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Distribution of Air Pollution Focused on Particulate Matter 2.5 ($PM_{2.5}$) Caused by Industrial Activities in Parit Raja

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Abstract: Particulate matter (PM) consists of a solid complex mixture and suspended liquid particles in the ambient air. Nine factories operated in Parit Raja that emitted many air particles and gaseous pollutants that may cause irritation of respiratory tracts and lungs for residents living near the area. The overall goal of this research was to analyze the distribution of particulate matter 2.5 ($PM_{2.5}$) in ambient air surrounding industrial areas in Parit Raja. 27 sampling locations chosen in this study with each sampling location was 0.16 km² and the total area for these sampling locations was approximately 2.52 km². $PM_{2.5}$ concentration and meteorological data were measured by using Temtop Airing-1000 Detector and Professional Weather Station device respectively. Air sampling data for these sampling locations were conducted simultaneously on the same day every hour for each sampling location within 24 hours. The result shows that the highest concentration of $PM_{2.5}$ ranges from 18.2 to 29.0 µg/m³ at the South direction, which was at the industrial area and residential area such as Taman Ria Baru due to wind direction from emission source pointed to that area and low wind speed. Therefore, all of the sampling locations must be measured simultaneously within 24 hours to ensure accurate data of $PM_{2.5}$ concentration may be achieved.

Keywords: Particulate Matter 2.5 ($PM_{2.5}$), Industrial Area, Sampling Locations

1. Introduction

Particulate matter (PM) consists of a solid complex mixture and suspended liquid particles in the ambient air. The particles of these PM are microscopic that cannot be viewed by using naked eyes. The $PM_{2.5}$ particles are smaller than particles of PM_{10} that have 10 micrometers in diameter that called fine particles. Several components lead to PM formation, including solids or liquids finely divided, such as dust, fly ash, soot, smoke, aerosols, fumes, mists and condensing vapor suspended in ambient air extended period.

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PM sources can be classified into two categories: primary sources of PM and secondary sources of PM. Human and natural activities may derive as primary sources of PM. The sources of PM are mainly generated from a variety of human activities that are called as anthropogenic sources. Operation of agricultural, processes from industrial, wood and fossil fuels combustion, construction and demolition activities are the example types of human activities. Natural sources also contribute to PM problems, called non-anthropogenic or biogenic sources such as dust and wildfires windblown. Directly emitting air contaminants into the atmosphere may define as secondary sources of PM. Sulfur oxide, nitrogen oxide, volatile organic compound and ammonia can be classified as pollutants that lead to the formation of PM by secondary sources. Indoor air particulate in developing countries may cause about 28% of sickness and death among the public [1]. Exposure to the PM from air pollution will associate with cardiovascular and respiratory disease endpoints. The scenario may also affect lung development, especially in children and may cause the function to be reversible due to the reduction of lung growth rate. Incomplete combustion from the black carbon part of $PM_{2.5}$ has attracted the community's attention about air quality that is owed to the evidence for effects of detrimental contribute to health and climate [2]. However, the release of PM can be reduced by ensuring the combustion appliances of fuel-fired such as stoves, heaters and furnaces are vented to the outdoors.

Deterioration quality of air that resulted from unwanted chemicals or other materials also can be defined as air pollution. The simple way that can be used to measure the level of air pollution is by calculating the amounts of natural or external substances in the atmosphere that may be affected by living things such as humans, animals and the environment. Air pollution was distributed unequally with varies of locations at any time that have been given [3]. Air pollution not only deleterious effected on human health, but it also may produce a negative impact on the ecosystems, materials, buildings and works art, environment and visibility. Poor condition of air pollution may extremely contribute to the detrimental of consequences health [4]. Humans that more exposure to pollutants usually occur in small parcels of the atmosphere that called as microenvironments. Natural sources such as the eruption of volcanoes and forest fires usually will create several tones of greenhouse gases and the other pollutants that obviously may produce the pollution which is the solution for the incidents are unable to find because it naturally occurred [5].

Almost all parts of the urban environment in the world are experienced high levels of air pollutants. Unplanned development and growth in Malaysia nowadays were initiated based on the needs and pressure of the time. An inversion in the valley can occur when the atmospheric problem related to the pollution becomes more hazardous. The Malaysia Air Pollution Index (API) was identified from the acceptable particle measurement below 10 μm and several gases such as carbon monoxide, sulphur dioxide and nitrogen dioxide [6]. Table 1 shows the API for Malaysia.

Table 1: The Malaysia Air Pollution Index (API)

Item	API	Diagnosis
1	0 - 50	Good
2	51 - 100	Moderate
3	101 - 200	Unhealthy
4	201 – 300	Very Unhealthy
5	>301	Hazardous

The Malaysian DoE also introduced policy development by using Recommended Malaysian Air Quality Guidelines 1989 (RMAQG) and the RMAQG was replaced with New Ambient Air Quality Standard as shown in Table 2 [7].

Table 2: New Ambient Air Quality Standard

Item	Pollutants	Averaging	Malaysian Guidelines
			μg m⁻³
1	Ozone (O^3)	1 hour 8 hours	180 100
2	Carbon Monoxide (CO)	1 hour 8 hours	30 10
3	Nitrogen Dioxide (NO_2)	1 hour 24 hours	280 70
4	Sulphur Dioxide (SO_2)	1 hour 24 hours	250 80
5	Particulate Matter (PM_{10})	24 hours 12 months	100 40
6	Particulate Matter ($PM_{2.5}$)	24 hours 12 months	35 15

Particulate matter (PM) is defined as a term for particles of solid or liquid found in the air. Some particles are dark and significant in size characteristics making them easily seen as soot or smoke. Chemical and physical compositions of the particulate matter vary widely because the particles originate from various mobile and stationary sources such as woodstoves, power plants and others. Therefore, it was very concerned about the sizing of particles in a smaller size, which is only 10 micrometers in diameters because it may pass through the human throat and nose and enter the lung [8].

Several complex factors influenced the dispersion and transportation of air pollutants in the ambient air. Dispersion and transportation of pollutants also affect by patterns of global and regional weather. For example, in a specific area, the degree of air pollution was determined by the number of pollutants that released into the atmosphere. Distribution of particulate matter led to the concerning of health public especially in countries with the growing of industrialization activities [9]. On the other hand, other factors that influenced the air pollution scenario are humidity, temperature inversions, wind speed and wind direction. Extreme of wind speed was the most important meteorological element that influenced the Air Quality Index (AQI) at the certain area [10]. An occurrence of air pollution also affects by the condition of meteorological [11]. Mobile laboratory was used in the urban area to investigate the transportation air pollutants in the vehicular that influenced by wind direction and speed [12]. Extremely variations of weather conditions whether in cold or hot condition has been contributed to the increasing rate of morbidity and mortality through the common of temperature range [13].

This research aims to measure the concentration of $PM_{2.5}$ at surrounding industrial area in Parit Raja and construct the contour mapping based on the measurement of $PM_{2.5}$ concentration at a surrounding industrial area in Parit Raja by using ArcGIS software. In addition, meteorological data such as wind direction, wind speed, temperature and humidity were also measured in this study. Nine factories operated the events that emit many air particles and gaseous pollutants including that may cause irritation of respiratory tracts and lungs for residents living near the industrial area. The activities carried out include electrical appliances manufacturing, wood processing plants, corrugated maker, and packaging facilities. Therefore, it is imperative to measure the level of air pollutants to overcome the problem of air pollution. Therefore, the information of air pollutants' status is essential to prevent the long-term effects.

2. Materials and Methods

2.1 Sampling Location Selection

There were 27 sampling locations in this study. The total area of the sampling locations is 2.52 km^2 with 0.16 km^2 in the area for each sampling locations. The locations were selected based on the grid that suitable for developing mapping of $PM_{2.5}$ concentrations. Figure 1 shows the chosen locations for air sampling surrounding the industrial area in Parit Raja.

Figure 1: Location grid for sampling data

Air sampling data for these 27 sampling locations were conducted simultaneously by using suitable equipments to measure the concentration of $PM_{2.5}$ and meteorological data. These activities also were conducted on the same day for each sampling locations. Then, the average for the concentration of $PM_{2.5}$ was calculated and data was recorded. The data were collected once per week for three consecutive weeks and the surrounding activities of the sampling locations were also observed to obtain precise data. Data collected during the observation include average concentration, average temperature, humidity, wind speed and wind direction.

2.2 Measurement of $PM_{2.5}$

Temtop Airing-1000 Detector device was used to measure the concentration of $PM_{2.5}$ in the unit of micro per meter ($\mu g/m^3$) at the selected sampling locations. Figure 2 shows the Temtop Airing-1000 Detector device. The Temtop Airing 1000 Detector was chosen due to the function of the device that may calibrate from the manufacturer for data accuracy and quality control. In addition, the data collected was compared to the E-sampler device which has an error of less than 5% in $PM_{2.5}$ concentration measurement.

Figure 2: Temtop Airing-1000 Detector

The Temtop Airing-1000 has an ideal multi-function tool to monitor the ambient air quality and as a safeguard especially for human health because this device is used to check the outdoor air quality and indoor air quality in the office area, home and environment in the car. This device was also used to collect all of the needed data because the unit was standardizing by using the standard unit and made it easy to read. For example, $PM_{2.5}$ concentration has been setting in a unit of micro per meter ($\mu g/m^3$) not in a unit of mass of particulate matter which is detailed data.

2.3 Sampling of Meteorological Data

Data of meteorological samplings such as temperature, humidity, wind speed and wind direction were collected during the sampling process at each sampling. The data of meteorological sampling at the sampling locations were collected per hour by using 100M Professional Weather Station Thermometer Humidity Rain Pressure Data Recorder and PC Solar Power Wireless Weather Center apparatus as shown in Figure 3 and Figure 4 respectively.

Figure 3: 100M Professional Weather Station Thermometer Humidity Rain Pressure Data Recorder

Figure 4: PC Solar Power Wireless Weather Center

The device was chosen because it can provide the most accurate data and easy to understand the given data to measure the data of outdoor temperature range (-40˚C to +60˚C), temperature accuracy (±1.0˚C), humidity range (20% to 90%), humidity accuracy (±5%), rain range (0 to 9999 mm), pressure range (750hpa to 1100hpa), data update in every 48s, anti-rainy, wind speed and direction and battery life is about two years.

2.4 Distribution of $PM_{2.5}$ concentration

After the process data collection process was done, mapping for concentration of $PM_{2.5}$ was conducted by using mapping software, ArcGIS software. The software was used to plot the highest risk location of the polluted area by $PM_{2.5}$. This ArcGIS software was also designed according to mapping of world technologies growth and analytics of data to provide an intelligence location and transformation of digital that needed for all organization sizes.

3. Results and Discussion

The air quality of the atmosphere in the surrounding industrial area was measured by observing the highest and lowest $PM_{2.5}$ concentration from this area in Parit Raja. The contour mapping of selected locations was constructed using ArcGIS software based on the measurement of $PM_{2.5}$ concentration in the industrial area at Parit Raja.

3.1 Measurement on $PM_{2.5}$ concentration

Figure 5 shows the $PM_{2.5}$ concentration versus time (hours). Based on the figure, the highest concentration of $PM_{2.5}$ was 29 µg/m^3 at 6.30 p.m. and the lowest concentration was 4.8 µg/m^3 at 7.00 a.m. This lowest concentration of $PM_{2.5}$ concentrations was observed during the non-activity hours in the industrial area from 7.00 to 7.30 a.m. The concentration of $PM_{2.5}$ was the lowest due to the movement of vehicles in the UTHM area was decreased due to the majority of students of UTHM were stayed at home during this open distance learning (ODL) on this Pandemic Covid-19. The concentration became increase exceeded 10 µg/m^3 started at 9.00 a.m. due to some of the factories detected, this situation was emitted dust to the ambient atmosphere that could affect the surrounding area which may increase the level of $PM_{2.5}$ concentration.

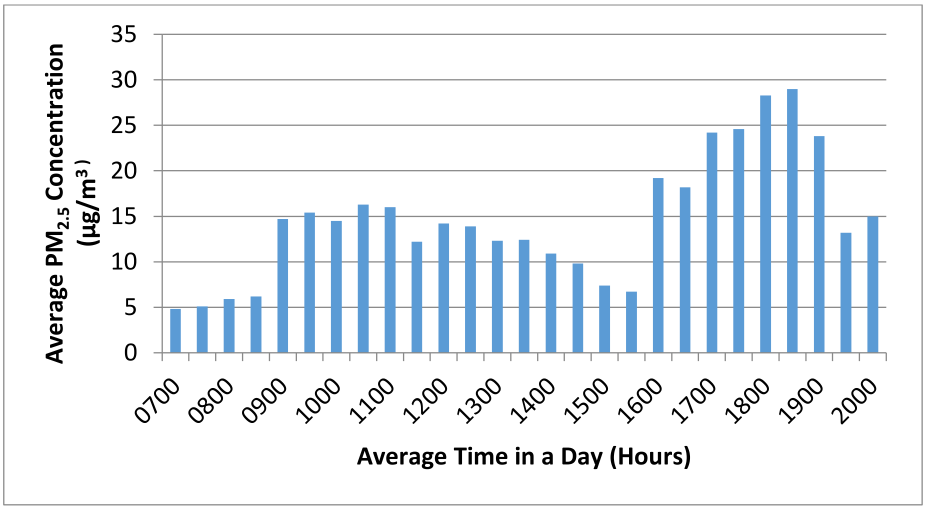

Figure 5: $PM_{2.5}$ Concentration versus Time (hours)

In the evening during this observation started at 4.00 p.m, the concentration of $PM_{2.5}$ was observed to increase more than the morning session. At this time, it was observed that there were many vehicles on the road because most people just finished their work and prepared to back home. Therefore, the roads around the industrial area also become more crowded and jammed. This condition contributed to the concentration of $PM_{2.5}$ rapidly increase. Furthermore, during the observation, a factory in the industrial area also released the dust in the evening. This kind of situation also may affect the $PM_{2.5}$ concentration of the surrounding area in Parit Raja.

Based on this observation, the range of $PM_{2.5}$ concentration in this study was from 4.8 to 29.0 29 µg/m^3 which was not exceeded the New Malaysia Ambient Air Quality Standard, 2020, within 24 hours which was 35 µg/m^3. Therefore, this study showed that the concentration of $PM_{2.5}$ around the UTHM campus was still in a safe condition.

3.2 Contour mapping on $PM_{2.5}$ concentration

Figure 6 shows a contour mapping on $PM_{2.5}$ concentration was constructed by ArcGIS software. Based on the figure, the sampling points area in this study was divided into three area which were UTHM campus area with the range of $PM_{2.5}$ concentration were from 4.8 to 16.3 µg/m^3, an industrial area with a range of concentration was from 18.2 to 24.6 µg/m^3 and residential area which was at Taman Ria Baru with range concentration was from 13.0 to 29.0 µg/m^3.

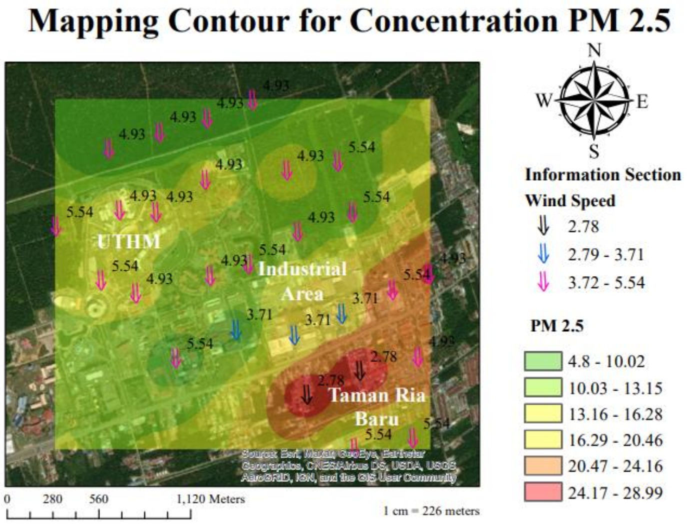

Figure 6: Contour Mapping on $PM_{2.5}$ Concentration

The highest concentration of $PM_{2.5}$ was detected at Taman Ria Baru with red colour contour with the range for $PM_{2.5}$ concentration were from 24.16 to 28.99 µg/m^3. The light red colour was also detected along Jalan Kluang. At the industrial area zone, there were three various colours of contour which were yellow colour with the range of $PM_{2.5}$ were from 16.28 to 20.46 µg/m^3, light yellow colour with a range of concentration was from 13.15 to 16.28 µg/m^3 and light red colour of the contour with a range of concentration was from 20.46 to 24.16 µg/m^3.

In the observation, the lowest concentration area of $PM_{2.5}$ detected at the UTHM campus area with the range concentration of $PM_{2.5}$ was from 4.80 to 10.00 µg/m^3 in the green colour of contour. There was no red colour contour in the UTHM campus area. It is shown that the UTHM campus had the lowest concentration of $PM_{2.5}$ compared to the industrial area and residential area at Taman Ria Baru. There were only specific points in the UTHM campus area that the $PM_{2.5}$ concentration had the light yellow colour of contour.

Based on the figure, Taman Ria Baru (residential area) had the highest concentration of $PM_{2.5}$ due to the wind speed of this location was low and wind direction was pointed at the South area. On the other hand, the UTHM campus area which was in the West area had the lowest concentration of $PM_{2.5}$ due to the average wind speed at this area was high compared to the wind speed at the residential area and the wind direction also not pointed at the West area on this study.

4. Conclusion

In this study, the highest polluted area was detected at the residential area at Taman Ria Baru with the range of $PM_{2.5}$ concentration was 28.3 to 29.0 µg/m^3. On the other hand, the lowest polluted area was detected at the UTHM campus area with the range of $PM_{2.5}$ were from 4.8 to 9.8 µg/m^3. Based on the contour mapping, wind direction and wind speed were the factors that influenced the concentration of $PM_{2.5}$. Therefore, areas with the lowest wind speed and the most wind direction that focused on the areas were the most polluted compared to the opposite area. In addition, measurement of $PM_{2.5}$ concentration should be conducted in other wind speeds and directions to ensure the emission effect from the industrial area to the air quality of this area can be measured.

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