A practical study to determine the percentage of radiation in medicinal herbs used in the Iraqi market

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Abstract. Some commonly used medicinal plants have been chosen to find out the radioactivity concentration and their annual effective dose for 10 samples, Because of that naturally arising radionuclides of $^{238}$U, $^{232}$Th and $^{40}$K. Have used Gamma ray spectroscopy was used to find activity concentrations and the results of the analysis indicated that the average activity concentration of $^{238}$U, $^{232}$Th and $^{40}$K in the medicinal plants, where the results was $38.12 \pm 1.619$ Bq kg$^{-1}$, $12.95 \pm 0.896$ Bq kg$^{-1}$ and $570.70 \pm 31.453$ Bq kg$^{-1}$ correspondingly. Chamomile noted ha the greatest concentration of activity to the $^{238}$U and $^{40}$K Whereas the maximum concentrations of radioactivity for $^{232}$Th in Officinalis Borago were noted. The values of the radium corresponding mean $(62.715)$ Bq kg$^{-1}$ (Outdoor and indoor absorbed dose, Outdoor annual effective dose equivalent, Indoor annual effective dose equivalent and Total annual effective dose equivalent). Where the effective committed annual dose value was less than the world average $(0.3$ for ingestion of probable radionuclides contained in the UNSCEAR 2000 report. Also Well we found a risk factor was $(1.4325 \times 10^{-5})$ significantly less than the ICRP cancer risk, all values were below the internationally allowed limits. The results provide baseline values that may be useful in developing radiation protection rules and regulations in addition to setting ideals and rules for the usage of therapeutic plants or herbal to the competent establishments.

1- Introduction

Agreeing to the International Food Security Authorities Network, Radioactivity (NORMS) Naturally Occurring Radioactive Materials in air, water, soil, food and persons. [1, 2]. It is assessed that 25% of current doses are resulting from Medicinal herbs, most of which are plants whose fresh parts of plants and excerpts are used in therapeutic crops[3, 4]. The increased focus on protective primary health are or basic health caution has made about 70-80% of the world's people depend on mostly on customary drug from plant bases because of this, long-established by the World Health Organization[5, 6]. plant development under certain surroundings from the geochemical fact of opinion and version. It can provide information in monitoring ecological radioactivity about levels of radioactivity of plants in the environs of importance within the environmental and [7]. Recognizable in epidemiologicals
revisions for merely dosages above 0.05-0.1 Sv brought at great dosage by Epidemiological programs have not revealed adverse condition belongings in people showing to minor doses (< 0.1 Sv) supplied in a historical of numerous ages with the concession health of radiogenic properties (chiefly tumor) which is charges [8-10].

Some researchers Approximation of Natural Radioactivity of Some Herbal Plants Rummage-sale in Iraq were investigated to limit accepted radioactivity. The radionuclides were firm by Gross alpha, beta and gamma technique Relational counter + NaI(Tl) indicator type(XLB5) and gamma-ray spectroscopy with (HPGe) techniques [11].This work tries to regulate the exact activity concentrations and the yearly operative doses owed to consumption of NORM due to $^{238}$U, $^{232}$Th and $^{40}$K current in some designated plants of therapeutic usually rummage-sale in Iraq to gauge the radiological danger related with the use of these Medicinal herbs. In Iraq, most people use medicinal herbs in many treatments since ancient times, so we wanted to study the level of radiation in some of these herbs .

Are the samples far from the harmful health?.

2- Materials and methods

2.1. Sample collection The superior of the sampling site was an significant issue in this study, the excellent of a hospital that has the maximum manufacture and use of Medicinal herbs in Iraq. The samples of 10 different Medicinal herbs parts examples were collected where was the weight of the samples(0.310 ,0.380, 0.320,0.460, 0.340, 0.305, 0.440,0.440,0.535 and 0.475 ) kg respectively (by means of a high complex numerical allowance equilibrium with a percentages of ±0.01%) and The samples were dried to get rid of the humidity affecting the measurements at a temperature of (42-44)°C to evade any moisture adsorption, and to keep the real encumbrance. The models were transferred in categorized polyethylene bags from the Centre to the laboratory, the information about all samples Record in Table 1.

2.2. Sample preparation: models were then punished into fine dust with a stainless steel droplet mortar. The equipped models, in processed form, were filled into evaluated one liter Marinelli plastic beaker, hermetically closed, reweighed and kept previous to including [12-14].The flasks were closed to elude any possibility of out- gassing of radon and reserved for a period of 1 month to make certain the models attained radioactive stability between Ra$^{226}$ and its decay foodstuffs in the uranium series, and Ra$^{228}$ and its decay foodstuffs in the thorium sequence [15, 16].
**Table 1.** Physical information of studies samples in this research.

| No. | S codes | Sample codes | Commonly name | Binomial name | Medicinal uses | Origin | Parts used |
|-----|---------|--------------|----------------|--------------|----------------|--------|------------|
| 1   | H₁      | Chamomile    | Matricaria chamomilla | used for lumbago, rheumatic problems[17] | Egypt | flower |
| 2   | H₂      | Rosemary     | Marinus officinalis ros sage | stimulate memory and brain[18] | Syria | flower |
| 3   | H₃      | Salvia Officnalis | Purification of the nervous sybark[19] | freshen the breath[20] | Syria | leave |
| 4   | H₄      | Anisumpimpin ella | Pimpinella anisum | Useful for digestion[21] | India | seed |
| 5   | H₅      | Mentha       | Peppermint | | Iran | leave |
| 6   | H₆      | Officinalis Borago Nigella sativa | Borage officinalis black cumin | Immune sybark stimulator[22] | Iran | flower |
| 7   | H₇      | Linum usitatissimum (Linaceae) | Flax | reduced the early phase of carcinogenes is[24] | Sudanain | seed |
| 8   | H₈      | Trigonella foenum-graecum L | Fenugreek | used for kidney ailments, a vitamin deficiency disease called beriberi[25] | Iraq | seed |
| 9   | H₉      | Cinnamomum zeylanicum J Prel | Cinnamomum zeilanicum Nees | used as a mouth rinse to prevent mouth | Iraq | bark |
| 10  | H₁₀     |              |                 |              |                |        |            |
3. Analysis of models

The models were totaled by means of a gamma-ray spectrometry which consist of NaI(Tl) system that involve of a scintillation gauge NaI(Tl) of (3”×3”) crystal measurement, provided by (Alpha Spectra, Inc.-12112/3), merged with a multi-channel analyzer (MCA) (ORTEC –Digi Base) with range of 4096 channel combined with ADC (Analog to Digital Converter) unit, anywhere using the Gamma-ray spectrum examination software, Ortec MAESTRO–32 at exact energies. through interface. Finally, the spectral data was rehabilitated directly to the PC of the laboratory introduced by using (MAESTRO-32) software. The detector is energy calibrated using the distinctive source of known energies like $^{22}$Na, $^{60}$Co and $^{137}$Cs . The activity of specific of $^{40}$K was straight recognized from the top parts at 1460 keV. The concentrations of $^{238}$U and $^{232}$Th were dignified arrogant earthly balance with their decay gathers. To find has concentration values of activity for radioisotope in the $^{238}$U-series, gamma transition lines of $^{214}$Bi (1765 keV) were working. Also, radioisotope activity attentions in the $^{232}$Th-series were recognized by coating gamma transition appearances of $^{208}$Tl (2614 keV). The regular comprising time is (5h) period for individually model, to confirm a decent arithmetical meaning.

3.1. Calculations

For respectively separate form, the activity of specific in Bq/kg units was intended by means of the comparison (1) [27].

$$\mathcal{E}_n = \frac{(C_n - C_b)}{\varepsilon_f I_p m_s t}$$  ……………………………..(1)

where $\mathcal{E}_n$ is the activity of specific of apiece isotopes in Bq/kg, $C_n$ the sum level in cps for a model, $C_b$ the count level in cps for background, $\varepsilon_f$ and $I_p$ are discovery efficacy and release possibility of γ-ray, $t$ is the including time and $m_s$ is the bulk of the model in kg unit.

A public feature was secondhand to $\text{\textgamma}_{\text{Raeq}}$ its joint radiological properties. This feature is named the Radium corresponding activity ($\mathcal{R}_{\text{aeq}}$). As planned by the Society of Trade and industry Support and Expansion , the allowable Radium equivalent activity values for harmless practice should
remain fewer than 370 Bq/kg. Equation (2) was rummage-sale to explore the radium equivalent activity (Ra_{eq}).[28].

\[ Ra_{eq} = \phi_{Ra} + 1.43A_{Th} + 0.077 \phi_{K} \] .................(2)

Where (\phi_{Ra}, A_{Th} and \phi_{K} ) are the specific activities of \(^{226}\)Ra, \(^{232}\)Th and \(^{40}\)K correspondingly.

The external (\mathcal{H}_{ex}) and internal (\mathcal{H}_{in}) hazard guides were planned by means of Equations (3) and (4) [29].

\[ \mathcal{H}_{ex} = \frac{A_{Ra}}{370} + \frac{A_{Th}}{259} + \frac{A_{K}}{4810} \] ..................(3)

\[ \mathcal{H}_{in} = \frac{A_{Ra}}{185} + \frac{A_{Th}}{259} + \frac{A_{K}}{4810} \] ..................(4)

If the intended values of guides are larger than unity, Radioactivity may source hurt to the people.

Equation (5) was rummage-sale to compute the outdoor dosage (D_{out}) [30].

\[ D_{out} = 0.462\phi_{Ra} + 0.604A_{Th} + 0.0417\phi_{K} \] .............(5)

Whereas the indoor absorbed dose level for studies models was designed by means of equation (6) [34].

\[ D_{in} = 0.92\phi_{Ra} + 1.1A_{Th} + 0.08\phi_{K} \] .................(6)

The yearly operational dose equivalent from outdoor worldly gamma radiation is[31]:

\[ D_{eff} = \text{Outdoor dose(n Gy h}^{-1}) \times 0.7(Sv Gy}^{-1}) \times 8760(h y}^{-1}) \times 0.2 \] .............(7)

For indoor introduction, by means of an tenancy factor of 0.8, the yearly effective dose corresponding is:

\[ D_{eff} = \text{indoor dose (n Gy h}^{-1}) \times 0.7(Sv Gy}^{-1}) \times 8760(h y}^{-1}) \times 0.8 \] .............(8)

the average yearly committed effective dose, Eave, for consumption of NORMS in the samples were considered using the appearance in equation under [32].

\[ E_{ave} = C_{r}DCFiA_{i} \] .................(9)

Where \(DCFi\) is the dosage convection impact for ingestion, \(Cr\) separately radionuclide \((4.5 \times 10^{-5}\) mSv Bq\(^{-1}\), \(2.3 \times 10^{-4}\) mSv Bq\(^{-1}\) and \(6.2 \times 10^{-6}\) mSv Bq\(^{-1}\) for \(^{238}\)U, \(^{232}\)Th and \(^{40}\)K correspondingly for an fully developed [33]. \(Cr\) the ingesting rate consumption of NORMS in pharmaceutical plants and \(Ai\) is the activity concentration in these samples. Usually in Iraq, the regular fraction plant substantial in grams rummage-sale in herbal groundwork or foodstuffs drugs and in eating that nasty about 1 kg for one person(adults) for one year. a ingesting rate of 1 kg yr\(^{-1}\) was expected for wholly the medicinal herbs used in this work, Average annual committed effective dosage(AACED) due to the
consumption of naturally happening radioactive materials (NORMs) for $^{40}$K, $^{238}$U and $^{232}$Th in these samples. By means of the equal equation, the threshold consumption amount for samples was dignified as follows [34].

$$C_r = \frac{E_{agg}}{\sum_{i=1}^{n}(E_{agg} \times A_i)} \cdots \cdots \cdots \cdots (10)$$

Where $E_{agg}$ = 0.3 mSv/y is the threshold AACED due to the consumption of NORM in these samples.

4. Results and discussions:

We noted from table 2 the $\varphi_{Ra}$ of $^{238}$U in the medicinal herbs varieties from 81.58±1.93 to 8.27±1.23 Bq kg$^{-1}$ with an average value of 38.12±1.61 Bq kg$^{-1}$. The maximum $\varphi_{K}$ of $^{238}$U was noted for Chamomile while the lowermost $A_i$ in (Linaceae). For the $\varphi_{Th}$ of $^{238}$Th, it wide-ranging from 23.90±1.19 to 3.27±0.98 Bq kg$^{-1}$ with an average value of 12.95±0.89 Bq kg$^{-1}$ in the medicinal herbs. The peak and bottom $A_i$ was noted for Officinalis Borago and Fenugreek correspondingly. $^{40}$K noted the main concentration of activity in wholly the medicinal herbs paralleled to the concentration activity ($^{238}$U and $^{232}$Th) detected where was the $\varphi_{K}$ diverse as of 780.72±11 to 374.36±6.91 Bq kg$^{-1}$ with an average value of 570.70±31.45 Bq kg$^{-1}$ for it. Chamomile documented the highest concentration of activity whilst the lowest was record in Cinnamomum zeylanicum. the proportion sandwiched between concentrations of Th/K and Ra/K is practically equivalent in models. the differences in the concentrations of activity could be outstanding toward changes in the physical site of the plants, the radiochemical procedure of the lands in which these therapeutic plants are developed or cultured since the heights of effectiveness of usual radionuclides are not regularized through the earth and the flora aptitude to engross actual features further than the others. also the in height activity of potassium concentration in these plants may perhaps be owing to the plants competence to engross potassium from the soil additional than the further components [35].

| sample code          | Activity of Specific (Bq/kg) | Ratios   |
|----------------------|-----------------------------|----------|
|                      | $^{226}$Ra                  | $^{232}$Th | $^{40}$K | Ra/K | Th/K | Th/Ra |
| S1(Chamomile)        | 81.58±1.93                  | 15.27±1.09 | 780.72±11.0 | 0.104 | 0.020 | 0.187 |
| S2(Rosemary)         | 59.83±1.79                  | 3.27±0.98  | 422.97±8.2  | 0.141 | 0.008 | 0.055 |
| S3(Salvia Officinalis)| 9.68±1.60                   | 10.17±1.09 | 549.54±86.0 | 0.018 | 0.019 | 1.051 |
The outcomes for outside, indoor and whole yearly effective dose counterparts are showed in table 3. The regular total (outside plus indoor)yearly actual dose corresponding from terrestrial radioactivity

Table 3. Results of some variables for annual effective dosage in studied samples

| Model code | Outdoor absorbed dose (nGy h⁻¹) | Indoor absorbed dose (nGy h⁻¹) | Outdoor yearly effective dose equivalent (mSv year⁻¹) | Indoor yearly effective dose equivalent (mSv year⁻¹) | Total yearly effective dose equivalent (mSv year⁻¹) |
|------------|---------------------------------|--------------------------------|-----------------------------------------------------|---------------------------------------------------|-------------------------------------------------|
| S1         | 78.518                           | 102.074                        | 0.096295                                             | 0.500732                                          | 0.597027                                         |
| S2         | 45.898                           | 59.668                         | 0.05629                                              | 0.292707                                          | 0.348997                                         |
| S3         | 34.496                           | 44.845                         | 0.042306                                             | 0.219989                                          | 0.262295                                         |
| S4         | 53.255                           | 69.231                         | 0.065311                                             | 0.33962                                           | 0.404931                                         |
| S5         | 57.008                           | 74.110                         | 0.069914                                             | 0.363555                                          | 0.433469                                         |
| S6         | 51.450                           | 66.885                         | 0.063099                                             | 0.328113                                          | 0.391211                                         |
| S7         | 58.447                           | 75.981                         | 0.071679                                             | 0.372731                                          | 0.44441                                          |
| S8         | 34.592                           | 44.970                         | 0.042424                                             | 0.220603                                          | 0.263027                                         |
| S9         | 44.802                           | 58.243                         | 0.054945                                             | 0.285715                                          | 0.34066                                          |
| S10        | 35.413                           | 46.037                         | 0.043431                                             | 0.225841                                          | 0.269272                                         |
| mean       | 49.388                           | 64.204                         | 0.060569                                             | 0.314961                                          | 0.37553                                          |
| max        | 78.518                           | 102.074                        | 0.096295                                             | 0.500732                                          | 0.597027                                         |
| min        | 34.496                           | 44.845                         | 0.042306                                             | 0.219989                                          | 0.262295                                         |
was established to be 0.375 mSv, of which 0.314 mSv derives from interior and 0.060 mSv from outside. It lies within the globally permitted limits [UNSCEAR 2000 Report].

Table 4. Results of related accounts derived from activity to find AACED in models.

| Model code | External radiation hazard, Hext | Internal radiation hazard, Hint | Radium equivalent activity, Raeq (Bq kg$^{-1}$) | Representative level index, Iγr (Bq kg$^{-1}$) | Annual committed effective dose AACED (mSv y$^{-1}$) |
|------------|---------------------------------|---------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|
| S1         | 0.442                           | 0.662                           | 163.540                                       | 1.2171                                        | 0.010399                                     |
| S2         | 0.262                           | 0.424                           | 64.580                                        | 0.7135                                        | 0.006709                                     |
| S3         | 0.180                           | 0.206                           | 24.299                                        | 0.5326                                        | 0.002819                                     |
| S4         | 0.291                           | 0.401                           | 56.235                                        | 0.8247                                        | 0.006011                                     |
| S5         | 0.313                           | 0.444                           | 62.003                                        | 0.8836                                        | 0.006691                                     |
| S6         | 0.275                           | 0.321                           | 51.205                                        | 0.7922                                        | 0.004779                                     |
| S7         | 0.331                           | 0.487                           | 83.300                                        | 0.9041                                        | 0.007802                                     |
| S8         | 0.180                           | 0.202                           | 24.061                                        | 0.5338                                        | 0.002757                                     |
| S9         | 0.249                           | 0.353                           | 54.617                                        | 0.6935                                        | 0.005471                                     |
| S10        | 0.195                           | 0.247                           | 43.307                                        | 0.5456                                        | 0.003861                                     |
| mean       | 0.272                           | 0.375                           | 62.715                                        | 0.7641                                        | 0.00573                                      |
| max        | 0.442                           | 0.662                           | 163.540                                       | 1.2171                                        | 0.010399                                     |
| min        | 0.180                           | 0.202                           | 24.061                                        | 0.5326                                        | 0.002757                                     |

We noted from Table 4. The AACED due to the consumption of radionuclides was lesser than the worldwide average (0.3 mSv/y). The AACED due to the consumption of radionuclides from these samples varies from 0.010399 to 0.002757 mSv y$^{-1}$. This shows that there is no radiological health risk in using these samples determinations. This work may also donate information on native medicinal for these models to formulate guidelines connected to radiological healthcare.

Well we noticed from the table the external hazard index, internal hazard, radium equivalent activity ($Ra_{eq}$), level index Iγr and Annual committed effective dose AACED. The determined values of these factors were (0.442), (0.662), (163.540), (1.2171) and (0.010399) respectively. While the minimum values were (0.180), (0.202), (24.061), (0.5326) and (0.002757) correspondingly. The considered mean values were (0.272), (0.375), (62.715), (0.7641) and (0.00573) respectively. While there is an important rise in the potassium concentration in samples, the designed rates of inside and...
outside risk guides and their nasty standards were fewer than unity, equally in unkind and ideals of outside engrossed does anywhere completely standards were under the allowable boundary [19].

4.1. Excess lifetime Cancer risk.

The risk of cancer due to radiation effects which is named excess lifetime cancer risk (ELCR) can be intended from the following equation [38]

\[ ELCR = (AACD) \text{ Sv.y}^{-1} \times F (\text{Sv}^{-1}) \] ........................(11)

Where, (AACD) the average duration of human life (50 years) and the value of risk factor (F) in the public is 0.05 per Sievert as suggested by ICRP for stochastic belongings [39].

The (AACD) for the measured medical plant in this study, 0.00573mSv, is used to estimate cancer risk for an adult person using the equation (11) above was estimated to be 0.2865 mSv duration for life of 50 years, which gives a risk factor of $1.4325 \times 10^{-5}$.

The estimated values are significantly less than the ICRP cancer risk of $2.5 \times 10^{-3}$ based on annual dose limit of 1mSv for general public. Which mean the average of all samples is saving healthy.

5. Conclusion

The study estimated the concentrations for activities $^{238}$U, $^{232}$Th and $^{40}$K in different plants that are regularly consumed by population of Iraq. The highest amount of $^{238}$U was in Chamomile while for $^{232}$Th in Officinalis Borago and for $^{40}$K in Chamomile which was low when comparing with UNSCEAR dose levels. The values of (Raeq) are curved to be within the international average allowed maximum value of 370 Bq.kg$^{-1}$.The average yearly effective dose strong-minded in this work due to the consumption of usual radionuclides in therapeutic herb plants is far lower 0.3 mSv/y received per person universal where was AACD in this study (0.00573)mSv for an adult person was estimated to be 0.2865 mSv in life of 50 years also was less than another studies [11]. which gives a risk factor of $1.4325 \times 10^{-5}$. The estimated values are significantly less than cancer risk of $2.5 \times 10^{-3}$ (UNSCEAR, 2000) based on annual dose so the radiological hazard related with consumption of the accepted radionuclides in these samples is trivial.

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