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Trace elements in hair of urban schoolboys: a diagnostic tool in environmental risk assessment

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Hair analysis may represent a means to quantify the relationship between human exposure to metal contamination and the environmental conditions of workplaces or residence sites. Hair are stable and their composition does not change over short time period. Furthermore, sampling procedure is very easy, requires no specific professional skills, is painless and non-invasive. 334 hair samples were collected from Caucasian children 11-13 years old, of both genders, without colored or treated hair, living in several Sicilian towns characterized by different geochemical environments: urban (Palermo), volcanic (Etna), mining area (Antillo-Fiumedinisi), industrial site (Pace del Mela), uncontamined area (Mistretta). Our study was divided into two parts. The first part was addressed to establish accurate coverage intervals for a cohort of elements (Al, As, Ba, Cd, Co, Cr, Cu, Li, Mn, Mo, Ni, Pb, Rb, Sb, Se, Sr, U, V and Zn).The obtained main results can be summarised as follows:
a) the most abundant chemical elements were zinc and copper (Zn>Cu), with concentrations exceeding 10μg/g. Next, we found Al>Sr>Ba>Pb>Se, all greater than 1μg/g. The remaining elements were all below 1μg/g;
b) mean concentrations of Al, Ba, Sr and Zn were significantly higher in girls' hair and those of Cr, Li, Rb, Sb, and V higher in boys' hair;
c) the predominance of Ba, Sr and Zn in girls seems to be attributable to puberty, whereas the higher levels of Cr, Li, Rb, Sb, U and V in boys may reflect the longer time boys spend outdoors with respect to girls.
d) Coverage intervals for each element were computed according to IUPAC criteria.
The second part was intended to provide more information about hair analysis by examining the impact of life ambient on the element concentrations in hair and evaluating whether differences exist among children residing in different places. Palermo represented the reference site. Data were analysed statistically with the STATISTICA program. Kolmogorov– Smirnov's test, with a level of significance set at $p < 0.01$, was used to verify the normality of data distribution. ANOVA (general linear model, GLM) at $p<0.001$ was used to verify the statistical significance of observed differences between genders. 0.95 central inter-fractile coverage intervals were computed with coverage uncertainty at confidence level 0.95. At the moment, with respect to Palermo, the following similarities were confirmed for each site:
• Zinc and copper are the most abundant elements, with Zn>Cu and both greater than 10μg/g.
• Sr levels in girls were always higher than those in boys.
Some differences could be also observed. It was found that the abundance order of elements having concentrations greater than 1μg/g, excluding Zn and Cu, differed significantly among the study sites:
• Al>Sr>Ba>Pb at Palermo
• Al>Sr>Pb>Ba at Antillo-Fiumedinisi (mineralized area)
• Al>Sr>Ba at Mistretta (rural area; Pb levels lower than 1μg/gr)
• Al>Mn>Sr>Pb at Nicolosi (volcanic area; Ba less than 1μg/gr)
• Sr>Al>Pb>Ba at Pace del Mela (industrial area)
Furthermore, when compared with the other sites, Nicolosi samples have the highest concentrations of seven elements out of the 18 determined: Co, Cr, Cu, Li, Mn, Sb, V and Zn. Pace del Mela samples show the highest concentrations of Cd, (Pb), and Sr; hair samples from the mineralized area (Antillo-Fiumedinisi) have the highest concentrations of Al, As, (Pb). Mistretta and Palermo samples have respectively the highest concentrations of Ba-Ni-Rb-Se and Mo. The linear discriminant analysis allowed us to statistically distinguish groups according to geographical sites.