Bull. Environ. Contam. Toxicol. (2004) 72:530–534

DOI: 10.1007/s00128-004-0276-5

Environmental Contamination and Toxicology

Trace Element Contents in Human Head Hair of Residents from Agra City, India

R. Sharma, L. Chandreshwor Singh, S. Tanveer, S. Verghese P., A. Kumar

School of Chemical Sciences, Department of Chemistry, St. John's College, Agra 282002, India

Received: 16 June 2003/Accepted: 4 December 2003

Trace element content of human hair depends on many factors (Valkovic 1977; Anke and Risch 1979; Brown and Crounse 1980; Gibson 1980; Valkovic 1984). Toxicological (Goyer and Mehlam 1977), clinical (Brown and Savory 1983), and environmental and/or occupational exposure aspects of the toxic heavy metals towards human beings have been investigated. It has been shown by a large number of investigators that environmental factors play an important role (Hammer et al. 1971, Valkovic et al. 1975). Elements from air particulates, water, shampoo or other media get incorporated into the hair structure. Hilderbrand and White (1974) and Flynn (1977) have advocated the use of human hair as an index to evaluate the environmental exposure of humans by toxic trace metals. Specific studies for individual trace elements in human hair further reveal the usefulness of the easily accessible biochemical sample; concentrations and distribution of toxic trace elements like mercury (Nord et al. 1973; Jakubezak 1974), lead (Petering et al. 1973; Chattopadhyay et al. 1977), heavy metals (Harrison et al. 1969; Herber et al. 1983) in hair have been determined to evaluate the levels of environmental exposures.

Hair as a biological tissue is unique in the sense that it serves as an accumulator for trace elements, and in addition, it is formed in relatively short period of time and remains isolated from the metabolic events in the human body. Thus, hair analysis has better chances of being used as a diagnostic tool. In view of the interest in the distribution of trace elements in human hair, a survey was conducted to study their distribution in population of Agra city.

MATERIALS AND METHODS

Hair samples were collected randomly from a total of 354 subjects (194 male and 160 female) ranged in age from 6-60 yr at Agra region. Each subject was asked to complete a personal questionnaire describing his/her age, domicile, general health, washing, occupation, occupational area and living habits (vegetarian/non-vegetarian, smoker/non-smoker, and alcoholic/non-alcoholic). The samples were procured by normal cutting and collected with care to avoid any external contamination, and sealed immediately in clean and numbered plastic bags after collection and transported to laboratory for further analysis.

Correspondence to: R. Sharma, 6/3 G, 23-A, Durga Bhawan, Shastri Nagar, Khandari, Agra-282002, U. P., India

Hair sample in each case was cut in the laboratory to about 3 mm lengths to bring it to a uniform size. The sample was then put into 250 ml beaker and washed with deionized double distilled water to remove all the water soluble impurities adhering to hair surface, followed by repeated washing with acetone to remove all organic substance adhering onto hair surface. Washed hair sample was dried at 60°C in an oven before digestion. One-gram portion of the dried sample was placed in a clean 100 ml conical flask 15 ml of digestion mixture was added to it. The entire sample was digested at 80°C until white fumes comes out. After digestion the sample was cooled, dissolved in aqueous N/10 nitric acid and the volume brought to 25 ml in a standard volumetric flask. Trace elements, cadmium, copper, iron, nickel, lead and zinc, were analyzed by Flame Atomic Absorption Spectrometer (Perkin Elmer AAnalyst 100). The instrumental parameters have been described in the instrumental manual supplied by the manufacturer. Three replicate determinations were made in each case and the analytical data thereby represent means of these measurements. The elements arsenic and mercury were analyzed through Atomic Absorption Spectroscopy following their hydride generation using sodium borohydride reduction method. All the chemicals were used of Merck, AR grade. The results have been reported in μg/g of hair sample.

RESULTS AND DISCUSSION

Arsenic, cadmium, copper, mercury, iron, nickel, lead and zinc concentrations in hair samples of male subjects and female subjects are shown in Table 1.

Table 1. Analytical data for elements in male and female hair samples of Agra city (values in μg/g).

Element	Mean concentrations		Range	
	Male	Female	Male	Female
As	0.013	0.008	0.000-3.100	0.000-1.200
Cd	1.3	1.3	0.02-21.0	0.0-12.0
Cu	9.0	15.6	1.2-51.1	1.8-90.1
Fe	230.7	177.5	53.0-547.4	24.1-421.0
Hg	0.73	0.77	0.0-21.0	0.0-19.5
Ni	6.1	5.6	0.4-33.9	0.005-23.4
Pb	7.3	8.3	0.2-100.0	0.6-41.7
Zn	166.6	177.1	61.0-464.1	60.9-410.0

It is evident that arsenic, copper, lead and zinc concentrations were higher in the female subjects than in the male subjects. However, iron concentrations in hair samples of female subjects were observed lower in comparison of male subjects. This is probable coincident due to the menstruation in female subjects. Apart from this, metal concentrations were found higher between the age of 21 and 40 yr.

The elemental concentrations in hair with vegetarian and non-vegetarian subjects are shown in Table 2. Hair cadmium, iron and mercury levels were found higher while arsenic, copper, nickel, lead and zinc levels were found lower in vegetarian subjects than non-vegetarians. Hair copper, nickel and lead levels were observed much higher in non-vegetarian subjects. Hair elemental concentrations with smoking, non-smoking, alcoholic and non-alcoholic subjects are shown in Tables 3 and 4, respectively. Only male subjects were considered for smoking and drinking habits. Hair arsenic, iron, mercury and nickel levels were higher in non-smoking subjects while hair cadmium, copper, lead and zinc levels were higher in smoking subjects. In case of alcoholic subjects hair levels of cadmium, copper, mercury and zinc were observed higher and arsenic, iron, nickel and lead levels were found lower than non-alcoholic subjects.

Acknowledgements. Authors are indebted to "Smt. Basanti Devi and Shri Chakkhan Lal Education Trust", New Delhi and department of Chemistry, St. John's College, Agra, for providing infrastructure facilities and financial assistance in the present work.

Table 2. Mean elemental concentrations in vegetarian and non-vegetarian subjects (male and female) of Agra city (values in μg/g).

Elements	Mean concentrations		Range	
	Vegetarian	Non-vegetarian	Vegetarian	Non-vegetarian
As	0.010	0.011	0.000-0.122	0.000-0.240
Cd	1.3	1.1	0.5-27.5	0.4-18.1
Cu	6.5	10.5	1.2-90.1	1.8-51.1
Fe	214.5	197.5	41.7-470.6	69.0-367.1
Hg	3.9	2.4	0.1-28.0	0.1-180.5
Ni	5.0	14.5	1.3-10.5	1.4-29.1
Pb	6.4	11.3	1.8-21.7	9.0-46.8
Zn	160.4	193.7	56.0-401.0	77.7-461.8

Table 3. Mean elemental concentrations in smoking and non-smoking male subjects of Agra city (values in μg/g).

Elements	Mean concentrations		Range	
	Smoking	Non-smoking	Smoking	Non-smoking
As	0.012	0.013	0.000-0.058	0.000-0.068
Cd	1.1	1.0	0.2-21.1	0.0-1.8
Cu	12.4	7.7	2.7-51.1	1.2-34.2
Fe	221.1	230.1	34.9-423.6	34.9-335.0
Hg	0.6	5.1	0.04-6.9	0.01-13.1
Ni	9.2	9.4	1.7-25.7	1.0-16.1
Pb	10.9	8.1	4.6-63.1	2.9-13.6
Zn	196.6	158.0	62.5-461.8	57.0-464.1

Table 4. Mean elemental concentrations in alcoholic and non-alcoholic male subjects of Agra city (values in μg/g).

Elements	Mean concentrations		Range	
	Alcoholic	Non-alcoholic	Alcoholic	Non-alcoholic
As	0.011	0.013	0.000-0.045	0.000-0.028
Cd	1.4	1.3	0.2-18.5	0.3-3.1
Cu	11.6	8.1	1.2-51.1	1.2-34.2
Fe	224.6	227.7	54.8-378.0	44.1-320.2
Hg	4.5	3.8	0.02-38.7	0.05-17.5
Ni	8.8	9.5	2.1-22.7	1.4-29.1
Pb	11.8	13.1	9.1-16.6	4.0-23.1
Zn	190.6	160.4	62.5-461.8	56.02-403.2

REFERENCES

Anke M, Risch M (1979) Haar analyse und Spurenelementen Status, Gustav Fischer Verlag, Jena

Brown AC, Crounse RG (1980) Eds. Hair trace elements in human illness. In: Proc. of the second Human Hair Symposium, Atlanta, Georgea

Brown SS, Sarvory J (1983) Chemical toxicology and clinical chemistry of metals. Proc. of the International Conference Academic Press, NewYork

Chattopadhyay A, Robberts TM, Jarvis RE (1977) Scalp hair as a monitor for community exposure to lead. Arch Environ Health 30:226-236

Flynn A (1977) Hair elemental analysis as a measure of mineral status. J Appl Nut 29:51-54

Gibson RS (1980) The trace elemental status of some Canadian full term and low birth weight infants of one year of age. J Hum Natur 34:405-416

Goyer R, Mehlman MA (1977) Advances in modern toxicology of trace elements, John Wiley and Sons, New York

Hammer Di, Finkles JF, Hendricks RH, Shy CM (1971) Hair trace metal levels and environmental exposure. J American Epidemiol 93:84-92

Harrison WW, Yurachek JP, Benson CA (1969) The determination of trace elements in human hair by atomic absorption spectroscopy. Clin Chim Acta 23:83-91

Herber RFM, Wibowo AAE, Das HA, EGER RJ, Van Deyck W, Zielhuis RL (1983) Trace elements in human hair of eight year old children. Int Arch Occup Environ Health 53:127-137

Hilderbrand DC, White DH (1974) Trace elements analysis in hair : An evaluation. Clin Chem 20:148-151

Jakubejak TG, Berg GC (1974) Measurement of mercury in human hair. Arch Environ Health 28:139-144

Nord PJ, Kadaba MP, Sorensen JRJ (1973) Mercury in human hair. Arch of Environ Health 27:40-44

Petering HG, Yeager DW, Witherup SO (1973) Trace metal content of hair : Cadmium and lead of human hair in relation to age and sex. Arch Environ Health 27:327-330

Valkovic V, Rendic D, Phillips GC (1975) Elemental ratios along human hair as an indicator of the exposure to environmental pollutants. Environ Sci Technol 9:1150

Valkovic V (1977) Trace elements in human hair. Garland Publishing, New York

Valkovic V (1984) Trace element in human hair : An update. J Appl Cosmetol 2: 28-40