Estimation Radiological Hazard Parameters In ingestion of foods in Rumaila area - north of Basra , southern Iraq.

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Abstract

Three radionuclide (^{238}U,^{232}Th and ^{40}K) were calculated in 19 food samples by a gamma ray detector for the Rumaila area , north of Basra governorate, southern Iraq. The highest activity value of ^{238}U is 2.031± 0.522 Bq/Kg in Eggplant , of ^{232}Th in Jew's mallow is 10.502 ± 0.907 Bq/Kg and of ^{40}K in Jew's mallow is 697.279 ± 21.100 Bq/Kg, the least activity value of ^{238}U is 0.058 ± 0.030 Bq/Kg in cowpeas, of ^{232}Th is 0.032 ± 0.032 Bq/Kg in orange, and of ^{40}K is 6.896 ± 1.625 Bq/Kg in Fish.

Keywords: ORTEC foodGuard-1 , Radioactive isotopes, Activity concentrations

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Introduction

Natural radionuclides-radioactive isotopes of elements, can be found in human bodies, food, and water. Radioactive waste in the environment by weapons manufacturers, civilian nuclear operations, military training centers, and nuclear research centers. Radioactivity can contaminate food and water.

Nuclear waste, whether man-made or natural, goes through into the food webs in about the same ways that non -radioactive object does, the amount of harm to human health can be determined according to the type of radionuclide and the time of exposure. The amount of exposure people to radiation varies according to the place in which they live.

A combination of radionuclides created inside the reactor, commonly known as "nuclear fission products," might contaminate land, lakes, seas, and building in the area of the power plant. As a result, individuals may be exposed to radiation from these fission products (Winteringham *et al*, 1989).

In the oil and gas industry, natural radioactive materials accumulate in heads of various children, such as well heads, pumps, and vessels. The accumulations have taken the form of scales, sludge and some other wastes. Work procedures and practices for these procedures and professional practices (Fisher *et al*, 1989).

Study area

Rumaila area which located at nourth Basra city at latitude N 30°34'23.3'' E047°21'02.4'' southern Iraq.

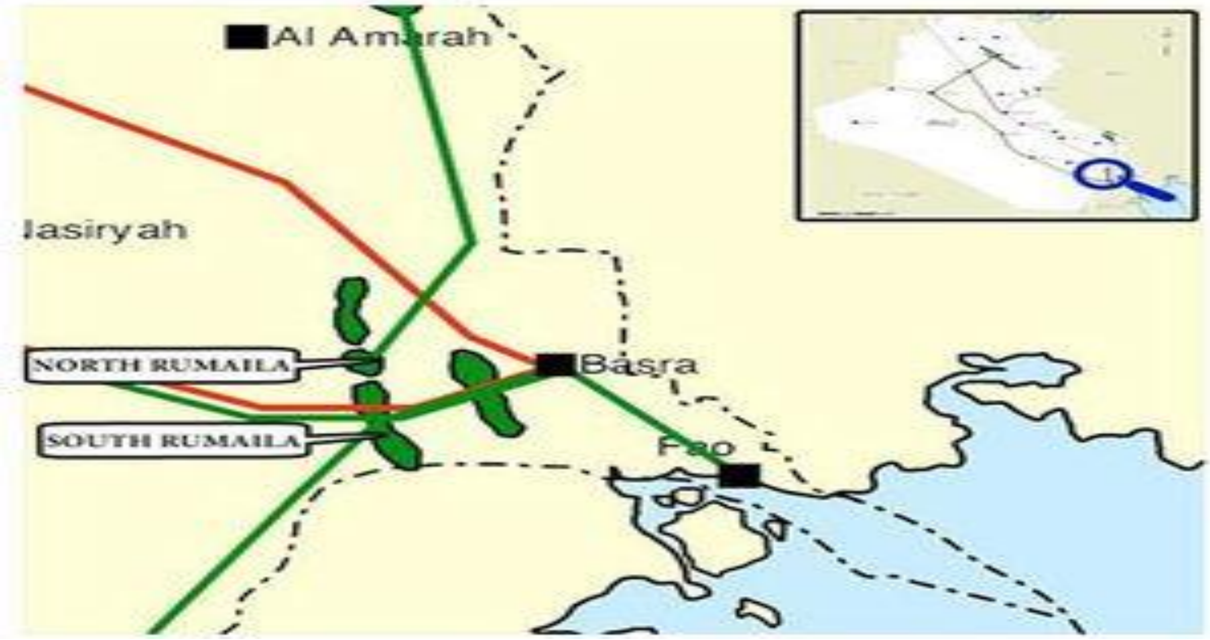

Figure (1) :AL-Rumalia area north Basra .

Rumaila contains the largest giant oil fields in the world, which extract more than one billion barrels of oil, Some sites must treat their waste management on an ongoing basis, such as water treatment, disposal of wells and burning bits. The industries of the Rumaila oil field, which located southern Iraq, is one of Iraq's largest industries for gas and oil. Natural radioactive materials (NORM) during the production process flow together with the oil and gas mixture in an accumulating form or form a thin film on the inner surfaces equipment and vessels. This affects the level of NORM accumulation (Ali *el at* , 2017).

Sample collection and preparation

Nineteen samples vegetables, leafy vegtables, fruits and meat are collected from the study area as shown in Table (1). All samples are cleansed with regular water and weighed as fresh (wet) for human consumption . After that, they are kept in a moisture-free oven for (1-10) days at 50°C to achieve a consistent weight and eliminate any humidity absorption before the radioactivity detection, after that ,the samples are electronically crushed by using an electric mill to ensure homogeneity (the loss ratio of samples when filtering is very low). To achieve a good homogeneity around the NaI (Tl) detector, the weight of the samples is determined by using a digital weighing balance ; then, each sample is put in a nylon bag which is tagged with it's name ,weight and city name. Store for a month to achieve radiological balance.

Table (1) : Foods categories samples.

No.	Name	Trade Name	Scientific Name	Code of Samples
1	Meat	Fish	Pisces	M1
		Chicken	Gallus gallus	M2
2	Vegetables	Cucumber	Cucumis sativus	V1
		Okra	Abelmoschus esculentus	V2
		Cayenne pepper	Capsicum annuum	V3

		Sweet pepper	Capsicum annuum	V4
		Eggplant	Solanum melongena	V5
		Cowpeas	Pumpkin	V6
3	Leafy Vegtables	Basil	Ocimum basilicum	L.V1
		Jew's mallow	Corchorus olitorius	L.V2
4	Fruits	Pomegranate	Punica granatum	F1
		Fig	Ficus carica	F2
		Orange	Citrus sinensis	F3
		Tangerine	Citrus reticulata	F4
		Pomelo	Citrus maxima	F5
		Bitter orange	Citrus aurantium	F6
5	Date	Khistawi Variet	Phoenix dactylifera	D1
		Zahdi Variety		D2
		Barben Variey		D3

The system used to detect

ORTEC foodGuard-1 Sodium Iodide is the company that designed the reagent shown in the Figure below (2) that examines all types of solid or liquid food and detects the extent of its contamination with radioactive materials.

FoodGuard-1 is primarily designed for a 'frontline' response.

1- The counting is highly efficient and the sampling method is easy.

2- It displays the spectra and intuitive programming and a high degree of accuracy and stores the results.

3- The results can be obtained by calculations such as the percentage of maximum allowable concentration.

4- It can be moved from one place to another

5- The device is easily calibrated and contains containers for examining samples (PEKŞEN *et al*, 2021).

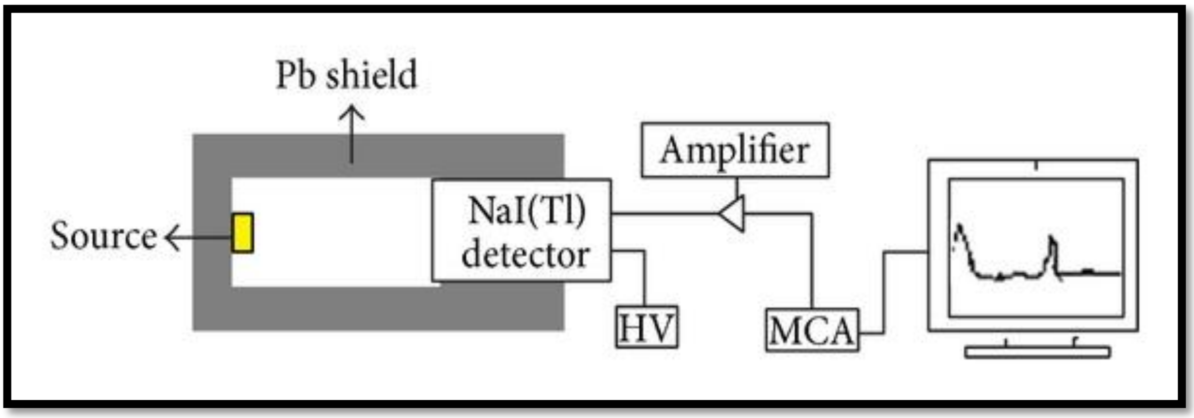

Figure (2): The diagram of the NaI(Tl) detector.

Mathematical Formula

The secular steady-state characteristic of the decay products is used to determine the activity of ^{238}U and ^{232}Th, such as ^{214}Bi (1764 KeV) and ^{208}Tl (2614 KeV), straight, while the highest peak reached about 1460 kilovolts, which is used to derive ^{40}K (Yousef *et al*, 2007). The time used to measure each sample is 18000 seconds.

1. Activity Concentrations

The following Equation (1) is used to extract the values of the activity concentrations radionuclides for measured samples (Knoll , 2010):

$$A\ (Bq/Kg) = N/(\varepsilon .t \cdot I\gamma \cdot M) \pm \sqrt{N}/(\varepsilon .t \cdot I\gamma \cdot M) \quad (1)$$

a: activity in (Bq/Kg), N: peak energy represents the area under peak, t: time taken to detect each sample in seconds Iγ: gamma emission potential, m: sample weight (Kg). ε: efficiency for detection gamma energy of the detector .

2. Radiological Hazard Parameters

The theoretical equations that used in the calculation of activity concentration and risk factors of radioactivity are :

A. Absorbed Dose Rate in Air (AD)

One way to determine external exposure to natural radionuclide radiation is to calculate the dose rate absorbed air at a height of 1m above the ground as in the Equation (2) for each activity concentration in Bq/L correspond to 0.462 nG/h for ^{226}Ra, 0.621 nG/h for ^{232}Th and 0.0417 nG/h for ^{40}K (Jose *et al*, 2005).

$$AD\ (nGy/h) = 0.462*A_U + 0.621*A_{Th} + 0.0417*A_K \quad (2)$$

where AD: is the dose average , A_U , A_{Th} and A_K are the effictivity concentration of ^{238}U, ^{232}Th, and ^{40}K.

B. Annual Effective Dose (AED)

This dose coming from consumption of food samples , and its determined by the formula (3) (Giri *et al*, 2013):

$$AED = AD* R* F \quad (3)$$

Where: AED = annual effective dose (μSv/y), AD : absorbed dose (Bq/Kg). R : Consumption rates of foods (Kg/year), F : ingestion dose conversion factor .

C. Radium Equivalent Activity (Ra_{eq})

Radium Equivalent Activity is the most important to assess radiation hazards which can be expressed by relation (Yu *et al*,1992):

$$Ra_{eq}\ (Bq/Kg) = A_U + 1.43A_{Th} + 0.077\ A_K \quad (4)$$

Where A_U, A_{Th}, A_K the specific activity levels (Bq/Kg) of ^{226}Ra, ^{232}Th and ^{40}K respectively**.**

D. Internal Radiation Hazard (H_{in})

The internal risk value arising from a short period of food can be calculated as relation (5) (Beretka *et al*, 1985):

$$H_{in} = A_U/185 + A_{Th}/259 + A_K/4810 \quad (5)$$

If the value of the internal risk is less than one, it is within the permissible limits globally, and it is safe and does not constitute any danger.

E. Activity Concentration Index (I_γ)

A factor referring to the level of radioactivity that can be estimated the radiation inside the human body and the extent of the radionuclide hazard in human body after exposure an amount of internal effective annual doses . Estimated values of Iɣ must be less than or equal to one. Iɣ values were calculated from Equation (9) (Shams *et al,*2013):

$$I_\gamma\ (Bq/Kg) = A_U/150 + A_{Th}/100 + A_K/1500 \quad (6)$$

Results and Discussions

Table (2) and Fig.(3) display the specific activity value of ^{238}U, ^{232}Th, and ^{40}K in food for 19 samples are collected from Al-Rumaila area which is located at nourth of Basra city with an average of ^{238}U 0.648 ± 0.211 Bq/Kg , for range 0.058 ± 0.030 Bq/Kg to 2.031 ± 0.522 Bq/Kg ,the average of ^{232}Th 1.145 ± 0.178 Bq/Kg with a range 0.032 ± 0.032 Bq/Kg to 10.502 ± 0.907 Bq/Kg . The specific activity of ^{238}U and ^{232}Th within the allowed limit. The average of ^{40}K 229.041 ± 7.742 Bq/Kg from 6.896 ± 1.625 Bq/Kg to 697.279 ± 21.100 Bq/Kg. The specific activity of ^{40}K values are higher than worldwide median value in (okra, cayenne pepper , basil and jew's mallow) .

Table (2): The specific activity of ^{238}U, ^{232}Th, and ^{40}K for food samples from Rumaila area, Basra.

No.	Code of Samples	Country	Specific Activity (Bq/Kg)		
			^{238}U	^{232}Th	^{40}K
1	M1	Iraq	0.075 ± 0.085	0.846 ± 0.199	6.896 ± 1.625
2	M2	Iraq	0.751 ± 0.068	0.744 ± 0.151	367.755 ± 9.641
3	V1	Iraq	1.452 ± 0.428	1.116 ± 0.263	160.245 ± 9.000
4	V2	Iraq	0.115 ± 0.074	0.237± 0.075	**563.757 ± 10.447**
5	V3	Iraq	0.554 ± 0.278	0.137 ± 0.097	**410.440 ± 15.159**
6	V4	Iraq	2.003 ± 0.474	1.268 ± 0.264	310.043 ± 11.803
7	V5	Iraq	2.031 ± 0.510	1.258 ± 0.281	169.166 ± 9.312
8	V6	Iraq	0.058 ± 0.031	0.104 ± 0.029	64.792 ± 2.061
9	L.V1	Iraq	0.127 ± 0.116	0.262 ± 0.117	**528.757 ± 15.047**
10	L.V2	Egypt	1.708 ± 0.522	10.502 ± 0.907	**697.279 ± 21.100**
11	F1	Iraq	0.318 ± 0.126	0.518 ± 0.113	336.818 ± 8.229
12	F2	Iraq	0.140 ± 0.070	0.086 ± 0.038	133.406 ± 4.346
13	F3	Iraq	0.424 ± 0.168	0.032 ± 0.032	39.072 ± 3.233
14	F4	Iraq	0.740 ± 0.245	0.797 ± 0.178	10.074 ± 1.809
15	F5	Iraq	1.130 ± 0.277	0.366 ± 0.110	129.288 ± 5.925
16	F6	Iraq	0.267 ± 0.134	0.397 ± 0.114	113.772 ± 5.538
17	D1	Iraq	0.560 ± 0.177	0.083 ± 0.048	18.763 ± 2.059
18	D2	Iraq	0.393 ± 0.127	0.731 ± 0.121	110.347 ± 4.272
19	D3	Iraq	0.138 ± 0.089	2.262 ± 0.254	181.049 ± 6.499
Av.			0.648 ± 0.211	1.145 ± 0.178	229.041 ± 7.742
Min.			0.058 ± 0.030	0.032 ± 0.032	6.896 ± 1.625
Max.			2.031 ± 0.522	10.502 ± 0.907	697.279 ± 21.100
World wide median value (Unscear *et al*, 2000).			35	30	400

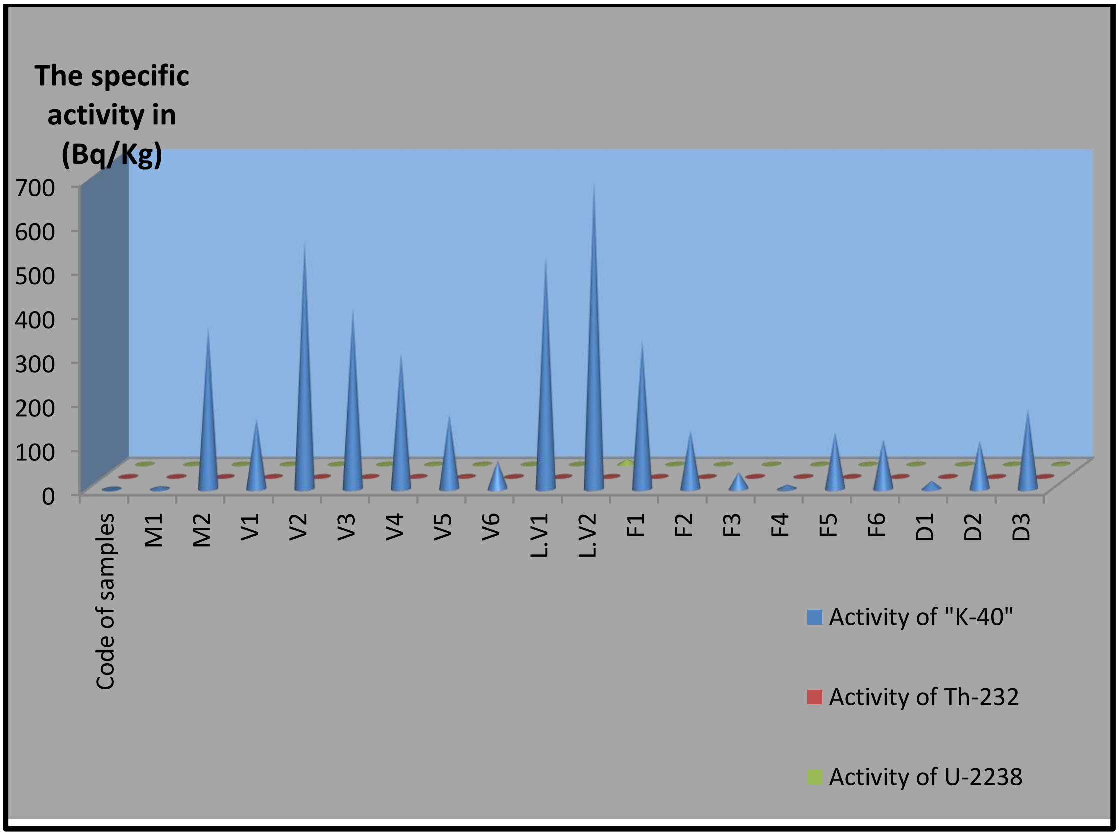

Figure (3): The specific activity in (Bq/Kg) of (^{238}U, ^{232}Th, and ^{40}K) for food samples from Rumaila area, Basra.

The level of health risks which consumers of the food analysed in the study could be exposed to was estimated, the radium equivalent was calculated Rumaila area, Basra, as shown in Table (3) and Fig. (4) show radium equivalent values of food samples from Rumaila area, Basra. with an average 19.921 ± 28.683 Bq/Kg, for range 1.817 ± 2.804 Bq/Kg to 70.417 ± 101.644 Bq/Kg ;the radium equivalent values within the allowed limit worldwide median value 370 Bq/Kg ,the average of absorbed dose rate values which are 9.018 ± 0.423 nGy/h with a range 0.848 ± 0.201 nGy/h to 36.387 ± 1.191 nGy/h so the absorbed dose rate within the allowed limit worldwide median value 55 nGy/h as seen in Fig.(5), the average of Internal radiation hazard value is 0.055 ± 0.003 Bq/Kg with a range 0.005 ± 0.001 Bq/Kg to 0.194 ± 0.010 Bq/Kg, so all samples within the allowed limit that is less than one as shown in Fig.(6) .

Table (3): Radium equivalent , absorbed dose rate and internal radiation hazard of food samples from Rumaila area, Basra.

No.	Code of Samples	Radium equivalent (Ra_{eq}) (Bq/kg)	Absorbed dose rate (AD) (nGy/h)	Internal radiation hazard (H_{in}) (Bq/kg)
1	M1	1.817 ± 2.804	0.848 ± 0.201	0.005 ± 0.001
2	M2	29.457 ± 42.280	15.832 ± 0.597	0.079 ± 0.002
3	V1	15.388 ± 22.302	8.046 ± 0.619	0.045 ± 0.005
4	V2	43.864 ± 62.806	23.709 ± 0.530	0.118 ± 0.002

5	V3	32.355 ± 46.386	17.457 ± 0.925	0.088 ± 0.005
6	V4	27.691 ± 39.899	14.642 ± 0.886	0.080 ± 0.006
7	V5	16.857 ± 24.426	8.774 ± 0.642	0.051 ± 0.005
8	V6	5.197 ± 7.463	2.793 ± 0.173	0.0141 ± 0.001
9	L.V1	41.222 ± 59.074	22.273 ± 1.244	0.111 ± 0.004
10	L.V2	70.417 ± 101.644	36.387 ± 1.191	0.194 ± 0.010
11	F1	26.995 ± 38.725	14.514 ± 0.425	0.073 ± 0.002
12	F2	10.536 ± 15.112	5.681 ± 0.234	0.028 ± 0.001
13	F3	3.479 ± 5.022	1.845 ± 0.323	0.010 ± 0.001
14	F4	2.657 ± 3.996	1.845 ± 0.323	0.009 ± 0.002
15	F5	11.610 ± 16.734	1.257 ± 0.257	0.034 ± 0.003
16	F6	9.595 ± 13.846	6.141 ± 0.446	0.026 ± 0.002
17	D1	2.123 ± 3.098	5.114 ± 0.322	0.007 ± 0.001
18	D2	9.935 ± 14.339	1.092 ± 0.243	0.027 ± 0.002
19	D3	17.314 ± 25.021	5.237 ± 0.395	0.047 ± 0.002
Av.		19.921 ± 28.683	9.018 ± 0.423	0.055 ± 0.003
Min.		1.817 ± 2.804	0.848 ± 0.201	0.005 ± 0.001
Max.		70.417 ± 101.644	36.387 ± 1.191	0.194 ± 0.010
World wide median value		> 370 (Al-Saleh *et al*, 2007).	55(UNSCEAR,1982).	>1(Al-Saleh *et al*, 2007).

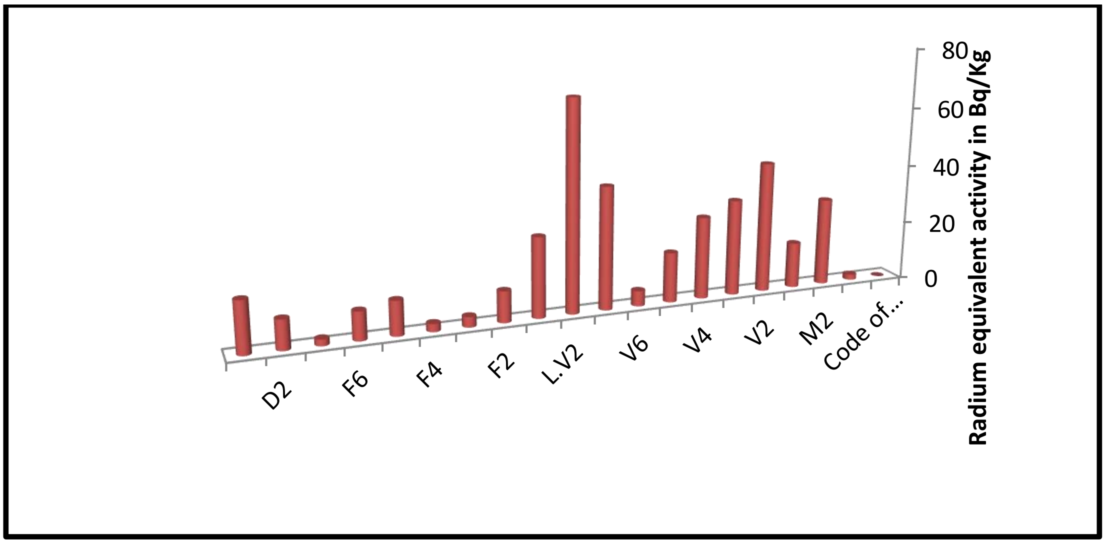

Figure (4):Radium equivalent activity in (Bq/Kg) of food samples from Rumaila area, Basra

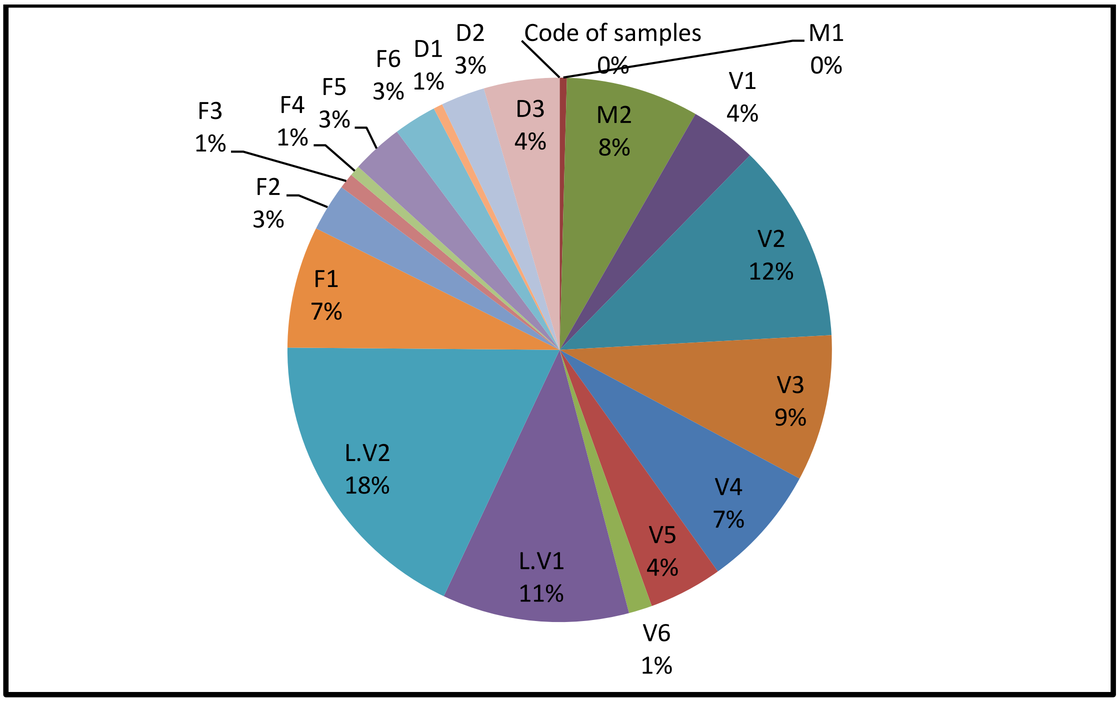

Figure (5): Absorbed dose rate in (nGy/h) of food samples from Rumaila area, Basra.

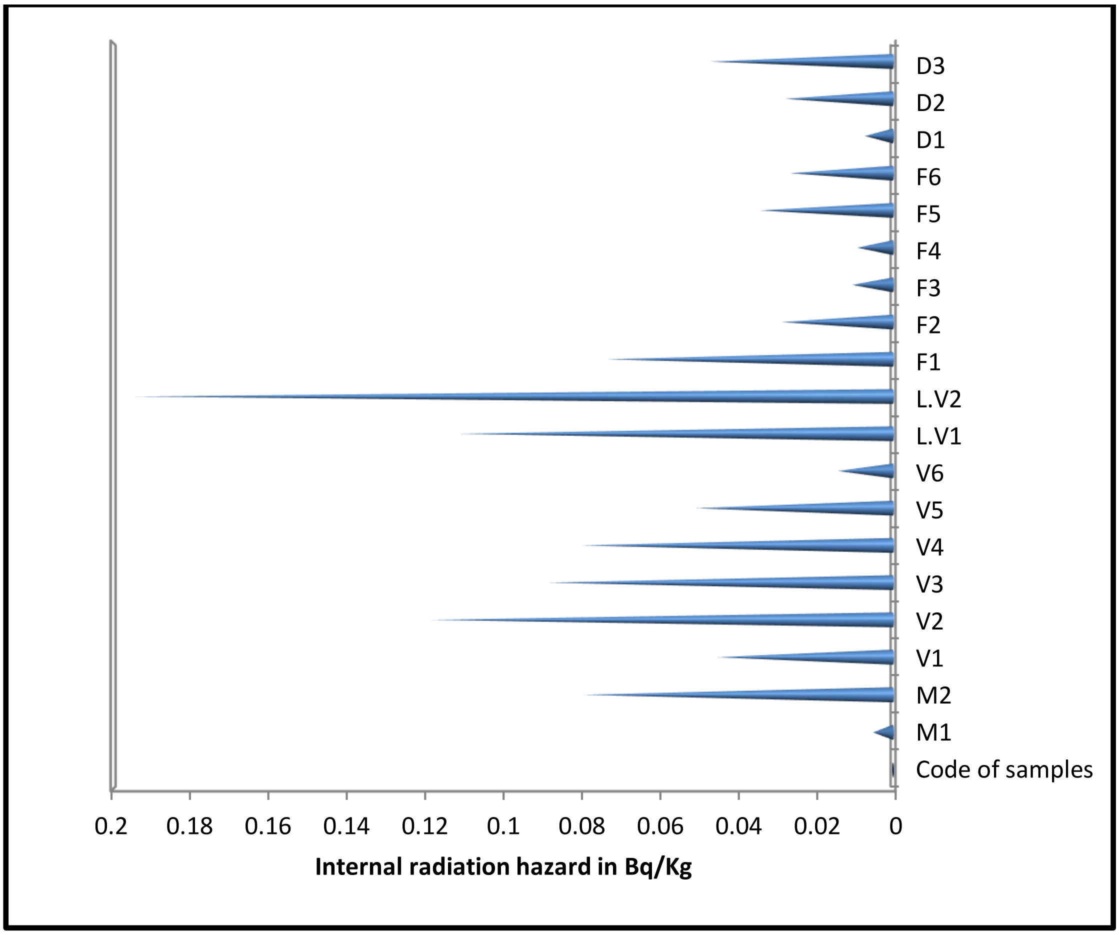

Figure (6): Internal radiation hazard in (Bq/Kg)of food samples from Rumaila area, Basra.

Table (4) and Fig.(7) indicate to the average of annual effective dose values of food samples from Rumaila area, Basra which are 0.051 ± 0.002 μSv/y with a range 0.004 ± 0.001 μSv/y to 0.178 ± 0.005 μSv/y; therefore all samples within the allowed limit (less than one). Fig.(8) shows the average of activity concentration index values that are 0.168± 0.008 Bq/Kg with a range 0.013 ± 0.003 to 0.581 ± 0.026 Bq/Kg , the activity concentration index values within the allowed limit for worldwide median value 1 Bq/Kg.

Table (4): The total annual effective dose and activity concentration index of food samples from Rumaila area, Basra.

No.	Code of Samples	Annual effective dose (AED) (μSv/y)	Activity concentration Index (I_{γ})(Bq/Kg)
1	M1	0.004 ± 0.001	0.013 ± 0.003
2	M2	0.077 ± 0.0029	0.253 ± 0.008
3	V1	0.039 ± 0.003	0.127 ± 0.011
4	V2	0.116 ± 0.002	0.378 ± 0.008
5	V3	0.085 ± 0.004	0.278 ± 0.012
6	V4	0.071 ± 0.004	0.232 ± 0.013
7	V5	0.043 ± 0.004	0.138 ± 0.012
8	V6	0.013 ± 0.001	0.044 ± 0.001
9	L.V1	0.109 ± 0.06	0.356 ± 0.011
10	L.V2	0.178 ± 0.005	0.581 ± 0.026
11	F1	0.071 ± 0.002	0.231 ± 0.007
12	F2	0.027 ± 0.001	0.090 ± 0.003
13	F3	0.009 ± 0.001	0.029 ± 0.003
14	F4	0.006 ± 0.001	0.019 ± 0.004
15	F5	0.030 ± 0.002	0.097 ± 0.006
16	F6	0.025 ± 0.001	0.081 ± 0.005
17	D1	0.005 ± 0.001	0.017 ± 0.003
18	D2	0.025 ± 0.001	0.083 ± 0.004
19	D3	0.044 ± 0.002	0.144 ± 0.007
Av.		0.051 ± 0.002	0.168 ± 0.008
Min.		0.004 ± 0.001	0.013 ± 0.003
Max.		0.178 ± 0.005	0.581 ± 0.026
Worldwide median value		1 (Shanthi *et al* ,1982).	≥1(UNSCEAR,1982).

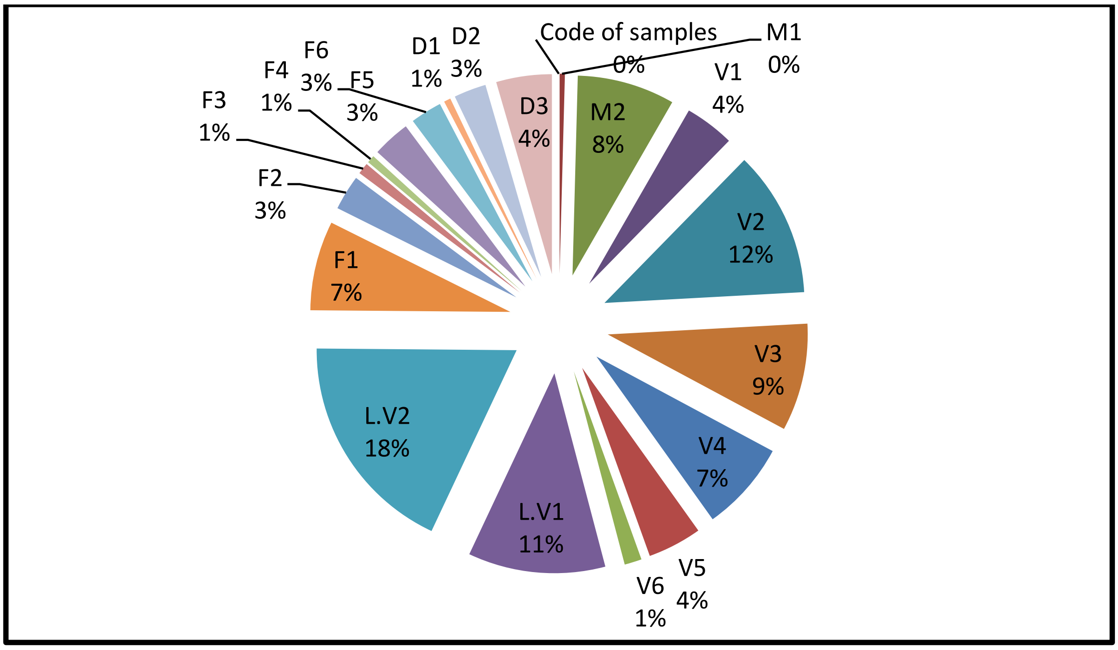

Figure (7): Annual effective dose in (μSv/y) of food samples from Rumaila area, Basra.

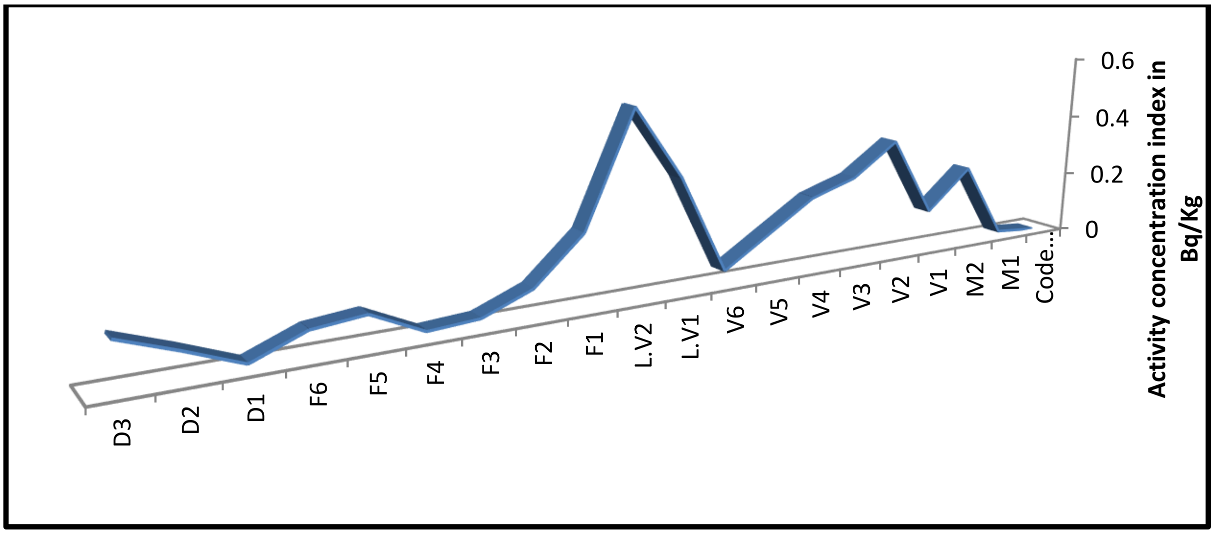

Figure (8): Activity concentration index in (Bq/Kg) of food samples from Rumaila area, Basra.

Conclusions

Activity concentrations for ^{40}K high in some samples under study due to clay minerals in the soil which may be attributed to kind of fertilizer used, or may be attributed to the environmental conditions, some values higher than the safe limits as recommended by UNSEAR and ICRP We conclude that the entry of foods contaminated with radionuclides into the human body at these sites can pose an internal health risk; therefore it is not safe for people to consume. It can be concluded that eating in the study areas over a long period of time can cause adverse effects.

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