

## DETERMINATION OF NATURAL RADIOACTIVITY AND HAZARD ASSESSMENT IN SOME MEDICINAL HERBS USED IN IRAQ

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### Abstract:

This study investigates the natural radioactivity levels in ten commonly used medicinal herbs in Iraq to assess their radiological risks. The specific activity concentrations of naturally occurring radionuclides, including  $^{238}\text{U}$ ,  $^{232}\text{Th}$ , and  $^{40}\text{K}$ , were measured using gamma-ray spectrometry with a high-purity germanium (HPGe) detector. The activity concentrations ranged from 1.79 to 22.94 Bq/kg for  $^{238}\text{U}$ , 0.55 to 5.5 Bq/kg for  $^{232}\text{Th}$ , and 6.3 to 421 Bq/kg for  $^{40}\text{K}$ . Radiological hazard indices, such as Radium equivalent activity (Raeq), Absorbed gamma dose rate (D<sub>γ</sub>), Annual effective dose equivalent (AEDE), Activity gamma Index (I<sub>γ</sub>), external and internal hazard index (H<sub>ex</sub>, H<sub>in</sub>), and Excess lifetime cancer risk (ELCR), were calculated to assess the potential health risks associated with consuming these herbs. The results indicate that all measured values are significantly lower than the global average limits recommended by UNSCEAR and ICRP, suggesting negligible radiological hazards. This study establishes baseline data for future evaluations of radiation exposure and affirms the safety of consuming these medicinal herbs.

**Keywords:** Natural radioactivity, radiological risk, herbal medicine, gamma spectrometry.

## 1. Introduction:

Medicinal plants are naturally occurring plants that are used to treat various ailments in humans and other living organisms. More than 500 kinds of medicinal plants have been utilized to make medications. Medicinal plants are a distinct category of natural products that necessitate particular attention due to their possible effects on human health. The pharmacological features of medicinal plants are ascribed to the existence of active chemical ingredients that are essential for significant physiological processes in living organisms [1]. The contamination pathway is particularly relevant for medicinal herbs, as these plants are often cultivated in soils with varying radionuclide concentrations. These radionuclides are then transferred to humans primarily through the major exposure pathway of soil-plant-human, which is especially significant for medicinal herbs due to their direct consumption by humans for therapeutic purposes [2].

Every element of the environment, including the air, water, soil, food, and people, contains naturally occurring radioactive materials (NORM). The International Food Safety Authorities Network claims that [3], food plants typically contain  $^{40}\text{K}$ ,  $^{232}\text{Th}$ , and  $^{238}\text{U}$ , as well as their progenies. Since plants are the main way that naturally occurring radionuclides enter the human body through the food chain, it is expected that the same would be found in plants used for medicinal purposes [4], and prolonged exposure to them may cause major health problems, such as cancer. Therefore, assessing the radioactivity levels in medicinal herbs is crucial for ensuring public health and safety[5].

Terrestrial primordial radionuclides, which originated in the Earth's crust and are the sources of natural radioactivity in the environment, include radionuclides and their decay products from the  $^{238}\text{U}$  and  $^{232}\text{Th}$  series, as well as  $^{40}\text{K}$ . [6].

People are exposed to radiation in the environment from sources that are commonly used in science, medicine, agriculture, and industry. The oldest method of treating diseases is with traditional medicine, which utilizes plants and herbs.[7].

Several studies have been conducted worldwide to evaluate the natural radioactivity levels in medicinal plants. For example, research in Nigeria, India, and Bangladesh has shown varying levels of radionuclides in herbal medicines, with some studies reporting concentrations above the permissible limits [8,9]. However, limited data are available for Iraq, making this study essential for filling this knowledge gap.

Many developed countries have also adopted herbal remedies. In the UK, the rest of Europe, North America, and Australia, complementary and alternative medicines (CAMs) are now widespread. [10].

In Iraq, People are becoming more interested in using herbal medicine to treat a wide range of illnesses. There are other reasons for this change besides the high cost of getting allopathic medicines to treat even common health problems. These include the fact that health institutions are hard to get to in rural or remote areas of the country and the fact that people are becoming more aware of the negative effects of some allopathic drugs.[11].

People have used herbal or medicinal plants in many forms to treat illness for hundreds of years in cultures all over the world and on every continent. Between seventy and eighty percent of people in the world, especially in developing countries, use alternative medicine as their main form of health care.[12]. A growing issue in many developing nations is industrial pollution that contaminates vegetation with heavy metals, pesticides, or radioactivity.[13]. Thus, the medicinal properties and efficiency of herbal medicines depend on environmental conditions. These conditions also directly affect how these plants grow in their natural habitats and in places where they are cultivated.[14].

Furthermore, the past studies didn't include medicinal plants, possibly because the potential for ingesting radioactive materials through their use wasn't recognized or was considered unimportant. The study of how much radionuclides are in plants used in traditional herbal medicine is very important, especially since these plants are often used to treat various health problems.[15].

The purpose of this research is to determine the specific activity concentrations of ( $^{238}\text{U}$ ,  $^{232}\text{Th}$ , and  $^{40}\text{K}$ ) present in some selected medicinal herbs frequently utilized in Iraq and to evaluate the radiation risk involved with using these therapeutic herbs by using a high-purity germanium (HPGe) detector. This research aims to provide valuable data for public health authorities and contribute to the global understanding of radioactivity in therapeutic medicinal herbs.

## 2. Methods and Materials

### 2.1 Collection and Preparation of the Samples

In this study ten types of therapeutic medicinal herbs (local and imported herbs) widely used in Iraq were chosen. Samples were obtained from different markets in Iraq. The country of origin and medicinal use of each sample are shown in Table 1.

After collecting, the samples were dried at room temperature to remove moisture and then ground into fine powder using an electric grinder. To ensure uniformity, the particle size was homogenized to be less than 1 mm. Each powdered sample (30 g) was packed in a Marinelli beaker, sealed tightly, and allowed to rest for a month to build up the secular equilibrium of  $^{238}\text{U}$  and  $^{232}\text{Th}$  and their progeny.[16].

**Table 1:** Medicinal herbs samples investigated in this study.

No.	Code No.	Medicinal herb	Medicinal uses	The Components	Country of origin
1	P1	Ginkgo Biloba	Alzheimer's Disease	Ginkgo leaf extract	Iraq
2	P2	Treatment of Vitiligo	Vitiligo	Herbal extract of Atrial	Iraq
3	P3	Joint Restorer	Joint Restorer	Curcumin, Green tea and Ginger extract, Chia powder	Iraq
4	P4	Ashwaganda Extract	Relivestress, anxiety, lower blood sugar & fat	Ashwaganda Extract	Iraq
5	P5	Curcumin turmeric	Cleansing the body of toxins and diseases of the digestive system and joints	Curcumin turmeric	Iraq
6	P6	Colon Herbs	Active stomach and intestines	Cumin and mint and other herbs	Iraq
7	P7	Saw Palmetto	Sexual dysfunction, prostate cancer	Type of palm tree	Iraq
8	P8	Nafis Salas Herb	Helps treat nocturnal enuresis	Plantago lanceolata, Cinnamomum aromaticum / Bark, Humulus Lupulus	Syria
9	P9	Nafis Gas Stop Herb	For cases of bloating and gas accumulation	Foeniculum vulgare, Mentha piperita, Marrubium vulgare / Aerial part	Syria
10	P10	Nafis Anti headache Herb	Chronic pain reliever, mood enhancer	Viola odorata / Leaf & Flower, Capsella bursa pastoris / Aerial Part, Rosmarinus officinalis / Leaf	Syria

## 2.2 High Purity Germanium (HPGe) Detector

Gamma-ray spectroscopy (Canberra Company, USA) with (HPGe) technique was utilized to calculate the radioactive isotope concentrations  $^{238}\text{U}$ ,  $^{232}\text{Th}$ , and  $^{40}\text{K}$ . Gamma-ray spectroscopy (Canberra Company, USA) was performed using a high-purity germanium (HPGe) detector with a relative efficiency of 55% and an energy resolution of 1.95 keV at the 1332 keV peak of  $^{60}\text{Co}$ . The detector was shielded with 5 cm thick lead walls lined

internally with graded absorbers (1.6 mm Cd and 0.4 mm Cu) to minimize background radiation. A multichannel analyzer (MCA) with 8192 channels was used to process the spectral data. A multi-gamma ray standard source was used to calibrate energy and efficiency (MGS-5, Canberra) in Marinelli beaker geometry. Background radiation was measured using an empty Marinelli beaker under identical conditions to account for environmental contributions.

### 2.3 Energy Calibration

A multi-gamma ray standard source (MGS-5, Canberra) with Marinelli beaker geometry was used to calibrate and assess the system's efficiency. The energy of each radionuclide's distinctive gamma emissions was analyzed in a library of radionuclides, and the software's data was used to construct the emission probabilities for each nuclide.

An empty Marinelli beaker container was counted in the same way as the samples to ascertain the background distribution caused by naturally occurring radionuclides in the vicinity of the detector.

The activity concentrations were computed after the background was measured and subtracted.

All samples were analyzed in the Directorate of Central Laboratory, Iraqi Atomic Energy Commission, Baghdad, Iraq.

### 2.4 Specific activity concentrations of radionuclides

The concentrations of specific activity  $A$  (Bq/kg) of radionuclides in medicinal herb samples were obtained by using the equation [17]:

$$A = \frac{(\text{Net Area} - \text{B.G})}{M \times I_{\gamma}(E_{\gamma}) \times \text{eff} \times T} \quad (1)$$

where:

B.G: Background activity.

A: The specific activity concentration of radionuclides measured in (Bq/kg).

M: mass of the soil sample (kg).

eff: The efficiency of the detectors at energy ( $E_{\gamma}$ ).

$I_{\gamma}(E_{\gamma})$ : is the abundance at energy ( $E_{\gamma}$ ).

T: The time of measurement, which was equal to (7200 s).

### 2.5 Radiation Hazard Indices

#### 2.5.1 Radium Equivalent Activity ( $Ra_{eq}$ )

A common radiological index has been introduced to represent the activity concentrations of  $^{238}\text{U}$ ,  $^{232}\text{Th}$ , and  $^{40}\text{K}$  by a single quantity that considers the radiation hazards associated with them. The index is called radium equivalent activity ( $Ra_{eq}$ ), which is used to ensure the uniformity in the distribution of

natural radionuclides  $^{238}\text{U}$ ,  $^{232}\text{Th}$ , and  $^{40}\text{K}$ , and it is given by the expression[18] :

$$\text{Ra}_{\text{eq}} (\text{Bq/Kg}) = A_{\text{U}} + 1.43 A_{\text{Th}} + 0.077 A_{\text{K}} \quad (2)$$

Where,  $A_{\text{U}}$ ,  $A_{\text{Th}}$ , and  $A_{\text{K}}$  represent the activity concentrations, in Bq/kg, of  $^{238}\text{U}$ ,  $^{232}\text{Th}$ , and  $^{40}\text{K}$ , respectively.

### 2.5.2 Absorbed Gamma Dose Rate (DY)

The specific activities of  $A_{\text{U}}$ ,  $A_{\text{Th}}$ , and  $A_{\text{K}}$  for  $^{238}\text{U}$ ,  $^{232}\text{Th}$ , and  $^{40}\text{K}$ , respectively, in Bq/ kg units were used to calculate the outdoor air absorbed gamma dose rate (DY) in (nGy/h) due to terrestrial gamma rays at (1 m) above the ground surface.[19]:

$$D_{\gamma} (\text{nGy/h}) = 0.462 \cdot A_{\text{U}} + 0.604 \cdot A_{\text{Th}} + 0.0417 \cdot A_{\text{K}} \quad (3)$$

### 2.5.3 Annual Effective Dose Equivalent (AEDE)

Using a conversion factor of (0.7Sv/Gy) to convert the absorbed rate to human effective dose equivalent, with an outdoor occupancy of 20% and an indoor occupancy of 80%, the estimated annual effective dose equivalent received by humans was calculated by using the following relations[20]:

The equation provided for calculating the Annual Effective Dose (AED) is:

$$\text{AED} = D (\text{out or in}) \times T \times \text{OF} \times \text{CC} \quad (4)$$

where:

$D(\text{out})$ : Outdoor absorbed dose rate (in Gy/h).

$D(\text{in})$ : indoor absorbed dose rate (in Gy/h).

T: Time in hours for one year (8760 hours).

OF: Occupancy Factor for outdoor exposure, with a value of 0.2.

OF: Occupancy Factor for indoor exposure, with a value of 0.8.

CC: Conversion Coefficient, with a value of 0.7 Sv/Gy.

#### 1. Indoor Annual Effective Dose Equivalent (AEDE<sub>in</sub>):

$$(\text{AEDE}_{\text{in}}) (\text{mSv/y}) = D (\text{nGy/h}) \times 10^{-6} \times 8760 \text{ h/y} \times 0.80 \times 0.7 \text{ Sv/Gy} \quad (5)$$

#### 2. Outdoor Annual Effective Dose Equivalent (AEDE<sub>out</sub>):

$$(\text{AEDE}_{\text{out}}) (\text{mSv/y}) = D_{\gamma} (\text{nGy/h}) \times 10^{-6} \times 8760 \text{ h/y} \times 0.20 \times 0.7 \text{ Sv/Gy} \quad (6)$$

$$\text{AEDE}_{\text{total}} = \text{AEDE}_{\text{in}} + \text{AEDE}_{\text{out}}$$

### 2.5.4 Activity gamma Index (I<sub>γ</sub>)

The following relationship was used to calculate the activity gamma index (I<sub>γ</sub>) for samples of medicinal herbs.[21]:

$$I_{\gamma} = \frac{A_{\text{U}}}{150} + \frac{A_{\text{Th}}}{100} + \frac{A_{\text{K}}}{1500} \quad (7)$$

### 2.5.5 External ( $H_{ex}$ ) and Internal ( $H_{in}$ ) Hazard Indices

The external ( $H_{ex}$ ) and internal ( $H_{in}$ ) hazard guides were planned employing equations [22]:

$$H_{ex} = \frac{A_U}{370} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \quad (8)$$

$$H_{in} = \frac{A_U}{185} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \quad (9)$$

### 2.5.6. Excess Lifetime Cancer Risk (ELCR)

Using the following formula, the excess lifetime cancer risk (ELCR) was determined.[23]:

$$ELCR = AEDE \times DL \times RF \quad (10)$$

AEDE is the annual effective dose equivalent, DL is the life expectancy (70 years), and RF is the risk factor ( $Sv^{-1}$ ) for deadly cancer per Sievert. For stochastic effects, ICRP 60 recommends values of 0.05 for the public.

## 3. Results and Discussion

The current study employed a gamma ray spectrometer to measure the radioactivity concentrations of NORMs in ten different medicinal herbs that are commonly used in Iraq. Equation (1) was used to calculate the mean concentrations of  $^{238}U$ ,  $^{232}Th$ , and  $^{40}K$ . Equations from (2–10) were also used to evaluate different hazard indexes and annual effective doses to estimate the possible radiation risks associated with the consumption of these medicinal herbs.

Our findings were contrasted with the UNSCEAR (United Nations Scientific Committee on the Effects of Atomic Radiation) established global average values and ICRP (International Commission on Radiological Protection for radiological safety) [24] as well as with the data measured in other countries. Our results and comparisons are furnished systematically in the following subsections. The activity concentration due to  $^{238}U$ ,  $^{232}Th$ , and  $^{40}K$  in different kinds of medical herb samples has been measured as shown in Table 2.

**Table 2:** Activity Concentrations for  $^{40}\text{K}$ ,  $^{232}\text{Th}$ , and  $^{238}\text{U}$  in Herbal Medicine Samples.

No.	Code	Activity concentration in (Bq.kg-1)		
		$^{238}\text{U}$	$^{232}\text{Th}$	$^{40}\text{K}$
1	P1	16.5	BDL	165.8
2	P2	15.187	BDL	362.192
3	P3	13.2	BDL	421
4	P4	7.05	3.48	68.52
5	P5	22.94	BDL	233.2
6	P6	11.75	BDL	288.1
7	P7	1.79	BDL	6.3
8	P8	17.1	4.8	255
9	P9	13	5.5	376.4
10	p10	15.4	0.55	376.1
<b>Max</b>		22.94	5.5	421
<b>Min</b>		1.79	0.55	6.3
<b>Average</b>		<b>13.3917</b>	<b>3.5825</b>	<b>255.2612</b>
<b>Global Limits</b>		<b>35</b>	<b>30</b>	<b>400</b>

BDL: below detection limit.

The range of specific activity concentration for  $^{238}\text{U}$  varied from 1.79 Bq/kg to 22.94 Bq/kg with an average of 13.391 Bq/kg, highest activity level was found in sample P5 with a value of 22.94 Bq/kg (Iraq), and the lowest activity level was found in sample P7 with a value of 1.79 Bq/kg (Iraq).

The range of specific activity for  $^{232}\text{Th}$  varied from 0.55 Bq/kg to 5.5 Bq/kg with an average of 3.582 Bq/kg. The highest activity level was observed in sample P9, with a value of 5.5 Bq/kg (Syria), and the lowest activity level was found in sample P10, with a value of 0.55 Bq/kg (Syria).

The range of specific activity for  $^{40}\text{K}$  varied from 6.3 Bq/kg to 421 Bq/kg. The average is 255.2612 Bq/kg. The highest activity level was found in sample P3 with a value of 421 Bq/kg (Iraq), and the lowest activity level was found in sample P7 with a value of 6.3 Bq/kg (Iraq). These values are significantly lower than the global average limits recommended by UNSCEAR [25].

Notably, the highest  $^{238}\text{U}$  concentration was observed in sample P5-curcumin turmeric, while the lowest was found in sample P7-saw palmetto. For  $^{232}\text{Th}$ , the highest concentration was in sample P9-Nafis Gas Stop Herb,

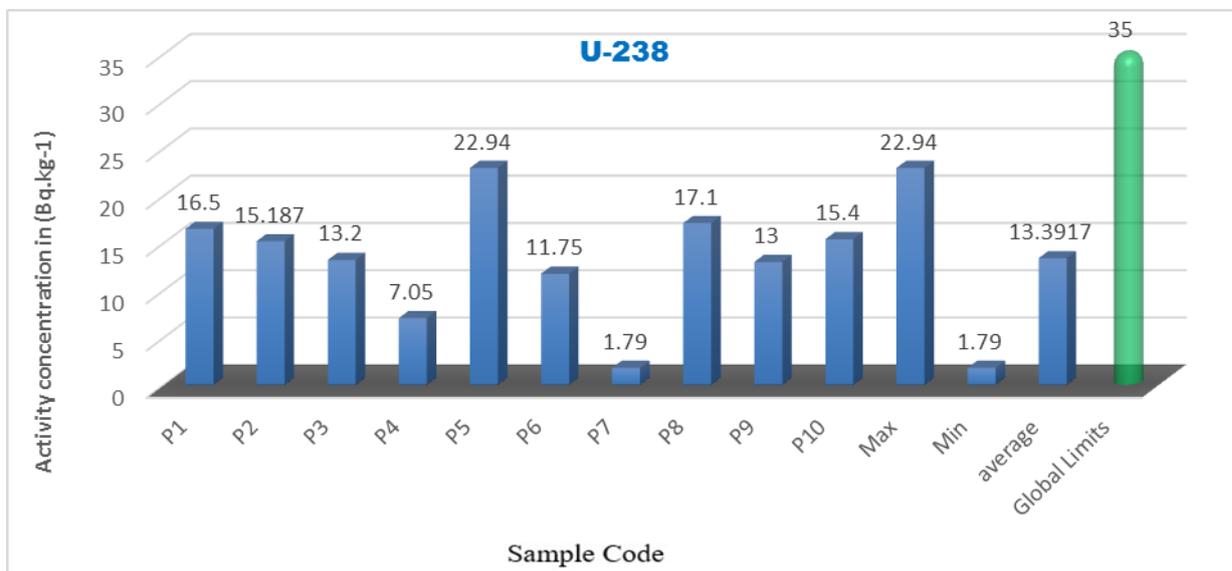
and the lowest was in sample P10-Nafis Anti-headache Herb. Similarly,  $^{40}\text{K}$  showed the highest concentration in sample P3-Joint Restorer and the lowest in sample P7-Saw Palmetto.

Most samples comply with the global limits recommended by UNSCEAR, indicating that these herbal products are generally safe for human use, except for samples p3 which exceeded the permissible limit for  $^{40}\text{K}$  activity, necessitating further investigation into its source and production conditions, contamination during its cultivation, pesticides used, or the intrinsic properties of the plant species used in the herbal medicines.

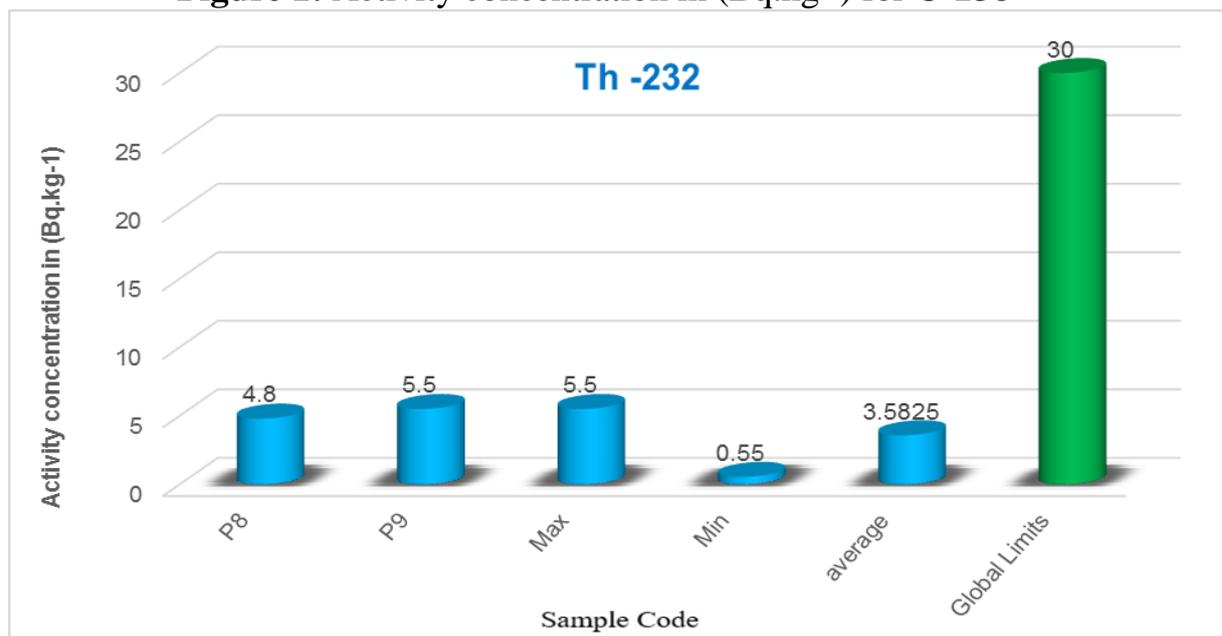
The mean activity concentrations (Bq/kg) of the natural radioactivity of medicinal herb samples in the current study are displayed in Table 3 and were compared with those from comparable studies conducted in other countries. This comparison with studies from other countries showed that the radioactivity levels in Iraqi medicinal herbs are similar to those reported in Jordan, Bangladesh, and Serbia, further confirming the safety of these herbs for human consumption.

**Table 3:** Comparison of the activity concentrations in the medicinal plants in the present work and other countries

Country	Activity concentration (Bq.kg <sup>-1</sup> )			Reference
	<sup>238</sup> U (Bq/kg)	<sup>232</sup> Th (Bq/kg)	<sup>40</sup> K (Bq/kg)	
Iraq	<b>16.79</b>	<b>3.61</b>	<b>288.2</b>	<b>present work</b>
Iraq	4.953	2.916	219.134	[26]
Jordan	2.63	1.44	593.97	[27]
Bangladesh	12.65	7.38	661.1	[28]
Ghana	31.8	56.2	839.8	[29]
Serbia	2.82	0.63	984.32	[30]
<b>World Average</b>	<b>35</b>	<b>30</b>	<b>400</b>	[31]



**Figure 1:** Activity concentration in (Bq.kg<sup>-1</sup>) for U-238



**Figure 2:** Activity concentration in (Bq.kg<sup>-1</sup>) for Th-232

### K-40

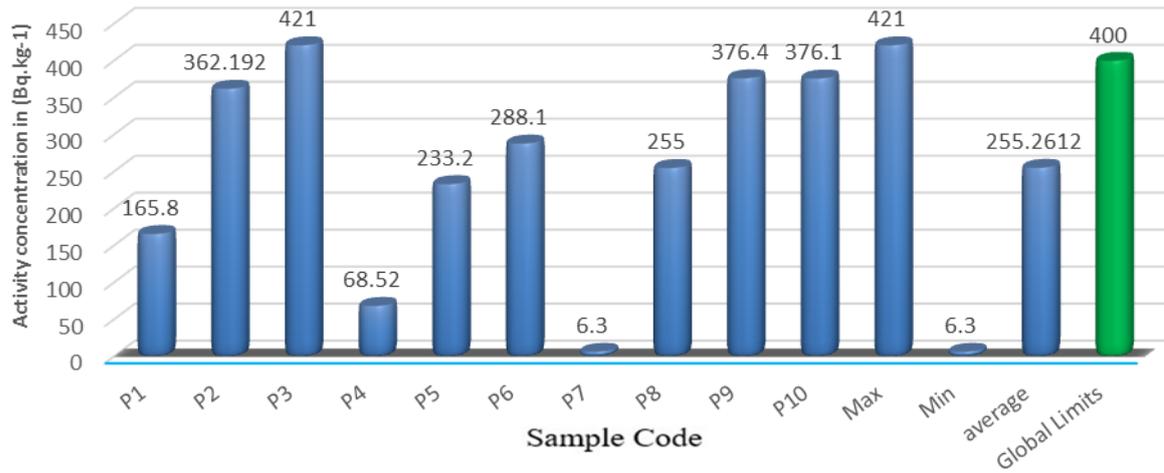


Figure 3: Activity concentration in (Bq.kg<sup>-1</sup>) for K-40

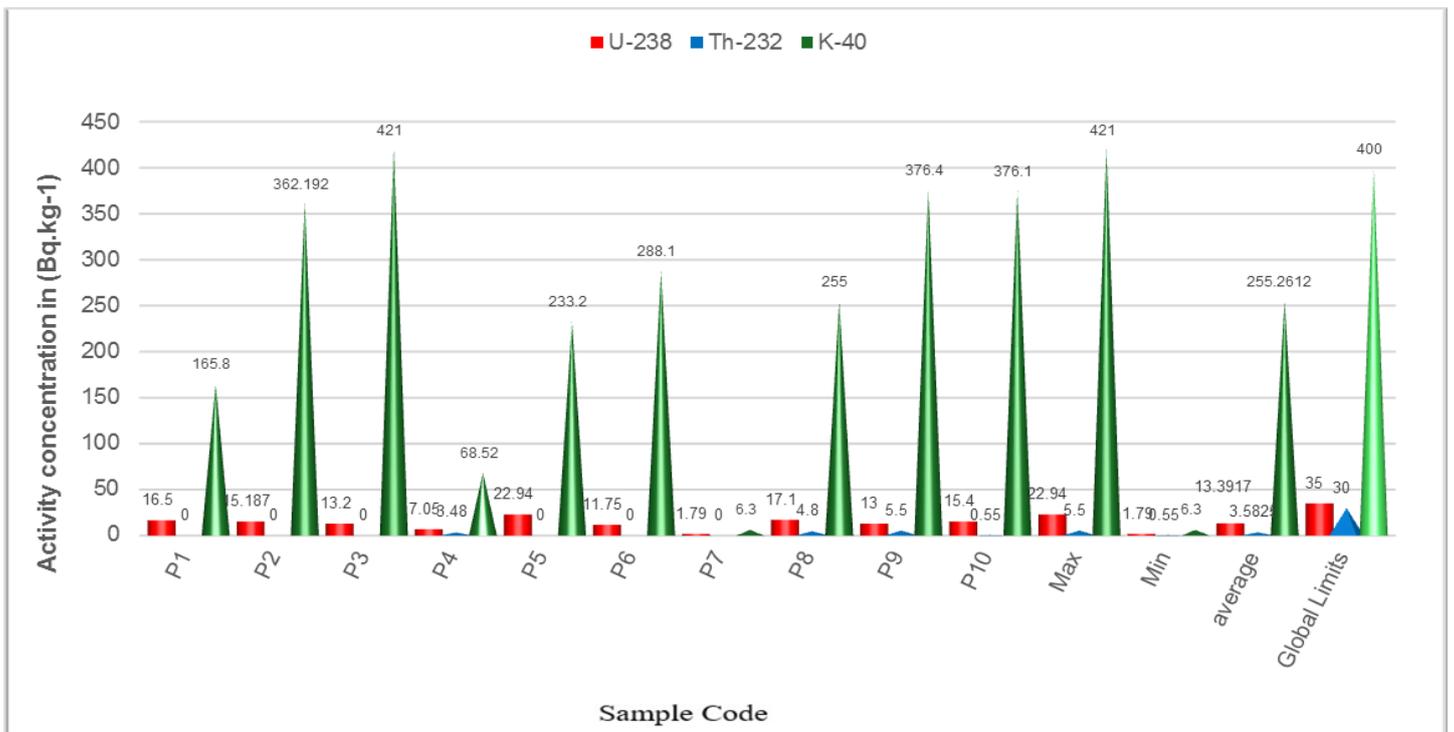


Figure 4: Activity concentration in (Bq.kg<sup>-1</sup>) for U-238, Th-232, and K-40

Table (4) shows Radium equivalent activity ( $Ra_{eq}$ ), absorbed gamma dose rate ( $D_\gamma$ ), annual effective dose equivalents ( $AEDE_{in}$ ), ( $AEDE_{out}$ ), and ( $AEDE_{total}$ ), Activity gamma Index ( $I_\gamma$ ), internal hazard index ( $H_{in}$ ), external hazard index ( $H_{ex}$ ), and Excess lifetime Cancer risk (ELCR) in selected herbal medicine samples in the Iraqi market.

**Table 4:** shows ( $Ra_{eq}$ ), ( $D_\gamma$ ), ( $AEDE_{in}$ ), ( $AEDE_{out}$ ), and ( $AEDE_{total}$ ), ( $I_\gamma$ ), ( $H_{in}$ ), ( $H_{ex}$ ), and (ELCR) in selected herbal medicine samples.

Sample	$Ra_{eq}$ (Bq/kg)	$D_\gamma$ (nGy/h)	Annual effective dose equivalent (mSv/y)		$AEDE_{total}$ (mSv/y)	$I_\gamma$	Hazard index		ELCR ( $\times 10^{-3}$ )
			$AEDE_{in}$ (mSv/y)	$AEDE_{out}$ (mSv/y)			$H_{in}$	$H_{ex}$	
P1	29.27	14.53	0.071	0.018	0.089	0.221	0.1237	0.0791	0.312
P2	43.08	22.11	0.108	0.027	0.136	0.342	0.1574	0.1163	0.475
P3	45.62	23.65	0.116	0.029	0.145	0.369	0.1589	0.1232	0.508
P4	17.31	8.22	0.040	0.010	0.050	0.1275	0.0657	0.0467	0.176
P5	40.90	20.32	0.099	0.025	0.125	0.308	0.1725	0.1105	0.436
P6	33.93	17.43	0.085	0.021	0.107	0.270	0.1234	0.0917	0.374
P7	2.28	1.09	0.005	0.001	0.007	0.0162	0.0110	0.0061	0.023
P8	43.60	21.43	0.105	0.026	0.131	0.332	0.1639	0.1177	0.460
P9	49.85	25.02	0.122	0.031	0.154	0.3926	0.1697	0.1345	0.539
<b>p10</b>	45.15	23.13	0.113	0.028	0.142	0.3589	0.1635	0.1219	0.496
<b>Average</b>	<b>35.099</b>	<b>17.693</b>	<b>0.0864</b>	<b>0.0216</b>	<b>0.108</b>	<b>0.27372</b>	<b>0.13097</b>	<b>0.09477</b>	<b>0.380</b>
<b>Global limits[25]</b>	<b>370</b>	<b>55</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>

Table 4 presents the calculated radiological hazard indices and dose estimates for the measured activity concentrations of natural radionuclides in the analyzed samples. From these measurements, the tested parameters, such as Radium Equivalent Activity ( $Ra_{eq}$ ), gamma absorbed dose in air ( $D_\gamma$ ), annual effective dose equivalent (AEDE), Activity gamma Index ( $I_\gamma$ ), External and Internal Hazard Indices ( $H_{in}$  and  $H_{ex}$ ), and Excess lifetime cancer risk (ELCR) were calculated.

All samples of The  $Ra_{eq}$  values were between 2.28 and 49.85 Bq/kg, with a mean value of 35.10 Bq/kg. These values are far lower than the limit of 370 Bq/kg prescribed by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) [25]. These findings indicate that the radiological content of the analyzed samples poses no significant threat to human health under typical exposure conditions.

Gamma dose rate (D<sub>γ</sub>) was between 1.09 to 25.02 nGy/h, with an average of 17.69 nGy/h, and it was much lower than the world average of 55 nGy/h [25], indicating minimum external exposure risk to gamma rays from the samples. And the annual effective dose equivalent (AEDE) was estimated for both indoor and outdoor environments to evaluate the potential hazard to health. Calculated AEDE<sub>total</sub> values varied from 0.007 to 0.154 mSv/y, with an average of 0.108 mSv/y; all these values are well below the ICRP recommended safety value of 1 mSv/y, for which there is no need for restriction. [25]. The results show that long-term exposure to gamma radiation from the investigated materials is not a radiological risk for people. Activity gamma Index (I<sub>γ</sub>) was between 0.0162 to 0.3926 with an average of 0.27372. All the calculated Activity gamma Index (I<sub>γ</sub>) values are below the permissible limit of unity. [25]. The study explicitly states that all samples complied with global standards (UNSCEAR, ICRP), indicating that radiological hazards were within global limits.

The external hazard index that was computed (H<sub>ex</sub>) values for the samples of herbal were found to range from 0.0061 to 0.1345, with an average of 0.09477, and the calculated internal hazard index (H<sub>in</sub>) values for the herbal Samples were found to range from 0.0061 to 0.1725, with an average of 0.13097.

The calculated of H<sub>ex</sub> and H<sub>in</sub> values for all the herbal samples were significantly less than the permitted threshold of unity. [25] These results indicate that there is no harm to the populations of the investigated site due to <sup>238</sup>U, <sup>232</sup>Th, and <sup>40</sup>K in herbal samples.

The calculated ELCR values for the risk of cancer development by chronic exposure to gamma radiation varied from 0.023 x 10<sup>-3</sup> to 0.539 x 10<sup>-3</sup>, with an average of 0.380 x 10<sup>-3</sup>. These values are consistent with ICRP recommended values and far below the maximum value of 0.1 (100 x 10<sup>-3</sup>), revealing that the exposed samples may have no significant risk for cancer development after prolonged exposure.

All samples of herbal medicines from medicinal preparations met the international guidelines set by UNSCEAR and ICRP and indicated that associated radiation hazards were within worldwide acceptable limits. The work can be a guide to radionuclide concentration and radiological hazard indices.

#### 4. Conclusions

Gamma rays from natural radionuclides, particularly  $^{238}\text{U}$ ,  $^{232}\text{Th}$ , and  $^{40}\text{K}$ , were measured in ten medicinal herb samples commonly used in the Iraqi market.

Analysis was conducted using gamma-ray spectrometry. The results indicate that the activity concentrations of these radionuclides in the examined herb samples are well below global average limits, posing minimal to no significant health risks to consumers.

These findings are especially important because they show that the radioactivity levels in commercially available medicinal herbs comply with international safety standards. The activity concentrations measured were similar to those in comparable studies from other countries and stayed within the permissible limits set by UNSCEAR, indicating that these herbal treatments do not pose significant radiological risks.

However, it is very important to bear in mind that the current work involved samples that were commercialized (dried, ground, and packed). Therefore, the determined radioactivity levels represent the end product marketed to consumers. The environmental conditions of the growing site, such as soil contamination, water quality, and atmospheric deposition, may have a significant impact on the initial radionuclide content of plants prior to harvesting and processing. Accordingly, the end-products analyzed have a low radiological risk; however, the findings may not be truly representative when cultivation conditions are modified or suboptimal.

It is suggested that further studies be committed to the direct examination of medicinal herbs at the place of their growth in relation influence of certain agronomic techniques and environmental conditions on the accumulation of radionuclides, aiming for safety under constantly changing conditions.

According to the findings, the herbal medicine samples examined in this work are safe for human consumption due to lower levels of radioactivity and hazards less than permissible thresholds. However, it is suggested that investigations on radioactivity in medicinal plants should be carried out periodically to verify the safety for their use. For a full evaluation of the safety of herbal medicine in Iraq, other herbs need to be studied. In addition, more contaminations should be investigated.

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تحديد النشاط الإشعاعي الطبيعي وتقييم المخاطر في بعض الأعشاب الطبية شائعة الاستخدام في العراق

مستخلص البحث:

تهدف هذه الدراسة إلى التحقيق في مستويات النشاط الإشعاعي الطبيعي لعشرة أعشاب طبية تُستخدم بشكل شائع في العراق، وذلك بهدف تقييم المخاطر الإشعاعية المرتبطة بها. تم قياس التركيزات النوعية للنويدات المشعة الطبيعية، وشملت هذه النويدات اليورانيوم-238 ( $^{238}\text{U}$ )، والثوريوم-232 ( $^{232}\text{Th}$ )، والبوتاسيوم-40 ( $^{40}\text{K}$ )، باستخدام تقنية مطيافية أشعة كاما بكاشف جرمانيوم عالي النقاوة (HPGe). وقد تراوحت التركيزات النشطة بين 1.79 إلى 22.94 بيكريل/كغم لليورانيوم-238، وبين 0.55 إلى 5.5 بيكريل/كغم للثوريوم-232، وبين 6.3 إلى 421 بيكريل/كغم للبوتاسيوم-40. كما تم حساب مؤشرات المخاطر الإشعاعية، مثل النشاط المكافئ للراديووم (Raeq)، ومعدل الجرعة الممتصة من أشعة جاما ( $\text{D}_{\gamma}$ )، والجرعة الفعالة السنوية المكافئة (AEDE)، ومؤشر كاما النشط ( $\text{I}_{\gamma}$ )، ومؤشر المخاطر الخارجية والداخلية ( $\text{H}_{\text{ex}}$ ,  $\text{H}_{\text{in}}$ )، إضافة إلى مخاطر الإصابة بالسرطان مدى الحياة الزائدة (ELCR)، وذلك لغرض تقييم المخاطر الصحية المحتملة المرتبطة باستهلاك هذه الأعشاب. أظهرت النتائج أن جميع القيم المقاسة أقل بكثير من المتوسطات العالمية الموصى بها من قبل لجنة الأمم المتحدة العلمية المعنية بآثار الإشعاع الذري (UNSCEAR) واللجنة الدولية للحماية من الإشعاع (ICRP)، مما يدل على أن المخاطر الإشعاعية ضئيلة. تُسهم هذه الدراسة في وضع بيانات مبدئية لتقييمات مستقبلية حول التعرض للإشعاع، وتوثيق سلامة استهلاك هذه الأعشاب الطبية.

**الكلمات المفتاحية:** النشاط الإشعاعي الطبيعي، المخاطر الإشعاعية، الأعشاب الطبية، مطيافية كاما.