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Levels of Selected Trace Metals in Hair of Urban and Rural Adult Male Population of Pakistan

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Human scalp hair as a biopsy material may well serve the purpose of estimating the degree of human exposure to environmental contaminants, especially trace metals (Valkovic 1984;Chatt 1988). To this effect, the levels of trace metals in hair of various groups of population living in areas with varying extent of environmental exposure are generally compared together (Obrusnik 1986). Such comparative evaluations are important since they are unique for each group of population 'and probably reflect not only a number of factors of genetical, nutritional and environmental origin (Limic 1986;Lal 1987)), but also indicate relationship with factors such as food, ambient air, drinking water, occupational exposure, age, race, sex and metabolic condition etc.(Takeuchi 1982;Chatt 1988;Eltayeb 1990). Also there are some elements (viz. As) which are selectively deposited in hair and may thus provide clinical information on the level of exposure and toxication (Obrusnik 1986).The aim of the present study was two-fold: to collect base-line trace metal data on hair and to evaluate the metal levels as measure of the nutritional status of the relevant groups of urban and rural population in terms of industrial, agricultural and occupational exposure. For this purpose, scalp hair samples were obtained from donors belonging to urban adult male population from the city of Peshawer and a rural town, Jamrood and were investigated for three essential metals (Na, K and Zn) and four non-essential metals (Co, Hg, As and Ag) by AAS technique. The impact of urban and rural environments, including the food habits of individuals, on trace metal distribution in scalp hair of the two classes of population is then reviewed with reference to the literature data available from other parts of the world.

MATERIALS AND METHODS

Scalp hair samples were obtained from local

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barber/beauty saloons located in Peshawar and Jamrood. The hair strands, 1-5 cm in length, were washed for each sample alternately with acetone and distilled water for about 10 minutes with continuous stirring (Ryabukhin 1978). The samples were then dried at 60 °C for 12h in an electric oven. An accurately weighed 0.50g portion of a sample was placed in a 50 mL Erlenmeyer flask and treated with 5.0 mL of concentrated (69%) nitric acid. The acid was allowed to react at room temperature to prevent foaming. The content of the flask was then heated and treated with 1.0 mL of perchloric acid (70%). The digestion was continued till dense white fumes were evolved, marking the completion of digestion (Harrison 1969). The content of the flask was transferred to a 50.0 mL volumetric flask and volume was made up to the mark with 2% nitric acid. Atomic Absorption Spectrophotometer (Shimadzu AA-670), interfaced with a hydride generator and a mercury analyzer, was used for the analysis of Hg, As, Na, K, Mg, Zn and Ag in the digested sample solutions. Three subsamples of each hair sample, digested separately, were run separately. Parallel metal estimations were made on IAEA reference material, HH-1 to validate the estimated metal concentrations in hair. The metal concentration results of triplicate measurements, which mostly agreed within +1%, were averaged on dry weight basis. In all, 39 hair samples belonging to adult male subjects from the urban segment and 28 samples from the rural segment, both within an age group of 20-25 years, were analyzed for their trace metal content. The correlation and regression analyses were conducted on the data using the MSTAT programme on a Dell 386 DX computer(Freed 1990).

RESULTS AND DISCUSSION

The levels of selected metals (μg/g;dry weight) estimated in hair samples of the urban and rural segments of population from Peshawar and Jamrood are given in Table 1 with relevant +SD values. Mean concentration of As, Hg and K was higher in hair of rural population while the concentration of Ag, Co, Zn and Na was higher in the hair of urban population. Of all the metals investigated, the maximum concentration was found for Na at 344.9 and 438.9μg/g for the rural and urban population respectively. A somewhat lower level was encountered for K for these segments of population at 363.1 and 133.2μg/g. Thus the essential metals Na and K exhibited dominant concentration levels over other essential metals, Zn and Co. On comparative ground, however, Na and K showed greater dispersions, measured as ±SD, in their concentration levels as against Zn for which the ±SD values were not that substantial. Similarly, the minimum and maximum concentrations of As showed a minimum scatter of about

Table 1. Levels of selected metals (μg/g;dry weight) in hair of urban(u) and rural(r) population

Metal	Location	Min.	Max.	Mean	±SD
Ag	r	0.20	4.60	1.26	1.42
	u	0.50	4.30	2.06	1.05
Co	r	0.10	4.80	2.05	1.39
	u	1.10	5.90	3.86	1.17
As	r	0.51	2.50	1.36	0.54
	u	0.11	1.17	0.36	0.38
Hg	r	0.60	11.5	5.35	3.69
	u	0.87	10.8	3.82	2.52
Na	r	119	675	344.9	130.1
	u	248	731	438.9	127.5
K	r	119	811	363.1	172.3
	u	71.2	911	133.2	153.9
Zn	r	99	251	164.1	36.2
	u	95	308	170.3	47.4

Table 2. Regression equations alongwith relevant statistical parameters for urban and rural population

Regression Equation	R	p
$[Ag]_u = -0.019\ [Ag]_r + 2.08$	-0.025	0.898
$[Co]_u = -0.116\ [Co]_r + 4.10$	-0.138	0.483
$[As]_u = -0.014\ [As]_r + 0.39$	-0.020	0.921
$[Hg]_u = 0.02\ [Hg]_r + 3.71$	0.029	0.885
$[Na]_u = -0.22\ [Na]_r + 515$	-0.227	0.246
$[K]_u = -0.23\ [K]_r + 214$	-0.252	0.196
$[Zn]_u = 0.21\ [Zn]_r + 134$	0.165	0.402

u = urban; r = rural

Table 3. Correlation coefficient matrix for rural(r) and urban(u) hair

u \ r	Ag	Co	As	Hg	Na	K	Zn
Ag	1.0	0.681	0.374	0.115	0.265	0.375	-0.247
Co	0.809	1.0	0.505	0.263	0.067	0.535	-0.492
As	0.514	0.294	1.0	0.265	0.207	0.417	-0.535
Hg	0.283	0.326	-0.048	1.0	-0.122	0.047	-0.412
Na	-0.005	0.014	0.140	-0.034	1.0	0.103	0.069
K	0.031	-0.001	0.015	0.073	0.376	1.0	-0.254
Zn	0.356	0.414	-0.001	0.019	0.099	-0.141	1.0

±0.5 on an average basis. The study thus indicated that the rural population was nutritionally better than the counterpart urban population in terms of K content of hair. The probable reason for this could be attributed to the availability of the metals from various sources of fresh and raw vegetables and other food commodities available in small towns. The overall metal distribution pattern for the rural population was: K> Na> Zn> Hg> Co> AS> Ag. Similarly, the following metal distribution pattern emerged for the urban population: Na> Zn> K> Co> Hg> Ag> As.

The foregoing analysis of the data revealed the following important aspects of metal levels in hair of rural and urban population. Firstly, the most toxic metal, As, was found at a four-fold level in the hair of rural subjects compared with the urban subjects. This situation was again seen in the case of Hg, but with a multiplication factor of 1.5 for the two classes of population. The obvious reason for the enhanced levels of the two elements in hair of rural population could be ascribed as arising from the frequent use of As and Hg compounds as fungicides, pesticides and preservatives for food crops grown in Pakistan, a practice also reported for other countries of the world (Takeuchi 1979). Secondly, high levels of Na indicated a good bodily nutrition in the two population segments further supported by substantial levels of essential metals Zn and Co. Thirdly, the minimum concentration was found for Ag in case of rural subjects and of As in case urban subjects. As the role and source of Ag at relatively high concentration in the urban segment is not understandable, it could perhaps be attributed to industrial emission processes or mode of cooking adopted by various segments of population using utensils alloyed with Ag.

Table 2 presents the urban versus rural metal regression equations with correlation coefficient (R) and probability (p) values. For a given metal representing the concentrations (put in square brackets in Table 2) in the hair of urban/rural subjects, it was observed that Hg in the hair of urban population was related with a positive slope value to the counterpart concentration of the metal in the rural population, as was the case with Zn. This positive correlation between the build up of Hg and Zn having positive intercept values showed that the two metals were only weakly correlated within the two population segments. This finding is further supported by the correlation coefficient values of the two metals for rural and urban population, which, though positive, were not very significant ($R < 0.500$).

Table 3 brings out inter-metal correlation for the rural and urban populations; the highest R value was found for Co-Ag (R=0.681) representing the rural population, and correspondingly high value (R=0.809) representing the urban population for the same pair of metals. Other strong correlations were found at R > 0.500 for As-Co representing the rural and urban population segments. A similar common feature was observed in case of As-Co for the rural segment and As-Ag for the urban segment. Similarly, Co-K exhibited a significant correlation at R = 0.535. The

Table 4. Multiple-metal linear regression analysis

Rural	Urban
[Co] = 0.669 [Ag] + 1.21	[Co] = 0.899 [Ag] + 2.01
[As] = 0.143 [Ag] + 1.19	[As] = 0.189 [Ag] - 2.01
[Hg] = 0.300 [Ag] + 4.98	[Hg] = 0.679 [Ag] + 2.42
[Na] = 24.28 [Ag] + 314	[Na] =-0.561 [Ag] + 440
[K] = 45.49 [Ag] + 305	[K] = 4.532 [Ag] + 123
[Zn] =-0.285 [Ag] + 172	[Zn] = 16.00 [Ag] + 137
[As] = 0.197 [Co] + 0.96	[As] = 0.097 [Co] - 0.01
[Hg] = 0.695 [Co] + 3.93	[Hg] = 0.703 [Co] + 1.10
[Na] = 6.229 [Co] + 332	[Na] = 1.497 [Co] + 433
[K] = 66.06 [Co] + 227	[K] =-0.129 [Co] + 133
[Zn] =-12.76 [Co] + 190	[Zn] = 16.74 [Co] + 105
[Hg] = 1.798 [As] + 2.90	[Hg] =-0.315 [As] + 3.94
[Na] = 49.59 [As] + 277	[Na] = 46.24 [As] + 421
[K] = 132.2 [As] + 182	[K] = 41.62 [As] + 117
[Zn] =-35.65 [As] + 212	[Zn] =-0.074 [As] + 170
[Na] =-4.310 [Hg] + 368	[Na] =-1.740 [Hg] + 445
[K] = 2.192 [Hg] + 351	[K] = 4.442 [Hg] + 116
[Zn] =-4.043 [Hg] + 185	[Zn] = 0.353 [Hg] + 169
[K] = 0.136 [Na] + 316	[K] = 0.454 [Na] - 66.0
[Zn] = 0.019 [Na] + 157	[Zn] = 0.037 [Na] + 154
[Zn] =-0.053 [K] + 183	[Zn] =-0.043 [K] + 176

Table 5 Comparative data on metal content(μg/g;dry weight) of hair of urban/rural population

Metal	Location	This work	Literature(References)
Ag	r	1.26	0.60 (Takeuchi 1979)
	u	2.06	0.20 (Takeuchi 1979)
Co	r	2.05	———
	u	3.86	0.421 (Senofonte 1989)
As	r	1.36	0.20 (Takeuchi 1979)
	u	0.36	0.198 (Senofonte 1989)
Hg	r	5.35	3.5 (Takeuchi 1979)
	u	3.82	2.90 (Airey 1983)
Na	r	344.9	———
	u	438.9	153 (Takagi 1986)
K	r	363.1	———
	u	133.2	0.94-310 (Takeuchi 1979)
Zn	r	164.1	182.50 (Leotsinidis 1990)
	u	170.3	105.10 (Senofonte 1989)

interdependence of these metals with the respective high correlation coefficient values indicated the specific metabolic processes in the body irrespective of the location or habitat of the subjects.
The dependence of various metals based on the present data for the rural and urban population is presented in Table 4, showing that this interdependence is critical between K and Ag, K and Co, and K and As for the rural population with respective slope values of 45.49, 66.06 and 132.2. On the other hand, Zn and Ag, Na and As, and K and As were found to be more critically correlated with respective slope values at 16.0, 46.24 and 41.62. The study thus revealed that for rural population it was only K that was critically linked with Ag, Co and As. However, in case of urban population three different metals namely Zn, Na and K were found to be dependent upon the levels of Ag and As. As such, interdependence of these metals in the rural environment was found to be more critical as compared with counterpart urban segment. Since the present study was conducted on 39 and 28 samples in the two groups of population, it might be expected that the conclusions drawn warrant no generality. Several investigators have reported data on hair analysis based on comparable number of representative samples (Ahmed 1991) with deductions in agreement with those of the present work. However, additional field work to produce a large body of data to further verify the present findings is underway. A comparative evaluation of data in relation to those from various parts of the world is presented in Table 5.

The present study furnished information on the levels of four essential and three non-essential trace metals in the hair of adult population of Pakistan habitating in urban and rural locations. The data indicated divergent levels of various metals in the scalp hair, reflecting different metabolic status and environmental conditions of living.

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