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RESEARCH ARTICLE

Elemental Characteristics of Particulate Matter (PM_{10} and $PM_{2.5}$) from Peat Swamp Area in Kuala Pahang

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ABSTRACT - Particulate matter (PM) is normally being divided into two common groups known as: the coarse fraction particle with a range of sizing from 2.5 to 10 UM (PM_{10}–$PM_{2.5}$), and the fine fraction particles with a dimension smaller than 2.5 µm ($PM_{2.5}$). It is also can be defined as a sum of solid and liquid particles which suspended in the air. The contribution of particulate matter towards the air pollution from peat swamp area in Kuala Pahang can be generated from various sources such as unpaved road, vehicle, open burning and uncover soil. In fact, monsoon season also play an important role where PM can be conveyed by wind from one location to another. Air pollution has become a matter of concern over Malaysia. The objective of this survey is to determine the particular matters in the air by using Aeroqual AQM 65 which is located in Kuala Pahang, Pekan. Air Pollution Index (API) is the reading to determine the quality of air whether it suitable and safe for human being. The data is obtained from the Aeroqual AQM 65 machine starting for April 2019 till March 2020. The survey will last for 12 months to generate a reliable result. From the API gain, the government can work out with some ideal on improving the surrounding air quality in the meantime to generate different strategy to overcome the problems. According to Aeroqual AQM 65, the reading of concentration of PM_{10} and $PM_{2.5}$ are almost the same yet the concentration of PM_{10} is still slightly higher than $PM_{2.5}$. According to the analysis, there is a rapid increase of concentration of PM form June to September and a sharp drop from September to March due to the happening of monsoon season. When the direction of monsoon season changes, the graph tends drop because the wind tends to convey the PM away. Therefore, the reading of API of $PM_{2.5}$ is higher than PM_{10} and the highest reading for both particular matter API is on September yet the lowest reading of API for both particular matters is on November.

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1. INTRODUCTION

Based on the powerful wisdom of mankind, the science is unearthed. In the hard work of human's generations, human beings are making more and more progress. However, they did not expect that all human civilization progress may harm the environment. As the time goes, air pollution is getting worse day by day. The main objective of this study is to monitor the reading of $PM_{2.5}$ and PM_{10} in Kuala Pahang's peat swamp area, by using real time air monitoring via Aeroqual AQM 65. In an addition, the happening of open burning in the wetland area will release a lot of harmful gases and increase the reading of API and particulate matter concentration value [1].

This study identifies the concentration level of $PM_{2.5}$ and PM_{10} in Kuala Pahang, due to open burning and the concentration of API of $PM_{2.5}$ and PM_{10} due to the effect of Monson seasons from April 2019 to March 2020. Haze, fog and mist are three different things although they look the same. There can reduce the visibility but haze is something that made out of extremely tiny and harmful airborne particular. Normally, people will misunderstand haze with mist or fog because they are reducing visibility. Actually, fog is a name given to resulting the visibility which is less than 1km range but mist is just the same phenomenon as fog but with a lower density and the visibility is increased to be 1km or more than 5 km in range. This phenomenon can strongly affect the operation of traffic [2].

Air Pollution Index (API) is a generalized way to describe the air quality, which is normally use in Malaysia. To identify the pollution index, it is calculated from various sets of air pollution data. If the API exceeds 500, a state of emergency is declared in the reporting area. The data that need to be recorded to calculate the air pollution index (API) are particulate matter 10 (PM_{10}), Ozone Level (O_3), Nitrogen Dioxide (NO_2), Sulfur Dioxide (SO_2), Carbon Monoxide (CO), Temperature, and Humidity [3]. In 1993 the DOE established its first air quality index system, known as the Malaysian Air Quality Index (MAQI), and played an important role in informing both decision makers.

The status indicator of API was divided into a few categories. For instance, good, moderate, unhealthy, very unhealthy, hazardous, and emergency as mentioned in Table 1 [4], which can be of air quality management level or decision making for data interpretation processes. The index system known as API is a simple comprehensive approach for defining air quality status that can be understood easily by the general public. It is categorized based on the highest values from five

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main air pollutants index values: particulate matter <10µm (PM_{10}), ozone (O_3), carbon monoxide (CO), sulphur dioxide (SO_2), and nitrogen dioxide (NO_2) for a particular time period, and where PM_{10} and SO_2 hourly value are averaged over a 24-hour running period, CO is averaged over an eight-hour period, and O_3 and NO_2 are read hourly before an hourly index is calculated with the use of sub index functions for each pollutant according to the standpoint of human health implications.

Table 1. API status indicator [4]

Air Pollutant Index (API)	Descriptor
0 – 50	Good
51 – 100	Moderate
101 - 200	Unhealthy
201 – 300	Very Unhealthy
>300	Hazardous
>500	Emergency

Each pollutant has a different impact on human health. For instance, PM can cause lung cancer and cardiopulmonary deaths while O_3 can reduce lung function and induce coughing and choking[5]. The presence of CO can cause mortal growth in pregnant women as well as affect tissue development of young children [6]. A non-irritating gas such as NO_2 may irritate respiratory infections with indications like a cough, sore throat, nasal congestion, and fever while SO_2 can narrow the airways for people with asthma and shortness of breath [7]. However, all the harmful gases may lead to immediate effects on cardiovascular hospitalisation [8].

2. MATERIAL AND METHODS

2.1 Study area

Ambient air quality was monitor continuously by using real time air monitoring system Aeroqual AQM 65. In this study, the monitoring system is located in Kuala Pahang, Pekan. It is strategically located in the area surrounded by peat swamp. The dataset was obtained from the machine from April 2019 to March 2020 monthly. Kuala Pahang, Pekan was selected for this study due to the surrounding of peat swamp around the area. The sampling station was located in University Malaysia Pahang (3º32'37.3''N 103º25'44.0''E)

Air contain many other gas particles such as oxygen, methane, hydrogen and so on. Air is also a comfort blanket for Earth. Without the present of air, the average temperature of the air will be at below freezing point which will not be suitable for living things to live on. So, the heat in the Earth's atmosphere helps to maintain the surface temperature to be warm.Air is a must to all living things on Earth. Our body need to consume clean air to make sure that we get enough oxygen to stay alive. While air contain oxygen, carbon dioxide, nitrogen and many other gases[9]. A clean air is air that do not contain any other chemical particles and dust particle that can harm the body. In Malaysia, the major air pollution that we will face is haze where there are a lot of tiny dust and smoke particles that can penetrate through lungs and go into the blood stream. So, API reading is widely use in all country to determine the quality of air whether the current air condition is suitable for outdoor activities. If the API reading is too high, it is not recommended for people to carry out door activities due to the polluted air where there are a lot of tiny dust and smoke particles that can penetrate through lungs and go into the blood stream. So, API reading is widely use in all country to determine the quality of air whether the current air condition is suitable for outdoor activities. If the API reading is too high, it is not recommended for people to carry any activities. Particulate matters are small tiny particles in the air that is floating free in the air. It is particles that are so small that we can see through our naked eye. There will have particulate matters in the air whenever we go.

2.2 Aeroqual AQM 65

Aeroqual AQM 65 is an advance air sensor technology that can provide multiple functions of monitoring air quality. Aeroqual AQM 65 is developed by Specto Technology which provide many advance wireless software and also hardware on field of Geotechnical, Environmental Monitoring, and Structural. With all these software and hardware provided, it is enough for us to monitor the air quality data conveniently through the internet since Aeroqual AQM 65 can deliver a complete wireless monitoring solution. The Aeroqual AQM 65 is also safe to be used since it attached with high security system to protect the database for managing data from any point of the world.

The Aeroqual AQM 65 is a water proof apparatus where it is specially customized to configuration might include sulfur dioxide (SO_2), ozone (O_3), nitrogen dioxide (NO_2), carbon monoxide (CO), $PM_{2.5}$, PM_{10}, temperature, humidity, wind speed and direction. All these measurements are the main sources to measure the API.

Figure 1. Aeroqual AQM 65

More than that, Aeroqual AQM 65 also provides air pollution measurement so that it can warn people when the air quality drops to unhealthy level. This instrument contains various sensor equipment such as outdoor air quality test kit, urban air quality monitor, air monitoring station and micro air monitoring. It also can install other optional external sensor and auxiliary modules such as MetOne MSO weather station, Cirrus MK427 noise meter, Vaisala WXT536 weather station, Gill Instrument Windsonic, and Li-Cor LI-200 Pyranometer [10].

AQM 65 is a very expensive apparatus and cannot be affected by any other external circumstance. So, there are factors that need to be considered before choosing the suitable site position for air monitoring to ensure that the data collected is valid and reliable. Since AQM 65 is a very sensitive apparatus and can be easily affected by other circumstance. So, the factors are as follow:

- Site area should be in the area where chemical or physical interference may occur.
- Site surrounding need to have good access and not vulnerable to vandalism.
- Site should not be easily affected by extraneous local emission.
- Site area should not be adjacent to structures that distort the air flow.

The apparatus will automatically generate data and upload it to the internet through online software. It will alert the user via email or SMS if the apparatus needs technical support, such as for changing of gas filters. Additionally, the apparatus will directly inform the user that the surrounding air pollutant is reaching a dangerous status and can warn the user to leave the current surrounding as fast as possible or warn the user to stay at home and prevent outdoor activities.

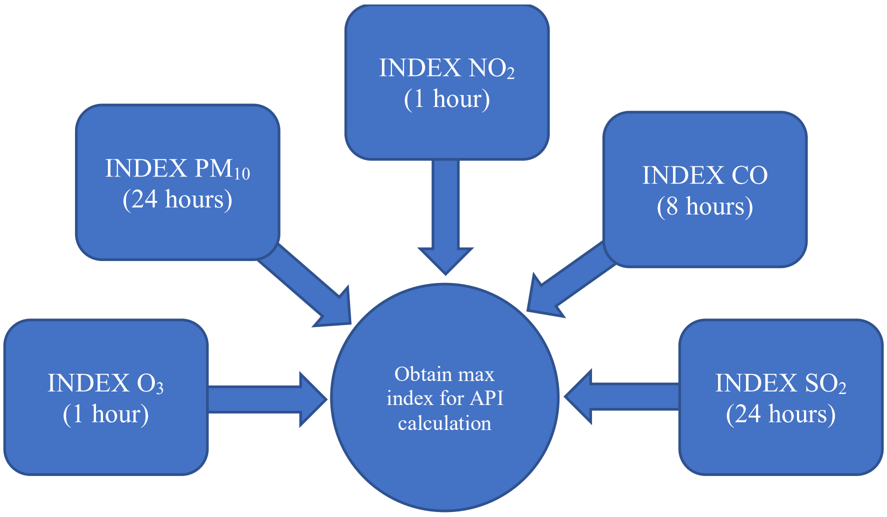

Figure 2. Air pollutant criteria [10]

By generate the calculation of API, there are some steps needed to be followed. In the first place, we need to identify the five main pollutants that are responsible for the API value which include CO, PM_{10}, NO_2, SO_2 and O_3 [10]. When all the data are recorded, take the value and substitute them into the equation for each particulate pollutant with the value falling in the specific range. After that, the value of API will be generated [11].

Table 2. Calculation for $PM_{2.5}$

Air Pollutant Index (API)	Equation for API
X < 0.2	API = conc. x 1000
0.2 < X < 0.4	API = 200 + ((conc. – 0.2) x 500)
X > 0.4	API = 300 + ((conc. – 0.4) x 1000)

Table 3. Calculation for PM_{10}

Air Pollutant Index (API)	Equation for API
X < 50	API = conc
50 < X < 150	API = 50 + ((conc. – 50) x 0.5)
150 < X < 350	API = 100 + ((conc. – 150) x 0.5)
350 < X < 420	API = 200 + ((conc. – 350) x 1.4286)
420 < X < 500	API = 300 + ((conc. – 420) x 1.25)
X > 500	API = 400 + (conc.- 500)

Table 4. Air Pollutant Index Classification [11]

API Value	API Category	API Colour
0-50	Good	Green
51-100	Moderate	Yellow
101-150	Unhealthy for sensitive group	Orange
151-200	Unhealthy	Red
201-300	Very Unhealthy	Purple
301-500	Hazardous	Maroon

3. RESULT AND DISCUSSION

3.1 Average Monthly Concentration of $PM_{2.5}$ and PM_{10}

Table 9. Average Monthly Concentration of $PM_{2.5}$ and PM_{10} (µg/m³)

Air Pollutant	Average Concentration (µg/m³)											
	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19	Oct-19	Nov-19	Dec-19	Jan-20	Feb-20	Mar-20
$PM_{2.5}$	3.11	2.61	2.28	2.73	4.91	8.09	5.70	1.88	2.01	2.65	2.79	3.29
PM_{10}	3.15	2.76	2.43	2.84	5.03	8.15	5.83	1.99	2.19	2.76	2.92	3.41

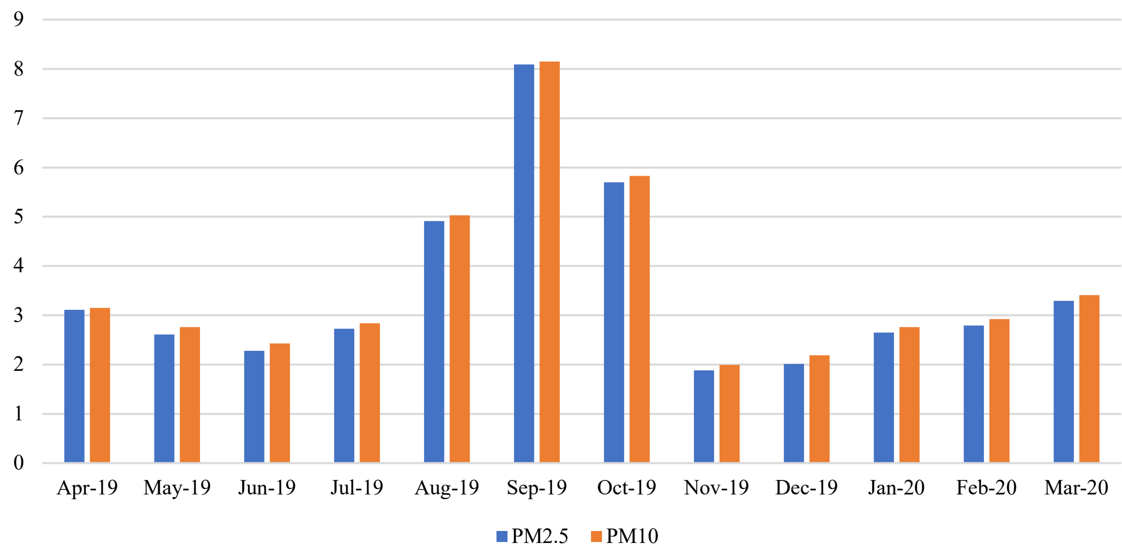

Figure 4. Average concentration of particulate matters

3.2 Average Monthly API of $PM_{2.5}$ and PM_{10}

Table 10. Average monthly API

Air Pollutant	API											
	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19	Oct-19	Nov-19	Dec-19	Jan-20	Feb-20	Mar-20
$PM_{2.5}$	12.947	10.855	9.489	11.386	20.438	33.727	23.752	7.818	8.386	11.044	11.615	13.700
PM_{10}	3.151	2.763	2.427	2.844	5.029	8.152	5.825	1.988	2.186	2.763	2.921	3.413

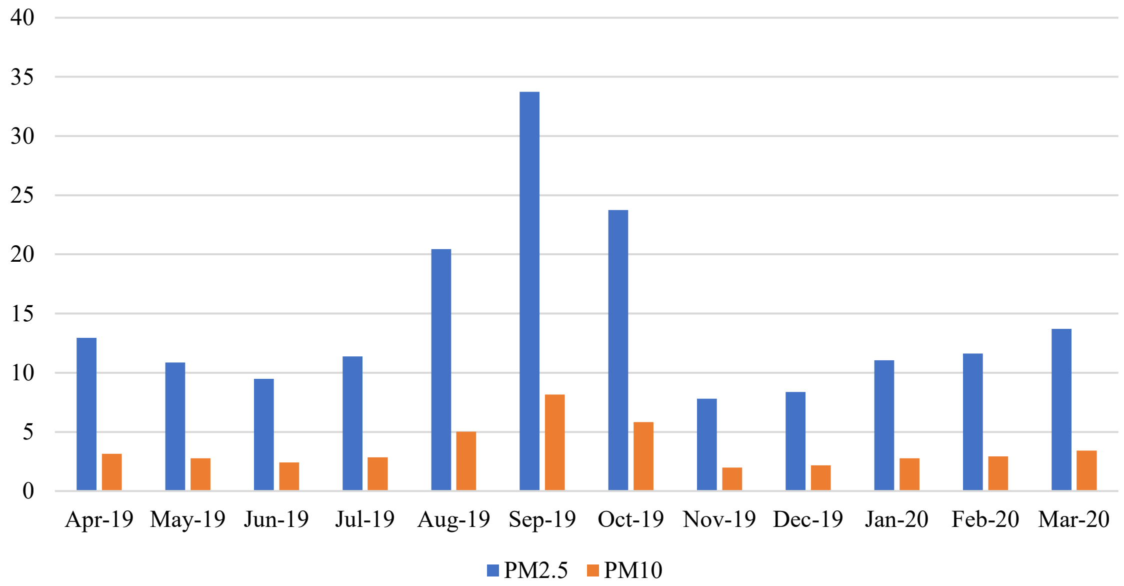

Figure 5. Average API for particulate matters

3.3 Data Analysis

The data were analyzed using transformation accessed in Excel add-on statistical software to generate the graph. There is a total of 12 month's data in total which were used to generate the graph. The graph shows a peak increase on July 2019 and a sharp decrease on November 2019 for both monthly concentration and monthly API of PM_{10} and $PM_{2.5}$.

This case study also tends to investigate the real time API level of PM10 and PM2.5 due to the effect of monsoon season in Pekan from April 2019 to March 2020. From the result obtain, we can conclude that throughout all the months, the reading of concentration for PM_{10} is higher than $PM_{2.5}$. Where the highest PM_{10} is 8.15µg/m³ and highest $PM_{2.5}$ is 8.09 µg/m³. Other than that, the reading of API for $PM_{2.5}$ is higher than PM_{10} which means that $PM_{2.5}$ has a higher pollution level than PM_{10}. By looking at the graph for monthly average API, they both start to increase from June 2019 and reach a peak level at September 2019. This happen because then happening of South-west Monsoon Season which happen from late May to September. During this month, the monsoon season blow lot of harmful gases to Pekan which are mainly from the open burning of Indonesia.

There is also happening of open burning in Pekan area in August where lot of particulate matters are being released into the air. The happening of open burning also increase the concentration of particulate matter in the air as well. After that, the trend of the graph starts to decrease from September 2019 till November 2019 where. This situation tends to happened because the happening of the Northeast Monsoon Season which happen from October to March. Then happening of the monsoon season blow the harmful gases away from Pekan making the surrounding air to turn clean. So, as a simple conclusion, the reading of concentration of PM_{10} is still slightly higher than $PM_{2.5}$ and they both have a same graph trend. Next, the API reading for both PM_{10} and $PM_{2.5}$ are affected by the monsoon season that happened in Malaysia. The monsoon season can cause the API reading to increase and also decrease by depending on the currently surrounding situation. Lastly, the happening of open burning in Pekan peat swamp area on August also tend to speed up the increase of particulate matter concentration and the API value as well

Looking at Table 9 and Figure 4, it shows the trend of monthly average particulate matter of $PM_{2.5}$ and PM_{10} from April 2019 to March 2020 in Kuala Pahang. The value of PM concentration of both PM shown a rapid increase from July 2019 to September 2019. Where the value for $PM_{2.5}$ reach the highest at 33.727 µg/m³ and PM_{10} reach 8.152 µg/m³ at the peak value. According to [12], the hazardous level for $PM_{2.5}$ falls at 350.4 µg/m³, very unhealthy level at 350.4-150.4 µg/m³, unhealthy for sensitive groups at 150.4-55.4 µg/m³, moderate level at 55.4-35.4 µg/m³ and acceptable / good level at 12 µg/m³ and below. Besides that, by according to [12], it shows the grading of PM_{10} which good level of PM_{10} is raging at 0-54µg/m³, Moderate level raging at 55-154µg/m³, unhealthy for sensitive individuals' level at 155-254µg/m³, unhealthy level raging at 255-354µg/m³, very unhealthy level raging at 355-424µg/m³ and hazardous level at 425µg/m³ and more. By using this guideline, we are able to determine the level of PM in Kuala Pahang.

The highest value of $PM_{2.5}$ and PM_{10} are at 8.09 µg/m³ and 8.15µg/m³. The peak increase of $PM_{2.5}$ and PM_{10} are due to the changes of monsoon season in Malaysia. In Malaysia, there are 2 types of monsoon season which namely known as northeast monsoon and southwest monsoon [13]. Each monsoon season happened on different months. Southwest monsoon happens on May to August where Northeast monsoon happens from November and ends in February [14]. Due to Malaysia's strategic location which it located between the Indian Ocean and Pacific Ocean, hence the climate is mainly affected by the natural climate variability of the ocean [15].

It was found that the PM was actually being conveyed by the monsoon wind from Indonesia[16]. According to[17], Indonesia's Environment and Forestry Minister stated that in the year 2019, the forest fire had burned 857,756 hectares of peat and mineral soil, which was almost 12 times the size of Singapore[18]. Due to the contribution of forest fire, $PM_{2.5}$ and PM_{10} in Malaysia tend to raise rapidly until September 2019. The PM will also affect the API too. The highest reading of API contributes by $PM_{2.5}$ is 33.772 µg/m³ where PM_{10} reach a reading of 8.152 µg/m³. The high API value might be due to the happening of monsoon season and also the open burning happened in Indonesia [19]. Besides, the API value also decrease rapidly from September to December 2019. This is because the happening of Northeast monsoon in Malaysia. By referring to[20], the harmful PM is being conveyed by the Northeast monsoon back to its original place.

4. CONCLUSION

As in a nut shell, the conclusions that could be drawn by the case study were as follows:

a) The readings of PM_{10} and $PM_{2.5}$ have almost the same concentration level. Both of the pollutant does not have major difference.
b) The reading of API for $PM_{2.5}$ is higher that PM_{10} where $PM_{2.5}$ reached a maximum at 33.727 while PM_{10} reach a maximum at 8.152, where both readings are still in the good category.
c) Concentrations for both PM_{10} and $PM_{2.5}$ begin to raise rapidly starting Jun 2019 until September 2019 and then drop back rapidly till November 2019 due to monsoon season.
d) Open burning at Pekan increase the concentration level of particulate matter and the API value which give a rapid increase in the reading.

Therefore, based on the conclusions that were outlined above, it can be summarized that PM_{10} has a slightly higher concentration level than $PM_{2.5}$ yet both of the pollutant has a same trend. Besides, $PM_{2.5}$ has a higher API value than PM_{10}. The rapid increasing of concentration of the particulate matter from Jun 2019 till September 2019 is caused by the Southwest Monsoon Season where haze from Indonesia was blew to Malaysia due to forest fire and open burning. The rapid drop of the reading is caused by Northeast Monsoon Season which happened from October till March as the monsoon blew the haze away from Malaysia.

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AUTHOR CONTRIBUTIONS

H.E. Eng, C.S. Teoh: Data curation, Writing- Original draft preparation

F. Ismail: Writing- Reviewing and Editing

A. S. Abd Razak: Conceptualization, Methodology, Software

S. Sulaiman: Supervision

DATA AVAILABILITY STATEMENT

The data used to support the findings of this study are included within the article.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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