Effective radium activity, radon exhalation rate and uranium concentrations in medicinal plants

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Abstract. In the present work, effective radium activity, radon exhalation rates and uranium in medicinal plants have been measured, samples collected from Iraqi markets. Sealed cup technique containing CR-39 solid state nuclear detector was used. Radium concentration varies from (0.0297±0.004) Bq/kg to (0.327±0.126) Bq/kg with an average of (0.142±0.025) Bq/kg. The radon exhalation rate in terms of area varies from (2.287±0.384) μBq/m².d to (25.193±9.729) μBq/m².d with an average of (10.986±1.989) μBq/m².d, while uranium concentrations were ranged from (0.018±0.002) ppm to (0.202±0.057) ppm with an average (0.087±0.002) ppm. The values of radium concentration, exhalation rates and uranium in all the medicinal plants samples were less than the recommended by the Organization of Economic Cooperation and Development (OECD), United Nations and Scientific Committee On The Effects Of Atomic Radiation (UNSCEAR) respectively. The results have revealed that the radium and uranium concentration as well as exhalation rates in studied medicinal plants and the associated exhalation radon does not pose risk to human health.

1. Introduction

The fundamental component of our life bolster system is considered to be within the soil, water, air and vegetation, from which it is breathed in and ingested into the body. These natural components contain quantifiable sum of radioactivity. The particular metabolic character of the plant species may lead to aggregation of radio-nuclides in their organs, which may assist depend upon the physic-chemical characteristics of the soil. In this manner, there may be expanded hazard to human populace through nourishment chain. The essential sources of components from the environment to plants are: air, water and the soil [1]. The radionuclides show within the environment are exchanged to plants by two ways to begin with backhanded strategy take-up from soil through roots. When food crops are developed within the sullied soil, the action is shifted from the soil to the roots and after that in shoots. At the conclusion, action is exchanged to the human count calories [2]. These radionuclides can get exchanged into plants at the side the supplements amid mineral take-up and gather in different parts and indeed reach consumable parcels [3]. Second, it is coordinate strategy assimilation through airborne parts of the plants. Nearness of radioactivity in plant organs has been surveyed by different laborers [1]. The plants roots are normally related to microorganisms, and these affiliations can have coordinate or circuitous impacts on the versatility, accessibility and securing of components by plants [4]. Generally radionuclides are the source of the three sorts of the radiation are alpha particles, beta particles and gamma beams [5]. The essential sources of components from the environment to plants are: air, water and the soil [1]. The radiological impact of the employments of fertilizers in soil is due to the internal irradiation of the respiratory organ by the alpha particles, brief lived radon - thoron offspring and the external irradiation of the body by gamma beams radiated from the radionuclides. Radon is carcinogenic...
to people and capable for primary common radiation presentation to human being [6,7]. There are many studies concern about study the concentration of radioactivity in medicinal plants [8-11].

The aim of this work is to measure effective radium activity, radon exhalation rate and uranium concentrations in some samples of medicinal plants that collected from Iraqi markets using SSNTD (CR-39).

2. Materials and methods

2.1. Collection samples
Forty samples of medicinal plants were collected from the local markets at various places in Najaf city, Iraq. Samples were classified into groups as shown in Table 1 and Figure 1 according to the medicinal plants part that used in treatment.

Table 1. List of medicinal plants used in the study

| No. | Sample Type | Sample Code | Trade name | Scientific name | Origin          |
|-----|-------------|-------------|------------|-----------------|-----------------|
| 1   | Leaves      | M1          | Senna      | CassaisennaL.   | Saudi Arabia    |
| 2   | Leaves      | M3          | Ziziphus   | Ziziphusspina-Christi L. | Iraq          |
| 3   | Leaves      | M5          | Peppermint | MenthapiperitaL. | Iraq          |
| 4   | Leaves      | M7          | Aekhenan   | Anabasis spp.   | Iraq          |
| 5   | Leaves      | M8          | Green tea  | Camellia sinensis | China         |
| 6   | Leaves      | M13         | Hawthorn   | Craegaugus spp. + | USA          |
| 7   | Leaves      | M15         | Myrtle     | MyrtuscommunisL. | Iraq          |
| 8   | Leaves      | M20         | Sage       | Salvia officinalis | India         |
| 9   | Leaves      | M21         | Maidenhair fern | Adiantumcapillus–venerisL. | USA          |
| 10  | Leaves      | M26         | Bay leaves | Laurasnobilis | Syria          |
| 11  | Flowers and Fruits | M2          | Safflower  | Carthamustictorius | Iran         |
| 12  | Flowers and Fruits | M6          | Balanite   | Balanitesaegyptica(L.) Del. | Egypt         |
| 13  | Flowers and Fruits | M12         | Greater plantain | Plantago major L. | India         |
| 14  | Flowers and Fruits | M16         | White cedar | Thujaocidentalis | Syria         |
| 15  | Flowers and Fruits | M19         | Chamomile  | Matricariachamomilla L. | Syria         |
| 16  | Flowers and Fruits | M24         | Hollyhock  | Alceasea L. | India          |
| 17  | Flowers and Fruits | M29         | Roselle    | Hibiscus sabdariffaL. | Iraq         |
| 18  | Flowers and Fruits | M36         | Colocynth  | Citrulluscolocynthis(L.) Shradc | Iraq         |
| 19  | Flowers and Fruits | M37         | Primrose   | Primula vulgaris L. | west Asia     |
| 20  | Flowers and Fruits | M38         | Borage     | Boragoofficinale | Iran         |
| 21  | other       | M4          | Hops       | HumuluslupulusL. | Iran         |
| 22  | other       | M9          | Fenugreek  | TrigonellafoenumgraecumL. | India         |
| 23  | other       | M10         | Sweet marjoram | Origanummajorana | Middle east    |
| 24  | other       | M11         | Ginger     | Zingiberofficinale | India         |
| 25  | other       | M14         | Chokecherry | PrunusvirginianaL. | Azerbaijan    |
| 26  | other       | M17         | Rosemary   | RosmarinusofficinalisL. | Mediterranean sea |
| 27  | other       | M18         | Chicory    | CichoriumintybusL. | Iraq         |
| 28  | other       | M39         | Coltsfoot  | Tassilagofarfa | North Asia     |
| 29  | other       | M22         | Black mustard | Brassica nigr(L.) W.D.J. Koch | China         |
| 30  | other       | M23         | Cyperus     | Cyperusesculentus | Egypt         |
| 31  | other       | M25         | Ginkgo     | Ginkgo biloba. | Iran          |
| 32  | other       | M27         | Com Mint or Bo He | Menthalhalpocalyx | India         |
| 33  | other       | M28         | Black cumin | Nigella sativa L. | India         |
| 34  | other       | M30         | Horse tail | EquisetiumvarvenseL. | Egypt         |
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| No | Code | Species         | Location       |
|----|------|-----------------|----------------|
| 35 | M31  | African Rue RutachalepensisL. | Saudi Arabia |
| 36 | M32  | Flax Linumusitatissimum L.    | Iran          |
| 37 | M33  | Stout bien Angelica archangelicaL. | China |
| 38 | M34  | Yarrow Achilleamillefolium | Iran |
| 39 | M35  | Nutgrass CyperusrotundusL. | Saudi Arabia |
| 40 | M40  | Rose of Jericho AnastaticahierochunticaL. | Palestine |

Figure 1. Pictures of medicinal plants studied
2.2. preparation samples

These samples were crushed to fine powder by using electrical mill, where we measured by using a highly sensitive scale with a tolerance ±0.01%, from five to twenty grams of each individual sample for further analysis. Before use, containers were washed with dilute hydrochloric acid and rinsed with distilled. Then put the samples in plastic containers and assigned a code specific to each individual sample. Measurements were carried out upon 30 days after reaching the radiation equilibrium [12]. Beacon covers were removed rapidly to prevent outside air from entering and changing the atmosphere in the cans. The nuclear detector CR-39 with dimensions of (1×1) cm² and 1mm thick was placed at the middle of the underside of the cover and affixed with an adhesive tape.

The distance between the surfaces of the sample and reagent was 5cm and the sample height was 2cm. The container was then sealed for three months; during that time, alpha particles emitted by radon and their daughters as show a diffusion chamber Figure 2.

![Figure 2. The plastic container used to study alpha particles of medicinal plant samples](image)

The detectors were developed in NaOH solution 6.25 N at 70°C for 7 hours; after chemical etching, α particle track densities were determined by an optical microscope (HDCE-50B digital cameras system microscope N-120A) of 400X Magnification power.

2.3. Calculation of radium, radon exhalation rate and uranium

The Radon centration \( C_{Rn} \) in (Bq/m³) was determined by the following equation[13,14]:

\[
C_{Rn} = \frac{\rho}{K T}
\]

(1)

Where, \( K \): is the calibration factor in terms of (track.cm²/Bq.d.m³), \( T \) was the total exposure time (90 day), \( \rho \) (Track /cm²) was the density of the tracks in the detectors was calculated according to the following equation [15].

\[
\rho = \frac{N_{ave}}{A}
\]

(2)

Where, \( N_{ave} \) was an average of total tracks (Track) and \( A \) is an area of a view field (cm²).

The radium concentration \( C_{Ra} \) (Bq/kg) in sample has been calculated according to the following relation [13]:

\[
C_{Ra} = \frac{\rho A}{\kappa T_{eff} m} \]

(3)
Where $h$ was the distance between the samples surface and detectors, $A$ (m$^2$) is the cross section area of the test tube, $m$ is the mass of sample and $T_{eff}$ (day) is the effective exposure time can calculated from [16]:

$$T_{eff} = T - \frac{1}{\lambda_{Rn}} \left(1 - e^{-\lambda_{Rn} T}\right)$$  \hspace{1cm} (4)

Where $\lambda_{Rn}$ was the decay constant of radon which equal to (0.1814d$^{-1}$). The radon exhalation rate in terms of area $Exim$ (Bq/m$^2$.d) was calculated as follows [17]:

$$Ex = CRa \left(\frac{R_{Ra}}{R_{Rn}}\right) \frac{1}{T_{eff}}$$  \hspace{1cm} (5)

Where $\lambda_{Ra}$ was the decay constant of radium (1.1814×10$^{-6}$d$^{-1}$). Can be calculated radon concentration within the sample $C_{Rn}$, the following relation was used [18]:

$$C_{Rn} \left(\frac{Bq}{m^3}\right) = \frac{C_{Rn} h t}{l}$$  \hspace{1cm} (6)

where, $C_{Rn}$ radon concentrations which culculate by equation $\rho/kt$, $t$ is the exposure time (90 d), and $l$ is the thickness of the sample in the tube.

The radon activity inside the sample $A_{Rn}$ was obtained using the following formulas:

$$A_{Rn}(Bq) = C_{Rn} V$$  \hspace{1cm} (7)

$$V = \pi l r^2$$  \hspace{1cm} (8)

where $V$ is the sample volume in(m$^3$).

The number of uranium ($^{238}\text{U}$) atoms in the sample $N_u$ at the secular equilibrium can be obtained by podgorsak [19]:

$$N_u = \frac{A_{Rn}}{\lambda_{U}}$$  \hspace{1cm} (9)

where $\lambda_{U}$ is the decay constant of uranium (4.9×10$^{-18}$/s). Therefore, the weight of uranium in the sample $M_u$ in gram can be determined as following [20]:

$$M_u = \frac{M_A A_U}{N_A}$$  \hspace{1cm} (10)

where $A_U$ is the mass number of ($^{238}\text{U}$) and $N_A$ is Avogadro’s number. Thus, the concentration of uranium $M_u$ in (ppm) is given by [21]:

$$C_u(\text{ppm}) = \frac{M_u}{M}$$  \hspace{1cm} (11)

3. Results and discussion

The results of effective radium activity, radon exhalation rate and uranium in the medical plants samples selected from Iraqi markts are shown in table 2. The effective radium activity ranged between 0.029±0.032 Bq/kg in sample (M6) to 0.327±0.028 Bq/kg in sample (M30) with an average value of 0.142±0.025 Bq/kg. Also from table 2, the radon exhalation rates has been found to vary from 2.287±2.497 μBq/m$^2$.d in sample (M6) to 25.139±2.210 μBq/m$^2$.d in sample (M30), with an normal esteem10.986±1.989 μBq/m$^2$.d. All results of effective radium activity and radon exhalation rate were smaller to the accordable limit, published by the OECD [22].The uranium concentrations was changed from 0.018±0.002 ppm at test (M6) to 0.202±0.057 ppm at test (M30) with an normal 0.087±0.002
The contrast within the viable radium movement at this think about is due to the distinction within the fundamental bedrocks and the geology of the examined regions as well because, It is found that, the normal esteem of radon exhalation rate for the ponder range was much less than the normal by UNSCEAR 2000 [12]. The variety in values of radon exhalation rate may be due to the contrasts in radium substance. In this manner, it postures no threat to human wellbeing from the point of see of radiation. The radium activity concentration in table 2 is higher than that of uranium, and thus uranium commitment to the alpha particles emanation is unimportant. Be that as it may, the concentrations of radionuclides within the current consider are much less than those of medicinal plants [23]. Usually since, amid the arrangement forms, the action concentrations of radionuclides are essentially decreased in restorative plant definitions compared to those within the crude plants. The variety in concentrations is likely due to the diverse common presence of uranium deepest plants. The variety in the alpha focuses can be ascribed to the various segments of these examples since they were of plant origin. The contamination that happened by radiation can be additionally specifically caused by the assimilation of radionuclides from the air. The take-up of radionuclides by plant changes depending on the soil crust, the plant itself and the manure. Thusly, the radiation contamination of the plant is profoundly foreseen. The activity concentration of radium changed in the formulations, and that might be credited to that the activity concentrations of radium and different radionuclides were in a state of variation from one soil of cultivation to another, and in addition plants likewise fluctuate in their take-up of radionuclides. Plants might be liable to contamination through numerous elements, for example, compost, coordinate testimony, root take-up, and inundating plants with polluted water. uranium commitment in the outflow of alpha particles is unimportant. This is because, during the preparing processes, the activity concentrations of radionuclides are significantly reduced in medicinal plant formulations with those in the crude plants. The variety in concentrations is probably attributed the difference in natural presence of uranium in many plants.

4. Conclusions

The consider the radium concentration and radon exhalation rate in samples of medical plants tests have been found to be well underneath that constrained by OECD and UNSCEAR 2000, separately. Moreover it is found that, all esteem of uranium concentrations are exceptionally small, hence, it may be chosen that the uranium concentrations in irrelevant. All final, the comes about have uncovered that the radium and uranium concentration within the ponder of therapeutic plants and the related exhalation radon does not effect to human health.

Table 2. Effective radium activity, radon exhalation rate and uranium concentrations in medicinal plants

| Sample | C_Ra (Bq/kg) | E_x (μBq/m²·d) | C_U (ppm) |
|--------|--------------|----------------|------------|
| M1     | 0.230±0.045  | 17.765±3.510   | 0.14±0.041 |
| M2     | 0.243±0.017  | 18.761±1.319   | 0.148±0.052|
| M3     | 0.155±0.037  | 12.007±2.895   | 0.096±0.026|
| M4     | 0.094±0.019  | 7.257±1.525    | 0.058±0.012|
| M5     | 0.101±0.014  | 7.796±1.127    | 0.062±0.007|
| M6     | **0.029±0.032** | **2.287±2.497** | **0.018±0.002** |
| M7     | 0.117±0.049  | 9.028±3.781    | 0.07±0.0104 |
| M8     | 0.074±0.019  | 5.717±1.537    | 0.046±0.007 |
| M9     | 0.089±0.034  | 6.908±2.664    | 0.058±0.009 |
| M  | Value       | Value       | Value       |
|----|-------------|-------------|-------------|
| M10| 0.121±0.016 | 9.356±1.257 | 0.074±0.009 |
| M11| 0.076±0.020 | 5.896±1.590 | 0.044±0.002 |
| M12| 0.124±0.023 | 9.566±1.827 | 0.078±0.003 |
| M13| 0.181±0.011 | 13.937±0.899 | 0.112±0.018 |
| M14| 0.066±0.018 | 5.145±1.416 | 0.04±0.011  |
| M15| 0.094±0.018 | 7.257±1.432 | 0.058±0.009 |
| M16| 0.061±0.028 | 4.739±2.199 | 0.04±0.007  |
| M17| 0.116±0.011 | 9.005±0.901 | 0.072±0.010 |
| M18| 0.241±0.009 | 18.582±0.701 | 0.146±0.017 |
| M19| 0.214±0.011 | 16.540±0.805 | 0.13±0.031  |
| M20| 0.190±0.010 | 14.702±0.810 | 0.08±0.010  |
| M21| 0.201±0.014 | 15.54±1.139  | 0.126±0.011 |
| M22| 0.115±0.032 | 8.862±2.512  | 0.07±0.010  |
| M23| 0.124±0.038 | 9.585±2.970  | 0.076±0.015 |
| M24| 0.208±0.042 | 16.081±3.249 | 0.128±0.036 |
| M25| 0.131±0.029 | 10.108±2.306 | 0.08±0.011  |
| M26| 0.135±0.037 | 10.452±2.857 | 0.08±0.019  |
| M27| 0.106±0.016 | 8.186±1.247  | 0.06±0.013  |
| M28| 0.075±0.023 | 5.801±1.831  | 0.046±0.005 |
| M29| 0.040±0.022 | 3.118±1.713  | 0.024±0.002 |
| M30| 0.327±0.036 | 25.139±2.210 | 0.02±0.005  |

Average | 0.142±0.025 | 10.986±1.989 | 0.087±0.002 |

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