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EVALUATION OF EXCESSIVE LIFETIME CANCER RISK AND ANNUAL GONADAL EQUIVALENT DOSE DUE TO NATURAL RADIOACTIVITY IN VERMICELLI

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ABSTRACT

Vermicelli is one of the common foods made from grains and it is a type of pasta and is characterized by ease of preparation. In the current study, the concentrations of ^{226}Ra, ^{235}U, ^{232}Th and ^{40}K Bq/kg was estimated in fourteen different types of vermicelli samples selected from markets in Iraq. Sodium Iodide NaI (Tl) detector was used to measure the concentration of these radionuclides. The concentrations of ^{226}Ra, ^{235}U, ^{232}Th and ^{40}K Bq.kg^{-1} were estimated to be 1.119, 0.051, 0.386 and 8.524. On the other hand, the average value of Ra_{eq} was 2.328 ± 0.184 Bq.kg^{-1}. Radiation hazard index of RLI, $I_{á}$, I_{C}, AUI, H_{ex} and H_{in} have been calculated, and depends on the permission limits recommended by UNSCER is lower than the unity. Radiation doses D_R, H_E, $AEDE_{in}$, $AEDE_{out}$, AGED and AID, all these values were universally accepted. The risk of cancer ELCR were also estimated to be lower than the values allowed worldly. All data were statistically treated to find the correlation between them and calculate the p-value for all variables, the Pearson factor for comparison between most of the radiation parameters was of a strong positive and statistically significant relationship except (^{226}Ra with ^{232}Th and ^{40}K) was weak and statistically insignificant. All results were less than the permissible limits assessed by UNSCER.

KEY WORDS : Radiation hazard indices, Excessive Lifetime Cancer Risk, Annual gonadal equivalent, Vermicelli.

INTRODUCTION

In fact, the natural radiation comes from many sources, where the sources of natural radioactivity are divided into three main types: cosmic rays, radionuclides generated as a result of cosmic rays and radionuclides of terrestrial origin (Reedy *et al.*, 1983). Cosmic rays and the earth's atmosphere are included for example Tritium, Beryllium-7 and Carbon-14. In addition, the radionuclides generated as a result of cosmic rays come from the interaction between the radionuclide of cosmic and the earth atmosphere. On the other hand, terrestrial origin represents the dangerous part due to these radionuclide is touch with human (Watson *et al.*, 2005; Arndt *et al.*, 2013). Uranium -238 (^{238}U), Actinum-235 (^{235}U) and Thorium- 232 (^{232}Th) are the largest naturally occurring radioactive elements in the earth's crust, and the half-life of these elements is estimated at millions of years (Watson *et al.*, 2005). The radioactive materials present in nature differ according to the location, height above sea level, the nature of the soil, there was a large number of radionuclides, which has decayed with the passage of time (Eisenbud and Gesell, 1997). The radionuclides may emit either alpha or beta particles, may be taken into the body through ingestion or inhalation (Arndt *et al.*, 2013). Therefore, it is worth studying the radioactivity in commonly consumed foodstuffs and estimating the potential risk ratio in order to protect the health of the consumer vermicelli is traditional product was chosen to evaluation of cancer risk and annual gonadal equivalent dose in it. In addition to being one of the types of pasta, vermicelli is considered one of the most important common foods manufactured from grains, due to its ease of preparation, long shelf life, storage and low cost, where a traditional product prepared from wheat flour (the fiber in it makes up to 3.4%). Vermicelli is classified into five basic classes, relative to the raw materials from which it is made and various other additives, also the nutritional value of vermicelli, as it contains per 100 g (9 g of protein, 78 mg of carbohydrates, 22 mg of Calcium, 92 mg of phosphorous and 2 mg of Iron) (Arya *et al.,* 2016). Due to the large consumption of this food item, many studies about foods have been conducted, where the radioactivity was studied and estimation of risk factors for radionuclides for some types of foods such as pasta and the other food (Hamza *et al.,* 2020; Ziqiang *et al.,* 1988). Therefore, it is necessary to study this food item and calculate some important transactions related directly and significantly to human health, as well as in order for a database of vermicelli material to be available. The aims of this study to measure the radionuclide of ^{226}Ra, ^{235}U, ^{232}Th, and ^{40}K and then evaluation of excessive lifetime cancer risk and annual gonadal equivalent dose.

Collection and Preparation of Sample

Fourteen vermicelli samples collected from the markets, some of them local and imported as shown in Table 1. Five hundred grams were taken from each sample, then they were ground into a powder and stored in special containers. The samples were kept in containers for 1 month to confirm the radioactive equilibrium between the series of Uranium and Thorium and their short-lived progenies (Aswood *et al.,* 2019). After that, the samples were ready for measurement. The time to get the spectrum was 18000 seconds also all samples were placed in the physics laboratory at the Faculty of Education, University of Kufa, to be ready for measurement.

Table 1. Name of samples and its origin that were collected from the local markets

Origin	Name of sample	Code
Turkey	Cihan	VER_{01}
Iran	NC	VER_{02}
Iran	Mumayz	VER_{03}
Turkey	Alkis	VER_{04}
Iraq	Bararee	VER_{05}
Italy	Divella	VER_{06}
Iran	Zar	VER_{07}
Iran	Tawtak	VER_{08}
Thailand	Erawan	VER_{09}
Kuwait	Number 1	VER_{10}
Iran	Pirooz	VER_{11}
Pakistan	Suayan	VER_{12}
Italy	Durra	VER_{13}
Kuwait	Number 2	VER_{14}

Gamma- Ray Detection System

Concentrations of ^{226}Ra, ^{235}U, ^{232}Th and ^{40}K (Bq/Kg) are measured using Sodium Iodide NaI (Tl) detector. A lead shielding as the circulator which was 5 cm in thickness, 10 cm in inner diameter and 50 cm in high surrounded the detector to reduce the background radiation. Spectral data from the detector is accumulated and analyzed using computer software MAESTRO-32 model (A65- B32) provided by ORTEC. Standard sources, ^{22}Na, ^{137}Cs, ^{60}Co, ^{133}Ba and ^{152}Eu from the IAEA, set no. 34 were used to calibrate energy and measured the absolute efficiency. The concentration of natural radionuclides calculated by equation (1) (Adhab and Alsabari, 2020; Ajay *et al.*, 2008).

$$A = \frac{N_{net}}{\varepsilon . I_{\gamma} . m.t} \pm \frac{\sqrt{N_{net}}}{\varepsilon . I_{\gamma} . m.t} \quad .. (1)$$

where N_{net} represent the net count (area under the specified energy peak after back ground subtraction) in (c/s), $\sqrt{N_{net}}$ is the random error in (c/s), ε is the efficiency of the detector, I_γ is the transition probability of the emitted gamma ray, *t* is the time (18000 s) for spectrum collected, and *m* is the sample weight (Kg).

Radium equivalent activity (Ra_{eq})

This parameter is used to describe gamma output from different mixtures of ^{226}Ra, ^{232}Th and ^{40}K in substances. It was calculated using special equation depending on activity concentrations for ^{226}Ra, ^{232}Th and ^{40}K respectively (Salman *et al.,* 2020; Hussain, 2009; Aswood *et al.,* 2019) depending on the equation (2).

$$Ra_{eq} = A_{Ra} + 1.43A_{Th} + 0.077A_K \quad .. (2)$$

where, A_{Ra}, A_{Th} and A_k are the activity of ^{226}Ra, ^{232}Th and ^{40}K, respectively.

Gamma Radiation Representative level index (RLI)

To estimate the level of associated gamma radioactivity for the three nuclides known as the representative level index, which given by the following expression (UNSCEAR, 1994):

$$RLI = \frac{1}{150}A_{Ra} + \frac{1}{100}A_{Th} + \frac{1}{1500}A_K \quad .. (3)$$

Representative Alpha index (I_α)

Alpha index was calculated for the vermicelli samples were used the equation below (Ziqiang *et al.*, 1988):

$$I_\alpha = \frac{A_{Ra}}{200} \quad .. (4)$$

Gamma activity concentration index I_C

To estimate Gamma activity concentration index I_C (Bq/ Kg), the following equation was relied upon (Dallner, 2000):

$$I_c = \frac{A_{Ra}}{300} + \frac{A_{Th}}{200} + \frac{A_K}{3000} \quad .. (5)$$

Activity Utilization Index (AUI)

In order to calculate the dose rates from different groups of three radionuclides in vermicelli by applying the appropriate conversion the indices is estimated (AUI) which is given by the following expression (Kolo *et al.*, 2015):

$$AUI = f_{Ra}\frac{A_{Ra}}{50} + f_{Th}\frac{A_{Th}}{50} + f_K\frac{A_K}{500} \quad .. (6)$$

where *fRa*, *fTh* and f_K are the fractional contribution to the total dose rate in air due to gamma radiation from the actual concentration of ^{226}Ra , ^{232}Th and ^{40}K, respectively (Ramasamy *et al.*, 2011).

Internal and external radiation hazard indices (H_{in}, H_{ex})

The internal hazard index is used to control internal exposure to ^{222}Rn and its radioactive progeny in addition to external exposure to radon gas, dangerous for the respiratory system. They are calculated from activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K (Hussain *et al.*, 2010; Alhous *et al.*, 2020).

$$H_{in} = \frac{A_{Ra}}{185} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \quad .. (7)$$

$$H_{ex} = \frac{A_{Ra}}{370} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \quad .. (8)$$

Effective dose equivalent (H_E)

It was defined the effective dose equivalent and estimated from equation below (McCollough and Schueler, 2000).

$$H_E = W_T \times H_T \quad .. (9)$$

Where W_T is the weighting coefficient per tissue T, H_T is the dose equivalent to tissue. To estimate the absorbed dose rate in air (D_R) due to gamma-ray emissions from ^{226}Ra, ^{232}Th and ^{40}K in (nGy.h^{-1}), it was used in this equation (Chikasawa *et al.*, 2001).

$$DR = 0.427A_{Ra} + 0.662A_{Th} + 0.043A_K \quad .. (10)$$

The Annual Effective Dose Equivalent (AEDE)

The annual effective dose equivalent from indoor $AEDE_{in}$ and outdoor $AEDE_{out}$ exposure gamma radiation (mSv.y^{-1}), which can be calculated in this study, which is related with (D_R) absorbed dose rate measured in nGy.h^{-1} (UNSCEAR, 2000; Aswood *et al.*, 2017).

Annual Gonadal Equivalent Dose (AGED) and Annual Ingestion Dose (AID)

The reproductive gland is important due to its high sensitivity to radiation; it assumed great importance in the UNSCEAR 2000. Therefore, should calculate the annual gonadal equivalent dose (AGED) due to the specific activities of ^{226}Ra, ^{232}Th, and ^{40}K, in addition to the annual ingestion dose (AID) using the following formulas, respectively:

$$AGED = 3.09A_{Ra} + 4.18A_{Th} + 0.314A_K \quad .. (11)$$

$$AID = A + C + FDC_{ING} \quad .. (12)$$

where, A is the average of activity concentration (Bq. kg^{-1}) of ^{226}Ra, ^{232}Th, and ^{40}K, while the C is the consumption rate (3.3 kg. y^{-1}) and FDC_{ING} is the ingestion dose coefficient of the ^{226}Ra, ^{232}Th and ^{40}K which was 0.28, 0.23 and 0.0062 in (μSv. Bq^{-1}) respectively (UNSCEAR, 2000; Aswood *et al.*, 2017).

Excess Lifetime Cancer Risk (ELCR)

Excess lifetime cancer risk (ELCR) is calculated using the following equation (Hamza *et al.*, 2020; El-Arabi *et al.*, 2001):

$$ELCR = AID \times DL \times RF \quad .. (13)$$

where, DL and RF are life expectancy (70 years) and risk factor (0.055 Sv^{-1}) respectively.

Statistical analysis

Statistical analysis (Pearson's correlation analysis) to find out the interrelation among the parameters obtained from natural radionuclides and the p-value whether it is statistically significant or not, depending on 0.05. In this work main statistical software 'Statistical program for the Science (SPSS by windows system, standard version 20.0) was used for statistical analysis.

RESULTS AND DISCUSSION

In this study, the natural radioactivity of ^{226}Ra, ^{235}U, ^{232}Th and ^{40}K in vermicelli samples have been evaluated by using NaI (TI) detector technique. Table 2 represents the concentrations (Bq/Kg) of ^{226}Ra, ^{235}U, ^{232}Th, and ^{40}K, in addition to the radium equivalent activity (Ra_{eq}) in the vermicelli samples. The highest concentrations of ^{226}Ra, ^{235}U, ^{232}Th, and Ra_{eq} were in VER_{11} sample, Pirooz (Iran) 2.25±0.15, .10±0.01, 0.67±0.05 and 3.66±0.23 respectively. Whilst, the lowest concentrations were 0.40±0.06, 0.02±0.01, 0.18±0.02, and 1.37±0.13 respectively, in VER_{13} sample, Durra (Italy), with an averages value 1.12±1.10, 0.05±0.03, 0.39±0.03, and 2.33±0.18, respectively. On the other hand, the highest and lowest concentration of ^{40}K (Bq/Kg) were 12.31±0.37 and 2.93±0.18 in samples $VER_{10,}$ Number1 (Kuwaiti) and VER_{01}, Cihan (Turkish) respectively, with an average of (8.52±0.30). Depending on the internationally permissible limits, the concentrations of ^{238}U, ^{235}U, ^{232}Th, ^{40}K and Ra_{eq} are lower than the values reported by UNSCEAR, 2000.

Table 3, the concentration (ppm) of ^{226}Ra, ^{232}Th and ^{40}K and radiation hazard index of vermicelli samples were estimated. The highest value for concentration were 0.18, 0.16, and 396.25 for samples VER_{11} (Iranian) VER_{04} (Turkey) and VER_{10} (Kuwait) respectively, while the lowest concentrations were 0.03, 0.04, 94.33 in the sample VER_{13} (Italy) and in sample VER_{01} (Turkey), with an averages of 0.09, 0.10, 274.49, respectively. On the other side, radiation hazard index of RLI, $I_á$, I_c, AUI, H_{in} and H_{ex} were calculated. The results have been shown the averages of all the radiometric parameters of the studied samples in this study were 0.0170, 0.006, 0.009, 0.016, 0.010 and 0.006) for RLI, $I_á$, I_c, AUI, H_{in} and H_{ex} respectively. In this work, the exemption dose criterion (0.3 mSv/y) corresponds to an activity concentration index I_c d" 2, while the dose criterion of 1(mSv/y) is met for I_c d" 6. The results have been noted that the average value of all radiation hazard index is less than the global value (Nordic, 2000) (Chikasawa *et al.*, 2001; El-Arabi *et al.*, 2001; WHO, 2001).

Table 4 represents the results of radiological parameters for vermicelli samples. The average values of H_E, DR, $AEDE_{in}$ and $AEDE_{out}$, ELCR, AGED, and AID were 1.56 mSv, 1.12nGy/h, 0.005mSv/y, 0.001mSv/y, 5.6E-03, 7.75 µSv/y, and 5.01E-04 mSv/y respectively. All the results of radiological parameters were less than the global permissible value. On the other hand, the average of ELCR was less than 2.5 $\times 10^{-3}$ recommended by ICRP and WHO, (2011).

Table 5 represents the ratio between ^{226}Ra- ^{232}Th, ^{232}Th- ^{226}Ra, ^{226}Ra- ^{40}K and ^{232}Th- ^{40}K. It is difficult to determine the concentration of ^{235}U, (The natural abundance is low 0.72%) from natural Uranium. The possibility of alpha emission in Uranium- 235 is higher than Uranium- 238, so it is considered less

Table 2. Activity concentration (Bq/Kg) of ^{238}U, ^{235}U, ^{232}Th, ^{40}K and Ra_{eq}

ID	Activity Concentration				Ra_{eq}
	^{40}K	^{232}Th	^{235}U	^{226}Ra	
VER_{01}	0.93±0.09	0.04±0.03	0.31±0.03	2.93±0.18	1.59±0.15
VER_{02}	0.65±0.08	0.03±0.06	0.27±0.03	4.41±0.22	1.37±0.14
VER_{03}	0.84±0.09	0.04±0.01	0.51±0.04	6.57±0.27	2.08±0.17
VER_{04}	1.08±0.11	0.05±0.04	0.67±0.05	9.77±0.33	2.80±0.20
VER_{05}	1.36±0.12	0.06±0.08	0.42±0.04	6.87±0.28	2.49±0.19
VER_{06}	1.22±0.11	0.06±0.01	0.37±0.03	11.05±0.36	2.60±0.19
VER_{07}	0.92±0.09	0.04±0.02	0.23±0.03	7.70±0.29	1.85±0.16
VER_{08}	0.52±0.07	0.02±0.03	0.43±0.04	8.20±0.30	1.76±0.15
VER_{09}	1.03±0.10	0.05±0.01	0.49±0.04	7.70±0.29	2.31±0.18
VER_{10}	1.88±0.14	0.09±0.06	0.33±0.03	12.31±0.37	3.30±0.22
VER_{11}	2.25±0.15	0.10±0.01	0.41±0.04	10.66±0.35	3.66±0.23
VER_{12}	1.09±0.10	0.05±0.02	0.37±0.03	9.18±0.32	2.32±0.18
VER_{13}	0.40±0.06	0.02±0.01	0.18±0.02	11.56±0.36	1.54±0.13
VER_{14}	1.51±0.12	0.07±0.04	0.43±0.04	10.44±0.34	2.93±0.21
Average	1.12±1.10	0.05±0.03	0.39±0.03	8.52±0.30	2.33±0.18

stable and therefore the percentage of its presence in nature is much less than 238, it will was explain through the study of ratios**.** Where found the ratio between Uranium 235 to Uranium 238, and it was 0.0461 for the studied samples, and it is considered high compared to the global ratio (WHO, 2001). The calculated average of the ratios ^{226}Ra- ^{232}Th, ^{232}Th- ^{226}Ra, ^{226}Ra- ^{40}K and ^{232}Th- ^{40}K were (3.04, 0.36, 0.15 and 0.05). The highest average was for ratio ^{226}Ra- ^{232}Th. From 1.22 to 5.64 in samples (VER_{08} and VER_{10}) and ^{232}Th- ^{226}Ra ratio ranges from 0.17 to 0.82 in samples (VER_{10} and VER_{08}) respectively. While, the ratio between ^{226}Ra- ^{40}K and ^{232}Th- ^{40}K were range from 0.04 to 0.32 and from (0.02 to 0.10) in samples (VER_{13} and VER_{01}), respectively.

Pearson's correlation

Mutual relationships and the level of association that may exist among the calculated radiological variables were assessed through the calculation of Pearson's correlation coefficients and when applied to perform a statistical test a *p*-value helps us determine the significance of our results in relation to the null hypothesis. A *p*-value less than 0.05 are statistically significant. It indicates strong evidence against the null hypothesis, as there is less than a 5% probability the null is correct (and the results are random). The results of correlation matrix among the radiological variables for vermicelli samples are presented in Table 6. The results have shown a positive relationship between ^{226}Ra and ^{232}Th. On the

Table 3. Elemental concentration (ppm) and radiation hazard indices of Vermicelli samples.

ID	Elemental concentration (ppm)				Radiation hazard indices < 1				
	^{226}Ra	^{232}Th	^{40}K	AUI	$I_á$	I_c	AUI	H_{in}	H_{ex}
VER_{01}	0.08	0.08	94.33	0.011	0.005	0.006	0.013	0.007	0.004
VER_{02}	0.05	0.07	141.86	0.010	0.003	0.005	0.010	0.006	0.003
VER_{03}	0.07	0.13	211.68	0.015	0.004	0.008	0.015	0.008	0.005
VER_{04}	0.09	0.17	314.55	0.020	0.005	0.010	0.019	0.010	0.007
VER_{05}	0.11	0.10	221.33	0.018	0.007	0.009	0.018	0.010	0.006
VER_{06}	0.10	0.09	355.77	0.019	0.006	0.010	0.017	0.010	0.007
VER_{07}	0.07	0.06	248.07	0.014	0.005	0.007	0.012	0.008	0.005
VER_{08}	0.04	0.10	264.04	0.013	0.003	0.007	0.011	0.006	0.004
VER_{09}	0.08	0.12	248.07	0.017	0.005	0.008	0.016	0.009	0.006
VER_{10}	0.15	0.08	396.25	0.024	0.009	0.012	0.022	0.014	0.008
VER_{11}	0.18	0.10	343.14	0.026	0.011	0.013	0.027	0.016	0.009
VER_{12}	0.09	0.09	295.61	0.017	0.006	0.009	0.015	0.009	0.006
VER_{13}	0.03	0.04	372.11	0.012	0.002	0.006	0.007	0.005	0.004
VER_{14}	0.12	0.10	336.09	0.021	0.008	0.011	0.020	0.012	0.007
Average	0.09	0.10	274.49	0.017	0.006	0.009	0.016	0.010	0.006

Table 4. Radiological parameters of ^{226}Ra, ^{232}Th and ^{40}K

ID	H_E*10^{-3} (mSv)	DR (nGy/h)	$AEDE_{in}$ (mSv/y)	$AEDE_{out}$ (mSv/y)	ELCR	AGED*10^{-3} (µSv/y)	AID (mSv/y)
VER_{01}	1.02	0.74	0.004	0.001	1.3E-03	5.08	3.84E-04
VER_{02}	0.90	0.65	0.003	0.001	3.4E-03	4.51	2.97E-04
VER_{03}	1.36	0.98	0.005	0.001	5.0E-03	6.79	4.32E-04
VER_{04}	1.84	1.32	0.007	0.002	6.6E-03	9.22	5.70E-04
VER_{05}	1.62	1.18	0.006	0.001	6.6E-03	8.11	5.72E-04
VER_{06}	1.76	1.25	0.006	0.002	6.3E-03	8.79	5.45E-04
VER_{07}	1.25	0.89	0.004	0.001	4.6E-03	6.23	3.95E-04
VER_{08}	1.19	0.85	0.004	0.001	3.7E-03	5.96	3.24E-04
VER_{09}	1.51	1.10	0.005	0.001	5.7E-03	7.62	4.92E-04
VER_{10}	2.21	1.59	0.008	0.002	8.6E-03	11.05	7.46E-04
VER_{11}	2.40	1.74	0.009	0.002	1.0E-02	12.02	8.69E-04
VER_{12}	1.56	1.12	0.005	0.001	5.7E-03	7.79	4.92E-04
VER_{13}	1.12	0.78	0.004	0.001	2.9E-03	5.61	2.47E-04
VER_{14}	1.95	1.40	0.007	0.002	7.5E-03	9.74	6.46E-04
Average	1.56	1.12	0.005	0.001	5.6E-03	7.75	5.01E-04

Table 5. The ratio between ^{226}Ra, ^{232}Th and ^{40}K in the vermicelli samples

ID	^{226}Ra- ^{232}Th	^{232}Th- ^{226}Ra	^{226}Ra- ^{40}K	^{232}Th- ^{40}K
VER $_{01}$	3.05	0.33	0.32	0.10
VER $_{02}$	2.39	0.42	0.15	0.06
VER $_{03}$	1.63	0.61	0.13	0.08
VER $_{04}$	1.61	0.62	0.11	0.07
VER $_{05}$	3.21	0.31	0.20	0.06
VER $_{06}$	3.28	0.31	0.11	0.03
VER $_{07}$	3.99	0.25	0.12	0.03
VER $_{08}$	1.22	0.82	0.06	0.05
VER $_{09}$	2.12	0.47	0.13	0.06
VER $_{10}$	5.64	0.18	0.15	0.03
VER $_{11}$	5.41	0.18	0.21	0.04
VER $_{12}$	2.97	0.34	0.12	0.04
VER $_{13}$	2.29	0.44	0.04	0.02
VER $_{14}$	3.55	0.28	0.15	0.04
Max.	5.64	0.82	0.32	0.10
Min.	1.22	0.18	0.04	0.02
Ave.	3.04	0.36	0.15	0.05
World-wide[29]	0.86	11.43	-	-

other hand, the correlation matrix among the radiological variables for vermicelli noted that the Pearson coefficient for ^{226}Ra with ^{232}Th is poorly correlated and not statistically significant despite of relationship is expected owing to the fact that radium and thorium decay series have an existence in nature (Ravisankar *et al.*, 2014), whilst, the ^{40}K Moderate association and also not statistically significant. As for the relationship of ^{226}Ra to each of $D_{R,}$ $Ra_{eq,}$ $H_{ex,}$ $H_{in,}$ RLI, AUI, $I_{c,}$ AGED, $H_{E,}$ AID and ELCR. They have a strong correlation, where the Pearson value is close to one and is statistically significant, while with $I_{á}$ Perfect positive association statically.

Pearson coefficient for ^{232}Th with ^{40}K is very weak and it is not statistically significant while with (DR, R_{aeq}, H_{ex}, RLI, H_{in}, AGED, H_E and I_c) Moderate association and not statistically significant while with (H_{in}, $I_{á}$, AID and ELCR) weak association is not statistically significant. Also from the results have been observed the relationship of ^{40}Kwith (D_R, R_{aeq}, H_{ex}, RLI, I_C and H_E) Strong and statistical relationship and with (H_{in}, AUI, $I_{á}$, AID and ELCR) Moderate association and not statistically significant. DR has a very strong and statistical positive correlation with (Ra_{eq}, H_{in}, H_{ex}, AUI, $I_{á}$, AID and ELCR). They has completed and statistical positive correlation with (RLI, I_C, AGED and $H_{E.}$ R_{aeq} has a very strong and statistical positive correlation with H_{in}, AUI, $I_{á}$, RLI, I_C, AGED, H_E, AID and ELCR, while, the perfect positive association with H_{ex} also statistically significant H_{in}. It must also be noted that the internal relationship is a very strong and statistically important correlation ($H_{ex,}$ RLI, AUI, $I_{C,}$ $I_{á}$, AGED, H_E, AID and ELCR). H_{ex} must also be noted that the internal relationship is a very strong and statistically important correlation (RLI, AUI, I_C $I_{á}$, AGED, H_E, AID and ELCR). Correlation of RLI is very strong and statistically significant with (AUI, $I_{á}$, AID and ELCR) while, it has a complete and statistical positive correlation with (I_C, AGED and H_E). AUI must also be noted that the internal relationship is a very strong and statistically important correlation ($I_{C,}$ $I_{á}$, AGED, H_E, AID and ELCR). I_C Correlation is very strong and statistically significant with ($I_{á}$, AID and ELCR) while with (AGED and H_E) is perfect positive association. $I_{á}$ with (AGED, H_E, AID and ELCR) is very strong and statistically significant. AGED has a complete and statistical positive correlation with (H_E) and very strong and statistically significant with (AED and ELCR). In the end, it must be noted (H_E), it has a very strong statistical relationship with (AID and ELCR).While the relation between AID and ELCR is perfect positive association.

CONCLUSION

In the current study, the samples reveal low values for radionuclide concentrations of ^{226}Ra, ^{235}U, ^{232}Th and ^{40}K, thus contributing to the low absorbed dose rates in the air. In general, the calculated radionuclides in terrestrial source have given lower concentrations than in the recent UNSCEAR 2008 report. The average values of AGED and AIG, ELCR are less than the world average value recommended 0.29 mSv/y as mentioned in UNSCEAR 2000). Internal and external radiation hazard indices are less than the unity as they mentioned in UNSCEAR 2000. The obtained ratio ^{226}Ra - ^{232}Th and ^{232}Th – ^{226}Ra concentration ratio is low compared to global ratio of food except for ^{226}Ra - ^{232}Th, it was above international values. Through the use of the statistical program for the science was used for statistical analysis (Pearson's Correlation) have been found, the strong relationship, depend of the results, the vermicelli samples were safe.

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Table 6. Pearson's Correlation and p-value on matrix of radioactive parameters of studies samples

Parameters	^{226}Ra	^{232}Th	^{40}K	DR	Ra_{eq}	H_{in}	H_{ex}	RLI	AUI	Ic	$I_á$	AGED	H_E	AID	ELCR
^{226}Ra	1														
^{232}Th	.226	1													
p-value	.437														
^{40}K	.426	.060	1												
p-value	.129	.840													
D_R	.923**	.424	.670**	1											
p-value	.000	.131	.009												
Ra_{eq}	.929**	.448	.637*	.999**	1										
p-value	.000	.108	.014	.000											
H_{in}	.976**	.360	.557*	.984**	.987**	1									
p-value	.000	.206	.039	.000	.000										
H_{ex}	.929**	.448	.637*	.999**	1.000**	.987**	1								
p-value	.000	.108	.014	.000	.000	.000									
RLI	.911**	.437	.684**	1.000**	.998**	.978**	.998**	1							
p-value	.000	.118	.007	.000	.000	.000	.000								
AUI	.960**	.486	.433	.959**	.971**	.983**	.971**	.953**	1						
p-value	.000	.078	.122	.000	.000	.000	.000	.000							
Ic	.911**	.437	.684**	1.000**	.998**	.978**	.998**	1.000**	.953**	1					
p-value	.000	.118	.007	.000	.000	.000	.000	.000	.000						
$I_á$	1.000**	.226	.426	.923**	.929**	.976**	.929**	.911**	.960**	.911**	1				
p-value	.000	.437	.129	.000	.000	.000	.000	.000	.000	.000					
AGED	.914**	.415	.693**	1.000**	.997**	.979**	.997**	1.000**	.950**	1.000**	.914**	1			
p-value	.000	.140	.006	.000	.000	.000	.000	.000	.000	.000	.000				
HE	.923**	.424	.670**	1.000**	.999**	.984**	.999**	1.000**	.959**	1.000**	.923**	1.000**	1		
p-value	.000	.131	.009	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000		
AED	.980**	.391	.498	.973**	.980**	.997**	.980**	.966**	.993**	.966**	.980**	.966**	.973**	1	
p-value	.000	.167	.070	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000		
ERLC	.980**	.391	.498	.973**	.980**	.997**	.980**	.966**	.993**	.966**	.980**	.966**	.973**	1.000**	1
p-value	.000	.167	.070	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	

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Ethical statement

This article does not contain any studies involving human participants performed by any of the authors.

Conflict of Interest

The authors declare that they have no conflicts of interest.

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