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Evaluation of the Correlation between Particulate Matter (PM2.5) and Meteorological Parameters

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Abstract: Particulate matters are emitted from a wide range of man-made and natural sources. Particulate Matters (PM2.5) pose the greatest problems and consequences to human health. Batu Pahat is considered as main urban area with high industrial activity and other anthropogenic activities. Due to awareness of the people health in Batu Pahat this study was performed. The focus of this research is to examine the levels of $PM_{2.5}$ in several areas in Batu Pahat and to examine the correlations of $PM_{2.5}$ with the weather parameters using the Pearson correlation coefficient. Two stations of selected areas were chosen, namely Batu Pahat, and Parit Sulong represented as an urban area, and residential area. Three parameters observed for 3 consecutive months starting from December 2020 to February 2021 in two phases which were phase 1 (7a.m.) and phase 2 (7p.m.). The data was obtained from the website of Department of Environment (DOE). The statistical analysis of the results obtained for the air particulate matters $PM_{2.5}$ at the study areas will be compared with the Malaysian Ambient Air Quality Guidelines (MAAQG). It was found out that the concentration of $PM_{2.5}$ at station B (Parit Sulong) the residential area, was higher in phase 1 and phase 2 with value of 15.04 μg/m^3 and 14.12 μg/m^3 respectively. It can be seen that station B have higher value of $PM_{2.5}$ than station A (Batu Pahat). Air Quality Index (AQI) values for both stations was less than the permitted value by Malaysian Ambient Air Quality Guidelines.

Keywords: Particulate Matters (PM2.5), meteorological parameters, Air Quality Index

1. Introduction

Particulate Matter (PM2.5) is the sum of all strong and liquid particles suspended in air, many of which can be unsafe. This complex mixture includes both natural and inorganic particles, consisting of dust, pollen, soot, smoke, and liquid droplets. In size, composition, and origin, these particles have various studies providing proof that particulate matter, mainly $PM_{2.5}$, which represents the dimensions of particles possibly to pass through the nostril and mouth, is related to a range of consequences on human differ greatly [1]. This fine particulate air pollutant, derived from human and natural activities, such as roads and agricultural activities, dust, tire wear pollution, wood burning, construction, demolition work, and the cement industry as well [2]. Traffic emissions contribute greatly to the quality and quantity of particulate matter in the ambient air. Emissions from traffic affect total particulate matter levels in urban areas. Exposures to particulate matter from vehicle emissions have been reported in recent decades to have harmful effects on human health, biogeochemical cycling in the environment, and effects on the radiation balance that affects the atmosphere as a result [3]. The United Nations has reported that more than 600 million urban citizens

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worldwide are exposed to harmful levels of air pollution arising from the transport of vehicles [4]. According to [5], particular health consequences include acute respiratory diseases, such as acute respiratory diseases, bronchitis, pathological fibrosis, emphysema, higher rate of cough, bronchopneumonia, shortness of breath, breathing, bronchitis, long-lasting colds and exhaustion. Hence, it is the responsibility of the Department of Environment (DOE) to monitor and manage the air quality in Malaysia.

2. Review of the Literature

Air pollution is known to be the pollution with the greatest effect on the environment. In recent years, global warming trends that endanger our planet are directly linked to the degree of air pollution caused by massive quantities of carbon emissions from automobile, petrol and diesel combustion, waste from ever-expanding processing sectors, unregulated fossil fuel combustion, and open-air burning at waste management sites. As a result, air pollution is increasingly becoming the world's priority for tackling. The Wisconsin Department of Natural Resources of Wisconsin reports that the specific pollutant, Ministry of Natural Resources and Environment, has confirmed that in Malaysia there are many sources of air pollution, such as factories, construction activities, and motor vehicles [6]. The Recommended Malaysian Air Quality Guidelines (RMAAQG) establish concentration limits for selected air pollutants that could have a negative effect on the health and welfare of the general public. Based on the Recommended Malaysia Ambient Air Quality Guideline expressed by the Department of Environment (DOE) since 1989, as; good, moderate, unhealthy, very unhealthy and hazardous. In 1993, the DOE established its first air quality index system known as the Malaysian Air Quality Index (MAQI), which has played an important role in updating decision makers and the general public on the state of ambient air quality. The management of air quality and public health protection has become successful through the implementation of this index, especially in industrialized countries.

This implement is an easily comprehensible range of unitless values instead of the real concentrations of air pollutants so that the general public should be able to identify air quality or the level of air pollution. The primary objective of the index system is to convey the ambient air quality status, which varies from safe to unsafe for the general public and offers suggestions for decision makers to efficiently control air quality. In this analysis, API scales and their terms are used to measure air quality, since the identification of poor air quality is important as an early warning system for the control and management of air quality. In terms of graphics presentation, profiling is developed. The data within the range are represented in these graphic presentations, suggesting the different health status used to provide visual information. In addition, it is also a fantastic way to highlight polluted areas and the time period for information to strengthen the steps to be taken. Particulate matter comes in different shapes and sizes, depending on its ability to create health problems. Exposure to bad air that contains a large amount of particulate matter will lead to extreme health conditions. Compared to larger particles, the relatively small size of particulate matter raises the risk of accessing the human body. When inhaled, the particles may affect the lungs and heart [7]. In addition to inhalation, as well as direct absorption through the skin and consumption of polluted food and water to which excessively dangerous air pollutants are exposed to, human beings can also have health effects.

3. Materials and Methods

The method used for data collection in this study is by going through the process of collecting and recording information from the real-time Air Quality Index (AQI) monitoring system in selected areas in Batu Pahat. This method enables this study to analyse particulate matter variables of interest in particulate matter, namely the observation of $PM_{2.5}$ levels and concentration of $PM_{2.5}$, temperature, wind speed, and humidity that were carried out for three consecutive months starting from December 2020 until February 2021. The observation was conducted in two phases in the morning and evening with the first phase started at 7 a.m., while for the second phase, the observation started at 7 p.m. These particular periods were selected considering the peak hour factor, people and traffic movement for people going to work and going back to home. The data collected during the study period of study was arranged in Microsoft Excel using the.csv format and then used to compute the relevant. In this study, the correlation of Particulate Matter (PM2.5) and the meteorological parameter is based on Pearson's correlation using Microsoft Excel. This correlation aims to draw the best fit line through the data of two variables and the correlation coefficient of Pearson r, shows how far apart all these data points are from this best-fit line. Microsoft Excel software is used to analyse statistics.

4. Results and Discussion

In this section, the objective in this study which was to determine the correlation between $PM_{2.5}$ and meteorological parameters (temperature, wind speed, and humidity) by using the Pearson's correlation coefficient. The meteorological parameter that was chosen to discuss in this section was humidity. Correlation analyzes between particulate matter and meteorological parameters were carried out to statistically analyse the relationship. The correlation coefficient (r) for particulate matter and meteorological parameters was carried out to gain the relationship between them. Each station was analysed for both phase which were phase 1 (7 a.m.) and phase 2 (7 p.m.) during those 3 months of observations. The significant (α), at the 0.05 level (2-tailed) was chosen. Values lower than this level are significantly important. In

this study, it can be observed that there was positive and negative correlations that were obtained between $PM_{2.5}$ and meteorological parameters. Graphical results of the correlation between $PM_{2.5}$ and humidity for both stations were shown.

The analysis results for station A (Batu Pahat) for humidity, the correlation coefficient values for phase 1 and phase 2 were -0.360 and -0.312, respectively. Both phases showed medium negatively correlation and there was a significant correlation coefficient during the study period based on Fig. 1 and Fig. 2. The rate of absorption of pollutants can be controlled by the relative humidity which should be inversely proportional to the particulate concentration of the pollutant. From this correlation analysis, only humidity may have significant correlation with p-values less than the significant value of 0.05 level, which there was inclusive evidence about the significant value of the correlation between the variables [8].

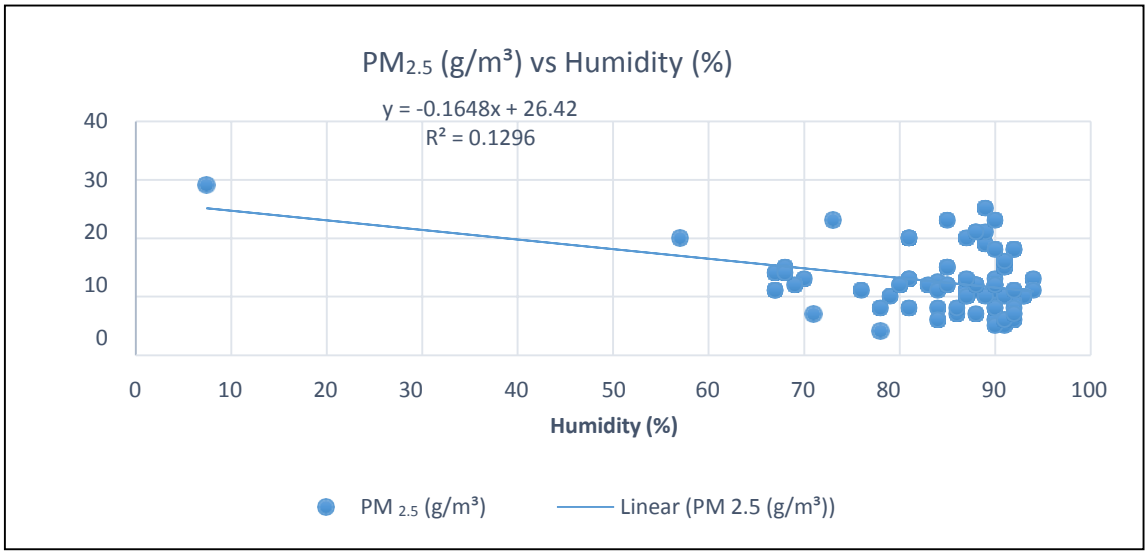

Fig. 1 - Graph of correlation between $PM_{2.5}$ and humidity (%) for phase 1 at Station A

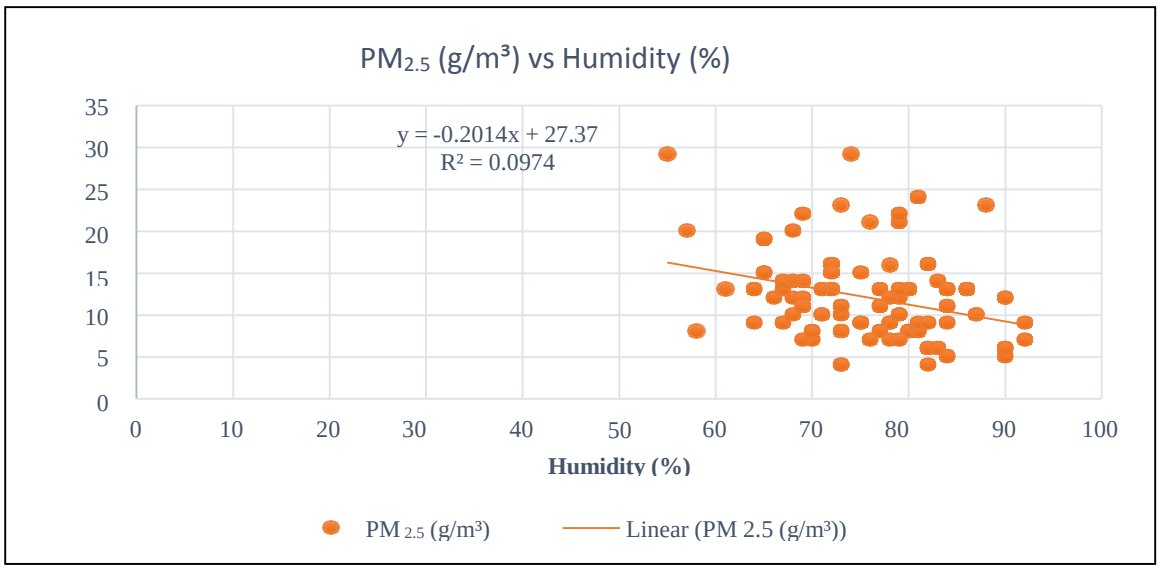

Fig. 2 - Correlation graph between $PM_{2.5}$ and humidity (%) for phase 2 at Station A

The analysis results for station B (Parit Sulong), in the case of humidity, the correlation coefficient values for phase 1 and phase 2 were 0.038 and -0.640, respectively. Both results can be seen in the graphs shown in Fig. 3 and Fig. 4. For phase 2 with moderate negative correlation but statistically significant at 0.05 level with $PM_{2.5}$. From this correlation analysis, it can be seen that temperature and humidity have statistically significant at the 0.05 level occurred with $PM_{2.5}$, both occurred in the evening. Rain displays an impact of moist removal on particulate

matter during the washing process. By making the soil humid, the impede by resuspended soil of the particles can be avoided by removing the particles in the air during rain [9].

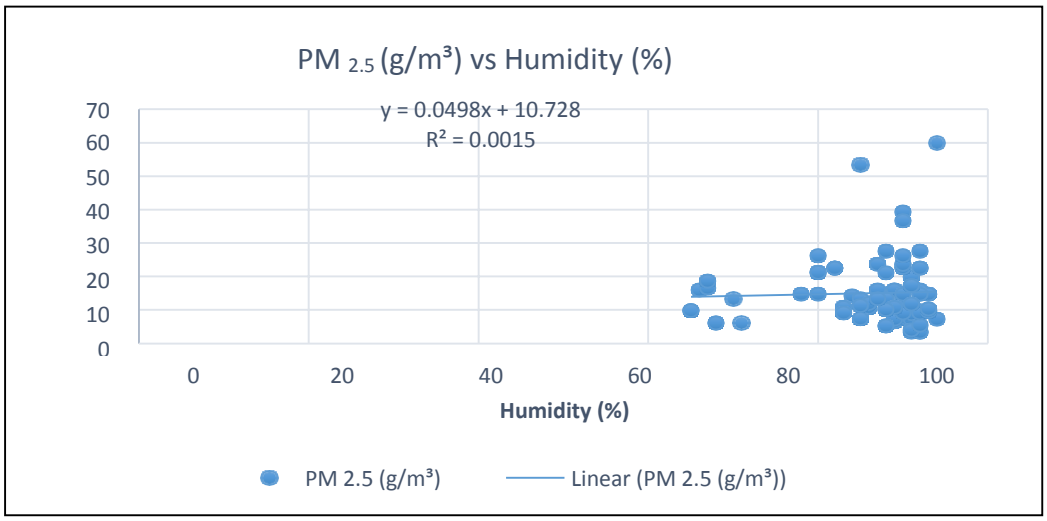

Fig. 3 - Correlation graph between $PM_{2.5}$ and humidity (%) for phase 1 at Station B

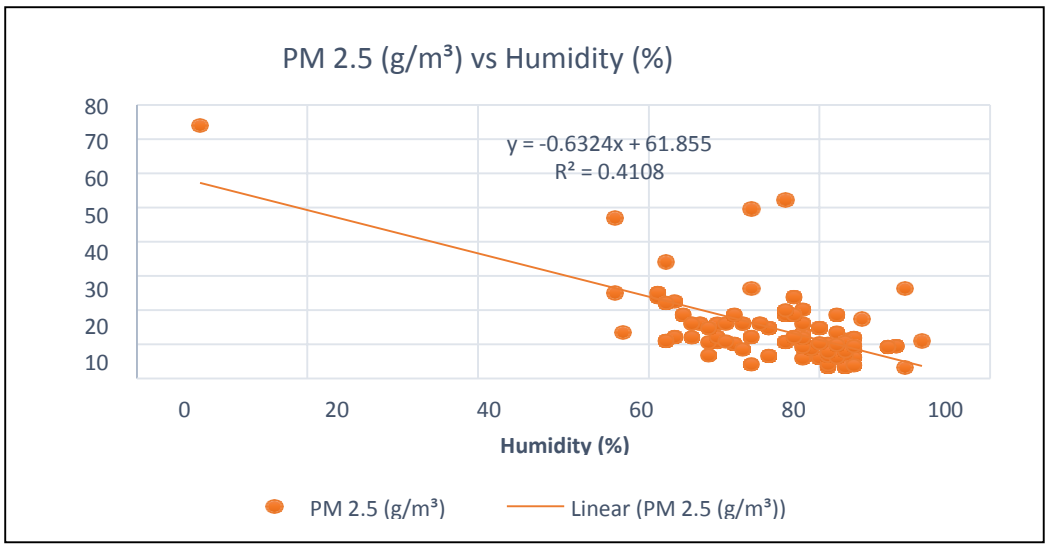

Fig. 4 - Graph of correlation between $PM_{2.5}$ and humidity (%) for phase 2 at Station B

5. Conclusions

As a conclusion of this study, two selected areas were observed to assess air quality in Batu Pahat area by evaluating the particulate matter and their trends. The permissible limits for particulate matter for a 24-hour average was 35 $\mu g/m^3$ which was provided by the Department of Environment (DOE). From the data analysis, for the station A, in the case of humidity, there was a low correlation for $PM_{2.5}$ and there was a significant correlation coefficient. For station B, from this correlation analysis, it can be seen that temperature and humidity have statistically significant at 0.05 level with $PM_{2.5}$ which both occurred in a evening and have the medium negative significant at 0.05 level. Therefore, in this study, it can be concluded that the correlation between $PM_{2.5}$ and meteorological parameters for both stations with Pearson's correlation coefficient (r) played a significant role in the variation of particulate matter. All meteorological parameters have a weak and low correlation coefficient with $PM_{2.5}$. Considering the significant (α), at the 0.05 level (2-tailed), among the meteorological parameters, only humidity shows a significant correlation for both stations compared to the speed and temperature.

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