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ANALYSIS FOR WIND CHARACTERISTICS IN TELUK KALUNG, KEMAMAN, TERENGGANU

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Abstract: Wind characteristics namely wind speed and direction are very important in the determination of air pollutant concentration. The industrial development in Teluk Kalung which has been expanding every year definitely will further increase the load of air pollution to the nearby area. Sampling of wind data in 2015 at the sampling station about 2 km away from the nearby industrial area in Teluk Kalung was collected in this study. The wind rose analysis found that the dominant wind direction was blowing from the North, Southeast and Northwest. Wind speed was blowing at the speed of below 3.5 m/s which was at the level of light and calm winds with percentages above 50% and most occurred during nighttime.
Keywords: Wind rose, wind direction, wind speed, pollutant, air pollution.

1. Introduction

Terengganu State is one of the states in Malaysia experiencing rapid industrial development, especially in Teluk Kalung area which is well known for its strategic location for heavy industries. Teluk Kalung Industrial Estate (TKIE), is a major industrial area located in Teluk Kalung and contains various industries such as oil and gas, chemical, petrochemical, manufacturing and industrial services. Due to the fact that TKIE is an industrial area containing various types of industries that have a high impact on environmental pollution, it is acknowledged that the pollution can also give impact to other areas nearby.

Wind rose diagrams is usually used to visualize wind patterns at a certain location. It shows wind data in a circular format of wind speed and direction [1]. Determination of wind rose is very important in many areas such as air quality monitoring, air dispersion modeling, planning for industrial areas and environmental impact study [2]. There is a correlation between air pollutants and meteorological parameters such as wind [3].

Wind rose can be shown in many ways such as annual or seasonal data set in a location that is measured. In Malaysia, wind rose can be expressed by four seasons namely, the southwest monsoon, northeast monsoon and two shorter periods of inter-monsoon seasons. The first inter-monsoon is in April until mid-May and the second inter-monsoon is in October. The

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southwest monsoon is between mid-May to September whereas northeast monsoon is between November to March [4].

2. Methodology

This study adopted the procedure suggested by the Ministry of Environment of New Zealand as the method to obtain the wind characteristics results [5]. Figure 1 describes the methodology flow chart for this study.

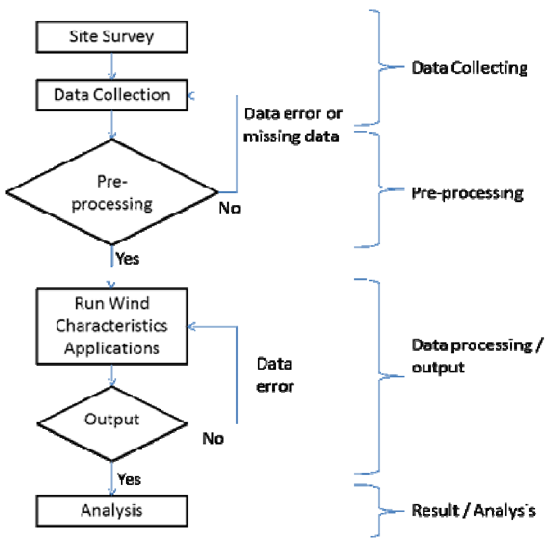


Figure 1: Methodology Flow Chart

2.1 Data Collection

The wind data namely wind speed and direction mostly collected from airports but sometimes measurements at the airport are very different from the wind patterns of the selected sites due to the fact that it is very far from the specified location. In this study, the distance between Teluk Kalung and the nearest airport in Kertih area is approximately 30 km. The data was obtained from Continuous Air Quality Monitoring Station (CAQMS) located at Teluk Kalung, Kemaman about 2 kilometers from TKIE. The locations of the CAQMS, TKIE and the nearest airport were shown in Figure 2.

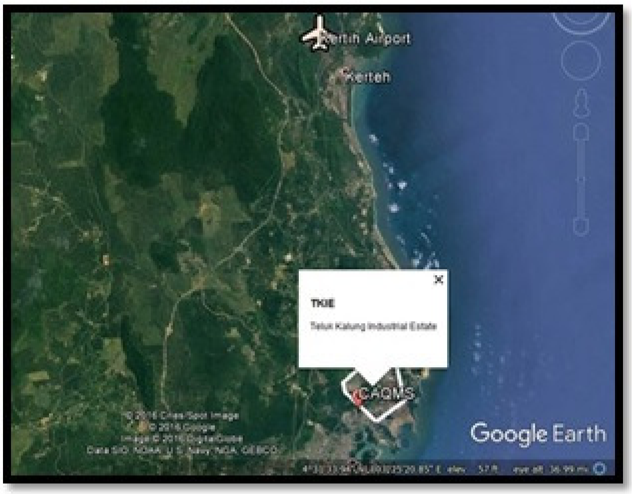


Figure 2: Location map of the CAQMS, TKIE and the nearest airport

The readings of wind speed and direction obtained from CAQMS Bukit Kuang, Kemaman in Figure 1 is the anemometer reading at the height of 10m. It gives a reading in time series format in hourly data set. The wind data used in this study is the data measured from January 2015 to December 2015.

2.2 Data Pre-processing

Since all the required data will be collected in excel data file format, some pre-processing has to be done accordingly to convert the input data. Input data cannot be used directly with the application so some conversion will be needed.

Mainly, the study will use WRPLOT View application to achieve the objectives. WRPLOT View is a software related to wind rose program for meteorological data. WRPLOT View is a fully operational wind rose program for meteorological data. It needs data such as wind direction, wind speed and location in coordinates of the meteorological station to generate the final wind profile results. It provides visual wind rose plots, frequency analysis, and plots in several meteorological data formats. It can quickly analyze meteorological data in many ways such as in the form of wind rose plots, frequency distribution tables and wind class frequency distribution graphs. The data has to be collected in Microsoft Excel format before being converted into a required format which is in the SAM file extension.

2.3 Data processing

The wind characteristics i.e. wind speed and wind direction had been analyzed with the WRPLOT View application to identify the possible affected area of air pollution impact. It would quickly and easily visualize the output of wind rose and could summarize large amounts of wind data and perform quality assurance such as wind rose plots, frequency distribution tables and wind class frequency distribution graphs. The wind speed is a very important parameter in measurements of air pollutants [6]. The wind characteristics are used to estimate the worst case pollutant concentration downwind of the air pollution source as the basis for the calculation formula [7].

$$C = \frac{10^9 Q}{UHW} \qquad (1)$$

Where C is the concentration of the pollutant, Q is the emission rate, U is the worst case wind speed, H is the worst case cloud depth and W is the worst case cloud width.

3. Results and Discussion

3.1 Frequency distribution for 2015

Table 1: The Frequency Distribution of Wind Characteristics In 2015

Wind Speed (m/s) / Wind Direction (°)	1.0 - 2.1	2.1 - 3.6	3.6 - 5.7	5.7 - 8.8	8.8 - 11.1	>= 11.1	Total (%)
337.5 - 22.5 (N)	3.45	1.98	2.29	2.38	0.25	0.01	10.14
22.5 - 67.5 (NE)	1.76	1.52	3.06	0.69	0.01	0.00	6.88
67.5 - 112.5 (E)	1.16	1.07	2.57	1.54	0.65	0.21	7.04
112.5 - 157.5 (SE)	0.47	0.81	1.95	5.30	4.28	1.67	14.16
157.5 - 202.5 (S)	0.48	0.83	1.75	1.79	0.72	0.16	5.61
202.5 - 247.5 (SW)	0.53	0.53	0.91	0.46	0.05	0.00	2.41
247.5 - 292.5 (W)	2.32	2.66	1.96	0.47	0.08	0.01	7.34
292.5 - 337.5 (NW)	8.79	5.48	2.84	1.00	0.04	0.00	17.75
Sub-Total	18.54	14.55	16.94	13.32	5.95	2.02	71.32
Calms							26.52
Missing/Incomplete							2.16

The frequency distribution (Table 1) displays the normalized frequency of occurrences of winds in each direction sector and each wind speed class. The sub-totals for each column and row (total occurrence of wind class and wind direction respectively) are displayed, as well as the number of calms, missing/incomplete and total wind data.

In general, the wind characteristics at the location of study is considered light and variable. Light speed (less than 3.6 m/s) and calm wind representing about 59.61% of the total wind speed percentage. The dominant wind directions in 2015 were from the Northwest (17.75%) and Southeast (14.16%). Factors affecting the direction of the wind might have been caused by land and sea breezes as the study area was located about 4 km from the coast. The effects of land and sea breezes on wind speed parameters were very significant in Malaysia, especially during a clear day [4].

3.2 Wind Rose Output

The wind rose diagrams were generated using the WRPLOT software divided into several segments for analysis according to the type of monsoon and time. In this case, daytime is defined as 7 am to 6 pm and nighttime is defined as 7 pm to 6 am. All wind roses use 8 cardinal directions such as North (N), Northeast (NE), East (E), Southeast (SE), South (S), Southwest (SW), West (W) and Northwest (NW). The wind roses show the winds blowing **from** particular directions. Figure 3 shows the wind rose diagrams during Northeast monsoon in early 2015, Southwest monsoon and at the end of 2015.

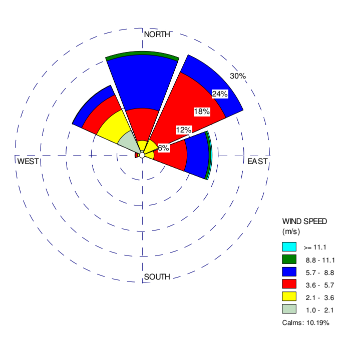
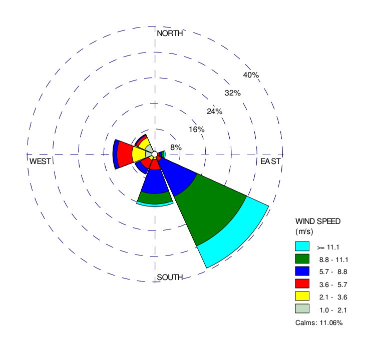
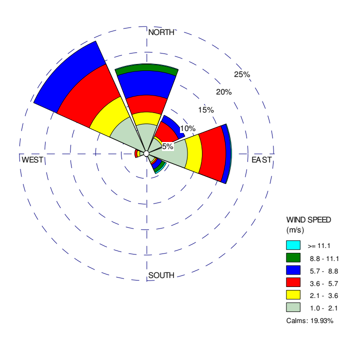
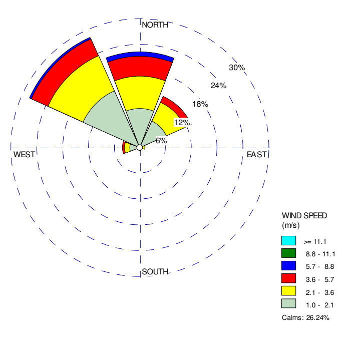
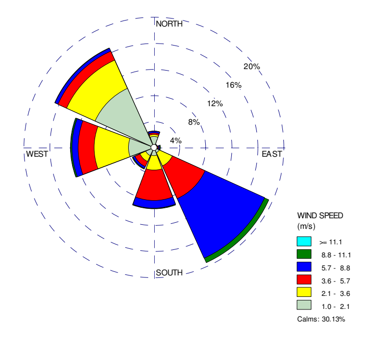
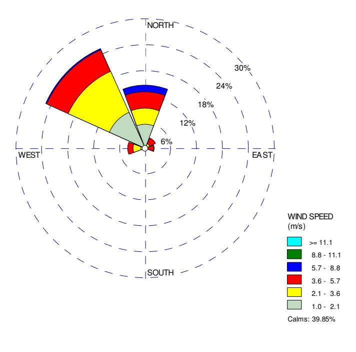
	Northeast Monsoon 1	Southwest Monsoon	Northeast Monsoon 2
Daytime (7am to 6pm)			
Nighttime (7pm to 6am)			

Figure 3. Wind rose diagrams during Northeast monsoon (at the beginning and end of 2015) and Southwest monsoon.

During the Northeast monsoon 1 and 2, it was confirmed that the wind blew dominantly from N, NE & NW directions for both day and nighttime. Wind speed during daytime was much stronger than wind speed at nighttime. Calm winds during daytime is less than nighttime.

During the Southwest monsoon, the wind blew dominantly from SE direction for daytime and SE & NW directions for nighttime. Wind speed during daytime was much stronger than nighttime. Just like the Northeast monsoon, calm winds during daytime was less than nighttime.

Figure 4 shows the wind rose diagrams during first inter- monsoon in 2015 from April to mid-May and second inter- monsoon in 2015 in October 2015.

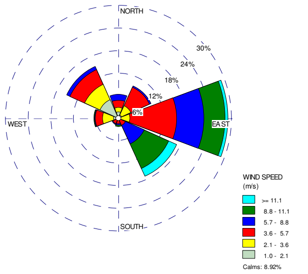
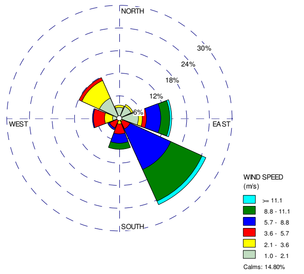
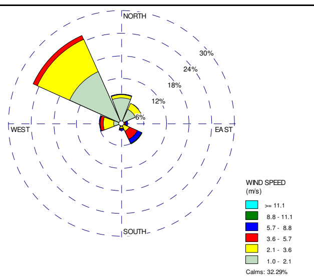
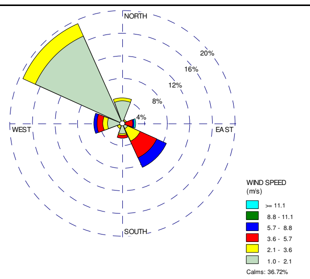
<table>
<tr><th></th><th>Inter-monsoon 1</th><th>Inter-monsoon 2</th></tr>
<tr><td>Daytime (7am to 6pm)</td><td>
</td><td>
</td></tr>
<tr><td>Nighttime (7pm to 6am)</td><td>
</td><td>
</td></tr>
</table>

Figure 4. Wind rose diagrams during first and second inter- monsoon in 2015.

The dominant wind directions during inter-monsoon 1 and 2 showed a similarity in characteristics. The wind blew dominantly from E & SE directions for daytime and NW direction for nighttime. Wind speed during daytime was stronger than wind speed at nighttime. Calm winds during daytime consist of more than 30% during nighttime.

4. Conclusion

The result showed that the wind direction was dependent on the monsoon season. The light and calm winds consist of 59.61% of the overall percentage whereas the strong wind was very little percentage with just 2%. Hence, the concentration of pollutants dispersed downwind of any source during the nighttime will be higher than the daytime due to the fact that dispersion of air pollutants is highly dependent on wind direction and speed. The slower the speed, the higher the probability of air pollutants dispersed downwind.

Therefore, based on this study, it can be concluded that the areas to be exposed to the impact of air pollution are on the NW and SE from the source of air emissions. It is proposed to any new or expansion plan of industrial activities that consist of air pollutant emissions to consider the wind rose which has been developed in this Teluk Kalung area. The wind rose analysis can also be applied in air quality management, Environmental Impact Assessment (EIA), development of Local Plan or preliminary site assessment in Teluk Kalung or nearby area.

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