

MONITORING OF MERCURY, LEAD AND CADMIUM IN HAIR AND TEETH
SAMPLES OF GENERAL POPULATION IN ALEXANDRIA

A.H. El-Sebae, Kawther S. El-Gendy, A. El-Bakary and
Nabila S. Ahmed

Pesticides Division, Faculty of Agriculture, Alexandria
University, Alexandria, Egypt

ABSTRACT

Forty human samples of scalp hair and teeth were collected to represent the general population in Alexandria during April, 1988. The weighed samples were mineralized in strong acid to convert mercury, lead and cadmium content to free inorganic cations. Both cadmium and lead were determined by atomic absorption spectrophotometry, while mercury was measured using atomic absorption spectrophotometry with flameless attachment.

Mercury levels in the forty hair samples varied in the range of 0.218 to 2.9 $\mu\text{g/gm}$ (13 fold), while the levels in the teeth samples were in the range of 0.060 to 5.019 $\mu\text{g/gm}$ (84 fold). In hair samples, the level of lead ranged from 5.54 to 19.38 $\mu\text{g/gm}$ (3.4fold), while cadmium was in the range of 0.45 to 1.6 $\mu\text{g/gm}$ (3.6 fold).

In teeth samples, lead was in the range of 4.54 to 32.0 µg/gm (7 fold), while cadmium was 0.256 to 0.960 µg/gm (4 fold). These variations might be attributed to differences in occupational exposure, age and type of profession. Besides, the three heavy metals vary in their input magnitude in the environment.

INTRODUCTION

The three heavy metals mercury (Hg), lead (Pb) and cadmium (Cd) are retained, bioaccumulated and biomagnified in human body. They tend to replace calcium in bones, and the general skeleton (Gross, et al., 1975 and Barry, 1975). Recently there has been an increasing interest in using hair and deciduous teeth as a monitor in environmental epidemiological trace element metabolism and predictive medicine studies (WHO, 1976 and Stenhou, 1982). The distribution of mercury between hair and blood tend to follow a constant ratio in people exposed to methyl mercury. The ratio of hair to blood concentrations was close to 250:1 (WHO, 1976). O'Brien, et al. (1980), reported that the quantity of lead in human bone increases with age up to age forty. Therefore, it was suggested that these heavy metals (Hg, Pb and Cd) can be detected and monitored in the scalp hair and in the teeth of unidentified general population in Alexandria as a measure of body burden.

MATERIALS AND METHODS

Forty samples from both scalp hair and teeth of the unidentified general population in Alexandria were collected in April, 1988 from dental clinics and barber shops. The weighed samples were digested with concentrated nitric acid using the method of Oien and Gjerdengen (1977). The digested samples were filtered to remove any insoluble materials. The filtrate was diluted with deionized water. The amounts of lead and cadmium were determined according to Zinterhofer, *et al.* (1971), in this solution by atomic absorption spectrophotometer (Shimadzu, A:AO-630-11) with the air-acetylene flame. The total mercury was determined using a Varian atomic absorption spectrophotometer with a flameless attachment, Model A.A.175.

RESULTS AND DISCUSSION

1. Heavy Metals Levels in Hair Samples

Scalp hair is recognized as a metabolic end product that incorporates elements into its structure during the growth process. It is also a stable material that is readily collected from individuals and can be analyzed for trace elements contents by sensitive methods.

Table 1 presents the levels of monitored mercury in scalp hair samples. The sampled individuals belong to the general population inhabiting Alexandria. There is a wide range of variation between the different individuals which reflects the variation in background exposure, age, food habits, and type of profession. The hair mercury content ranged between 0.218 to 2.90 ppm. According to Jervis, et al. (1977), the recorded levels of mercury are similar to those recorded in the Canadian general population which was shown to be in the range of 0.28 to 3.5 ppm in rural populations and 0.24 to 5.4 ppm in urban populations in 1976. The WHO recommended limits (1980) in occupational exposure to heavy metals, considered that the accepted level in hair will be within 5 ppm of mercury. Higher levels of mercury in hair are expected to reach 20 to 50 ppm or higher in populations consuming fish heavily polluted with mercury (Nomura, 1968 and Tsubaki, 1977). In Alexandria region there are two main industries in which the potential of exposure of workers to heavy levels of mercury is expected. These are in a plant that manufactures chlorine and sodium hydroxide, in the electrolysis of sodium chloride, and the electronic plant for the manufacture of mercury bulbs and lamps.

Table 1 also presents the levels of lead and cadmium in the same group of samples. The levels of lead ranged between 5.54 to 19.38 ppm with an average of

Table 1

Hair mercury, lead and cadmium levels (ppm) in general population from Alexandria.

Sample No.	Heavy metals concentrations $\mu\text{g/gm}$ hair		
	Hg	Pb	Cd
1	0.781	11.07	1.6
2	0.454	12.46	0.64
3	0.345	9.69	0.918
4	0.599	9.69	0.81
5	0.410	12.46	0.78
6	0.400	8.31	0.82
7	0.218	9.69	0.76
8	0.418	16.62	0.58
9	0.440	8.31	0.58
10	0.550	11.08	0.45
11	0.833	12.46	0.72
12	0.663	6.92	0.66
13	1.011	9.69	0.84
14	0.833	8.31	0.72
15	0.900	5.54	0.60
16	0.500	9.69	0.84
17	0.333	12.46	0.84
18	0.660	5.54	0.78
19	0.583	9.69	0.72
20	0.599	15.23	0.90
21	0.411	6.92	0.78
22	0.583	6.92	0.72
23	0.500	6.92	0.84
24	0.663	6.92	0.84
25	0.333	9.69	0.95
26	0.450	9.69	0.48
27	1.000	19.38	0.78
28	2.900	11.08	0.78
29	0.700	9.69	0.78
30	0.411	16.62	0.84
31	0.400	9.69	0.78
32	0.500	13.85	0.84
33	0.700	12.46	0.66
34	1.200	12.46	0.84
35	0.400	9.69	0.66
36	0.700	13.85	0.78
37	0.633	12.46	0.54
38	1.400	12.46	0.78
39	1.000	11.08	0.78
40	0.700	17.99	0.78
Mean	0.679	10.686	0.771
$\pm$ SD	± 0.444	± 3.096	± 0.179

10.686 $\pm$ 3.096 and of cadmium ranged between 0.45 to 1.6 ppm with an average of 0.771 $\pm$ 0.179. From this Table it is noticed that the highest metal content in hair is lead, while those of mercury and cadmium are less and are almost at the same level. Cadmium is excreted mainly through urine and to a much lesser extent through bile, gastrointestinal secretion, sweat, saliva, hair and nails, therefore, estimation of cadmium in hair has been proposed as a measure of body burden (WHO, 1980).

2. Heavy Metals in Teeth Samples

Table 2 presents the levels of mercury, lead and cadmium in forty teeth of another group of the unidentified people which were collected from the dental clinics in Alexandria. The data reveals a wide variation in the content of each metal. The average levels of mercury, lead and cadmium in teeth were 0.66, 15.83 and 0.489 ppm, respectively. The level of cadmium in the teeth being the least one, followed by mercury. Lead is the highest level with about 31 fold more than cadmium.

The major characteristics of lead distribution are a rapid profound transfer to bone and a progressively decreasing rate of excretion. In fact, autopsy studies of lead in people of different ages do indicate that lead accumulates throughout life, at least in bone including teeth (Gross, et al., 1975; Bary, 1975 and Stennhout, 1982). Approximately 90% of the total body burden of

TABLE 2

Teeth Mercury, Lead and Cadmium Levels (ppm) in General
Population From Alexandria

Sample No.	Heavy Metals Concentrations $\mu\text{g/gm}$ tooth		
	Hg	Pb	Cd
101	0.160	16.62	0.453
102	0.107	9.73	0.342
103	0.095	8.34	0.333
104	0.124	32.00	0.960
105	0.178	13.56	0.443
106	0.201	11.79	0.256
107	1.004	23.08	0.519
108	1.859	6.52	0.261
109	0.271	15.36	0.312
110	0.148	16.22	0.324
111	0.325	24.20	0.577
112	0.545	4.54	0.455
113	0.426	8.33	0.750
114	1.010	9.16	0.764
115	0.063	6.56	0.438
116	0.060	19.66	0.807
117	0.093	16.34	0.316
118	0.358	16.13	0.818
119	0.564	25.65	0.584
120	2.074	19.26	0.837
121	5.019	19.65	0.358
122	0.275	12.03	0.431
123	4.058	13.87	0.190
124	1.029	22.73	0.440
125	0.282	8.14	0.490
126	0.730	14.62	0.500
127	0.183	14.44	0.350
128	0.063	24.08	0.604
129	0.130	20.65	0.340
130	0.060	15.14	0.630
131	0.284	22.22	0.330
132	0.183	15.07	0.390
133	0.402	14.97	0.280
134	0.099	17.14	0.460
135	0.262	14.29	0.450
136	0.277	14.02	0.396
137	0.320	8.24	0.430
138	2.019	13.28	0.820
139	0.377	29.77	0.650
140	0.200	10.14	0.790
Mean	0.66	15.83	0.489
$\pm$ SD	± 1.055	± 6.42	± 0.191

lead, with long-term exposure, is in the bones. Generally lead has the highest metal content in both hair and teeth samples. On the other hand, the levels of cadmium in hair samples are higher than those recorded in the teeth samples. This may be because cadmium is excreted through hair (WHO, 1980). The average lead content in hair samples is lower than the average in teeth samples. This may be attributed to the higher potential of lead to be precipitated by replacing calcium in the bones and teeth. The excretion of heavy metal burden in the hair is another mechanism which may explain the difference and variation in levels.

The results of this survey show that these metal levels do not indicate any serious acute hazard, but they still indicate the possible chronic effects through bioaccumulation and biomagnification, which is characteristic of all toxic heavy metals. The body burdens of occupationally exposed workers were shown to be much higher, as was described in the traffic controllers (Ahmed *et al*, 1987) and the smelter workers (El-Gendy *et al*, 1988). Higher occupational levels are expected in the plants for manufacturing of batteries, plastics, paints, petrochemicals and in gasoline stations.

REFERENCES

- Ahmed, N.S.; K.S. El-Gendy; A.Kh. El-Refaie; S.A. Marzouk; N.S. Bakry; A.H. El-Sebae and S.A. Soliman. (1987). Assessment of lead toxicity in traffic controllers of Alexandria, Egypt road intersections. Arch. Environ. Health, 42 (2): 92-95.
- Barry, P.S.I. (1975). A comparison of concentrations of lead in human tissues. Br. J. Ind. Med., 32: 119-139.
- El-Gendy, K.S.; N.S. Ahmed; A.S. El-Bakary and S.A. Soliman. (1988). δ Aminolevulinic acid dehydratase in relation to blood lead level in occupational lead exposure. J. Pest Control and Environ. Sci., 1: 35-39.
- Gross, S.B.; E.A. Pfitzer; D.W. Yeager and R.A. Kehoe. (1975). Lead in human tissues. Toxicol. Appl. Pharmacol., 32: 638-51.
- Jervis, R.E.; B. Tiefenbach and A. Chattopadhyay. (1977). Scalp hair as a monitor of population exposure to environmental pollutants. J. Radioanalytical Chem., 37: 751-760.
- Nomura, S. (1968). Epidemiology of Minamata disease. In: Minamata disease. M. Katsuma, Ed., pp 5-36. Kumamoto, Japan: Study group of Minamata disease. Kumamoto University Medical School.
- O'Brien, B.J.; S. Smith and D.C. Doleman. (1980). Lead pollution of global environment. Tech. Report

No. 16, Monitoring and Assessment Research
Centre, Chelsea College, Univ. London, pp 41.

Oien, A. and K. Gjerdengen. (1977). Determination of
cadmium and lead in soils by means of solvent
extraction and atomic absorption. *Acta. Agric.
Scand.* 27: 67-69.

Steenhout, A. (1982). Kinetics of lead storage in teeth
and bones. An epidemiologic approach. *Arch.
Environ. Health*, 37: 224-30.

Tsubaki, T. (1977). History and background. Case
history of Niigata. In: *Minamata disease:
Methylmercury poisoning in Minamata and
Niigata, Japan.* T.Tsubaki and K. Irukayama,
Eds., pp. 57-95. Tokyo: Kondansha, Inc.

WHO. (1976). Environmental health criteria for mercury.
Geneva: 136.

WHO. (1980). Recommended health-based limits in
occupational exposure to heavy metals. *Tech.
Report Series*, Geneva: 647.

Tinterhofer, D.J.M.; P.T. Catlow and A. Pappano
(1971). Atomic absorption determination of
lead in blood and urine in the presence of
EDTA. *J. Lab. Clin. Med.*, 78: 664-74.

الطخمي

في هذه الدراسة تم تقدير مستويات بعض المعادن الثقيلة (الزئبق والرصاص والكاديوم) في شعر واسنان بعض الافراد من محافظة الاسكندرية . وقد وجد ان تركيز الزئبق في الشعر ينحصر بين ٢١٨-٢٩٩ ميكروجرام / جرام شعر بينما متوسط تركيز الرصاص والكاديوم كان ١٠٦٨٦ ، ٧٧١ ميكروجرام / جرام على التوالي ويتضح من هذه النتائج ان اكثر معادن مستوى في الشعر الرصاص يليه الكاديوم والزئبق . بينما كان متوسط مستويات المعادن الثلاثة في الاسنان كالتالي : ٦٦ ر ، ١٥٨٣ ، ٤٨٩ ر جزء في المليون من الزئبق والرصاص والكاديوم على التوالي . ويتضح من ذلك ان مستوى الكاديوم كان اقلهم يليه الزئبق بينما الرصاص كان اكثرهم مستوى في الاسنان بحوالى ٢١ مرة قدر الكاديوم . ويمكن ان يعزى الاختلاف في مستوى المعادن بين الافراد الى الاختلاف في التعرض الوظيفي ، مستوى المعيشة ، عمر الفرد ، نوع الغذاء .

ويتضح من هذه النتائج ان هذه المستويات من المعادن الثقيلة لاتحدث اضرار حادة سريعة للافراد لانها اقل من الحدود المسموح بها تبعا لمنظمة الصحة العالمية . ولكن نتيجة فترة هذه الطوائف على التراكم داخل جسم الانسان وصعوبة التخلص منها فانها يمكن ان تسبب تاثيرات ضاره مزمنة بعد فترة من الزمن .