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Investigation for Thorium Activity levels by using semiemperical equation for γ-ray Energy of (511)keV

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Abstract

In this work a new method for determining the specific activity for Thorium-232 was applied by using γ-energy of 511 keV. This method was a semiemperical equation related to the system we used it (γ -spectroscopy).It helps us to get the specific activity of Thorium at low level count or even under the detection limit of the system.The efficiency of the detector for 511 keV that make the peak visible in the spectrum and help us to make our calculation.

Key words :- Thorium Activity, γ-energy 511 keV, annihilation peak

الكشف عن فعالية الثوريوم باستعمال المعادلة شبه التجريبية لطاقة ذروة اشعة كاما (511 keV)

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الملخص

في هذا البحث استعملت طريقة جديدة لتحديد الفعالية النوعية لنويدة الثوريوم – ٢٣٢ بالاعتماد على طاقة ذروة 511keV .

هذه الطريقة تمثلت بايجاد المعادلة شبه التجريبية والتي تكون خاصة بكل منظومة القياس لاشعة كاما ، حيث حيث يمكن استعمالها لإيجاد الفعالية النوعية للثوريوم ذات المستويات القليلة جدا او حتى التي تحت حد الكشف بالنسبة لمنظومة القياس ، حيث ان الكفاءة وقدرة التحليل لذروة 511keV اكثر مما يجعلها ظاهرة بشكل جيد في الكيف والتي تساعد في اجراء الحسابات المطلوبة .

كلمات مفتاحية:- الفعالية النوعية للثوريوم ، طاقة اشعة كاما 511keV ، ذروة الفناء.

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Introduction

Gamma – ray spectroscopy is the quantitative study of the energy spectra of gamma ray sources , also determines the energies of the gamma – ray photons emitted by the source. Radioactive nuclide (radionuclide) commonly emit gamma rays in the energy range from a few keV to ~ 10 MeV corresponding to the typical energy level in the nuclei with reasonably long lifetimes [1].

Most radioactive sources produce gamma rays of various energy and intensities. When these emissions are collected and analyzed with a gamma – ray spectroscopy system, a gamma – ray energy spectrum can by produced a detailed analysis of this spectrum is typically used to determine the identity and quantity of gamma emitters present in the source . the gamma – ray of natural Uranium or Thorium showing a dozen discrete lines superimposed on smooth continum , allows the identification the nuclides such as ^{226}Ra , ^{214}Pb , ^{214}Bi of the Uranium decay , chain ^{228}Ac and ^{288}Tl of the Thorium decay chain[1,2]. Annihilation radiation is a tem used Gama-spectroscopy for he gamma radiation produced when a particle and antiparticle collide. Most commonly, this refers to 511keV gamma rays produced by a gamma ray undergoing pair production [2].

Annihilation radiation is not monomergetic, unlike gamma rays produced by radioactive decay. The production mechanism of annihilation radiation introduces Doppler broadening [3].The annihilation peak produced in a gamma spectrum by annihilation radiation there fore has a higher full width at half maximum (FWHM) than other gamma rays in spectrum–because of their well-defined energy(511 keV) and characteristic, Doppler–broadened shape, annihilation radiation can be often be useful in defining the energy calibration of agama ray spectra as shown in figure (1) [3].

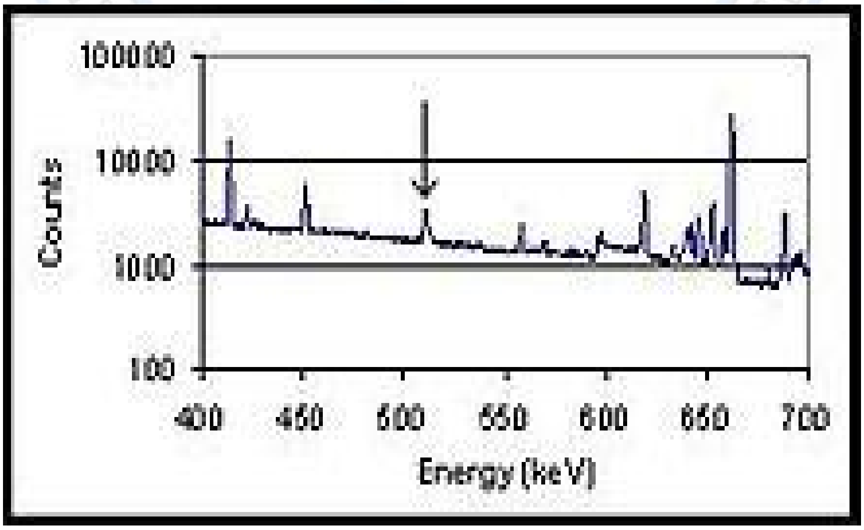

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Figure (1) the annihilation radiation peak(under the arrow)

The semiemperical equation :

We got this equation for specific activity (S.A.) of Thorium-232 calculation, that is equivalent to S.A. of Thallium – 208(γ – energy is 583 keV with abundance 86%) this procedure is followed in calculation of ref. [4].

At first we calculated the ratio for Tl – 208 and K-40 that every one contribute in the peack for 511 keV, the Tl–208 have energy of 510.7 keV with abandence 22.5% and k–40 have γ-energy of 511keV with abundance of 10.7% [5], the other isotopes that can contributed in this peak have low half-life time found .

By using the data of ref. [6], we found that the equation for determining the S.A. of Tl – 208 or Thorium is:

$$[S.A.]_{Tl\ 208} = C\ [S.A.]_{511} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where $[S.A.]_{Tl\ 208}$ is the specific activity of Tl -208 for energy of 583 keV;$[S.A.]_{Tl\ 511}$ is the specific activity for energy of 511 keV and C is a constant that depends on the measured system, and we can calculate this constant by using the following equation:

$$C = ad / a+b \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Were is S.A. for Tl–208 for γ energy of 583 keV; b is S.A. for k–40 for γ energy of 1460 keV and d is the S.A. for γ-energy of 511 keV.

By using eq.(1) we can evaluate the S.A. for Thorium in all samples, when S.A. is very low level or even when it is bellow the detection limited .

Results and conclusion

The constant C was calculated from the average of 50 different samples soil and sediments from ref. [6] by using simple Matlab program, which was (0.426 ± 0.102) and equation (1) will be:

$$[\ s.a.]_{Tl\text{-}208} = (\ 0.426 \pm 0.102\ )\ [s.a]_{511} \quad \ldots\ldots\ldots\ldots\ldots\ldots..(3)$$

for the system that used by ref. [6] .

The eq.(3) was applied for another samples that peak of γ-energy of 583 keV appeared or not (which is b.d.l.) table[1].

We can conclude that S.A. will be evaluated by using this method for Thorium – 232 by using 511 keV peak, so this technique is very useful and powerful for this purpose of determining the low level of radioactive which is very useful to know the bad effect of the accumulation of it, such as Thorium [7] . At first the efficiency of the detector for the energy 511 keV is more than the efficiency for the energy 583 keV and the second contribution of K-40 at this peak increases the appearance of it, that can help us to determine the S.A. of 511 keV peak. Our conclusion from this work that we can applied this method for any γ-ray system by calculating the constant C for the system than evaluated the S.A. for thorium in different samples .

Table (1): The S.A. for Tl-583 keV as S.A. of this work using semiemperical equation ref.[6].

Sample no. ref.[6]	S.A. of 511 keV	S.A. of Tl-208 (this work)	S.A. of Tl-208 ref.[6]
KL28	28.199	12.013±2.876	15.341
LC2	31.356	13.358±3.198	16.183
LC1	30.564	13.020±3.118	16.385
LC3	14.869	6.334±1.517	b.d.l"
13R	15.805	6.733±1.612	b.d.l"
12R	20.207	8.608±2.061	1.404
11R	18.022	7.677±1.838	b.d.l"
10R	17.040	7.259±1.738	8.679
9R	18.528	7.893±1.890	b.d.l"
8R	15.203	6.476±1.551	3.473
7R	15.710	6.692±1.602	b.d.l"
5R	15.588	6.640±1.590	b.d.l"
4R	19.067	8.123±1.945	b.d.l"
3R	18.465	7.866±1.883	b.d.l"
2R	16.596	7.067±1.693	2.067
1R	15.741	6.706±1.606	3.278
RL11	21.281	9.066±2.171	11.687
RL12	21.595	9.199±2.203	9.400
RL13*	20.312	8.652±2.072	11.902
RL13**	25.610	10±2.612	14.136

b.d.l. " below the detection limit

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