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Application of INAA to Determine Major Elements Concentrations in Head Hair of Street Children of Isfahan City, Iran

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Abstract: The street children phenomena and the number of street children is an increasing social problem in Isfahan and other big and growing towns. Because of the number of street children and the way that they affect society in childhood and when they become old, it is important to study their health and have baseline data on theire health problems. Hair element analysis is an important tool in the nutritional and environmental pollutions and measuring pollutions and measuring elemental concentrations in recently-grown hair provides a good way of studing their health. This study aimed to assess major element concentrations in the hair of street children in Isfahan using instrumental neutron activation analysis method. Six major elements (Ca, Cl, K, Mg, Na and S) of 17 Iranian street children (Isfahan) were determined. Data analysis found different profiles of the concentrations of Ca, K, Mg and S in samples. These results were discussed with reference to show of nutritional and environmental effects.

Key words: Hair · INAA · Isfahan · Street children · Major elements

INTRODUCTION

According to UNICEF and WHO, street children are devided in four groups. First are called Cathen and have no family and home. The second group have both family and home but because of some reasons are aparted from their family and live in small groups and bands. The third group have been homelessed before but now are living in support organizations and centers and the last are children who have home and family but because of welfare situations and specially depauperation spend most of their time in streets. All of the above, although have difference but are common in two ways. First, spending most of their time in streets and second is that they are devested from basic rights like education, nutrition, hygiene, safety and so on and the last is that because of spending most of their time in streets, they will experience many problems and traumas.

However, although there are studies which focus on the health status of street children in aspecific area of the world [1, 2], to date, few studiesactually investigate the major element nutrition status of the street children.In fact, major elements, play an important role in maintaining metabolic homeostasis and electrolyte equilibrium so it is needed to study the major elements in order to preventof many diseases and to keep equilibrium of other elements in body [3, 4].

Scalp hair is a potentially valuable tissue in that it can record the level and changes of many elements in the body over a long period of time. The most benefits of hair samples are that it could be removed painlessly and it is so easy to collect, store and transport and the level of elements in hair are more than other tests like blood and urine [3].

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MATERIAL AND METHODS

The 17 children (5 boys and 12 girls), aged 6-15 selected in the Isfahan city where is an industrial region and have traffic contamination with just 25 clean days in last 2011. Also, to compare the 3 children (1 boy and 2 girls), aged 8-12, living with their family are selected. Approximately 5g of hair was cut from back of the head with stainless steel scissors and it was cut into small pieces to obtain a representative homogeneous samples. About 200 mg of samples were washed according to the procedure recommended by the IAEA with acetone and water to remove any external contaminants and then dried in a desiccator at room temperature [5]. Seven biological standard reference materials, Peach Leaves NIST-1547, Bovine Liver NIST-1577b, Rice Flour NBS-1568a, Coal Fly Ash NIST 1633b, Pine Needles NIST-1575, Apple Leaves NIST-1515 and Trace Elements in Human Hair CRM-397 were chosen as quantity control SRM. Samples or standards were placed in a 5×5 cm^2 polyethylene film that had been cleaned with C_2H_5OH and deionized water.

The samples and standards were irradiated with thermal neutrons from a Miniature Neutron Source Reactor, Atomic Energy Organization of Iran. The irradiation, cooling and counting times for first and second counting of radioactivity measurements and the determined isotopes for each cycle by comparative method are summarized in Table 1. Gamma ray spectra of the irradiated samples were obtained with a well type HPGE detector. This type of detectors was mainly used to minimize the geometry errors arising during gamma ray counting of the hair samples. The resolution of this detector was 2.0 keV for the 1332 keV peak of ^{60}Co. The NAA software SPAN was used for the identification of the radio nuclides and the calculation of their activities.The used procedure to calculate concentration in the hair sample is to irradiate the hair sample and a standard reference material containing a known amount of the element of interest together in the reactor. If the hair sample and the standard reference material are both measured on the same detector, then one needs to correct the difference in decay between the two. One usually decay corrects the measured counts (or activity) for both samples back to the end of irradiation using the half-life of measured isotope. The equation used to calculate the mass of an element in the sediment sample relative to the standard reference material is

$$\frac{A_{sam}}{A_{std}} = \frac{M_{sam}}{M_{std}} \cdot \frac{\left(e^{-\lambda td}\right)sam}{\left(e^{-\lambda td}\right)std}$$

where A, M, λ and td are activity of sample (sam) and standard (std), mass of the element, decay constant for the isotope and decay time, respectively. We performing irradiation, the irradiation, decay and counting times are normally fixed the same for all samples and standards such that the time dependent factors can be cancel. Thus the above equation simplifies into:

$$C_{sam} = C_{std} \cdot \frac{W_{sam}}{W_{std}} \cdot \frac{A_{sam}}{A_{std}}$$

Where C is concentration of element and W is weight of the sample and standard. The analytical results of the samples are in good agreement with the certified values.

RESULTS AND DISCUSSION

We determined the concentration of major elements in human hair samples from street children and students (control group). The precision and accuracy of the experiment was tested by analyzing5standard reference materials and found that they are in good agreement. The data have been presented by average value (Average), standard deviation (SD) and Coefficient of Variation (CV). Wedetected 37 elements in hair samples, out of those six elements; Ca, Cl, K, Mg, Na and S to bepresented in this paper. Figure 1 shows the energy spectrum of the elements taken from sample of street child #1 with range of 278 to 2754 keV. Table 2 shows raw data for street children and control group, which list individual concentration for detected elements Ca, Cl, K, Mg, Na and S, together with their Average, SD and CV inpercent. There is no correlation for the major elements content in the hair as a function of sampling data. Forindicating the precision of the method, duplicate of reference material are

Table 1: Neutron activation analysis conditions for human hair

Neutron flux $\times 10^{11}$ $ncm^{-2}s^{-1}$	Irradiation time	Decay time	Counting time	Elements determined
1	2 Min	80 Sec	500 Sec	Ca, Cl, Mg, S
5	7 Hour	4 Days	1500 Sec	K, Na

Table 2: Raw data for street children group with individual concentration for detected elements;Ca, Cl, K, Mg, Na and S

	concentration(ppm)					
sample	Ca	Cl	K	Mg	Na	S(%)
1	3163.7	29.6	177.4	158	271.3	3.7
2	2042	67.7	189.6	133.8	310.5	4.3
3	2767.3	194.9	108.2	195.7	216.6	4.3
4	827.8	456.5	87.2	0	177.9	4.2
5	5348.3	95.6	94.4	213.9	144.4	4.0
6	1050.4	808.2	98.4	86.8	159.7	4.8
7	4193.2	171.2	78.5	187.8	135.5	4.2
8	1221.9	456.2	132.1	86.1	201.4	4.3
9	2016.8	201	76.5	192.17	146.8	4.6
10	3413.1	156	93.4	120.8	155.7	4.1
11	3765	169.3	209.2	245.5	392.3	4.2
12	3549	220.8	97.7	172	170.6	4.6
13	782.1	1021.4	73.8	58.5	113.7	3.6
14	927.8	939.3	122.08	71.6	231.3	4.7
15	873.1	1973.2	132.6	74.8	198.2	4.7
16	737.3	2024.3	81.6	59.9	145.9	4.7
17	1002.1	810.4	109.9	63.1	248.7	4.6
AVERAGE	2216.524	576.212	115.446	124.734	201.206	4.340
Min	737.3	29.6	73.8	0.0	113.7	3.6
Max	5348.3	2024.3	209.2	245.5	392.3	4.8
SD	1458.92	623.65	41.02	68.80	72.14	0.35
CV	151.93	92.39	281.45	181.30	278.89	1256.89
Sample	Ca	Cl	K	Mg	Na	S(%)
1	1533.9	537.1	88.1	101.4	179.1	4.5
2	1447.8	504.5	140.8	85.8	318	4.7
3	990.7	622.7	43.1	103.9	104.1	4.7
AVERAGE	1324.133	554.767	90.667	97.033	200.400	4.599
Min	990.7	504.5	43.1	85.8	104.1	4.5
Max	1533.9	622.7	140.8	103.9	318.0	4.7
SD	291.95	61.05	48.90	9.81	108.53	0.10
CV	453.54	908.73	185.41	989.30	184.65	4716.07

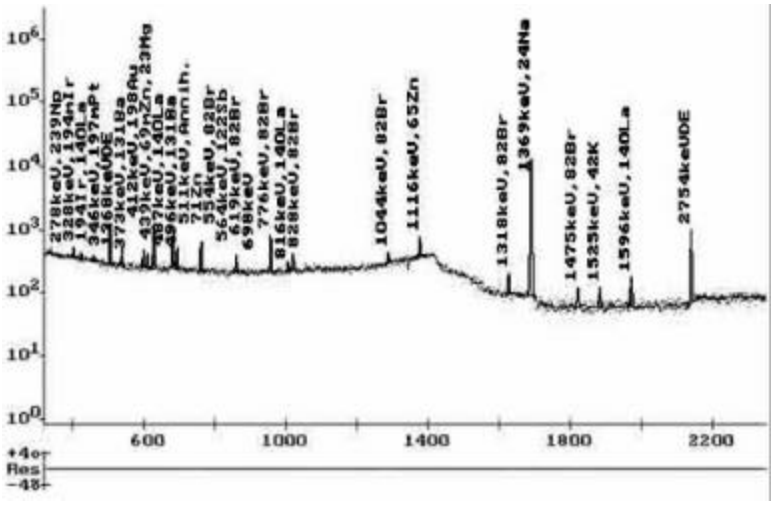

Fig. 1: Spectrum of elements detected in human hair sample

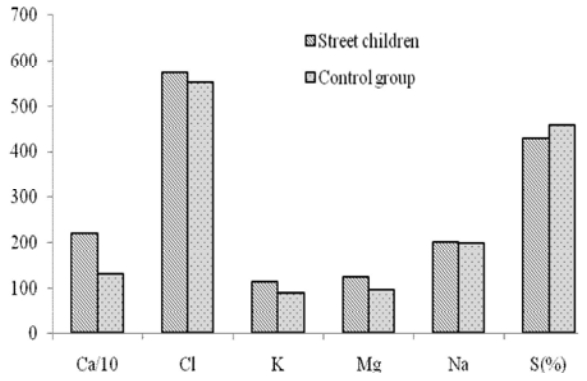

Fig. 2: Comparison of mean concentration between street children and control group

prepared and analyzed, the standard deviations of the measurement for most of the elements in the reference materials are at an acceptablelevel.The hair of the street children groupshows a range of 737.3-5348.3µg/gfor Ca, 29.6-2024.3µg/g forCl, 73.8-209.2µg/g forK, 0-245.5µg/gfor Mg,113.7-392.3µg/gfor Na and 3.6-4.8(%)for S. We did not found anycorrelation between concentrations of major elementsin this research.Comparison for the average of each element in the two groups was performed as shown in Figure2. The SD for each element within each group has been calculated. The meanconcentrations are: Ca (2216.5 ± 59.7) µg/g, Cl (576.2 ± 10.9) µg/g, K (115.4 ± 16.1) µg/g, Mg (124.7± 9.9) µg/g, Na (201.2 ± 0.6) µg/gand S (4.34% ± 0.18%) for street children group and Ca (1324.1 ±36.3) µg/g, Cl (554.7 ± 13.2) µg/g, K (90.7 ± 14.1) µg/g, Mg (97.0 ± 12.3) µg/g, Na (200.4 ± 0.7) µg/g and S (4.59% ± 0.18%) for control group, respectively. Moreover, theaverage of Cl, Na is almost the same in both. Significant elevated concentration of two elementsK andMg suggests the possible uptake from exposure of street children during longtime staying in traffic jam or in the streets outside of their houses.Our data are compared with normal concentrations and ranges of some major elements in humanhair of Isfahan city published in the literatures [6, 7]. The results show overall theconcentration of major elements of Cl, K, Mg and S in hair of street children were well agreedwith those obtained for the control group and those reported for population in Isfahan, but the concentration of Ca in street children and the concentration of Na for population in Isfahan is lower than the other[6, 7].Moreover, the comparison of our data (Ca and S concentrations) with those of other countries,such as Iran, China, England, New Zealand, Pakistan, India, Indonesia, Sweden, France, Poland, Spanish, USA and Canada shows that mean values of our data are lower than those countries [6, 8, 9]. We were interested to know the probable differences between other elemental concentration content of streetchildren in Isfahan area and those other people. The mean concentration of someelements in thiswork was found to be different than those of other people but it is needed to mention the age of oursamples was not the same of others. We also compare the concentration of heavy metals and trace elements in Isfahan children and the results also show some differences between groups [10].

CONCLUSION

This study determined major element concentration in the hair of street children for the first time. Hair samples are much simpler to collect, transport and store than other samples like blood and urine. Six major elements (Ca, Cl, K, Mg, Na and S) in the hair of 17 healthy street children living in Isfahan, Iran, were determined by INAA. The average values of these major elements together with their respective ranges and coefficient variation values were presented. Street children spend most of their time in the street so they are influenced mostly by environmental situation. We hypothesized that these baseline data obtained from the healthy street children could be reliably used as monitors leading to better assessment of the health status in this social group.

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