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Transfer Factor of Radionuclides from Soil to Plant

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Abstract: ***In the present study an environmental radiation and determination of contamination of natural radionuclides such as Uranium, Thorium and Potassium in soil and herbs(Salsola imbricate) detected in The total of 20 samples (10 soil samples and 10 plant samples) were collected at 20th July , 2016 from different sites in Nahrawan hand is one of the aspects of Iraq to eliminate the towns in the province of Baghdad, in the west of the capital ,And the northern part of which is located near the meeting place of the Diyala River with the Tigris River, and is an agricultural area originally recently turned into a city in the suburbs and the site actually contaminated with military equipment through 2003 .The transfer factor (TF) of uranium for five different sites was measured by the Gamma ray spectroscopy and high-purity Germanium (HPGe) detector the transfer factor for ^{238}Uranged 0.00019, 0.24. Whereas the TF values of thorium were found to be ranged 0.09 to 1.24. On the other hand for potassium the TFs values ranged from(0.9 to 5.1). The transfer factor values in the present study are satisfied the standards of IAEA except TF for ^{40}K in plant species were found to be higher than IAEA value. The data compiled by IAEA for soil to plant transfer factor of ^{40}K in leaves was in the range of (0.49 to 5.6) with average value of (1.4).***

Keywords: Radioactivity, soil, herbs, radionuclide, transfer factor

1. Introduction

Man has continuously been exposed to natural ionizing radiation from both terrestrial and extraterrestrial origin. Terrestrial radiation is emitted from natural radionuclides present in varying amounts in all types of soils, rocks, air, water, food, in the human body itself and other environmental materials around us. Extraterrestrial radiation originates in outer space as primary cosmic rays and reaches the atmosphere, with which the incoming energy and particle interact, giving rise to secondary cosmic rays. The rate at which radiation doses from cosmic rays are delivered is fairly constant at any point on the earth's surface but varies with latitude and to a greater extent with altitude. The major natural radionuclides result from three decay series namely, Uranium, Thorium and Actinium. The total number of radionuclides in the above mentioned decay series would be around fifty having varying metabolic, chemical and physical properties. In addition, there are certain non-series single natural radionuclide, like ^{40}K, ^{87}Rb. ^{138}In, ^{138}La, ^{147}Sm and ^{138}La etc. which contribute to man both internally (when the source is inside the body) and externally (when the source is outside the body). Some of the exposures from the above mentioned radionuclides are fairly constant and uniform for all individuals, for examples ^{40}K in food. Other exposures vary widely with location. The external as well as internal radiation dose in human body may increase the probability of induced cancer and various radiation-induced problems in the body organs and may be harmful to the whole population [1].

1.1 Plants Absorb Uranium

Uranium absorption process occurs mediated by plant roots as a result of interactions of ion exchange between the mobile uranium in the soil solution and tissue in the roots and different plants in it from the last element may be a difference due to non-availability of environmental factors conducive to it as is the case in uranium as data research and studies carried out showed in this particular the following:

- Uranium absorption occurs best of high reciprocity power plants.
- Plants with high rates of sweating, as most of the ions move, including uranium to the upper parts of the plant.
- Low levels of concentrations of carbonate in the soil works to increase the viability of the plant to absorb the uranium.
- Activates the absorption of uranium when the potassium concentration is a little bit in the soil[2].
- When the concentrations of certain salts increasingly high proportion of the soil, the uranium tends to stay in and not go to the roots of the plant.
- Also, the absorption of plant components varies by plant type as well as the nature of the elements, there are types of plants have a selective ability to absorb some metals and some types of plants have a selective ability to lack of absorption of certain elements present in the soil, and as a result, there are several behavioral patterns of plants from hand tendency selective activities to absorb the elements or chemical compounds, including lead to a marked variation in the concentration of the element in plants compared with the concentration in the soil as well as the tendency of some plants to grow in soils with certain concentrations of certain elements[3].

1.2 Soil to Plant Transfer of Radionuclides and Transfer Factor

Plants are the primary recipients of radioactive contamination to the food chain following atmospheric releases of radionuclides. Vegetation may be the subject to direct or indirect contamination [4].

Absorption of radionuclides from soils into plants is usually quantified in terms of the transfer (or concentration) factor, which is defined as the ratio of the radioactivity per unit dry

weight of plant to the radioactivity per dry weight of soil in the rooting zone [5]. Transfer factor (TF) is defined as the ratio of radionuclide concentrations in vegetation and soil.
The soil to plant transfer factors were determined according to the relation (IAEA, 1994)

$$TF = \frac{\text{Activityof uranium in plant Bq.kg}-1\text{dry crops}}{\text{Activityof uranium in soil Bq.kg}-1\text{dry soil}} \quad ...(1)$$

The dry weight was preferred because the amount of radioactivity per kilogram dry weight is much less variable than the amount per unit fresh weight. It reduces uncertainties [6].

Factors effect on the behavior of radio nuclides in soil :the concentration of naturally occurring radio nuclides in soil depends on the rock type from which the soil is formed. The soil can be contaminated by radio nuclides deposition either from what originally discharged into the atmosphere , or from discharged of waste to land or water ways .the amount of radio nuclides in the soil depends on its organic matter content , soil to water ratio , site characteristics , rate and amount of rainfall and soil drainage (NCRP.,1975).moreover the behavior of radio nuclides in soil is affected by different biochemical processes[7].

2. Materials and Methods

2.1 Sample Collection

A total of 20 samples (10 soil samples and 10 plant samples) were collected during the period from 20^{th}July, 2016 from different sites in NAHRAWAN hand is one of the aspects of Iraq to eliminate the towns in the province of Baghdad, in the west of the capital, and the northern part of which is located near the meeting place of the Diyala River with the Tigris River, and is an agricultural area originally recently turned into a city in the suburbs. Study Soil samples were collected from different depths viz. 0–5 cm refer to soil A, 5–10 cm refer to soil B, 10–15 cm refer to soil C, 15–20 cm refer to D and 20–25 cm refer to soil E. In each case of plant samples, leaves and branches well exposed to the atmosphere were collected separately. In the case of grass, whole plant was collected. Soil samples were collected from the same location from where vegetation samples were collected.

2.3 Sample Preparation

To prepare the soil samples for measuring activity concentrations in the laboratory at first, all the samples were collected and dried under direct sun and humidity condition for 2 days. After that these samples have been placed in an electrical oven at a temperature of 80 ^{0}C for 2 hours,especially samples that have been collected after the rain, thus ensuring complete removal of any residual moisture. The dried samples are crushed into a downy powder and passed through a standard 75µm mesh size. The prepared samples have been filled into 500g (Marinelli beakers) which are then closed well and labeled with the plastic tape to prevent outflow of airborne from the samples. These samples were a stored for about 30 days to allow ^{214}Bi and ^{208}Tl to reach a secular equilibrium with ^{238}U and ^{232}Th and their respective daughters. Further, the containers were preserved airtight by plastic packets to ensure that Rn^{222} and Rn^{220} is confined within the volume [8].

The following classical formula to determine the activities in the prepared samples of the soil, grass and plant by the mentioned detector and eventually to determine the TFs due to natural and anthropogenic radionuclides from soil to plant [9]:

$$A = \frac{\text{CPS} \times 100 \times 100}{\text{E} \times \text{I} \times \text{W (gm)}} \quad (2)$$

Where:
CPS = net count per second,
E = counter efficiency,
I = Intensity of gamma ray, and
W = weight of the sample
The counting time sample was kept enough to minimize the counting error. Afteradjustment of necessary parameters, the airtight containers contained the standard; soil and herbs samples were placed on the top of the detector and counted for 3600s.

3. Results and Discussion

The activity concentrations of natural radionuclides ^{228}Ac,^{214}Pb,^{212}Pb, ^{238}U, 234Pa,^{238}Th, ^{40}K and anthropogenic radionuclide ^{137}Cs in soil samples collected from different sites in Nahrawan hand is one of the aspects of Iraq to eliminate the towns in the province of Baghdad are shown in Table 2. The activity concentration of^{228}Ac ranges from10.73±1.23 to18.91±1.06Bq.kg^{-1},^{212}Pb ranges from 10.44±0.66 to 15.83±0.28 Bq.kg^{-1}, ^{238} U series ^{234}Pa ranges from1480.77±100.37 to 102008.2±1994.69 Bq.kg^{-1},^{214} Pb ranges from 12.8±0.79 to 18.18±0.83 Bq.kg^{-1}, ^{40}K ranges from 211.09±11.71 to 345.68±16.19 Bq.kg^{-1}and ^{137}Cs ranges fromB.D.L to 3.24±0.41 Bq.kg^{-1}. The sample numbers of high activity concentrations for each of four radionuclides are S3,S4, S6, and S9; particularly for sample 9, which had a very high concentration of ^{234}Pa as shown in Table 1. Conversely, low activity concentrations were detected in samples S1, S2 and S10. In all samples, the activity concentrations of Uranium are higher than those of Thorium.

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Table 1: Activity concentrations of radionuclides in soil samples

Sample code	Site of orgene	CS-137	K-40	U-138 Series		Th-232	
				Pb-214	Pa-234	Pb-212	Ac-228
S_1	Nahrawan	2.27±0.38	262.02±13.6	15.07±0.83	2811.4±50.19	11.13±0.80	16.06±1.07
S_2	Nahrawan	2.46±0.36	268.19±12.58	18.18±0.83	6671.14±225.55	15.83±0.28	18.91±1.06
S_3	Nahrawan	1.1±0.28	291.25±13.7	16.20±0.79	1480.77±100.37	13.05±0.73	15.42±0.9
S_4	Nahrawan	B.D.L	345.68±16.19	14.58±2.70	60970.35±1258.47	B.D.L	B.D.L
S_5	Nahrawan	3.24±0.41	292.13±14.32	17.20±0.85	3029.84±153.52	14.66±0.85	17.67±1.07
S_6	Nahrawan	2.37±0.54	237.14±12.55	15.73±1.00	21857.08±532.67	11.03±0.95	10.73±1.23
S_7	Nahrawan	B.D.L	255.93±11.56	13.23±0.68	2219.79±110.94	10.44±0.66	13.67±0.82
S_8	Nahrawan	0.82±0.35	211.09±11.71	16.01±0.88	12229.35±349.68	15.56±0.95	B.D.L
S_9	Nahrawan	B.D.L	337.09±16.30	32.47±2.04	102008.2±1994.69	B.D.L	B.D.L
S_{10}	Nahrawan	B.D.L	219.83±12.38	12.8±0.79	5442.4±216.4	10.83±0.78	10.99±1.00

3.2 Radionuclide Concentrations in Plant (herbs) and Transfer Factor (TF)

The activity concentrations of natural radionuclides ^{228}Ac,^{214}Pb,^{212}Pb, ^{238}U, ^{234}Pa,^{238}Th, ^{40}K and anthropogenic radionuclide ^{137}Cs in plants samples collected from different sites in Nahrawan ass shown in Table2. The activity concentration of plant (herbs)^{234}Pa ranged from B.D.L to1182.24±97.49 Bq.kg^{-1}, ^{40}K ranged from253.77±13.22 to 1259.55±59.66 Bq.kg^{-1}, ^{212}Pb ranged from B.D.L to9.47±0.65 Bq.kg–1, ^{214}Pb ranged from B.D.L to13.49±0.72 Bq.kg–1.

Table 3: Representing the results of measurements of plant samples of the Nahrawan site

Sample code	Site of orgene	CS-137	K-40	U-138 Series		Th-232	
				Pb-214	Pa-234	Pb-212	Ac-228
S_1	Nahrawan	B.D.L	675.31±39.86	15.09±1.44	B.D.L	4.45±1.19	B.D.L
S_2	Nahrawan	B.D.L	913.35±47.14	B.D.L	B.D.L	B.D.L	B.D.L
S_3	Nahrawan	B.D.L	439.79±27.95	B.D.L	B.D.L	B.D.L	B.D.L
S_4	Nahrawan	B.D.L	348.08±18.60	B.D.L	291.5±59.44	B.D.L	B.D.L
S_5	Nahrawan	B.D.L	471.73±24.72	B.D.L	738.83±112.86	B.D.L	B.D.L
S_6	Nahrawan	B.D.L	510.95±28.45	2.97±0.69	569.54±106.15	B.D.L	B.D.L
S_7	Nahrawan	B.D.L	1259.55±59.66	7.39±1.36	B.D.L	B.D.L	B.D.L
S_8	Nahrawan	B.D.L	1091.84±51.07	B.D.L	B.D.L	B.D.L	B.D.L
S_9	Nahrawan	B.D.L	317.57±21.25	8.12±0.86	954.91±123.59	4.97±0.84	B.D.L
S_{10}	Nahrawan	B.D.L	253.77±13.22	13.49±0.72	1182.24±97.49	9.47±0.65	B.D.L

Table 4: Transfer factor for radionuclides for different parts of plant

Sample number	K-40	U-238	Th-232
1	2.577	0.0008287	0.1158157
2	3.406	0.0003493	0.0983607
3	1.51	0.0016539	0.1206226
4	1.007	0.004781	1.2483222
5	1.615	0.2438512	0.1052632
6	2.155	0.0260575	0.1733458
7	4.921	0.0010496	0.1360644
8	5.172	0.0001905	1.2483222
9	0.942	0.0093611	1.2483222
10	1.154	0.2172277	0.1692448

In general, the values of ^{232}Th TF were lower than those values reported in other studies and the default values suggested by IAEA [10]. Higher levels of uptake of^{40}K. It is interesting to note that although all the plant species are grown in soils of similar physical -chemical characteristic and similar concentration of these radionuclides, the TF value are different for different species. This indicated that, some plant species concentrate higher ^{40}K radionuclides than others, and plants may uptake potassium from soil as an essential element of metabolism and other radionuclides may be taken as a homologue of an essential element [11].

The data compiled by IAEA for soil to plant transfer factor of ^{40}K was in the range from (0.9 to 5.1) In the present study the average value of TF for ^{40}K in plant species was found to be higher than IAEA value [10].The higher transfer factor of potassium at that time was not at risk streak because that value was not at staid position to harm the body. The high average values of TF (TF >1) for all radionuclides is attributed to the abundance of the organic matter in the zone soils. The variation observed in TFs for the plant samples is due to various factors such as age of the plant, and the environment in which the plant is grown. In the present study the average values of TF for all radionuclides except ^{40}K were found to be higher than IAEA values [10]. This was possibly due to low concentrations of radioactive elements in the soil that the grass grown on it.It is worthy to note that if TF >1, this will lead to a transfer of radionuclides from plants to livestock and finally to humans through the food chain, this may lead to many radiation hazards to the human population. In general, the comparative uptake of ^{238}U and ^{232}Th, by different plants is affected by numerous physical, chemical and biological conditions of the soil. The combined effects of these conditions, as well as the individual chemical properties of the nuclides, tend to affect its uptake by plants. For example, retention of radionuclides onto the soil particles will affect their availability for plant uptake. ^{232}Th exhibited a much lower mobility than ^{238}U, which is consistent with our observations that ^{232}Th has smaller TF values [12]. The transfer factor for 40K, 232Th and 238U are shown in Figures: 1, 2 and 3.

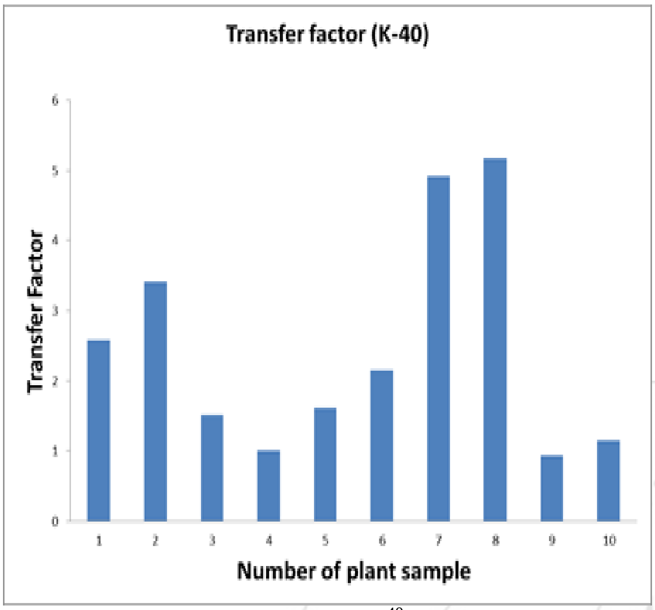

Figure 1: Transfer factor for ^{40}K in all samples

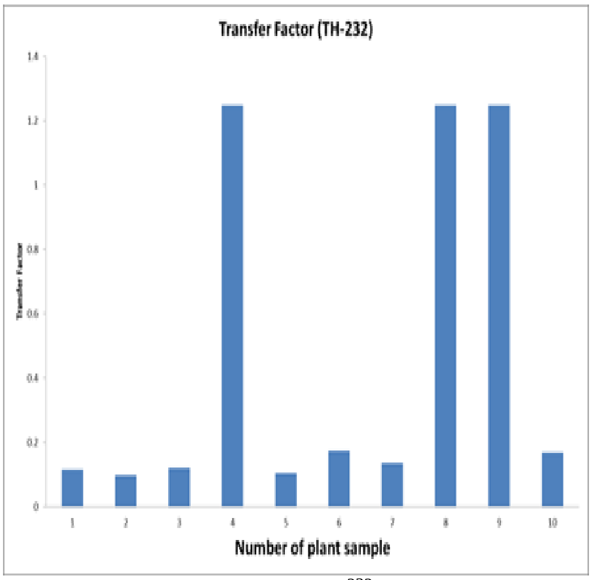

Figure 2: Transfer factor for ^{232}Th in all samples

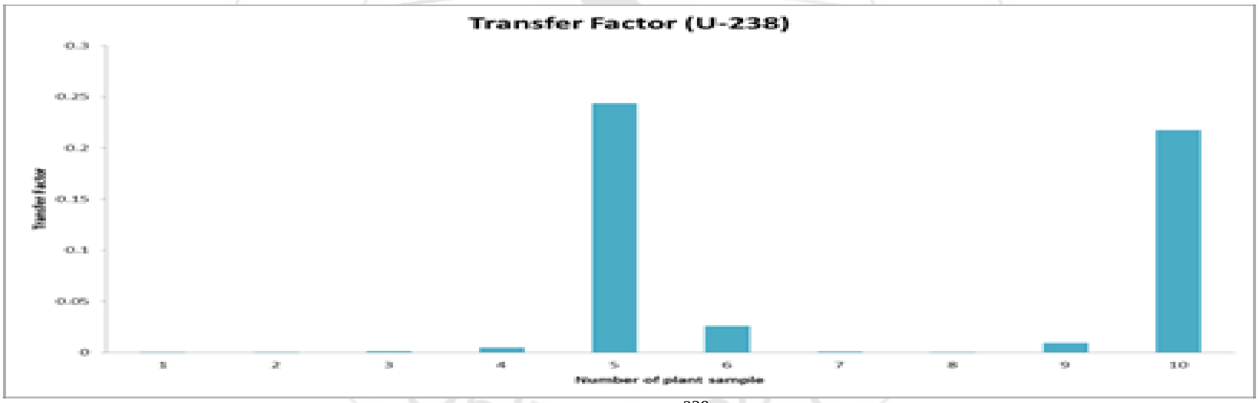

Figure 3: Transfer factor of ^{238}U in all samples

4. Conclusion

Conclusions that are derived from the present work can be summarized as follows:

1) Results predicted that for all transformation from soil to plant, potassium has highest average TF. This was due to the fact that potassium is an important element to plant fertility, even though potassium is a radioactive element, but it does not harm the environmental system.
2) From plant radionuclide analysis, the younger plants have the highest average TF values.
3) The average values of TF from soil to plant for^{40}K was found to be higher than IAEA value, while in another radionuclides, The average values of TF are within the IAEA range. The information on the concentration level and transfer of radionuclides from soil to plants will provide important data for the environmental risk assessment at such zones.

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