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Wind Rose Analysis for UTHM and Possible Pollution Sources Zone

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Abstract: The nearby urban area such as industrial park or a city can contribute of factor of increased distance from the pollution concentration. The concentrations of pollutants that dispersed in atmosphere then can be affected by several factors such as wind speed, wind direction, air concentration, temperature and precipitation. Pollution that caused by non-point sources and unknown sources can make the source identification become more difficult. Therefore, in this study the wind speed and the wind direction at three different sites at UTHM - Parit Raja Campus were analyzed in order to predict the possible pollution sources zones. Due to the Movement Control Order (MCO) during COVID-19 pandemic, the analysis was only conducted to the previous collected $PM_{2.5}$ data from 4 March 2020 until 31 July 2020 in three different location at UTHM Parit Raja campus. The data obtained then was analyzed for the daily concentration and was reported per month. Then, WRPlot View software then was used to generate the wind rose and the pollution rose for the selected months. The results showed that the maximum concentration of $PM_{2.5}$ is 113.71 µg/m^3 in 30 July 2020 at Post Guard. The wind rose analysis showed that most of the time wind was directed from southern east for March 2020, southern east for April 2020, northern east for June 2020 and northern west. The maximum wind speed for 4 months was 0.855 m/s. Most of the time, wind speed was measured at 1.05 m/s on June 2020, Finally, by analyzing the wind rose and the pollution rose of each location, a projection of pollution sources was made to predict the possible pollution sources that contributed to the $PM_{2.5}$ concentration to UTHM - Parit Raja Campus during the studied months.

Keywords: Air Pollution, Wind Rose Diagram, Pollution Rose Diagram, Air Pollution Modelling

1. Introduction

Air pollution and air movement are very significant in increasing of air pollution in that area which is nearly with air pollution emission area such as city, industrial area, mining area and another related place. Given the influence of weather patterns, local air quality usually varies over time [1] For example,

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air pollutants are diluted and distributed horizontally by prevailing winds and are distributed vertically by atmospheric instability Air pollutants can accumulate near the ground when there is little to no vertical air movement which is call stable conditions and cause temporary but severe outbreak of air pollution.

Air pollution can occur due to distribution of wind into nearby areas such as residential area, collage area and other related [3]. This distribution air pollution by wind can affected the higher of harmful chemical substance such as Sulphur dioxide, carbon monoxide, and other chemical substance which is called to VOCs [4]. The VOCs can affect to human life such as human can expose to lung cancer, asthma, skin disease and other. The effect from VOCs to human can occur in long-time effect or short time effect depends on concentration of gases expose to human [5].

DOE Malaysia updated its index system in 1996 for easy comparison with countries as well as for national standardization where the API was adopted, closely following the U.S. PSI system. Before that, the API is a simple systematic approach for identifying air quality status which the general public can easily understand [2]. In Malaysia, is used to the quality of ambient air is referred to the Ambient Air Quality Standard as shown in Figure 1.

Pollutants	Averaging Time	Ambient Air Quality Standard		
		IT-1 (2015)	IT-2 (2018)	Standard (2020)
		µg/m³	µg/m³	µg/m³
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/m³

Figure 1: The Ambient Air Quality Standard

Air Pollution Index (API) has been used to define and classify Malaysia's ambient air quality based on potential public health implications, it is a non-dimensional number but calculated according to the daily urban average pollutant concentration. Figure 2, there are five indications to indicate the air quality status by referring API standard. The range of API are starting from 0-50. 51-100, 101-200, 201-300 and more then 301. Every range shows that good, moderate, unhealth, very unhealthy and hazardous.

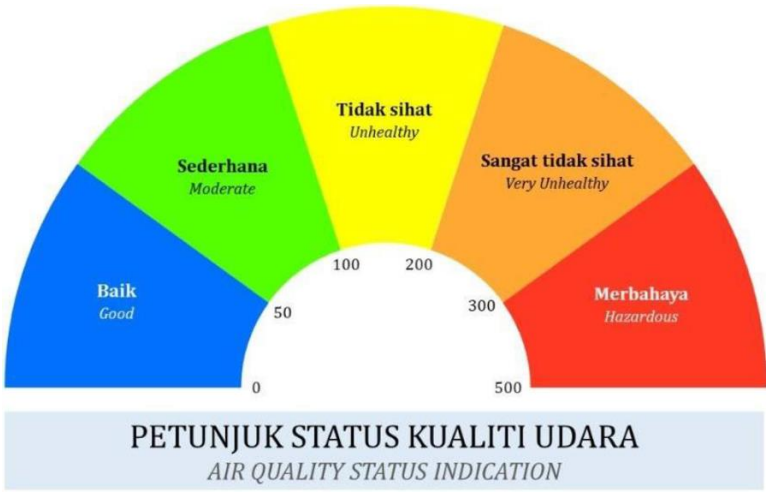

Figure 2: The range of API Indication

1.2 Objective Project

The aim of this study is to predict the possible air pollution sources through wind rose projection at Universiti Tun Hussein Onn Malaysia (UTHM) - Parit Raja Campus. The main objectives of this project are:

i. To determine the Air Pollution Index (API) based on the maximum $PM_{2.5}$ concentration in March 2020, April 2020, June 2020 and July 2020.
ii. To establish Wind Rose and Pollution Rose at UTHM-Parit Raja Campus in March, April, June and July 2020 by using WRPlot View software.
iii. To identify the possible pollution sources zone based on the projection of 1 km distance from the sampling point at three selected location in UTHM-Parit Raja Campus.

1.3 Project Scope and Limitation

The limitation for this project was the data used for this study was taken from previous collected data on March 2020 until July 2020 due to no collection data was conducted during MCO and equipment availability. There were three selected location such as Tun Dr Ismail Hostel, Rugby Field and Post Guard. There was limited software can be free access in analysis the air pollution movement.

2. Materials and Methods

The process of study is shown that the step by step from the experiment. The purpose of this part is to ensure no errors or processes are taken in the project.

2.1 Site Selection

UTHM is public university located close to the town of the Parit Raja and city of Batu Pahat. For this study, the E-Sampler has been installed in selected area which is strategic area and focusing area for UTHM and public area especially to evaluate air quality in specific time. This study measured the $PM_{2.5}$ concentration at three selected locations in UTHM Parit Raja Campus which was Rugby Field, Tun Dr Ismail Hostel and Post Guard.

2.2 Collection $PM_{2.5}$ concentration

By using E-Sampler, the data was collected at every selected point for four months such as March, April, June and July. The data was collected in previous study and insert manually which is in the data logger for getting all parameter needed. The parameter has been taken in previous collected data such as wind speed, wind direction, all particulate matter concentration and temperature.

2.3 API calculation on the maximum concentration monthly

The data then was analyzed for the daily average concentration using the Excel spreadsheet. In a day, 24 readings of of $PM_{2.5}$ concentration were recorded. Then, the daily concentration was obtained by the average of 24 readings of the day with the started time of 12 a.m to 12 a.m at the next day. This average concentration than become the average concentration of the day. Then, the graph of PM2.5 concentration against day was plotted. The data plotted then was also compared to the Ambient Air Quality Standard to assess the allowable limit of $PM_{2.5}$ at the particular day.

The API then was calculated for the daily maximum concentration of $PM_{2.5}$ only as the maximum concentration of the month indicates the maximum API obtained for the month. The API obtained than was referred to Figure 2 in order to evaluate the API status and its according health advice.

2.4 Wind Rose and Pollution Rose Generation using WRPlot View Software

The previous collected wind speed and wind direction data then was analyzed by WRPlot View Software to generate the wind rose at the selected place. The data was exporting from excel file into the

WRPlot View Software. The data needed in generate wind rose diagram are time, days, year, wind direction and wind speed. Meanwhile, the pollution rose was generated by using the similar software by replacing the wind speed with the pollution concentration.

2.5 Prediction of Possible Pollution Source by Wind Rose Projection.

The wind rose diagram was exported to the google earth to get the prediction of possible pollution sources. In google earth, the diagram was shows that the air movement from selected point to possible source at nearby of selected area.

3. Results and Discussion

3.1 $PM_{2.5}$ Concentration

Three selected places were chosen as the sampling locations. Data for Tun Dr Ismail Hostel and Rugby Field were collected in March 2020 and April 2020, respectively. While, data for Post Guard Station was recorded in two consecutive months.

a) Tun Dr Ismail Hostel

Monitoring at Tun Dr Ismail Hostel (TDI) was recorded from 4 March 2020 to 31 March 2020. The average per day was plotted in Figure 3. From this figure it was shown that the maximum concentration of $PM_{2.5}$ was 51.67 µg/m^3 on 10 March 2020. Then, at the maximum concentration, the API calculated for the day was 80.63. The API also shown the highest status of API measured for that month and location. The status of API at 10th March was moderate which does not have any harmful health effect in short term effect. The health advice was no limits on public recreational events. Keep your lifestyle safe.

From Ambient Air Quality Standard, the concentration $PM_{2.5}$ at this location show that there were three days from 9 March 2020 until 11 March 2020 has been exceeded from the standard in 24 hours.

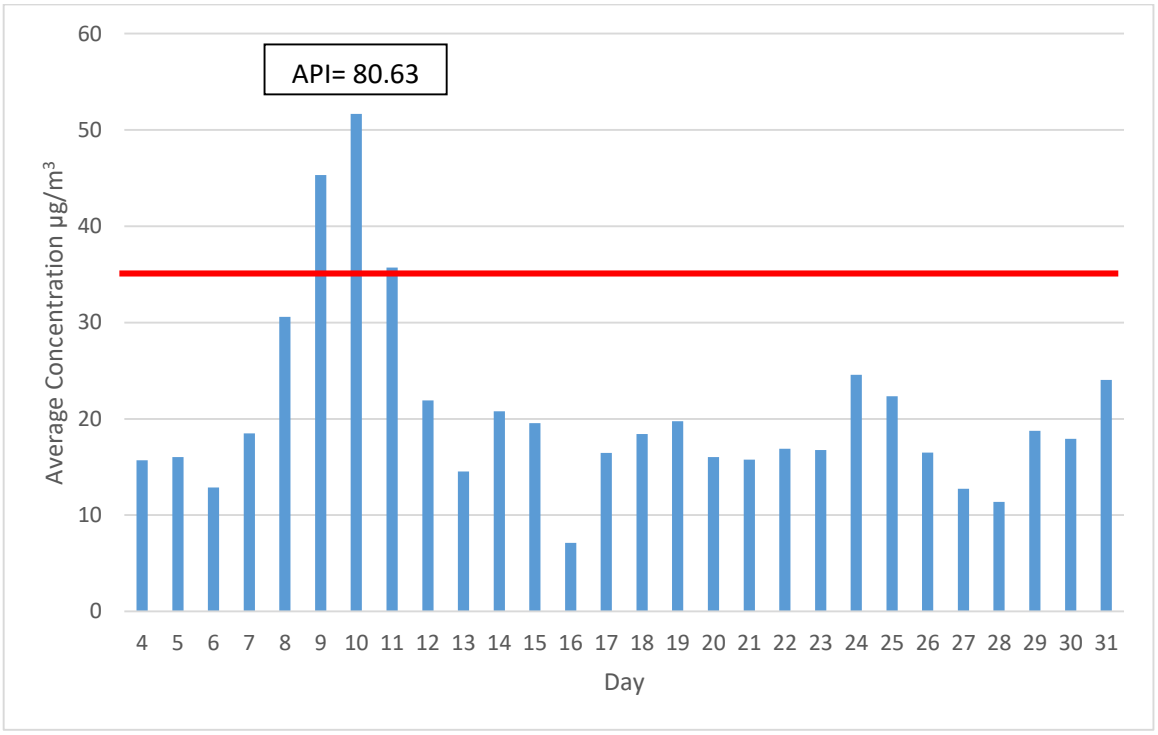

Figure 3: Daily average of PM2.5 concentration from 4 March 2020 until 31 March 2020 at Tun Dr Ismail Hostel

b) Rugby Field

Figure 4 shown that the graph of daily average concentration $PM_{2.5}$ in April 2020 at Rugby Field. The monitoring at this location was started from 1 April 2020 until 19 April 2020. That figure shown that the highest of concentration was 32.00 µg/m^3 and the highest value of API was 66.4. The status of this API value is moderate due to range between 51 until 100 of API. This API value was doing not expose with harmful effect on health. From that figure, the concentration was didn't exceed the Ambient Air Quality Standard at 24 hours value.

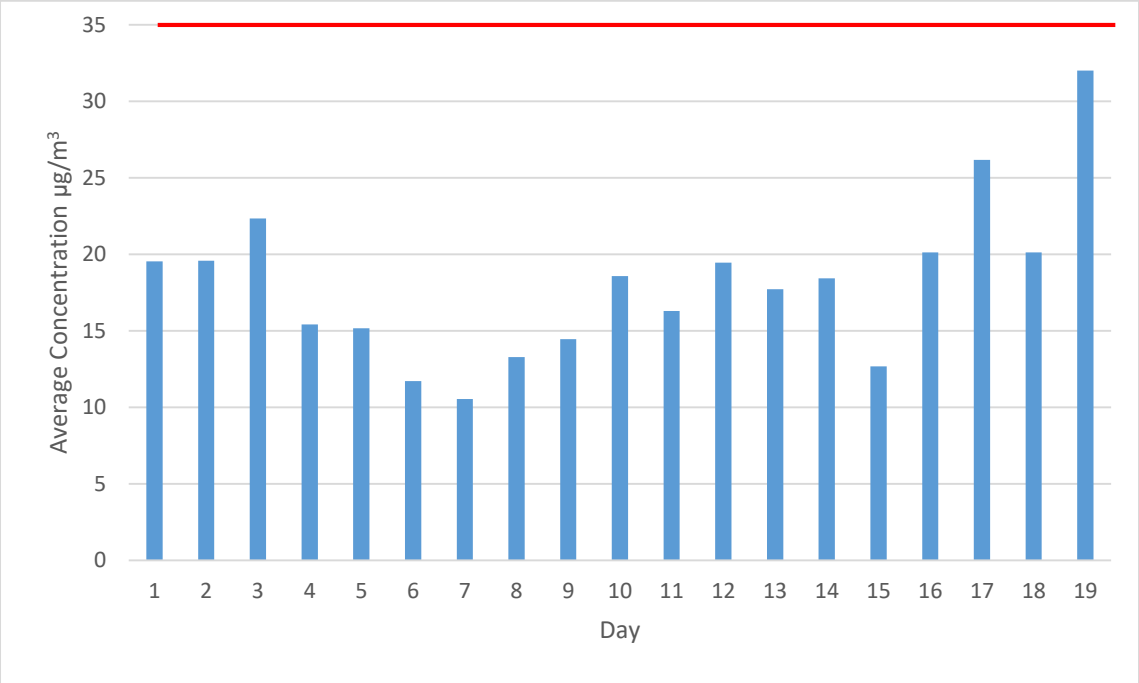

Figure 4: The daily average concentration at Rugby Field from 1 April 2020 until 19 April 2020

c) Post Guard

i) June 2020

At Post Guard, the monitoring of concentration has been started from 1 June 2020 until 30 June 2020. By referring Figure 5, the highest of concentration $PM_{2.5}$ was 21.71 µg/m^3 and the highest of API was 58.44. The status of that API value was moderated due to in range 51 until 100 and it did not give harmful effect to human life. The people needed maintain their healthy lifestyle. From the graph shown that the value did not exceed to 35.00 µg/m^3 from 24 hours of Ambient Air Quality Standard.

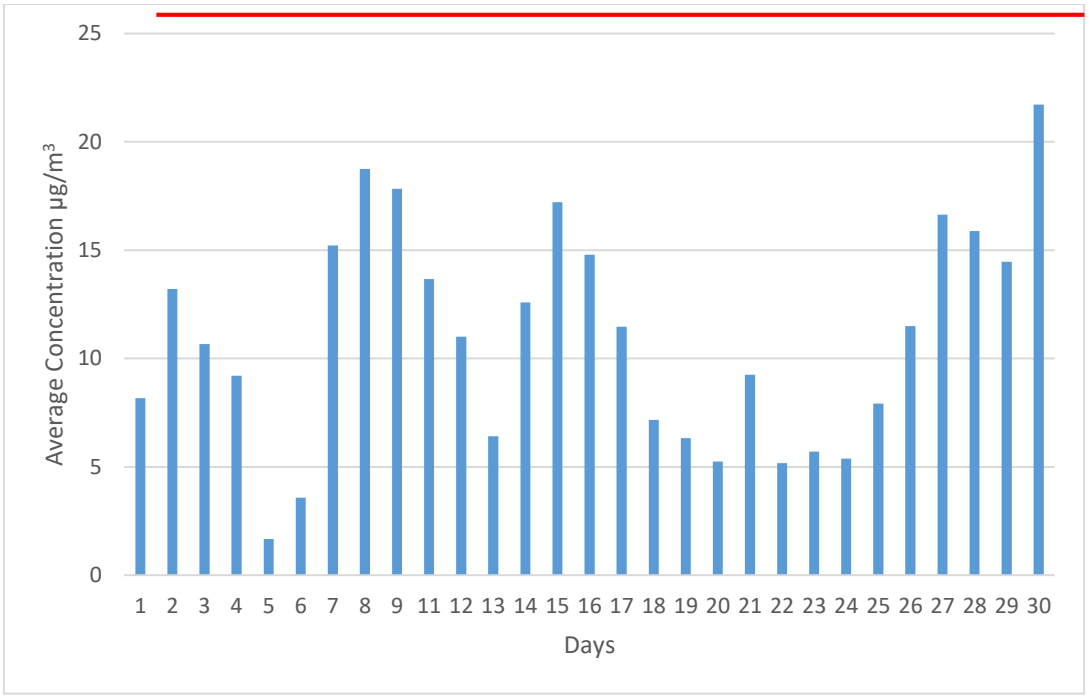

Figure 5: The daily average concentration at Post Guard from 1 June 2020 until 31 June 2020

ii) July 2020

At July 2020, the monitoring of concentration was started from 1 July 2020 until 31 July 2020 at Post Guard. By referring Figure 6, the highest of concentration $PM_{2.5}$ was 113.71 µg/m^3 and the highest of API value was 151.51 which was unhealthy for sensitive group. This situation was worsening health problems for older people, pregnant women, infants, and people with complications of the heart and lungs. The community was advised to limit their outdoor activities for the highest risk people. From that figure shown that the at 30 July 2020 was exceed to the Ambient Air Quality Standard in 24 hours.

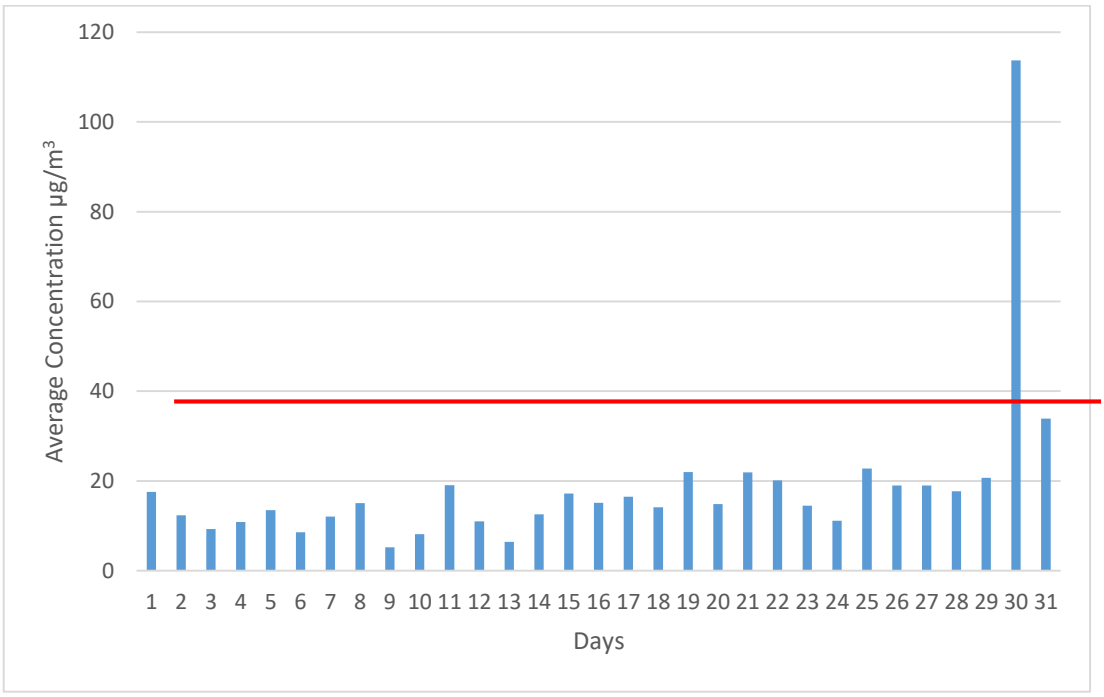

Figure 6: The daily average concentration at Post Guard from 1 July 2020 until 31 July 2020

3.2 Monthly Prediction of Possible Pollution Sources Zone

To prediction of this pollution source basically used google earth to easier analysis of wind rose diagram in radius of 1 km from the sampling site.

a) March 2020

Figure 7 shows that the wind rose diagram at Tun Dr Ismail Hostel from 4 March 2020 until 31 March 2020. The radius of air pollution was 1 km from source of industrial area and main road.

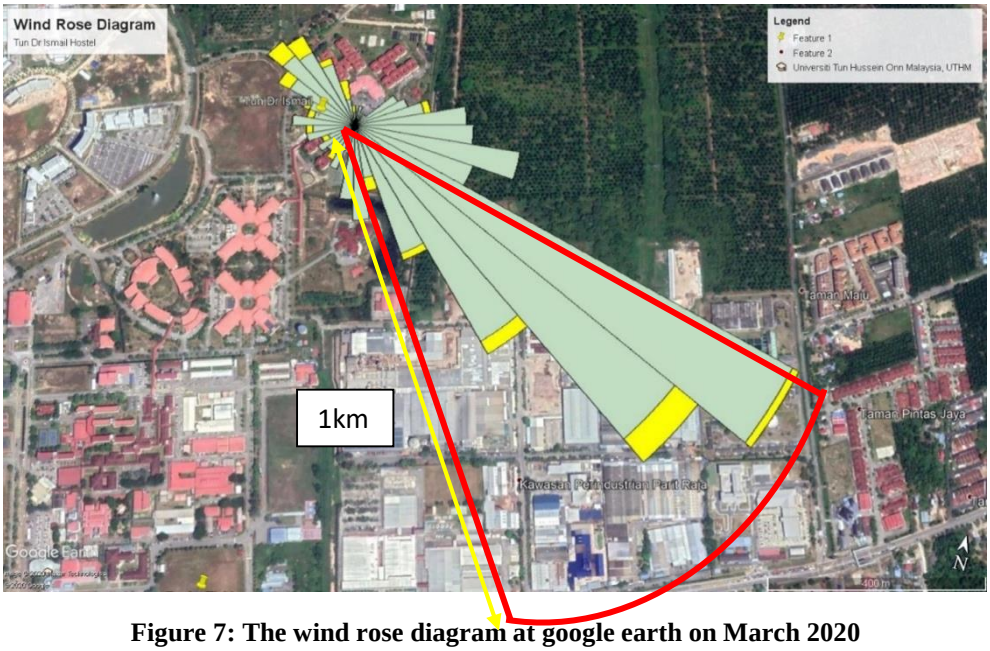

Figure 7: The wind rose diagram at google earth on March 2020

b) April 2020

On April 2020, the radius of wind rose diagram was 0.14 km from industrial area and main road. From result at Figure 8 shows that the main source determine was from main road which 0.14 km from Rugby Field.

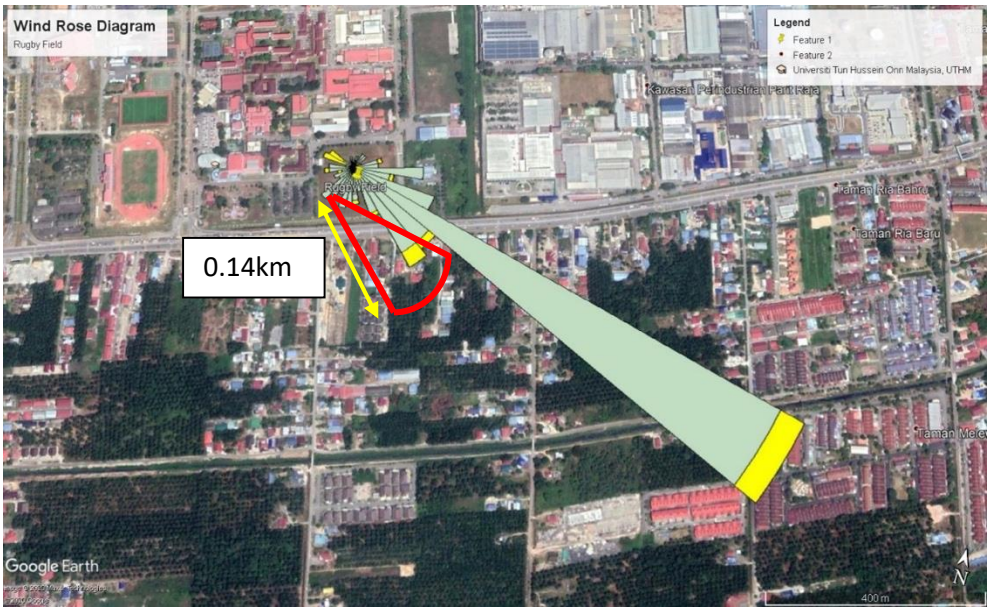

Figure 8: The wind rose diagram at google earth on April 2020

c) June 2020

From Figure 9 shows that wind direction was more to the northern east which was no point source from this wind direction. On this month, the air pollution concentration not highest at UTHM campus due to wind direction did not towards the UTHM campus.

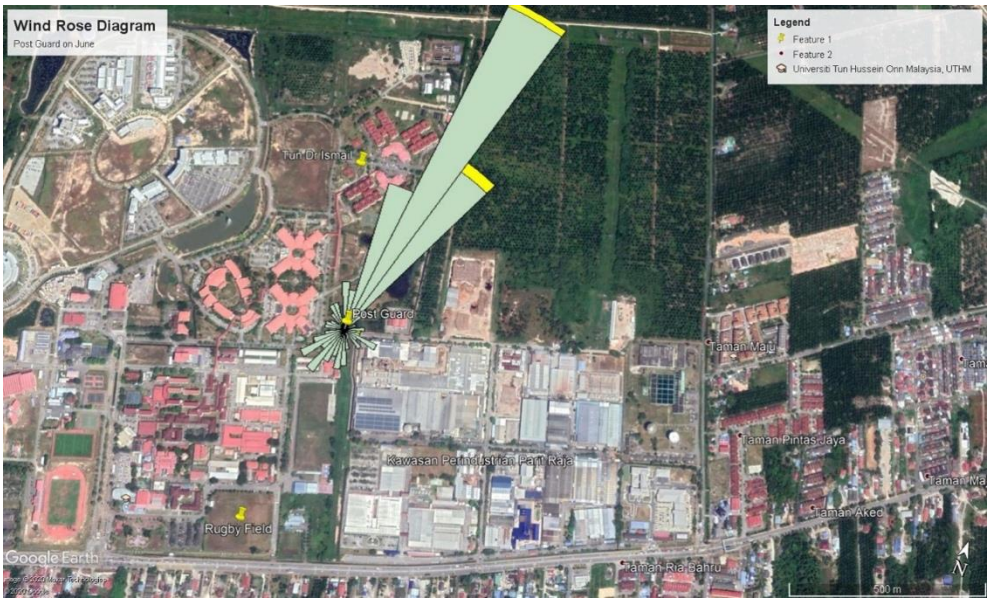

Figure 9: The wind rose diagram at google earth on June 2020

d) July 2020

Based on Figure 10 shows that the wind direction has been distribute to all direction with almost average speed. On this distribution of wind direction, it can be increasing the air pollution at UTHM campus due to wind can bring particulate matter from pollution source such as industrial area and main road.

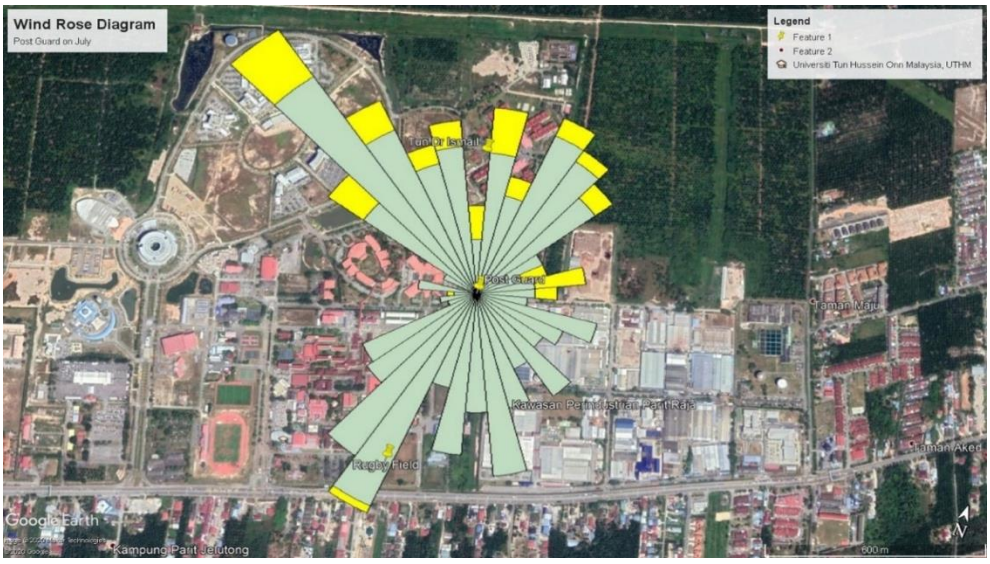

Figure 10: The wind rose diagram at google earth on July 2020

3.5 Pollution Rose diagram

a) Tun Dr Ismail Hostel

From Figure 11 show that average of wind direction at Tun Dr Ismail Hostel was at southern east. The average of concentration $PM_{2.5}$ at this location was 20.78 µg/m^3. By referring Figure 11, the highest range was more than 11.10 µg/m^3 shown in that pollution rose which was more than 18.80 % of concentration $PM_{2.5}$. It was very worrying due to highest of data has been collected in Pollution rose diagram. From the figure shows that the highest concentration $PM_{2.5}$ was blowing from industrial area and the roadway.

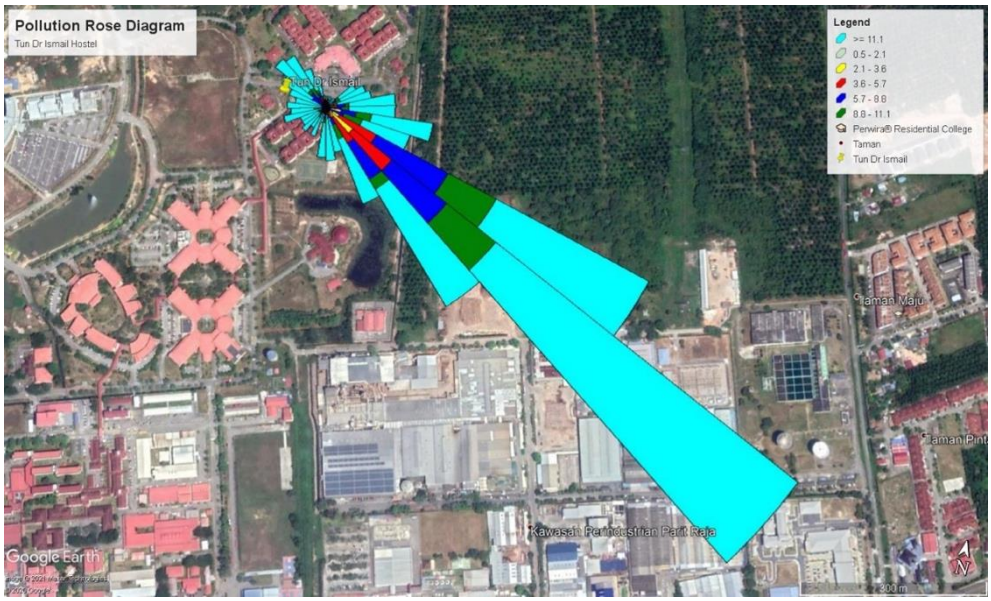

Figure 11: The pollution rose diagram at Tun Dr Ismail Hostel at March 2020

b) Rugby Field

The concentration $PM_{2.5}$ has been collected at Rugby Field on 1 April 2020 until 19 April 2020. Base on Figure 12, the pollution rose show that more than 26.20 % of concentration $PM_{2.5}$ has been recorded at direction southern west of Rugby Field. From pollution rose shown that the highest range was more than 11.10 µg/m^3 follow by 5.70 µg/m^3 until 8.8 µg/m^3. The people need to get precaution due to the highest of concentration $PM_{2.5}$ at this location. At this figure shows that highest concentration was move to the residential area.

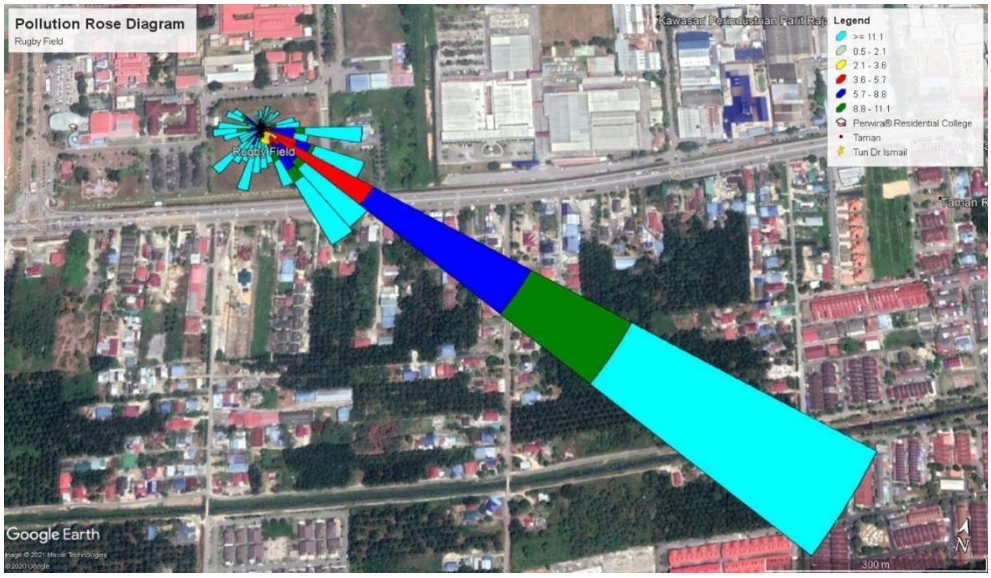

Figure 12: The pollution rose diagram at Rugby Field on April 2020

c) Post Guard

i) June 2020

The Post Guard area was collected data form 1 June 2020 until 31 June 2020. Base on Figure 13 show that pollution rose at this location which ware show that the direction ware mostly at two direction such as southern east and northern west. At southern east direction, the concentration $PM_{2.5}$ shown that several range in almost same range which ware 0.5 µg/m^3 until 2.10 µg/m^3, 2.10 ug/m^3 until 3.60 µg/m^3 and 3.60 µg/m^3 until 5.70 µg/m^3. The average of concentration PM2.5 at this location was 10.38 µg/m3 and more than 10.20 % of concentration $PM_{2.5}$ has been recorded. The pollution movement at this location was to southern west which was we predict that the wind direction was from industrial area to campus area.

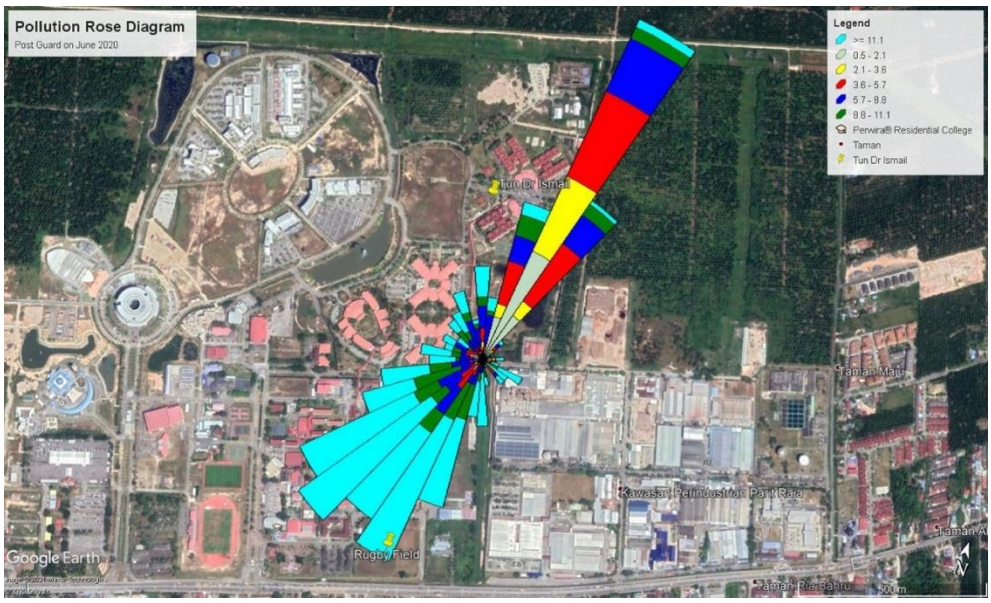

Figure 13: The pollution rose diagram at Post Guard on June 2020

ii) July 2020

At July 2020, the data has been collected of data at Post Guard UTHM. The data started collected at 1 July 2020 until 31 July 2020 to produce pollution rose diagram as shown in Figure 14. Base on that figure, all direction shown the highest of concentration $PM_{2.5}$ which was more than 11.10 µg/m^3. The highest data was recorded at direction northern west and southern west which was more than 5.48 % of concentration $PM_{2.5}$ and average of concentration $PM_{2.5}$ was recorded was 16.88 µg/m^3. From this diagram shows that pollution movement was moving on campus with the highest of concentration.

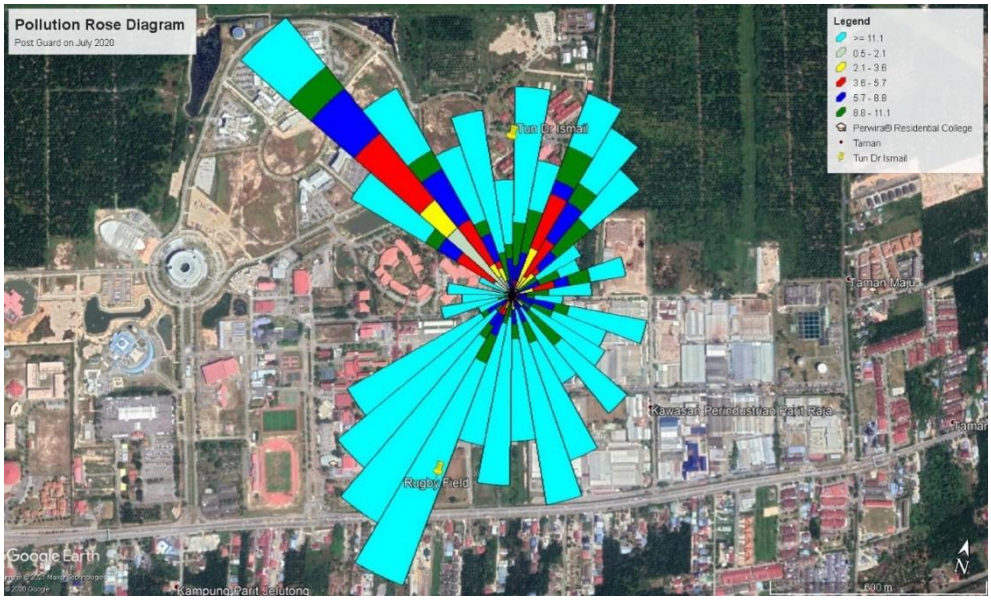

Figure 14: The pollution rose diagram at Pose Guard on July 2020

4. Conclusion

This project has been chosen three locations which has Rugby Field, Tun Dr Ismail Hostel and Post Guard. The reason chosen this location due to it nearly with industrial area and focusing people.

The results showed that the maximum concentration of $PM_{2.5}$ was 113.71 in 30 July 2020 at Post Guard. On 10 March 2020 has been shows maximum concentration of $PM_{2.5}$ was 51.67 μg/m^3 at Tun Dr Ismail Hostel and 32.00 μg/m^3 of maximum concentration $PM_{2.5}$ at Rugby Field. At June 2020, the maximum concentration $PM_{2.5}$ was 21.71 μg/m^3 recorded at Post Guard. To prediction of air movement, this project has been establishing wind rose diagram and pollution diagram at UTHM-Parit Raja Campus on March 2020, April 2020, June 2020 and July 2020.

The wind rose analysis showed that most of the time wind was directed from southern east for March 2020, southern east for April 2020, northern east for June 2020 and northern west. The maximum wind speed for 4 months was 0.855 m/s. Most of the time, wind speed was measured at 1.05 m/s on June 2020, Finally, by analyzing the wind rose and the pollution rose of each location, a projection of pollution sources was made to predict the possible pollution sources that contributed to the $PM_{2.5}$ concentration to UTHM - Parit Raja Campus during the studied months. From analysis of wind rose diagram, the project has been determined that possible sources were 1 km distance from sampling location at UTHM-Parit Raja Campus are possibility generated from industrial area and main road sources.

Acknowledgement

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