Natural Radioactivity and Transfer Factors from Agricultural Soil to Tomato Crop which Irrigation Groundwater in Areas of Al-Heidrya district in Al-Najaf, Iraq.

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ABSTRACT

Twenty (20) samples were collected from the agricultural and twenty (20) samples of tomato crops of of Al-Heidrya districts in Al-Najaf Al- Ashraf,Iraq. Prepared, analysis and measurement for by useing gamma-ray spectroscopy detector NaI(Tl) with a "3x3" crystal. The average of specific activity of ^{238}U , ^{232}Th and ^{40}K respectivelyfor the soil were found to be 32.98$\pm$1.198 Bq/kg, 62612.815$\pm$0.348 Bq/kg, 1.52$\pm$0.097 Bq/kg, 1.52$\pm$0.097 Bq/kg and 626.555$\pm$5.893 Bq/kg. The values of ^{238}U, ^{232}Th much lower and the values of ^{40}K much higher than global averages and for the tomato crop were found to be 14.1±1.29 Bq/kg , 9.705±0.593 Bq/kg and 3545.037±23.766 Bq/kg The values of ^{238}U, ^{232}Th much lower and the values of ^{40}K much higher than global averages are when compared with than the permissible limits (33, 45, and 412 Bq/kg for ^{238}U, ^{232}Th and ^{40}K respectively) as reported by UNSCEAR. And were found the value of both Radium equivalent activity (Ra_{eq}) with unit Bq/Kg, absorbed dose rate (D_r) with unit nGy/h, Indoor hazard index (H_{in}), Indoor external dose (H_{ex}), Gamma index (I_γ) andAlpha Index (I_α), where the average values were respectively for the soil were found to be 99.549$\pm$4.805 Bq/Kg, 32.921 to 49.104$\pm$ 2.397 Bq/Kg, 0.358 $\pm$0.018, 0.269$\pm$0.013, 0.383$\pm$0.019 and 0.165$\pm$0.011,all values were less the World Wide average and for thetomato crop were fount to be 300.949$\pm$9.166, 160.205$\pm$4.627,0.851$\pm$0.03, 0.813$\pm$0.025, 1.277$\pm$0.037, 0.071$\pm$0.012 , all values were below the acceptable international standards, with the exception of the (D_r) and (I_γ). And were found of the average value of both Exposure rat (X), the total annual effective dose equivalent($AEDE_{total}$), Annual Gonadal Equivalent Dose(AGED) andexcess lifetime cancer risk (ELCR) respectively, for the soil were found to be 195.517$\pm$9.712 μR/h, 0.241$\pm$0.011 mSv/y, 352.212$\pm$17.274, 1.079$\pm$0.052, and for the tomato crop were found to be 752.536$\pm$21.320, 0.786$\pm$0.022, 1197.286$\pm$33.744, 3.521$\pm$0.102the averages of all results are comparable to the World Wiede Average of the UNSCEAR, all values of the soil and tomato crop were below the acceptable international standards, with the exception of the AGED and ELCR of soil and tomato crop, which were higher than the World Wiede Average by the UNSCEAR. for^{238}U and ^{232}Th it was observed that all results of the radiological hazard parameters related to a given activity were within the World Wiede Average of safety limits, with the exception of the ^{40}K, which were higher.the mean of the transfer factor values from soil to tomato crop for ^{238}U , ^{232}Th and ^{40}K were found to be 0.477, 0.816 and 6.075, respectively. it was highest for ^{40}K.This present study shows that the use of these tomato crop will pose radiological health risks for humans.

Keywords: Risks of Natrail Radioactivity **-** Natural radionuclides in Agricultural soil - Gamma spectrometry (NaI(TI) detector) - Transfer Factors from Agricultural Soil to Tomato Crop - Agricultural soil Hazards indices in Al-Hayderiah.

INTRODUCTION

All human environments, including soil, water, food, and air, include naturally occurring radioactive nuclides, and our bodies also contain such materials[1]. Naturally occurring materials typically contain radioactive nuclides from long-lived radioactive nuclides like ^{40}K as well as from the primary decay chains for ^{238}U , ^{232}Th and their daughter products [2,3].The primary source of background radiation naturally occurs when radioactive nuclides are released into the soil through weathering of the earth's crust[4]. Moreover, it is thought that fertilizer components like potassium and phosphates, which are employed in plant nitration processes and include the radioactive elements ^{238}U and ^{232}Th, are significant contributors of soil contamination[5].To protect the public's health, estimating the release of radioactivity into the environment is crucial, especially if it enters the food chain[6].For radiological evaluations, the transfer factor (TF) is a crucial element. The TF, which is the relative ratio of the radioactive nuclide concentrations in plants and soil (Bq/kg dry weight plant to Bq/kg dry weight soil), typically describes the uptake of radioactive nuclides by plants from the soil. Broadly speaking, TFs vary widely based on numerous factors, including soil characteristics, plant species, and other environmental circumstances[7].According to their capacity for radiation absorption, plants are divided into two categories. The first kind has a low radiation absorption capacity, making it safe to grow in radioactively contaminated soils without endangering plants and safe for humans to consume. The second category consists of plants that are defined by their strong radiation absorption capacity and that can be grown without risk in polluted soil. The assessment of the transport influences of ^{238}U , ^{232}Th and ^{40}Kfrom soil to plants and whether the amount of consumption of radioactive isotopes exceeds their normal level is one of the most significant studies currently being conducted to determine the level of danger the natural radiation that may be caused [8-10].Environmental monitoring systems benefit from the measurement of naturally occurring radioactive nuclides in food. Studies of low dose rate exposure resulting from environmental sources are acknowledged by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) as having the potential to improve knowledge of the possibility of radiation-induced cancer. Recommendations based on these studies is crucial because the general public primarily receives low dose rates of radiation exposure[11]. We measured the activity concentrations of ^{238}U , ^{232}Th and ^{40}K in soils and tomota crops in the Al-Heidrya district of Al-Najaf, Iraq.By using these measurements was determined the TFs from soil to tomato crops . Additionally, estimates of the annual effective doses from tomato crop consumption were made.

The area of study

Al-Haydariyah, an administrative sub-district of the Najaf district, is situated in the northern section of the Najaf governorate, 40 km from the governorate seat, and on the road connecting the two holy towns of Karbala and Najaf. Its astronomical coordinates are 32°18' 28" and 32°20' 25" north and 44°14'.30" and 44°17'.13" east, respectively, Figure (1).

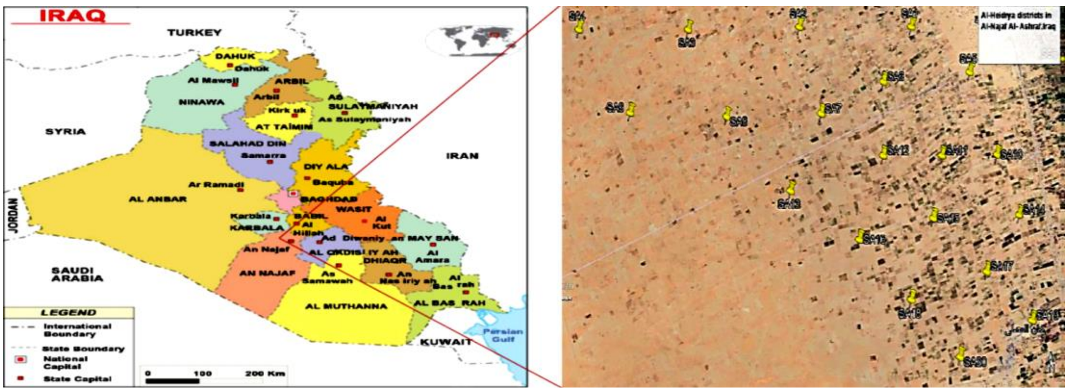


Figure 3: Geological map of the study area

MATERIALS AND METHODS

Twenty samples of agricultural soil were collected and prepared from a depth of 15 cm for each sample. Twenty samples of the tomato crop were also collected and prepared from agricultural soil sites, whose locations were as in Table (1) from Al-Haydaria area in Al-Najaf Al-Ashraf in Iraq to measure the natural radioactivity and transfer factor from Agricultural soil to tomato fruits irrigated with groundwater.The samples were exposed to sunlight for (48 to 72) hours in an open area to obtain dried samples free of moisture and samples were grounded and then sieved using a (1 mm) mesh size sieve to obtain homogeneous soil free of impurities.

Table (1): The location of the selected samples.

Site Number of Grauond water	Position	
	Latitude (°N)	**Longitude (°E)**
SA1	32°18'52.94"	44°14'5.61"
SA2	32°18'52.83"	44°11'40.40"
SA3	32°18'50.62"	44° 9'16.28"
SA4	32°18'50.78"	44° 6'54.78"
SA5	32°18'13.45"	44°15'19.85"
SA6	32°18'5.55"	44°13'28.53"
SA7	32°17'38.32"	44°12'7.96"
SA8	32°17'35.87"	44°10'6.92"
SA9	32°17'39.32"	44° 8'3.79"
SA10	32°17'3.31"	44°15'51.55"
SA11	32°17'2.71"	44°14'41.65"
SA12	32°17'2.83"	44°13'26.76"
SA13	32°16'33.70"	44°11'28.51"
SA14	32°16'13.15"	44°16'17.19"
SA15	32°16'10.68"	44°14'28.49"
SA16	32°15'53.23"	44°12'55.00"
SA17	32°15'26.81"	44°15'34.15"
SA18	32°15'4.33"	44°13'58.77"
SA19	32°14'47.31"	44°16'28.81"
SA20	32°14'18.43"	44°14'57.89"

The samples were placed into an electric oven at (80 °c) for three hour for complete dryness and to reach fixed weight, to ensure a complete removal of any residual moisture, and the dried samples were placed in a one liter Marinelli container which were washed with diluted hydrochloric acid and then washed with distilled water.The samples were then sealed with a tape to prevent the escape of ^{222}Rn and ^{220}Rn gases.All samples were weighed using a sensitive digital weight with ± 0.01%, and the samples were stored for (30) days prior to the measurement in order to achieve the permanent radiation balance among ^{226}Ra ,$^{228}Ac$and short-term chains (half-life > 7), $^{222}Rn$and ^{220}Rn.

Measurement of natural radioactivity

As shown in Figure (1), natural radioactivity levels were determined using a gamma spectrometer equipped with a gamma multichannel analyzer and a (3″ × 3″) crystal-size NaI(Tl) detector. The ORTEC Maestro-32 data gathering and processing system was used to evaluate the gamma spectra. This detector's energy is calibrated using a standard gamma-ray source set of 37,000 Bq, including active 137Cs, 60Co, 54Mn, and 22Na sources from USNRC and State License Expert Quantities, "Gamma Source Set," Model RSS-8. The detector was designed with coaxial, closed-facing geometry and the following specifications: For an energy of 661.66 keV from a 137Cs standard source, the computed resolution is 7.9%.Each sample's counting time was set to 18000 seconds.

Radiation indices measurements

Radiation hazards, or radiological hazards, are defined as the unintended exposure to radiation by all living creatures on Earth. Radiation dangers result from inhalation or ingestion of these radioactive elements, which directly impact living tissue. The evaluations of radiation hazard indices are methods for calculating the cumulative impact of a material's activity concentrations of 226Ra, 232Th, and 40K in a single amount. Beretka and Mathew [12], the UNSCEAR study [13, 14].

Measurement of natural radioactivity

Specific Activity (A)

The equation (1) can be used to determine the specific activity (A) of the gamma-emitting radionuclides in the samples. [15]:

$$A(\mathrm{Bq\ Kg^{-1}}) = \frac{\text{Net Aera} - \text{BG}}{\mathrm{I_\gamma\ \varepsilon\ M\ T}} \quad (1)$$

Net Area = Net Area below the energy peak (count). B.G = for the number of background spectrum counts, I_γ is the probability of gamma decay, ε is the efficiency of the gamma-ray detector at energy E, M is the weight ofthe measured sample in kg, and T is the life time for collecting the spectrum in seconds.

Radium Equivalent Activity (Ra_{eq}):

Radium Equivalent Activity (Ra_{eq})is a hazard index that is calculated using by equation (2) [16]:

$$\mathrm{Ra_{eq}}(Bq/kg) = A_U + 1.43A_{Th} + 0.07A_K \quad (2)$$

Where A_U, $A_{Th}$and A_K are the specific activity of ^{238}U, ^{232}Th and ^{40}K, respectively.

Absorbed Dose Rate in Air (D_r):

The Absorbed Dose Rate in Air(D_r) can be calculated from of the following equation (3), [17].

$$D_r\left(\frac{nGy}{h}\right) = 0.462\ A_U + 0.604\ A_{Th} + 0.0417A_K \quad (3)$$

External hazard index (H_{ex}):

The External hazard index (H_{ex}) can be calculated from of the following equation (4), [18]:

$$H_{ex} = \frac{A_U}{370} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \quad (4)$$

Internal hazard index (Hin):

The Internal hazard index (Hin) limits the internal exposure to ^{222}Rn and its radioactive daughters. It can be calculated using the following equation [19]:

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

Representative Level Index (I_γ):

The Representative Level Index (I_γ), itwas used to estimate the radiation hazards of the specific radionuclides of ^{238}U, ^{232}Th and ^{40}K. It can be calculated using the following equation [20] :

$$I_\gamma = \left(\frac{1}{1150}\right)A_U + \left(\frac{1}{1100}\right) A_{Th} + \left(\frac{1}{11500}\right)A_K \quad (6)$$

Alpha index (I_α):

The Alpha index (I_α)was evaluation of the increase in alpha radiation resulting from radon inhalation. The equation (7), it use for calculate the alpha- index e the alpha- index [21]:

$$I_\alpha = \frac{A_U}{200(\frac{Bq}{kg})} \quad (7)$$

Exposure rate ($X^{\cdot}$):

The Exposure rate (X) was calculated using the formula of equition (8), it produced because the uniformly distributed by decay series of the ^{238}U, ^{232}Th and ^{40}K in the material[22, 23].

$$X\left(\frac{\mu R}{h}\right) = 1.90\ A_U + 2.82\ A_{Th} + 0.197A_K \quad (8)$$

Annual gonadal equivalent dose (AGED):

Annual gonadal equivalent dose (AGED) can be calculated using the following equation (9) [24-26]:

$$AGED\left(\frac{\mu Sv}{y}\right) = 3.09\ A_U + 4.18\ A_{Th} + 0.314\ A_K \quad (9)$$

Annual Effective Dose Equivalent (AEDE):

The Annual Effective Dose Equivalent (AEDE) can be calculated from sum the annual effective dose indoor and outdoor which deoend on occupation factor (indoor = 0.2 and outdoor = 0.8) and absorbed dose rate in air (D_r), from the equations (10-12) can be calculated the annual effective dose indoor, outdoor and the total annual effective dose equivalent, [24, 27].

$$\mathrm{AEDE_{indoor}}\left(\frac{mSv}{y}\right) = \left[D_r\left(\frac{mGy}{hr}\right) \times 8760\,hr \times 0.8 \times 0.7\left(\frac{Sv}{Gy}\right)\right] \times 10^{-6} \qquad (10)$$

$$\mathrm{AEDE_{outdoor}}\left(\frac{\mathrm{mSv}}{\mathrm{y}}\right) = \left[\mathrm{D_r}\left(\frac{\mathrm{mGy}}{\mathrm{hr}}\right) \times 8760\,\mathrm{hr} \times 0.2 \times 0.7\left(\frac{\mathrm{Sv}}{\mathrm{Gy}}\right)\right] \times 10^{-6} \qquad (11)$$

$$\mathrm{AEDE_{total}} = \mathrm{AEDE_{indoor}} + \mathrm{AEDE_{outdoor}} \qquad (12)$$

Excess Lifetime Cancer Risk (ELCR):

Assuming a human life expectancy of 70 years and at a particular exposure level the probability of cancer throughout a lifetime can be calculated from equation (13) [28,18].

$$ELCR = AEDE \times DL \times RF \qquad (13)$$

Where AEDE is the total annual effective dose equivalent**,** DL is life expectancy (70 y), while RF is a fatal risk factor in un (Sievert), and it is pegged at 0.05 per Sievert.

Transfer Factor

The transfer factor is a tool that expresses the uptake of radionuclides by plants from soil through a mathematical equation. It is calculated for radionuclides ^{238}U, ^{232}Th and ^{40}K by dividing the activity of plant dry matter by the activity of ground deposition[29].

$$TF_{soil-plant} = \frac{AC_{plant}(Bqkg^{-1}, dry\ weight)}{AC_{soil}(Bqkg^{-1}, dry\ weight)} \qquad (14)$$

Where

$TF_{soil-plant}$: The transfer factor of the radionuclide.

AC_{plant}: The activity concentrations of the radionuclide in plant samples ($Bqkg^{-1}, dry\ weight$).

AC_{soil}: The activity concentrations of the radionuclide in soil samples ($Bqkg^{-1}, dry\ weight$).

RESULTS AND DISCUSSION

The natural radioactivity of selected agricultural soil samples in the study area was measured and all these values were significantly compared with the allowable limits (33, 45 and 412 Bq/kg for ^{238}U, ^{232}Th and ^{40}K) of the UNSCEAR, 2010 [30] and Raeq 370 [31]. The results were as in Table (2), where is the specific activity of ^{238}U, ^{232}Th and ^{40}K was found as follows: The average specific activity of ^{238}Uwas found of with average 32.98$\pm$1.198 Bq/kg, ^{232}Thwith an average 62612.815$\pm$0.348 Bq/kg and ^{40}K with an average 626.555$\pm$5.893 Bq/kg. The values of ^{238}U slightly lower than global averages, ^{232}Th much lower than global averages and ^{40}K much higher than global averagesare when compared with than the permissible limits (33, 45, and 412 Bq/kg for ^{238}U , ^{232}Th and ^{40}K respectively) as reported by UNSCEAR[30].

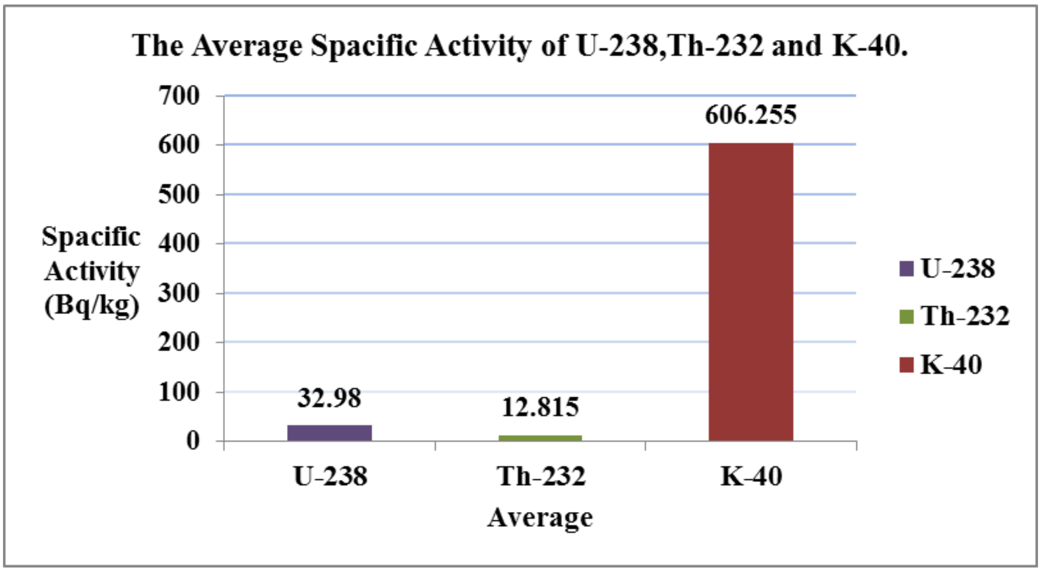
From Table(3) we found the value of both radium equivalent activity(Ra_{eq}) with unit Bq/Kg, absorbed dose rate (AD) with unit nGy/h, Indoor hazard index (Hin), Indoor external dose (H_{ex}), Gamma index (I_γ) and Alpha Index (I_α), where the values were respectively with average 99.549$\pm$4.805 Bq/Kg, with average 49.104$\pm$ 2.397 Bq/Kg, with average 0.358 $\pm$0.018, from 0.181 to 0.329 with average 0.269$\pm$0.013, average 0.383$\pm$0.019 and with average 0.165$\pm$0.011.

From Table(4) was found the value of both Exposure, AEDE, AGED, ELCR, with average 195.517$\pm$9.712 μR/h, with average 0.241$\pm$0.011 mSv/y, with average 352.212$\pm$17.274 and with average 1.079$\pm$0.052.

Figure (1) represents the spaific activity average of ^{238}U, ^{232}Th and ^{40}K.

Table (2): The specific activity of ^{238}U , ^{232}Th and ^{40}K in agricultural soil.

No.	Sample code	Specific activity in (Bq/kg)			
		^{238}U	^{232}Th	^{40}K	^{235}U
1	SA1	31.267±1.182	14.54±0.374	669.9 ± 6.161	1.441
2	SA2	26.368±1.037	12.663±0.333	566.65±5.417	1.215
3	SA3	33.801±1.139	13.801±0.338	625.142± 5.516	1.558
4	SA4	39.834±1.296	16.024±0.381	702.922± 6.134	1.836
5	SA5	32.205±1.199	12.176±0.342	670.127± 6.162	1.484
6	SA6	24.238±1.015	14.748±0.367	699.516± 6.143	1.117
7	SA7	41.966±1.37	16.354±0.397	755.11± 8.118	1.934
8	SA8	29.814±1.137	8.6552±0.284	492.914±5.209	1.374
9	SA9	32.934±1.279	12.055±0.359	677.015±6.532	1.518
10	SA10	17.851±0.866	13.863±3.54	669.967±5.975	0.823
11	SA11	45.077±1.491	15.279±0.403	614.66± 6.201	2.077
12	SA12	18.523±0.913	10.602±0.32	524.349± 5.469	0.854
13	SA13	38.307±1.268	13.664±0.351	684.406± 6.039	1.765
14	SA14	42.892±1.371	16.072±0.389	725.549± 6.35	1.977
15	SA15	21.015±1.01	10.494±0.331	453.988± 5.287	0.968
16	SA16	49.801±1.505	13.259±0.36	624.119± 6.001	2.295
17	SA17	37.59±1.286	12.01±0.337	561.004± 5.597	1.733
18	SA18	43.707±1.436	11.861±0.347	591.909± 5.953	2.014
19	SA19	26.139±1.115	10.184±0.323	433.108± 5.11	1.205
20	SA20	26.267±1.044	7.9903±0.267	382.731± 4.488	1.21
Minimum		**17.851±0.866**	**7.9903±0.267**	**382.731± 4.488**	**0.823**
Maximum		**49.801±1.505**	**16.354±0.397**	**755.11± 8.118**	**2.295**
Average ± S.D		**32.98±1.198**	**12.81±0.348**	**606.255±5.893**	**1.52±0.097**
World Wide average [30]		**33**	**45**	**412**	**..........**



Figure(2): The Averag Spaific activity of U-238, Th-232 and K-40.

Table (3): Results Ra_{eq}, D_r, H_{in}, H_{ex}, I_{γ}, and I_{α}in agricultural soil.

No.	Sample code	Ra_{eq} (Bq/kg)	D_r (nGy/h)	H_{in}	H_{ex}	I_{γ}	I_{α}
1	SA1	103.641	51.162	0.364	0.28	0.4	0.156
2	SA2	88.109	43.46	0.309	0.238	0.34	0.132
3	SA3	101.672	50.02	0.366	0.275	0.39	0.169
4	SA4	116.873	57.393	0.423	0.316	0.447	0.199
5	SA5	101.216	50.177	0.36	0.273	0.392	0.161
6	SA6	99.190	49.276	0.333	0.268	0.388	0.121
7	SA7	123.495	60.754	0.447	0.334	0.473	0.21
8	SA8	80.144	39.556	0.297	0.216	0.307	0.149
9	SA9	102.304	50.729	0.365	0.276	0.396	0.165
10	SA10	89.262	44.558	0.289	0.241	0.352	0.089
11	SA11	114.255	55.685	0.43	0.309	0.432	0.225
12	SA12	74.058	36.826	0.25	0.2	0.29	0.093
13	SA13	110.546	54.491	0.402	0.299	0.424	0.192

14	**SA14**	121.741	59.779	0.445	0.329	0.465	0.214
15	**SA15**	70.978	34.979	0.248	0.192	0.274	0.105
16	**SA16**	116.818	57.042	0.45	0.316	0.44	0.249
17	**SA17**	97.966	48.017	0.366	0.265	0.372	0.188
18	**SA18**	106.245	52.039	0.405	0.287	0.402	0.219
19	**SA19**	74.0522	36.288	0.271	0.2	0.282	0.131
20	**SA20**	67.1632	32.921	0.252	0.181	0.255	0.131
Minmum		**67.1632**	**32.921**	**0.248**	**0.181**	**0.255**	**0.089**
Maxmum		**154.757**	**60.754**	**0.271**	**0.329**	**0.609**	**0.249**
Average ±S.D		**99.549 ± 4.805**	**48.258± 2.397**	**0.354± 0.018**	**0.265± 0.013**	**0.376± 0.019**	**0.165± 0.011**
World Wide average [31]		**<370**	**<55**	**≤1**	**≤1**	**≤1**	**≤1**

Table (4): Exposure rate, AEDE$_{total}$, AGED and ELCR in agricultural soil.

No.	**Sample code**	**Exposure (μR/h)**	**AEDE$_{total}$ (mSv/y)**	**AGED (mSv/y)**	**ELCR×10^{-3}**
1	**SA1**	207.054	0.251	367.74	1.124
2	**SA2**	176.083	0.213	312.34	0.955
3	**SA3**	198.915	0.245	358.428	1.099
4	**SA4**	227.081	0.282	410.783	1.261
5	**SA5**	201.454	0.246	360.828	1.103
6	**SA6**	205.814	0.242	356.191	1.083
7	**SA7**	320.6	0.381	562.623	1.707
8	**SA8**	154.008	0.194	283.077	0.869
9	**SA9**	203.267	0.249	364.742	1.115
10	**SA10**	190.534	0.219	323.476	0.979
11	**SA11**	213.309	0.273	396.158	1.224
12	**SA12**	153.383	0.181	266.197	0.809

13	**SA13**	215.115	0.267	390.387	1.197
14	**SA14**	235.007	0.293	427.537	1.314
15	**SA15**	141.936	0.172	251.355	0.769
16	**SA16**	214.624	0.28	405.28	1.254
17	**SA17**	185.364	0.236	342.526	1.055
18	**SA18**	197.694	0.255	370.492	1.144
19	**SA19**	142.534	0.178	259.337	0.797
20	**SA20**	126.561	0.161	234.741	0.723
Minmum		**126.561**	**0.161**	**234.741**	**0.723**
Maxmum		**235.007**	**0.381**	**562.623**	**1.707**
Average + S.D		**195.517±9.712**	**0.241±0.011**	**352.212± 17.274**	**1.079±0.052**
World Wide average[32-35]		**............**	**0.50**	**300**	**1.45**

Results of Gamma Emitters inTomato Crop Irrigte with Groundwater.

The natural radioactivity of selected fruit samples in the study area was measured and all these values were significantly compared with the allowable limits (33, 45 and 412 Bq/kg for ^{238}U, ^{232}Th and ^{40}K) of the UNSCEAR[30] and Raeq 370 [31]. The results were as in Table (5), where is the specific activity of ^{238}U, ^{232}Th and ^{40}K was found as follows: The specific activity of ^{238}Uwas found with an average 14.1±1.29 Bq/kg, ^{232}Thwith an average 9.705±0.593 Bq/kg and ^{40}K with an average 3545.037±23.766 Bq/kg. The values of ^{238}U lower than global averages , ^{232}Th much lower than global averages and ^{40}K much higher than than the World Wiede as reported by UNSCEAR [30].

From Table (6) was found the value of both Radium equivalent activity(Raq) with unit Bq/Kg, absorbed dose rate (AD) with unit nGy/h, Indoor hazard index (Hin), Indoor external dose (Hex), Gamma index ($I\gamma$) andAlpha Index ($I\alpha$), where the values were respectively with average 300.949±9.166 Bq/Kg, with average 160.205±4.627(nGy/h), with average 0.813±0.025, with average 0.813±0.025, with average 1.277±0.037 and with average 0.071±0.012.The averages of all results are comparable to the World Wiede Average of the UNSCEAR [32], all values were less than the permissible international levels, except for the absorbed dose rate (AD) andGamma index ($I\gamma$) , which was higher than the World Wiede Average.

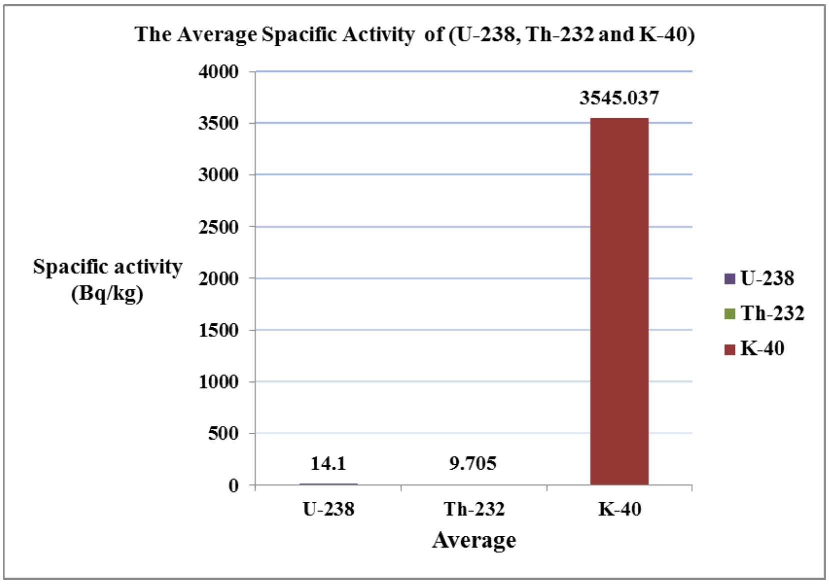
From Table (7) was found the value of both Exposure,the annual effective dose equivalent(AEDE), the the annual gonadal equivalent dose (AGED), excess life-time cancerrisk (ELCR) , where the values were respectively with average 752.536±21.320 μR/h,with average 0.786±0.022 mSv/y, with average 1197.286±33.744, with average 3.521±0.102.

The averages of all results are comparable to the World Wiede Average of the UNSCEAR [32], all values were less except for the AGED and ELCR, which was higher than the World Wiede Average.

Figure (3) show that nearly the high values of the ^{40}K activities were distributed,almost all much higher than the World Wiede Average of the study-area.

Table (5): Results of natural radioactivity in fruit by irrigte with groundwater.

No.	Sample code	Specific activity in (Bq/Kg)		
		^{238}U	^{232}Th	^{40}K
1	SAF1	2.934±0.64	4.924±0.505	3154.739±21.868
2	SAF2	21.84±1.601	15.33±0.622	3606.747±23.175
3	SAF3	33.88±1.969	16.65±0.64	3439.772±22.348
4	SAF4	5.578±0.882	9.12±0.523	3854.68±26.112
5	SAF5	29.14±1.866	17.29±0.667	3937.79±24.425
6	SAF6	10.64±1.104	3.792±0.306	2853.191±20.353
7	SAF7	2.814±0.614	1.789±0.298	3252.244±21.742
8	SAF8	22.77±1.829	20.01±0.795	4091±27.61
9	SAF9	5.982±0.855	3.021±0.282	3455.675±23.134
10	SAF10	13.33±1.499	10.2±0.799	4016.833±27.113
11	SAF11	19.09±1.804	14.8±0.987	3782.433±26.447
12	SAF12	1.621±0.468	4.711±0.486	3259.009±21.855
13	SAF13	8.594±1.192	6.744±0.192	3818.913±26.167
14	SAF14	8.703±1.184	16.08±0.184	3430.107±24.49
15	SAF15	14.85±1.397	10.52±0.397	3431.783±23.92
16	SAF16	2.063±0.486	2.807±0.386	3124.99±19.714
17	SAF17	18.94±1.631	6.715±0.631	3540.267±23.216
18	SAF18	4.974±0.75	3.061±0.75	3185.955±19.767
19	SAF19	30.65±2.206	12.2±0.206	3893.521±25.9
20	SAF20	23.67±1.826	14.34±0.826	3771.091±25.959
Minimum		1.621±0.468	1.789±0.298	3124.99±19.714
Maximum		33.88±1.969	20.01±0.795	4016.833±27.113
Average ± S.D		14.1±1.29	9.705±0.593	3545.037±23.766
World Wide Average[30]		33	45	412



Figure(3): Spaific activity average of U-238, Th-232 and K-40.

Table (6): Results Raeq , Dr , Hex , Hin and Iγ of Fruit fruit irrigte with groundwater.

No.	Sample code	Raeq (Bq/kg)	D_r (nGy/h)	Hin	Hex	Iγ	Iα
1	**SAF1**	252.891	135.883	0.691	0.683	1.086	0.015
2	**SAF2**	321.478	169.749	0.927	0.868	1.352	0.109
3	**SAF3**	322.547	169.146	0.963	0.871	1.343	0.169
4	**SAF4**	315.43	168.826	0.867	0.852	1.349	0.028
5	**SAF5**	357.082	188.115	1.043	0.964	1.496	0.146
6	**SAF6**	235.763	126.186	0.665	0.637	1.006	0.053
7	**SAF7**	255.795	137.999	0.698	0.691	1.102	0.014
8	**SAF8**	366.385	193.198	1.051	0.989	1.54	0.114
9	**SAF9**	276.389	148.69	0.762	0.746	1.187	0.03
10	**SAF10**	337.209	179.82	0.947	0.911	1.434	0.067
11	**SAF11**	331.497	175.485	0.947	0.895	1.398	0.095
12	**SAF12**	259.301	139.495	0.704	0.7	1.115	0.008
13	**SAF13**	312.294	167.292	0.866	0.843	1.335	0.043
14	**SAF14**	295.82	156.771	0.822	0.799	1.253	0.044

15	**SAF15**	294.142	156.321	0.834	0.794	1.246	0.074
16	**SAF16**	246.701	132.961	0.672	0.666	1.063	0.01
17	**SAF17**	301.149	160.438	0.864	0.813	1.277	0.095
18	**SAF18**	254.67	137.001	0.701	0.688	1.094	0.025
19	**SAF19**	347.892	183.887	1.022	0.939	1.461	0.153
20	**SAF20**	334.541	176.847	0.967	0.903	1.408	0.118
Minmum		**235.763**	**132.961**	**0.665**	**0.637**	**1.006**	**0.025**
Maxmum		**366.385**	**193.198**	**1.051**	**0.989**	**1.496**	**0.169**
Average + S.D		**300.949± 9.166**	**160.205± 4.627**	**0.851± 0.03**	**0.813± 0.025**	**1.277± 0.037**	**0.071± 0.012**
World Wide average[32]		**<370**	**<55**	**≤1**	**≤1**	**≤1**	**≤1**

Table (7): Exposure, AEDE ,AGED and ELCR of Fruit fruit irrigte with groundwater.

No.	**Sample code**	**Exposure (μR/h)**	**AEDE (mSv/y)**	**AGED (mSv/y)**	**ELCR×10^{-3}**
1	**SAF1**	640.945	0.667	1020.238	2.986
2	**SAF2**	795.25	0.833	1264.073	3.73
3	**SAF3**	788.951	0.83	1254.361	3.717
4	**SAF4**	795.689	0.828	1265.727	3.71
5	**SAF5**	879.883	0.923	1398.803	4.134
6	**SAF6**	592.998	0.619	944.6461	2.773
7	**SAF7**	651.084	0.677	1037.378	3.033
8	**SAF8**	905.606	0.948	1438.557	4.246
9	**SAF9**	700.653	0.729	1116.194	3.268
10	**SAF10**	845.401	0.882	1345.101	3.952
11	**SAF11**	823.138	0.861	1308.524	3.856
12	**SAF12**	658.389	0.684	1048.028	3.065
13	**SAF13**	787.671	0.821	1253.882	3.676
14	**SAF14**	737.622	0.769	1171.174	3.445

15	**SAF15**	733.946	0.767	1167.445	3.435
16	**SAF16**	627.459	0.652	999.3551	2.922
17	**SAF17**	752.365	0.787	1198.254	3.526
18	**SAF18**	645.716	0.672	1028.556	3.011
19	**SAF19**	859.652	0.902	1368.254	4.041
20	**SAF20**	828.299	0.868	1317.177	3.886
Minmum		**592.998**	**0.619**	**944.6461**	**2.773**
Maxmum		**905.606**	**0.948**	**1368.254**	**4.246**
Average + S.D		**752.536± 21.320**	**0.786± 0.022**	**1197.286± 33.744**	**3.521± 0.102**
World Wide average[32-35]		**.............**	**≤ 1**	**300**	**1.45**

The Transfer Factor from agricultural soil to fruit which irrigte with groundwater

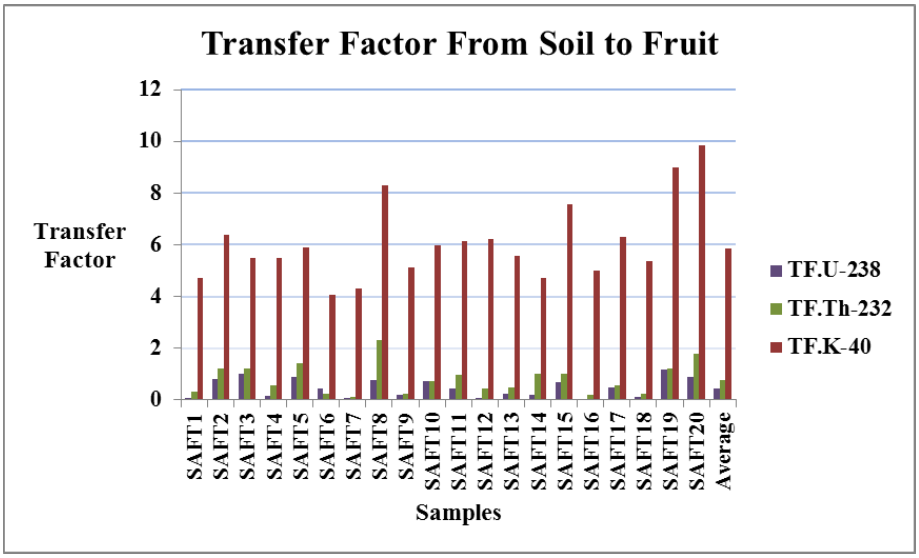
The results are summarized in the Table (8), Figure (4). The resulte in this table show that the ranges of TF of ^{238}U , ^{232}Th and ^{40}K respectively, with average 0.477±0.084,with average 0.816±0.134 and with averge 6.075±0.350.

The research results in this study show that the transfer factors of ^{238}U , ^{232}Th in most samples are less than (1). This indicates that the activity concentrations of ^{238}U , ^{232}Thin plants are less than those in the soil.The values of transfer factors of^{40}K in the agricultural soil recorded high values compared to ^{238}U, ^{232}Th, as all the transfer factors in this area were greater than one Figure (5).

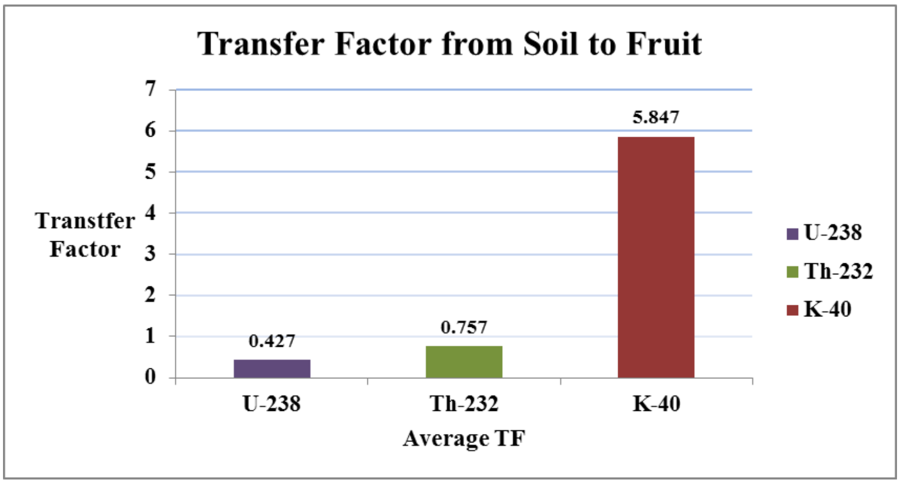
Table (8): The Transfer factor of ^{238}U , ^{232}Th and ^{40}K from agricultural soil to fruit which irrigte with groundwater.

No.	**Sample code**	**Transition factor**		
		^{238}U	^{232}Th	^{40}K
1	**SAFT1**	0.094	0.339	4.709
2	**SAFT2**	0.828	1.211	6.365
3	**SAFT3**	1.002	1.206	5.502
4	**SAFT4**	0.14	0.569	5.484
5	**SAFT5**	0.905	1.42	5.876
6	**SAFT6**	0.439	0.257	4.079
7	**SAFT7**	0.067	0.109	4.307
8	**SAFT8**	0.764	2.311	8.3

9	**SAFT9**	0.182	0.251	5.104
10	**SAFT10**	0.747	0.736	5.996
11	**SAFT11**	0.424	0.968	6.154
12	**SAFT12**	0.088	0.444	6.215
13	**SAFT13**	0.224	0.494	5.58
14	**SAFT14**	0.203	1.001	4.728
15	**SAFT15**	0.707	1.002	7.559
16	**SAFT16**	0.041	0.212	5.007
17	**SAFT17**	0.504	0.559	6.311
18	**SAFT18**	0.114	0.258	5.383
19	**SAFT19**	1.173	1.197	8.99
20	**SAFT20**	0.901	1.794	9.853
Minimum		**0.094**	**0.109**	**4.079**
Maximum		**1.173**	**2.311**	**9.853**
Average ± S.D		**0.477±0.084**	**0.816±0.134**	**6.075±0.350**



Figure(4): Transfer Factor of ^{238}U , ^{232}Th and ^{40}K for samples from agricultural soil to fruit which irrigte with groundwater.



Figure(5): Comparison average TF of ^{238}U , ^{232}Th and ^{40}K for agricultural soil to fruit which irrigtation with groundwater.

CONCLUSION

Based on the above results, the following conclusions are drawn.

1- The average of ^{238}U activity concentration was observed to be slightly less than the world average value reported by UNSCEAR 2000 except for some samples. However the average radium equivalent activity(Ra_{eq}) concentration in soil samples of studied area was found to be lower to the World Wide average. As for the tomato crop, the results indicate that it is less than the World Wide average.

2- The estimated average activity concentration of ^{232}Th was found to be lower to the World Wide averagefor soil and tomato crop samples.

3- The average of ^{40}K activity concentration was observed to be in soil samples of these studied areas was found to be higher than the World Wide average.As well as for the tomato crop, it is much higherthan the World Wide average.

4- The results obtained have shown that radiological hazards such as gamma index, External hazard index and indoor hazard index are well within the World Wide average value. Finally we conclude that the radiation emitted from the radionuclides present in the soil of the study area do not pose any radiological health hazard to the public of the area. As for the tomato crop, the results indicate that the rate of specific effectiveness of potassium was much higher than the global rates, as well as Absorbed Dose Rate in Air (D_r), Representative Level Index (I_γ), Annual gonadal equivalent dose (AGED) and Excess Lifetime Cancer Risk (ELCR) are a higher than the permissible international rates, so it poses a danger to humans.

5- The average absorbed dose rate for the soil and tomato crop samples of the study area are slightly higher than the World Wide average values.

6- The results obtained have shown that the total annual effective dose equivalent due to natural radioactivity of soil samples is lower than the World Wide average value.

7- Maybe the use of chemical fertilizers were behind the relatively highter radioactivity in these soil.

8- Gamma ray spectrometry was used in this study to assess the activity concentrations of ^{238}U, ^{232}Th and ^{40}K in selected soil and associated tomato crops. As well as the transfer factor (TF) from the soil to the tomato crops. Where it showed the average activity concentrations of radionuclides in soils showed that this ranking was ^{40}K>^{238}U>^{232}Th. and in tomato crops the ranking was also ^{40}K>^{238}U>^{232}Th. When compared to the global average, the soil samples show a high ^{40}Kspecific activity ratio, while tomato crop samples had the greatest ^{40}Kisotope specific activity ratio. The radiation transfer factor is typically influenced by the type of fertilizers and plants, and the plants capacity to absorb radioactive isotopes. It was also the result of calculating the transfer factor (TF) from soil to tomato crops for each sample. Where it showed the tomato crops samples have the radiation transfer factor for ^{238}U isotope with less than (1), also found that the transfer factor for ^{232}Th isotope with less than (1), but the ^{40}K radiation transfer factor was the highest in tomato crops sample.The results that were obtained for the chosen samples for the ^{40}K higher than the allowed global limit. For the tomato crops, the radiation transfer factor TFs are highest.

9- The data obtained in this study will serve as a baseline for assessing the radiation exposure of the residents.

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