CONCENTRATIONS OF LEAD (Pb) IN ROAD DUST IN BANDAR SERI BEGAWAN, BRUNEI DARUSSALAM

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ABSTRACT

A first-ever survey of lead (Pb) in road dust in Bandar Seri Begawan (B.S.B.), the capital of Brunei Darussalam, was carried out in 1996, three years after the introduction of unleaded petrol. The concentration of Pb at 114 sites varied between 12 and 544 $\mu\text{g/g}$ (mean: 125 $\mu\text{g/g}$; standard deviation: 103 $\mu\text{g/g}$). There was a significant correlation ($r=0.546$) between lead in road dust and traffic volume at 17 sites for which traffic counts were available. An assessment of the potential hazard posed to children was made. It is concluded that concentration levels of Pb in road dust in B.S.B. are considerably lower than levels found in London and Hong Kong, and they do not pose a major public health hazard.

1. INTRODUCTION

The major source of lead (Pb) in the environment of Brunei Darussalam is the use of tetraalkyllead as a petrol additive. In order to protect the public, measures were taken to reduce emissions of Pb. In 1992, the Pb content of petrol was reduced from 400 to 150 mg/L, and in January 1993 unleaded petrol was introduced for the first time. Unleaded petrol assumed a 50% market share within two years of its introduction.

Earlier studies of Pb in the environment of Brunei, involving mainly analysis of surface waters, revealed low levels of Pb contamination¹. As the major fate of Pb emitted from motor vehicles is deposition at the roadside it was decided that a detailed survey of Pb in road dust of Bandar Seri Begawan (B.S.B.) was required. The survey was carried out during 1996.

Bandar Seri Begawan (B.S.B.) is the capital of Brunei Darussalam. It is the major urban area in the country with a population of *ca.* 50,000. Per capita car ownership in Brunei is among the highest in the world; it exceeds 0.3. The number of registered motor vehicles in the whole country was *ca.* 150,000 in 1996, the majority of these being in the B.S.B. area.

2. MATERIALS AND METHODS

Road dust samples were collected at 114 sites throughout the B.S.B. area covering a variety of roads from busy town centre streets to quiet, suburban roads in residential areas. Samples were collected after several days of dry weather as rain could bring considerable reduction in the level of lead in road dust. Approximately 5g of dust were collected from the roadside using a dustpan and brush, and stored in a polyethylene bag. Samples were sieved, dried in an oven at 110°C for one hour and cooled in a desiccator. Approximately 2g of dried dust were accurately weighed and placed inside a 100 millilitre (mL) beaker together with 50 mL of 2 M nitric acid. Boiling chips were added and a watch glass was placed on the beaker. The mixture was heated on a hotplate until the volume was reduced to about 10 mL and then cooled. The mixture was then filtered through a Whatman No. 91 filter paper into a 25 mL volumetric flask, and the beaker and paper were washed with small volumes of 1 M nitric acid which were also added to the flask. The flask was made up to the mark and the extract was analysed by means of flame atomic absorption spectrophotometry (AAS) using a Philips PU9100 Atomic Absorption Spectrophotometer in an air/acetylene flame at a wavelength of 217 nm. Eight standards covering the range from 1 to 25 µg/mL were prepared by dilution from a 1000 µg/mL Pb stock solution and analysed to give a calibration curve.

3. RESULTS AND DISCUSSION

3.1 Level of contamination

The concentration of Pb in dry dust samples varied between 12 and 544 µg/g. The mean concentration was 125 µg/g and the standard deviation was 103 µg/g. Concentrations of Pb in B.S.B. are considerably lower than concentrations reported for other cities; for example, concentrations of Pb in road dust in London in the early 1990s varied between 400 and several thousand µg/g according to Evans *et al*². There are no international standards for Pb in road dust but the Greater London Council recommended a guideline value of 500 µg/g and a similar guideline has been proposed in the U.S.³ Since concentrations of Pb in road dust of B.S.B. rarely exceed this value it can be concluded that Pb pollution is not a major environmental problem in Brunei Darussalam.

3.2 Distribution of Pb in B.S.B.

The spatial distribution of relative Pb concentrations in road dust and traffic volume around the city is illustrated in Figure 1 based on measurements at representative sites. Highest concentrations were recorded in the downtown and commercial districts with higher traffic, whereas lower concentrations were observed in suburban and residential areas.

Figure 1: Distribution of Pb in road dust and traffic volume at selected sites in the Bandar Seri Begawan area.

3.3 Intrasite variability

Intrasite variability was studied by taking five roadside dust samples at 1m intervals. These tests showed coefficients of variation of *ca.* 50% for Pb in road dust. High variability has also been noted in other studies. For example, coefficients of variation between 17% and 45% were reported for street dust in London². High variability is to be expected since Pb in roadside dust depends on many factors including traffic volume, driving mode, street-cleaning practices, non-traffic sources (e.g. print works), meteorological conditions (e.g. rainfall, wind speed), etc.

3.4 Relationship between Pb concentration and traffic volume

Traffic counts were available for 17 sites in B.S.B. Traffic counts were made one year prior to the lead survey. The total number of registered motor vehicles in the whole country increased by 26% during the period 1995-1996. Although the amount of traffic in the city had increased, there had been no major change in the relative traffic volumes at each site by the time the survey was carried out. Concentrations of Pb measured in several samples collected at these sites were averaged (Table 1) and correlated with the traffic volume. A plot of Pb versus traffic volume is shown in Figure 2. The value of Pearson's correlation coefficient was 0.546 indicating a significant relationship between Pb in road dust and traffic volume ($P>0.05$). Although this relationship is to be expected, as vehicular traffic is the main source of Pb in urban environments, previous studies at other locations have failed to find any significant relationship between Pb in road dust and traffic volume. For example, studies in Hong Kong observed a significant relationship between traffic volume and Pb in roadside soil and grass⁴, but failed to observe a significant correlation with road dust⁵.

Figure 2: Correlation chart of Pb in road dust versus traffic volume ($r=0.546$).

Table 1: Traffic volume, mean Pb in road dust, Pb concentration range, and contribution to Pb in blood of children at several sites in Bandar Seri Begawan.

Site	Traffic volume (cars/day)	Mean Pb road dust ($\mu\text{g/g}$)	Pb concentration range ($\mu\text{g/g}$)	N	Contribution to Pb in blood ($\mu\text{g/DL}$)
Jln. Sultan	23910	252	109-398	6	1.81
Jln. Residency	12754	245	155-278	6	1.76
Jln. Kota Batu	9300	84	54-108	3	0.61
Jln. Stoney	12685	68	45-90	2	0.49
Jln. Kebangsaan	10464	55	54-56	3	0.39
Jln. Muara	9176	97	45-180	3	0.70
Jln. Berakas	8718	79	42-138	5	0.57
Jln. Gadong	21559	113	48-229	13	0.81
Jln. Tutong	14068	319	69-544	3	2.30
Jln. Menteri Besar	2538	63	49-78	2	0.46
SHB Highway	20670	118	22-294	12	0.85
Tungku Link	10984	43	12-66	5	0.31
Coastal Highway	4984	30	13-90	7	0.22
North Rimba Road	2055	27	14-50	4	0.20
Jln. Sungai Kianggeh	12532	179	115-211	3	1.29
Berakas Roundabout	7874 (from B.S.B.)	146	23-322	4	1.04
Berakas Roundabout	9148 (from airport)	91	NA	1	0.65

N refers to the number of sampling sites along a particular road. NA denotes not available.

3.5 Degree of hazard posed to children

As many of the sites surveyed in this study are in close proximity to schools, kindergartens and public housing, we decided to estimate the contribution of Pb in dust to blood lead levels in children. The contribution of road dust to the blood levels of Pb in children was estimated using the United States Environmental Protection Agency (US EPA) biokinetic uptake model as described by Evans *et al*². The main assumptions of this model are that children in the 0 to 6 year range ingest some 60 mg of dust per day and that 30% of the ingested Pb is absorbable. The amount of absorbable Pb, in μg , is multiplied by 0.4 to convert to μg of Pb per decilitre (dL) of blood. In the absence of data on indoor Pb concentrations, we assumed a ratio of indoor to outdoor Pb in dust of 1:1. Contributions to blood Pb in B.S.B. at 17 road sites covering a range of traffic conditions are given in

Table 1. Contributions to Pb in blood of children vary between 0.2 and 2.3 µg/dL. In a similar study conducted in London², contributions of road dust to blood Pb varied from 3.6 to 20.3 µg/dL, considerably higher than in B.S.B.

4. CONCLUSIONS AND RECOMMENDATIONS

A detailed survey of lead (Pb) in road dust of Bandar Seri Begawan was carried out. The concentration of Pb varied between 12 and 544 µg/g in 114 samples collected at various sites throughout the city. A significant correlation was observed between Pb in road dust and traffic volume at 17 sites for which traffic counts were available, indicating that vehicle emissions were the dominant source of Pb. Concentrations of Pb in road dust of Bandar Seri Begawan are considerably lower than concentrations reported for London and Hong Kong, and they are well below recommended guideline values. The contribution of road dust to blood levels of Pb in children in Bandar Seri Begawan was estimated to be considerably lower than that in a major urban area such as London, and it can be concluded that Pb is not a significant environmental hazard in Brunei Darussalam.

This study should be extended to include other important urban pollutants in dust (Zn and Cd) and in the air (NO_x, O₃ and CO).

5. ACKNOWLEDGEMENT

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6. REFERENCES

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