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The influence of living habits and family relationships on element concentrations in human hair

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Abstract

The paper discusses the content of elements in hair of subjects studied over several years. The study was performed on 5 subjects ($N=28$) that lived together or were family related. The elemental composition of hair of the studied subjects was compared with the average content of the population living in the same urban area (Wrocław city, south-west Poland), with the population of a non-industrialized area in Poland (Silesian Beskid), as well as with the population of north-east Sweden and Rio de Janeiro. When comparing the composition of hair from the studied subjects with the people living in the same city, it was found that the differences resulted mainly from different living habits (Na, Si, Co, Fe, Mn, Zn) and local exposure (Pb, Cd, Al). When comparing with the reference material for unexposed population, it was found that the studied subjects were exposed to Al.

Time profile of element contents in hair of a given person showed that the level changed significantly (even several fold) with changes of living habits or environmental exposure. Also, it was found that there were similar tendencies in the accumulation of the majority of elements by people that lived together. The effect of living habits on the level of a given element was found to be stronger than the influence of either sex or family relationship.

The paper also discusses inter-element interactions within the studied group. Statistically significant ($p<0.05$) correlations were found between elements that occur together: Ca–Mg, Fe–Mn, Na–K, Co–K, Au–Pt, Cd–Pb. In order to determine the influence of various elements on the content of another element, linear multiple regression was performed that revealed the following relationships: Ca = f(Mn, Sr), Na = f(K, Mn), K = f(V, Ti).

Keywords: Hair; Elements; Sex; Living habits

1. Introduction

Hair analysis has become important in the estimation of the degree of human exposure to some toxic elements (Apostoli, 2005; Hać et al., 1997; Sera et al., 2002; Wang et al., 1995). Hair analysis is considered as the potential diagnostic tool that might be used in the future for the clinical diagnosis (Austin and Soloway, 1992), however some uncertainties must be eliminated (Almeida et al., 1999; Bencko, 1995; Bermejo-Barrera et al., 2002). Reference values for element levels in hair have been determined (Table 1), although they are characterized by large variations in mean values, standard deviations and ranges (Austin and Soloway, 1992; Lekouch et al., 1999). Therefore, hair analysis was used mainly to assess heavy metals toxicity and as an indicator of nutritional status (Austin and Soloway, 1992).

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Table 1
Reference values for human hair (Miekeley et al., 1998), element concentrations (mg kg^{-1}) in hair for 83 subjects living in an urban area in south-west Poland (Wrocław city) (Chojnacka et al., 2005), for 266 subjects living in a non-industrialized region of south Poland (Silesian Beskid Śląski) (Nowak, 1998), for 114 subjects from an urban population group living in north-east Sweden (Rodushkin and Axelssom, 2000) and for 1091 subjects of Rio de Janeiro City (Miekeley et al., 1998)

Element	Reference values	Wrocław	South Poland	Sweden	Rio de Janeiro
Ag	<0.7	0.395		0.231	1.19
Al	<12	14.938		8.2	8.3
As	<7	0.044		0.085	<0.04
Au	0.002–0.75	0.049		0.03	0.01
B	1.0–3.0	2.041		0.670	
Ba	0.3–3.5	2.025		0.64	6.9
Be		0.055		0.0013	
Ca	350–860	1087.8	825.91	750	802
Cd	<1.0	0.114	0.61	0.058	0.59
Co	0.26–0.47	0.034	0.44	0.013	0.13
Cr	0.78–1.0	0.568	0.60	0.167	<0.3
Cu	13–35	12.352	7.96	25	44.1
Fe	6.0–15	15.000	45.70	9.6	20.8
Hg	<1.2	0.500		0.261	0.62
Mg	40–110	66.991		46	43.9
Mn	0.26–0.75	0.601	2.41	0.560	5
Mo	0.21–0.44	0.017		0.042	0.05
Na	18–87	217.330	242.16	147	87.7
Ni	<1.6	0.838	0.75	0.430	0.7
P	120–180	132.031		133	119
Pb	<6.0	1.046	4.99	0.960	12.5
Pt		≤0.00013		0.00015	
Sb	<1.8	0.455		0.022	0.02
Se	0.38–0.7	0.679		0.830	129
Si		57.506		33	
Sn	<3.0	1.205		0.320	0.13
Sr	1.0–7.6	2.882		1.20	5.1
Ti		1.491		0.830	
U		0.208		0.057	
V	0.35–0.80	0.092		0.027	0.07
W		0.002		0.0053	
Zn	125–165	156.5	128.94	142	156
Zr		0.568		0.155	

Hair is the body tissue that is the most feasible to study (when comparing with other tissues, blood or urine): it is not painful to sample and reflects the history of personal exposure in time (Tabrizian, 2002), since hair accumulates inorganic components over extended period of time (Teresa et al., 1997). Elements that are present in hair are divided into macro- and microelements (trace elements). The latter group is divided into essential trace elements (also called microelements or micronutrients) and toxic trace elements. In the group of essential trace elements major (Fe, Zn, Cu) and minor (Mn, Se, Cr, Co, Ni, Si, F, I) essential trace elements are distinguished (Rahil-Khazen et al., 2002).

The level of elements in hair is affected not only by environmental exposure but also by many factors, including living habits (dietary intakes) and personal propensity (genetic abilities, hair color, sex, age, illness, ingestion of drugs). Also, seasonal variations and other variables influence the level of elements in hair (Teresa et al., 1997). The level of elements in hair can be also influenced by the level of other elements: synergistic and antagonistic effects were detected. This could be due, for instance to common exposure to a pair of elements or increased ability to accumulate a given element if another element is present (Ashraf et al., 1995; Ashraf and Jaffar, 1997). The common pairs of elements reported in the literature are: Ca–Mg, Na–K, Cu–Zn, Cu–Mo, Co–K, Cr–V (Tabrizian, 2002).

The aim of the present work was to study the content of hair from related individuals obtained over several years. The impact of common dietary and living habits, sex and family relations on element levels in hair as well as on inter-element interactions was investigated.

2. Materials and methods

2.1. Hair samples

The studied material was sampled in the period 1996–2005 from 5 subjects (5–6 samples from each subject sampled in the following years: 1996, 1999, 2000, 2003, 2004, 2005, totally 28 samples) living in an urban, industrialized (heavy industry dominates) area in Poland, Wrocław city. The subjects were either family related and/or lived together: two females (denoted as F1 and F2) and three males (denoted as M1, M2 and M3), according to the following key:

- F1 was married to M1 since 1999; they lived together since 1999,
- F2 was married to M2 since 1970; they lived together since 1970,
- F1 was a daughter of F2 and M2, but they did not live together since 1994,
- M3 was a son of F2 and M2, they still live together.

Hair of F1, M1, M2 and M3 did not undergo any cosmetic treatments. Hair of F2 was dyed (black color) in the whole studied period.

Hair (directly after washing with shampoo and drying) was sampled from nape of the neck. The length of hair was 4 cm that represented the period of the past ca. 4 months. Samples were washed using acetone and distilled water (Nowak, 1998) in order to elute the external contaminations (Martin et al., 2005). Hair was