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The Natural Activity Concentration And Transfer Factor Of Radionuclide In Soil-Plant In North Eastern Libya

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Abstract: *The activity concentrations of natural radionuclides in soil and plant were measured in this study with an aim to determine the activity concentrations and transfer factors of radionuclides such as ^{226}Ra, ^{238}U, ^{232}Th and ^{40}K from soil to plant collected from north eastern Libya. The samples were collected from different locations in north eastern Libya. The activity concentrations of radionuclides in soil and plant samples were recorded for ^{226}Ra at range (43 -94.10) $Bq.kg^{-1}$ and (46 -159.01) $Bq.kg^{-1}$ respectively, ^{238}U at range (35.37 -83.40) $Bq.kg^{-1}$ and (41.32 -144.08) $Bq.kg^{-1}$ respectively, ^{232}Th at range (39.37 -59.35) $Bq.kg^{-1}$ and (78.40 -166.11) $Bq.kg^{-1}$ respectively, and for ^{40}K at range (384.80 -561.28) $Bq.kg^{-1}$ and (600.21 -1344.90) $Bq.kg^{-1}$ respectively. The transfer factor (TF) was measured by the high-purity germanium detector (HPGe) for all samples. The results recorded that the values were fluctuated for ^{226}Ra at range 0.59 to 2.65, ^{238}U at range 0.62 to 2.61, ^{232}Th were found at range 1.58 to 3.38, and for ^{40}K the TFs values were 1.08 to 3.03 respectively.*

Key words: *Activity concentration, HPGe detector, Transfer factor.*

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I. Introduction

This is first study to determine the information about natural radionuclides and terrestrial environment, which predicted mathematically in the transfer of radionuclides from soil to the plant, this quantity described with the transfer factor **(TF)**. The most commonly radionuclides are ^{226}Ra, ^{238}U, ^{232}Th and ^{40}K. The behavior of natural radionuclides in the environment very important to under-stand because the information can be used as a natural comparison for the long-term behavior of materials and processes in developing **[1]**. The natural radionuclides in soil transfer in to plant incorporated metabolically, and eventually find their way into food and water. As same as the manmade radionuclides behave **[2]**. The study of the radionuclides ^{226}Ra, ^{238}U, ^{232}Th and ^{40}K in soil is important as it is the main source of radionuclides into the food. Many authors in many parts of the world to determine the activity concentration of radionuclides in the food chain and to determine the soil-plant transfer **[3]**. The quantity describe the radionuclides transfer to plants from the soil is the transfer factor **(TF)** and the ratio of activity concentration ($Bq{\cdot}kg^{-1}$) in dry weight of plant to activity concentration ($Bq{\cdot}kg^{-1}$) in dry weight of soil **[4]**.

II. Material And Method

Sampling

Twenty samples ten soil and ten plant were collected from different locations in north eastern Libya. Before measured the samples by high pure germanium spectrometer (HPGe), the first step the samples were dried for 24 hours by the Jovan oven with the temperature 100°C, weighted and placed in polyethylene bottles of 250 cm^3 volume. The bottles were completely selected more than one month to allow radioactive equilibrium to be reached between ^{238}U and ^{232}Th and their corresponding daughters. This step is very necessary to ensur the radon gas is confined within the volume and the doughter stile also remain in the sample.The samples placed in the detector manullay during the work and each sample mesurd for a time 24 hour. The gamma emitting radionuclies recoreded ^{226}Ra, ^{238}U, ^{232}Th and ^{40}K. Fig. (1) shows the collected samples locations.

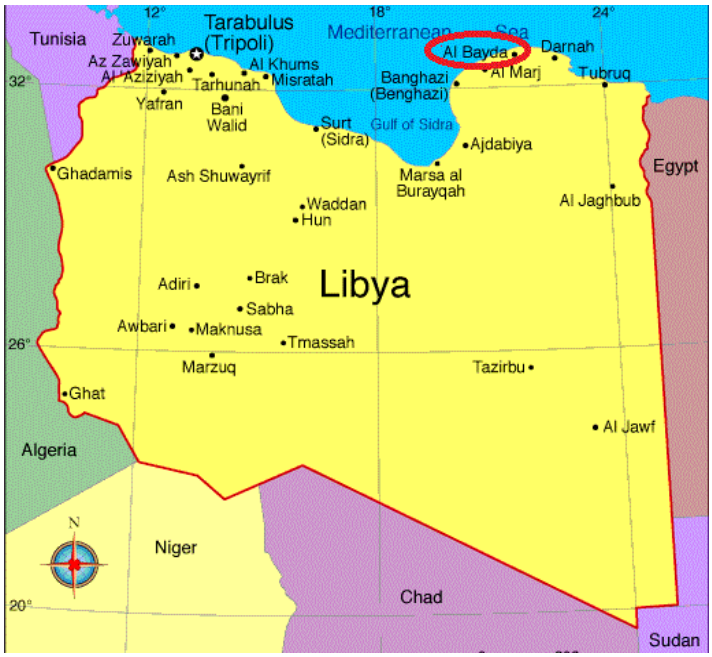

Fig. (1): The sample locations.

Experimental Setup

High purity vertical germanium was coupled to a PC-computer with a special electronic card to make it equivalent to a multichannel analyzer. The system also contains the usual electronic components of preamplifier, amplifier and power supply. The detector has resolution (FWHM) of 1.85 keV for the 1332.5 keV γ-ray line of ^{60}Co. The γ-ray spectrometer energy calibration was performed using ^{60}Co, ^{226}Ra and ^{241}Am point sources. The detector was surrounded by a special heavy lead shield of about 10cm thickness with inside dimension 28 cm diameter 40.5cm height. The absolute detection efficiency of the HPGe detector was determined by using four well-known reference materials obtained from the International Atomic Energy Agency for Ra, U, Th and K activity measurements:RGRa-1, RGU-1, RGTh-1 and RGK-1 **[5, 6]**. The sample containers were placed on top of the detector for counting. The same geometry and size were used for both the samples and the reference materials **[7]**. The uranium standard (RGU-1) is U-ore diluted with silica with 4940 Bq.kg^{-1} of ^{238}U, 228 Bq.kg^{-1} of ^{235}U, a negligible amount of ^{40}K (less than 0.63 Bq.kg^{-1}) and some traces of ^{232}Th (less than 4 Bq.kg^{-1}). The thorium standard (RGTh-1) is Th-ore diluted with silica having 3250 Bq.kg^{-1} of ^{232}Th, but containing some ^{238}U (78 Bq.kg^{-1}) and ^{40}K (6.3 Bq.kg^{-1}). The potassium calibration standard (RGK-1) is produced from high purity (99.8%) potassium sulphate with 14000 Bq.kg^{-1} of potassium with uranium and thorium contents lower than 0.001 and 0.01 ppm (parts per million), respectively **[6]**.

The γ-ray transitions used to measure the concentration of the assigned nuclides in the series are follows:^{238}U was determined from the gamma rays emitted by its daughter products **[8]**, ^{214}Bi (609.3, 1120.3, 1238.1, 1377.7, and 1764.5 keV), ^{214}Pb (295.1 and 352.0 keV), The specific activity of ^{226}Ra was measured using the 186.1 keV from its own gamma-ray. The specific activity of ^{232}Th were measured using the 338.4, 911.2 and 968.9 keV from ^{228}Ac and 583 keV from ^{208}Tl and ^{40}K was measured using 1460.8 keV.

In order to determine the background contribution due to naturally occurring radionuclides in the environment around the detector, an empty polyethylene beaker of the same 250 cm^3 volume was counted with the same geometrical conditions as the sample. The measurement time for both activity and background measurement was 70.000 s. The background spectra were used to correct the net- gamma- ray peak areas for the studied isotopes.

III. Calculation Activity And Transfer Factor

Activity Concentration

The activity concentration (A), of naturally radionuclide in the samples was measured by the relation [9]:

$A = N/(\varepsilon \, I\gamma \, t \, m)$

where N is the corrected net photo-peak area at energy peak, and given by:

$N = Ns - NB$

Where :

Ns : is the net photo peak area in the sample.

NB : is the corresponding net photo peak area in the background spectrum.

ε : is the absolute efficiency at photopeak energy.

t : is the time of the sample spectrum collection in seconds.
I_γ : is the gamma-ray emission probability corresponding to the peak energy.
m : is the mass (kg) of the measured sample.

Transfer Factor (Tf)

In this study the transfer factor was calculated from the activity concentration in the plant dry weight divided by the activity concentration in the soil dry weight. The soil - to- plant transfer factor (TF) of a radionuclide is given by [10]:

TF = Activity concentrations in the plant (Bq.Kg-1)
Activity concentrations in the soil (Bq.Kg-1)

IV. Result And Discussion

The results of the activity concentrations of natural radioactivity of ^{226}Ra, ^{238}U, ^{232}Th and ^{40}K for soil samples are shown in Table (1). The results of ^{226}Ra at range (43-94.10) Bq.kg^{-1}, its higher than world population. For ^{238}U the results are higher than permissible limit at range (35.37-83.40) Bq.kg^{-1}. The result of ^{232}Th were showed at range (39.37-59.35) Bq.kg^{-1}, its higher than permissible limit. The activity concentrations of ^{40}K at range (384.80-561.28) Bq.kg^{-1} up to permissible limit expect two soil sample **[11]**.

Table (1) : The activity concentrations in(Bq.kg^{-1}) for the radionuclides of ^{226}R, ^{238}U, ^{232}Th and ^{40}K in soil samples.

Samples	^{226}Ra	^{238}U	^{232}Th	^{40}K
S1	60.01	55.20	55.10	472.87
S2	65.50	57.19	51.39	515.18
S3	53.43 ذ	48.90	50.59	500.02
S4	58.11	55.29	49.56	454.59
S5	78.64	66.39	55.98	554.74
S6	43.09	35.37	41.02	384.80
S7	46.46	41.57	39.37	485.09
S8	45.83	43.38	48.41	386.30
S9	94.10	83.40	59.35	545.06
S10	63.21	50.65	47.82	561.28
Avg.	60.84	53.73	49.86	485.99
Range	43 -94.10	35.37 -83.40	39.37 -59.35	384.80 -561.28

Table(2) shown the result of activity concentrations of plant samples, the activity concentrations of ^{226}Ra, ^{238}U, ^{232}Th and ^{40}K at range (46-159.01) Bq.kg^{-1}, (41.32-144.08) Bq.kg^{-1}, (78.40-166.11) Bq.kg^{-1} and (600.21-1344.90) Bq.kg^{-1} respectively and all values higher than permissible limit **[11]**.

Table (2) : The activity concentrations in ($Bq.kg^{-1}$) for the radionuclides of ^{226}R, ^{238}U, ^{232}Th and ^{40}K in plant samples.

Samples	^{226}Ra	^{238}U	^{232}Th	^{40}K
P1	159.01	144.08	166.11	1344.90
P2	108.19	91.24	155.85	784.16
P3	89.10	81.52	106.19	1047.89
P4	93.80	72.42	78.40	874.20
P5	46.47	41.32	88.31	600.21
P6	59.79	58.12	104.52	772.85
P7	105.35	99.05	89.197	1194.10
P8	79.73	77.76	101.36	1221.03
P9	181.44	140.23	128.85	1840.39
P10	51.01	50.61	107.54	946.68
Avg.	97.39	85.63	112.63	1062.64
Range	46 -159.01	41.32 -144.08	78.40 -166.11	600.21 -1344.90

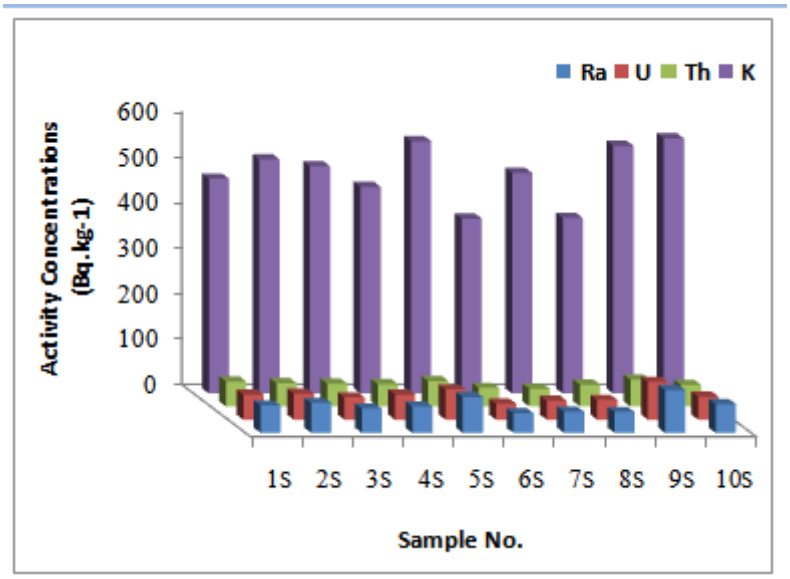

Fig. (2) : Activity concentration of radionuclides in soil samples.

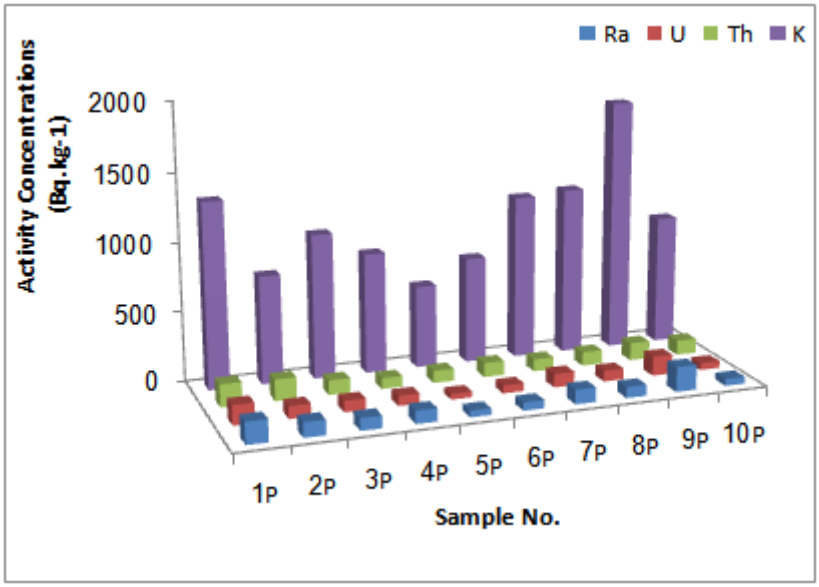

Fig. (3) : Activity concentration of radionuclides in plant samples.

Table (3) showed the values of transfer factor **(TF)** from soil to plant for natural radionuclides ^{226}Ra, ^{238}U, ^{232}Th and ^{40}K were ranged (0.59 to 2.65), (0.62 to 2.61), (1.58 to 3.03), and (1.08 to 3.38) respectively. It was reported that the transfer factor **(TF)** of soil-to-plant depends on soil properties such as nutrient standard, exchangeable K content, pH and moisture content **[12]**. In the present study, the average values of transfer factors plant parts was found to be high compared with IAEA **[9]**.

Table (3) : Transfer factor from (TF) soil to plant for ^{226}Ra, ^{238}U, ^{232}Th and ^{40}K in study area.

Samples	Transfer factor from Soil to Plant			
	^{226}Ra	^{238}U	^{232}Th	^{40}K
1	**2.65**	**2.61**	**3.01**	**2.84**
2	**1.65**	**1.59**	**3.03**	**1.52**
3	**1.68**	**1.67**	**2.10**	**2.09**
4	**1.61**	**1.31**	**1.58**	**1.92**
5	**0.59**	**0.62**	**1.58**	**1.08**
6	**1.39**	**1.64**	**2.55**	**2.01**
7	**2.27**	**2.38**	**2.27**	**2.46**
8	**1.74**	**1.79**	**2.09**	**3.16**
9	**1.93**	**1.68**	**2.17**	**3.38**
10	**0.81**	**1.00**	**2.25**	**1.69**

Losses of radionuclides from the plant root zone by infiltration into deeper soil layers are generally neglected in estimating radionuclide accumulation in soils. These losses are significant where soil permeability is high and the adsorption of radionuclides to soil particles is low. The low radionuclide adsorption capacity to soil particles leads to relatively high radionuclides uptake by plants. Also some of biochemical processes affecting on the behavior of radionuclides in soil, where if the organic matter decomposition change the soil property from oxidizing state to reducing state. There are many factors which mainly affecting on the ratio of plant-soil radioactive content including (properties, fertilizers and pesticides, the chelating agents) .

The soil type affecting on the behavior or radionuclides in soil and soil retention characteristics, where the sandy soil do not have the retention capacity of clay soils **[13].** Organic fertilizer affects the ion exchange capacity, pH, stable of element in soil. **[14]**. Concluded that the Chelating agents affecting on the ion mobility and reduce soil retention leading to the increases of plant uptake preside enhancing the translocation ability within plant itself **[15]**. Some studies revealed that the plants nutrient deficiencies decreasing the soil retention,

leading to the increasing of plant uptake, this is also depended upon the type of soil properties, radioactive element type and the contents of chelating agent **[16]**. The PH values of soil effects on the plant uptake, insoluble salts may be formed. Those salts reduce the availability of radionuclides for plants. Wears at acidic PH the adsorbed cations which become more available to plant.

V. Conclusion

The activity concentration of natural radionuclides in soil and plant, and TF for soil and plant were measured in north eastern Libya. The average activity concentrations of ^{226}Ra, ^{238}U, ^{232}Th and ^{40}K in soil sample are 60.84, 53.73, 53.73 and 53.73 Bq. kg^{-1} respectively while in plant they have the values of 97.39, 85.63, 112.63 and 1062.64 Bq .kg^{-1} respectively. Soil to plant (TF) for ^{226}Ra, ^{238}U, ^{232}Th and ^{40}K are (0.59 to 2.65), (0.62 to 2.61), (1.58 to 3.03), and (1.08 to 3.38) respectively, and in all plant species it is in the order of ^{40}K > ^{232}Th > ^{238}U > ^{226}Ra. The studied radionuclides are of radiological importance to human; soil plant and water and aquatic lives. Thus, the collected data from this study will help to develop a reference database on this important issue so that any change in this respect in future due to nuclear phenomenon can be ascertained and radiation safety measurements may be taken accordingly. In conclusion the relationship of distribution the radioactive element become the plants and soil samples are mainly affecting by different conditions, as soil type, some physicochemical parameters of radioactive element type.

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