**Natural Radioactivity Levels in Some Vegetables and Fruits Commonly Used in Najaf Governorate , Iraq**

(1) Ali Abid Abojassim Al-Hamidawi (2) Heiyam Najy Hady (3) Zahrah Baqer Mohammed

(1) University of Kufa /Faculty of Science / Department of Physics .

(2)(3) University of Kufa / Faculty of Education for Girls / Department of Physics .

Email :[ali.alhammedawi@uo.kufa.edu.iq](mailto:ali.alhammedawi@uo.kufa.edu.iq)

**Abstract :**

Radioactivity in Food may be contaminated with radioactive materials due to the natural and a nuclear emergency. The vegetables and fruits will become radioactive by deposit of radioactive materials falling on that from the air or through rain water. The aims of the present work were measured the specific activity and annual effective dose as a result of the intake of Vegetables and Fruits that it collected from local market in Najaf governorate. Natural radioactivity were measured in samples in this study using gamma ray spectrometer. The results show that, the average specific activities in fresh vegetables samples for 238U, 232Th, and 40K were 5.21, 4.76, and 186.15 Bq/kg, respectively, the average specific activities for 232Th, 40K in fruit samples were 2.53, 211.64 Bq/kg, while the total average annual effective dose in fresh vegetables samples for adults, children and infants is estimated to be 0.117, 0.122, and 0.179 mSv, respectively, while the total average annual effective dose in fruit samples for adults, children and infants is estimated to be 0.141, 0.295, and 0.388 mSv, respectively. The values found for specific activity and the annual effective dose in all samples in this study were lower than worldwide median values for all groups; therefore, these values are found to be safe.

**Keyword**: Natural Radioactivity, Vegetables and Fruits, Gamma spectrometer and Najaf Governorate .

**1.Introduction**

Radionuclides is found throughout nature which it is exist in the soil ,water and food. These radionuclides have half-lives that are approximately Earth's age or older (i.e. about 4 to 5 billion years) [1]. Natural radioactive decay series such as 238U and 232Th as well as singly occurring radionuclides such as 40K exist in the earth and atmosphere in varied levels. The radioactivity present on air or in the agricultural land and in soil may transfer to the crops grown on it. It happens, however that an amount of some radioactive elements find their way into human bodies [2]. Generally, the plants (vegetables and fruits) may cause accumulation of radionuclides in their organs, which may additional rely on the chemical and physic properties of the soil.. So, there may be multiplied risk to human population via food chain. The main sources of components from the environment to plants are: air, water and also the soil [3]. There are two ways for transferring of the radionuclides present in the environment in to plants by indirect and direct methods. The first method (indirect) was happen by uptake from soil through roots. When plants are grown in the contaminated soil, the radioactivity is transferred from the soil to the roots and then in shoots. At the last, the radioactivity is shifted to the human diet [3]. These radionuclides will get transferred into plants together with the nutrients throughout mineral uptake and accumulation in varied components and even reach edible portions [4]. The second method (direct) was happen by absorption through aerial elements of the plants. Presence of emission in plant organs has been reviewed by varied staff [2].

Many are revealed works on radioactive food contamination within the environment and its transfer or pathway mechanism to plants, animals and human population. Uptake of natural radionuclides depends on the consumption rate of food, water and also the radionuclide concentrations [2,4]. There are some studies found that the levels of natural radioactivity in Vegetables and Fruits samples consumed in different counters in the world [5-13]. The present study in literate are which aimed to radioactive content of the vegetables and fruits consumed by infants, children and adults in in Najaf Governorate, Iraq. The present study also aims to estimate annual effective doses from consumption samples under study among various age groups.

**2. Material and methods**

**2.1. Sample collection and preparation**

This work focuses on the vegetables and fruits consumed by the overall public in Najaf Governorate, Iraqi. Samples from thirty one vegetables and nine fruits samples were collected in study area are presented in Table (1) and Table (2) respectively.

**Table (1) : Food categories of vegetables samples in this study.**

|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Name of samples** | **Code of samples** | **Country of origin** |
| 1 | Tomato | Veg1 | Iraq (Kufa) |
| 2 | Potato | Veg 2 | Iraq (Kufa) |
| 3 | Eggplant | Veg 3 | Iraq (Kufa) |
| 4 | Onion | Veg 4 | Iraq (Kufa) |
| 5 | Okra | Veg 5 | Iraq (Babylon) |
| 6 | Okra | Veg 6 | Iraq(Kwt) |
| 7 | Pumpkin | Veg 7 | Iraq (Kufa) |
| 8 | Cucumis | Veg 8 | Iraq(Yousefah) |
| 9 | Zucchini | Veg 9 | Iraq (Kufa) |
| 10 | Bell Pepper | Veg 10 | Iraq (Kufa) |
| 11 | Celery | Veg 11 | Iraq (Kufa) |
| 12 | Parsley | Veg 12 | Iraq (Kufa) |
| 13 | Watercress | Veg 13 | Iraq (Kufa) |
| 14 | Cabbage | Veg 14 | Iraq (Kufa) |
| 15 | Spearmint | Veg 15 | Iraq (Kufa) |
| 16 | Basil | Veg 16 | Iraq (Kufa) |
| 17 | Leeks | Veg 17 | Iraq (Kufa) |
| 18 | Fenugreek | Veg 18 | Iraq (Kufa) |
| 19 | Portulaca | Veg 19 | Iraq (Kufa) |
| 20 | Tomato | Veg 20 | Iran |
| 21 | Potato | Veg 21 | Iran |
| 22 | Eggplant | Veg 22 | Iran |
| 23 | Onion | Veg 23 | Iran |
| 24 | Dill | Veg 24 | Iran |
| 25 | Lettuce | Veg 25 | Iran |
| 26 | Zucchini | Veg 26 | Iran |
| 27 | Carrot | Veg 27 | Iran |
| 28 | Cauliflower | Veg 28 | Iran |
| 29 | Bell Pepper | Veg 29 | Iran |
| 30 | Chili Pepper | Veg 30 | India |
| 31 | Garlic | Veg 31 | China |

**Table (2) : Food categories of Fruits samples in this study**

|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Name of samples** | **Code of samples** | **Country of origin** |
| 1 | Rearrange | Fr1 | Iraq |
| 2 | Pomegranate | Fr2 | Iraq |
| 3 | Pear | Fr3 | Iraq |
| 4 | Watermelon | Fr4 | Iran |
| 5 | Apple | Fr5 | Iran |
| 6 | Banana | Fr6 | Egypt |
| 7 | Orange | Fr7 | Egypt |
| 8 | Lemon | Fr8 | Turkey |
| 9 | Apricot | Fr9 | Turkey |

The foodstuff samples were cleaned and dried under the sun and after drying, each sample is placed in a plastic bag and labeled by name and country of origin. Then the samples were crushed electronically, using electric mill. for homogeneity, the samples were sieved (0.8-mm-pore-size sieve); they were kept moisture-free in an oven, in order to reach a constant weight. Samples were packed in Marinelli beakers that it is constant volume, to attain a good homogeneity around the NaI(Tl) detector. The weighting of samples were measured using digital weighing balance (60.01%). At the end, the Marinelli beakers were stored for about 1 month before measuring, to permit secular equilibrium to be investigated between 226Ra and 222Rn .

**2.2. *NaI(TI) Gamma Ray Spectroscopy***

Gamma ray spectroscopy with scintillation detector NaI(TI) from ORTEC has an active area of "3×3" inches (Figure1), energy resolution 7.9% and Efficiency of 4.6% at the 662 KeV . Energy calibration and efficiency calibration of gamma spectrometer were carried out using (60Co,137Cs, 22Na and 54Mn) form the Nuclear Lab. in Physics department, Which has seven gamma-ray emitters ranged from 511 KeV to 2500 KeV. The lowest limit of detection (LLD) for 238U, 232Th and 40K were 3.17 Bq/kg, 1.2 Bq/kg and 11.54 Bq/kg respectively. The standard source put over the detector with a geometric match exactly to the geometrical sample form and with same distance between the sample and the detector. The radioactive background decrease for different radiations using shield which consist of two layers, first one of stainless steel with width ( 10 mm) and the second layer lead (30 mm).



**Figure (1):** The diagram of the NaI(Tl) detector.

The specific activity of 238U and 232Th were measured using property of secular equilibrium with their decay products such as transition lines of 214Bi (1765 KeV) and transition lines of 208 Tl (2614 KeV) respectively. While 40K were measured directly from the photo peak at 1460 KeV. The measuring time for all samples under study was 24 hour.

**2.3. Data Analysis & Mathematical Formula**

The specific activity for each detected photo-peak was calculated in (Bq/kg) by equation [14-16]:

where **Ar** is the specific activity of the radionuclide in the sample, **N** is the net counts of a given peak for a sample, No is the background of the given peak, , **Iγ** is the number of gamma photons per disintegration, **ε** is the detector efficiency at the specific gamma-ray energy, **m** is the mass of the measured sample and **t** is the measuring time for the sample.

Also during this study, we have calculate the annual effective dose as a result of the intake of foods was performed supported the metabolic model developed by ICRP[17] which it's can be determined using equation[5,8,18]:

where Drf is the annual effective dose, Cr is the effective dose conversion factor of the nuclide (r) (table (3)), Arf is the specific activity of the nuclide (r) in the ingested food (f, Bq/kg wet weight), and Rf is the consumption rate of the food item (f, kg/y) table(4) [7, 8, 19].

**Table(3): Dose convection factors for different Radionuclides in nSv.Bq-1 [16].**

|  |  |  |  |
| --- | --- | --- | --- |
| **Age Groups** | **238U** | **232Th** | **40K** |
| **Adults** | 280 | 230 | 6.2 |
| **Children(10year old)** | 800 | 290 | 13 |
| **Infant** | 960 | 450 | 42 |

**Table(4): Consumption rates for fresh vegetables and fruits[20].**

|  |  |  |  |
| --- | --- | --- | --- |
| **Food categories** | **\*Average of Consumption Rates (kg/y)** | | |
| **Adult** | **Children(10 year old)** | **Infant** |
| **Green vegetables** | 45 | 20 | 10 |
| **Potatoes** | 120 | 85 | 35 |
| **Root** | 170 | 110 | 60 |
| **Fruit** | 75 | 50 | 35 |

\* These rates are the 97.5th percentile of the distribution across all consumers.

**Table(5):The specific activity of 238U, 232Th, and 40K in fresh vegetables samples under study.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No.** | **Code of samples** | **Specific activity (Bq/kg)** | | |
| **238U** | **232Th** | **40K** |
| 1 | Veg1 | 5.12±0.22 | 2.22±0.05 | 219.99±1.29 |
| 2 | Veg 2 | 4.24±0.17 | 3.11±0.07 | 116.91±0.07 |
| 3 | Veg 3 | 6.47±0.37 | 10.56±0.18 | 209.56±1.35 |
| 4 | Veg 4 | 3.63±0.20 | 3.08±0.05 | 274.65±3.07 |
| 5 | Veg 5 | BLD a \* | 5.15±0.08 | 138.64±0.86 |
| 6 | Veg 6 | BLD | 6.64±0.11 | 141.51±0.92 |
| 7 | Veg 7 | BLD | 6.47±0.13 | 164.93±1.05 |
| 8 | Veg 8 | BLD | 5.67±0.10 | 193.73 ±1.17 |
| 9 | Veg 9 | BLD | 5.06±0.10 | 226.56±1.34 |
| 10 | Veg 10 | BLD | 5.76±0.12 | 147.16±0.95 |
| 11 | Veg 11 | BLD | 5.14±0.10 | 156.67±0.96 |
| 12 | Veg 12 | BLD | 5.23±0.10 | 206.35±1.21 |
| 13 | Veg 13 | BLD | 4.38±0.11 | 140.95±0.90 |
| 14 | Veg 14 | BLD | 4.90±0.09 | 131.52±0.84 |
| 15 | Veg 15 | BLD | 5.12±0.10 | 179.53±1.14 |
| 16 | Veg 16 | BLD | 4.83±0.11 | 236.39±1.43 |
| 17 | Veg 17 | BLD | 6.54±0.14 | 274.46±1.71 |
| 18 | Veg 18 | BLD | 3.75±0.08 | 276.89±1.35 |
| 19 | Veg 19 | BLD | 3.04±0.04 | 108.99±1.40 |
| 20 | Veg 20 | 6.99±0.20 | 3.95±0.08 | 155.86±0.99 |
| 21 | Veg 21 | 5.02±0.15 | 2.30±0.04 | 155.40±0.72 |
| 22 | Veg 22 | 6.26±0.01 | 8.98±0.16 | 317.75±2.17 |
| 23 | Veg 23 | 3.99±0.01 | 2.84±0.05 | 238.72±1.49 |
| 24 | Veg 24 | BLD | 6.29±0.11 | 180.98±1.11 |
| 25 | Veg 25 | BLD | 2.21±0.05 | 319.21±1.74 |
| 26 | Veg 26 | BLD | 3.11±0.07 | 139.92±0.88 |
| 27 | Veg 27 | BLD | 5.24±0.11 | 124.06±0.83 |
| 28 | Veg 28 | BLD | 3.42±0.07 | 140.25±0.97 |
| 29 | Veg 29 | BLD | 3.96±0.08 | 139.38±0.91 |
| 30 | Veg 30 | BLD | 5.23±0.10 | 159.27±1.03 |
| 31 | Veg 31 | BLD | 3.55±0.09 | 154.64±1.09 |
| Average ± S.D | | 5.21±0.47 | 4.76±0.34 | 186.15±10.78 |
| Worldwide median value b | | 35 | 30 | 400 |

**Table(6):The specific activity of 238U, 232Th, and 40K in fruit samples under study.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No.** | **Code of samples** | **Specific activity (Bq/kg)** | | |
| **238U** | **232Th** | **40K** |
| 1 | Fr1 | BLD | 2.85±0.06 | 285.83±1.85 |
| 2 | Fr2 | BLD | 2.04±0.05 | 223.74±1.51 |
| 3 | Fr3 | BLD | 2.51±0.06 | 206.61±1.38 |
| 4 | Fr4 | BLD | 2.63±0.06 | 144.35±1.20 |
| 5 | Fr5 | BLD | 2.14±0.05 | 185.73±1.27 |
| 6 | Fr6 | BLD | 2.92±0.05 | 154.26±0.94 |
| 7 | Fr7 | BLD | 2.58±0.06 | 195.50±1.46 |
| 8 | Fr8 | BLD | 2.73±0.06 | 218.57±1.46 |
| 9 | Fr9 | BLD | 2.37±0.05 | 290.20±1.78 |
| Average ± S.D | | BLD | 2.53±0.106 | 211.64±17.96 |
| Worldwide median value b | | 35 | 30 | 400 |

\* BDL a , below detection limit and b Data from UNSCEAR (2000) [21].

**Result and Discussion:**

Specific activity of radionuclides The results of specific activity in the food samples for natural radionuclides such as 238U, 232Th and 40K, are given in Table(5) and Table(6).

The highest concentrations displayed in Table(5) correspond to The naturally occurring radionuclide 40K.The highest concentration of 319.21±1.74 Bq kg−1 was measured in sample Veg 25 (Lettuce, made in Iran). The spread of measured values is rather large, sample Veg 24 (Dill, made in Iran) was the lowest concentration: 108.99±1.40 Bq kg−1 with an average 186.15±10.78 Bq kg −1.

40K was found to contribute the highest activity in all the food samples. However, 40K is an essential biological element and its concentration in human tissue is under close metabolic control. Sample Veg 20 (Tomato, made in Iran) was the food type that contained the highest concentration of 238U, at 6.99±0.20 Bq kg−1,while the lowest concentration, at 3.63±0.20 Bq kg−1, was measured in sample Veg 4 (Onion, made in Iraq) with an average 5.21±0.47 Bq kg−1. The highest concentration of 232Th – 10.56±0.18 Bq kg−1 – was measured in Veg 3 (Eggplant, made in Iraq), The lowest concentration of 232Th −2.21±0.05 Bq kg−1 – was measured in Veg 25 (Lettuce, made in Iran) with an average 4.76±0.34 Bq kg−1. 238U and 232Th concentrations in all samples were lower than concentrations from other countries.

The highest concentrations displayed in Table (6) correspond to The naturally occurring radionuclide 40K.The highest concentration of 290.20±1.78 Bq kg−1 was measured in sample Fr9 (Apricot, made in Turkey). The spread of measured values is rather large, sample Fr4 (Watermelon, made in Iran) was the lowest concentration: 144.35±1.20Bq kg−1 with an average 211.64±17.96 Bq kg −1. 40K was found to contribute the highest activity in all the food samples. However, 40K is an essential biological element and its concentration in human tissue is under close metabolic control. All values of the specific activity of 238U were below limit detection. The highest concentration of 232Th – 2.92±0.05 Bqkg−1 was measured in sample Fr6 (Banana, made in Egypt), The lowest concentration of 232Th −2.04±0.05 Bq kg−1 was measured in sample Fr2 (Pomegranate, made in Iraq)with an average 2.53±0.106 Bq kg−1. As seen in Tables (7),(8) and fig.(2), annual effective dose from vegetables and fruits consumption by children is larger than the dose from consumption by adults and infants. This larger value for children is due to the dose conversion factor for the radionuclide and the annual intake of sample. This indicates that the annual effective dose in all vegetables and fruits samples was lower than the permissible limit of 1 mSv recommended by the International Commission on Radiological Protection [17]. The table (9) consist of Comparison of specific Activity (Bq.Kg-1) of 238U, 232Th and 40K, in the in vegetables and fruits Samples at different countries.

**Table(7): Summation of annual effective dose in in fresh vegetables samples at different age groups (adults, children and infants).**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No.** | **Code of samples** | **Annual effective dose (mSv/y)** | | |
| **Adults** | **Children** | **Infants** |
| 1 | Veg1 | 0.147 | 0.15 | 0.15 |
| 2 | Veg 2 | 0.313 | 0.493 | 0.361 |
| 3 | Veg 3 | 0.149 | 0.218 | 0.196 |
| 4 | Veg 4 | 0.136 | 0.146 | 0.245 |
| 5 | Veg 5 | 0.091 | 0.065 | 0.081 |
| 6 | Veg 6 | 0.107 | 0.074 | 0.088 |
| 7 | Veg 7 | 0.112 | 0.079 | 0.719 |
| 8 | Veg 8 | 0.112 | 0.082 | 0.106 |
| 9 | Veg 9 | 0.115 | 0.087 | 0.117 |
| 10 | Veg 10 | 0.1 | 0.071 | 0.086 |
| 11 | Veg 11 | 0.096 | 0.069 | 0.088 |
| 12 | Veg 12 | 0.111 | 0.083 | 0.109 |
| 13 | Veg 13 | 0.084 | 0.061 | 0.078 |
| 14 | Veg 14 | 0.086 | 0.062 | 0.077 |
| 15 | Veg 15 | 0.102 | 0.075 | 0.098 |
| 16 | Veg 16 | 0.114 | 0.089 | 0.12 |
| 17 | Veg 17 | 0.143 | 0.108 | 0.144 |
| 18 | Veg 18 | 0.115 | 0.092 | 0.132 |
| 19 | Veg 19 | 0.068 | 0.049 | 0.061 |
| 20 | Veg 20 | 0.171 | 0.173 | 0.149 |
| 21 | Veg 21 | 0.091 | 0.568 | 0.432 |
| 22 | Veg 22 | 0.258 | 0.234 | 0.233 |
| 23 | Veg 23 | 0.129 | 0.141 | 0.226 |
| 24 | Veg 24 | 0.115 | 0.083 | 0.788 |
| 25 | Veg 25 | 0.111 | 0.094 | 0.143 |
| 26 | Veg 26 | 0.071 | 0.054 | 0.071 |
| 27 | Veg 27 | 0.078 | 0.062 | 0.113 |
| 28 | Veg 28 | 0.074 | 0.055 | 0.073 |
| 29 | Veg 29 | 0.078 | 0.058 | 0.075 |
| 30 | Veg 30 | 0.098 | 0.071 | 0.089 |
| 31 | Veg 31 | 0.07 | 0.06 | 0.12 |
| Average ± S.D | | 0.117±0.009 | 0.122±0.021 | 0.179±0.031 |

**Table(8): Summation of annual effective dose in fruits samples at different age groups (adults, children and infants).**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No.** | **Code of samples** | **Annual effective dose (mSv/y)** | | |
| **Adults** | **Children** | **Infants** |
| 1 | Fr1 | 0.181 | 0.226 | 0.464 |
| 2 | Fr2 | 0.139 | 0.435 | 0.36 |
| 3 | Fr3 | 0.139 | 0.17 | 0.693 |
| 4 | Fr4 | 0.112 | 0.968 | 0.253 |
| 5 | Fr5 | 0.122 | 0.151 | 0.306 |
| 6 | Fr6 | 0.121 | 0.142 | 0.271 |
| 7 | Fr7 | 0.134 | 0.164 | 0.327 |
| 8 | Fr8 | 0.148 | 0.181 | 0.363 |
| 9 | Fr9 | 0.174 | 0.222 | 0.463 |
| Average ± S.D | | 0.141±0.008 | 0.295±0.094 | 0.388±0.101 |

**Figure (2):** Summation of Annual effective dose (mSv/y) invegetables and fruits by all age groups

**Table (9): Comparison of specific activity (Bq/kg) of natural radio‐nuclides in vegetables and fruits at different countries.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Region/country** | **Food categories** | **Specific activity (Bq kg-1)** | | | **References** |
| **238U** | **232Th** | **40K** |
| Qena/Egypt | vegetables | 0.01± 0.02 | 0.01 ± 0.05 | 26.65±1.24 | [5] |
| Fruits | 2.56 ± 1.11 | 1.22 ± 0.56 | 536.64±23.03 |
| Bangladesh | vegetables | 64.77±38.47 | 83.53 ± 0.5 | 1691.45±244.98 | [6] |
| Elazıg˘/Turkey | vegetables | 0.64 ± 0.26 | 0.65 ± 0.14 | 13.98 ±1.22 | [7] |
| Fruits | 1.52 ± 0.34 | 0.98 ± 0.23 | 18.66 ± 1.13 |
| Rize/Turkey | Eggplant | 0*.*20 ± 0*.*02 | 0*.*52± 0*.*06 | 517*.*19 ± 51*.*91 | [8] |
| Pepper | 1*.*73 ± 0*.*33 | 0*.*57± 0*.*06 | 421*.*20 ± 14*.*48 |
| Cucumber | 1*.*20 ± 0*.*18 | 1*.*37± 0*.*41 | 366*.*17 ± 19*.*49 |
| Tomato | 9*.*43 ± 1*.*28 | 1*.*35± 0*.*35 | 373*.*03 ± 9*.*67 |
| Parsley | 8*.*36 ± 0*.*92 | 2*.*64± 1*.*51 | 1014*.*72 ±42*.*64 |
| Apple | 0*.*50 ± 0*.*07 | 0*.*38± 0*.*08 | 49*.*15 ± 1*.*17 |
| Lemon | 0*.*36 ± 0*.*04 | 0*.*45± 0*.*07 | 50*.*47 ± 1*.*20 |
| Pear | 0*.*29 ± 0*.*02 | 0*.*25± 0*.*03 | 40*.*39 ± 0*.*74 |
| South India | Leafy vegetable | 0.03±0.01 | 1.03±0.5 | 49.5±8.4 | [10] |
| Cucumber | 0.097±0.02 | 0.14±0.04 | 29.67±9.1 |
| Tomato | 0.06±0.03 | 0.17±0.02 | 71.92±8.4 |
| Banana | 0.094±0.02 | 1.1±0.2 | 136.2±8.3 |
| Southwest India | Cucumber | 0.07±0.03 | 0.14±0.06 | 29.64±9.1 | [11] |
| Tomato | 0.08±0.02 | 0.17±0.01 | 71.92±8.4 |
| Banana | 0.12±0.04 | 0.965±0.4 | 136.2±41.1 |
| Alexandria/Egypt | Carrot | ----- | ----- | 42.38 ± 3.93 | [12] |
| Cucumber | ----- | ----- | 68.55 ± 4.34 |
| Tomato | 0.96 ± 0.30 | ----- | 49.48 ± 3.45 |
| Lettuce | 1.05 ± 0.48 | ----- | 166.0 ± 16.69 |
| Potato | 0.80 ± 0.49 | ----- | 118.75 ± 2.34 |
| Green okra | 0.86 ± 0.05 | ----- | 117.98 ± 7.32 |
| Apple | 1.25 ± 0.35 | ----- | 32.27 ± 2.70 |
| Water-melon | 0.85 ± 0.32 | ----- | 40.37 ± 3.07 |
| Root Vegetables | ----- | ----- | 210 - 448 |
| Fruit | ----- | ----- | 490 - 510 |
| Parana´/ Brazil | Potato | ----- | ----- | 166.7 | [22] |
| Najaf/Iraq | Vegetable | 5.21±0.47 | 4.76±0.34 | 186.15±10.78 | Present study |
| Fruit | ----- | 2.53±0.106 | 211.64±17.96 |

**CONCLUSIONS**

Natural radioactivity (238U, 232Th and 40K) and annual effective dose in some samples of vegetables and fruits that are produced and frequently consumed in Najaf, Iraq were determined in this study. Specific activity of these radionuclides in samples under study were lower than those reported by UNSCEAR. Also it is found that annual effective doses due to the ingestion of all three natural radionuclides by adults, children, and infants below the limit recommended by the World Health Organization and by the International Commission on Radiological Protection for radiological safety .

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