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NATURAL RADIOACTIVITY TRANSFER FACTORS FROM SOIL TO PLANTS IN WASIT GOVERNORATE MARSH

Study on environmental radiation protection and determination of contamination of natural radionuclides such as ^{40}K, ^{226}Ra, and ^{228}Ra/^{228}Th in soil and plants is important for the protection of public health. The environmental health surveillance program to develop a subject of interest in environmental science is therefore necessary for the awareness and the benefit of mankind. This study is focused on the transfer factors of isotopes from soil to plants. Transfer factor is a value used in evaluation studies on the impact of accidental release of radionuclide into the environment. 80 samples (40 reed plants and 40 soils) were collected from Dulmaj marsh. Dulmaj is in the southwest of Wasit and northeast of Diwaniyah. ^{40}K, ^{226}Ra, and ^{228}Ra/^{228}Th activities were measured by using NaI(Tl) 3" × 3". ^{40}K, ^{226}Ra, and ^{228}Ra/^{228}Th activity concentrations ranged from 87 to 706, 1.2 to 35.7, and 2.6 to 17 Bq·kg^{-1}, respectively in soil. ^{40}K, ^{226}Ra, and ^{228}Ra/^{228}Th activity concentrations ranged from 9.6 to 472, 0.26 to 30, and 0.09 to16.1 Bq·kg^{-1} (dry mass), respectively in the plants. The transition factors of ^{40}K, ^{226}Ra, and ^{228}Ra/^{228}Th ranged between 0.02 to 0.97, 0.07 to 0.99, 0.09 to 0.99, respectively. Transfer factors had shown different values in all locations. However, all the rates of values of the transfer factors have been shown to be less than one.

Keywords: transfer factors, Dulmaj marsh, plants, soil, radionuclides, soil-to-plant transfer factor.

1. Introduction

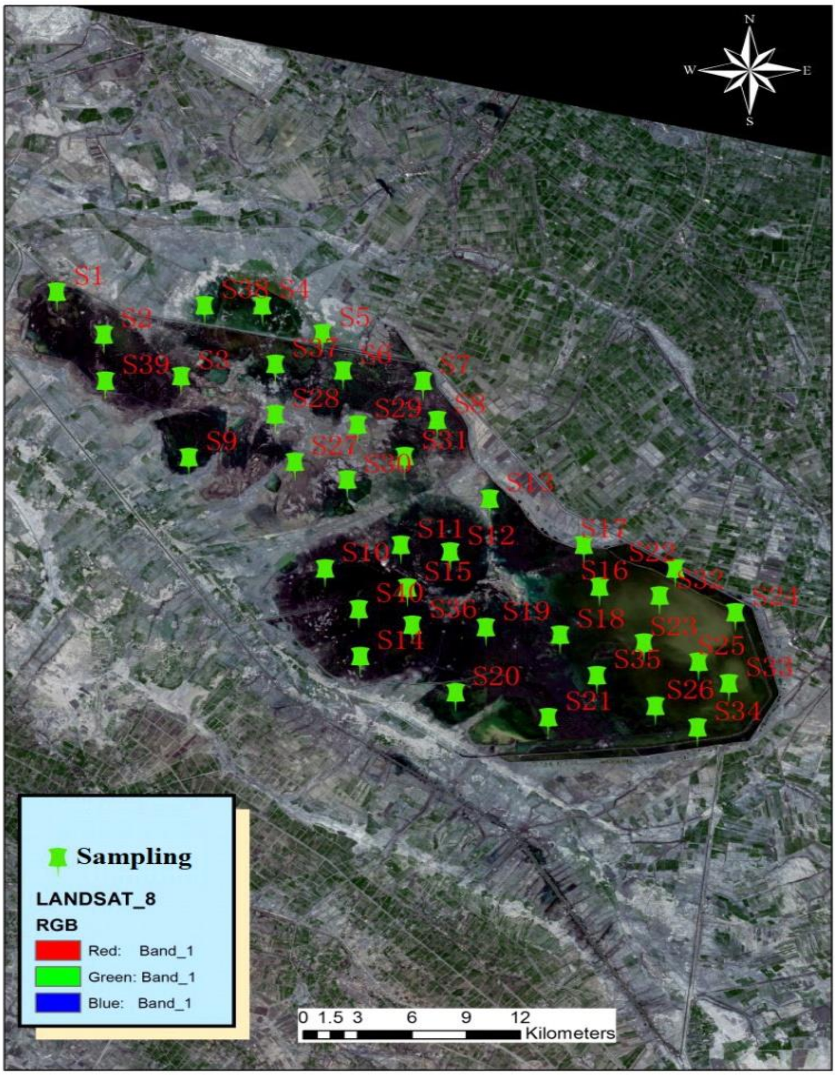
The natural radioactivity or radionuclide discharged into the earth may lead to potential radiation exposure of the adjacent biota and people. Many countries around the world measure the average exposure caused by natural radiation for various purposes, such as choosing the location of nuclear facilities and contingency plans to monitor any case of increased radioactivity and its source and reason to ensure the security of the country and citizens [1]. The life of organisms especially humans is endangered by the presence of radiation in the environment as the high concentration of radioactive elements causes contamination [2, 3]. One of the causes of radioactive contamination in the world is due to the use of alternative energy sources such as nuclear reactors, electric-nuclear power plants, and the dumping of nuclear waste, as well as the use of missiles and explosives containing such radioactive materials in nuclear explosions during the war and nuclear testing on the land, sea, and air. The knowledge of geochemical and ecological cycles is needed. Hence an investigation is useful for both the assessment of public dose rates and the performance of epidemiological studies. Therefore, the need arises for investigating potential radiation risk to non-human biota and ecosystem is now internationally recognized. The environmental health and status risk assessment is monitored by international organizations and committees such as International Commission on Radiological Protection (ICRP), International Atomic Energy Agency (IAEA), and other international organizations specialized in radiological and radiological protection [4, 5]. Environmental pollution is the biggest obstacle to the development of tourist positions, because of the degradation it causes and the reduction in its hypothetical life. Hence countries all over the world that are prominent for their natural and cultural tourist attractions have also faced environmental pollution. The most prominent theoretical results that have emerged from the study are the weak environmental awareness among the citizens in the study area and that the environmental balance is necessary for the continuation of the ecosystem, whether it was for humans or animals and plants. This work is a study on the natural radioactivity in soil and plant. The objectives of this research are to study the transfer factors of radionuclides from soil to plant and show the contamination.

2. Area of the Study

Al Kut is a city connected to many popular cities in Iraq but has few tourist attractions. The total population of Al Kut is 315162. Dulmaij marsh is located to the southwest of Wasit and the northeast of Qadisiyah, with coordinates of latitudes 08°32' to the north and 25°32' and longitude 09°452' and 42°45' to the east. The total area of the submerged and non-submerged marsh is approximately 682 km^2 divided between 267 km^2 in Wasit and 435 km^2 in Qadisiyah. The source of its water is from the main river which passes through the Taghdeyya canal within the boundaries of Qadisiyah. The geographical creation of the marsh goes back to the era of the quadrilateral within the Holocene. It is characterized by being large longitudinal basins formed by the rivers of the hills and the river Tigris during the fractured edge. It is covered by water during the seasons. The precipitations are either on the surface or buried under sediments. The area of the study is located within the flood. It is characterized by plain descends from the northwest to the southeast. The deep of the marsh starts from approximately 1m to 4.5 m. The largest deep of the marsh is in the southeast part. It is noted that the water of the Dulmaj marsh has various levels of immersion of more than 70 % of the total area in 2002 but this percentage decreased to 18 % of the total area in 2016 [6]. Some literature studies in the investigation of radionuclides in many samples such as soil, bone, teeth, and meat have been examined [7 - 11].

3. Materials and methods

80 samples from Dulmaj marsh in Wasit were collected and divided into 40 samples of marsh soil (the depth is 10 cm) and 40 of the plant (reed plant) growing in the marshes. Reed had spread in the area with an average depth of 25 cm to ensure the root coverage. Dulmaj marsh is characterized by the presence of vegetation consisting of prominent water plants such as reeds, papyrus, golan, and immersed water plants such as shambles. Various wild plants such as tartai, turfaa, and others, and the reed covers the largest percentage of the area. The reed plant was collected from the Dulmaj marsh in Kut and placed in a bag and the sample details were written on it. The samples were transferred to the laboratory for testing. The suspended organic matter was separated in the plant and the samples were cleaned and washed well with water. All locations were coordinated using a GPS device. 2 kg soil was collected from each site. Then the samples were transferred to the research lab of the Department of Physics at the Faculty of Education for Women. The soil and plant samples were well dried using the oven. Later it was crushed, sifted, and packed in a special container for measuring. Marinelli container is plastic cylindrical in shape that has a gap in the center to put the detector crystal. The sample was placed around the crystal allowing for high efficiency. The containers were numbered and sealed tightly to ensure that the radon does not leak then it was stored for 4 weeks before the measurement process is initiated to reach the equilibrium of radiation. Figure shows the area of study and from where the samples were collected.



Area of study and sampling.

^{226}Ra was measured by the quality activities of ^{214}Bi with an energy of 1764 keV. $^{228}Ra/^{228}Th$ was measured using ^{208}Tl at the energy of 2614 keV which represents the quality activity of $^{228}Ra/^{228}Th$. Then ^{40}K was measured directly at 1460 keV. The natural quality radioactivity of gamma-ray was measured by the high penetration strength of gamma rays in the material. The measurement time for all samples was 18000 s, then the net area was calculated under the curve for each nucleus.

The transfer factor for radionuclides of soil to plant using the equation [12]

$$TF = \frac{Activity\,in\,Plant}{Activity\,in\,Soil}.$$

4. Results and discussions

The results of measure the radioactivity in this study were divided to 3 parts:

1. The radioactivity in soil.

Table 1 shows ^{226}Ra, $^{228}Ra/^{228}Th$, and ^{40}K concentrations in the soil sample. The highest ^{226}Ra activity concentration was found to be 35.7 ± 1.2 Bq·kg^{-1} in the soil sample (S19) and the lowest ^{226}Ra activity concentration was found to be 1.24 Bq·kg^{-1} soil sample (S24). The highest $^{228}Ra/^{228}Th$ activity concentration was found to be 17.0 Bq·kg^{-1} in S19 and the lowest $^{228}Ra/^{228}Th$ activity concentration was found to be 2.6 in S4. The highest ^{40}K is found to be 706 Bq·kg^{-1} in S15 and the lowest ^{40}K was found to be 125.46 Bq·kg^{-1} in S4.

Table 1. ^{226}Ra, $^{228}Ra/^{228}Th$, and ^{40}K activity concentrations (Bq·kg^{-1}) in the soil sample

Sample code	^{226}Ra	$^{228}Ra/^{228}Th$	^{40}K
S1	12.9 ± 0.7	5.6 ± 0.3	299 ± 3
S2	25.8 ± 0.9	6.1 ± 0.2	352 ± 3
S3	6.1 ± 0.5	12.0 ± 0.4	502 ± 4
S4	11.6 ± 0.7	2.6 ± 0.2	126 ± 2
S5	30.9 ± 1.0	3.2 ± 0.2	174 ± 3
S6	6.4 ± 0.5	7.6 ± 0.3	360 ± 4
S7	8.1 ± 0.6	6.8 ± 0.3	362 ± 4
S8	27.1 ± 1.0	3.2 ± 0.2	477 ± 4
S9	10.8 ± 0.6	5.7 ± 0.3	480 ± 4
S10	11.9 ± 0.7	17.0 ± 0.5	606 ± 5
S11	8.7 ± 0.5	11.5 ± 0.4	151 ± 2
S12	13.3 ± 0.7	14.9 ± 0.4	364 ± 4
S13	8.1 ± 0.5	9.7 ± 0.3	439 ± 4
S14	10.2 ± 0.6	7.3 ± 0.3	221 ± 3
S15	11.0 ± 0.6	15.7 ± 0.5	706 ± 5
S16	29.0 ± 0.9	16.2 ± 0.4	434 ± 4
S17	26.5 ± 0.9	12.1 ± 0.4	528 ± 4
S18	3.5 ± 0.3	7.9 ± 0.3	387 ± 4
S19	35.7 ± 1.2	8.9 ± 0.4	498 ± 5
S20	30.1 ± 1.1	7.6 ± 0.3	393 ± 4

Continuation of Table 1

Sample code	^{226}Ra	$^{228}Ra/^{228}Th$	^{40}K
S21	24.8 ± 1.0	10.8 ± 0.4	410 ± 4
S22	17.1 ± 0.8	14.1 ± 0.4	423 ± 4
S23	14.2 ± 0.7	10.7 ± 0.4	548 ± 4
S24	11.6 ± 0.7	9.5 ± 0.4	383 ± 4
S25	1.2 ± 0.2	9.2 ± 0.4	255 ± 3
S26	12.8 ± 0.7	7.7 ± 0.3	148 ± 2
S27	11.1 ± 0.6	6.3 ± 0.3	405 ± 4
S28	23.9 ± 1.0	10.5 ± 0.4	508 ± 5
S29	8.2 ± 0.5	8.8 ± 0.3	266 ± 3
S30	12.0 ± 0.6	8.4 ± 0.3	402 ± 4
S31	9.4 ± 0.5	11.6 ± 0.3	371 ± 3
S32	12.9 ± 0.7	12.9 ± 0.4	393 ± 4
S33	9.1 ± 0.5	10.3 ± 0.3	384 ± 3
S34	9.6 ± 0.5	6.8 ± 0.3	407 ± 4
S35	7.4 ± 0.5	12.3 ± 0.4	247 ± 3
S36	10.5 ± 0.5	6.7 ± 0.3	378 ± 3
S37	2.1 ± 0.2	0.4 ± 0.3	318 ± 3
S38	13.6 ± 0.7	11.5 ± 0.4	458 ± 4
S39	10.7 ± 0.6	12.6 ± 0.4	349 ± 3
S40	9.2 ± 0.6	9.2 ± 0.4	352 ± 4
S average	13.9	9.4	344
S max	35.7	17.0	706
S min	1.2	2.6	126

2. The radioactivity in plant.

Table 2 shows ^{226}Ra, $^{228}Ra/^{228}Th$, and ^{40}K activity concentrations in the plant sample. The highest ^{226}Ra activity concentration is found to be 29.94 Bq·kg^{-1} in the plant sample (P20) and the lowest ^{226}Ra activity concentration was found to be 0.26 Bq·kg^{-1} plant sample (P25). The highest $^{228}Ra/^{228}Th$ activity concentration was found to be 17 in P10 and the lowest $^{228}Ra/^{228}Th$ activity concentration was found to be 0.14 Bq·kg^{-1} in P15. The highest ^{40}K activity concentration was found to be 472 Bq·kg^{-1} in P23 and the lowest ^{40}K activity concentration was found to be 9.6 Bq·kg^{-1} in P3.

Table 2. **^{226}Ra, $^{228}Ra/^{228}Th$, and ^{40}K activity concentration (Bq·kg^{-1}) in plant samples**

Sample code	^{226}Ra	$^{228}Ra/^{228}Th$	^{40}K
P1	10.0 ± 1.1	3.2 ± 0.4	75 ± 3
P2	4.7 ± 0.7	3.9 ± 0.4	57 ± 2
P3	6.0 ± 0.1	7.6 ± 0.7	10 ± 1
P4	1.5 ± 0.5	1.9 ± 0.4	84 ± 4
P5	29.0 ± 2.0	0.7 ± 0.2	117 ± 4
P6	4.9 ± 0.9	5.9 ± 0.6	115 ± 4
P7	1.3 ± 0.4	3.6 ± 0.4	278 ± 7
P8	2.5 ± 0.6	2.5 ± 0.3	218 ± 6
P9	5.2 ± 0.9	5.1 ± 0.5	464 ± 9
P10	10.6 ± 1.4	17.0 ± 1.0	254 ± 7
P11	6.0 ± 1.0	6.6 ± 0.6	80 ± 4
P12	13.2 ± 1.3	9.0 ± 0.7	60 ± 3
P13	7.3 ± 1.0	8.8 ± 0.6	63 ± 3
P14	7.4 ± 1.1	7.0 ± 0.6	154 ± 5
P15	3.4 ± 0.7	0.20 ± 0.08	435 ± 8

Continuation of Table 2

Sample code	^{226}Ra	^{228}Ra/^{228}Th	^{40}K
P16	20.2 ± 1.7	13.8 ± 0.8	135 ± 4
P17	23.4 ± 1.5	8.5 ± 0.6	132 ± 4
P18	1.2 ± 0.4	5.6 ± 0.5	339 ± 6
P19	24.9 ± 1.7	8.2 ± 0.6	373 ± 7
P20	29.9 ± 2.0	5.7 ± 0.5	130 ± 4
P21	17.6 ± 1.6	8.5 ± 0.7	146 ± 5
P22	14.6 ± 1.5	9.4 ± 0.7	113 ± 4
P23	6.6 ± 1.0	7.4 ± 0.6	472 ± 9
P24	6.5 ± 1.0	7.5 ± 0.3	120 ± 4
P25	0.3 ± 0.2	7.5 ± 0.6	187 ± 5
P26	4.8 ± 0.8	3.1 ± 0.4	115 ± 4
P27	9.1 ± 1.1	6.2 ± 0.5	117 ± 4
P28	9.1 ± 1.2	4.7 ± 0.5	425 ± 8
P29	4.4 ± 0.7	2.8 ± 0.3	109 ± 3
P30	9.8 ± 1.1	6.0 ± 0.5	358 ± 7
P31	4.7 ± 0.7	7.8 ± 0.6	94 ± 3
P32	6.4 ± 0.9	6.2 ± 0.5	74 ± 3
P33	5.1 ± 0.7	8.6 ± 0.5	245 ± 5
P34	1.3 ± 0.4	LD	351 ± 7
P35	6.6 ± 0.9	4.1 ± 0.4	74 ± 3
P36	9.4 ± 0.8	LD	184 ± 4
P37	1.8 ± 0.4	0.7 ± 0.5	93 ± 3
P38	9.3 ± 1.1	7.1 ± 0.6	358 ± 7
P39	9.4 ± 1.0	7.2 ± 0.5	97 ± 3
P 40	LD	LD	129 ± 4
P average	8.8	5.8	168
P max	29.9	16.1	472
P min	0.3	0.1	10

3. The transfer factor from soil to plant.

Transfer factor (TF) from soil to plant in all locations was measured. The highest TF of ^{226}Ra was found to be 0.999. The highest TF of ^{228}Ra/^{228}Th was found to be 0.995. The highest TF of ^{40}K was found to be 0.965.

^{226}Ra, ^{228}Ra/^{228}Th, and ^{40}K activity concentration was found to be 1.24 to 35.7 Bq·kg^{-1}, 2.6 to 17 Bq·kg^{-1}, 87 to 76 Bq·kg^{-1}, respectively in soil. The corresponding concentration was found to be 0.26 to 29.9 Bq·kg^{-1}, 0.09 to 16.1 Bq kg^{-1}, 9.6 to 472 Bq·kg^{-1}, respectively in plant. The highest TF of ^{226}Ra, ^{228}Ra/^{228}Th, and ^{40}K were 0.99, 0.99, 0.96, respectively. These values were different due to the geological nature of the soil and climate in that region. The global limit of ^{226}Ra, ^{228}Ra/^{228}Th are 35 Bq·kg^{-1} and 30 Bq·kg^{-1}, respectively [13]. The quality efficiency of ^{40}K was of disparity values between regions. There was an increase in the concentration of potassium nuclide in some regions. However, all the findings were within the global limits of 400 Bq·kg^{-1} [13].

Man has always been exposed to both natural and artificial radiation amongst which on average, 79 % of natural sources, 19 % from medical application, and the rest of 2 % from the fallout of weapons testing and the nuclear plant [14]. The relationship between activity, TF, and soil parameters can be obtained by analyzing their effects. Results showed that ^{40}K has the highest concentration. This is because ^{40}K is an important element to fertile the crop [15]. Even though ^{40}K is a radioactive element omit this word it does not harm the aquatic system [16]. ^{40}K is important for plants to grow and adapt to environmental stress. The higher ^{40}K was not at risk streak because that value was not at a staid position to harm the body [16].

It has been found in some studies that there are some specific activities of radium and thorium in soil, ecosystem, human, and animal tissues [17 - 21]. Whereas, some studies have shown to find the radionuclides in soil, water, and find the relationship with the human [22 - 25]. Radiation pollution and cancer risks, spatial and temporal variability of environmental radioactivity, the water and environmental reality of the marshlands in Iraq have been studied [26 - 28].

5. Conclusion

Among the different outcomes of the research, this study focused on the concentration of ^{226}Ra, ^{228}Ra/^{228}Th, and ^{40}K in soil and plant at Dulmaj marsh. Uranium and thorium were distributed with differential values in all the measured samples. The concentration and transfer factors of soil to plant in Wasit were experimentally estimated. The reason for the low increase in the concentration of radionuclides is due to the geological nature of the soil and climate in that region. The quality efficiency of potassium takes disparity values between regions. It is noted that there is an increase in potassium in some regions. The result predicted that the values of concentration of uranium, thorium, and potassium are at the safe level at Dulmaj marsh. However, all the concentrations of radionuclide were within and close to the global recommended limits. The rates of values of the transfer factor from soil to plant for radioactive elements are less than one.

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ФАКТОРИ ПЕРЕДАЧІ ПРИРОДНОЇ РАДІОАКТИВНОСТІ З ҐРУНТУ ДО РОСЛИН У БОЛОТАХ ПРОВІНЦІЇ ВАСІТ

Дослідження захисту навколишнього середовища від радіації та визначення забруднення ґрунту та рослин природними радіонуклідами, такими як ^{40}K, ^{226}Ra та ^{228}Ra/^{228}Th, є важливим для захисту здоров'я населення. Тому програма охорони навколишнього природного середовища необхідна для обізнаності та вигоди людства. Дане дослідження зосереджено на факторах передачі ізотопів від ґрунту до рослин. Фактор передачі – це величина, що використовується для оцінки впливу випадкового викиду радіонуклідів у навколишнє середовище. З болота Дульмай було зібрано 80 зразків (40 очеретяних рослин та 40 ґрунту). Болото Дульмай знаходиться на південному заході провінції Васіт і північному сході провінції Діванія. Активність ^{40}K, ^{226}Ra та ^{228}Ra/^{228}Th вимірювали за допомогою NaI(Tl) 3" × 3". Концентрація активності ^{40}K, ^{226}Ra та ^{228}Ra/^{228}Th у ґрунті була в межах 87 – 706, 1,2 – 35,7 та 2,6 – 17 Бк·кг$^{-1}$ відповідно. Концентрація активності ^{40}K, ^{226}Ra та ^{228}Ra/^{228}Th у рослинах (суха маса) коливалась у межах 9,6 – 472, 0,26 – 30 та 0,09 – 16,1 Бк·кг$^{-1}$ відповідно. Фактори передачі ^{40}K, ^{226}Ra та ^{228}Ra/^{228}Th були в межах 0,02 – 0,97, 0,07 – 0,99 та 0,09 – 0,99 відповідно. Фактори передачі мали різні значення у всіх місцях. Однак показано, що всі фактори передачі мають значення менше одиниці.

Ключові слова: фактори переносу, болото Дульмай, рослини, ґрунт, радіонукліди, фактор передачі ґрунт-рослини.

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