DIURNAL AND MONTHLY VARIATIONS OF PM_{10} CONCENTRATIONS IN PULAU PINANG

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Mass concentration of ambient particulate matter with aerodynamic diameter less than 10 um (PM_{10}) are reported for two sites in Penang state over three 6 months period from 1st January 1998 to June 30th 1998, 1st January 2000 to June 30th 2000 and 1st January 2002 to 30th June 2002. The PM_{10} were measured using a tapered element oscillating microbalance (TEOM) PM_{10} mass monitor for the first two measurement campaign and using Beta Attenuation (BAM) monitor for the third. Analysis of the ambient mass concentration data with reference to hourly and daily averages is presented. Results of the first six months in 1998 shows that the daily average PM_{10} values range from a high of 158.7 ugm^{-3} to 9.7 ugm^{-3}. Second six months of 2000 shows values range from 63.0 ugm^{-3} to 13.3 ugm^{-3}. Third six months in 2002 shows values range from 131 ugm^{-3} to 22.0 ugm^{-3}. There were noticeable monthly and diurnal variations for the concentrations of PM_{10} in ambient air in Penang Island.

Introduction

Particulate matter (PM_{10}) have been highlighted since the last decade for causing adverse health effects (Schwartz, 1994; Dockery and Pope, 1994; Pope et al., 1995). Dockery and Pope, (1994) reported that for each 10 ugm^{-3} increase in PM_{10} concentration, there is an estimated increase of 0.6-1.6% in mortality.

Previous work on PM_{10} and total suspended particulate (TSP) in Malaysia for example, Sham (1979), Azman (1984, 1987), Azman et al. (1987) and Latif et al. (2002) tended to concentrate within the Lembah Kelang and Langat Basin. These studies showed that PM10 concentrations within these areas were below the annual Recommended Malaysia Guidelines (RMG) of 50 ugm^{-3}. However, in many instances the daily average RMG of 150 ugm^{-3} were breached.

To date not many reports are readily available reporting PM_{10} levels for northern region of Peninsular Malaysia. Ramli et al. (2002), and Ibrahim & Ramli (2002) have reported high air pollution levels in developing towns in North Perak. However, these studies concentrate on the traffic derived air pollution. This paper intends to study the PM_{10} concentration trends for three different years in Pulau Pinang. Results obtained from two continuous air quality monitoring stations in Penang Island are presented. The diurnal variations and monthly variations of PM_{10} for this island are examined.

Experimental

Air quality monitoring data from continuous air monitoring stations (CAMS) in Penang was gathered and collated. There are two CAMS in Penang Island, one measuring PM_{10} using Tapered Element Oscillating Microbalance (TEOM) method and another employing Beta Attenuation Method (BAM). Both methods are certified as Federal Equivalent Method (FEM) for measuring PM_{10} by the United State Environmental Protection Agencies (USEPA). Each annual data set contains hourly PM_{10} concentration data of January to June for the year 1998, 2000 and 2002.

Results and discussion

A total of 180, 179 and 178 samples of daily PM_{10} measurements based on hourly readings were collected from the CAMS. Statistics for all valid observations of monthly PM_{10} average concentrations for 1998, 2000 and 2002 are presented in Table 1,2 and 3, respectively. PM_{10} concentrations for the six months in 1998 ranges between minimum 9.7 ugm^{-3} to maximum hourly average of 158.7 ugm^{-3}. In 2000 the concentrations ranges between 13.3 ugm^{-3} and 63 ugm^{-3}. The PM_{10} concentrations were higher in 2002 between 22-131 ugm^{-3}. The monthly averages concentration in 1998 ranges between 28.2-43.7 ugm^{-3}, with highest in March. The highest monthly average concentration in 2000 was in June at 33.9 ugm^{-3}. The PM_{10} monthly averages concentrations ranges between 22.8 ugm^{-3} to 33.9 ugm^{-3}. Monthly PM_{10} average concentrations in 2002 ranged between minimum 41.0 ugm^{-3} to 64.1 ugm^{-3}. Highest monthly average was recorded in March 2002 at 64.1 ugm^{-3}.

Table 1: PM_{10} Concentrations for Penang Island 1998

Month	Jan	Feb	March	April	May	June
Average	28.2	30.7	43.7	42.6	30.7	29.2
Maximum	43.2	43.6	158.7	61.0	50.5	50.5
Minimum	18.3	22.2	20.1	28.6	9.7	10.4
Std. Dev.	5.9	5.7	25.3	7.9	9.8	10.0

Table 2: PM_{10} Concentrations for Penang Island 2000

Month	Jan	Feb	March	April	May	June
Average	25.2	30.7	28.2	22.8	29.5	33.9
Maximum	41.2	48.6	41.0	33.5	63.0	46.9
Minimum	13.8	14.8	15.0	14.7	13.3	18.2
Std. Dev.	6.6	9.1	6.9	5.8	11.9	7.3

Table 3: PM_{10} Concentrations for Penang Island 2002

Month	Jan	Feb	March	April	May	June
Average	41.0	55.8	64.1	44.1	43.4	53.8
Maximum	65	82	131	120	79	105
Minimum	27	32	27	26	22	22
Std. Dev.	10.6	12.0	29.8	7.9	15.9	26.8

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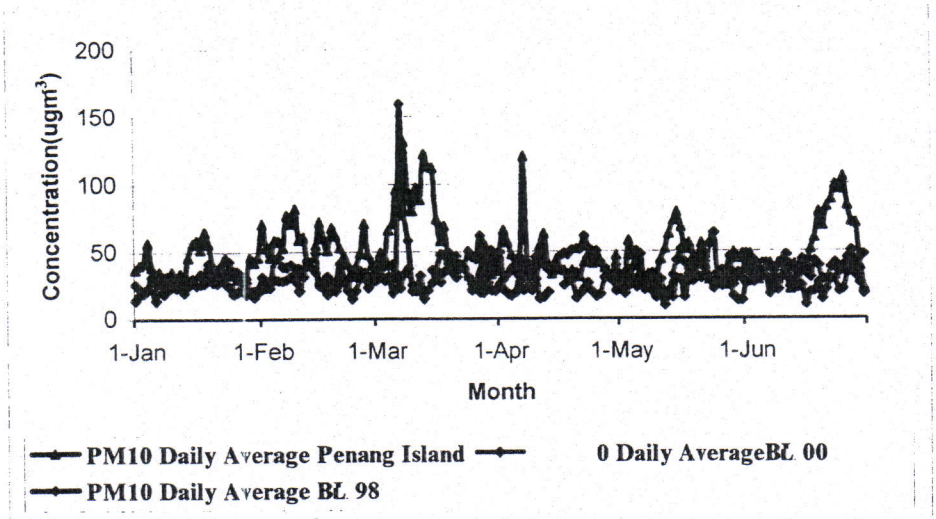

Figure 1: Comparisons between daily averages PM_{10} concentrations for six months in 1998, 2000 and 2002.

Figure 1, shows the trends of PM_{10} between January to June of 1998, 2000 and 2002. The daily average concentration of PM_{10} for Penang Island represents monitoring in 2002. Of note, the higher concentrations of PM_{10} recorded in this year compared to the two previous years. There are two possible explanations for this observation. First, the PM10 concentrations in 2002 were higher than 1998 and 2000, perhaps, due to the increase in emissions from local as well as transboundary sources. Secondly, the monitoring method used to measure PM10 concentrations in 1998 and 2000 was TEOM compared to BAM in 2002. TEOM instrument, although received certification from the USEPA, the measurement method has been a matter of debate internationally. The fact

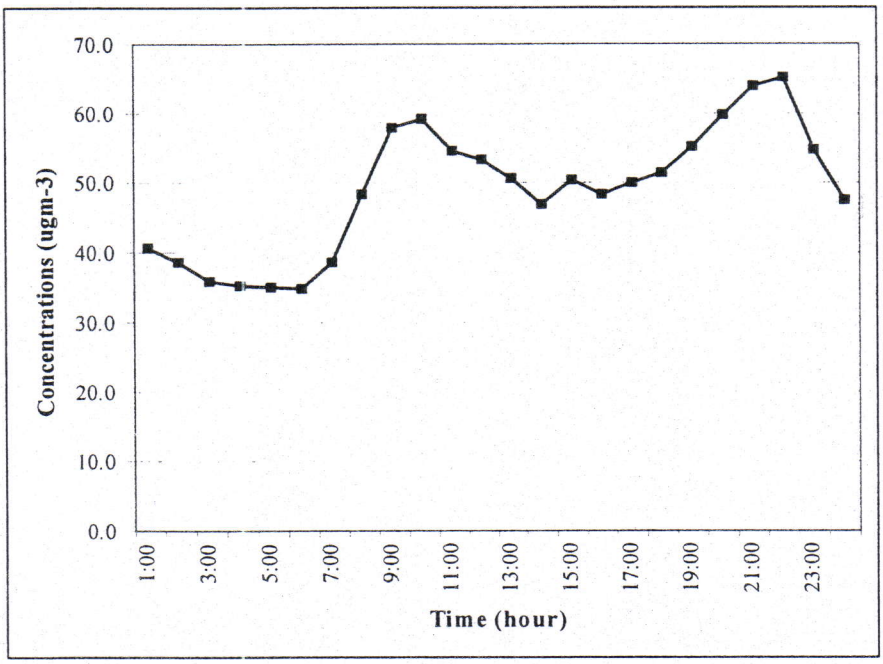

Figure 2: Diurnal variations on PM10 concentrations January to June 2002.

that in TEOM, the sample inlet is heated at 50oC to eliminate problem with condensation tend to 'under-measure' the PM10 concentrations in ambient air. APEG (2000) and Ramli (2001) discuss this issue of possible error in detail.

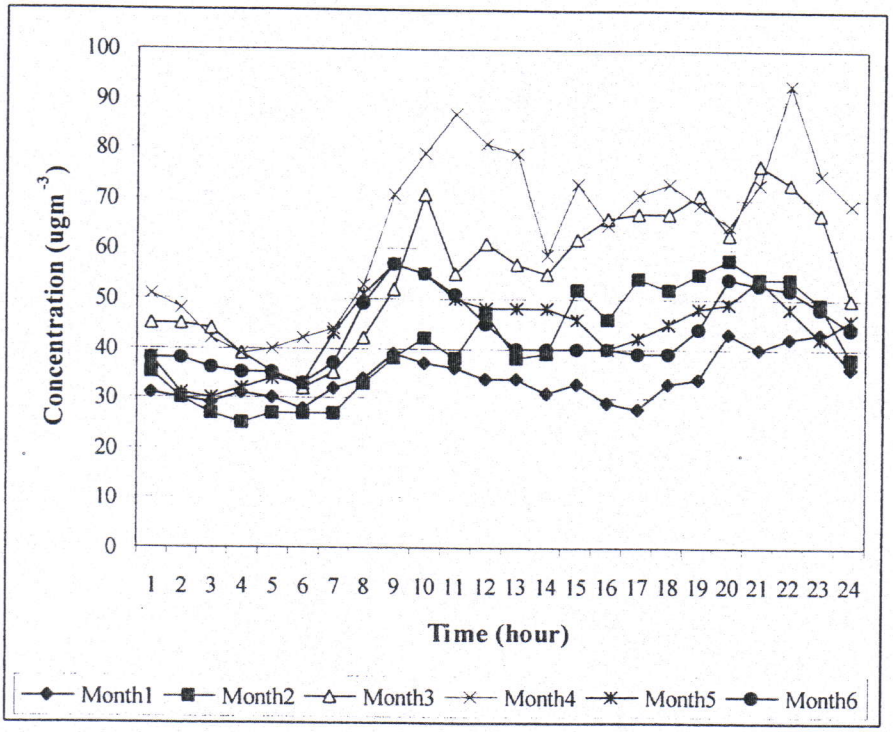

Figure 3: Diurnal variation of PM10 concentrations for every month (2002)

The diurnal variations of PM10 concentrations as shown in Figure 2 and Figure 3, illustrate the 24 hours variations. PM10 diurnal variations for Penang Island shows that two 'major peaks' exist. The first 'major peak' (Figure 2) occurred between 7 a.m. and 10 a.m., followed by the first off-peak. A minor peak can be observed at approximately 1.00 p.m. and last for about an hour. Second 'major peak' conspicuously begin at 5.00 p.m. and extend up to 10 p.m. PM10 concentrations during the second 'major peak', were higher than the first, in the morning. This trend is different from other diurnal studies that have been carried out in Malaysia, i.e. Ramli (2001), Ramli et al. (2001). Perhaps the fact that an island has different microclimatic conditions as compared to mainland had contributed to this. Furthermore, Penang Island has high number of registered vehicles that was nearing one million in 2000. In addition, there were multiple sources available from industries and that could have contributed to this trend. Finally, perhaps, there are transboundary movements of particulate pollutants into Penang Island.

Conclusion

In this study we found that the levels of PM10 concentrations been recorded in this study are well below the daily RMG of 150 ugm-3 and annual RMG of 50 ugm-3. Although,

there were days that exceed the daily RMG, the numbers were relatively low. Fifteen out of eighteen month records PM10 average concentrations below 50 ugm-3. However, monitoring and manipulation of data from different year had suggested that PM10 concentrations in Penang Island are rising. Further intensive investigations are required to identify and further control the source to ensure that the air quality in Penang could be sustained at good level.

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