Bull. Environ. Contam. Toxicol. (1989) 43:660–666

Bulletin of Environmental Contamination and Toxicology

Lead Pollution in Urban and Rural Saudi Arabian Children

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In the last two decades, vehicular traffic increased spectacularly in Saudi Arabia, from 243,000 registered motor vehicles in 1973 to over 5 million at present. All these vehicles use leaded gasoline, one of the major sources of lead contamination in the ambient air and dusts in the cities. Although the lead content of gasoline produced in Saudi Arabia has recently been reduced from a very high value of 0.84 g/l to 0.60 g/l at present (Petromin, Jeddah, personal communication), the concentration is still higher than the maximum permissible levels in many industrialized countries, such as 0.15 g/l in UK and West Germany (UK Department of Environment 1987; Harrison and Laxen 1981). Several studies show increasing lead contamination in air and dusts in some Saudi Arabian cities. Khattak (1982) reported that the lead levels in dust in Dhahran were higher than many industrial cities of Europe and America. Shobokshy (1984) found that the lead concentrations in ambient air in Riyadh city center during peak traffic hours varied from 4.37 ug/cu m to 5.83 ug/cu m, much higher than the maximum limit of 1.5 ug/cu m set by USEPA (1981) and 2.0 ug/cu m set by EEC (1977). Jeddah street dusts from several locations were found to contain more than 1000 ppm Pb by Nasralla (1984). The lead concentrations in dust samples from downtown Jeddah were found to be nearly 2000 ppm (Mousli 1987).

To evaluate the impact of this high levels of environmental lead, scalp hair of 200 school boys, aged 6-8 years, from each of the two Cities (Makkah in the western region and Riyadh in the central region) and two Village Groups (one around Makkah City and the other around Riyadh City) were analysed in this study for lead concentrations. Makkah is one of the oldest and most densely populated

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cities with congested housing and narrow winding streets. Riyadh on the other hand is the newly developing, planned capital city of Saudi Arabia. The Village Groups were chosen so as to reflect a 'control' environment away from heavy traffic and industrial activity. The usefulness of hair as an important biopsy material for environmental pollution studies has been demonstrated in a large number of studies (Jenkins 1979; Katz and Wood 1980). Children are unfortunately more vulnerable and easily susceptible to lead toxicity than adults. Effect of lead on the central nervous system of the children may result in mental retardation and even death in case of acute encephalopathy.

MATERIALS AND METHODS

Determination of Pb-concentration in Hair Samples : Approximately 40 mg of hair was obtained from the scalp of each boy using high-quality, surgical-grade scissors. Hair strands, roughly 1 cm long from the proximal end, were washed according to a modification of the IAEA recommended procedure (Raybukhin 1980; Ahmed et al.; 1986), using ultrapure, special low-lead chemicals and solvents. This involved 5 steps of soaking and agitating the hair samples in acetone, water, water, water, and acetone, for 5 minutes in each solvent, followed by decantation. 25 mg of each cleaned and dried hair sample was weighed out accurately in acid-leached and thoroughly-washed pyrex test tubes. The hair samples were then digested in 7 ml of 20 % nitric acid (v/v) at a temperature of 90-95 C, avoiding frothing and sputtering until only the dried hair residue was left. Finally the residue was dissolved in distilled and deionized water to obtain the assay solution for the measurement of Pb with an Electrothermal Atomic Absorption Spectrometer (VARIAN SpectrAA-30P). A 4-stage temperature programming was used for drying, ashing, atomization and tube clean-out processes for each 20 microlitre aliquot delivered into the graphite furnace by the auto-sampler System. The Argon gas flow through the furnace was stopped during the atomization and signal read-out steps. The standard addition technique was used for calibration purposes. Each of the 800 hair samples was measured in triplicate. Adequate quality control procedures and periodic instrumental checks were maintained throughout this work (Ahmed et al.; 1988).

A quality control program was followed by assaying periodically a Human Hair Standard Reference material, with certified values for several elements including Pb (Okamoto et al.; 1985). Measurements were done in triplicate on three different vials of the above stan-

dard reference materials ; and the results are given later in the Results and Discussion section.

RESULTS AND DISCUSSION

The reliability and accuracy of the methodology adopted in this study was found to be satisfactory on the basis of the results obtained with the standard reference material. In triplicate independent measurements the mean Pb concentration in the standard reference material was found to be 5.52 ppm (+ 6.7 % RSD). The certified value is 6.0 ppm.

The results obtained for 800 school boys, 200 from each of the 4 stated locations, are summarized in Table 1, showing the number of samples analyzed, mean hair-lead concentrations with the standard deviations, the median value, and the range. The distribution of the children as a function of the Pb-concentration in hair is shown in Table 2 and is presented graphically in Figure 1.

Table 1. Summary of Results

Location	No. of Samples	Mean Concentration of Pb in Hair (ppm) $\pm$ SD	Median (ppm)	Range (ppm)
Makkah City	200	17.6$\pm$12.8	14.2	1.8-70.4
Riyadh City	200	5.1$\pm$4.2	3.9	1.0-35.4
Village Group around Makkah	200	6.6$\pm$6.2	4.6	0.2-45.8
Village Group around Riyadh	200	3.0$\pm$2.1	2.4	0.4-10.2

The data obtained were subjected to an Analysis of Variance (ANOVA), as presented in Table 3. For the data, the computed value of F, the Variance Ratio is 140.5. The critical value of F for (3,796) degrees of freedom at 95 % level of confidence is 8.53. This indicates that the differences between the means of the 4 locations are significant and is due to the inherent nature of these places, rather than due to chance. These differences were further investigated by the Tukey's HSD (Honest Significant Difference) Test, the results of which are shown in Table 4.

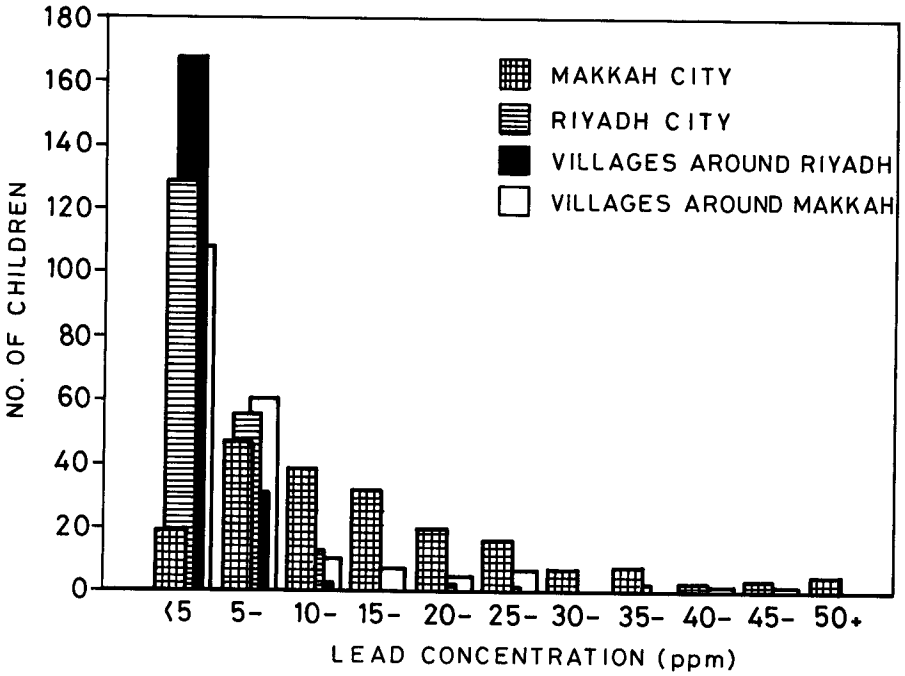

Figure 1. Frequency distribution of hair-Pb concentrations for the four locations.

Table 2. Distribution of Hair-Pb Concentrations in the School Children from 2 Cities and 2 Village Groups in Saudi Arabia

Range of Lead Concentration (ppm)	Makkah City (% of total)	Riyadh City (% of total)	Village Group around Makkah (% of total)	Village Group around Riyadh (% of total)
0.0 - 5.0	9.5	64.0	53.5	83.5
5.1 - 10.0	23.5	27.5	30.5	15.5
10.1 - 15.0	19.5	6.5	5.5	1.0
15.1 - 20.0	16.0	0	3.5	0
20.1 - 25.0	10.0	1.0	2.5	0
25.1 - 30.0	8.5	0.5	3.5	0
30.1 - 35.0	3.5	0	0	0
35.1 - 40.0	4.0	5.0	0.5	0
40.1 - 45.0	1.0	0	0.5	0
45.1 - 50.0	2.0	0	0.5	0
Above 50	2.5	0	0	0

Table 3. Analysis of Variance.

Sources	Sum Square	Degrees of Freedom	Mean Sum Square	The Value of F (Conclusion at 95 % level of confidence)
Between	25226.9	3	8409.0	140.5
Within	47640.2	796	59.8	Significant
Total	72867.1	799		

Table 4. Tukey's HSD Test. Critical HSD Value = 2.00

Compare the Sample Means of	Absolute Difference Sample Means	Conclusion at 95 % Level of Confidence
Makkah City - Riyadh City	12.5	Significant
Makkah City - Village Group around Makkah	11.0	Significant
Makkah City - Village Group around Riyadh	14.6	Significant
Riyadh City - Village Group around Riyadh	2.1	Significant
Riyadh City - Village Group around Makkah	1.5	Insignificant
Village Group around Makkah_Village Group around Riyadh	3.6	Significant

Of the two cities studied,Makkah has a much higher hair-Pb concentration than Riyadh. Makkah City is one of the oldest human settlements in Saudi Arabia. It has a high population density which increases many fold during the annual pilgrimage season when an additional 1-2 million people arrive by road which is the only means of transportation. Even in other seasons, a large number of visitors come to Makkah causing a continuous heavy flow of traffic in the narrow roads between the hills of this valley. The cleaner of the two cities in terms of lead pollution is Riyadh, the ultra-modern capital of Saudi Arabia. It is a relatively new and sprawling city with well-planned commercial and residential districts having large open spaces. Although its population is increasing, the density of traffic is less with fewer congested areas. All these make Riyadh a comparatively cleaner city until now.

Of the two village groups studied, those around Makkah have understandably higher hair-Pb concentration than those around Riyadh. These village groups reflect the nature of the two cities around which they are situated. The mean hair-Pb concentration of Makkah City is nearly six times higher than that of Riyadh City, which may explain why the Village Group around Makkah has Pb-concentrations higher than even Riyadh City. This implies that Makkah region as a whole has a higher Pb pollution than the Riyadh region. The lowest Pb levels found in the Village Group around Riyadh indicate that these children can be considered as 'controls' being in an environment relatively free from traffic and industry. The only likely sources of Pb in these villages could be endemic in the soil and water, and perhaps in the fertilizers and chemicals used in agriculture.

Results of the present investigation show a marked variation of the hair-Pb concentrations measured in the four locations. Such variation have been noticed not only among the city locations but also among the village locations, reflecting differences in environmental gradients in these locations. It appears that at present the Pb levels in hair in the school children in Saudi Arabian cities are within the reported 'normal range' (Jenkins 1979) and below toxic levels. However, the problem in some cities, such as Makkah, is heading for a situation of concern which requires early attention.

Acknowledgments. The authors are grateful to the King Abdulaziz City for Science & Technology, Riyadh, and the Scientific Research Administration, King Abdulaziz University, Jeddah, for financial support and research grants. Our thanks are also due to Mr. A. Saber for statistical analysis and Mr. S. Qurashi for technical assistance

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Received February 2, 1988; accepted April 4, 1989.