Particulate Matter Levels in Ambient Air Adjacent to Industrial Area

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Abstract: Air quality in the residential areas adjacent to the industrial regions is of great concern due to the association with human health risks. In this work, the concentrations of particulate matter (PM₁₀) in the ambient air of UTHM campus was investigated to study the air quality and their compliance to the Malaysian Ambient Air Quality Guidelines (AAQG). The PM₁₀ samples were taken over 24 hours from the most significant area at UTHM including Stadium, KolejKediamanTunDr. Ismail (KKTDI) and MakmalBahan. The meteorological parameters; temperature, relative humidity, wind speed and wind direction as well as particulate matter were estimated by using E-Sampler Particulate Matter (PM₁₀) Collector. The highest concentrations of PM₁₀ (55.56 µg/m³) was recorded at MakmalBahan during the working and weekend days. However, these concentrations are less than 150 µg/m³. It can be concluded that although UTHM is surrounded by the industrial area, the air quality in the campus still within the standards limits.

Keywords: Air pollution, particulate matter.

1. Introduction
The economic growth in Malaysia depends on the manufacturing industries, especially electronics, chemicals and rubber. The developments in industrial sector has increased from 38.5% in 1980 to 44.5% in 2002. This developments has contributed in increasing of the gross domestic product (GDP) from 19.64% in 1980s to 31.56% in 2004 [1]. The electrical and electronics manufacturing sector has enhanced the Malaysian economic by more than 60% during the period from 1991 to 1996 [2]. However, most of industrial activities including the large combustion installations burning fuel oil or coal; cement factories; waste incinerators and road traffic, wood industries and others are correlated with the increasing of air pollution [3].

According to Tiwari et al. [4], the air quality in the developing countries has decreased due to the industrial growth, fossil fuel combustion, rapid urbanization and population growth that lead to the adverse effects on the climate. There are many of industrial areas around the world with a poor air quality due to coal combustion method in their industrial processes. For instance, Turkey is one of the most industrialized area with high PM₁₀ concentration ranged from 102.3µg/m³ during winter to 59.9µg/m³ during summer [5]. In India, the PM₁₀ concentrations is varied depended on the season. Certain areas such as Delhi has particulate concentrations as high as 435 µg/m³ [6].

In order to protect the public health from the adverse effects of air pollutants, several countries have adopted regulations for air quality standards based on Particulate Matter (PM₁₀). In Malaysia, the Ambient Air Quality Guidelines (AAQG) has recommended that the PM₁₀, should be less than 150 µg/m³/ 24 hours or less than 50 µg/m³/ 12 months. Some countries such as Australia recommended more stringent standards where,
PM$_{10}$ should be less than 50 µg/m$^3$/24 hours and 0 / 12 month. In Japan, PM$_{10}$ should be between 100-200 µg/m$^3$/24 hours and 0 / 12 months (Table 1).

In Malaysia, the highest concentrations of PM$_{10}$ was recorded in Penang near industrial areas. The annual average PM$_{10}$ concentrations were 61.73 µg/m$^3$ in 2001, 75.03 µg/m$^3$ in 2002, 80.13 µg/m$^3$ in 2003, 92.31 µg/m$^3$ in 2004, 78.99 µg/m$^3$ in 2005, 49.81 µg/m$^3$ in 2006 and 45.45 µg/m$^3$ in 2007 [7]. However, those concentrations are still within AAQG standards.

The high concentrations of PM$_{10}$ leads to several health concerns. Therefore, the current work aimed to quantify the PM$_{10}$ in Universiti Tun Hussein Onn Malaysia (UTHM) campus to study the air quality and their compliance to AAQG.

Table 1. Ambient Air Quality Standard (AAQS).

| Country Name     | AAQS Particulate Matter (PM$_{10}$) | Average time | Guidelines (µg/m$^3$) |
|------------------|-------------------------------------|--------------|-----------------------|
| Malaysia         | 24 Hour                             |              | 150                   |
|                  | 1 Year                              |              | 50                    |
| Australia        | 24 Hour                             |              | 50                    |
|                  | 1 Year                              |              | None                  |
| China            | 24 Hour                             |              | 150                   |
|                  | 1 Year                              |              | None                  |
| European Union   | 24 Hour                             |              | 50                    |
|                  | 1 Year                              |              | 35                    |
| Hong Kong        | 24 Hour                             |              | 100                   |
|                  | 1 Year                              |              | 9                     |
| Japan            | 24 Hour                             |              | 100 or 200            |
|                  | 1 Year                              |              | None                  |
| United States    | 24 Hour                             |              | 150                   |
|                  | 1 Year                              |              | 1                     |
2. Materials and Methods

2.1 Study area
University Tun Hussein Onn Malaysia (UTHM) is a public university established on 2007 and located at Parit Raja, Batu Pahat, about 100 km from Johor Baru, Malaysia (see Figure 1.)

![Google map of study area Malaysia.](image)

Three monitoring stations included, the Stadium (Station 1), Kolej Kediaman Tun Dr. Ismail (KKTDI) (Station 2), and Makmal Bahan (Station 3) were selected for measuring the particulate matter, PM10 in UTHM campus. These locations were selected because they represent recreational areas, residential colleges and the laboratories which are significant points for estimating air quality in UTHM. Figure 2. shows the UTHM locations and sampling stations distance from the Parit Raja industrial areas.

![The study area (Observed on (December, 2015) googlemap.com).](image)
2.2 Estimation of PM$_{10}$

The E-Sampler Particulate Matter (PM$_{10}$) Collector was used in this study (see Figure 3.). It was placed in open areas away from trees and buildings. Humidity sensor and a combined set for wind speed and wind direction was directed to the sky. The data of particles in the air, humidity, wind direction and wind speed as well as the ambient temperature from sampling area was recorded by E-Sampler. The filter paper was used for taking the particulate matter samples from ambient air. Filter paper was weighing before and after the sampling. The data was recorded over 24 hours. The concentration PM$_{10}$ from E-Sampler was compared with data taken from the filter paper. The PM$_{10}$ was estimated during working days and weekend day for three weeks between Jun to December 2011. The sampling was performed at least once a week at each stations.

![Image of E-Sampler Particulate Matter (PM$_{10}$) Collector.](image)

3. Results and Discussions

Air quality in urban areas is of great concern due to the association with human health risks [6]. Knowledge of the distribution and sources of PM$_{10}$ is essential in understanding and establishment of a control strategy. According to AAQG six parameters namely carbon monoxide, nitrogen dioxide, ozone, sulphur dioxide and PM$_{10}$ are the criteria for the air quality and should be determined to estimate the air pollutants. However, PM$_{10}$ is the most important ambient air polluters which harmfully affect human health [8]. PM$_{10}$ is used as a primary indication of air pollution because it is associated with the exacerbation of respiratory and cardiovascular conditions [9,10]. Therefore, this study focused on determination of PM$_{10}$ concentrations. The increasing of PM$_{10}$ to more than the standards limits recommended by AAQG should be followed by measuring the above criteria. In the present work, the mean of PM$_{10}$ concentrations in the selected locations during the working days are presented in Figure 4.
Figure 4. Concentration of PM$_{10}$ in the selected locations during working days.

It can be noted that the highest PM$_{10}$ concentrations were recorded at Makmal Bahan (55.56 µg/m$^3$), while the lowest PM$_{10}$ concentrations were observed at Stadium during the second and third week (12.03 µg/m$^3$). In the first week, the estimation of air pollution at Stadium and KKTDI stations recorded higher PM$_{10}$ concentrations than Makmal Bahan, 42 vs. 28 µg/m$^3$. Air quality at KKTDI station exhibited the lowest PM$_{10}$ concentrations during the third week (12.03 µg/m$^3$), while were 28µg/m$^3$ in the second week.

Figure 5. Concentration of PM$_{10}$ in the selected locations during weekend days.

However, KKTDI station occurred the highest PM$_{10}$ during the second week (42µg/m$^3$). PM$_{10}$ did not differ significantly during the first week among three stations (15µg/m$^3$). In the comparison with AAQG, these concentrations are within the standard limits. Besides, the PM$_{10}$ concentrations were quite less than the annual mean PM$_{10}$ concentrations in India [6], Egypt [11], Eastern Mediterranean and Africa [12].

The differences in PM$_{10}$ among the three stations might be due to the distance from the industrial area. Makmal Bahan is the nearest station of industrial area (300 m), while Stadium station is located 1000m from the industrial area. On the other hand, the differences between PM$_{10}$ concentrations during the working and weekend days would be related to the meteorological factors. Therefore, the correlation between meteorological factors including temperature, humidity, wind direction and wind speed was analysed based on Pearson correlation coefficient (p<0.05).
At Stadium station, temperature and wind speed correlated significantly with PM$_{10}$ concentrations during the working and weekend days. At Makmal Bahan station wind speed also correlated significantly with PM$_{10}$ concentration during the working and weekend days, while temperature and humidity correlated significantly with PM$_{10}$ concentrations during the weekend days only. Humidity correlated significantly with PM$_{10}$ concentration at KKTDI station during the working days, in the contrast, wind direction correlated with PM$_{10}$ concentration during the weekend days. The results demonstrated effect of meteorological factors on PM$_{10}$ concentrations. These findings are consistent with Barmpadimos et al. [13] who indicated that there is a correlation between meteorological parameters and PM$_{10}$ concentrations.

4. Conclusion
It can be concluded that although UTHM is surrounded by the industrial area, the air quality within the campus still within the standards limits. The meteorological factors play important roles in the PM$_{10}$ concentrations. However, sampling station nearest to the industrial area, which was located at Makmal Bahan has shown a highest value of PM$_{10}$.

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