VARIATION OF ELEMENTAL CONCENTRATIONS IN HAIR IN RELATION TO BILHARZIA DISEASES

T. Elnimr*

Department of Physics, Tanta University
Tanta, Egypt

and

N. B. Rofail and A. M. Hassan

Reactor & Neutron Physics Department
Nuclear Research Center, AEE, Cairo, Egypt

الخلاصـــة :

لتطبيق الفيزياء في الطب تـمَّ استخدام التحليل التنشيطي بالنيوترونات لدراسة العلاقة بين تركيز بعض العناصر ومرض البلهارسيا وذلك باستخدام طريقة K_0 كأسلوب عياري جديد ، وأُخِذ في الاعتبار معالجة مصادر الخطأ التي تؤثر على النتائج التحليلية . ولوحظ أنَّ هناك اختلافـاً واضحاً في تركيز عناصر النحاس والزنك والكادميوم بين عينات شَـعَر المرضى والأصحاء ، بينما لم يُلاحظ اختلاف يُذكر لعناصر المنجنيز والنيكل والسيلينيوم والزئبق . ولقد أشارت النتائج إلى إمكانية تشخيص مبدئي باستخدام هذه الطريقة ، ولسوء الحظ ، لا توجد نتائج مشابهة بحيث يمكن مقارنتها مع نتائج هذا العمل .

ABSTRACT

With the help of reactor neutron activation analysis, investigations of trace elements such as copper, manganese, selenium, nickel, cadmium, and mercury have been performed with the purpose of differentiation between healthy persons and patients suffering from Bilharzia diseases.

We applied the K_0-method as a new standardization technique, in which the deviation of the $1/E^{1+\alpha}$ epithermal neutron flux distributions from the $1/E$ law, the true coincidence effects of cascade γ-rays, and the efficiency of the Ge(Li) detector were taken into consideration. Short-lived nuclides were determined by a short activation with the help of a pneumatic irradiation facility with automatic correction of dead time and decay rate. The medium and long lived nuclides were determined after 48 hours irradiation and ten days cooling. The patients' head hair samples showed significant differences in Cu, Zn, and Cd but had no clear significant effect in Mn, Ni, Se, and Hg. The result obtained indicates that early diagnosis by means of trace element determination could be possible. Unfortunately there are no similar published results for comparison.

*To whom correspondence should be addressed .

T. Elnimr, N. B. Rofail, and A. M. Hassan

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INTRODUCTION

The concentration of trace elements in different organs is known to be affected by occupational and environmental exposure, nutrition, and disease. Reactor neutron activation analysis is a suitable method for determining trace elements in biological materials, especially in hair.

The purpose of this paper is to determine the concentrations of certain elements such as Zn, Cd, Cu, Mn, Ni, Se, and Hg in hair of normal and diseased persons and the investigation of possible correlations with the bilharzia diseases. Bilharzia is wide spread in villages. It is caused by worms that spend a part of their life cycle in the water. Infection is caused if we drink, or bathe in, this infected water [1].

K_o-Neutron Activation Analysis

The K_o-method [2, 3] differs from the relative method in its treatment of standards; it simplifies preparation, activation, and measurement of individual standards through replacing them by the nuclear data. For this reason the method is advantageous over the relative method for multielement analysis of hair samples, because it precludes the problems involved in preparation of multielement standards in a condition similar to hair samples.

METHOD

When applying the K_o-method to reactor neutron activation analysis (RNAA), the concentration of an element i can be calculated from the following equation:

$$\rho_i(\text{ppm}) = \frac{10^6}{W} \times \frac{1}{K_{o,\text{Au}(i)}} \times \frac{\left[\dfrac{N_p/t_m}{SDC}\right]_i}{\left[\dfrac{N_p/t_m}{SDC\ w}\right]_{\text{Au}}} \times \frac{F+Q_{o,\text{Au}(\alpha)}}{F+Q_{o,i(\alpha)}} \times \frac{\varepsilon_{p,\text{Au}}}{\varepsilon_{p,i}}$$

where W and w are expressed in the same units, and Au is the selected comparator. In the above equation the following parameters need to be considered:

$$K_{o,\text{Au}(i)} = \frac{M_{\text{Au}}\,\theta_i\,\sigma_{o,i}\,\nu_i}{M_i\,\theta_{\text{Au}}\,\sigma_{o,\text{Au}}\,\nu_{\text{Au}}}\,;$$

and the following K_o factors listed in Table 1.

N_p — peak area, to be corrected for real coincidence effect and corrections for spectral interferences and ^{235}U-fission can be performed with increased accuracy by applying K_o-factors.

S, D, C — saturation, decay, and counting factors; appropriate formula for specific count rate calculations.

F — thermal-to-epithermal flux ratio; can be determined by coirradiation with the sample of a Zr-foil (^{95}Zr$-^{97}$Zr).

$$Q_{o(\alpha)} = \frac{Q_o - 0.429}{\bar{E}_r^{\alpha}} + \frac{0.429}{(2\alpha+1)(0.55)^{\alpha}}\,;$$

ratio of the resonance integral to the 2200 m s^{-1} cross section (Q_o), corrected

Table 1. Nuclear Data Involved in the Present Study.

Element	Produced isotope	Q_o [4]	$\bar{E}_r$ (eV) [7, 9]	$T_{1/2}$	E_γ (keV)	K_o [8]
Mn	^{56}Mn	1.07	468	2.577 h	846.8	4.96×10^{-1}
Ni	^{65}Ni	0.67	14 200	2.520 h	1481.8	1.27×10^{-4}
Cu	^{66}Cu	1.06	766	5.10 m	1039.2	1.86×10^{-3}
Zn	^{65}Zn	1.96	2560	243.8 d	1115.5	5.60×10^{-3}
Se	^{75}Se	10.9	29.4	119.8 d	136.0	6.89×10^{-3}
Cd	^{115}Cd	77.7	207	2.2 d	336.3	7.23×10^{-4}
Hg	^{203}Hg	0.88	1960	46.58 d	279.2	1.10×10^{-2}
Au	^{198}Au	15.7	5.65	2.696 d	411.8	1

for non-ideality of the epithermal spectrum ($\sim 1/E^{1+\alpha}$);
Q_o: the principles applied for the experimental determination and the critical evaluation of Q_o-values were outlined and applied in [4]; Q_o-values with related parameters are included in Table 1.

α — the experimental determination of the non-ideality of the epithermal spectrum has been discussed in detail in references [5, 6]; a simple procedure using a Zr foil together with a 0.5% Au–Al wire allows simultaneous determination of α and F.

$\bar{E}_r$ — effective resonance energy; recently introduced in activation analysis, $\bar{E}_r$ values have been calculated for 96 isotopes [7, 9].

ε_p — full energy peak efficiency; a procedure for the calculation of ε_p (including γ-attenuation) for bulky samples at any source–detector distance was presented and proved to be accurate to within 2–3% [5].

EXPERIMENTAL [2]

Hair samples were washed with distilled water, acetone, and distilled water and then dried in a dry oven at 40°C. To determine the elements producing nuclides with short and medium half lives, samples as well as comparator (Au–Al wire) were irradiated in polyethylene vials for 20 s in the pneumatic irradiation facility in the Egyptian reactor. This procedure was applied for ^{65}Ni, ^{66}Cu, and ^{56}Mn. Radionuclides such as ^{203}Hg, ^{115}Cd, ^{65}Zn, and ^{75}Se were measured for 1 ks with 12 days cooling after 48 hours irradiation. The decays during the measurement and the dead time losses in the multichannel analyzer were accounted for. Among the large number of samples 40 samples of patients and 40 samples of healthy individuals were selected because of the similarities in their historical conditions.

RESULTS AND DISCUSSION

Mn, Ni, Se, and Hg were determined and the results are given in Table 2. The data obtained so far do not shown any significant differences between the normals and cases samples.

We determined the contents of Cu, Zn, and Cd in the hair of control subjects (normals) and in the hair of men suffering from bilharzia disease. The values in Tables 2 and 3 show significant differences in the concentration of trace elements in hair of normal and diseased persons. These results could be use to diagnose the early occurrence of bilharzia.

Table 2. Elemental Concentration (ppm) in Hair of Normal Persons and Patients

	ρ_{Hg}(ppm)	ρ_{Cd}(ppm)	ρ_{Zn}(ppm)	ρ_{Ni}(ppm)	ρ_{Cu}(ppm)	ρ_{Se}(ppm)	ρ_{Mn}(ppm)
Normal persons	$1.83 \overset{\div}{\times} 1.2$	$0.76 \overset{\div}{\times} 1.4$	$99.70 \overset{\div}{\times} 1.3$	$2.5 \overset{\div}{\times} 1.1$	$7.86 \overset{\div}{\times} 1.2$	$1.82 \overset{\div}{\times} 1.8$	$5.92 \overset{\div}{\times} 2.0$
Patient (Bilharzia)	$1.91 \overset{\div}{\times} 1.3$	$1.09 \overset{\div}{\times} 1.3$	$25.15 \overset{\div}{\times} 1.1$	$2.56 \overset{\div}{\times} 1.4$	$3.21 \overset{\div}{\times} 1.3$	$1.71 \overset{\div}{\times} 1.5$	$5.8 \overset{\div}{\times} 2.1$

Table 3. Summary of Patient Data (in the Case of Zinc)

Patient	Age (year)	Occupation	Smoking History	Hair Zn (ppm)
A	22	Student	Non-smoker	19.76
B	21	,,	20 Cig/day for 5y	24.86
C	23	,,	20 Cig/day for 4y	23.52
D	23	,,	30 Cig/day	28.98
E	24	,,	20 Cig/day for 8y	19.75
F	22	,,	Non-smoker	27.53
G	22	,,	30 Cig/day	23.87
H	27	,,	Non-smoker	23.67
I	23	,,	Non-smoker	24.91
J	23	,,	20 Cig/day for 4y	21.65

CONCLUSIONS

We have shown here trace element levels can be affected by certain diseases and environmental factors. Figure 1 shows some ratios:

$$S = \frac{\text{content in hair of diseased persons}}{\text{content in hair of healthy persons}}$$

for Hg, Cd, Zn, Ni, Cu, Se, and Mn. The statistical confidence limits of the S values is low due to the small number of samples investigated, but we hope that further studies will verify our findings.

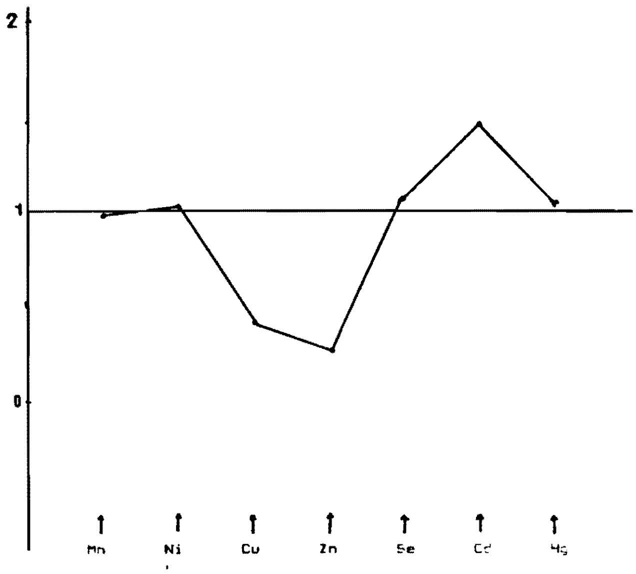

Figure 1. Concentration Ratios of Mn, Ni, Cu, Zn, Se, Cd, and Hg for Bilharzia Disease.

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