American Journal of Engineering Research (AJER)
e-ISSN : 2320-0847 p-ISSN : 2320-0936
Volume-4, Issue-3, pp-126-132
www.ajer.org

Research Paper Open Access

Measuring radioactivity level in various types of rice using NaI (Tl) detector

Laith A. Najam[1], Nada F. Tawfiq[2] and Fouzey H. Kitha[3]
[1] *Physics Dept., College of Science, Mosul Univ., Mosul, IRAQ*
[2] *Physics Dept., College of Science, Al-Nahrain Univ., Baghdad, IRAQ*
[3] *Ministry of Science and Technology, Baghdad, IRAQ*

ABSTRACT: *A study of long- lived gamma emitting radionuclides in rice consumed in Nineveh Province (IRAQ) were performed. The study targeted the natural radionuclides* ^{226}*Ra,* ^{232}*Th and* ^{40}*K .The rice samples originated from seven different countries. NaI(Tl) detector was used to measure the radionuclides level. The radioactivity concentrations of* ^{226}*Ra,* ^{232}*Th and* ^{40}*K ranged from 51.15 to 109.26 Bq/kg,13.67 to 71.97 Bq/kg and 231.87 to 691.71Bq/kg. In order to evaluate the radiological hazard of the natural radioactivity, radium equivalent activity, gamma absorbed dose rate, internal and external hazard indices , gamma index and finally alpha index have been calculated . Hence rice consumption in Nineveh province (IRAQ) is radiologically safe for the presence of the investigated radionuclides.*

KEYWORDS: *NORM, Gamma spectrometry, Rice samples, Activity concentration, Nineveh province.*

I. INTRODUCTION

Radioactivity in the environment originates from natural and anthropogenic (man-made) sources. Natural radionuclides include isotopes of potassium (^{40}K), uranium (^{238}U and its decay series), and thorium (^{232}Th, and its decay series). These natural occurring radioactive materials (NORM) are long-lived (in the order of 10^{10} year) and are typically present in environmental samples [1,2].

Anthropogenic radionuclides are products of nuclear processes in industrial, medical, and military applications. Releases to the environment can be either controlled (regulated discharges) or uncontrolled (accidents). For example, it was estimated that 9 x 10^{16} Bq of the cesium isotope ^{137}Cs, were released to the environment from the Chernobyl accident in environmental samples is an indicator of a previous contaminating event [3]

Natural and anthropogenic radionuclides are found in terrestrial and aquatic food chains, with subsequent transfer to humans through ingestion of food. Therefore, there is a global interest in human radiation exposure due to radionuclide intake from food [4,5].

Among the types of food that are commonly consumed worldwide is rice. Hence, studies on the radioactivity of rice have been performed in various regions across the globe Results of these studies helped in establishing baselines of radiation exposure to people from consumption of rice [6].

Gamma radiation has always been existed in environment since the big bang occurred. During the last few decades radioisotopes and nuclear explosions in upper layers of the atmosphere contaminated and polluted the earth badly .The radioactive nuclides, produced due to those explosions, contaminated the entire environment. At surface layers of soil, these radioactive elements have higher level of concentration because their migration to down to the earth is limited [7,8].

Rice is the staple food of Asia, including Malaysian community. An average quantity of rice taken by an adult is about 100 g per day. The quantity is seen to be very small, but without realizing there are radionuclides present in the rice that can affect the body. Amount of radionuclides accumulated in the body can be known by measuring the concentration of radionuclide contained in the rice. Present study was conducted to measure and compare the concentration of uranium, thorium and potassium in the different samples of rice. The effective dose per annum contributed was also accounted as well [7].

The plants absorb these radionuclide from soil with some others minerals during their growth. These dangerous isotopes enter to human beings as food. Most of the non-edible parts in these components are returned to the soil as organic fertilizer where they may again be utilized in the soil–plant pathway and/or are mixed with feed for livestock [9].

Foodstuffs are known to contain natural and man-made radionuclides which after ingestion, contribute to an effective internal dose. The naturally occurring radionuclides especially ^{40}K and the radionuclides of ^{238}Uand ^{232}Th series are the major source of natural radiation exposure to the man. It has been estimated that at least one-eighth of the mean annual effective dose due to natural sources is caused by the consumption of foodstuff [10,11].

Man- made radionuclides, produced by human activities also contribute to the environmental radioactivity, and one of these important radionuclides of environmental concern, is ^{137}Cs [12].

For contamination assessment of the foodstuff consumed by the population, it is very important to know the baseline value, or the level of radiation dose of both natural and synthetic radionuclides received by them [11].

Some researchers have performed on determination of different radionuclides concentration in Iranian food samples, and dose assessment from consumption of that foodstuff by the population [13].Hence the aim of this study was to quantify the content of ^{226}Ra, ^{232}Th and ^{40}K of rice samples consumed in Nineveh province (IRAQ), and to estimate radium equivalent activity, gamma absorbed dose rate, external and internal hazard indices, gamma index and alpha index by using NaI(Tl) detector.

II. MATERIALS AND METHODS

2.1 Sampling and samples preparing

Rice samples were collected from Nineveh province(IRAQ) local market . The collection took place between Dec. 2013 and Feb. 2014. Seven samples of rice were collected , every one of these samples weight about (900) gm. The samples dried by placing it in the oven of 110 $^{\circ}$c about 24 h, then crushed to pass through 2 mm sieve to be homogenized in size. The homogenized rice samples were sealed in plastic containers and left for at least 4 weeks to reach secular equilibrium between parent radionuclides and the daughters [14,15].

2.2 Gamma spectrometry

Gamma- ray spectrometry analysis of the rice samples for natural radioactivity was carried out by using Na(Tl) detector of radius(3(3.8cm) and thickness(2.5cm).The detector was interfaced to a PC-computer with a program installed for this purpose to make it equivalent to a multi-channel analyzer .The system also contains the usual electronic components of preamplifier, amplifier and power supply. The detector has resolution (FWHM) of (33.3keV) for the (1332 keV) γ-ray line of ^{60}Co. The γ-ray spectrometer energy calibration was performed using ^{137}Cs and ^{60}Co point source in a lead protected box ,then the concentration of natural radionuclides in these samples was determined from the peaks at 911 keV ^{228}Ac for ^{232}Th, the peak at 1460 keV for ^{40}K and the peak at 609keV(^{214}Bi)for ^{226}Ra .

The activity concentration of ^{226}Ra, ^{232}Th and ^{40}K was calculated using the following relation[16] :

$$A = \frac{\sum N - \sum B.G}{\varepsilon . I . t . m} \qquad (1)$$

A: The activity concentration

$\sum N$: The net peak area at energy E of radionuclides ^{226}Ra, ^{232}Th and ^{40}K at presence the samples.

$\sum B.G$: The net peak area at energy E of radionuclides ^{226}Ra, ^{232}Th and ^{40}K for background radiation at the absence the samples.

ε : Gamma efficiency evaluated in function of the transition energy.

I: The absolute intensity of transition.

t : The sample counting time 10800 sec.

m: The weight of the sample 0.9 kg.

III. RESULTS AND DISCUSSION

3.1. Activity concentrations of ^{232}Th, ^{40}K and ^{226}Ra

Table(1) shows the activity concentrations of the main natural radionuclides of the ^{238}U series , ^{232}Th series and ^{40} K in seven rice samples of Nineveh province (IRAQ).From table1, it is observed that, the activity concentration of ^{232}Th ranged from 13.67 Bq/kg (Kalrose sample) to 71.97 Bq/kg (Amber sample) with an average value of 39.11 Bq/kg, for the ^{226}Ra concentration ranged from 51.15 Bq/kg (Amber sample) to 109.26 Bq/kg (Kalrose sample) with an average value of 84.12 Bq/kg, and ^{40}K activity concentration ranged from 231.87(Kalrose sample) to 691.71Bq/kg (Amber sample) with an average value of 435.34 Bq/kg .

The average activity concentration of the present study of ^{232}Th is lower than the world average value of 45 Bq/kg, activity concentration of ^{226}Ra is higher than the world average of 32 Bq/kg, and the activity concentration of ^{40}K also higher than the world average of 412 Bq/kg [17]. Other observation of table1is the average activity concentration of ^{40}K is higher than the average activity concentration of ^{232}Th and ^{226}Ra.

The activity concentration of ^{232}Th , ^{226}Ra and ^{40}K of different samples of rice in Nineveh province are shown in figs.1, 2 and 3.

Table1: Activity Concentration in (Bq/kg) of ^{226}Ra, ^{232}Th and ^{40}K in rice samples investigated in this study

Sample No.	Sample Name	Origin	^{226}Ra	^{232}Th	^{40}K
1	Amber	IRAQ	51.15	71.97	691.71
2	Nawras	Turkey	80.82	43.31	483.22
3	Al-deek	Thailand	80.20	40.70	500.76
4	Mahmoud	India	86.75	53.73	331.24
5	Kalrose	America	109.26	13.67	231.87
6	Al-alah	Pakistan	73.45	32.56	502.71
7	Abu-alnessr	Uruguay	107.21	17.85	305.91
Average±S.D.	--------	----------	84.12± 19.99	39.11± 20.23	435.34± 155.89

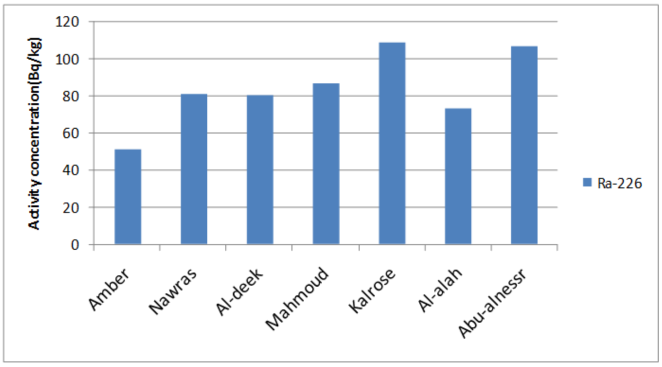

Fig.1: Activity concentration of ^{226}Ra in rice samples.

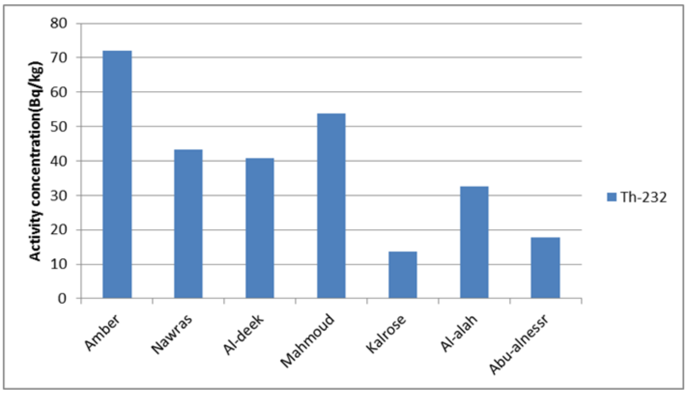

Fig.2: Activity concentration of ^{232}Th in rice samples

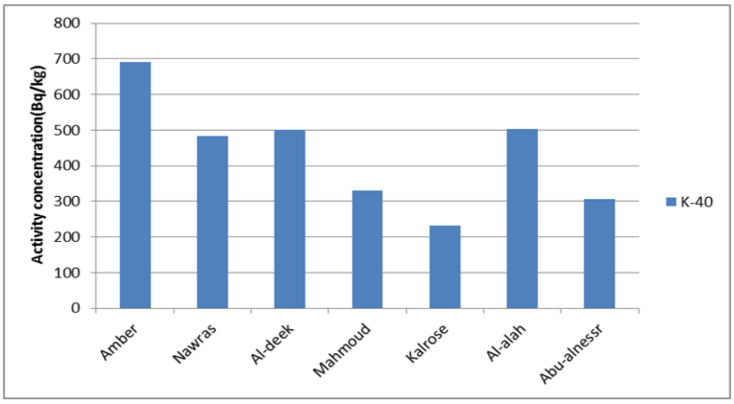

Fig.3: Activity Concentration of ^{40}K in rice samples

3.2 Radiological Parameters

3.2.1. Radium equivalent activity (Ra_{eq})

To represent the activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K by a single quantity, which takes into account the radiation hazards associated with them, a common radiological index has been introduced. The index is called radium equivalent activity (Ra_{eq}) which is used to ensure the uniformity in the distribution of natural radionuclides ^{226}Ra, ^{232}Th and ^{40}K and is given by the expression [18]:

$$Ra_{eq}\,(Bq/kg) = A_{Ra} + 1.43A_{Th} + 0.077A_K \qquad (2)$$

Where ,A_{Ra}, A_{Th} and A_K are the specific activities concentrations of ^{226}Ra,^{232}Th and ^{40}K in (Bq/kg) respectively.

The calculated values are varied from 146.67 Bq/kg (Kalrose sample) to 207.33Bq/kg (Amber sample) (table 2). These values with an average value of 173.52 Bq/kg are lower than the permissible maximum value of 370 Bq/kg [19].

3.2.2 Gamma Absorbed Dose Rate (D)

The total absorbed dose rate (nGy/h) in the outdoor at 1 m above the ground due to the activity concentrations,^{226}Ra, ^{232}Th and ^{40}K was calculated by using the following equation [10]:

$$D\,(nGy/h) = 0.462A_{Ra} + 0.604A_{Th} + 0.0417A_K \qquad (3)$$

The absorbed dose in the present study ranged from 68.47 nGy/h in (Kalrose sample) to 97.20 nGy/h in (Amber sample) with an average value of 81.24 nGy/h (table 2), which is higher than the permissible maximum value of 51 nGy/h reported by [10]. The relation between radium equivalent and gamma absorbed dose rate is shown in fig.4 below.

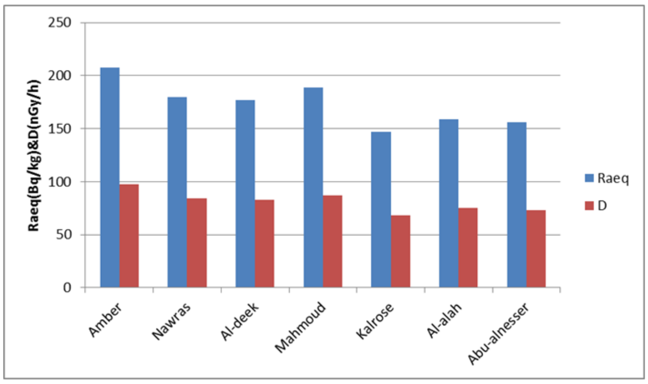

Fig.4: Radium Equivalent activity and Absorbed dose rate for rice samples.

3.2.3 External hazard index (H_{ex})

To limit the external gamma-radiation dose from building materials, an extensively used hazard index, the external hazard index (H_{ex}) was calculated from the equation [20].

$H_{ex} = A_{Ra}/370 + A_{Th}/259 + A_K/4810 \leq 1$ (4)

The values of outdoor radiation hazard index (H_{ex}) vary from 0.396 (Kalrose sample) to 0.559 (Amber sample) with an average value of 0.467 ,where all values of H_{ex} are less than the critical value of unity.

3.2.4 Internal hazard index (H_{in})

Radon and its short-lived products are also hazardous to the respiratory organs. So internal exposure to radon and its short-lived products is quantified by internal hazard index and is expressed mathematically as [21] :

$H_{in} = A_{Ra}/185 + A_{Th}/259 + A_K/4810 \leq 1$ (5)

The calculated values of H_{in} are ranged from 0.627 (Al-a'lah sample) to 0.745 (Mahmoud sample) with an average of 0.695, this is lower than the recommend limit.

The relation between the values of H_{ex} and H_{in} with rice samples is shown in fig.5 below.

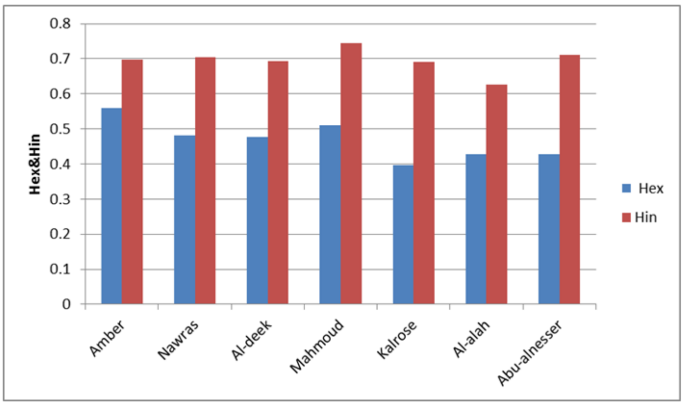

Fig.5: External and Internal hazard indices for rice samples.

3.2.5 Gamma Index (I_γ)

The gamma index (I_γ) for rice samples was calculated by using the following equation [22] :

$$I_\gamma = \frac{A_{Ra}}{150} + \frac{A_{Th}}{100} + \frac{A_K}{1500} \leq 1 \quad (6)$$

I_γ varies from 1.01 (Al-a'lah sample) to 1.52 (Amber sample), with an average value of 1.20.

The values of I_γ for all rice samples are higher than the critical value of unity.

3.2.6 Alpha index (I_α)

Also several indexes dealing with the assessment alpha radiation due to the radon inhalation. In the present study, the alpha index was determine through the following formula [23]:

$I_\alpha = A_{Ra}/200$

I_α varies from 0.255 (Amber sample) to 0.546 (Kalrose sample) with an average value of 0.420.

The values of I_α for all rice samples are less than unity.

The relation between the values of I_γ and I_α with rice samples is shown in fig.6 .

The values of radium equivalent activity (Ra_{eq}), gamma absorbed dose rate(D), external and internal hazard indices (H_{ex}, H_{in}), gamma index(I_γ) and alpha index are listed in table 2.

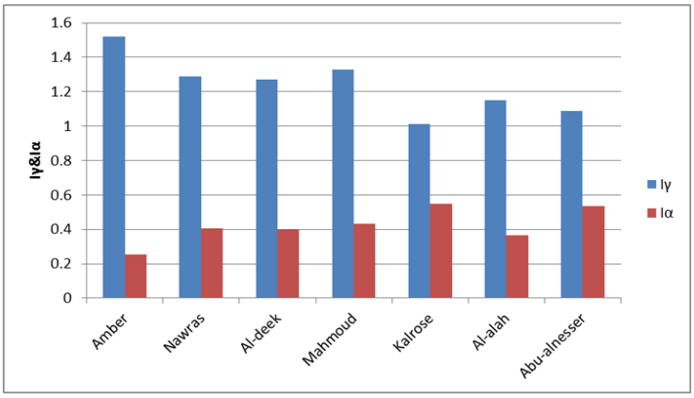

Fig.6: Gamma index (I_γ) and Alpha index (I_α) for rice samples.

Table 2: Radium equivalent activity, gamma absorbed dose rate, external hazard index, internal hazard index, gamma index and alpha index for rice samples consumed in IRAQ.

Sample No.	Sample name	Origin	R_{aeq} (Bq/kg)	D (nGy/h)	H_{ex}	H_{in}	I_γ	I_α
1	Amber	IRAQ	207.33	97.20	0.559	0.698	1.52	0.255
2	Nawras	Turkey	179.96	84.32	0.481	0.704	1.29	0.404
3	Al-deek	Thailand	176.97	83.16	0.478	0.694	1.27	0.401
4	Mahmoud	India	189.09	87.13	0.510	0.745	1.33	0.433
5	Kalrose	America	146.67	68.47	0.396	0.691	1.01	0.546
6	Al-alah	Pakistan	158.73	75.09	0.428	0.627	1.15	0.367
7	Abu-alnesser	Uruguay	155.9	73.36	0.428	0.710	1.09	0.536
Average±S.D.	--------	------	173.52±21.17	81.24±9.70	0.467±0.05	0.695±0.03	1.2±0.17	0.420±0.10

CONCLUSION

It is important to determine the activity concentration level in order to evaluate the health hazard. The results of the average activity concentrations of ^{226}Ra, and ^{40}K for seven rice samples collected of seven countries from Nineveh province (IRAQ) were higher than the permissible maximum values reported by the world average, but the average activity concentration of ^{232}Th was lower than the permissible maximum value reported by world average. The results of the present work values of average radium equivalent, average external hazard index, average internal hazard index and average alpha index were found to be lower than their corresponding allowed limits given by world average, while the average values of gamma absorbed dose rate and gamma index were higher than the allowed limits given by world average. It was found that rice consumption in Nineveh province (IRAQ) is radiologically safe for the presence of the investigated radionuclides.

REFERENCES

[1]. Alrefae Tareq and Nageswaran Tiruvachi, (2013), Radioactivity of long lived gamma emitters in rice consumed in Kuwait, Journal of the Association of Arab Universities for Basic and Applied Sciences 13,24-27.

[2]. Alrefae Tareq, Nageswaran Tirruvchi Natarajan, Al-Failakawl alaa and Al-Shemali Taher,(2012), Radioactivity of long lived gamma emitters in milk powder consumed in Kuwait and estimates of annual effective dose, Kuwait J. Sci. Eng., 39(1A),143-158.

[3]. IAEA(International Atomic Energy Agency), (2006), Environmental Consequences of Chernobyl Accident and their Remediation : Twenty Years of Experience , Vienna.

[4]. Ababeneh, Z.Q.,Alyassin,A.M.,Al jarrah,K.M., Ababneh, A.M., (2009), Measurement of natural and artificial radioactivity powered milk consumed in Jordan and estimates of the corresponding annual effective dose. Radiation Protection Dosimetry 138,278-283.

[5]. Alrefae,T.,(2012), Investigation of ^{238}U content in bottled water consumed in Kuwait and estimates of annual effective doses. Health Physics 102(1), 85-89.

[6]. Yu,K.N.,Mao,S.Y.,(1999), Assessment of radionuclide contents in food in Hong Kong .Health Physics 77,686-696.

[7]. Saeed,A.M., Wahab, N.A., Hossain ,I., Ahmed, R., Abdullah,H.Y.,Ramli,A.T.,Tahir,B.A.,(2011), Measuring radioactivity level in various types of rice using hyper pure germanium (HPGe) detector. International Journal of Physical Sciences 6(32),735-7340.

[8]. Myasoedov B.F., Pavlotskaya F.J.,(1999), Measurement of Radioactive Nuclides Environ. Analyst., 114-255.

[9]. Jibiri N.N., Emelue H.U., (2008), Soil radionuclide concentrations and radiological assessment in and around a refining and petrochemical company in warri, Niger Delta,Nigeria.J.Radiol Prot., 28(3) 361-368.

[10]. UNSCEAR (2000) United Nations Scientific Committee on the Effects of atomic Radiation, Sources and effects of ionizing radiation, vol.1,New York, United Nation Publication.

[11]. Hosseini t., Fathirand A.A., Barati H. and Karimi M., (2006) . Assessment of radionuclides in imported foodstuffs in Iran, Iran J. Radiat. Res., 4(3), 149-153.

[12]. Venturini,L. and Sordi ,G AA (1999). Radioactivity in and committed effective dose from some Brazilian foodstuffs. Health Phys.,76: 311-313.

[13]. Hosseini, T., Fathivand AA, Abbasisiiar F., Karimi M., Barati H(2006). Assessment of annual effective dose from ^{238}U and ^{226}Ra due to consumption of foodstuffs by inhabitants of Tehran City, Iran. Radiat. Prot. Dos. ,121(3) 330-332.

[14]. Ibrahim, N.M., Abd El Ghani, A.H., Shawky E.M., Ashraf, E.M.,& Farouk, M.A. (1993). Measurement of radioactivity levels in soils in the Nile delta and middle Egypt. Journal of Health physics, 64**,** 620-627.

[15]. Ramli, A.T. (2009). Assessment of Radiation Dose Rates in the High Physics terrestrial Gamma Radiation Area of Selama District, Perak, Malaysia Applied Research, 1**,** 45-52.

[16]. Al-Maqtary,K.,Murshed,M.,Bazohair,A.,& Al Zuhairy, M. (2008). Determination of radio nuclides for some local foodstuffs in republic of Yemen ,by using gamma rays spectral analysis technique. Abdhath AL-Yarmook: Basic Sci and Eng, 17,415-423.

[17]. UNSCEAR. (2008). Sources and effects of ionizing radiation. Report to the General Assembly. New York, United Nation.

[18]. Jose, A., Jorge, J., Cleomacio, M., Sueldo, V., &Romilton, S.(2005).Analysis of the ^{40}K Levels in Soil using Gamma Spectrometry. Brazilian Archives of Biology and Technology Journal, 221-228.

[19]. NEA-OECD.(1979) Nuclear Energy Agency (NEA) Paris

[20]. Xinwei, L. (2005). Natural radioactivity in some building materials of Xi'an, China. Radiation Measurements,40,94–97.

[21]. Berekta, J., & Mathew, P. J. (1985). Natural radioactivity in industrial waste and by product. Health Physics, 48, 87-95.

[22]. Kafala, S. I.,& Macmahon, T. D**.** (2007).Comparison of neutron activation analysis methods Radiation physics and chemistry,71,507-516.

[23]. Stoulos, S., Manolopoulou, M., Papastefanou, C. (2003). Assessment of Natural Radiation Exposure and Radon Exhalation from Building Materials in Greece. *J. Environ. Radioactivity*, 69: 225-240.