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Table of Contents: Volume 11 Number 14, 30 July, 2016

## ARTICLE

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*Full Length Research Paper*

# Measurement of natural radioactivity in selected samples of medical plants in Iraq

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**In present study, natural levels of radiation in some selected medical plants existing in the Iraqi stores were estimated to determine any activity concentration, radium equivalent and internal hazard index due to radionuclide, of 238U, 232Th as well as 40K, which occurs naturally. This activity concentration was identified by gamma-ray spectroscopy (NaI(Tl)). The findings indicate that, the rate of activity concentration for Uranum-238, Thorium-232 and Potasium-40 in the medical plants were (4.953$\pm$0.37) Bq.kg$^{-1}$, (2.916$\pm$0.12) Bq.kg$^{-1}$ and (219.134$\pm$2.24) Bq.kg$^{-1}$ respectively. The values of the radium equivalent ranged from (6.081$\pm$0.09) Bq.kg$^{-1}$ to (44.608$\pm$0.46) Bq.kg$^{-1}$ with the rate of (20.278$\pm$0.38) Bq.kg$^{-1}$, while the values of the internal hazard index ranged from (0.016) to (0.135) with the rate of (0.060). The natural radionuclides and activity of the radium equivalent in the medical plant samples were far below the world for the ingestion of naturally occurring radionuclide provided in UNSCEAR 2000 report. Also there was calculated the internal hazard index for all samples that were less than unity. The samples under study were analysed and discharged, therefore they can no be consumed anymore.**

**Key words:** Natural radioactivity, medical plants, gamma-ray spectroscopy, radium equivalent and Iraqi markets.

## INTRODUCTION

Natural radioactive decay like $^{238}$U and $^{232}$Th series in addition to radionuclide that occurs singly such as $^{40}$K is found in the atmosphere and the earth in varied levels. The radioactivity in the agricultural land and in soil may transfer to the plants around. The radionuclide available in the environment is transferred to plants by two ways, first of which is the indirect method uptake from soil through roots. When food plants are developed in a polluted soil, the activity is switched to the roots from the soil and then in shoots. At the end, it transfers to the human diet Ramiza et al. (2010). This radionuclide can get into the plants during mineral uptake along with the nutrients and accrue in different areas and even it could reach the edible parts Brianna (2011). First, the direct method absorption; it occurs through aerial plant areas. A variety of workers have reviewed the presence of radioactivity in the plant organs Pooja and Rishi (2014). Herbs used as medicines for living beings may be called

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medical plant. Some of these plants are used as raw materials for the manufacture of drugs Kalač (2001). The level of natural radioactivity in some of these herbs is interesting taken from different viewpoints as, for instance, from the environmental point of view Kalač (2001). Viewed differently, medical plants are excluded from the edible plant group under study possibly due to the fact that the absorption of radioactive material through consumption has not been recognized or was considered insignificant (Ele Abiama et al., 2012). A medical plant with high levels of natural radioactivity can lead to health problems because they are usually consumed for long time.

There are many studies about the concentration of radioactivity in medical plants from different countries Desideri et a. (2010), Oni et al. (2011), Tettey et al. (2013) and Fahad et al. (2014). There was clear data base on natural radioactivity levels in medical plant samples despite the wide intake of these kinds of plants as medical treatment. The aim of the present study is to measure the naturally occurring levels of radioactivity ($^{238}$U, $^{232}$Th and $^{40}$K) in some selected herbs usually used in Iraq, and calculate the radiological hazard of the use of these herbs such as radium equivalent activity and internal hazard indices.

## MATERIALS AND METHODS

### Preparation and collection of samples

In September 2015, forty different samples of medical plants were collected from the local markets in various places in Najaf city as shown in Table 1. It is consist of the cursor in front of each sample represents the sample code, trade name, scientific name, Part used and country of origin.

After collecting the samples, each one was put in a plastic bag and given a label to show its name. The samples have been dried, ground homogenization and sieved. The samples are dried before radioactivity measurement for (2-4) days at a temperature of (42-44)°C to avoid any humidity adsorption, and to maintain the actual weight. The dried samples under study were have been ground and milled using a blender to obtain an equal size particles. Later, equal weight (0.75) kg of each sample (using a high sensitive digital weighting balance with a percent of ±0.01%). Then the samples have been kept in the containers. These samples were put into a 1 liter polyethylene plastic Marinelli beakers of a fixed volume to reach a geometric homogeneity all around the detector, then the net weights were measured and recorded with a highly sensitive digital weighing balance at ±0.01%.

### Laboratory procedure

Measurements are carried out by adopting systems of gamma spectrometry from ORTEC, equipped with a high efficiency scintillation detector, an NaI(Tl) detector of (3"×3") crystal dimension, with resolution 9.2% for $^{137}$Cs (661.7 keV). A lead shield of ten cm thickness was put around the detector to lessen the background, with a 0.3 cm layer of copper to weaken x-rays emitted by the lead shield. The spectra are analyzed off-line using the ORTEC Maestro-32 data acquisition and analysis system. The activity concentration is expressed in (Bq.kg$^{-1}$) dry weight depending on the sample type. The detector is energy calibrated using the standard source of known energies like $^{22}$Na, $^{60}$Co and $^{137}$Cs . The specific activity of $^{40}$K was directly identified from the peak areas at 1460 keV. The activity concentrations of $^{238}$U and $^{232}$Th were measured presuming secular equilibrium with their decay products. To measure the activity concentration of radioisotope in the $^{238}$U-series, gamma transition lines of $^{214}$Bi (1765 keV) were employed. Also, radioisotope activity concentrations in the $^{232}$Th-series were identified by applying gamma transition lines of $^{208}$Tl (2614 keV). The average counting time is 24 hour for each sample, to ensure a good statistical significance.

### Calculations

Activity concentration ($A_c$) can be determined as follows (Al-Hamidawi, 2014):

$$A_c = \frac{C - BG}{\varepsilon\% M.t.I_\gamma} \dots\dots \quad (1)$$

where Ac means the activity concentration, C refers to the spot under the photo peaks, BG is background, ε% is energy efficiency percentage, M means mass of sample, t is counting time and Iγ means the percentage of gamma-emission probability for the radionuclide under consideration.

Radium equivalent activity ($Ra_{eq}$) is utilized to evaluate the risks of materials that contain $^{238}$U, $^{232}$Th and $^{40}$K in Bq.kg$^{-1}$ (Nasim et al., 2012), which is identified by presuming that 370 Bq.kg$^{-1}$ of $^{226}$Ra or 260 Bq.kg$^{-1}$ of $^{232}$Th or 4810 Bq.kg$^{-1}$ of $^{40}$K produce the same gamma dose rate.

The $Ra_{eq}$ of a sample in (Bq.kg$^{-1}$) can be achieved using the following relation (Ali Abid et al., 2014; Yu et al. 1992; El-Arabi, 2007; Quindos et al., 1987):

$$Ra_{eq.} = A_U + (1.43\, A_{Th}) + (0.077\, A_K) \dots\dots \quad (2)$$

The internal hazard index can be quantified by the internal hazard index ($H_{in}$). This is given by the following equation (Ali Abid et al., 2014; Yu et al., 1992; El-Arabi, 2007; Quindos et al., 1987):

$$H_{in} = \frac{A_U}{185} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \dots\dots\dots\dots\dots \quad (3)$$

The internal hazard index has to be less than one as well to provide safe radionuclide levels in medical plants.

## RESULTS AND DISCUSSION

The activity concentration due to $^{238}$U, $^{232}$Th, and $^{40}$K in different kinds of medical plant samples has been measured (Table 2). The $^{238}$U activity concentration was turned to be within the scope of (<BDL) Bq.kg$^{-1}$to (12.59±0.43) Bq.kg$^{-1}$with an average of (4.68±0.26) Bq.kg$^{-1}$, $^{232}$Th from (<BDL) Bq.kg$^{-1}$to (14.63±0.24) Bq.kg$^{-1}$with an average of (2.91±0.12) Bq.kg$^{-1}$ and $^{40}$K from (78.56±1.15) Bq.kg$^{-1}$to (579.32±5.21) Bq.kg$^{-1}$within an average of (219.13±2.24 Bq.kg$^{-1}$. The radium equivalent and internal hazard indices were calculated for the whole samples in this research as in Table 3. The $Ra_{eq}$ and ($H_{in}$) varied from (0.016) to (0.135) with (0.060) average and from (6.08±0.09) Bq.kg$^{-1}$ to (44.61±1.08) Bq.kg$^{-1}$ at an average of (20.27±0.38) Bq.kg$^{-1}$ respectively. When

**Table 1.** Medical plant samples.

| S/N | Sample code | Traditional name | Scientific name | Part used | Country of origin |
|---|---|---|---|---|---|
| 1 | H1 | Senna | *Cassai senna* L. | Leaves | Saudi Arabia |
| 2 | H2 | Safflower | *Carthamus tinctorius* | Flowers | Iran |
| 3 | H3 | Ziziphus | *Ziziphus spina-Christi* L. | Leaves | Iraq |
| 4 | H4 | Hops | *Humulus Lubulus* L. | Peduncle | Iran |
| 5 | H5 | Pepper mint | *Mentha piperita* L. | Leaves | Iraq |
| 6 | H6 | Balanitea | *Balanites aegyptiaca* (L.) Del. | Fruits | Egypt |
| 7 | H7 | Aelchenan | *Anabasis* | Leaves | Iraq |
| 8 | H8 | Green tea | *Camellia sinensis* | Leaves | China |
| 9 | H9 | Fenugreek | *Trigonella foenum-graecum* L. | Seeds | India |
| 10 | H10 | Sweet marjoram | *Origanum majvrana* | Aerial parts | Middle east |
| 11 | H11 | Ginger | *Zingiber officinale* Roscoe. | Roots | India |
| 12 | H12 | Grea plantain | *Plantago major* L. | Peel fruits and seeds | India |
| 13 | H13 | Hawthorn | *Crataegus spp.* | Leaves | USA |
| 14 | H14 | Mahleb | *Prunus vinginiana* | Seeds | Azerbaijan |
| 15 | H15 | Myrtle | *Myrtus Communis* L. | Leaves | Iraq |
| 16 | H16 | Barberry | *Thuja occidentalis* L. | Fruits | Syria |
| 17 | H17 | Rosemary | *Rosmarinus officinalis* L. | Aerial parts | Mediterranean sea |
| 18 | H18 | Chicory | *Cichorium intybus* L. | Roots,stalk and leaves | Iraq |
| 19 | H19 | Chamomile | *Matricaria chamomilla* L. | Flowers | Syria |
| 20 | H20 | Sage | *Salvia Officinalis* | Leaves | India |
| 21 | H21 | Maidenhair fern | *Abiantum capillus-Veneris* L. | Leaves and stalk | USA |
| 22 | H22 | Leaf mustard | *Brasica nigra* (L.) Koch | Seeds | China |
| 23 | H23 | Cyperus | *Cyperus* esculentus | Seeds | Egypt |
| 24 | H24 | Rose-Mallow | *Althaea rosea* L. | Flowers | India |
| 25 | H25 | Blinko | *Ocimumba silicum* | Seeds | Iran |
| 26 | H26 | Bay leaves | *Laurus nobilis* | Leaves | Syria |
| 27 | H27 | Corn Mint | *Mentha hapolcaltt* | Aerial parts | India |
| 28 | H28 | Black cumin | *Nigella sativa* L. | Seeds | India |
| 29 | H29 | Roselle | *Hibiscuc sabddariffa* L. | Flowers | Iraq |
| 30 | H30 | Horse tail | *Equisetium arvense* L. | Aerial parts | Egypt |
| 31 | H31 | African rue | *Ruta chalepensis* L. | Aerial parts | Saudi Arabia |
| 32 | H32 | Flax | *Linum Usitatissimum* L. | Seeds | Iran |
| 33 | H33 | Stout bien | *Angelica archangelica* L. | Each herb | China |
| 34 | H34 | Yarrow | *Achillea nillefolium* (Forssk)Sh-Bip | Aerial parts | Iran |
| 35 | H35 | Nutgrass | *Cyperus rotundus L.* | Roots and leaves | Saudi Arabia |
| 36 | H36 | Colocynth | *Citrullus colocynthis* (L.) *Shradc* | Fruits | Iraq |
| 37 | H37 | Primrose | *Primula vulgris* L. | Flowers | west Asia |
| 38 | H38 | Alkanet | *Borago officinalis* | Flowers | Iran |
| 39 | H39 | Coltsfoot | *Tassilago Farfar* | Leaves and flowers | North Asia |
| 40 | H40 | Rose of jericho | *Anastatica Hierochuntica* L. | Branches | Palestine |

compared to the obtained results with the world wide average recommended by UNSCEAR (2000), we have found that $^{238}$U and $^{232}$Th are lower but higher in the case of $^{40}$K in some samples such as H18, H30, H36 and H38 UNSCEAR (2000). The highest allowable activity concentration in some samples because increase in the concentration of potassium nuclide in some areas of the reason is due to the existence of agricultural land and areas containing phosphate fertilizers in which the focus increasingly peer-potassium ($^{40}$K). The values for the radium equivalent activity ($Ra_{eq}$) are found to be within the world average allowed maximum value of 370 Bq.kg$^{-1}$ UNSCEAR (2000). All values of internal hazard indices are lower than the international permissible value of unity UNSCEAR (2000). However, comparing these results with earlier studies (Table 4) indicates that the levels of

**Table 2.** Activity concentration of $^{238}U$, $^{232}Th$ and $^{40}K$ in medical plant samples.

| Sample code | Activity concentration in ($Bq.kg^{-1}$) | | |
|---|---|---|---|
| | $^{238}U$ | $^{232}Th$ | $^{40}K$ |
| H1 | 3.58±0.25 | BLD | 139.90±1.63 |
| H2 | BLD | BLD | 274.51±2.925 |
| H3 | 4.09±0.26 | BLD | 261.73±2.19 |
| H4 | 2.96±0.23 | BLD | 108.79±1.49 |
| H5 | 2.61±0.23 | BLD | 234.57±2.33 |
| H6 | 1.98±0.13 | BLD | 133.96±1.18 |
| H7 | 4.42±0.23 | BLD | 289.03±1.94 |
| H8 | 7.11±0.34 | 1.86±0.10 | 167.49±1.72 |
| H9 | 2.45±0.17 | BLD | 144.60±1.40 |
| H10 | BLD | BLD | 186.02±2.02 |
| H11 | 3.13±0.23 | 3.17±0.14 | 213.77±2.00 |
| H12 | 12.59±0.43 | 2.24±0.12 | 187.05±1.75 |
| H13 | BLD | BLD | 119.03±1.84 |
| H14 | BLD | BLD | 84.10±1.28 |
| H15 | 1.08±0.14 | BLD | 154.74±1.80 |
| H16 | BLD | BLD | 87.46±1.08 |
| H17 | BLD | BLD | 116.19±1.79 |
| H18 | BLD | BLD | 579.32±5.21 |
| H19 | BLD | BLD | 338.94±3.57 |
| H20 | BLD | BLD | 208.82±3.03 |
| H21 | 11.47±0.62 | 2.10±0.16 | 237.860±2.95 |
| H22 | 1.17±0.14 | BLD | 106.05±1.40 |
| H23 | BLD | 1.43±0.09 | 78.56±1.15 |
| H24 | BLD | 1.29±0.10 | 308.44±2.78 |
| H25 | BLD | 1.46±0.08 | 136.353±1.43 |
| H26 | BLD | BLD | 135.561±1.61 |
| H27 | BLD | 1.35±0.10 | 297.128±2.74 |
| H28 | BLD | BLD | 130.36±1.53 |
| H29 | 2.38±0.16 | 3.02±0.11 | 283.65±1.91 |
| H30 | BLD | 1.62±0.13 | 449.231±3.96 |
| H31 | BLD | BLD | 108.94±1.39 |
| H32 | BLD | BLD | 78.98±1.17 |
| H33 | BLD | 1.49±0.11 | 370.10±3.18 |
| H34 | BLD | BLD | 296.57±3.21 |
| H35 | 8.89±0.31 | 14.63±0.24 | 150.24±1.34 |
| H36 | BLD | BLD | 440.43±3.12 |
| H37 | BLD | 2.739±0.23 | 211.11±3.48 |
| H38 | BLD | BLD | 409.26±4.02 |
| H39 | 4.95±0.37 | 2.39±0.15 | 185.68±2.40 |
| H40 | 2.75±0.22 | BLD | 320.99±4.09 |
| Average | 4.68±0.26 | 2.91±0.12 | 219.13±2.24 |

**Table 3.** Radium equivalent internal hazard index in medical samples in this study.

| Sample code | $Ra_{eq}$ ($Bq.kg^{-1}$) | $H_{in}$ |
|---|---|---|
| H1 | 14.35±0.37 | 0.048 |
| H2 | 21.13±0.31 | 0.057 |
| H3 | 24.25±0.43 | 0.076 |
| H4 | 11.39±0.43 | 0.038 |
| H5 | 20.67±0.49 | 0.062 |
| H6 | 12.30±0.22 | 0.038 |
| H7 | 26.68±0.47 | 0.084 |
| H8 | 22.66±0.62 | 0.080 |
| H9 | 13.68±0.28 | 0.043 |
| H10 | 14.32±0.36 | 0.038 |
| H11 | 24.12±0.59 | 0.073 |
| H12 | 30.20±0.73 | 0.115 |
| H13 | 9.16±0.25 | 0.024 |
| H14 | 6.47±0.09 | 0.017 |
| H15 | 13.00±0.28 | 0.038 |
| H16 | 6.73±0.08 | 0.018 |
| H17 | 8.94±0.13 | 0.024 |
| H18 | 44.60±0.46 | 0.120 |
| H19 | 26.09±0.27 | 0.070 |
| H20 | 16.07±0.23 | 0.043 |
| H21 | 32.79±1.08 | 0.119 |
| H22 | 9.34±0.25 | 0.028 |
| H23 | 8.08±0.21 | 0.021 |
| H24 | 25.60±0.36 | 0.069 |
| H25 | 12.59±0.23 | 0.033 |
| H26 | 10.43±0.19 | 0.028 |
| H27 | 24.81±0.36 | 0.067 |
| H28 | 10.03±0.22 | 0.027 |
| H29 | 28.54±0.47 | 0.083 |
| H30 | 36.91±0.50 | 0.099 |
| H31 | 8.38±0.15 | 0.022 |
| H32 | 6.08±0.09 | 0.016 |
| H33 | 30.62±0.41 | 0.082 |
| H34 | 22.83±0.38 | 0.061 |
| H35 | 41.42±0.76 | 0.135 |
| H36 | 33.91±0.34 | 0.091 |
| H37 | 20.13±0.59 | 0.054 |
| H38 | 31.51±0.44 | 0.085 |
| H39 | 22.66±0.78 | 0.074 |
| H40 | 27.45±0.51 | 0.081 |
| Average | 20.27±0.38 | 0.060 |

natural radioactivity in this study are moderate, where Table 4 shows a comparison between the average value of the current work and the average values for medical plants sample in some countries.

## Conclusions

The values of activity concentration of $^{238}U$, $^{232}Th$ and $^{40}K$ in samples of medical plants are found to be lower than the world average allowed maximum values 32, 30 and 400 $Bq.kg^{-1}$ respectively, except the activity concentration

**Table 4.** Comparison of the activity concentrations in the medical plants.

| Country | Activity concentration (Bq.kg$^{-1}$) | | | Reference |
|---|---|---|---|---|
| | $^{238}$U | $^{232}$Th | $^{40}$K | |
| Iraq | 4.68 | 2.91 | 219.1 | This work |
| Italy | 0.4 | - | 654.7 | Desideri et al. (2010) |
| Brazil | - | 21.7 | 976.3 | Scheibel and Appoloni (2007) |
| Nigeria | - | 35.1 | 171.7 | Njinga et al. (2015) |
| Ghana | 31.8 | 56.2 | 839.8 | Tettey-Labri et al. (2013) |
| Serbia | 2.6 | 7.4 | 589.6 | Milutin et al. (2011) |

of 40K that found to be higher in samples H18, H30, H36 and H38. This can be explained by the soil ails that come as a result of an abundance of this isotope concentration. The values for the radium equivalent activity ($Ra_{eq}$) are turned to be within the international average allowed maximum value of 370 Bq.kg$^{-1}$. This study could be of help as a data base for radionuclide concentration and radium equivalent activity. The value of hazard internal is lower than the international permissible value of unity. In general terms, it can be concluded that the implemented technique show good results when matched with other literature data. Also it can be concluded that samples under study, which have been analyzed, are safe for human consumption because their radioactivity levels are less than the maximum permitted level.

## Conflict of Interests

The authors have not declared any conflict of interest.

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