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Lead and Cadmium Content of Total Suspended Particulates in the Atmosphere over the Klang Valley

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ABSTRAK

Lima lokasi (bandar, pinggir bandar, bandar baru, perindustrian, dan luar bandar) telah dipilih untuk persampelan partikel terapong di udara (TSP) dengan menggunakan alat persampelan high-volume. TSP tersebut telah dianalisa kandungan plumbum dan kadmiumnya dalam 3 pecahan ekstrak. Lokasi yang paling tercemar oleh plumbum ialah lokasi bandar BBP (Balai Bomba Pudu), manakala bagi kadmium pula ialah lokasi pinggir bandar UPM (Universiti Pertanian Malaysia). Lokasi yang paling bersih bagi kedua-dua logam tersebut adalah sama, iaitu lokasi luar bandar KSM (Kampung Sungai Merab). Perbandingan corak taburan temporal untuk TSP, plumbum, dan kadmium menunjukkan bahawa perubahan pemusatan TSP tidak mempengaruhi perubahan pemusatan plumbum maupun kadmium. Analisa corak pecahan ekstrak mencadangkan bahawa peratus plumbum dan kadmium dari sumber antropogenik yang baru adalah lebih tinggi di lokasi bandar BBP, berbanding dengan lokasi-lokasi lain.

ABSTRACT

Five sites (urban, suburban, new township, industrial, and rural) were selected and sampled for total suspended particulates (TSP) using high-volume samplers. The TSP were then analysed for their lead and cadmium content in 3 extraction fractions. While the most polluted sites for atmospheric lead and cadmium were different, namely the BBP (Pudu Fire Station) urban and UPM (Universiti Pertanian Malaysia) suburban sites, respectively, the least polluted site was the same for both metals, namely the KSM (Sungai Merab Village) rural site. Comparisons of the temporal distribution patterns of TSP, lead and cadmium indicate that variation in TSP concentrations does not seem to influence variations in lead and cadmium concentrations. Analysis of fractionation patterns suggests that the BBP urban site has slightly higher percentages of anthropogenic lead and cadmium from fresh sources than the other sites.

Keywords: total suspended particulates, atmospheric lead, atmospheric cadmium, fractionation

INTRODUCTION

The topography and climate of the Klang Valley have the potential of trapping air pollutants in the atmosphere. The atmosphere over the valley has a low mean ventilation volume, creating a high accumulating potential for air pollutants (Sham 1979, 1987). Motor vehicles are the major source of atmospheric lead, with unleaded gasoline being introduced just before this study, in early 1992. The sources for atmospheric cadmium are less obvious, but contributors would be various industrial activities throughout the Klang Valley. However, motor vehicles are also minor sources of atmospheric cadmium from rubber tyre wear and the burning of gasoline and motor oil (Fleischer *et al.* 1974; Voldner and Smith 1989).

METHODOLOGY

Five sites were selected and sampled for total suspended particulates (TSP), as shown in *Fig. 1*. The urban site at the Pudu Fire Station (BBP) is located within Kuala Lumpur city centre, a highly traffic-congested commercial area. A suburban site situated at the Agricultural University of Malaysia (UPM) is 30 km south of the city centre. A new township site located at the Standards and Industrial Research Institute of Malaysia (SIRIM) is 30 km west of the city centre. An industrial site at the Johnson and Johnson factory (J&J) is in Petaling Jaya, 20 km west of the city centre. A rural site situated in Sungai Merap Village (KSM) is 40 km south of the city centre.

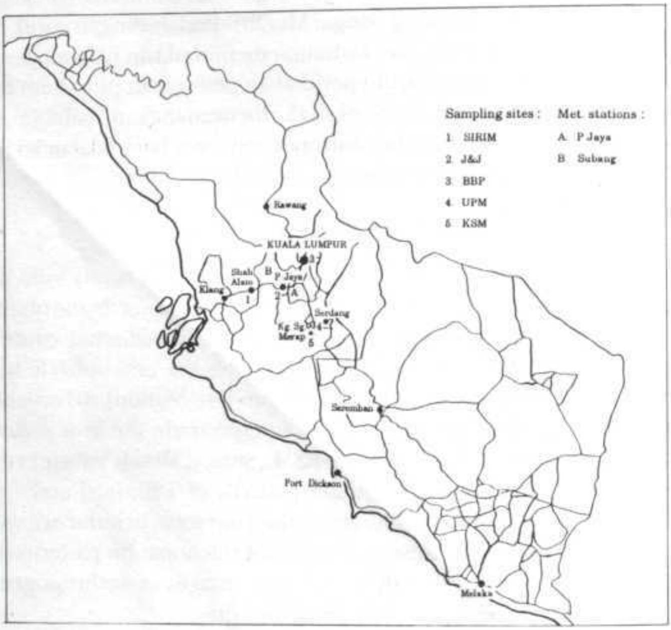

Fig. 1: Map showing the sampling sites in Klang Valley, Malaysia

Air sampling was done using the Sierra 305-2000 high-volume samplers, calibrated to run at a flow rate of 67.96 m^3/hr. Sampling was conducted on alternate days from March 7 to March 27, 1992. On each sample run, each high-volume sampler was operated from 7.30 a.m. on one day to 7.30 a.m. the next day. The sampling media were fibreglass type A/E filters.

The lead and cadmium extraction procedure employed was a modified version of the one used by Lindberg and Harriss (1983). Three consecutive extracts were obtained from each filter for lead and cadmium analysis. A 2.25 in^2 filter piece was placed in a polyethylene (HDPE) vial with 15 ml of deionised distilled water (DDW), and ultrasonicated for 2 hours. The content was then filtered through a 0.45 µm Millipore filter. This filtrate represents the DDW extract. The Millipore filter was then placed in the same vial, and 15 ml of 0.08 N Ultrex grade HNO_3 was added. The vial was ultrasonicated for another 2 hours. The content was then filtered through a 0.45 µm Millipore filter. This filtrate represents the 0.08 N dilute acid extract. The second Millipore filter and the vial contents were heated with 10 ml of concentrated HNO_3 (ultra-analysed grade) to dryness in a 50-ml beaker. Another 10 ml of the acid was added to the beaker and the contents again heated to dryness. Ten ml of concentrated ultra-analysed HCl was then added to the beaker and its contents heated to dryness. Next, 15 ml of 1.0 M ultra-analysed HCl was added to the beaker and its contents warmed to about 40 to 50°C. The contents were allowed to cool and then filtered through a 0.45 µm Millipore filter. This filtrate represents the acid digest extract. The filtrate was adjusted to volume with 1.0 M ultra-analysed HCl in a 50-ml volumetric flask.

Lead and cadmium in the filter extracts were analysed with a Perkin Elmer graphite furnace atomic absorption spectrometer (GFAAS). The analytical method employed is the EPA Method 200.9 (Creed *et al.* 1991) which describes the determination of applicable elements by stabilized temperature platform graphite furnace atomic absorption (STPGFAA).

RESULTS

The relative distributions of total suspended particulates (TSP) are given in Table 1, while Table 2 gives the distributions for atmospheric lead and cadmium at the 5 sampling sites. There is little similarity in the ranking of these sites with respect to mean atmospheric concentrations of TSP, lead and cadmium. The exception was the UPM suburban site, which recorded the highest mean concentrations for both TSP and cadmium, while the KSM rural site showed the lowest mean concentrations for lead and cadmium and the second lowest for TSP.

Table 2 also indicates that the ranking of the sites for lead and cadmium is somewhat contrasting. The BBP urban site clearly shows the highest mean lead concentration, while it is only the third highest for cadmium. The UPM suburban site gave the highest mean cadmium level, but only recorded the

TABLE 1

Total suspended particulates at sampling sites in Klang Valley, March 1992

		Total suspended particulates concentration in µg/m³			
Sampling site	Sample size	Range	Mean	Median	S.D.
SIRIM	10	14.25-107.96	74.16 (5)	87.35 (4)	30.48
J&J	10	72.26-200.66	116.97 (3)	110.85 (3)	38.84
BBP	10	18.48-157.86	125.12 (2)	133.87 (2)	40.97
UPM	11	14.16-266.32	130.07 (1)	140.98 (1)	67.89
KSM	3	34.39-212.13	103.41 (4)	63.70 (5)	95.29

( ) : relative ranking of sites.

second highest mean lead level. The J&J industrial site has the second highest ranking for cadmium and third for lead. The SIRIM new township and the KSM rural sites, however, show the same ranking for lead and cadmium, which is fourth and fifth, respectively.

Table 3 gives the mean percentages of lead and cadmium extracted in the 3 extraction fractions. These are the distilled deionised water fraction, the dilute acid fraction, and the concentrated acid digest fraction. The first 2 fractions can be considered as containing anthropogenic lead and cadmi-

TABLE 2

Atmospheric lead and cadmium at sampling sites in Klang Valley, March 1992

		Atmospheric lead and cadmium concentrations			
Sampling site	Sample size	Mean Pb conc. (ng/m³)	S.D. Pb conc.	Mean Cd conc. (ng/m³)	S.D. Cd conc.
SIRIM	10	151.10 (4)	38.48	1.17 (4)	0.32
J&J	10	171.98 (3)	64.97	1.63 (2)	0.75
BBP	10	461.51 (1)	135.97	1.39 (3)	0.59
UPM	11	188.60 (2)	59.49	1.85 (1)	0.91
KSM	3	30.10 (5)	0.40	0.28 (5)	0.26

( ) : relative ranking of sites.

TABLE 3

Lead and cadmium percentage in extraction fractions from atmospheric TSP samples in Klang Valley, Malaysia, March 1992

Sampling site	Mean % of lead and cadmium in extraction fraction					
	Dist. Deion. Water		Dilute Acid		Conc. Acid Digest	
	Cd	Pb	Cd	Pb	Cd	Pb
SIRIM	41.50	10.70	38.40	61.19	20.10	28.11
J&J	42.60	13.75	34.90	60.72	22.50	25.53
BBP	40.90	6.16	42.10	74.38	17.00	19.47
UPM	46.40	13.53	31.80	64.11	21.80	22.37

um, while the third fraction contains mainly lead and cadmium from natural and old sources. Old sources are atmospheric lead and cadmium which have been removed from the atmosphere by dry and wet depositions and are organically bound in soil particles. These are then resuspended in the atmosphere by wind action and other mechanical processes.

The temporal distributions of atmospheric TSP, lead, and cadmium for 4 of the sites (the KSM rural site was excluded due to its small sample size) are depicted in *Fig. 2-5.* The figures indicate that variations inTSP concentrations do not seem to influence variations in lead and cadmium concentrations. However, there are some similarities in the temporal distributions of lead and cadmium for the SIRIM new township (*Fig. 2*) and the J&J industrial (*Fig. 3*) sites.

DISCUSSION

Table 2 indicates that while lead is generally an urban atmospheric pollutant as indicated by the relatively much higher mean lead concentration recorded at the BBP urban site, cadmium may not be necessarily so as the UPM suburban site demonstrated the highest mean cadmium concentration. The high cadmium concentration at the UPM site may be due either to nearby land development projects producing windblown dusts, or the application of superphosphate fertilizers and fungicides on agricultural lands surrounding the site; these being reported sources of atmospheric cadmium (Fleischer *et al.* 1974).

However, there is agreement between lead and cadmium with respect to the lesser polluted sites, namely the SIRIM new township and KSM rural sites, where there are fewer human activities. This, therefore, indicates that most of the lead and cadmium found at the other sites tend to be anthro-

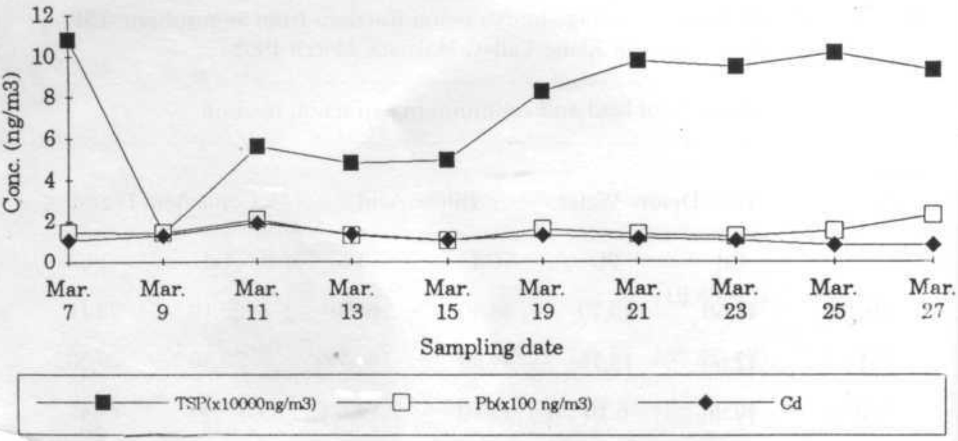

Fig. 2. Atmospheric TSP, Pb and Cd at SIRIM site, Malaysia, March 1992

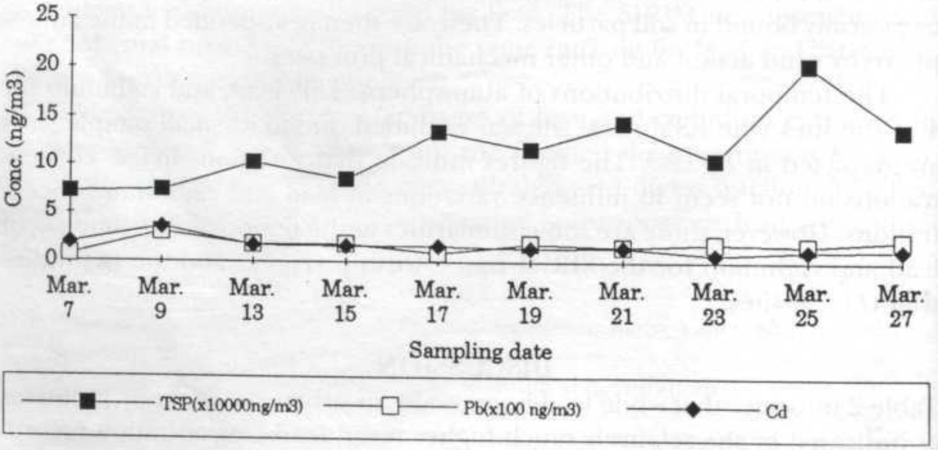

Fig. 3. Atmospheric TSP, Pb and Cd at J & J site, Malaysia, March 1992

pogenic. The much lower mean atmospheric lead and cadmium concentrations measured at the KSM rural site may be taken as the natural background level for the Klang Valley.

The fractionation pattern of lead and cadmium into the 3 extraction fractions as indicated in Table 3 gives interesting results. Most of the atmospheric lead species tend to be dilute acid soluble. These species are mainly halogenated lead species from motor vehicle exhaust. Therefore, these rep-

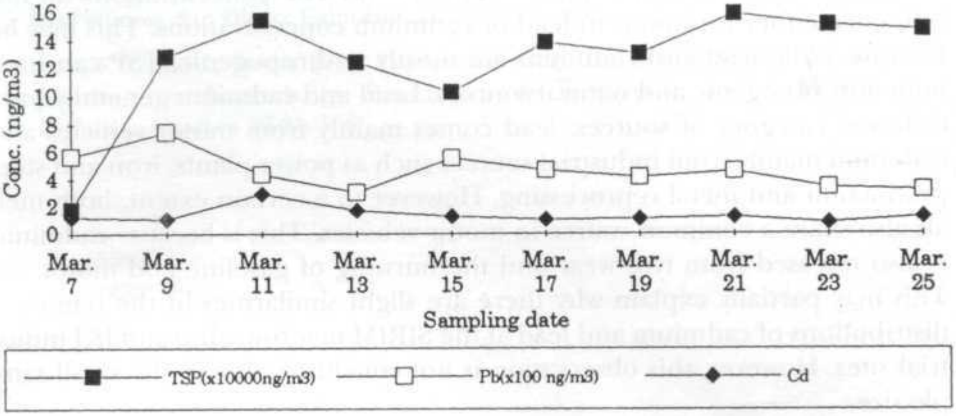

Fig. 4. Atmospheric TSP, Pb and Cd at BBP site, Malaysia, March 1992

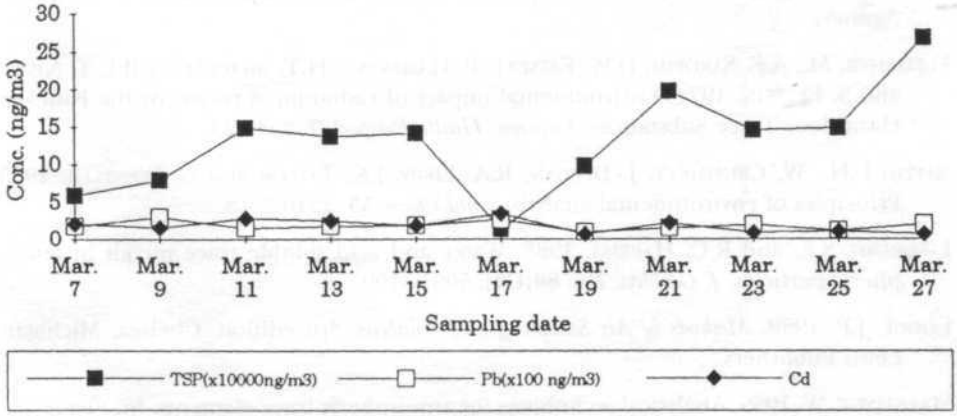

Fig. 5. Atmospheric TSP, Pb and Cd at UPM site, Malaysia, March 1992

resent fresh or primary lead. On the other hand, most of the atmospheric cadmium species tend to be water soluble. These tend to be mainly cadmium sulphate and nitrate, formed by the reaction of cadmium oxide (a product of combustion), with sulphur trioxide and nitrogen oxides, respectively. Therefore, these represent secondary pollutant species. The low percentages of acid digested lead and cadmium (mainly from natural and old sources), especially at the BBP urban site, suggest that the anthropogenic sources of both metals are dominant at all 4 sites.

Fig. 2-5 indicate that temporal variations in TSP concentrations do not influence either variations in lead or cadmium concentrations. This may be because while lead and cadmium are mostly anthropogenic, TSP can have both anthropogenic and natural sources. Lead and cadmium generally have different category of sources; lead comes mainly from motor vehicles and cadmium mainly from industrial sources such as power plants, iron and steel production and metal reprocessing. However to a certain extent, both metals also share a common source in motor vehicles. This is because cadmium is also released from tyre wear and the burning of gasoline and motor oil. This may partially explain why there are slight similarities in the temporal distributions of cadmium and lead at the SIRIM new township and J&J industrial sites. However, this observation is not conclusive due to the small sample size.

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