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Impact of Meteorological Conditions on Airborne Particulates ($PM_{2.5}$ & PM_{10}) Concentration on Universiti Tun Hussein Onn Malaysia (UTHM) Ambient

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Abstract: The goal of this study at Universiti Tun Hussein Onn Malaysia is to determine the impact of meteorology on the concentration of airborne particulates in the ambient air. Many human activities contribute to air pollution at UTHM. Primary and secondary air pollutants exist. Carbon monoxide (CO) and particulate matter (PM) are principal pollutants in Malaysia, while sulphur dioxide, nitrogen oxides, and ozone are minor pollutants. In terms of type, affordability, flexibility, and accuracy, there are now more options. UTHM used the Met One E – Sampler and the Meteo Compact Station to collect data on particulate matter and weather conditions. A total of 14 days of data were gathered at FKAAB and Makmal Kejuruteraan Bahan Termaju (FKAAB). This study looked at particulate matter concentration, wind speed, relative humidity, and temperature. The greatest average levels of PM_{10} and $PM_{2.5}$ were found in Makmal Kejuruteraan Bahan Termaju (FKAAB), with 33.21 $\mu g/m^3$ and 29.0 $\mu g/m^3$, respectively. However, both stations' particulate concentrations are below the New Ambient Air Quality Standard (NAAQS). The concentration measured may be generated by surrounding human activity such as manufacturing plants, construction, heavy traffic, and other human activities. As a conclusion, future research should focus on determining the most significant human activities that contribute to the presence of contaminants in the ambient air at UTHM.

Keywords: Meteorological Conditions, Airborne Particulate Concentration, Air Pollution

1. Introduction

Air pollution is the presence of contaminants into the air that can impair both human and environmental health. These pollutants or impurities in the air also impact the population's degree of comfort. Air pollution is described as a chemical or physical situation that harms humans, other animals, vegetation, or materials [1] . Air pollution occurs when gases, fine particles, or liquid aerosols are

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released into the atmosphere at rates exceeding the environment's natural capacity to dissipate, dilute, or absorb them. These substances may cause detrimental health, economic, or aesthetic effects in the air [2]

Airborne particulate is divided into two types: coarse and fine. Particles larger than 2.5 microns are termed coarse particles, whereas those smaller than 2.5 microns are termed tiny particles [3]. Solids less than 10 m in diameter are the most hazardous to human health because they can be inhaled deeply and stuck in the lower respiratory system. The most dangerous particles for human health are those with a diameter of less than 2.5 micrometres ($PM_{2.5}$).

Department of Environment has established the New Malaysia Ambient Air Quality Standard to replace the previous Malaysia Ambient Air Quality Guideline that has been used since 1989. The NAAQS provide the standard of allowable level of harmful pollution in our ambient air to ensure that the air quality always complies the standard. In order to ensure that the air quality complies the standard, Air Pollution Index (API) is used to indicate the air quality status at any area [4].

Meteorological circumstances have a significant impact on ambient air pollution because they influence emissions, movement, production, and deposition of air pollutants both directly and indirectly. Several research investigations on the impacts of weather and atmospheric pollution on humans have established relationships between meteorological circumstances and parameters and air pollutants, as well as between air pollutants and human health [5]. As a result of these investigations, it has been established that meteorological element such as wind velocity and direction, temperature, and relative humidity can have a major impact on air quality. In addition to industrial and heavily urbanised areas, air pollution levels and air quality also an issue in traditional agricultural settings. The amount of pollution in the air is influenced by the amount of sunlight, rain, temperature of the air, and wind. The inflow of cold air from the east has resulted in extremely high mass concentrations of particulate matter PM10 and PM2.5 being observed in Poland's high-altitude weather during the winter season, when negative temperatures, low wind, and temperature inversion are observed, as has been observed in other parts of Europe [6].

One of the most common pollutions that happen in Universiti Tun Hussein Onn Malaysia (UTHM) is ambient air pollution. Presence ambient air pollution in UTHM is possibly due to surrounding natural events and human activities as it is located near to manufacturing factories and Batu Pahat-Kluang main road, that is strongly related to anthropogenic air pollution. Air quality in UTHM ambient shall be considered carefully as it will give unsatisfactory comfort level and affecting the health of the occupants in UTHM.

2. Materials and Methods

2.1 Study area

The study was carried out at two monitoring stations in the UTHM area: the Faculty of Civil Engineering and Built Environment (1°51'49"N 103°05'01"E) and Makmal Kejuruteraan Bahan Lanjutan FKAAB (1°51'28.6"N 103°05'24.0"E). The monitoring stations were chosen for their proximity to emission sources, transportation routes, and other human activities including oil palm plantations and landfills. The following maps show the locations of monitoring stations.

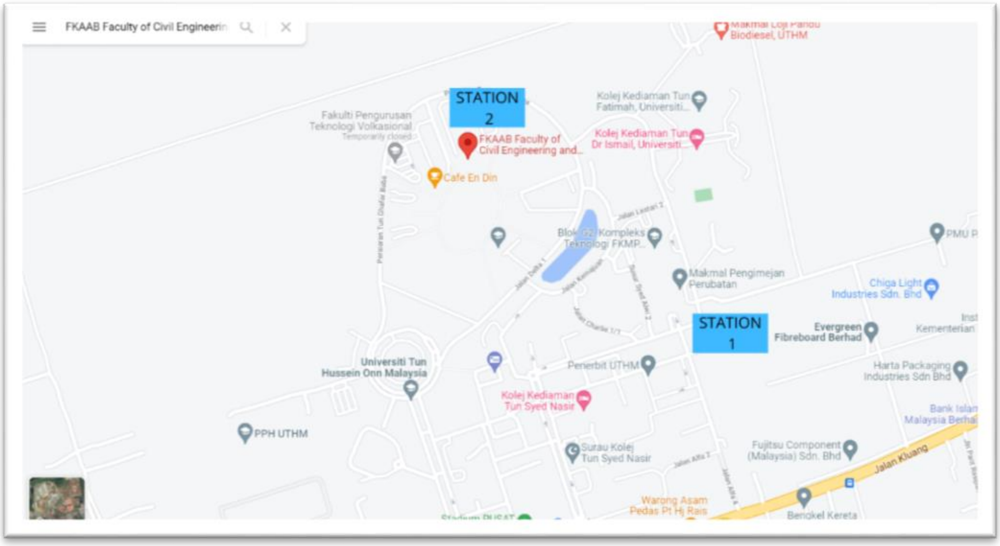

Figure 1 Study area (adopted from Google Map, retrieved on 18 December 2021)

2.2 Methods and Instruments

The guideline this is used in this study is The New Ambient Air Quality Standard (NAAQS), as it is the guideline that is used in monitoring the air quality in Malaysia. NAAQS was established to replace the previous Malaysian Ambient Air Quality Guideline, which had been in operation since 1989. The NAAQS recommends PM_{10} levels below 150 µg/m^3/24 hours or 50 µg/m^3/year. Meanwhile the standard limit for $PM_{2.5}$ is 35 µg/m^3/24 hours. In Figure 2 shows the NAAQS set by Department of Environment (DoE).

Pollutants	Averaging Time	Ambient Air Quality Standard		
		IT-1 (2015) µg/m^3	IT-2 (2018) µg/m^3	Standard (2020) µg/m^3
Particulate Matter with the size of less than 10 micron (PM_{10})	1 Year	50	45	40
	24 Hour	150	120	100
Particulate Matter with the size of less than 2.5 micron ($PM_{2.5}$)	1 Year	35	25	15
	24 Hour	75	50	35
Sulfur Dioxide (SO_2)	1 Hour	350	300	250
	24 Hour	105	90	80
Nitrogen Dioxide (NO_2)	1 Hour	320	300	280
	24 Hour	75	75	70
Ground Level Ozone (O_3)	1 Hour	200	200	180
	8 Hour	120	120	100
***Carbon Monoxide (CO)**	1 Hour	35	35	30
	8 Hour	10	10	10

*mg/m^3

Figure 2 New Ambient Air Quality Standard (NAAQS) (adopted from the website of Department of Environment, retrieved on 26 June 2021)

There are 2 types of instruments were used in collecting data at both stations. Due to the availability of instrument, two different equipment were used throughout this study. This is to ensure that the parameter from both locations can be collected and compared at the same time. Meteo Compact Station instrument and data were provided by FKAAB Building Services & Maintenance Cluster. The location of Meteo Compact Station was installed were selected by FKAAB Building Services & Maintenance Cluster. Table 1 present briefly the instrument installed at each location.

Table 1 Monitoring Stations and Instruments

Monitoring Station	Locations	Instrument
1	Makmal Kejuruteraan Bahan Lanjutan FKAAB	Met One E-Sampler
2	Faculty of Civil Engineering and Built Environment (FKAAB)	Meteo Compact Station

2.2.1 Met One E-Sampler

Met One E-Sampler is a two-in-one device that uses both real-time light scatter measurement and industry-leading filter accuracy. Met One E-sampler can monitor particulate matter, temperature, wind speed, wind direction, and humidity. The total suspended particle (TSP) inlet and the cyclone draw in ambient air at 2.0 LPM. It's only accurate at 2.0 LPM because the cyclone's cut point depends on particle velocity. The air sample enters the laser optical module through the vertical inlet tube. Currently, particulate matter concentration is monitored. The data was acquired from Met One E-Sampler using COMET.

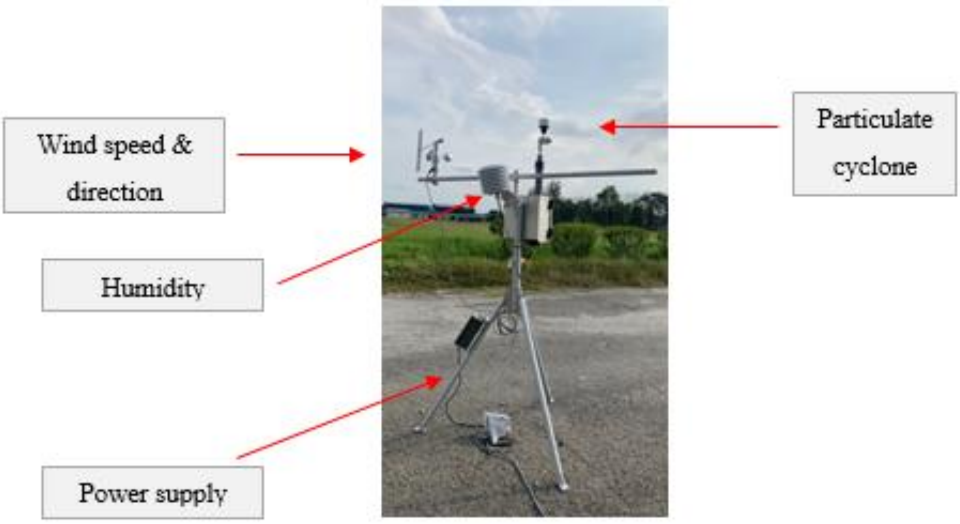

Figure 3 Met One E-Sampler

2.2.2 Meteo Compact Station

The most widely used compact meteorological data logger is the HD33MT.4. The solar charger and regulator are already built into the logger. Once configured, this instrument may communicate all measured data to your FTP server or the Delta OHM Cloud [7] . This instrument can measure numerous parameters simultaneously, including particulate matter, carbon dioxide (ppm), rainfall quantity (mm), wind rise, wind speed (m/s), wind direction (degree), atmospheric temperature (ºC), relative humidity (%), barometric pressure, and solar radiation (W/m²).

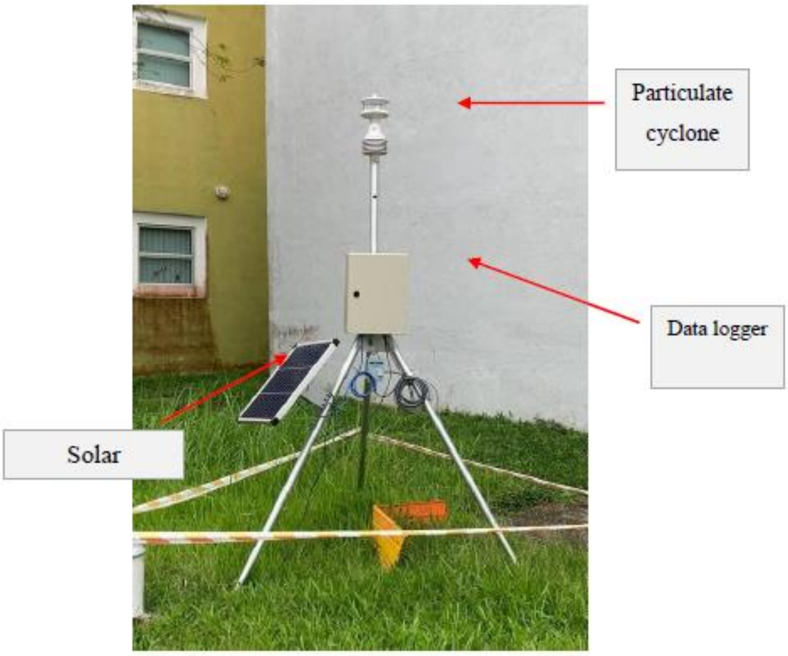

Figure 4 Meteo Compact Station

2.4 Data comparison process

The data was collected over 14 days at Stations 1 and 2. The meteorological data collected were analysed and relate with the concentration of particulate matter. Data for Station 1 was retrieved using COMET software. The data for Station 2 was obtained from FKAAB Building Services & Maintenance Cluster. The data gathered in this study was analysed using quantitative approaches because it contains numerical data. Both Station 1 and 2 statistical analyses were performed using Microsoft Excel. The obtained data was then compared to the NAAQS to check if it met the standard. On the first week of monitoring, the concentration of PM_{10} was collected on both stations. The data for $PM_{2.5}$ was collected on the second week of monitoring. Other parameters that were collected and analysed in this research is atmospheric temperature, relative humidity, wind speed and wind direction.

3. Results and Discussion

3.1 Data of PM_{10} concentration and meteorological data

The data of PM_{10} and its meteorological data is collected for 7 days at Station 1 and Station 2. Station 2. In Table 2 present the highest and lowest concentration at both locations together with the meteorological data. The table is retrieved from the data collected on the first day of monitoring at Station 1 and Station 2.

Table 2 Data of PM_{10} concentration and humidity

Stations		PM_{10}	Humidity (%)
1	Highest	46.0	82.0
	Lowest	18.0	51.0
2	Highest	37.1	91.7
	Lowest	13.0	66.0

From the data obtained from the research, it shows that the concentration at Station 1 is greater than Station 2. As shown in Table 2, the concentration of particulate matter is higher when the humidity is at peak. Meanwhile, when the humidity is lower, the concentration also drops.

3.2 Data of $PM_{2.5}$ concentration and meteorological data

In Table 3 present the highest and lowest concentration of $PM_{2.5}$ detected at Station 1 and Station 2 on the third day of monitoring. This data is chosen as it has the highest average daily concentration throughout the 7 days of observation.

Table 3 Data of $PM_{2.5}$ concentration and humidity

Stations		$PM_{2.5}$(µg/m³)	Humidity (%)
1	Highest	82.0	91.0
	Lowest	8.0	57.0
2	Highest	21.6	92.7
	Lowest	1.7	82.3

As shown in Table 3, the concentration of $PM_{2.5}$ are higher at Station 1 compared to Station 2. On the third day of $PM_{2.5}$ monitoring at Station 1 recorded the highest concentration of 82.0 µg/m³ with the humidity of 91.0%. Meanwhile the highest concentration recorded at Station 2 is 21.6 µg/m³ with the percentage of humidity of 92.7%. It is also observed that when high humidity occurred, the concentration of both stations is higher compared to when the concentration is lower.

3.3 Discussion

Based on the finding of the study, when the percentage of humidity is higher, the concentration of particulate matter increases as a result. Particulate matter concentrations grow as humidity rises, due to the increasing size of particulate matter when there is an increase in relative humidity levels. It ultimately becomes too heavy to maintain its position in the air and crashes to the earth. Dry particle matter deposition is the term used to describe this process [8]

The relative humidity of an atmosphere is defined as the ratio of the current absolute humidity to the maximum absolute humidity that can exist (which depends on the current air temperature). A reading of 100 percent relative humidity indicates that the air has become completely saturated with water vapour and is unable to hold any more, hence increasing the likelihood of rain [9]. This means that humidity has an effect on the quality of the air we breathe at all times of the day and night. As the humidity levels increase, the weather becomes warmer. As a result of the hot weather dispersing the particles, the concentration of the particles falls.

The data from previous study that was conducted on 2008 were compared with the data collected in this study [10]. The previous study used E-sampler to evaluate PM2.5 and PM10 concentrations at UTHM. The highest average concentration for both parameters from the previous and current studies are compared to shows the rough value of the concentration of particulate matters detected in UTHM ambient air.

Based on the comparison with past research on airborne particulate in UTHM ambient air, the analysis shows that $PM_{2.5}$ concentration increases within 13 years. Increasing concentration may be attributable to increased human activity in UTHM surroundings over time.

Table 4 Data comparison with previous study

Research		Concentration($\mu g/m^3$)	
		PM_{10}	$PM_{2.5}$
Previous study (2008)	Highest	33.08	0.72
	Lowest	12.04	0
Current study (2021)	Highest	33.21	29.0
	Lowest	11.75	5.95

However, the average concentrations of particulate matters remain below the new Malaysian ambient air quality guideline (NAAQS).

4. Conclusion

According to the data collected, the highest concentrations of particulate matter are recorded at Station 1, Makmal Kejuruteraan Bahan Lanjutan FKAAB. The collected data was compared to the New Ambient Air Quality Standard (NAAQS and the impact of meteorological data was analysed.

Based on the data, the greatest concentration of $PM_{2.5}$ is 29 $\mu g/m^3$. Meanwhile, the greatest average concentration for PM_{10} is 33.21 $\mu g/m^3$. The concentrations of $PM_{2.5}$ and PM_{10} measured at Station 1 are, however, still below the NAAQS. Aside from the meteorological conditions, barriers such as buildings may influence the concentration of particulate matter. Higher concentration was recorded at Station 1 are possibly due to the station being exposed to more human activities that produce particulate pollution. On the other hand, the instruments installed at Station 2 are located adjacent to a building and trees, which may have an impact on the reading of concentration and climatic parameters.

Acknowledgement

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