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Blood Lead Levels of People Living in Traffic Areas in Benin City, Nigeria

C.M.A. Ademoroti and A.P. Oviawe
Department of Chemistry, University of Benin, P.M.B. 1154, Benin City, Nigeria

Abstract: Blood samples were obtained by vein-puncture from residents living or trading along traffic areas of Benin City, Nigeria, where traffic counts were also conducted. The residents had no history of occupational exposure to lead or consumption of alcohol/cigarettes. The blood samples were analysed for lead and their values were found to vary between 8.6 and 43.2 μg/100 mL. These values were also found to vary essentially according to traffic volume and the length of exposure to automobile exhaust by the residents. High blood lead levels (22.1-43.2 μg/100 mL) were recorded for very high traffic areas and for residents with 20-30 years exposure. Low levels (8.6-18.0 μg/100 mL) were recorded for low traffic areas and for residents with few years of exposure. Blood lead distribution in males and females were nearly identical. A sizeable number of residents exceeded the normal level of 30 μg/100 mL but are well below the toxic level of 100 μg/100 mL. Very low levels (2.0-4.4 μg/100 mL) were recorded for people living in virtually emission-free (rural) areas far away from the city.

Key words: Traffic volume, exhaust emission, years of exposure, automobile exhaust, blood lead levels, emission-free

INTRODUCTION

In Nigeria, automobile exhausts constitute 75-80% of the gross air pollution (Oluwande, 1977). Organometallic compounds such as tetraethyl lead, $(C_2H_5)_4Pb$ or TEL, an additive to petrol, are sources of lead in automobile exhausts. The levels of lead in petrol vary from country to country but that of Nigeria super-grade is in the range of 210-520 mg L^{-1} (Ademoroti, 1986). In urban vicinities where there are no local point sources (e.g., battery manufacturing factories or lead smelting plants), the major source of lead in the air comes from automobile exhausts. The extent of lead pollution by the exhausts depends on a number of factors viz., lead content in petrol, traffic volume, traffic speed, weather and other local geographical conditions (Barbosa *et al*., 2005). The heavy vehicular traffic in Nigerian major cities, the high ambient day temperatures (the annual minimum and maximum average in the South are 24 and 29°C, respectively and 27 and 36°C respectively in the North) and the fairly high lead content in petrol are pointers to environmental lead pollution.

Quinche *et al.* (1969) have stated that 15-30% of lead emitted from automobiles is air borne. Thus, the inhaled air, particularly in the traffic areas, must contain lead. It has been estimated that about 40% of inhaled lead is captured and absorbed by the body (Giddings, 1973). Lead levels in blood (PbB) or urine (PbU) constitute the most positive indication of absorption of a lead compound. The estimation of PbB is at present the most commonly used index of lead exposure and absorption by humans. A close correlation has been established between PbB levels and the amount of lead added to petrol (Houk, 1982).

Lead is one of the most serious of metallic poisons. It causes the disease called plumbism. It is known to interfere with the biosynthesis of hemoglobin which results in anaemia. For hundred of years lead has been mined, smelted refined and used in products (e.g., as an additive in paints, gasoline, leaded pipes). Refining activities have resulted in substantial increase in lead levels in the environment, especially near some types of industrial facilities and adjacent to highways, (Chaney, 1984). Some authors have stated that lead is usually stored in the bones as phosphates but returns to the blood stream during circumstances such as infections and decalcification. It is mainly excreted in stools and urine while small quantities appear in saliva and sweats (Phoon and Ong, 1982).

The studies reported in this research were conducted in Benin City, the Capital of Edo State, Nigeria having a population of about 650,000. Blood samples of people living or trading along traffic areas of the city were obtained and analysed for lead. The lead levels were correlated with traffic volume and period of exposure.

Corresponding Author: A.P. Oviawe, Department of Chemistry, University of Benin, P.M.B. 1154, Benin City, Nigeria

MATERIALS AND METHODS

Samples and sampling techniques: Traffic volumes of the sampled areas in Benin City were obtained by taking traffic counts at strategic positions in the city over 12 h (0700 - 1900) daily for 7 days. The traffic counts were made up of all types of motorised vehicles: trailers, tankers, tippers, trucks, buses, motor cars and motor cycles.

Dry months (December, 1998-February 1999) were chosen for the exercise to avoid disturbance by rain. From the results obtained, the volume of traffic per hour was computed for the different areas (Table 1) and classified into four different categories: very high (above 1,000), high (601-1000), medium (201-600) and low (200 and below) as reported in an earlier paper (Ademoroti, 1986).

Prior to blood samples collection, over 1,000 people living/trading in the traffic areas were interviewed using standard questionnaire to collect pertinent information viz: name, age and period of exposure by living or trading along the traffic areas, occupation to date and smoking or drinking habits. From them, 440 people made up of 240 men and 200 women of ages 20-30 years, living or trading within a distance of not more than 50 m from the road, were carefully selected. Unfortunately, only 140 (70 men and 70 women) of these could make themselves available continuously for the entire period of blood sample collection. Among them, those located in areas of very high traffic volume were 61 represented by S1-S40 and S65-S85; 37 for high volume areas: S51-S64, S86-S98, S109-S118; 32 for medium: S41-S50, S99-S108, S119-S130 and 10 for low: S131-S140 (Table 2). Those sampled had no history of occupational exposure (e.g. working in battery or paints manufacturing factory, lead smelting plants, oil refineries) or consumption of alcohol or cigarettes or both. So, their blood lead (PbB) levels could be tied almost entirely to that derived from traffic exhausts.

In a similar manner and for purposes of comparison, 30 people, aged 20-30 years (15 men, 15 women) living in a remote village, about 50 km from Benin City, that is virtually free of motorised vehicle exhaust emissions, were selected for blood sample collection.

About 5 mL blood was collected from each person by vein-puncture fortnightly for three months. Precautions were taken during each collection to prevent contamination. The punctured site was cleaned with methylated spirit prior to procedure and each time plastic disposable syringes were used separately for each person. The blood samples were collected in heparinized, lead-free polystyrene tubes which were sealed immediately and transported quickly to the laboratory for analysis. Direct hand contact with the samples was avoided throughout.

Table 1: Traffic counts taken at different points over 12 h (0700-1900 h) daily for seven days in Benin city (December 1998-February 1999)

Names of traffic areas	Average volume of traffic (h^{-1})	Blood samples collected from residents/traders (aged 20-30 years) along traffic areas
Lagos Road/New Lagos Road	1800	S1- S10 (10)
Sapele Road	1700	S76-S85 (10)
New Benin Market	1700	S11-S20 (10)
Ring Road	1680	S65-S75 (11)
Urubi Street	1360	S21-S30 (10)
Mission Road	1300	S31-S40 (10)
Akpakpava Road	910	S51-S64 (14)
Ekenhuan Road	850	S109-S118 (10)
First East Circular Road	850	S86-S98 (13)
Forestry Road	520	S41-S50 (10)
West Circular Road	500	S119-S130 (12)
Akenzua Road	350	S99-S108 (10)
University of Benin, Ugbowo Campus	80	S131-S140 (10)
Total number of samples collected		140

In order to speculate on how much lead reaches man through food chain, some samples of Nigerian staple food stuffs were collected for analysis. Six samples each of grains (rice, maize), legumes (beans, cow peas), tubers (yam, cocoyam) and root crop (cassava) were collected from different locations of their cultivation in the vicinity of the emission-free village.

Distilled water used for the analysis was obtained by demineralising water through a Barnsted demineraliser and then distilled in an all-glass apparatus.

Stock and standard lead solutions were prepared as given by Welcher Standard Methods (Welcher, 1963). One gram pure lead metal, or 1.599 g analar grade nitrate of the metal, was weighed accurately, dissolved in 1% HNO_3 and then diluted to 1 L with distilled water. This gave the stock solution of 1 mL ≡ 1 mg. The standard solution was prepared by adding 10 mL stock solution to 1% HNO_3 and then making it up to 100 mL. This was further diluted, stepwise, as found necessary such that 1 mL standard solution was equivalent to 1 μg Pb.

Sample analysis: Analysis for lead in the blood samples was carried out in duplicates as recommended by the Standard Methods (Blanke, 1976). Perkin-Elmer Atomic Absorption Spectrophotometer model 380 was used; graphite furnace was incorporated to it for accurate determination of low levels of lead. The mean values of each person's PbB were calculated from his/her six blood samples.

Samples of yam, cocoyam and cassava were peeled using stainless steel pen-knife. They were cut into very thin slices. About 10 g of each was placed in labelled

Table 2: Lead in blood samples of residents in different traffic areas

Lead levels in blood (μg/100 mL)	Number of samples obtained for Very high traffic (A) areas (>1000 h^{-1})	High traffic areas (B) (601-1000 h^{-1})	Medium traffic (C) areas (201-600 h^{-1})	Low traffic (D) areas (<200 h^{-1})	Summary of No. of samples
8.1-10.0	-	-	S99-S103,S105, S107 (7)	S131-S134S140 (5)	12
10.1-12.0	-	-	S104, S106-S108, S119-S123 (8)	S139 (1)	9
12.1-14.0	-	S87 (1)	S124, S126, S127 (3)	S135, S137 (2)	6
14.1-16.0	-	S86 (1)	S125, S S128 (2)	S138 (1)	4
16.1-18.0	S21 (1)	S88 (1)	S41, S43,S129 – S130 (4)	S136 (1)	7
18.1-20.0	S32 (1)	S89 - S90 (2)	S42, S44 (2)	-	5
20.1-22.0	-	S116 - S118 (3)	-	-	3
22.1-24.0	S22 (1)	S114 - S115 (2)	S45 (1)	-	4
24.1-26.0	S31, S65 (2)	S63 - S64, S91 - S95 (7)	S46-S47 (2)	-	11
26.1-28.0	S11, S28-S30, S33-S40 (12)	S58-S62,S96-S98 (8)	S48, S50 (2)	-	22
28.1-30.0	S12-S14S66-S75 (13)	S55-S57 (3)	-	-	16
30.1-32.0	S15-S20S76-S78 (9)	S52-S54 (3)	S49 (1)	-	13
32.1-34.0	S23-S27 (5)	S51 (1)	-	-	6
34.1-36.0	S1-S2, S6-S9 (Uselu (6)	S112-S113 (2)	-	-	8
36.1-38.0	S79-S85(Delta garage) (7)	S110-S111 (2)	-	-	9
38.1-40.0	S3 (1)	-	-	-	1
40.1-42.0	S4 (1)	S109 (1)	-	-	2
42.1-44.0	S6, S10 (2)	-	-	-	2
Total	61	37	32	10	140

crucibles and dried to constant weight in an oven maintained at 103-105°C. Similarly, about 10 g of each of the grain samples were dried to constant weight.

A laboratory grinder, washed thoroughly, rinsed with distilled water and dried, was used for grinding the samples to fine powder. They were preserved in labelled clean polythene bags. The grinder was washed after each use to avoid contamination.

From each sample, 2 g was accurately weighed into clean platinum crucibles, ashed at 450-500°C and then cooled in a desiccator. The ash was dissolved in 5 mL 20% HNO_3 and the whole was carefully transferred into 100 mL volumetric flask. The crucible was well rinsed with distilled water and transferred to the flask, made up to the mark with distilled water and shaken to mix well. Analysis for lead was carried out in duplicates on the AAS.

RESULTS AND DISCUSSION

The results obtained from the analysis of samples were as shown in Fig. 1-4. The results showed marked variations in PbB concentrations with traffic volume (Fig. 1 and 3) and to period of exposure (Fig. 4).

The total number of blood samples obtained for the studies was 140. The PbB concentrations obtained varied between a minimum of 8.6 μg/100 mL and a maximum of 43.2 μg/100 mL. The average normal PbB in adults is 30 μg 100 mL and an amount of 100 μg/100 mL represents toxic level; in children, levels of 15-20 μg/100 mL are considered normal while 40 μg/100 mL may represent an abnormal exposure to lead compounds (Blanke, 1976).

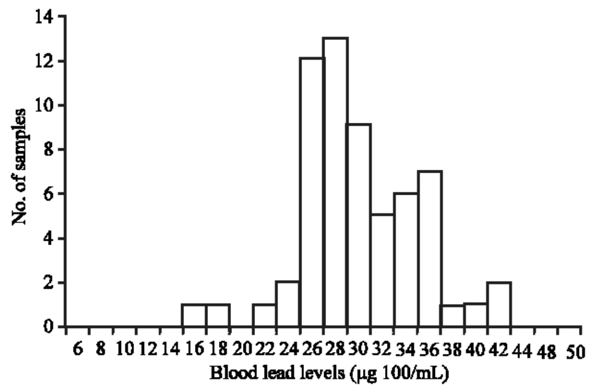

Fig. 1a: Very high traffic areas (>1000 h^{-1})

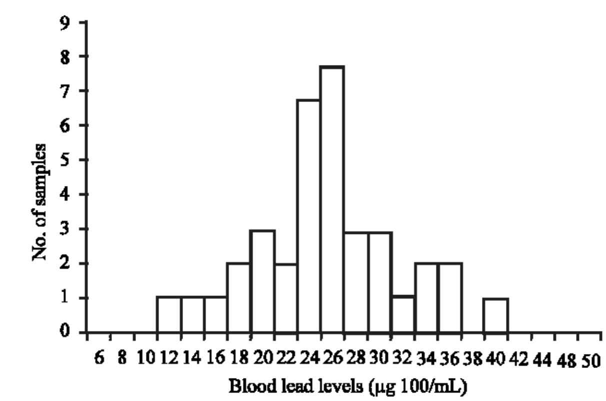

Fig. 1b: High traffic areas (601-1000 h^{-1})

Only adults (ages 20-30 years) were sampled for the studies; their PbB concentrations were easily separable into two: Those in the range of 8.6-30 μg/100 mL which

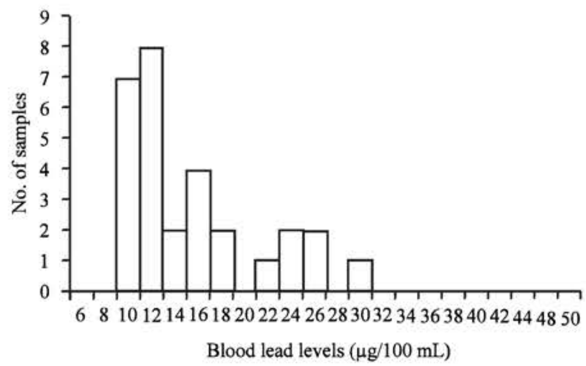

Fig. 1c: Medium traffic area (201-600 h^{-1})

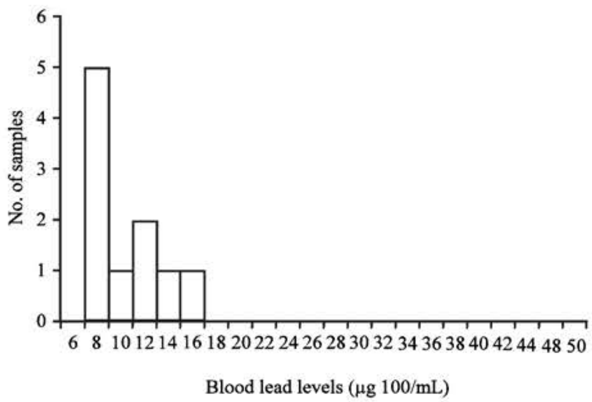

Fig. 1d: Low level traffic area (<200 h^{-1})

amounted to 70.7% of the total samples and the remaining 29.3% had their PbB in the range of 30-44 µg 100 mL (Table 2).

The PbB concentrations for the 61 samples obtained for the very high traffic areas ranged between 16.1 and 44.0 µg/100 mL; 30 (49.2%) of the samples had PbB concentrations between 16.1 and 30 µg/100 mL while the remaining 50.8% had values between 30.1 and 44.0 µg/100 mL which could be said to be above normal. Most of the population sampled (85.2%) in the area had their PbB between 26.0 and 38.0 µg/100 mL (Fig. 2a and 3). For the 37 samples obtained in the high traffic areas, the PbB levels varied between 12.1 and 42.0 µg/100 mL; 28 (75.7%) of the samples had PbB levels between 12.1 and 30 µg/100 mL and the rest (24.3%) had 30.1-42.0 µg/100 mL which were above normal. Most (70.3%) of the samples fell in the 20.1-32.0 µg/100 mL PbB range (Fig. 1b and 3).

For the medium traffic area, 31 (96.9%) of the 32 samples fell in the region 8.6-30.0 µg/100 mL PbB while the remaining 3.1% had 30.1-32.0 µg/100 mL PbB (Fig. 1c and 2). All the 10 samples obtained for the low traffic area had 8.6-18.0 µg/100 mL PbB (Fig. 1d and 2). The people living in virtually emission-free area had 2.0-4.4 µg/100 mL PbB while 83.3% of them had PbB ranging between 2.61 and 3.6 µg/100 mL (Table 3).

The high PbB levels obtained for the very high traffic areas were expected. Most of the sampled residents/traders have lived for 20-30 years in the areas as

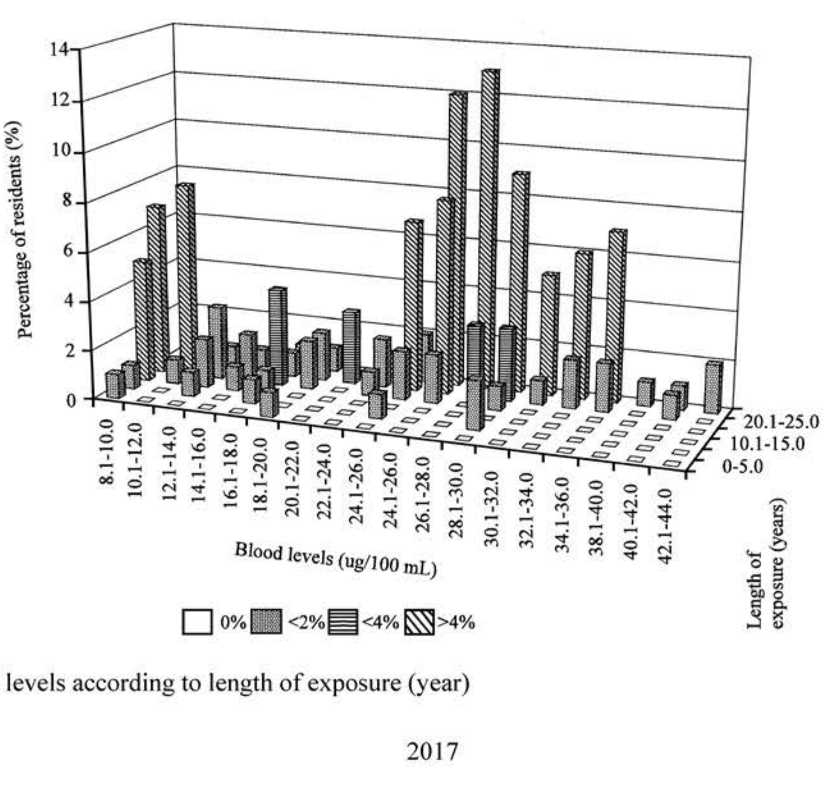

Fig. 2: Lead blood levels according to length of exposure (year)

Table 3: Blood Lead Levels in Rural (emission-free) Area Dwellers (aged 20-30 years)

Range of blood levels (μg/100 mL)	Emission-free blood samples (EFS)	No. of samples
2.00-2.20	EFS 2	1
2.21-2.40	-	-
2.41-2.60	EFS 7	1
2.61-2.80	EFS 23,25-26	3
2.81-3.00	EFS 8, 16-20, 30	7
3.10-3.20	EFS 3-4, 9-12	6
3.41-3.60	EFS 5-6, 21-22, 24	5
3.61-3.80	EPS 1	1
3.81-4.0	EFS 29	1
4.01-4.20	-	-
4.21-4.40	EFS 28	1
Total	EFS 1-30	30

- means "nil", 83.3% of these 30 samples have PbB between 2.61 and 3.60 μg/100 mL

Table 4: Lead Mean Values in some Nigeria Staple Food Stuffs

Food Stuffs common name	Botanical names	Lead mean values (μg/100 g)
Rice	*Oryza sativa*	1.03
Maize	*Zea maize*	1.02
Beans	*Phaseolus vulgaris*	0.15
Cowpeas	*Vigna ungulaculata*	0.18
White yam	*Dioscorea rotundata*	0.22
Coco yam	*Colocosia esculenta*	0.14
Cassava	*Manihot utilisima*	0.32

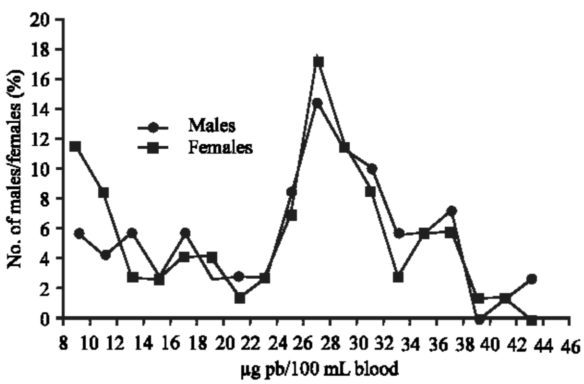

Fig. 3: Blood lead distribution by sexes

some of them were born there. This means that they had been exposed to inhalation of automobile exhausts for about 24 h daily for those years. Most of the traders have their shops in motor parks selling for about 18 h (0600-2400 h) daily. Although air lead levels in the immediate localities of the motor parks were not monitored, daily heavy concentrations of motorised vehicles are likely to produce much higher daily average air lead levels than other places. Daily exposure by traders leads to daily inhalation of lead particulates which enhance lead levels in their blood. Hence, samples S1-S5 obtained from Ugbowo Taxi park terminus along Lagos/New Lagos road; S6-S9 obtained at Uselu Motor park where all vehicles from the five Western States of Nigeria are parked; S23-S27 obtained at Urubi Motor park, the place specified for all vehicles from the five Eastern States of Nigeria; S79-S85 from Sapele Road Motor Park, the place for all vehicles from the Delta and Rivers states; and S109-S113 obtained from Oba Market/Ekenhuan Taxi park which is a convergence point for about 60% of the taxis in Benin City, all have values between 34.1 and 44.0 μg/100 mL PbB (Table 2).

It shows that the distribution was nearly identical; 67.3% of the males and 74.3% of the females have PbB between 8.6 and 30.0 μg/100 mL, respectively while the remaining were above 30.0 μg/100 mL.

The longer the period of exposure to traffic exhausts, the more the PbB levels in the samples. Those who have been exposed for 20-30 years have PbB between 26.1 and 44.0 μg/100 mL.

The study has revealed that exposure of people to traffic exhausts has effect on their PbB levels; a good number of which has exceeded the normal level of 30 μg/100 mL but much less than the toxic level of 100 μg/100 mL.

Similar work in other parts of the world has shown that people living in traffic areas accumulate considerable amounts of lead in their blood. The studies by Bryce-Smith (1971) in Philadelphia, U.S.A. revealed that 10-40 μg/100 mL PbB were recorded for blood samples collected from the residents; 65% of them had PbB of 10-20 μg/100 mL and the remaining 35% had 20- 40 μg/100 mL. About 43.4% of those living in the suburban areas had accumulated as much as 20-30 μg/100 mL PbB.

Fergusson (1990) has related the concentration of lead in air to traffic volume and mode of operation. According to him more lead is released to the atmosphere on highways where traffic speed was high than in the cities where speed was less. In Western Germany, petrol lead was reduced from 0.6 to 0.4 g L^{-1} in 1972 and then to 0.15 g L^{-1} in 1976. The reduction in the lead content in 1976 by 60% produced a reduction in air lead by 55-60% in streets carrying heavy traffic. For example, in Frankfurt the mean air lead was 2.56 μg m^{-3} before reduction in petrol lead and 1.04 μg m^{-3} after Jost and Sartorius 1979, Nriagu 1978 and Simmonds *et al.* (1983) carried out analysis of automobile exhaust emissions and found that 21-28% of petrol lead is retained in the exhaust system.

In all these studies, traffic exhaust emission has been implicated as the source of lead in the atmosphere. Human beings and vegetation are the 'sink' for the lead. It finds its way to human blood stream.

The study being reported shows significant amounts of lead in the blood of the residents in Benin City heavy

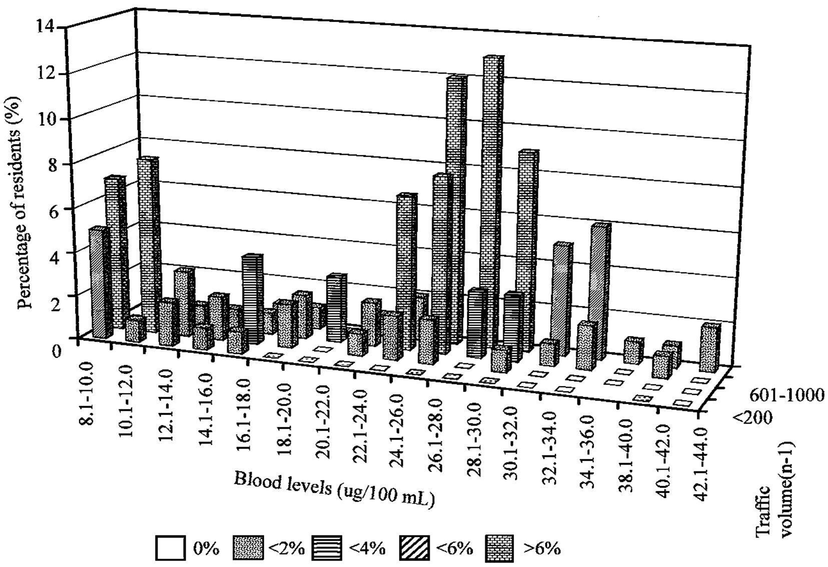

Fig. 4: Blood lead levels according to traffic volumes

traffic areas. The amounts of the metal in some of the foodstuffs eaten are low (Table 4) compared with the amounts of lead in their blood.

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