AN INVESTIGATION OF PM_{10} CONCENTRATIONS AT ONE SITE OF KUALA LUMPUR

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ABSTRACT

The measurement of total suspended particulate (TSP) matter and PM_{10} (mass of particles with diameter less than or equal to 10 μm) concentractions were made between September 1986 - May 1987 at the Universiti Teknologi Malaysia monitoring station.

On the average, the TSP concentration was 63.3 $\mu g/m^3$ while the PM_{10} concentration was 47.6 $\mu g/m^3$ or 75 percent of the TSP.

Both PM_{10} and TSP were well correlated ($r = 0.92$) with a positive intercept on the TSP axis. This clearly indicates that the PM_{10} constitutes a portion of the TSP concentration.

The TSP and PM_{10} concentrations were higher in the weekdays than the weekend. This can be directly related to the daily human activities during the weekdays. The studies also high-lighted the impact of industrial activities on the PM_{10} level within the area.

INTRODUCTION

A greater part of the vast amount of data on ambient suspended particulate matter has been gathered using the well known high volume sampling method (HVS).[1] These HVS data have been widely used in epidemiological studies aimed at obtaining a direct relationship between ambient particulate matter and its effects on man. Accordingly, air standards for particulate matter do apply to so-called TSP (solid or liquid particles suspended in air).

Recent studies, have shown that only particles which are less than 10μm in size (PM_{10}) are said to be health-hazard[2]. These small particles are able to penetrate into the human respiratory system and deposited in the lungs. The total health-effect of these particles are not only governed by their physical nature but also by their chemical composition.

Particles in the size range of 1 to 10 μm tend to have characteristics which are common with local soil conditions or from local industrial emissions. For an example, in maritime areas, airborne sea salt spray falls in this size range. But almost exclusively, the release of fine particles are related to high energy process systems such as combustion, metal processing furnaces, smelting etc. Therefore, the influence from the local industrial emission sources around the receptor site can likely be felt and quantified.

Beginning September 1986, the Universiti Teknologi Malaysia has started a vigorous monitoring program for the measurement of ambient PM_{10} as well as the TSP. The main objective of this program was to quantify the level of PM_{10} whether it contributes a significant amount to the urban particulate matter of Kuala Lumpur.

The daily and monthly ratio of the PM_{10} to TSP and the significant influence of industrial emissions on the monitoring site based on wind direction are also discussed in this paper.

METHODOLOGY

Site description.

The data presented in this paper were gathered at a comprehensive monitoring site located in Universiti Teknologi Malaysia. The locations of the site and potential emission sources of particles are shown in Figure 1. The site is situated about 2 KM northeast of the Central Business District of Kuala Lumpur and approximately 10 KM northeast of the largest industrial area of Petaling Jaya. Other important industrial areas are located north-west (Gombak & Kepong areas) and light metal work industries in the south and southeast of the site. The Ulu Kelang trade free zone area situated northeast of the site is the most important industrial emission of the area. These industries may contribute significantly to the amount of particulate matter on the site and this study will quantify the impact of these industrial areas accordingly to their pollution contribution.

Sampling.

The equipment used to collect the TSP was the standard high-volume air sampler (SAUV-1H) which virtually collects any particle regardless of its size up to about 100 m. The PM_{10} was sampled using the size-selective high-volume air sampler (SAUV-10H) which has a cutoff diamter (d_{50} = collection of particle at 50% efficiency) of 10 m^3. These equipments were located on the roof top of a 4-storey building of 15 meters in height. Both samplers were calibrated and operated at 1.13 m^3/min for 24 hr. sampling period with a sampling frequency of once in four days. The 8" x 10" glass fiber filters (EPM 2000) were employed to collect the particulate mass of the PM_{10} and TSP. These filters were calibrated and condition in a dry incubator in a constant room temperature before and after the sampling events. Each batch of sample filters were weighted with 3 extra control filters to correct for relative humidity effect but this effect was later found to be insignificant.[4] The average difference in weight of the sample filters were divided by the total volume of air sampled to give the airborne particulate matter concentration present in the air.

RESULTS & DISCUSSION

A total of 54 samples were collected from September 1986 - May 1987 and presented in this study. Table 1 gives the daily concentrations of PM_{10} and TSP as well as the daily PM_{10}/TSP ratio. The overall concentrations mean of PM_{10}, TSP and PM_{10}/TSP ratio are also included in the table. Both PM_{10} and TSP were very well correlated ($r = 0.92$) with a positive intercept on the TSP axis. This suggests that the PM_{10} constitues a portion of the TSP concentration collected by the HVS.

The average TSP value of 63.3 $\mu g/m^3$ was fairly below the annual guidelines mean of 75 $\mu g/m^3$ imposed by the Department of Environment. While the average PM_{10} is 47.6 $\mu g/m^3$ which is closed to the preamble lower end value of PM_{10} annual standard of 50 $\mu g/m_3$ as proposed by the National Atmospheric Air Quality Standards (NAAQS). The presence of PM_{10} in this region may be considered relatively high and this is clearly shown in this study that on average 75 percent of the TSP is contituted by the PM_{10}. This means that the environment is more likely to be exposed to fine particles because of their longer atmospheric residence times (compared to larger particles). Also, the situation may affect the public especially with regard to possible eventual deep lung deposition if this is not checked.

Daily concentration of PM_{10} and TSP for the study period is given in figure 2. As expected, figure 2 illustrates that the TSP are always higher than PM_{10} in each sampling day. The 'gaps' shown in the figure indicate that there was a discrepancy in the data collection during a particular month due to technical problems.

The concentrations of PM_{10} and TSP during the weekdays and weekends are given in figure 3 and 4 respectively. Most PM_{10} and TSP concentrations were higher during the weekdays than the weekends. This can be directly related to the daily human activities during the weekdays.

A day to day PM_{10}/TSP ratio and monthly average PM_{10}/TSP ratio variations are represented in figure 5 and 6 respectively. There was no 'distinct' variation in the average monthly PM_{10}/TSP ratio during the study period except between the month of October to December. A lower PM_{10}/TSP ratio could be expected in this transitional monsoon period as the west coast is experiencing plenty of rainfall during this season.[5] A constant wet ground condition and 'scavenging' effect of the rainfall may therefore lower the PM_{10}/TSP ratio during these months as compared to the other months. A complete interpretation of seasonal PM_{10}/TSP ratio could have been made if a full year data set was available.

Effect of wind direction on the concentration of suspended particulate matter.

Studies have shown that wind direction plays an important role in transporting air pollutants to the receptor.[6] A wind direction approach to quantify the contribution of potential industrial emission with respect the their importance was considered in this study. The wind direction were divided into four sectors at the receptor site; NW, NE, SW and SE. The daily PM_{10} and TSP concentrations were grouped accordingly with respect to their vector average wind direction for the day. The highest average of PM_{10} and TSP in a given wind category will indicate or estimate the direction of the highest contribution of PM_{10} or TSP upwind of the receptor site.

Table 2 presents the sectorial contributions of PM_{10} and TSP by the wind direction. As expected, the highest contribution of the PM_{10} or TSP is from the SW direction where the most important industrial area is located. A tremendous industrial development has been achieved in this particular area for the past 20 years. Here, the industries are diversified in nature ranging from a small to a big scale manufacturing industries. It was estimated that in 1971 survey, 82% of the total industrial establishments in the region was found in both Kuala Lumpur and Petaling Jaya areas alone. The second, third and fourth largest contributions of PM_{10} and TSP by the wind direction were NE, NW and SE sectors respectively. The study reveals that the high PM_{10} and TSP contributions from the NE direction could be due to the major housing development projects and contructions undergoing in this area. But the high PM_{10}/TSP ratio from this direction does not negate the important of industrial contribution from the area.

The NW and SE wind sectors contribute almost equally the same in both PM_{10} and TSP. One interesting point to note in this study is that the contributions of PM_{10} and TSP was consistant for any given wind direction.

CONCLUSION

A simple analysis of PM_{10} and TSP measured at one site of Kuala Lumpur was reported. The average mass concentrations of TSP and PM_{10} were found to be 63.3 $\mu g/m^3$ and 47.6 $\mu g/m^3$ respectively. The PM_{10} represents 75 percent of the TSP and therefore there is a possible threat of health-hazard to the public at large. Thus, future monitoring program will need to emphasize more in the collection of fine particulate matter which gives a better understanding of epidomiological relationship studies between man and his environment.

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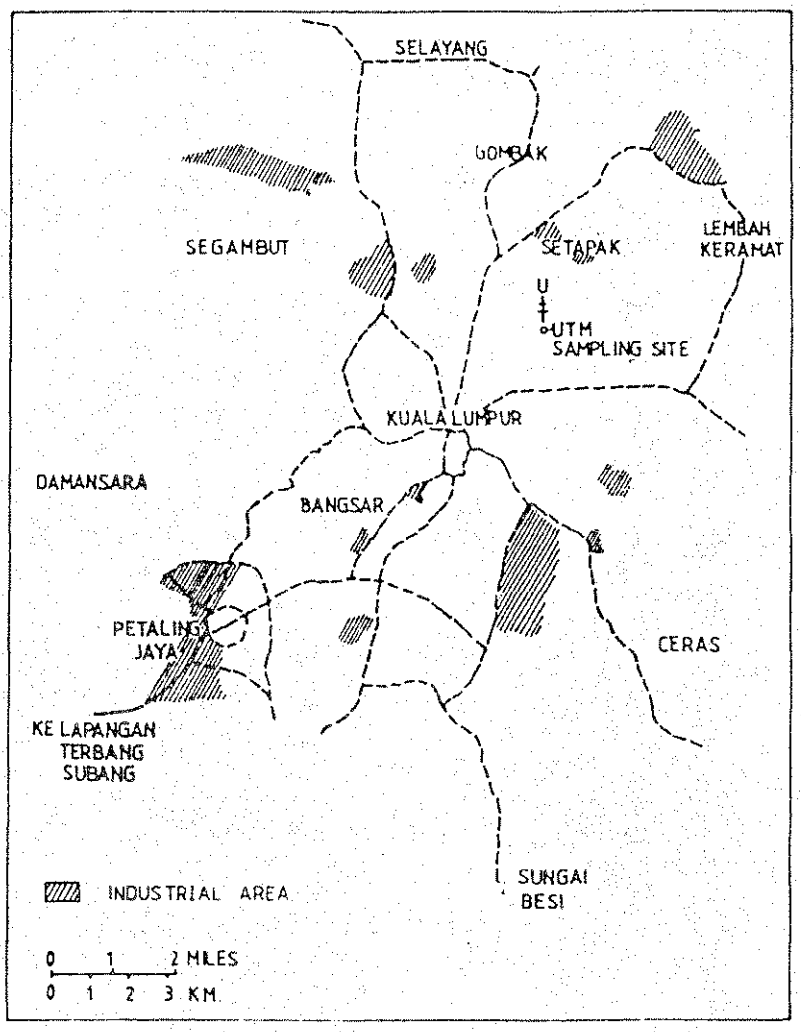

Fig. 1. Location of the sampling site.

TABLE 1: THE SUSPENDED PARTICULATE MATTER CONCENTRATION ($\mu g/m^3$)

DAY	PM_{10}	TSP	PM_{10}/TSP
1	41.17	51.9	0.80
2	47.3	60.1	0.79
3	50.4	71.5	0.70
4	43.1	56.7	0.76
5	56.8	78.5	0.72
6	55.2	78 3	0.70
7	42.4	55.7	0.76
8	44.9	61.0	0.74
9	28.2	65.0	0.43
10	39.1	81.9	0.48
11	30.5	39.3	0.78
12	36.7	53.6	0.68
13	44.7	62.6	0.71
14	60.9	80.5	0.76
15	33.4	46.5	0.72
16	40.2	54.5	0.74
17	26.6	39.0	0.68
18	35.9	48.8	0.74
19	39.1	54.2	0.72
20	37.8	51.7	0.73
21	65.0	85.9	0.76
22	49.6	64.7	0.77
23	59.8	81.2	0.74
24	42.9	62.4	0.68
25	38.2	53.0	0.72
26	50.6	58.7	0.86
27	43.7	54.8	0.80
28	68.0	84.3	0.81
29	54.6	68.9	0.78
30	50.5	63.5	0.80
31	45.6	57.8	0.79
32	24.6	32.2	0.76
33	38.3	51.8	0.74
34	25.4	35.9	0.71
35	51.2	64.6	0.79
36	57.9	74.4	0.78
37	58.8	72.6	0.81
38	50.1	62.8	0.80
39	61.4	76.4	0.80
40	69.8	92.5	0.75

DAY	PM_{10}	TSP	PM_{10}/TSP
41	22.9	33.5	0.68
42	35.8	46.4	0.77
43	79.5	95.1	0.84
44	54.8	68.1	0.80
45	52.3	66.5	0.79
46	65.1	85.0	0.77
47	45.5	61.0	0.75
48	57.0	76.0	0.75
49	41.1	51.9	0.79
50	76.4	94.1	0.81
51	35.6	46.7	0.76
52	64.8	80.6	0.80
53	53.8	68.2	0.79
54	42.8	53.4	0.80
Mean	47.6	63.3	0.75
Std.dev.	13.0	15.5	0.07

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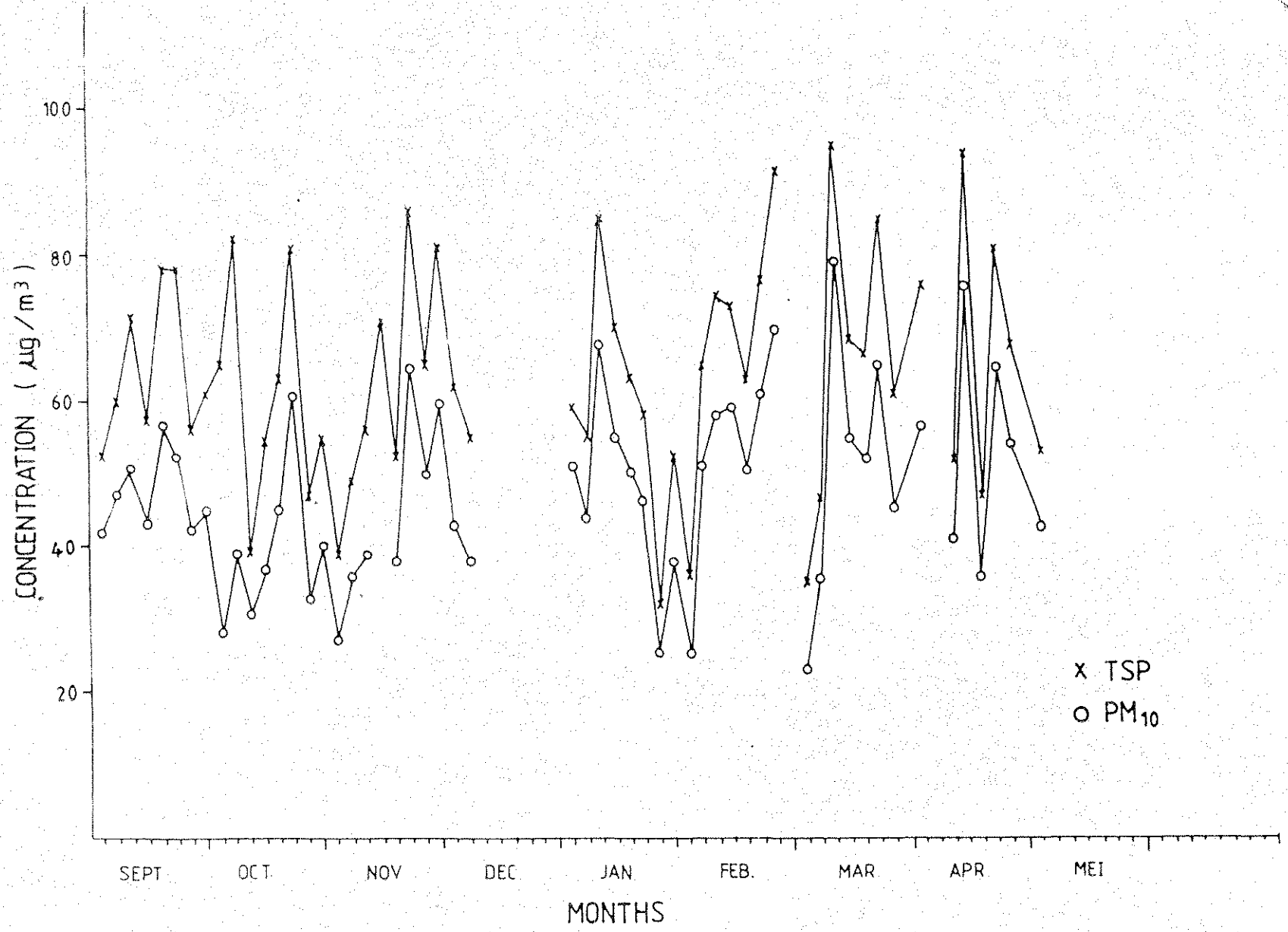

FIGURE 2 : Daily Concentration of PM_{10} and TSP

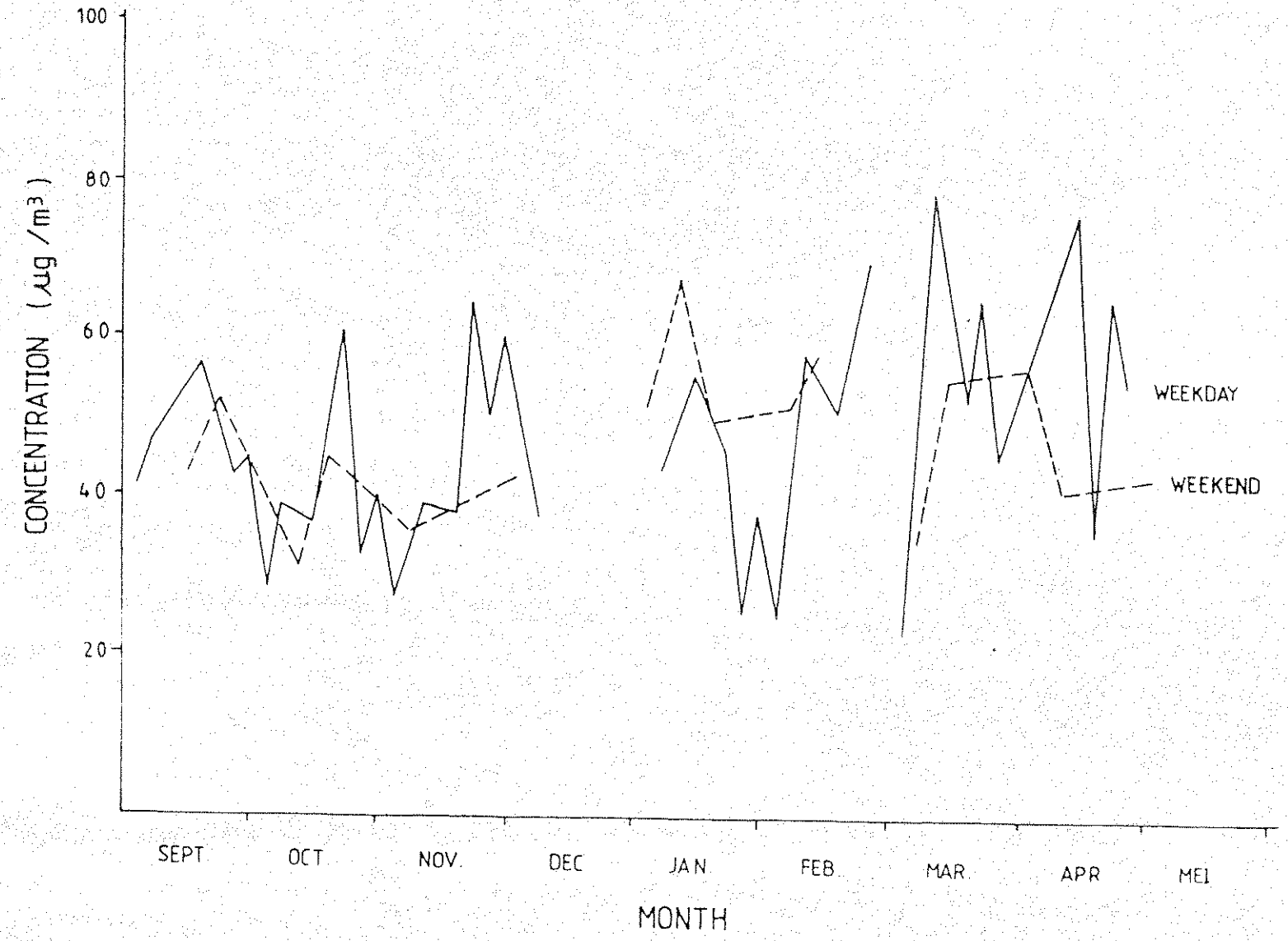

FIGURE 3: PM_{10} Concentration during weekdays and weekend.

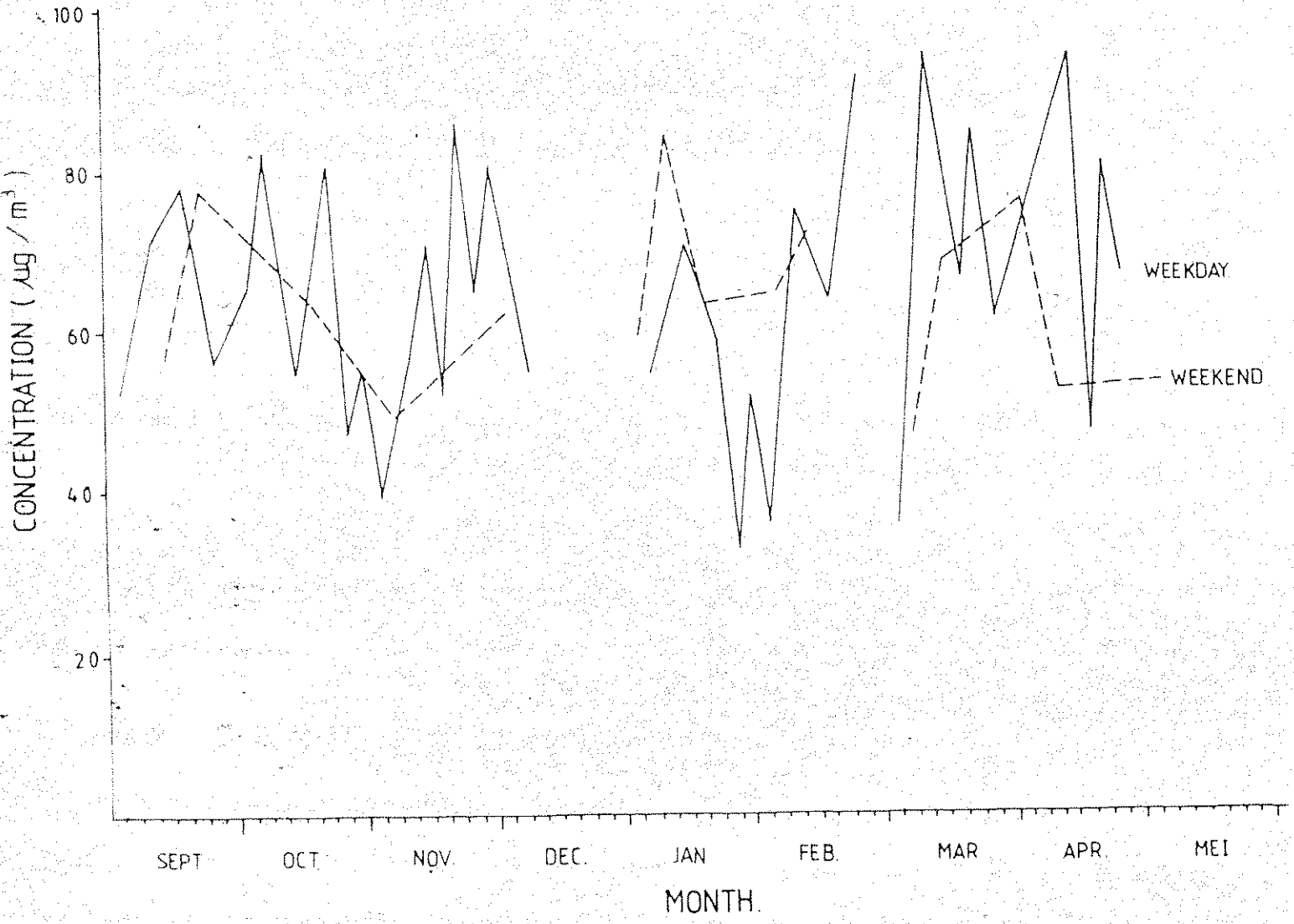

FIGURE 4: TSP Concentrations during weekday and weekend.

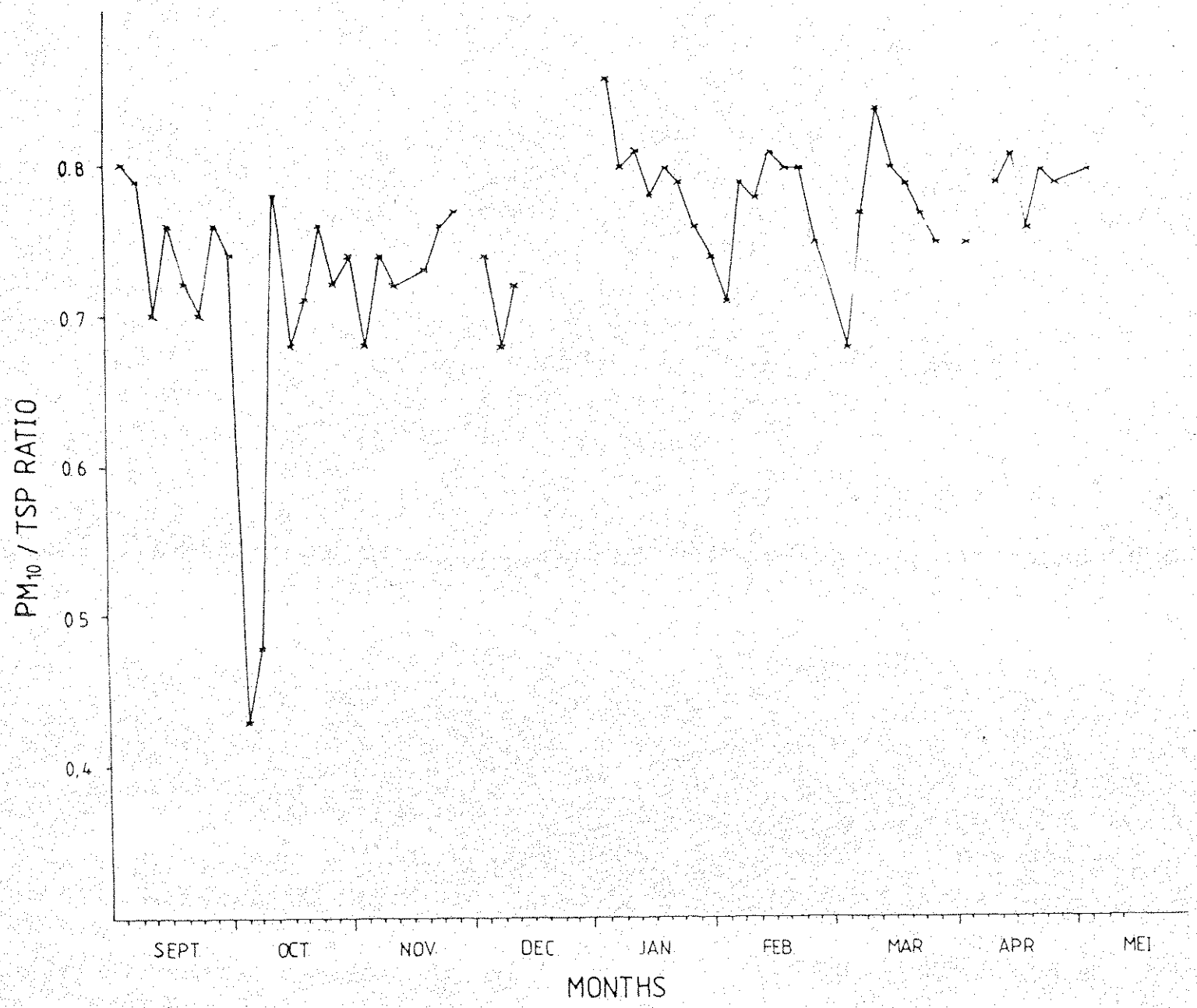

FIGURE 5 : Daily PM_{10}/TSP Ratio

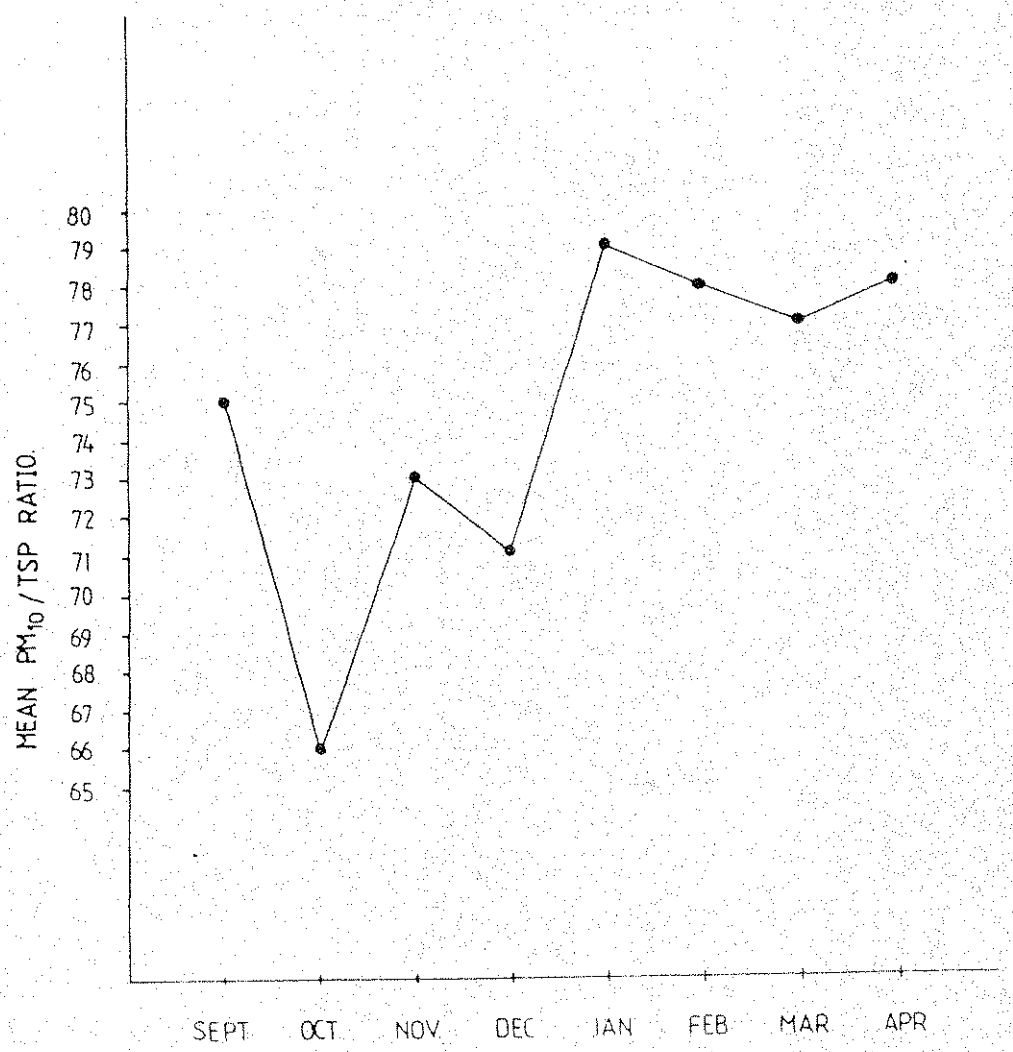

FIGURE 6 : Monthly Average PM_{10} / TSP Ratio

TABLE 2: AVERAGE PM_{10} AND TSP CONTRIBUTIONS BY WIND DIRECTION

Suspended Particulate	Wind Direction			
	SW	SE	NW	NE
PM_{10}	58.9 (11.8)	41.4 (11.9)	43.2 (9.1)	48.7 (7.2)
TSP	75.65 (16.0)	58.0 (13.1)	60.9 (12.9)	62.9 (6.4)
$\frac{PM_{10}}{TSP}$	0.78	0.71	0.71	0.77

( ) = Std. dev.