Journal of Physics: Conference Series

PAPER • OPEN ACCESS

Transfer Factors from Soil to Plant of Natural Radionuclides at Abu-Ghraib City, Iraq Using Gamma Ray Spectroscopy

To cite this article: Rand Mudher Ebraheem *et al* 2021 *J. Phys.: Conf. Ser.* **1879** 032071

Transfer Factors from Soil to Plant of Natural Radionuclides at Abu-Ghraib City, Iraq Using Gamma Ray Spectroscopy

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Abstract. Activity concentrations of natural radionuclides, artificial radio-cesium, and soil-to-plant transfer factor in common different plants species grown at Abu-Ghraib city in the capital Baghdad have been evaluated using NaI(Tl) gamma spectroscopy. Five species of plants have been selected, namely green pepper, cucumber, celery, basil, and mint. The measurements were made on four parts of each plant sample which were included soil, roots, stalk, and leave for knowledge and evaluation the transfer factors. The maximum mean specific activity concentration of U-238 and Th-232 was 9.853±10.904 Bq/kg, 6.005±2.729Bq/kg in celery, while the maximum mean specific activity concentration of K-40 was 141.172±71.703 Bg/kg in cucumber, respectively. The results showed that the uranium, thorium, potassium and cesium concentration not exceeded the permissible limit. The mean Radium equivalent activity was 35.553 Bq\kg lower than 370 Bq\kg recommended by UNSCEAR. The maximum absorbed dose rate in root-mint samples was 30.290 nGy/h which is lower than 84 nGy/h, while the mean annual outdoor effective dose equivalent in root samples was148.597 mSv/y which is lower than 290 mSv/y recommended by UNSCEAR, respectively. The maximum H hazard index was 0.097 in root samples which is less than ≤1 recommended by UNSCEAR. The excess lifetime cancer risk (ECLR) ranged from 5.441×10^{-3} to 520.081×10^{-3}. This value is higher than recommended limit 0.29×10^{-3} and 1.16×10^{-3} reported by UNSCEAR. The ELCR is a function of environmental geology and K-40 has very high soil-to-plant transfer factor compared to other radionuclides in the samples. Therefore, there is a risk of their administration. The maximum of radioactivity level index was 0.265 Bq/kg which is less than ≤1.

Keywords: plants; transfer factor; radionuclides; hazards; cancer risk; Abu-Ghraib

1. Introduction

Natural radionuclides are found in the environment such as soil, water, air and plants, and by eating them; our bodies contain these natural radioactive materials. They usually have a low concentration of radioactivity. The natural background radiation originates from the uranium series 238, thorium 232 chain and from potassium 40, while cesium 137 originates from industrial sources [1-3]. Radionuclides are released from the soil, which is the main source of the natural background radiation. The plants will acquire these radionuclides through the roots, sticks and leaves. These radionuclides are transferred to humans by directly eating plants as food. Radionuclides that are ingested by food constitute a large part of the average dose of radiation received by the various parts of the human body, including the skeleton [4]. The dissolution of these radionuclides (uranium and thorium) in foodstuffs and inside the human body deserves to be monitored and evaluated, and the most important thing is the naturally occurring potassium 40 as an essential component of cellular materials in all foodstuffs, where the person receives approximately 180 μSv annually from it. The average total amount of natural potassium in a normal human is about 0.14 kg, so the natural background can be considered as a constant source of human radioactivity. These have disadvantages and accumulated damage on humans that must be taken into consideration [5-6]. There are two mechanisms of plant contamination, either through absorption by roots or directly by atmospheric precipitation of radionuclides that fall on plants. So most of the radiation doses that humans receive can be considered from the consumption of food contaminated with various radionuclides, whether from natural or industrial sources, or from radioactive pollution to the environment [7-9]. That is why we found it necessary in this research to conduct an accurate assessment of radionuclides activity in plants and their transfer factor from soil to plants that are an important part of the food today used by humans and to determine the resulting risk factors.

2. Materials and methods

2.1. Collection and preparation of samples

Twenty samples of plant were collected at Abu-Ghraib city. Fifteen samples of plants and five samples of soil for each plant. Three samples parts representing (root, stalk, and leave) for each type of plants, namely cucumber, green pepper, celery, mint and basil. All samples have undergone drying, crushing, and grinding processes. Then, they were stored in tightly closed Marinelli Beckers for 30 days to achieve secular equilibrium.

2.2. Radioactivity measurement

Detection of natural radioactivity for U-238, Th-232, and K-40 in different parts of plants (cucumber, green pepper, celery, mint, basil) and soil samples were measured using sodium iodide detector technique. The standard samples were used for the calibration and the absolute efficiency of the detector as recommended by IAEA. The mixture of radionuclides with their corresponding energies are Am-163 (59.3keV), Co-60 (1173.24 and 1332.50 keV), Cs-137 (661.66 keV). The background was measured too; both were counted for two hours. U-238 activity was given by the product decay of Bi-214 (1764.5 keV). The activity of Th-232 was given by the product of Tl-208 (583.19 and 2614.5 keV). The K-40 (1460.8 keV) and Cs-137 (661.61 keV) concentrations were measured gamma lines of their energies, respectively.

3. Parameters calculation

3.1. Specific activity

The specified activity in unit Ci/kg or Bq/g is given by [10]:

$$A_i(E,\gamma) = \frac{N}{\varepsilon\,(E_\gamma)\times\, I_\gamma\,(E_\gamma)\times t \times m} \tag{1}$$

Where, N and m are the counts of area under the curve and mass of sample in kg, respectively.

3.2. Absorbed dose rate D

The outdoor absorbed dose rate can be calculated using the following formula [11, 12]:

$$D_{out}(nGyh^{-1}) = 0.427\,A_U + 0.662A_{Th} + 0.043\,A_K \tag{2}$$

Where, A_U, A_{Th} and A_K are the activity concentrations in (Bq/kg) of uranium, thorium and potassium respectively.

The indoor absorbed dose aye is given by [13]:

$$D_{in}(nGyh^{-1}) = 0.92\,A_U + 1.1A_{Th} + 0.081\,A_K \tag{3}$$

3.3. Radium equivalent Ra_{eq}

The radium equivalent activity can be expressed by [1]:

$$Ra_{eq}(Bq.kg^{-1}) = A_U + 1.43\,A_{Th} + 0.077\,A_K \quad (4)$$

The recommended limit of Ra_{eq} is 370 $Bqkg^{-1}$ given by UNSCEAR, 2000 [1].

3.4. *Hazard index H*

The external (H_{ex}) is given by UNSCEAR, 2000 [1]:

$$H_{ex} = \frac{A_U}{370\,Bq.kg^{-1}} + \frac{A_{Th}}{259\,Bq.kg^{-1}} + \frac{A_K}{4810\,Bq.kg^{-1}}$$

(5)

The internal radiation exposure is quantified by the internal hazard index (H_{in}) given by UNSCEAR, 2000 [1]:

$$H_{in} = \frac{A_U}{185\,Bq.kg^{-1}} + \frac{A_{Th}}{259\,Bq.kg^{-1}} + \frac{A_K}{4810\,Bq.kg^{-1}} \quad (6)$$

The limit of these indexes should be less or equal to unity, as reported by UNSCEAR and ICRP [1, 14].

3.5. *Annual effective dose equivalent AEDE*

The outdoor and indoor annual effective dose equivalents are given as the following [1]:

$$AEDE_{out}(\mu Sv/y) = D_{out}(nGy/h) \times 8760(h/y) \times 0.20 \times 0.7(Sv/Gy) \times 10^{-3} \quad (7)$$

$$AEDE_{in}(\mu Sv/y) = D_{in}(nGy/h) \times 8760(h/y) \times 0.80 \times 0.7(Sv/Gy) \times 10^{-3} \quad (8)$$

3.6. *Life-time cancer risk ELCR*

The excess life-time cancer risk ($ELCR$) which is given by Taskin et al. 2009 is as follows [15]:

$$ELCR_{out} = AEDE_{out} \times DL \times RF \quad (9)$$

$$ELCR_{in} = AEDE_{in} \times DL \times RF \quad (10)$$

Where; DL, and RF are the life span and risk factor respectively as given by ICRP, 2012 [16].

3.7. *Annual gonadal dose equivalent AGDE*

The annual gonadal dose equivalent ($AGDE$) can be calculated as follows [11]:

$$AGDE\left(\frac{\mu Sv}{y}\right) = 3.09A_U + 4.18A_{Th} + 0.314A_K \quad (11)$$

3.8. *Radioactivity level index I_γ*

This index is used to estimate the level of radiation risk, especially γ -rays, associated with natural radionuclides in material. It is defined as follows [17].

$$I\gamma(Bq/kg) = A_{Ra}/150 + A_{Th}/100 + A_K/1500 \le 1 \quad (12)$$

Where A_{Ra}, A_{Th} and A_K are the activities of Ra-226, Th-232 and K-40 in Bq/kg respectively.

3.9. *Soil-to-plant transfer factor TF*

Using (IAEA) guidelines, the soil-to-plant transfer factor TF was estimated as follows [18, 19]:

$$TF = Cp\,/\,Cs \quad (13)$$

Where Cp and Cs are radionuclide concentration in plant and soil in Bq/kg respectively.

4. Results and discussion

Table 1 and Figs. 1 to 6 show the variation of activity concentrations of U-238, Th-232, K-40 and Cs-137 in green pepper, cucumber, celery, basil, mint and soil samples in Abu-Ghraib city in different parts of each sample. For the green pepper the activity concentrations of U-238 were varied from 1.504 to 12.155 to Bq/kg with an average value of 7.068±4.949 Bq/kg. Whereas, for Th-232 it was varied from 7.403 to 0.180 Bq/kg with an average value 2.909±3.424 Bq/kg. The activity concentrations of K-40 ranged from 26.570 to 76.738 Bq/kg with average value 68.633±34.272 Bq/kg, and 0.014 to 1.588 Bq/kg with an average value 0.617±0.746 Bq/kg for Cs-137. For cucumber, the results were 7.068±4.949, 2.909±3.424, 0.617±0.746, 68.633±34.272 Bq/kg. For celery, the average activity concentrations were

9.853±10.904, 6.005±2.729, 1.198±0.591, 93.320±85.462 Bq/kg. For basil, the average activity concentrations were 3.737±5.631, 4.200±2.536, 0.455±0.756, 71.687±54.966 Bq/kg. For mint, the average activity concentrations were 4.390±5.067, 8.483±6.199, 0.517±0.722 and 61.863±53.147 for U-238, Th-232, and K-40, respectively. All these values are significantly less than permissible limits (33, 45, 412, and 2.0 Bq/kg) for U-238, Th-232, K-40, and Cs-137, respectively [12, 20].

Table 1. Specific Activity Concentration for U-238, Th-232, K-40 and Cs-137 of samples, at Abu-Ghraib city.

Sample Name	Sample parts	U-238			Th-232	K-40	Cs-137
		Ra-226	Bi-214	Pb-214	Ac-228		
Green pepper	Soil	4.138	8.524	12.155	7.403	76.738	1.588
	Root	0.382	1.192	10.183	3.756	125.650	0.820
	Stalk	0.164	0.390	4.430	0.297	45.574	0.047
	Leaves	0.013	0.178	1.504	0.180	26.570	0.014
	Average	1.174 ±1.981	2.570 ±3.993	7.068 ±4.949	2.909 ±3.424	68.633 ±34.272	0.617 ±0.746
Cucumber	Soil	4.216	8.869	12.910	7.814	76.865	1.759
	Root	2.094	1.036	16.123	6.373	224.612	0.128
	Stalk	1.668	0.303	1.337	4.677	177.110	0.154
	Leaves	0.137	0.037	0.939	2.370	86.230	0.039
	Average	2.009 ±1.648	2.475 ±4.054	7.648 ±7.683	5.206 ±2.199	141.172 ±71.703	0.500 ±0.728
Celery	Soil	4.128	8.089	12.125	7.009	76.016	1.513
	Root	4.069	0.746	24.277	7.552	215.222	1.673
	Stalk	3.756	0.415	2.809	7.147	65.459	1.154
	Leaves	0.922	0.183	0.170	1.919	15.859	0.378
	Average	3.221 ±1.541	2.467 ±4.044	9.853 ±10.904	6.005 ±2.729	93.320 ±85.462	1.198 ±0.591
Basil	Soil	3.910	7.998	11.918	6.801	75.910	1.532
	Root	0.369	1.898	1.566	4.966	146.524	0.109
	Stalk	0.172	1.519	0.753	2.756	42.850	0.105
	Leaves	0.054	0.888	0.473	1.676	20.636	0.017
	Average	1.183 ±1.973	3.207 ±3.568	3.737 ±5.631	4.200 ±2.536	71.687 ±54.966	0.455 ±0.756
Mint	Soil	4.065	7.610	10.198	7.315	74.018	1.593
	Root	0.641	0.980	4.727	17.375	130.715	0.322
	Stalk	0.418	0.766	1.707	6.087	21.835	0.101
	Leaves	0.209	0.532	1.132	3.067	18.163	0.058
	Average	1.351 ±1.865	2.700 ±3.886	4.390 ±5.067	8.483 ±6.199	61.863 ±53.147	0.517 ±0.722
Limit UNSCEAR, 2010 [12]			33		45	412	2.0 UNSCEAR, 1993[20]

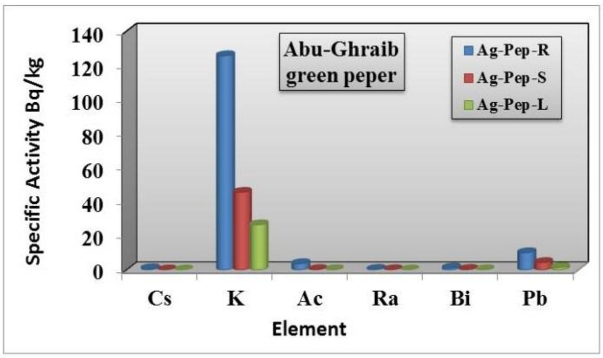

Fig. 1. Specific activity of Green pepper sample in Abu-Ghraib city.

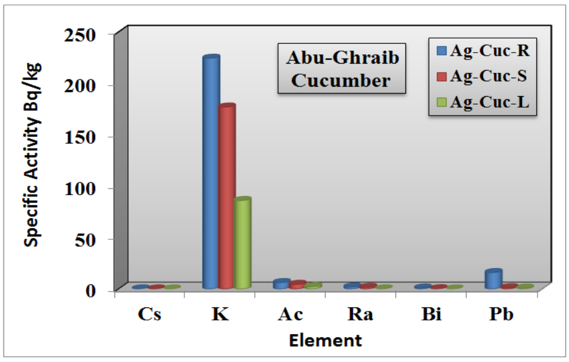

Fig. 2. Specific activity of Cucumber sample in Abu-Ghraib city.

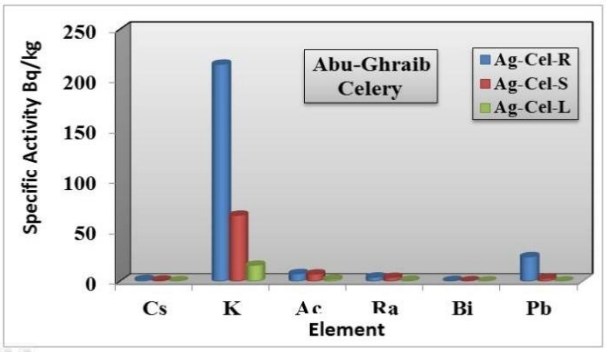

Fig. 3. Specific activity of Celery sample in Abu-Ghraib city.

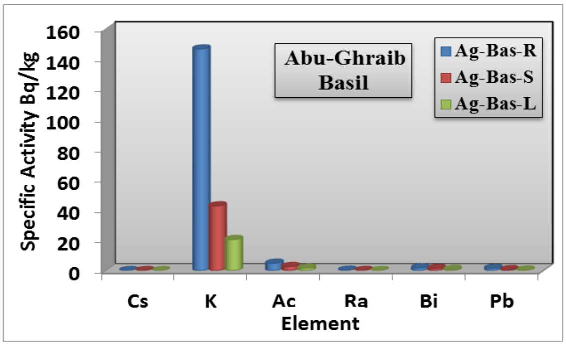

Fig. 4. Specific activity of Basil sample in Abu-Ghraib city.

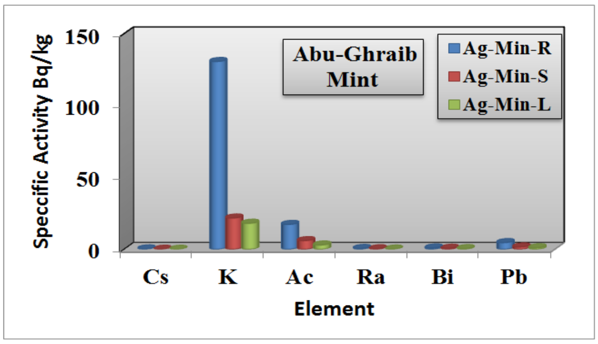

Fig. 5. Specific activity of Mint sample in Abu-Ghraib city.

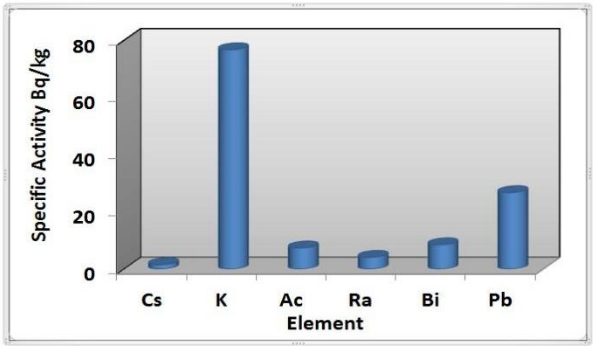

Fig. 6. Specific activity of Soil sample in Abu-Ghraib city

Table 2 and Figs. 7, 8 and 9 show the calculated results of radiation hazard indices (absorbed dose, annual effective dose, annual gonadal dose equivalent (dose ingested)) respectively. The estimated average values for the outside absorbed dose rate in green pepper, cucumber, celery, basil and mint varied from 14.772 nGy/h in cucumber-root to 2.020 nGy/h in basil-leaves. However, the inside absorbed dose rate varied from 30.290 nGy/h in mint –root to 2.363 nGy/h in green pepper-leaves. It seems clear that the results are less than the worldwide permissible limits, 84 nGy/h [12]. The highest value of the annual effective dose inside and outside the body was shown in mint sample. The results of annual gonadal dose were varied from 115.655 µSv/y in mint-root to 9.139 µSv/y in green pepper-leave. All results of annual effective dose equivalent and annual gonadal dose equivalent were below the allowable limit 290 µSv/y according to UNSCEAR, 2008 [21], and below 1000 µSv/y limit, according to ICRP, 1996 [22].

Table 3 and Figs. 10, 11, 12 and 13 explain the results of the Hazard index, Life-time cancer risk, radium equivalent activity and radioactivity level index. The results show that all hazards were less than ≤1 limit [1]. The results explain that there is a variation in cancer risk. The highest life-time cancer risk, in and out of the body was found in green pepper-soil, cucumber-root, celery-root, basil-root, and mint-root. As wall, the lowest values were found in leave for each the plants. The Ra_{eq} in green pepper, cucumber, celery, basil and mint varied from 35.553 Bq/kg in mint-root to 2.137 Bq/kg in green pepper-leave. Subsequently, the highest radium equivalent was recorded in green pepper-soil, cucumber-root, celery-root, basil-soil, and mint-root while; the lowest highest radium equivalent values were in leaves of each type of plant. So, all values were less than 370 Bq/kg limit recommended by UNSCEAR, 2000 [1]. Also, Table 3 and Fig. 13 show the results of radioactivity level Index. The highest value recorded 0.265 Bq/kg in mint-root while; the lowest value was 0.019 Bq/kg in green pepper-leaves. All results of radioactivity level index were below the permitted limit 1Bq/kg [17].

As tabulated in Table 4 and illustrated in Fig. 14, the average rate of transition factor in green pepper sample of U-232, Th-232, K-40, and Cs-137 was 0.045±0.044, 0.190±0.274, 0.859±0.685 and 0.185±0.287. For cucumber sample it was 0.314±0.248, 0.604±0.271, 1.406±0.568 and0.086±0.057. With regard to celery sample was 0.704±0.418, 0.748±0.424, 0.812±0.586 and 0.673±0.410. For Basil the average rate of transform factor was 0.048±0.038, 0.423±0.226, 0.912±0.8745 and 0.048±0.032. As for mint sample was 0.102±0.052, 1.194±1.018, 0.741±0.833 and 0.101±0.089. The highest rate for transform factor was 1.194±1.018 recorded in the mint sample at a concentration of Th-232respectively. The lowest rate for the transfer from the root to the leaves was in the basil sample in Cs-137 concentration at a rate of 0.048±0.032. The results show that the highest rate of transfer factor was to the roots and the highest rate of uranium transmission was 0.983 in the celery roots sample. As well the highest transfer rate for thorium was 2.347 in mint roots while; the highest transfer rate for potassium is 1.909 to the basil roots, were comparable to those reported elsewhere. Roots won the highest transmission factor for potassium-40 which was found in most of the study samples. Extremely high K-40 transfer factor values were found in cases where the concentration of potassium was very low in soil samples. This is because of the continuous accumulations for prolonged absorption by roots of potassium-40. The mean concentrations of activity of K-40 in basil samples were greater than those in green pepper, cucumber, celery and mint and were all less than the permissible value. Finally, the highest transfer rate for Cs-137 was 1.053 in celery root.

The highest K-40 transfer factors values were concentrated in the roots and were close to the limit recommended by UNSCEAR, 2010. This high absorption i.e. uptake of K-40 by the roots, it may be due to its presence in food crops while; for U-238 differed in the average range from 0.045±0.044 in green pepper to 0.704±0.418 in celery plant. And also for Th-232 were 0.024 in the green pepper leaves to 2.247 in the root of the mint sample, with an average range of 0.190±0.274 in the green pepper plant to1.194±1.018 in mint plant. The transfer factors for Th-232 were higher than that obtained for U-238 in this study. The average soil-to-plant transfer factors for Cs-137 varied from 0.048±0.032 in basil plant to 0.673±0.410 in celery plant. These transfer factors for Cs-137 are not significant because of their low concentration in environmental samples which was obtained in this study**.**

Table 2 Absorbed dose rate, Annual effective dose equivalent and Annual gonadal dose equivalent, at Abu-Ghraib city.

Sample Name	Sample Part	$D\ (nGy/h)$		$AEDE\ (\mu Sv/y)$		$AGDE$ $(\mu Sv/y)$
		Outside	inside	outside	Inside	
Green Pepper	Soil	9.967	18.166	12.224	89.119	67.8229
	Root	8.057	14.661	9.875	71.921	56.335
	Stalk	2.227	4.170	2.731	20.461	16.065
	Leaves	1.267	2.363	1.554	11.592	9.139
Cucumber	Soil	10.752	18.519	13.120	89.592	68.129
	Root	14.772	27.131	18.116	133.097	103.643
	Stalk	11.424	21.025	14.010	103.143	80.318
	Leaves	5.335	9.718	6.543	47.676	37.410
Celery	Soil	9.319	18.092	11.930	88.021	67.872
	Root	15.992	29.485	19.612	144.642	111.725
	Stalk	9.150	16.620	11.221	81.531	62.036
	Leaves	2.346	4.244	2.877	20.819	15.851
Basil	Soil	9.138	17.932	12.015	88.432	67.510
	Root	9.746	17.671	11.952	86.689	67.910
	Stalk	3.740	6.662	4.587	32.678	25.509
	Leaves	2.020	3.565	2.477	17.492	13.656
Mint	Soil	9.091	17.619	12.095	87.944	66.543
	Root	17.347	30.290	21.335	148.597	115.655
	Stalk	5.147	8.849	6.312	43.410	33.592
	Leaves	2.901	5.038	3.558	24.715	19.173
Limit		84 UNSCEAR,2010 [12]		290 UNSCEAR, 2008 [21] 1000 ICRP, 1996 [22]		

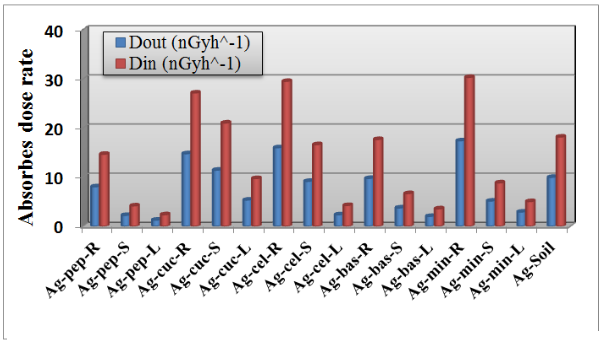

Fig. 7. Absorbed dose rate in samples at Abu-Ghraib city.

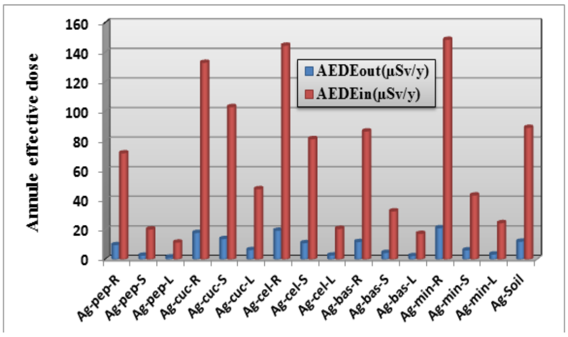

Fig. 8. Annual effective dose in samples at Abu-Ghraibcity.

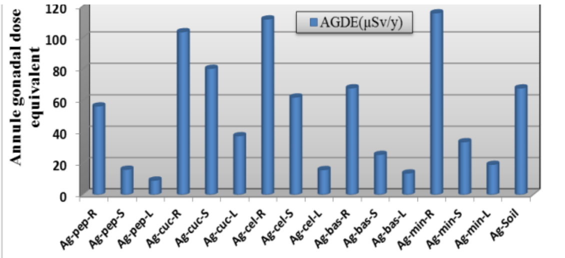

Fig. 9. Annual gonadal dose equivalent in samples at Abu-Ghraib city.

Table 3. Hazard index, lifetime cancer risk, radium equivalent and radioactivity level index, at Abu-Ghraib city.

Sample Name	Sample Part	Hazard index (Bq/kg)		ELCR		Ra_{eq} (Bq/kg)	Iγ (Bq/kg)
		H_{ex}	H_{in}	Outside $\times 10^{-3}$	Inside $\times 10^{-3}$		
Green Pepper	Soil	0.055	0.066	42.786	311.919	20.634	0.152
	Root	0.041	0.042	34.565	251.725	15.428	0.123
	Stalk	0.011	0.015	9.560	71.613	4.100	0.034
	Leaves	0.006	0.002	5.441	40.574	2.137	0.019
Cucumber	Soil	0.070	0.069	42.922	312.129	20.891	0.212
	Root	0.077	0.082	63.407	465.842	28.504	0.227
	Stalk	0.059	0.063	49.038	361.001	21.994	0.175
	Leaves	0.027	0.027	22.903	166.869	10.167	0.082
Celery	Soil	0.050	0.061	40.312	309.965	19.764	0.149
	Root	0.084	0.095	68.645	506.248	31.442	0.246
	Stalk	0.051	0.061	39.276	285.358	19.017	0.140
	Leaves	0.013	0.015	10.070	72.868	4.887	0.035
Basil	Soil	0.053	0.064	42.193	311.310	20.109	0.150
	Root	0.050	0.051	41.675	303.412	18.753	0.149
	Stalk	0.020	0.024	16.057	114.374	7.413	0.057
	Leaves	0.010	0.011	8.672	61.224	4.040	0.030
Mint	Soil	0.054	0.066	42.587	311.432	20.109	0.148
	Root	0.096	0.097	74.675	520.081	35.553	0.265
	Stalk	0.029	0.030	22.093	151.937	10.804	0.078
	Leaves	0.016	0.017	12.453	86.505	5.994	0.044
Limit UNSCEAR, 2000 [1]		≤1		0.29	1.16	370	≤1 [17]

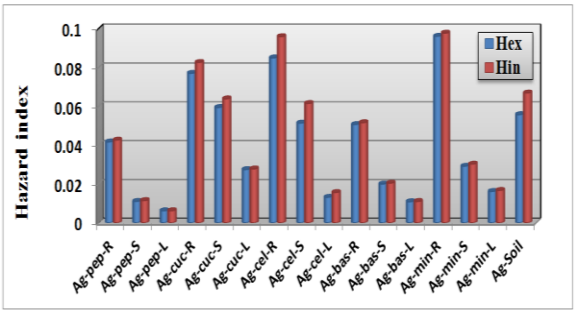

Fig. 10. Hazard index of samples at Abu-Ghraib city.

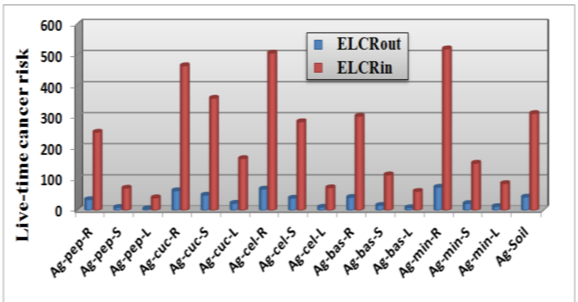

Fig. 11. Live Time cancer risk in samples at Abu-Ghraib city.

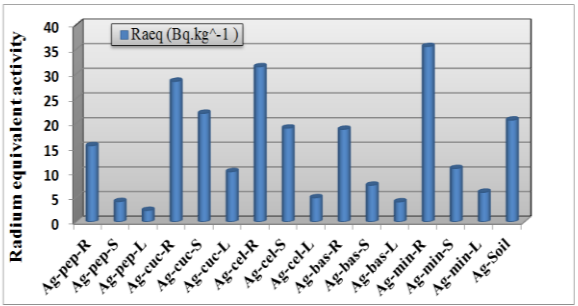

Fig. 12. Radium equivalent activity in samples at Abu-Ghraib city.

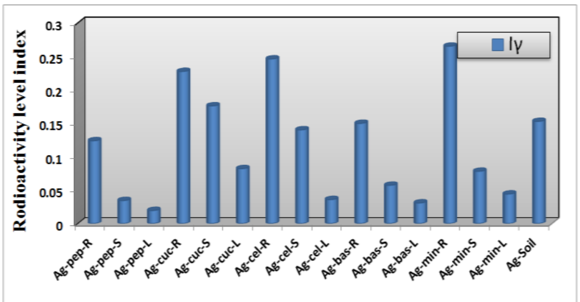

Fig. 13. Radioactivity level index in samples at Abu-Ghraib city.

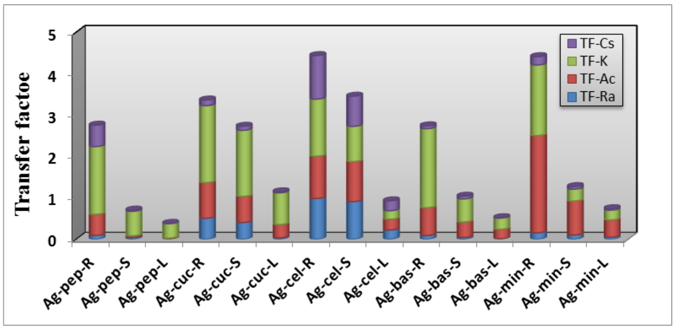

Fig. 14. Transfer factor from soil to plant in samples at Abu-Ghraib city.

Table 4. Soil-to-plant transfer factor (TF) of natural radionuclides and artificial C-137 at Abu-Ghraib city.

Sample Name	Sample Parts	Transfer factor			
		U-238	Ac-228	K-40	Cs-137
Green Pepper	Root	0.092	0.507	1.637	0.516
	Stalk	0.039	0.040	0.593	0.029
	leaves	0.003	0.024	0.346	0.009
	Average	0.045 ±0.044	0.190 ±0.274	0.859 ±0.685	0.185 ±0.287
Cucumber	Root	0.506	0.860	1.857	0.1377
	Stalk	0.403	0.631	1.594	0.097
	leaves	0.033	0.320	0.767	0.024
	Average	0.314 ±0.248	0.604 ±0.271	1.406 ±0.568	0.086 ±0.057
Celery	Root	0.983	1.020	1.378	1.053
	Stalk	0.907	0.965	0.853	0.726
	leaves	0.222	0.259	0.206	0.238
	Average	0.704 ±0.418	0.748 ±0.424	0.812 ±0.586	0.673 ±0.410
Basil	Root	0.089	0.670	1.909	0.068
	Stalk	0.041	0.372	0.558	0.066
	leaves	0.031	0.226	0.268	0.011
	Average	0.048 ±0.038	0.423 ±0.226	0.912 ±0.875	0.048 ±0.032
Mint	Root	0.154	2.347	1.703	0.202
	Stalk	0.101	0.822	0.284	0.063
	leaves	0.050	0.414	0.236	0.036
	Average	0.102 ±0.052	1.194 ±1.018	0.741 ±0.833	0.101 ±0.089

5. Conclusions

The radioactivity was measured in samples of green pepper, cucumber, celery, basil, mint, and their soils on a regular basis. Specific activity concentrations U-238, Th-232, K-40, and Cs-137 using the NaI (Tl) gamma ray spectrum detector. To assess radiological hazards, radium-equivalent equivalents, absorbed dose rate, annual effective dose rate, hazard indices, annual gonadal dose equivalent and radioactivity level index were all estimated below the permissible limits that are considered safe from radiological hazards. In this study K-40 transfer factors were found to be arranged at the roots. Gradually, descending from the roots to the stalk and then to the leaves in the selected basil, celery and mint plants under study. Therefore, the current study proved that the samples selected under study do not have dangerous radiological effects. We recommend studying and measuring the concentrations of radionuclides and their activities in terms of availability in the local market to determine the quality of consumer foodstuffs.

Acknowledgements

The authors would like to knowledge all those contributed in declaring this work. Special thanks to the staff of nuclear physics lab. for post graduate students, College of Science, Mustansiriyah University. The authors also extend their thanks and gratitude to the employees of the Nuclear Laboratory at the College of Science, Al-Nahrain University for allowing measurements. There is no financial support for this work leading to this publication. We the authors confirm that we have not any organizations that funded our research. It is noteworthy that the transfer of radionuclides from plants to

livestock and then to humans through the food chain, may lead to many radiation hazards to the humans if the transfer factor exceed unity.

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