Investigation of Natural Radioactivity Concentration in Leaf Part of Some Medicinal Herbs Used in Iraq

Sana Thamer Kadhem[1], Muhanad Alrakabi[2], Jabbar M. Rashid[3]
[1, 2]Department of Physics, College of Science, University of Mustansiriyah/Iraq
[3]Department of Physics, College of Science, University of Thi Qar, Iraq
Email: sanaathamir8181@gmail.com

Abstract
Natural radioactive materials may be present in the environment and substances that are used as health complementary in medicine and pharmacy. Medicinal herbs are as old as human history and have been used for the treatment and prevention of various diseases and ailments because they contain elements of vital importance for human metabolism. The objective of this research study was to determine the specific activity concentrations and the annual effective dose of naturally occurring radioactive materials that exist in commonly used medicinal herbs in Iraq. A total of 25 medicinal herbs were randomly collected to calculate the activity concentrations and all health risk parameters of 238U, 232Th, 226Ra, 228Ra, and 40K. Using a gamma spectroscopy system According to the study's findings, the specific activity concentration of 238U ranged from (5.95 to 1.49) Bq/Kg with an average (3.89) Bq/Kg and standard deviation (0.86); that of 232Th ranged from (3.07 to 1.06) Bq/Kg with an average (1.87) Bq/Kg and standard deviation (0.51), and that of 228Ra ranged from (8.3 to 0.98) Bq/Kg with an average (4.49). Finally, the range of specific activity concentration for 40K was (196.68 to 106.26) Bq/Kg, with an average of (147.08) Bq/Kg and a standard deviation of (25.49). The results of all calculated parameters for each sample are within the limits allowed by the recommendations of ICRP, WHO, and UNSCEAR, and therefore there is no major risk to workers and the public who are using the herbs in this study.
Keywords: NORM, Medicinal herbs, Radiation hazard, Activity concentration, Gamma-ray spectroscopy, Medicinal Plant, Natural radioactivity.

1. Introduction

The primordial radionuclides, such as 40K, and the radionuclides from the 238U and 232Th decay series are the most common radionuclides in all environmental media, including vegetables, and ingestion exposure dose mainly results from these radionuclides [1]. In the terrestrial ecosystem, the soil is the main reservoir for radioactivity contamination [2]. If elevated levels of these radionuclides accumulate within the body, then the organs will be subject to continuous exposure from the emitted photons and particulate forms of radiation, creating radiation damage and biochemical and morphological changes [3].

Since the dawn of human civilization, human beings have found remedies within themselves and have adopted different therapeutic strategies depending upon climatic, phytogeographic, sociocultural, floral, and faunal characteristics. Traditional systems thus contain beliefs and practices to avoid, present, or avert ailments, which constitute traditional preventive medicine [5]. According to a World Health Organization (WHO) survey, about 70% to 80% of the world's population rely on conventional medicine, mainly from herbal sources, for primary health care. Plants are used for medicinal purposes in many countries. Today, herbal medicines are being employed worldwide in a variety of healthcare settings as well as home remedies. Medicinal plants are also important for pharmacological research and drug development, not only when plant constituents are used directly as therapeutic agents, but also when they are used as basic materials for the synthesis of drugs [5]. It is estimated that 25% of modern medicines are directly or indirectly derived from local medicinal plants [6]. Climatic conditions, different places, as well as environmental factors can affect the medical properties and effectiveness of medicinal plants and may also have a direct influence on their growth in the place of their occurrence and cultivation [7].

An emerging problem in many developing countries is industrial waste pollution that threatens the local environment's health and causes contamination of vegetation by heavy metals, pesticides, and radioactivity [8]. It happens, however, that a small amount of some radioactive elements find their way into human bodies [9]. When plants are grown in contaminated soil, radioactivity is transferred from the soil to the roots. In the end, the radioactivity is shifted to the human diet [10]. These radionuclides will get transferred into plants together with the nutrients throughout mineral uptake and accumulation in varied components and even reach edible portions [11]. Plants used as food commonly have 238U, 232Th, and 40K and their progenies [12]. Therefore, these similarities would be found in plants used for medicinal purposes since plants are the primary pathway for natural radionuclides to enter

doi.org/10.31838/hiv22.02.467 Received: 17.04.22, Revised: 31.05.22, Accepted: 05.08.22

the human body via the food chain. Thus, the contamination level in the medicinal plants should therefore be monitored and analyzed [13].

2. Assessment of Radiation Hazards (Theoretical Considerations)

2.1. Minimum Detectable Activity

The Minimum Detectable Activity (MDA) is very important if low-concentration radioactive elements such as NORM are detected. The sample count rate is often the same as the radiation background count. Radiation background without the sample should be measured under the same conditions and preferably at the same time as the sample. Measurement for a sample (MDA) depends on the detection limit level (LLD) and the counting efficiency of the detection system [14]. The LLD detection limit level of the detector system can be calculated from the following equation:

$LLD = (4.66x\sigma_b) + 3$ (1)

The minimum effectiveness of MDA detection can be calculated from the following equation:

$MDA = \frac{LLD}{k.t}$ (2)

Or as follows:

$MDA = \frac{(4.66x\sigma_b)+3}{k.t}$ (3)

Where σb is the standard deviation of the radiation background, t is the measurement time of the radiation background, and the sample k is a coefficient that contains both the efficiency of the detection system and the abundance of the element under measurement and the weight of the sample according to the following formula:

$k = \varepsilon(E_\gamma).I_\gamma(E_\gamma).W$ (4)

Where W is the weight of the sample measured in Kg. Equation (3) can be redrafted as follows:

$MDA = \frac{(4.66x\sigma_b)+3}{\varepsilon(E_\gamma).I_\gamma(E_\gamma).W.t}$ (5)

Equations (1) and 3) are valid for use only when the sample and background time is equal and otherwise the following general equations are used:

$LLD = 3.29\sqrt{n_b t_s\left(1+\frac{t_s}{t_b}\right)}+3$ (6)

$MDA = \frac{3.29\sqrt{n_b t_s\left(1+\frac{t_s}{t_b}\right)}+3}{\varepsilon(E_\gamma).I_\gamma(E_\gamma).W.t}$ (7)

Where nb is the rate of the detection of the radiation background detection for the period tb and ts is the total time of the sample [14].

3.2 Radioactivity Concentration

The activity each unit of mass of radioactive material is defined as the concentration of specific radiation activity, which is measured in curies per gram or Bq/Kg. The following equation [15] can be used to calculate the activity concentration A in Bq/kg for each radioactive element:

$A(Bq/Kg) = \frac{N}{t.I_\gamma(E_\gamma).\varepsilon(E_\gamma).m}$ (8)

Where N is the net area under the gamma-ray peak measured for the spectrum after subtraction of the radiation background, t measurement time (sec), $I_\gamma(E_\gamma)$ intensity of measured gamma ray energyE_γ, $\varepsilon(E_\gamma)$ is the efficiency of the gamma ray energy line, and m is the weight of the sample Kg.

3.3 Radium Equivalent Activity (Ra_{eq})

The equivalent concentration value of the radium element (Ra _eq) used to estimate the hazards associated with substances containing radium-226, thorium-232 and potassium-40 radionuclides, calculated to assume a concentration of 370 Bq / kg for radium 226 in this substance or 260 Bq / kg for thorium - 232 or 4810 Bq / Kg of potassium-40 which produces the same dose for gamma rays. The equivalent radium efficiency (Ra _eq) can be calculated using the following equation [16]:

$Ra_{eq}(Bq/kg) = A_{Ra} + 1.43A_{Th} + 0.077A_K$ (9)

Where ARa, ATh, and AK are the efficiencies of radium, thorium and potassium, respectively, and measured by Bq/Kg. This indicator can be circulated on both potassium and thorium according to the following equations:

$Th_{eq}(Bq/kg) = A_{Th} + 0.7A_{Ra} + 0.055A_K$ (10)

$K_{eq}(Bq/kg) = A_K + 18.46A_{Th} + 13.24A_{Ra}$ (11)

3.4 The External Hazard Index (H_{ex})

This term is used to determine the external risk of gamma rays and to estimate the expected gamma dose that may be exposed to external agents when they deal with substances containing gamma rays. The objective of this factor is to ensure that the effective dose of this radiation does not exceed permissible limits. The external risk factor can be calculated using the following equation:

$H_{ex} = \frac{A_{Ra}}{370} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \leq 1$ (12)

Where Hex is the external risk factor, ARa, ATh, and AK are the radioactivity concentration of radium-226, thorium-232 and potassium-40, respectively, measured by Bq/Kg [17].

3.5 The Internal Hazard Index (Hin)

The internal risk factor determines the dose limits received by workers in fields containing normal radiation activity, which reached the workers by swallowing or inhaling. The internal risk factor is a measure of radiation dose control and is given by the following formula:

$H_{in} = \frac{A_{Ra}}{185} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \leq 1$ (13)

Where ARa, ATh and AK are the radioactivity concentrations of radiation activity in (Bq/Kg) for radium-226, thorium-232 and potassium-40, respectively, where internal risk factor values should be less than one in the ideal environment to get a proper job opportunity for respiratory organs because they have dangerous respiratory effects [18].

3.6 Absorbed Gamma ray Dose (D_γ)

The absorbed dose is the absorbed energy in the mass unit of the body exposed to radiation. This term is used for all types of radiation, energies, and all objects and materials. The rates of the absorbed doses due to gamma – ray radiation of a naturally occurring radionuclide (226Ra, 232Th,40K) were calculated based on the recommendations of ICRP

[nGy / h] using the following equation [19]:

$D_{\gamma(ICRP)} = 0.427A_{Ra} + 0.662A_{Th} + 0.043A_K$ (14)

For each radioactivity concentration (1 Bq/Kg), the conversion factors used to calculate the absorption rate of gamma rays are radium-226 (0.462 nGyh), thorium-232 (0.604 nGyh), and potassium-40 (0.0417 nGyh). Additionally, the absorbed dose can be calculated using Beck's [20] relationship:

$D_{\gamma(Beck)} = 0.420A_K + 0.429A_{Ra} + 0.666A_{Th}$ (15)

And according to the formula adopted by UNSCEAR [21],

$D_{\gamma(UNSCEAR)} = 0.533A_{Ra} + 0.827A_{Th} + 0.0537A_K$ (16)

3.7 Representative level index ($I_{\gamma r}$)

It is used to estimate the level of gamma rays' radiation risk associated with natural radionuclides in the measured samples, a factor representing the OECD index can be calculated from the following equation derived by the OECD [22]:

$I_{\gamma r(OECD)} = \frac{A_{Ra}}{150} + \frac{A_{Th}}{100} + \frac{A_K}{1500}$ (17)

Where the radioactivity concentration of radium-226 (A_{Ra}), thorium-233(A_{Th}) and potassium-40 (A_K), respectively are in Bq/Kg.

3.8 The Annual Effective Dose (AED)

To calculate the effective dose of the gamma-emitting element from the absorbed dose and internal survival factor, UNSCEAR2000 [23] has adopted 0.7 Sv / Gy as a conversion factor from the absorbed dose in the air to the annual effective dose received by adults. The calculations adopted that 80% of the person's lifetime spent in dwelling and 20% of time spent a board. From these data, the annual effective dose was calculated as follows:

$AED_{in}(mSv/y) =$

$D_\gamma(nGy/h)x10^{-6}x\,8760h/y\,x0.8x0.7\,Sv/G$ (18)

$(mSv/y) = slashyx10^{-6}x\,8760h/y\,x0.2x0.7\,Sv/G$ (19)

Where the number (8760) is the number of hours per year.

3.9 Excess Lifetime Cancer Risk (ELCR)

It is a factor used to calculate the risk of gamma-rays associated with radionuclides in the studied samples. It gives the percentage of those who develop cancer because of the annual effective doses received. ELCR is calculated as follows:

$ELCR = AEDxDLxRF$ (20)

Since AED is the annual effective dose, DL is the expected life expectancy of approximately 70 years and RF is the risk of fatal injury per Sievert and is equal to 0.05 for the public according to ICRP [19].

2. Material and Methods

(2.1) Samples Collection and preparation

25 samples of various kinds of popular medicinal herbs that are broadly used to treat various diseases or as complementary, were collected from different regions of Iraq in sealed polyethylene bags and transported to the laboratory. The samples were open air-dried on trays for one week at room temperature in a dust-free environment, then dried in a drying oven at a temperature of 110 °C for 24 hours, and then ground to a granular size of fewer than 1000 µm using a laboratory grinder. After drying and grinding the samples were placed in plastic boxes and stored in the laboratory for 30 days to achieve an appropriate radioactive equilibrium of the natural radioactive elements in the samples. Plants were identified at Thi-Qar University's Department of Physics, College of Science. Table (1) summarizes the medicinal herbs and parts used in this study.

Table (1): Medicinal herbs samples used in this study.

No.	Sample ID	scientific name	common name	The used part
1	L1	Teucrium polium	Germander	leaf
2	L2	Vitex agnus - Castus	Chasteberry	leaf
3	L3	Achillea millefolium	Yarrow	leaf
4	L4	Salix babylonica	Willow	leaf
5	L5	Tribulus terrestris	Puncturevine	leaf
6	L6	Lawsonia inermis	Henna blossom	leaf
7	L7	Equisetum arvense	Common horsetail	leaf
8	L8	Laurus nobilis	Bayleaf	leaf
9	L9	Rosmarinus officinalis	Rosemary	leaf
10	L10	Thymus Vulgaris	Thyme	leaf
11	L11	Mentha spicata	Mint	leaf
12	L12	Crataegus azarolus	Hawthorn	leaf
13	L13	Myrtus communis	Common myrtle	leaf
14	L14	Artemisia absinthium	Santonica	leaf
15	L15	Urtica dioica	Nettle	leaf
16	L16	Juniperus communis	Juniper	leaf
17	L17	Cassia angustifolia	Senna	leaf
18	L18	Origanum majorana	Marjoram	leaf
19	L19	Alchemilla Vulgaris	Lady's mantle	leaf
20	L20	Zea mays subsp. Mays L	Corn silk	leaf
21	L21	Hibiscus sabdarriffa	Roselle	leaf
22	L22	Ruta graveolens	Rue	leaf
23	L23	Cichorium intybus	Chicory	leaf
24	L24	Salvia officinalis	Sage	leaf
25	L25	Melissa officinalis	Lemon balm	leaf

2.3 Samples measurement

Samples measurements were carried out using a gamma spectrometry system consisting of Teledyne Isotope 3"×3" NaI (Tl) high-efficiency scintillation detector with a resolution of 7.5% at 661.7 KeV which is the gamma-ray energy of 137Cs standard source. The detector is surrounded by a 4 cm thick lead shield to lessen the radiation background. Fig. (2) shows a diagram of the Gamma spectroscopy system used in the present study.

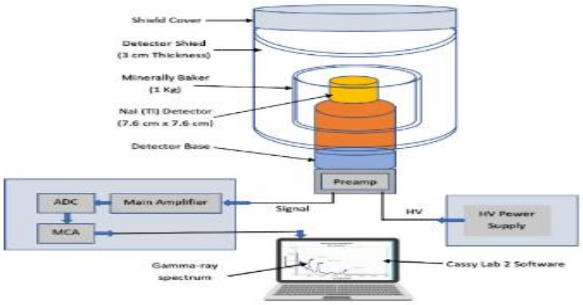

Fig. (2): Experimental Setup of Gamma spectroscopy system used in the present Study.

Before the measurements, two spectrums were collected and measured to specify all the variables that occurred in spectrum shape before and after applying the Marinelli beaker in the same manner as the samples to determine the background effects. This process must be repeated to know the radiation background of the detection system to attain greater accuracy and reliability, which then would be subtracted from all the spectra of the measured samples.

All operating parameters of the system were fixed for all samples and radiation backgrounds. The measurement time was 64800 sec, and the operating voltage of the system was 750 volts. Based on the measured γ-ray peaks, emitted by daughter radionuclides in the 238U and 232Th decay series, and 40K. Depending on the sample type, the activity concentration was expressed as (BqKg-1) dry weight. The quantitative analysis of the spectra acquired from the Gamma-ray spectrometry using the gamma-ray spectrum analysis software called 'Cassy Lab' at specific energies and measured from the characteristic gamma–lines as shown in table (2) to determine the specific activity concentration of the Natural radioactive elements targeted in the current study.

Table (2): Natural radioactive elements targeted in the current study.

Parent nuclide	Daughter nuclide	Energy (KeV)	Abundance (%)
19K40	Natural	1460.8	10.66
92U238	83Bi214	1764.5	15
92U238	83Bi214	1120.3	14.7
92U238	83Bi214	609.3	45.49
92U238	82Pb214	351.9	35.6
90Th232	81Tl208	583.2	85
90Th232	81Tl208	2614.6	99
90Th232	89Ac228	911.2	25.8

3. Results and Discussion

The Minimum Detectable Activity (MDA) was calculated in the present study using eq. (5) as shown in table (3).

Table (3): Minimum Detection Activity (MDA) of measurement system used in current study.

Parent nuclide	Daughter nuclide	Energy (KeV)	Abundance (%)	ε(Eγ)	MDA(Bq/Kg)
19K40	Natural	1460.8	10.66	0.01762	10.93
92U238	83Bi214	1764.5	15	0.01301	0.2289
92U238	83Bi214	1120.3	14.7	0.02701	0.166
92U238	83Bi214	609.3	45.49	0.07128	0.110
92U238	82Pb214	351.9	35.6	0.17351	0.138
90Th232	81Tl208	583.2	85	0.07643	0.121
90Th232	81Tl208	2614.6	99	0.00694	0.325
90Th232	89Ac228	911.2	25.8	0.03745	0.130

The specific activity concentration of natural radionuclides, 238U, 232Th, 226Ra, 228Ra), and 40K in samples were calculated from eq. (8). The range of specific activity concentration for 238U in all samples with varied from (5.95 to 1.49) Bq/Kg with average (3.89) Bq/Kg and standard deviation (1.36). The ranges of specific activity for 232Th were between (4.84 and 1.74) Bq/Kg with average (3.55) Bq/Kg and standard deviation (0.86); that of 226Ra varied from (3.07 to 1.06) Bq/Kg with an average (1.87) Bq/Kg and standard deviation (0.51); that of 228Ra varied from (8.3 to 0.98) Bq/Kg with average (4.49) Bq/Kg and standard deviation (1.87). Finally, the range of specific activity concentration for 40K was between (196.68 and 106.26) Bq/Kg with an average (147.08) Bq/Kg and standard deviation (25.49). Figs. (4.1), (4.2), (4.3), (4.4), and (4.5) shows the activity concentration of the natural radionuclides 238U, 232Th, 226Ra, 228Ra, and 40K in Bq/Kg for all samples respectively. The figs. (4.1) and (4.2) indicate that the maximum specific activity concentration levels for both 238U and 232Th were found in sample (L22) and the lowest was found in sample (L19). In fig. (4.3), the highest specific activity

concentration level for 226Ra was found in sample (L2) and the lowest was found in sample (L19). In fig. (4.4), The highest specific activity concentration level for 228Ra was found in sample (L21) and the lowest activity concentration was found in sample (L13). In fig. (4.5), The highest specific activity concentration level for 40K was found in sample (L14) and the lowest activity concentration was found in sample (L16).

In all figures, the values of activity concentration for other samples were various and in the maximum permissible limits recommended by ICRP, WHO, and UNSCEAR. The difference in the activity concentration of the various kinds of samples may be related to the fact that some samples tend to absorb and accumulate more of certain radionuclides than the other kinds. Also, the activity concentration is related to the soil, and the geographic region in which the herbs cultivate.

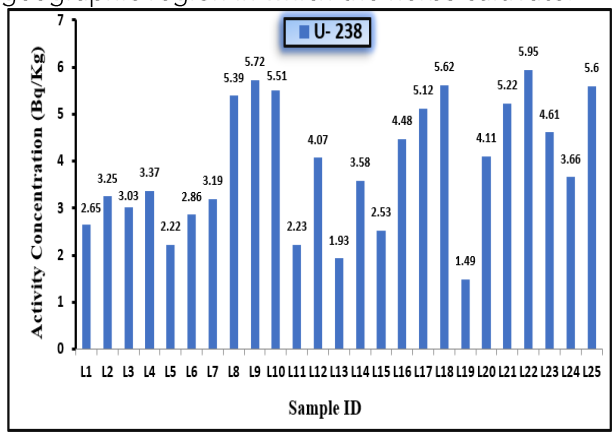

Fig. (4.1): Specific activity concentration of ^{238}U.

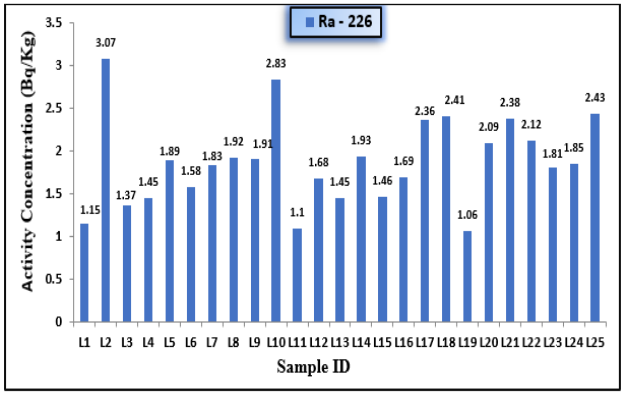

Fig. (4.2): Specific activity concentration of 232Th

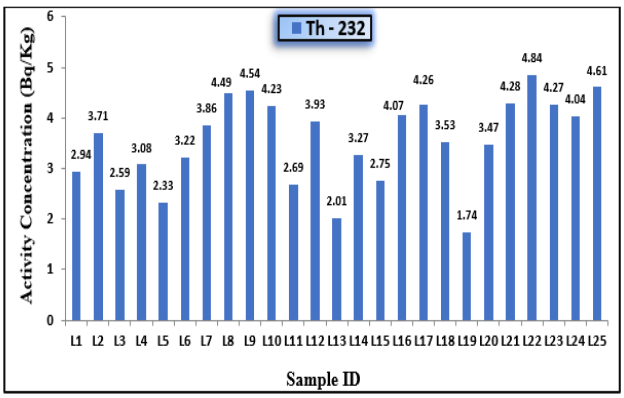

Fig. (4.3): Specific activity concentration of 226Ra

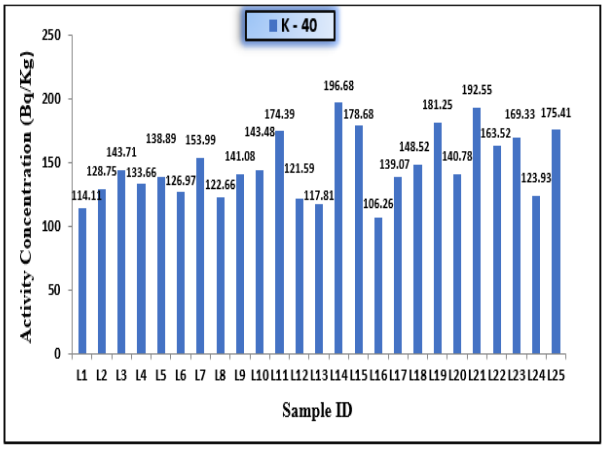

Fig. (4.4): Specific activity concentration of ^{228}Ra.

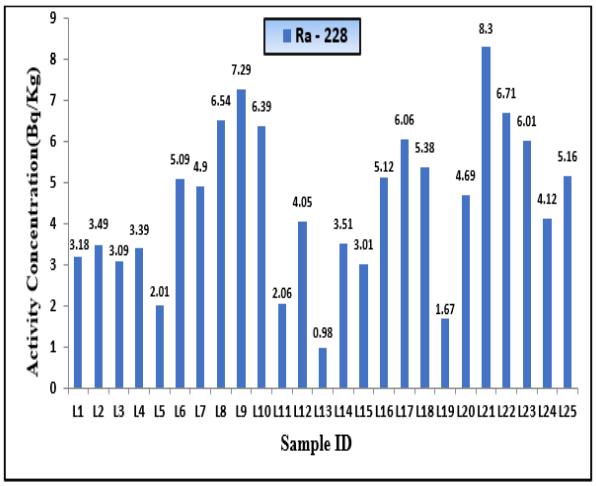

Fig. (4.5): Specific activity concentration of 40K.

The equivalent activity concentrations of Radium, Thorium, and Potassium, Raeq, Theq, and Keq in different types of samples have been calculated using equations (9), (10), and (11) respectively. The equations depend on that the concentrations of 370 Bq/Kg from radium – 226, that of 260 Bq/Kg from thorium – 232, and that of 4810 Bq/Kg from potassium – 40 give the same radiation dose of gamma rays which also represent the maximum permissible limits of concentrations of radium, thorium, and potassium equivalent. The radium equivalent ranges from (23.32 to 13.39) Bq/Kg with an average (18.27) Bq/Kg and a standard deviation of (2.52). For the thorium equivalent, it varies from ranges from (16.53 to 9.49) Bq/Kg with average (12.95) Bq/Kg and standard deviation of (1.79). Potassium equivalent concentration was between (303.04 and 173.99) Bq/Kg with an average value of (237.44) and a standard deviation of (32.79). The highest equivalent concentration for radium thorium and potassium were found in the sample L21while sample L13 had the lowest radium, thorium, and potassium equivalent concentrations. From the figure (4.6), there was a difference in the other values of concentrations of radium, thorium, and potassium equivalent and in the maximum permissible limits recommended by ICRP, WHO, and UNSCEAR.

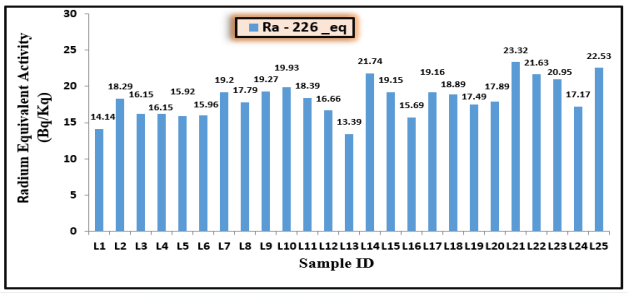

Fig. (4.6): Raeq for medicinal herbs samples.

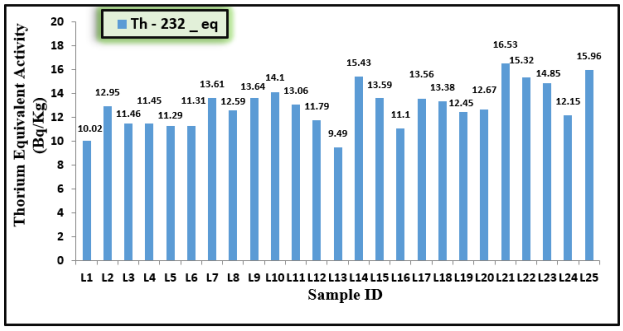

Fig. (4.6): Theq for medicinal herbs samples.

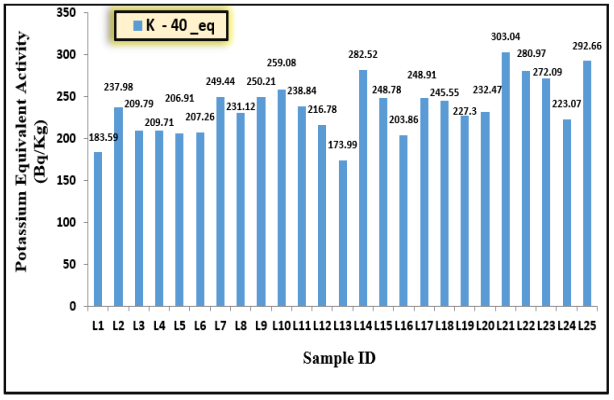

Fig. (4.6): Keq for medicinal herbs samples.

The absorbed dose DICRP, DBECK, and DUNSCEAR of naturally radionuclides in different samples of medicinal herbs had been determined and shown in table (4). The adsorbed dose was measured in nGy/h from equation (14) dependence on ICRP60 which the highest value of 12.13 nGy/h has been recorded in sample L21 and the lowest absorbed dose of 7.01 nGy/h has been found in sample L13 with an average value (9.47) nGy/h and standard deviation (1.31).

The absorbed dose was also determined from equation (15) which is derived by Beck. The average absorbed dose was found (10.21) nGy/h and standard deviation of (1.56), to vary from 13,17 nGy/h in sample L21 to 7.11 nGy/h in sample L13. There was another equation from which the absorbed dose had been calculated based on UNSCEAR, equation (16), for the absorbed dose, it ranges from (15.15 t 8.76) nGy/h with an average value (11.83) nGy/h and standard deviation of (1.64). The lowest absorbed dose was recorded for sample L13 while the highest absorbed dose was observed in sample L21. From table (4) we can see that there was a variation in the absorbed dose measured from the three equations according to the type of sample and the equation used. We also see that the absorbed doses DICRP and DBECK had been comparable and less than the absorbed dose Dunscear

The estimated internal and external hazard indices, Hin and Hex were also presented in table (4, column 4,5) and determined from equations (13) and equation (12) respectively. The estimated internal hazard index of the study ranged from 0.069 in sample L21 to 0.040 in sample L13 with an average value of (0.054) and standard deviation (0.008). The external hazard index of the study was found in the range of 0.063 to 0.036 with an average value of (0.049) and standard deviation (0.007); the highest value obtained in sample L21 and the least value in sample L13. It was observed that the value of the internal hazard index is higher than that of the external hazard index. The values of the two hazard indices are less than the unity of international permissible value that authenticates the safety of using herbs for the therapeutic process and hence it is safe to be considered for human use.

The excess lifetime cancer risk ELCR due to the ingestion of natural radionuclides in the medicinal herbs during an individual's life span with leaf part was also given in table (4.3, column8) which obtained from equation (20). We can see that the highest and lowest excess lifetime cancer risk was observed in sample L21 and sample L13, respectively. The ELCR varies in the range of 0.521×10– 4 to 0.3 ×10– 4with a mean value of (0.407×10– 4) and standard deviation (0.057×10– 4). The figure shows that there is a variation of ELCR due to the type of samples. Table (4) also contains the results of the annual effective dose (AED) due to ingestion of natural radionuclides 238U, 232Th, 226Ra, 228Ra, and 40K in the medicinal herbs of leaves part which was calculated from equation (19). Based on Table (4), AED ranges from 0.0086 mSv/y to 0.0149 mSv/y with a mean value of (0.0116 mSv/y) and standard deviation (0.0016).

The highest value was recorded for sample L21 while sample L13 recorded the lowest. The results show the discrepancy in the values of AED for different samples. However, the calculated average annual effective dose to any person due to the ingestion of natural radionuclides in the medicinal herb's samples appear to be lower than the value of the world average radiation dose of 0.3 mSv/y received per person worldwide.

Finally, the results of the representative level index (Iγer) were also presented in table (4, column6) and measured from equation (17). The results varied from (0.187 to 0.108) Bq/Kg with an average value (0.146) Bq/Kg and standard deviation (0.020). The highest representative level index was found in sample L21. On the other hand, the lowest representative level index was recorded for sample L13. The results of representative level index Iyr show a difference in the levels of the representative index according to the type of sample.

Table (4). The Absorbed Dose, Hazard Indices, Annual Effective Dose, Excess Lifetime Cancer Risk, and Representative Level Index for all samples.

Sample ID		D ICRP (nGy/h)	DBECK (nGy/h)	DUNSCEAR (nGy/h)	Hin (Bq/Kg)	Hex (Bq/Kg)	Iyr (Bq/Kg)	AED (mSv/y)	ELCR* 10-4
L1		7.34	7.89	9.17	0.041	0.038	0.113	0.009	0.315
L2		9.31	9.28	11.62	0.058	0.049	0.143	0.0114	0.399
L3		8.48	9.07	10.59	0.047	0.044	0.131	0.0104	0.364
L4		8.41	9.11	10.49	0.048	0.044	0.129	0.0103	0.361
L5		8.32	8.34	10.39	0.048	0.043	0.128	0.0102	0.357
L6		8.26	8.7	10.32	0.047	0.043	0.127	0.0101	0.355
L7		9.96	10.41	12.44	0.057	0.052	0.153	0.0122	0.427
L8		9.07	10.46	11.33	0.053	0.048	0.139	0.0111	0.389
L9		9.89	11.4	12.35	0.057	0.052	0.152	0.0127	0.445
L10		10.18	11.06	12.71	0.061	0.054	0.157	0.0125	0.437
L11		9.76	10.08	12.19	0.053	0.049	0.151	0.0119	0.419
L12		8.55	9.48	10.67	0.049	0.045	0.132	0.0105	0.367
L13		7.01	7.11	8.76	0.04	0.036	0.108	0.0086	0.3
L14		11.44	11.97	14.29	0.064	0.059	0.177	0.014	0.491
L15		10.13	10.42	12.65	0.056	0.052	0.156	0.0124	0.435
L16		7.99	9.09	9.98	0.047	0.042	0.123	0.0098	0.343
L17		9.81	10.87	12.25	0.058	0.052	0.151	0.012	0.421
L18		9.75	10.99	12.18	0.058	0.051	0.15	0.0119	0.419
L19		9.39	9.41	11.73	0.05	0.047	0.145	0.0115	0.403
L20		9.24	9.99	11.54	0.041	0.048	0.142	0.0113	0.397
L21		12.13	13.17	15.15	0.069	0.063	0.187	0.0149	0.521
L22		11.14	12.64	13.91	0.064	0.058	0.172	0.0137	0.478
L23		10.88	11.93	13.59	0.061	0.057	0.168	0.0133	0.467
L24		8.79	9.47	10.99	0.051	0.045	0.135	0.0108	0.378
L25		11.63	12.84	14.53	0.067	0.061	0.179	0.0143	0.499
Min.		7.01	7.11	8.76	0.04	0.036	0.108	0.0086	0.3
Max.		12.13	13.17	15.15	0.069	0.063	0.187	0.0149	0.521
STDEV		1.31	1.56	1.64	0.008	0.007	0.020	0.0016	0.057
Average		9.47	10.21	11.83	0.054	0.049	0.146	0.0116	0.407

4. Conclusion

The present research estimated the activity concentrations of natural radionuclides of 238U, 232Th, 226Ra, 228Ra, and 40K in different kinds of medicinal herbs that are commonly used and regularly consumed by the population in Iraq. As a result of the study, the values of activity concentration 238U,232Th, and 40K in samples are found to be lower than the world average allow maximum value 32, 30, and 400 Bq/Kg respectively and there is a variety in values of activities among the species. Calculated values of hazard coefficients are also lower than the world average of about 0.5 mSv per year. Therefore, this study may provide us a database for radionuclides as quality control and regulation and indicated that the samples under study are with safety for human consumption. The level of gamma radiation in medicinal herbs relies on the content of natural radionuclides in soil. Therefore, it is necessary to have possession of excellent quality control of herbal medicines to keep consumers from contamination when medicinal herbs may be contaminated during cultivating and progression.

References

[1] Canbazoğlu, C. and Doğru, M. A preliminary study on ^{226}Ra, ^{232}Th, ^{40}K and ^{137}Cs activity concentrations in vegetables and fruits frequently consumed by
inhabitants of Elazig Region, Turkey. J. Radioanal. Nucl. Chem. Vol. 295, no.2, pp.1245 – 1249(2013)

[2] Asaduzzaman, Kh., Khandaker, M.U., Amin, Y.M. and Mahat, R. Uptake and
distribution of natural radioactivity in rice from the soil in north and west part of peninsular Malaysia for the estimation of ingestion dose to man. Ann. of Nucl. Energy. Vol.76, pp.85 - 93(2015).

[3] Akhter, P., Ramjan, K., Orif, S. D. and Ahmed, N. Radiological impact of dietary intakes of naturally occurring radionuclides on Pakistani adults. Food Chem.Toxicol.Vol.45, no.2, pp.272 – 277(2007).

[4] Eddouks, M., Chattopadhyay, D., De Feo, V. and Cho, W. C. Medicinal Plants in The Prevention and Treatment of Chronic Diseases. Evid Based Complement
Alternat Med. 2012; 2012: 458274. Published online 2012 Sep 18. DOI: 10.1155 /2012/458274

[5] Narayana, Y., and Prakash. Radioactivity in ayurvedic medicinal plants. Int. J. Low Radiation. Vol.4, No.3, pp.184 – 188 (2007).

[6] Chan, K. Some aspects of toxic contaminants in herbal medicines. Chemosphere. Vol.52, no.9, pp.1361 – 1371(2003)

[7] Salamon, I. and Haban, M. The Radioactivity Evaluation of Selected Species of Medicinal Plants. Acta. Cytotec. Zootechn. Vol.7, no.4, pp. 103 – 106(2004).

[8] Duffy, S., Simon, S. L. and Whisker, F.W. 137Cs Contamination of Plants Used for traditional Medicine and Implication for Human Exposure. J. Environ. Radioact. Vol. 46, pp.27 – 44 (1999).

[9] U.S. Environmental Protection Agency, Radiation Protection Program - Uranium, (2015)

[10] The Governorate of the Hong Kong Special Administrative, Radiation and Food Safety. (2013)

[11] Laith, A. N., Nada, F. T., Fouzey H. K. Estimation of Natural Radioactivity of Some Medicinal or Herbal

Plants Used in Iraq. Detection. Vol.3, no.1, pp.1 – 7(2015).
[12] World Health Organization (WHO), Information on nuclear accidents and radioactive contamination of foods, International Food Safety Authorities, Network, Geneva, (2011).
[13] Varier, M.K. Nuclear radiation detection: Measurements and analysis. New Delhi, India: Narosa Publishing House, (2009).
[14] WHO. Guideline: Sodium intake for adults and children Geneva, World Health Organization (WHO), (2012).
[15] Canadian Nuclear Safety Commission, "Naturally occurring Radioactive Material (NORM)", fact sheet, (2016).
[16] Thormod, H. and David H. M., "Radiation and Health", Taylor and Francis Group, New York and London (2003)
[17] Mohamed A. M., "Specific Activity of ^{226}Ra, ^{232}Th and ^{40}K for Assessment of Radiation Hazards from Building Materials Commonly Used in Upper Egypt" SDU Journal of Science (E-Journal), Vol.6, pp.120-126 (2011).
[18] Xinwei Lu, "Natural Radioactivity in Some Building Materials of Xi'an, China ", Radiation Measurements, Vol.40, pp.94-97 (2005).
[19] ICRP, "1990 Recommendations of the International Commission on Radiological Protection", Publication 60, Annals of the ICRP 21(13), Pergamon Press, Oxford 1991.
[20] Beak, H. L., Decompo, J. and Gologok, J." In suit Ge (ii) and NaI (Tl) Gamma- Ray spectrometry. Health and Safety Laboratory AEC: Report HASL 258, (1972).
[21] United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR)," Ionizing Radiation Sources and Biological Effects", Report to the General Assembly, United Nations, New York (2000).
[22] Harb, S., El-Kamel, A. H., Abd El-Mageed, A. I. Abbady, A. and Wafaa, R., "Concentration of U-238, U-235, Ra-226, Th-232 and K-40 for Some Granite Samples in Eastern Desert of Egypt", Proceedings of the 3rd Edition Environmental Physics Conference, Aswan, Egypt (2008).
[23] Mirjana, B. and Saucepan, S., "Radioactivity of Sand from Several Renowned Public Beaches and Assessment of the Corresponding Environmental Risks", Journal of the Serbian Chemical Society, Vol.74, no.4, pp.461-470, (2009).