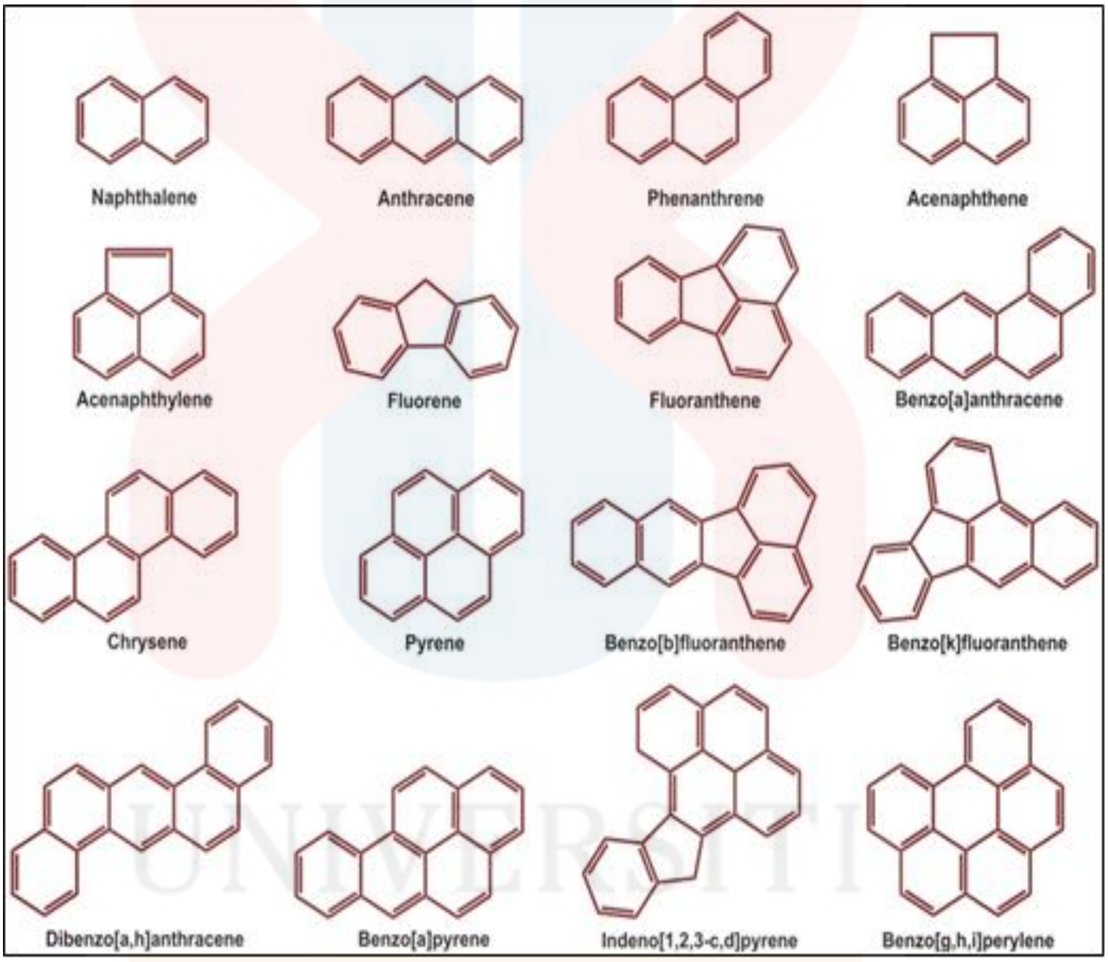


Figure 2.2 showed the chemical structure of 16 PAHs (source US EPA, 2008).

2.4.1 Sources of Polycyclic Aromatic Hydrocarbons (PAHs)

PAHs can be classified into natural sources and anthropogenic sources however it is mainly derived from anthropogenic sources that related with incomplete combustion of organic matter and pyrolysis. Anthropogenic sources are major contribution to the PAHs. For example, anthropogenic sources include of petroleum spills, pesticides from the agricultural sector, road dust, vehicle smoke emission in terms of transportation, smoke from cigarettes, illegal open burning and industries smoke emission (Abdel-Shafy & Mansour, 2016). Combustion process emit CO_2 and water (H_2O) as the main products plus produce incomplete fuel oxidation such as hydrocarbons, and aerosol particles. The main sources of PAHs in urban areas are industrial activity and transportation which are vehicle smoke emission (Ravindra, Mittal, & Grieken, 2001). The emission of PAHs can affect the distribution, characterization and its toxicity (Lee & Vu, 2010). It can divide into four categories for sources of PAHs include natural sources, stationary course, mobile emission and agricultural activity.

2.4.1.1 Natural Sources

Natural sources are one of the contributions for PAHs detection which includes plant synthesis, natural petroleum, rare minerals, vegetative decay, fires or even volcanic eruption (Abdel-Shafy & Mansour, 2016). Fires and volcanic eruption are the incomplete combustion happened that can give negative side to environment. Natural sources of PAHs include accidental burning of forest and woodland, volcanic eruption and decay of the organic matter (Lee & Vu, 2010). Natural sources of PAHs do not significantly contribute for the present overall of PAH emission (Maliszewska-Kordybach, 1999).

2.4.1.2 Stationary Sources

Stationary sources include domestic and industrial sources. Heating and cooking are the examples for domestic sources. The burning of oil, gas, coal wood, garbage and also organic substances are the main sources (Lee & Vu, 2010). Domestic sources contribute more on total emission of PAHs in environment. The example for indoor exposure for domestic sources is heating the emission and cooking. According to WHO, it was reported that more than 75% of people in India, China and South East Asia use combustion of solid fuels such as wood for their daily cooking style. The industrial sources for PAHs are produced from burning fuels such as coal, oil and gas (Lee & Vu, 2010). It includes with the emission from industrial activity like petrochemical industries, wood preservation, rubber tire and cement manufacturing and waste incineration. In petrochemical industries, most of the emission were categorize on two and three ring compounds that depends on the process studied by each company (Dybing et al., 2010).

2.4.1.3 Mobile Sources

Mobile sources can be major sources for urban and rural area due to urbanization, growth of population and broadly used of transportation. For mobile sources, PAHs emitted from the vehicles of exhaust fumes including railways, motocycle, ships automobile and aircraft. It is associated through the use of coal, lubricant, diesel, and gasoline. The mechanisms of PAHs form through pyrosynthesis and depends with other factors such as fuel composition, mileage, and engine type. PAHs is used as emission control air pollution devices such as filters (Ravindra, Mittal & Grieken, 2001).

2.4.1.4 Agricultural Sources

Fires and volcanic eruption are the incomplete combustion happened that can give negative side to environment. Equatorial Asia is an area that of the widespread of the biomass burning from the various of sources (Ravindra, Mittal & Grieken, 2001). Among the sources, wildfires that affected to the forest and peat burning that use to improve the quality of industrial sectors was practice in Indonesia. These results on 2015, air pollution happened due to the wildfire of forest burning that affected on Malaysia where the haze and global warming happened due to spread of smoke and warmth temperature that pass by the wind.

2.5 Effects of Polycyclic Aromatic Hydrocarbons (PAHs) to Human Health

It has been proved that PAHs is carcinogenic and mutagenic that can give negative effects to human health (Abdel-Shafy & Mansour, 2016). The present of PAHs within the environment because of the emissions that comes from the incomplete combustion of carbon that contain fuels from natural sources, commercials, industrial, residential area and also from the transportation (Kim, Jahan, Kabir, & Brown, 2013). Human exposure of PAHs can be happened due to breathing, consumption of food that contains PAHs, and smoking or breathing the cigarettes. From the tobacco smokes, the PAHs can be detected and can exposed on carcinogenic effect to humans. For non-smokers, the smoke that expose in the atmosphere can be the contribution to carcinogenic effect of human health (Kim et al., 2013). The human health effect can be introduced to acute and chronic exposure. The acute exposure depends on the exposure time, concentration of PAHs while chronic exposure of PAHs due to exposure of chemicals or series of work for the health problems that can lead to cancer.

2.6 Air Quality Standard of Particulate Matter (PM_{10})

Table 2.1 showed for Malaysia Air Quality Guidelines by Department of Environment (2015) with difference time of standard for concentration of PM_{10}. Based on Table 2.1, the standard guidelines of PM_{10} from MAAQG for 24-hours was 150 $\mu g/m^3$ and for 1 year was 50 $\mu g/m^3$.

Table 2.1: Malaysia Ambient Air Quality Guidelines (MAAQG)

Pollutant	Time	Malaysian Guidelines	
		ppm	$\mu g/m^3$
Particulate Matter (PM_{10})	1 year	-	50
	24 hours	-	150

CHAPTER 3

MATERIALS AND METHOD

3.1 Sampling Sites

The study area was conducted in the East Coast region of Malaysia (Kelantan and Pahang) which are Jeli, Kelantan (5.6990°N, 101.8464°E) and Balok, Pahang (03°57’39.1”N, 103°22’55.2”E) as shown in Figure 1 and 2.

Figure 3.1: Jeli, Kelantan. (Source from Google map, 2019).

Figure 3.2: Balok, Pahang. (Source from Google map, 2019).

Jeli district covered for about 30.55 km² where the district is the gateway for Kelantan that link with the South of the Kelantan of the Jeli-Dabong highway. 82% of the Jeli are full of the green scenery includes of jungles, hilly, river and also groves. There were so many protected areas for the green resources at the Jeli. There were less industrial company in Jeli and East-West highway located near Jeli town.

Department of Environment (2015) reported that the Air Quality Index (AQI) in Balok Baru, Kuantan Pahang recorded was 101 which means in poor quality. Balok Pahang has been facing an air pollution crisis due to the bauxite mining on 2016 that been vigorously voice out from the citizens who are dissatisfied with the bauxite issues since they concern with human health effect and environment.

Balok Pahang is the area that rapidly development built that totally secured with the industrial area that booming presence of Malaysia-Chinese industrial area in Kuantan and Gebeng industrial area (Figure 3.2). Gebeng industrial estates covering for 8600 hectares that includes of CSA Chemicals Sdn. Bhd., ChemStation Asia, Lynas Malaysia Sdn. Bhd., BASF Petronas Chemical Sdn. Bhd. and more. In addition, Lynas Malaysia Sdn, Bhd. is one of the radioactive industrial. Based on the Figure 3.2 the area of Balok is near to the industrial area thus Balok becomes the major road for the industries that transport the production of the factory to or from the Kuantan Port and neighbour country. Besides, urbanization is major attribution since the near Balok is an industrial so it can be as an attraction to outsiders for job scarcity. Dumping sites and illegal landfill is also an addition of activities at Balok Pahang where the irresponsible agencies simply threw the waste and burn those waste without considering the standard of procedures.

3.2 Data Analysis Using Automatic Weather Station

Automatic weather station is one an equipment used to measure the atmospheric condition that can provide information of weather forecast and study the weather and climate. Weather station can capture the data of wind speed, rainfall, air temperature, dew point temperature, air humidity and wind direction. It was applied of four legs for the mast construction then sink it in the ground surface to stand with measurement of stable height (Wal et al., 2005). All the wires and socket were applied with its pair correctly. The data were stored instantaneously for every 6 hours of period for continuously data for 3 days.

Weather station showed the results of hourly data for air humidity (%), air temperature (°C) and wind speed (m/s). Wind speed are measured using a rotating cup anemometer and a weather station located typically at 10 m from surface ground. Air humidity and air temperature are measured by using relative humidity sensor with radiation shield. All data were recorded in data logger.

3.3 Data Analysis Using Low Volume Air Sampler

3.3.1 Preparation of Laboratory Equipment

The aluminium foils were rinsed with the n-hexane solution meanwhile all the glassware rinsed with the n-hexane, acetone and washed with the water to make sure the glassware used in good condition that free from the dirt and contamination. All the glasswares were baked in furnace for 400 °C (Jamhari et al., 2014). Laboratory glassware were made of borosilicate glass that can reaches to maximum temperature of 500 °C but special precautions must be followed above 150 °C (Scharlab, 2012). It is conducted for the quality control to reduce the sampling errors. Extra care needed to remove the baked glassware from high temperature to low temperature which the glasswares need to cool down first in the furnace before put it out to prevent from thermal shock and crack (Corning, 2008).

3.3.2 Sample Preparation and Collection

The Quartz fibre filters were cut fitted into the PM_{10} ring holder. Those filters were baked in the furnace for 300 °C within 5 hours to remove the organic contaminants (Jamhari et al., 2014). Low volume air sampler (LVAS) model of LV-20P, Shibata, Japan was used to collect the 24-hours of aerosols samples that fitted with the selective inlet of PM_{10}. For the sampler it was setting of 1.5 m height and the air flow rate was 20 L/min. The filters were place into dessicator to maintain the temperature and humidity

3.3.3 Sample Weight, Record and Storage

Before and after sampling, the Quartz fibre filters were weighed using microbalance then placed into dessicator. The mass of the PM_{10} on the filter paper were determined through gravimetric methods of accuracy ±0.000001 g. The mass of filter papers and concentration of PM_{10} were calculated and recorded. All the filter papers were wrapped and folded with aluminium foil and stored in a fridge at 4 °C until the day for the sample analysis. The mass concentration of PM_{10} can be calculated through the Equation (3.1):

PM_{10} mass concentration in mg/m^3 (3.1)

$$\text{Concentration of } PM_{10}\ (mg/m^3) = \frac{mass\ of\ sample\ particulate\ matter\ (PM_{10})\ x\ 10^6}{Flow\ rate\ \left(\frac{1}{min}\right)\ x\ Elapsed\ time\ (\text{min})}$$

3.3.4 Preparation of Internal Standards

The detailed sample preparation and collection methods were described by (Salam et al., 2011). The surrogate standard that used as the internal standards were naphthalene-d_8, acenaphtene-d_{10}, anthracene-d_{10}, perylene-d_{12}, chrysene-d_{12} and p-terphenyl-d_{14}. Those standards were prepared for 1.5 ppm (part per million) using n-hexane and dichloromethane (DCM) by following the formula of Equation (3.2).

$M_1V_1 = M_2V_2$ (3.2)

M_1 = Concentration for standard (in ppm)

M_2 = Concentration for new standard (in ppm)

V_1 = Volume of standard needed (in mL)

V_2 = Volume of standard needed for dilution (in mL)

3.3.5 Extraction of PAHs

The Quartz fibre filter that had stored in fridge were used to undergo the PAHs extraction. Those filters were cut into (1 cm x 1 cm) and put into the universal bottles. Spike the sample with the 100 µL of the internal standards which are naphthalene-d_8, acenaphtene-d_{10}, perylene-d_{12} and chrysene-d_{12} (Blasco et al., 2007) and also the rest of internal standard which area anthracene-d_{10} and p-terphenyl-d_{14}.

Add 5 mL of n-hexane and DCM then continue sonicated the samples within 30 min for three series which total to 90 min where sonicated for 2 min and rest for 1 min. The samples in the universal bottles needs to transfer into new SPE test tube for each series of sonication method. Each 30 min that done with sonicate needs to collect the samples and put it into the same SPE test tube to undergo nitrogen evaporator. This is to make sure just the wanted compounds there.

Those samples were blow down till 200 µL with nitrogen evaporator and labelled the mark before and after the blow process to identify the benchmark of the solution in the samples. The test tubes were sealed with the aluminium foil and parafilm and keep in the fridge at 4 °C until the day for the sample analysis of solid phase extraction (SPE) method.

3.3.6 Solid Phase Extraction (SPE) Method

To undergo SPE method, the SPE were condition first by added of n-hexane solution in the cleanert to make sure the cleanert can filter the solution through drops by drops. 6.5 mL of n-hexane and 3.5 mL DCM were added into the samples. The samples were poured through the cleanert until it is done and this step were repeated for three times to make sure the right presence of compound there and also to make sure it is easily detected by GC-MS. Done with it, the samples needs to blow down with nitrogen evaporator until 200 μL.

3.3.7 PAHs Analysis Using Gas Chromatography Mass Spectrophotometer

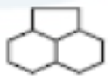
By using GC-MS the extract sample are analysed used column type HP-5MS UI with 30 mm fused silica capillary column, 0.25 mm internal diameter and 0.25 μm film thicknesses and temperature limits from -60 °C to 325 °C. According to (Christidis et al., 2003) method can be followed by using column type HP 1 that can help for the PAHs compounds to be identify. The temperature for GC is 60 °C and hold time for 7 °C/min then rise to 225 °C and hold for 15 °C/min. For 11.43 min the samples isothermally hold at 300 °C by using helium as the carrier gas. 1 μL of samples is inject under the SCAN model for qualitative analysis of PAHs. The PAHs was identified by comparing the spectrum found in the sample with the GC-MS library.

3.3.8 Sample Analysis

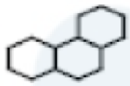
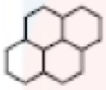
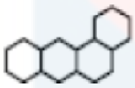
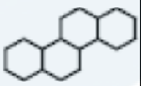
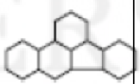
3.3.8.1 Target PAHs

Table 3.1 showed for 16 compounds of Polycyclic Aromatic Hydrocarbons (PAHs) that includes of abbreviations, structural formula, molecular mass, ring number and boiling point.

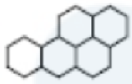
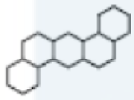
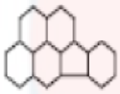
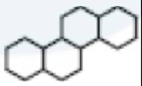
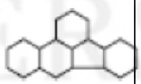
Table 3.1: 16 priority PAHs.

PAH	Abbreviation	Structural Formula	Molecular mass	Ring number	Boiling Point (°C)
Naphthalene $C_{10}H_8$	Nap		128	2	218
Acenaphthene $C_{12}H_{10}$	Ace		152	3	96
Acenaphthylene $C_{12}H_8$	Acy		154	3	275
Fluorene $C_{13}H_{10}$	Flu		166	3	295
Anthracene $C_{14}H_{10}$	Ant		178	3	340

(Continued)

Phenanthrene $C_{14}H_{10}$	Phe		178	3	340
Fluoranthene $C_{16}H_{10}$	Flt		202	4	375
Pyrene $C_{16}H_{10}$	Pyr		202	4	375
Benzo (a) anthracene $C_{18}H_{12}$	BaA		228	4	448
Chrysene $C_{18}H_{12}$	Chry		228	4	448
Benzo (b) fluoranthene $C_{20}H_{12}$	BbF		252	5	480
Benzo (k) fluoranthene $C_{20}H_{12}$	BkF		252	5	480

(Continued)

Benzo (a) pyrene $C_{20}H_{12}$	BaP		253	5	495
Dibenzo (a,h) anthracene $C_{22}H_{14}$	DBA		278	5	524
Indeno (1,2,3-cd) pyrene $C_{22}H_{12}$	Ind		276	6	530
Benzo (g,h,i) perylene $C_{22}H_{12}$	BghiP		276	6	550
Chrysene $C_{18}H_{12}$	Chry		228	4	448
Benzo (b) fluoranthene $C_{20}H_{12}$	BbF		252	5	480
Benzo (k) fluoranthene $C_{20}H_{12}$	BkF		252	5	480

(sources US Environmental Protection Agency, (2008)).

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Comparisons for Weather Station Data

This study was conducted on March and July in Balok and Jeli respectively. Malaysia will faces with Southeast Monsoon (SWM) from May until September while on November until March it is known as Northeast Monsoon (NEM) (Wong et al., 2016). In Malaysia, in industrial, urban and semi-urban area most of the PAHs detected were ranging from 4 – 6 rings during monsoon season (Jamhari et al., 2014). This can show that the types of PAHs could be different for various of locations because of meteorological factors and temporal fluctuations for concentration of PAHs that due to anthropogenic activities. Based on Figure 4.1, 4.2, 4.3, 4.4, 4.5 and 4.6 showed for the average hours data for air temperature, air humidity and wind speed for 3 days by using automatic weather station.

4.1.1 Air temperature (°C)

Based on Figure 4.1 and 4.2 showed for average hours of air temperature for 3 days sampling.

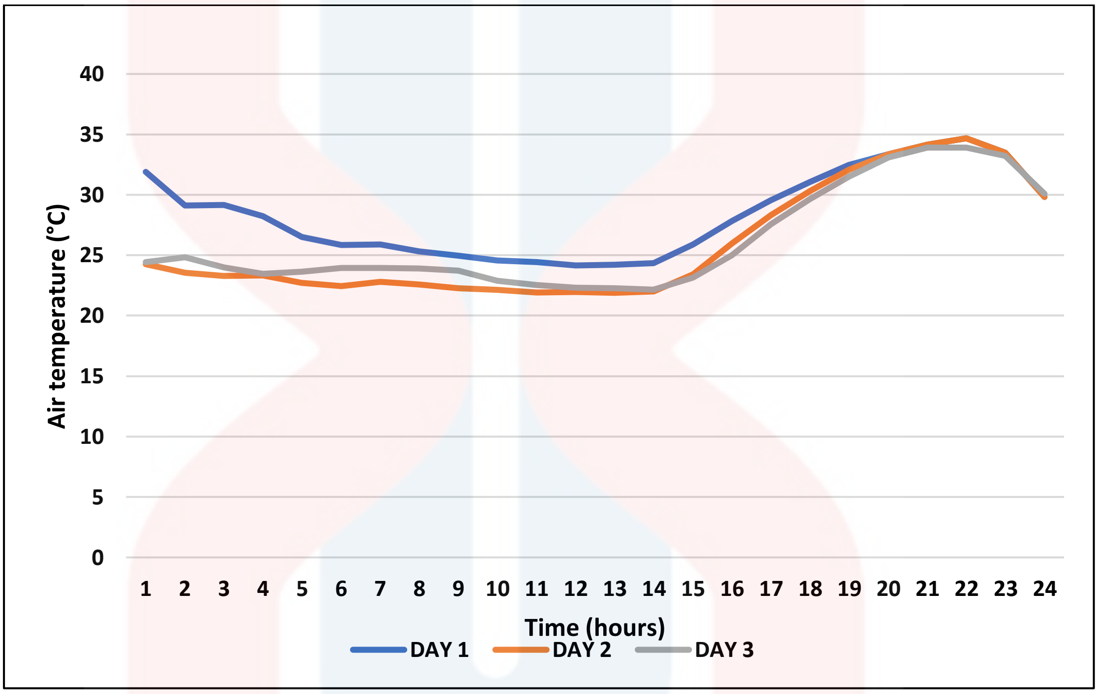


Figure 4.1: Average hours of air temperature data for 3 days in Balok.

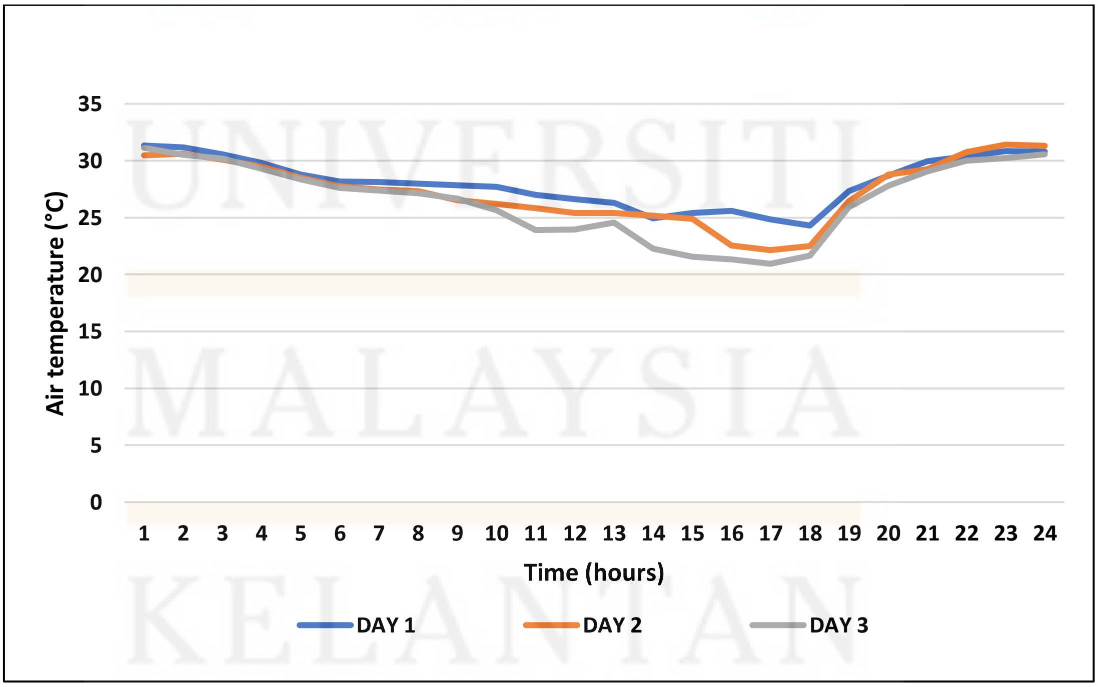


Figure 4.2: Average hours of air temperature data for 3 days in Jeli.

4.1.2 Relative humidity, RH (%)

Relative humidity represents for percentage of water vapor in the atmosphere that show for changes of air temperature. Based on Figure 4.3 and 4.4 showed for average hours of relative humidity for 3 days sampling.

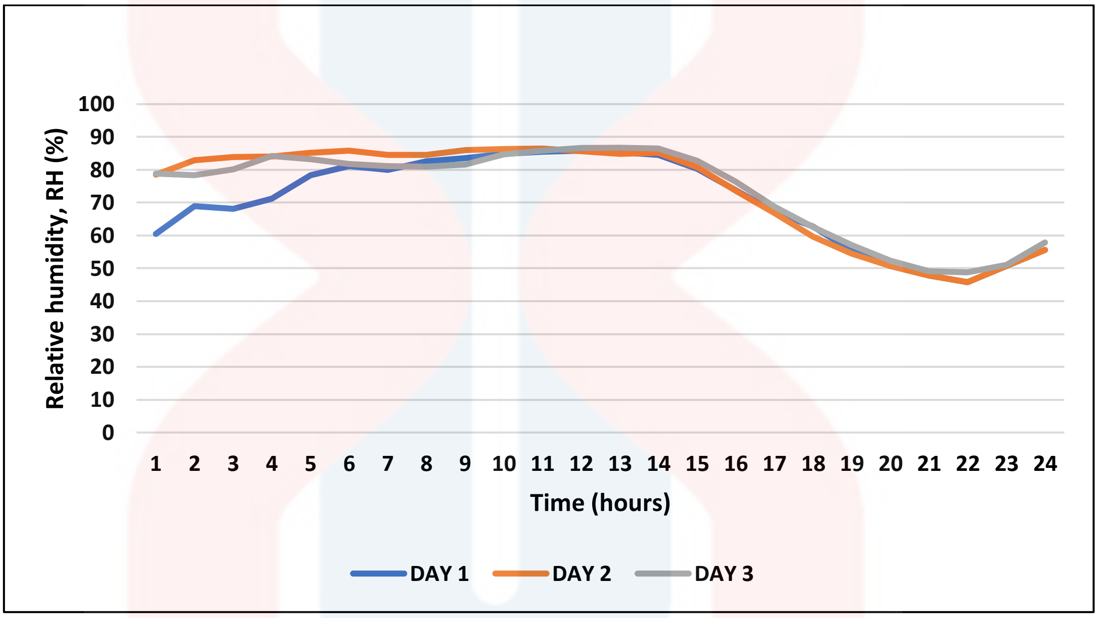


Figure 4.3: Average hours of relative humidity data for 3 days in Balok.

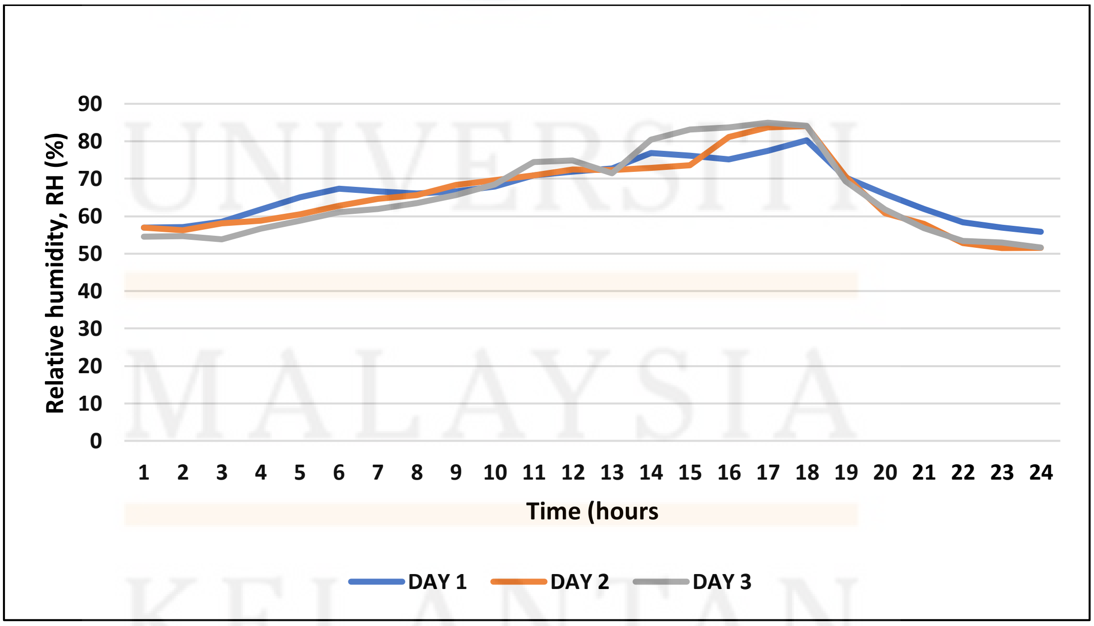


Figure 4.4: Average hours of relative humidity data for 3 days in Jeli.

Based on Figure 4.3 the relative humidity recorded in Balok ranged between 51 % and 85 %. For the first day recorded that the minimum of air humidity was 56 % and maximum of 80 %. For the second day recorded that the minimum of air humidity was 51 % and maximum of 84 %. For the third day recorded that the minimum of air humidity was 52 % and maximum of 85 %. Based on Figure 4.4 showed for the relative humidity in Jeli ranged between 46 % and 87 %. For the first day recorded that the minimum of air humidity was 46 % and maximum of 86 %. For the second day recorded that the minimum of air humidity was 46 % and maximum of 86 %. For the third day recorded that the minimum of air humidity was 49 % and maximum of 86 %.

Based on Figure 4.1, 4.2, 4.3 and 4.4 it showed that between graph of air temperature and relative humidity it was inversely proportional. As air temperature increase, the relative humidity will decrease as the air can hold more water vapor. When temperature decrease, the relative humidity will increase. When dew point approaches (RH=100 %), the high relative humidity of the air will occur. Relative humidity and rain for particulate matter can be increase during the monsoon season. This can be supported by Bathmanabhan & Madanayak (2010) that made a research on the effect of the monsoon season on the particulates and the outcomes showed the concentration of particulates highest during post-monsoon and winter season than summer season due to percentages of coarse particles accumulated highly on post-monsoon and winter season.

4.1.3 Wind speed (m/s)

Wind functions to carries the air contamination causing the pollutants to disperse from its source. If the wind speed is increase, there will be more contaminants that dispersed through the atmosphere. Based on Figure 4.5 and 4.6 showed for average hours of wind speed for 3 days sampling.

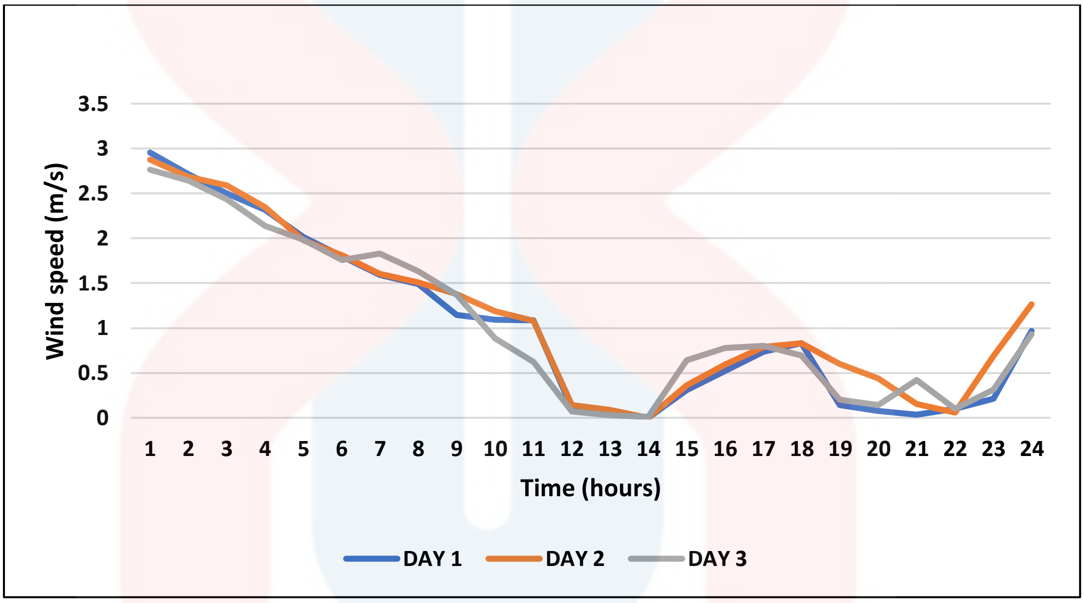


Figure 4.5: Comparison of weather station data of wind speed for 3 days in Balok.

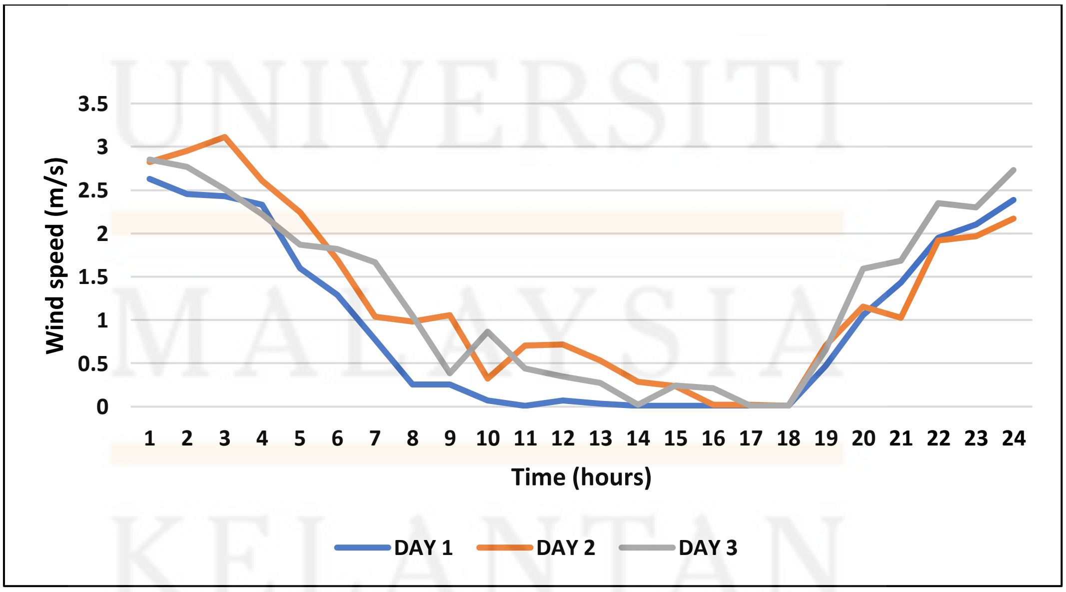


Figure 4.6: Comparison of weather station data of wind speed for 3 days in Jeli.

Wind speed and temperature plays an important role for the transportation and dispersion of air pollutants. Based on the Figure 4.5 and 4.6, showed for the average hours for wind speed minimum and maximum values ranged between 0 till 3 m/s.

Meteorological and atmospheric includes of relative humidity, air temperature and wind speed with PM_{10} showed that the temperature has positive correlation with PM_{10} concentration however it showed negative correlation with relative humidity. Increase in wind speed would help PM_{10} to dilute by dispersion and hence decrease its concentrations in the atmosphere (Akpinar, Oztop, & Akpinar, 2008). During high air temperature, the surface ground is warmer and the heat exchange in the air much more intense. So, the mixing of the air and increase the size of eddies which helps to reduce the concentration of pollutant (Afzali et al., 2014). Temperature increases the chemical reaction in the atmosphere resulting in the formation of finely divided particulate matter that naturally contributes to the concentration of PM_{10}. Besides, for air humidity it is normally affected by the numbers of rain occasion which through the wash-out methods of the atmospheric aerosols that reduces the concentration of pollutants in the air (Azmi et al., 2010). PM_{10} can be depending on the sources, geographical factors and also meteorological factors. Therefore, transportation and meteorological factors are relatable to explains the concentrations of PM_{10} in urban and rural area. The movements of air influence the air pollution. When air is in calm and pollution cannot disperse around, so the concentration of the pollutants will rise up. However, when strong wind blows, the pollutants can disperse quickly and resulting on the lower pollutant concentrations. Wind speed does not remove the pollutants in the air but rain will help to remove the pollutants from the air. Rain helps to lower down the severity of pollution.

4.2 Comparisons of Concentration of PM_{10} Between Urban and Rural Area

There are 6 aerosol samples that collected from Balok and Jeli on 28th February untill 2nd March 2019 and 10th July until 12th July 2019 with 24-hours. Table 4.1 showed for concentration of PM_{10} between urban area (Balok) and rural area (Jeli) followed by Equation (3.1).

Table 4.1: Concentration of PM10 between Balok and Jeli.

Contents/Samples	BALOK 1	BALOK 2	BALOK 3	JELI 1	JELI 2	JELI 3
Date	28/02/19	01/03/19	02/03/19	10/7/19	11/7/19	12/7/19
Initial weight (g)	0.0977	0.0965	0.0973	0.0839	0.0848	0.0803
Final weight (g)	0.1009	0.0998	0.0985	0.0851	0.0854	0.0807
Mass of samples (g)	0.0032	0.0033	0.0012	0.0005	0.0006	0.0004
Initial weight (µg)	97700	96500	97300	83900	84800	80300
Final weight (µg)	100900	99800	98500	85100	85400	80700
Mass of samples (µg)	3200	3300	1200	500	600	400
Average duration (min)	1440	1440	1440	1440	1440	1440
Air flow rate of LVAS (m^3/min)	0.02	0.02	0.02	0.02	0.02	0.02
Volume of air sampler (m^3)	28.80	28.80	28.80	28.80	28.80	28.80
Concentration of PM_{10} (µg/m^3)	111.111	114.583	41.667	17.361	20.833	13.889

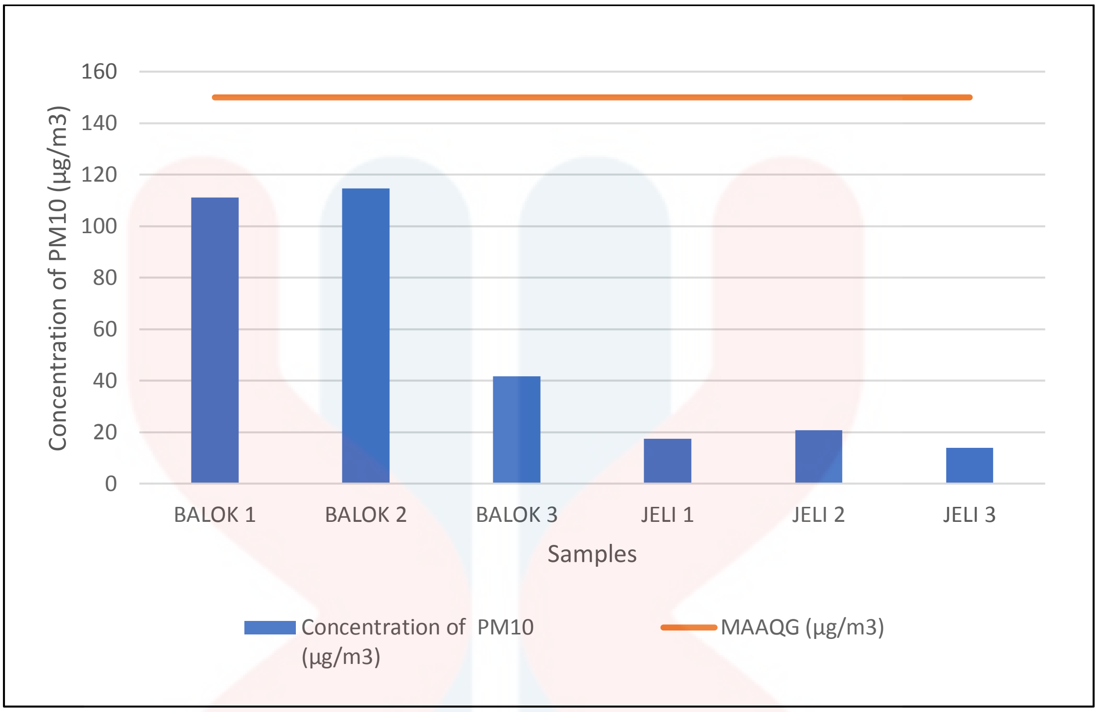


Figure 4.7: PM_{10} concentrations for Balok and Jeli with standard for Malaysian Guidelines by MAAQG.

The number of days that recorded for PM_{10} concentration were tabulated on Figure 4.2. The concentration for exceeding 100 µg/m^3 considered to be moderate for the children, the elderly and pregnant women and for exposure level exceeding 150 µg/m^3 considered as unhealthy for populations (Latif, Abidin, & Praveena, 2015). It showed that Balok for 2 days (28/2/19 and 2/3/19) showed 111.111 and 114.583 µg/m^3 respectively, in which it is exceeding 100 µg/m^3 but not exceeding to 150 µg/m^3. Based on the MAAQG, the average of PM_{10} concentration for 24-hours for Malaysia Guideline is 150 µg/m^3. Based on Figure 4.7, both urban and rural area for PM_{10} concentration does not exceed the limit for MAAQG.

Table 4.2 showed the descriptive analysis of PM_{10} concentration during the sampling time by using Independent Samples t-Test.

Table 4.2: Descriptive analysis of concentrations of PM_{10} in Balok and Jeli.

Variable	Statistic	Site	
		Balok	Jeli
Concentration of PM_{10} ($\mu g/m^3$)	Minimum	41.667	13.889
	Maximum	114.583	20.833
	Mean	89.120	17.361
	Standard Deviation	41.132	3.472
	p-value (0.05)	0.040	

Descriptive analysis on Table 4.2 used to analyse the recorded data to determine the intensity of concentration of PM_{10}. Based on Table 4.2 the average concentration of PM_{10} that recorded in Balok (urban) and Jeli (rural) was 89.120 $\mu g/m^3$ (ranging from 41.667 – 114.583 $\mu g/m^3$) and 17.361 $\mu g/m^3$ (ranging from 13.889 – 20.833 $\mu g/m^3$). This shows that the means for concentration of PM_{10} for Balok was much higher than Jeli during the sampling duration for PM_{10} concentration. The result of Independent Samples t-Test as in Table A2 (Appendix A) showed there is significant difference in mean of concentration of PM_{10} for both locations ($p<0.005$). This is due to the Balok is located in an industrial area with high traffic emission which are covered up for 8600 hectares for Gebeng industrial estates on Figure 3.2. The higher number of industrial activities, vehicle and street dust that expected to contribute to the release of suspended particulate matters in Balok than Jeli.

4.3 PAHs Compound That Found in Rural and Urban Area

Total of 6 aerosol samples was analysed to detect the presence of Polycyclic Aromatic Hydrocarbon (PAHs) within 3 samples from each of urban and rural area that showed on Table 4.3 and 4.4.

Table 4.3: PAHs compound that found from concentration of PM_{10} in urban area.

No.	Sites	PM_{10} Concentration (µg/m^3)	PAHs detected
1	BALOK 1	111.111	16 PAHs
2	BALOK 2	114.583	16 PAHs
3	BALOK 3	41.667	16 PAHs

Table 4.4: PAHs compound that found from the concentration of PM_{10} in rural area.

No.	Sites	PM_{10} Concentration (µg/m^3)	PAHs detected
1	JELI 1	17.361	Naphthalene Acenaphthene
2	JELI 2	20.833	Naphthalene Acenaphthene
3	JELI 3	13.889	Naphthalene Acenaphthene

The average concentration of PM_{10} in urban area was 89.120 µg/m^3 (ranging from 41.667 – 114.583 µg/m^3) meanwhile for rural was 17.361 µg/m^3 (ranging from 13.889 – 20.833 µg/m^3). Based on Table 4.3, Balok found 16 compounds of PAH which are naphthalene, anthracene, phenanthrene, acenaphthene, acenaphthylene, fluorene, fluoranthene, benzo (a) anthracene, chrysene, pyrene, benzo (b) fluoranthene, benzo (k) fluoranthene, dibenzo (a,h) anthracene, benzo (a) pyrene, indeno (1,2,3-c,d) pyrene and benzo (g,h,i) perylene. Based on Table 4.4, for Jeli, the PAHs compounds found only 2 which are naphthalene and acenaphthene.

4.4 Comparisons of PAHs Between Urban and Rural Area

Total PAHs was found out to be more effective when the air sampler whether it is low volume sampler or high volume air sampler was placed on rooftop of a three-storey building due to the meteorological conditions such as rainfall and wind (Jamhari et al., 2014). The important factor that affect the distribution of PAHs from the atmosphere includes of meteorological factors such as air temperature, air humidity and wind speed. Based on Figure 4.1, 4.2, 4.3, 4.4, 4.5, and 4.6 showed the relationship between meteorological factors during the period. This might be the reason PAHs cannot be detected on July because it is wettest during sampling. Furthermore, high wind speeds and heavy rainfall might show that the air particles to be dispersed.

There were slightly differences between the compound of PAHs that found in urban and rural area which urban showed for 16 PAHs while Jeli only posed 2 compound of PAHs presence. Based on Table 3.1, showed the characteristic of 16 PAHs includes of number of rings. PAHs that had two or three benzene rings will exist in vapour form. This is due to the warm temperature might increase the rate for volatilization of PAHs with two or three rings. The boiling point for two benzene ring was low compared to six benzene ring. If the number of rings is increase, it is hard for the bonds to split since the pressure is stronger on six benzene ring rather than two benzene ring. This can be shown that six benzene ring took longer time to disperse since the boiling point is high since it needs to break up the bonds on more than 530 °C.

This can be related on the location and the activity around or near the area. Balok located near to industrial area and the use of vehicles in-and-out such as lorry that transport bauxite or cement was high. However, Jeli is located on rural area that mainly on green cover area and surrounds by mountains. In addition, the sample for Balok was collected on weekends where most people might travel to shopping and buy their own needs that means the concentration on the vehicle smoke that contribute to concentration of PM_{10} and the industrial training keeps on operation even though it is weekend that made it is obvious the contribution of higher concentration of PM_{10} in Balok is much more relevant according to the results compared to Jeli.

The other PAHs were not detected in Jeli from the GC-MS analysis because the PAHs might not be present in the samples. The location and the height of instruments to collect the ambient data were not good enough which maybe the source of particulate matter that collected the ambient air might originally came from mixture from street dust and some particles that dispersed through atmosphere by the heavy transportation such as lorries. Besides, the difference used of GC column and temperature that inappropriate for the compounds to be detected which every single compound had it is own characteristics to spark up the retention times on GC-MS.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The quality of outdoor air pollution is one of the highlight issues that has been concerned in serious way by government and public. Based on the result, the average concentration of PM_{10} of Balok was much higher than Jeli which was 89.120 µg/m^3 (ranging from 41.667 – 114.583 µg/m^3) and 17.361 µg/m^3 (ranging from 13.889 – 20.833 µg/m^3). The urban area (Balok) showed for posed high threats on air pollution of particulate matter (PM_{10}) and Polycyclic Aromatic Hydrocarbon (PAHs) compared to Jeli.

The compound of PAHs that detected from sample of urban sample is 16 PAHs which are naphthalene, anthracene, phenanthrene, acenaphthene, acenaphthylene, fluorene, fluoranthene, benzo(a)anthracene, chrysene, pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenzo (a, h) anthracene, benzo (a) pyrene, indeno (1, 2, 3-c, d) pyrene and benzo (g, h, i) perylene. For Jeli, the PAHs compounds found only 2 which are naphthalene and acenaphthene. In addition, most PAHs were detected from samples of urban area is due to anthropogenic activities such as transportation and industrial activities that located near to Balok and meteorological activity that helps to spread the air pollution that air can longer in atmosphere for longer period of time. Based on the Earth's condition that turbulent, such as for country that lives in windy season, the air pollution can spread for in single time. It can be concluded that the urban site (Balok) is high in PM_{10} concentration than rural area (Jeli). Balok and Jeli can detected 16 PAHs and 2 PAHs respectively. However, both were still under standard of PM_{10} concentration of ambient air quality standard and it is not affected with US EPA 16 priority PAHs. But, rules and regulations of Malaysia air quality standards need to followed not only for industrial activities but also for other human activities. If the situation where the air pollution happens, it needs to give full attention to overcome it.

5.2 Recommendations

In future study, the collection of data can be collected during weekends and weekdays to see the patterns and the relationship between range number of PM_{10} concentration and also the existence of populations and the causes. Moreover, the sample monitoring and precision in handling the preparation of samples need to highlight since the volume and concentration of each samples determine the recovery internal standards. Besides, the use of apparatus need to be concern by using only glassware apparatus because the precision of the result might affect outcomes. Furthermore, the best condition to set up the GC-MS with its heat and injection spike with time and heat and also the use of type of column is important since it determines whether can or not the compounds can be spike on its retention time.

REFERENCES

Abdel-Shafy, H. I., & Mansour, M. S. M. (2016). A review on polycyclic aromatic hydrocarbons: Source, environmental impact, effect on human health and remediation. *Egyptian Journal of Petroleum*, *25*(1), 107–123. https://doi.org/10.1016/j.ejpe.2015.03.011

Afzali, A., Rashid, M., Sabariah, B., & Ramli, M. (2014). PM10 pollution: Its prediction and meteorological influence in PasirGudang, Johor. *IOP Conference Series: Earth and Environmental Science*, *18*(1). https://doi.org/10.1088/1755-1315/18/1/012100

Akpinar, S., Oztop, H. F., & Akpinar, E. K. (2008). Evaluation of relationship between meteorological parameters and air pollutant concentrations during winter season in Elaziğ, Turkey. *Environmental Monitoring and Assessment*, *146*(1–3), 211–224. https://doi.org/10.1007/s10661-007-0073-9

Azmi, S. Z., Latif, M. T., Ismail, A. S., Juneng, L., & Jemain, A. A. (2010). Trend and status of air quality at three different monitoring stations in the Klang Valley, Malaysia. *Air Quality, Atmosphere and Health*, *3*(1), 53–64. https://doi.org/10.1007/s11869-009-0051-1

Baldwin, A. K., Corsi, S. R., Lutz, M. A., Ingersoll, C. G., Dorman, R., Magruder, C., & Magruder, M. (2017). Primary sources and toxicity of PAHs in Milwaukee-area streambed sediment. *Environmental Toxicology and Chemistry*, *36*(6), 1622–1635. https://doi.org/10.1002/etc.3694

Bathmanabhan, S., & Saragur Madanayak, S. N. (2010). Analysis and interpretation of particulate matter - PM10, PM2.5 and PM1 emissions from the heterogeneous traffic near an urban roadway. *Atmospheric Pollution Research*, *1*(3), 184–194. https://doi.org/10.5094/APR.2010.024

Bernstein, J. A., Alexis, N., Barnes, C., Bernstein, I. L., Bernstein, J. A., Nel, A., … Williams, P. B. (2004). Health effects of air pollution. *Journal of Allergy and Clinical Immunology*, *114*(5), 1116–1123. https://doi.org/10.1016/j.jaci.2004.08.030

Blasco, M., Domeño, C., Bentayeb, K., & Nerín, C. (2007). Solid-phase extraction clean-up procedure for the analysis of PAHs in lichens. *International Journal of Environmental Analytical Chemistry*, *87*(12), 833–846. https://doi.org/10.1080/03067310701381615

Byeong-Kyu Lee, & Vu, T. V. (2010). Sources, Distribution and Toxicity of Polyaromatic Hydrocarbons (PAHs) in Particulate Matter. *Air Pollution*, (May 2014). https://doi.org/10.5772/10045

C.H Monn, O. Braendli, G. Schaeppi, C.H Schindler, U. Ackerman-Liebrich, P. L. and S. T. (1995). *13s2-2310(95)0027{. 29*.

Christidis et al., 2003. (2003). *Estimation of selected physicochemical properties for methylated naphthalene compounds*. *52*, 869–881. https://doi.org/10.1016/S0045-6535(03)00288-1

Corning. (2008). *Care and Safe Handling of Laboratory Glassware*.

Department of Environment, (DOE). (2015). *Table 1 : New Malaysia Ambient Air Quality Standard*. 1989.

Drahansky, M., Paridah, M. ., Moradbak, A., Mohamed, A. ., Owolabi, F. abdulwahab taiwo, Asniza, M., & Abdul Khalid, S. H. . (2016). We are IntechOpen , the world ' s leading publisher of Open Access books Built by scientists , for scientists TOP 1 %. *Intech*, *i*(tourism), 13. https://doi.org/http://dx.doi.org/10.5772/57353

Dybing, E., Schwarze, P. E., Nafstad, P., Victorin, K., & Penning, T. M. (2010). Hydrocarbons in Ambient Air and Cancer. *Iarc Scientific Publication*, *161*, 75–94.

Environmental Protection Agency (EPA). (2011). *Particulate Matter Emissions*. (1), 1–9. Retrieved from http://www2.cec.org/site/PPE/content/particulate-matter-emissions-0

Goodale, B. (2013). *Developmental Toxicity of Polycyclic Aromatic Hydrocarbons: Defining Mechanisms with Systems-based Transcriptional Profiling*.

Han, B., Bai, Z., Guo, G., Wang, F., Li, F., Liu, Q., … Hu, Y. (2009). Characterization of PM10 fraction of road dust for polycyclic aromatic hydrocarbons (PAHs) from Anshan, China. *Journal of Hazardous Materials*, *170*(2–3), 934–940. https://doi.org/10.1016/j.jhazmat.2009.05.059

Isa. (2010). *a Study of Indoor Air Quality in Dormitories of Unwersiti*. (November).

Jamhari et al., 2014. (2014). Concentration and source identification of polycyclic aromatic hydrocarbons (PAHs) in PM10 of urban, industrial and semi-urban areas in Malaysia. *Atmospheric Environment*, *86*, 16–27. https://doi.org/10.1016/j.atmosenv.2013.12.019

Joseph, A. E., Sawant, A. D., & Srivastava, A. (2003). PM10 and its impacts on health - A case study in Mumbai. *International Journal of Environmental Health Research*, *13*(2), 207–214. https://doi.org/10.1080/0960312031000098107

Kawanaka, Y., Matsumoto, E., Wang, N., Tsuchiya, Y., Yun, S. J., Zhao, W. J., & Sakamoto, K. (2006). Mutagenic activity of atmospheric ultrafine particles at a roadside site and a suburban site. *Journal of Health Science*, *52*(4), 352–357. https://doi.org/10.1248/jhs.52.352

Kibble, A., & Harrison, R. (2005). Point sources of air pollution. *Occupational Medicine*, *55*(6), 425–431. https://doi.org/10.1093/occmed/kqi138

Kim, K. H., Jahan, S. A., Kabir, E., & Brown, R. J. C. (2013). A review of airborne polycyclic aromatic hydrocarbons (PAHs) and their human health effects. *Environment International*, *60*, 71–80. https://doi.org/10.1016/j.envint.2013.07.019

Kim, K. H., Kabir, E., & Kabir, S. (2015). A review on the human health impact of airborne particulate matter. *Environment International*, *74*, 136–143. https://doi.org/10.1016/j.envint.2014.10.005

Lancet, T. (2006). *More testing for HIV needed WHO ' s global air-quality guidelines*.

2006.

Latif, M. T., Abidin, E. Z., & Praveena, S. M. (2015). The Assessment of Ambient Air Pollution Trend in Klang Valley. *World Environment*, *5*(1), 1–11. https://doi.org/10.5923/j.env.20150501.01

Maliszewska-Kordybach, B. (1999). Sources, Concentrations, Fate and Effects of Polycyclic Aromatic Hydrocarbons (PAHs) in the Environment. Part A: PAHs in Air. *Polish Journal of Environmental Studies*, *8*(3), 131–136.

Mearns, L. O., & Hulme, M. (2001). Climate Scenario Development. *Climate Change 2001: The Physical Science Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change*, 739–768. https://doi.org/10.1111/j.1749-8198.2011.00426.x

Nordin, N., Majid, M. R., Siong, H. C., & Kurata, G. (2016). Co-benefit modeling and optimization of air pollution control in Iskandar Malaysia: A methodology using BenMap. *Planning Malaysia*, *4*(Special Issue 4), 285–294.

Pope, C. A., Bates, D. V., & Raizenne, M. E. (1995). Health effects of particulate air pollution: Time for reassessment? *Environmental Health Perspectives*, *103*(5), 472–480. https://doi.org/10.1289/ehp.95103472

Radzi Abas, M., Oros, D. R., & Simoneit, B. R. T. (2004). Biomass burning as the main source of organic aerosol particulate matter in Malaysia during haze episodes. *Chemosphere*, *55*(8), 1089–1095. https://doi.org/10.1016/j.chemosphere.2004.02.002

Ravindra, Mittal, A. K., & Van Grieken, R. (2001). Health risk assessment of urban suspended particulate matter with special reference to polycyclic aromatic hydrocarbons: A review. *Reviews on Environmental Health*, *16*(3), 169–189. https://doi.org/10.1515/REVEH.2001.16.3.169

Salam, M. A., Shirasuna, Y., Hirano, K., & Masunaga, S. (2011). Particle associated polycyclic aromatic hydrocarbons in the atmospheric environment of urban and suburban residential area. *International Journal of Environmental Science and Technology*, *8*(2), 255–266. https://doi.org/10.1007/BF03326214

Scharlab, 2012. (2012). *Laboratory Glassware*. (2).

Schindler, C., Keidel, D., Gerbase, M. W., Zemp, E., Bettschart, R., Brändli, O., … Rochat, T. (2009). Improvements in PM10 exposure and reduced rates of respiratory symptoms in a cohort of swiss adults (SAPALDIA). *American Journal of Respiratory and Critical Care Medicine*, *179*(7), 579–587. https://doi.org/10.1164/rccm.200803-388OC

Sierra-Vargas, M. P., & Teran, L. M. (2012). Air pollution: Impact and prevention. *Respirology*, *17*(7), 1031–1038. https://doi.org/10.1111/j.1440-1843.2012.02213.x

Thongsanit, P., Jinsart, W., Hooper, B., Hooper, M., & Limpaseni, W. (2003). Atmospheric Particulate Matter and Polycyclic Aromatic Hydrocarbons for PM10and Size-Segregated Samples in Bangkok. *Journal of the Air and Waste Management Association*, *53*(12), 1490–1498.

https://doi.org/10.1080/10473289.2003.10466325

US Environment Protection Agency. (2013). Extra_Polycyclic Aromatic Hydrocarbons (PAHs) Fact Sheet. *Environmental Health*, 1–2. Retrieved from https://www.epa.gov/sites/production/files/2014-03/documents/pahs_factsheet_cdc_2013.pdf

Van de Wal, R. S. W., Greuell, W., Van den Broeke, M. R., Reijmer, C. J., & Oerlemans, J. (2005). Surface mass-balance observations and automatic weather station data along a transect near Kangerlussuaq, West Greenland. *Annals of Glaciology*, *42*(August 2004), 311–316. https://doi.org/10.3189/172756405781812529

WHO. (2003). *Health Aspects of Air Pollution with Particulate Matter, Ozone and Nitrogen Dioxide Report on a WHO Working Group OZONE-adverse effects NITROGEN DIOXIDE-adverse effects AIR POLLUTANTS, ENVIRONMENTAL-adverse effects META-ANALYSIS AIR-standards GUIDELINES*. (January), 30. Retrieved from http://www.euro.who.int/__data/assets/pdf_file/0005/112199/E79097.pdf

Wong, C. L., Liew, J., Yusop, Z., Ismail, T., Venneker, R., & Uhlenbrook, S. (2016). Rainfall characteristics and regionalization in peninsular malaysia based on a high resolution gridded data set. *Water (Switzerland)*, *8*(11). https://doi.org/10.3390/w8110500

APPENDIX A

Table A1: Statistical table for concentration of PM_{10} in Balok and Jeli

	Treatment	N	Mean	Standard Deviation	Standard Error Mean
Concentration of PM_{10} ($\mu g/m^3$)	Balok	3	89.120	41.132	23.748
	Jeli	3	17.361	3.472	2.005

Table A2: Independent samples t-Test for Balok and Jeli.

		Levene's Test for Equality of Variance		t-Test for Equality of Means						
		F	Sig	t	df	Sig. (2-tailed)	Mean Difference	Standard Error	95% Confidence Interval of the Differences	
									Lower	Upper
PM_{10}	Equal variance assumed	13.248	0.022	3.011	4	0.040	71.760	23.832	5.590	137.929
	Equal variance not assumed			3.011	2.028	0.093	71.760	23.832	-29.414	172.933

APPENDIX B

Figure B1: The instalment and position of weather station and low volume air sampler during sampling days.

Figure B2: Furnace used to bake all the glassware and aluminium foils.

Figure B3: The arrangement of apparatus, chemicals and nitrogen evaporator used in fume hood.

Figure B4: The samples need to wrapped with baked aluminium foils and stored in chiller.