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Sewage Water Irrigation and Radioecology Affect in Soil and Plants

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Abstract

The present study was aims to focus on the accumulation of the concentrations of the nuclides of heavy and rear metals in the soil and plants due to irrigation process by sewage water. In this study about 100 test samples from soil and plants irrigated by Nile and sewage water as well as Nile and sewage water were collected from different areas in El-Sharkia Governorate, in Egypt. The study concluded that the mean values of the activity concentrations of the heavy and rare earth elements in soil and plants which irrigated by sewage water are relatively high compared with the same values in soil and plants which irrigated by Nile water. also, the same results were found in both sewage and Nile water. in most test samples the values of activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K were found below the average world values (32, 45 and 412 Bq/kg, respectively). Also, different radiation hazards parameters were calculated depending on the activity concentrations of the primordial radionuclides. The values of different radiation hazards parameters were found below the international permissible values in most test samples. The results in terms of the concentrations of natural radionuclides showed that the irrigation process by sewage water is relatively safe under special control rules and/or treated the sewage water before irrigation.

Keywords: Nil water, sewage water, irrigation, soil, plants, natural radionuclides.

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. Introduction

At present time, many poor countries suffer greatly from various environmental sector excessive accumulation of various toxic pollutants, hazardous fallout contaminants and many natural radionuclides, including potassium-40, thorium-232 and uranium-238, with a natural decay chain of Th and U as well as many other man-made radionuclides. It is now of common practice to regulate any uncontrolled release of hazardous wastes in different environmental compartment [1, 2]. The regulatory agency, when it wishes to reorganize, must have clear limits and specifications for determining and describing the physical and chemical properties of various types of waste. The limits of hazardous waste vary from country to country depending on the economic situation. One of the most widely definitions however is given in the [3]. considers toxic and hazardous wastes if they significantly contribute to an increase in mortality or cause serious irreversible or incapacitating illness. or pose substantial presence of potential hazardous to environment or the human health, when incorrectly treated, transported, stored or subjected to a number of dispersal options [4].

Cosmic radiation incoming from the atmosphere and Natural radionuclides in the Earth's crust and water bodies are the main sources of the existence of a natural radiation background. and we note that (^{238}U, ^{226}Ra, ^{232}Th and ^{40}K) are most common isotopes in the environment [5]**.** The activity concentrations of natural radionuclides in the soil ranged from μBq/Kg to thousands of Bq /Kg, [6]. The Earth's crust contains a percentage of natural materials and radionuclides since the beginning of creation, distributed in slightly varying proportions [7]. and in some rare cases, those percentages rise, so we find some sites with great competition between the great countries. The scarcity of fresh water is currently the most exciting issue, as the population is increasing steadily and fresh water is scarce, which is why some farmers resort to irrigating agricultural land with sewage water, in addition, Sewage water is a major source of many micronutrients and macronutrients necessary for plant growth such as (nitrogen, phosphorus and potassium), which are important elements for soil and plants, The flow of wastewater containing nutrients from waterways to the soil quickly causes an increase in nutrient ratios, and as a result of the process of time accumulation and the continuation of the irrigation process exacerbates environmental damage, depletion of dissolved oxygen, extinction of aquatic species, public health risks [8]. So, the use of wastewater in irrigation is a great attraction for farmers in developing and low-income countries, in order to reduce the cost of crop production by about 10-20%. Due to the great industrial revolution in the modern era, the percentage of radionuclides in wastewater is increasing, as factories are discharged the wastes of manufacturing processes in various forms, [9,12]. Accordingly, the proportion of radionuclides in the soil increases and in the long term they have harmful effects, since a large percentage of these radionuclides are transmitted to plants and vegetables, and the high concentration of radionuclides in the soil is accompanied by a rise in the plant [13]. A large percentage of wastewater generated by human activity is discharged into rivers, oceans and environmental without any treatment, which leads to improved plant growth, but epidemics are steadily increasing, as well as the death rate rises up to 50% of child deaths worldwide as a result of poor quality of water [14]. The non-biological cycle of radionuclide transport in the biosphere of the cycle of living organisms consists of three main stages: 1- Filling the material during irrigation. 2- Transportation (transfer of radionuclides to the soil). 3- Deposition and concentration during the photosynthesis process.

The transport process is the main source of the presence and concentration of radionuclides entering the vital cycle.

There are many radionuclides in the environment, namely the isotopes of uranium ^{238}U, thorium ^{232}Th and potassium ^{40}K, in the natural [15].

As we have mentioned, the enormous modern industrial revolution has caused a steady increase in the proportion of radionuclides in the environment in general and in sewage in particular as it is a collection of industrial renaissance waste in its various forms, exhaust and natural human waste. It shows us the life cycle (water-soil irrigation-transition to plants-animal food-human food), it is noted that man is the source and the last vessel for the concentration of radionuclides and non-radionuclides (metal ions).

The main goal of this study is to assess the concentrations of radionuclides of primordial natural radioisotopes, (^{238}U, and ^{232}Th as well as ^{40}K) in soil and plants that are irrigated by both Nile water, and by sewage water, in order to study the effect of risks and impact of radiation from plants and estimate the different radiation hazardous resulting from it.

2. Materials and methods

The samples were collected (30 samples of plants irrigated by Nile water, 30 of plants irrigated by sewage water, 10 samples of soil irrigated by Nile, 10 samples of soil irrigated by sewage, 10 samples of Nile water and 10 samples of sewage water) from an area next to the borders of ElSharkia and AlQalyubia Governorates, As follows:

A- A number of 30 samples of plants (Taro - Strawberry - Corn) were collected, as well as a number of 10 soil samples from both sides of the waste waterways, at a distance of more than 20 km along the drainage, which is fertile agricultural land where the cultivation of fruits and vegetables is widespread.

B- A number of 30 samples of plants (Taro - Strawberry - Corn) were collected, as well as a number of 10 soil samples from both sides of a canal, which is a branch stream of one of the tributaries of the Nile River, in a distance of more than 20 km along the riverbed, which is fertile agricultural land, where the cultivation of fruits and vegetables is widespread.

The samples were prepared and processed in several stages and steps:

1- Samples dried at room temperature for one week.

2- Samples dried in the convection oven at a temperature of 100 ^{0}C for 24 hours.

3- Samples crushed so that we could sift them.

4- Samples sieved until the size and diameter of the granules were standardized.

5- Physical properties of the samples and the pH degree were measured.

6- Samples were weighed 50 g per sample.

7- Samples placed in a polyethylene bottles with tight closures for more than 30 days until it reaches to secular equilibrium between the parent and daughter radio nuclides.

8- After more than 30 days of storage, the samples were measured using high pure germanium detector (HPGe) with gamma spectroscopic system. The test samples were prepared and closed for 30 days before measuring by gamma spectroscopy device, because the radon-222 is one of the daughters in uranium-238 series and it is gas, therefor, all samples should be closed tightly for 7 half liv times of radon (3.8 days) before measuring [19].

9- Background Radiation was measured from time to time to correct the values of count rate of different gamma ray energies.

10- Energy and efficiency calibrations have been made for the Gamma - Ray Spectroscopic system equipped with a High Purity Germanium (HPGe- detector) Using standard reference sources (^{226}Ra, solution from USA and also Certified reference material IAEA-314 from IAEA, also, point sources from Burbank, California, USA - (^{22}Na, ^{60}Co, ^{133}Ba and ^{137}Cs), used for energy calibration. The efficiency calibration was performed for the used γ- ray spectroscopic system for both aquatic and soil samples.

2.1. Dose Assessments

Different radiation hazards parameters were evaluated depending on the activity concentrations of radionuclides for ^{226}Ra, ^{232}Th and ^{40}K. These parameters refer to the risks which arises from test samples.

1- Radium equivalent activity (Ra_{eq}). It is given by:

$$Ra_{eq} = C_{Ra} + 1.43\, C_{Th} + 0.077\, C_K \quad (1)$$

where C_{Ra}, C_{Th} and C_K are the activity concentrations of ^{226}Ra,^{232}Th and ^{40}K, respectively, in Bq/kg. The Ra_{eq} is used to compare the activities of the soil samples containing different concentrations of radionuclides due to the presence of primordial radionuclides.

The assumed criterion is that 1 Bq kg^{-1} of ^{226}Ra, 0.7 Bq kg^{-1} of ^{232}Th and 13 Bq kg^{-1} of ^{40}K produces the same γ-ray dose rate and that the Ra_{eq} should not exceed a maximum of 370 Bq kg^{-1}, [16].

2- The measured activity concentrations were also used to assessment the dose rate in outdoor air (nGy h^{-1}) at a height of 1 m above the ground surface. The dose conversion factors for converting the activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K into doses (nG/ h per Bq/kg) are 0.462, 0.662 and 0.0432, respectively [17] used for this purpose is, therefore, given by:

$$D = 0.462\, C_{Ra} + 0.662\, C_{Th} + 0.0432\, C_K \quad (2)$$

where C_{Ra} is the activity concentration of ^{226}Ra, in Bq/kg. The world average for absorbed dose rate value is 57 nGy y^{-1}.

3- The effective dose equivalent was calculated [18]. by assuming a Dose Conversion Coefficient (DCC) of 0.72 Sv Gy^{-1} for the absorbed dose in air (D) to the effective dose in the human body (Eff. D. eq.) and indoor and outdoor occupancy factors (OF) of 0.8 and 0.2, respectively. The annual effective dose equivalent (AEDE) can be calculated as follows:

$$AEDE = D \times DCC \times OF \times T \quad (3)$$

where T is the number of hours in one year (8760 h). The top 10 cm of soil was considered the layer that makes the predominant contribution to external irradiation above the ground. The *Eff. D. eq.* from outdoor terrestrial gamma radiation is 70 µSv [18].

4- The external and internal hazard index (H_{ex} and H_{in}, respectively) are calculated as followings:

$$H_{ex} = 0.0027C_{Ra} + 0.00386C_{Th} + 0.0002079\, C_K \quad (4)$$

$$H_{in} = 0.0054C_{Ra} + 0.00386C_{Th} + 0.0002079\, C_K \quad (5)$$

Both H_{in} and H_{ex} should not exceed unity.

5- The **γ-**radiation level index is calculated as the following:

$$I_{\gamma r} = 0.0067C_{Ra} + 0.01C_{Th} + 0.00067\, C_K \qquad (6)$$

The value of $I_{\gamma r}$ should be not exceeding unity [19].

6- The annual gonadal dose equivalents the annual gonadal dose equivalent (AGED) is the genetic relevance of the dose equivalent received each year by the reproductive organs (gonads) of the exposed population can be calculated according the following equation (7), [20]:

$$AGDE\ (\mu Sv/y) = 3.09C_{Ra} + 4.18C_{Th} + 0.314C_K \qquad (7)$$

7- The activity utilization indexes the dose rate in air from different combinations of the three original radionuclides present in soil samples are expressed by the activity utilization index, AUI [20]. AUI is calculated by applying the appropriate conversion factors, along with the radioactivity concentrations of the three respective radionuclides from the following equation (8) [20]:

$$AUI = \left(\frac{C_{Ra}}{50\ Bq/kg}\right) f_{Ra} + \left(\frac{C_{Th}}{50\ Bq/kg}\right) f_{Th} + \left(\frac{C_K}{500\ Bq/kg}\right) f_K \qquad (8)$$

where: f_{Ra}, f_{Th} and f_K are the respective fractional contributions from the actual activities of radionuclides Ra, Th and K which equal 0.462, 0.0604 and 0.041 respectively. 2.5.8. Excess lifetime cancer risk factor Consequent according the evaluation of annual effective dose equivalent (AEDE).

8- The excess lifetime cancer risk factor (ELCR) was estimated using equation (9) [20]:

$$ELCR = AEDE \times DL \times RF \qquad (9)$$

where: DL and RF are the duration of life (70 year) and risk factor (0.05 Sv^{-1}).

2.2. Samples collection

The locations of the samples of both Nile water and sewage water irrigation have been identified on the map, all samples were collected from ElSharkia governorate, Egypt as shown in figures (1,2).

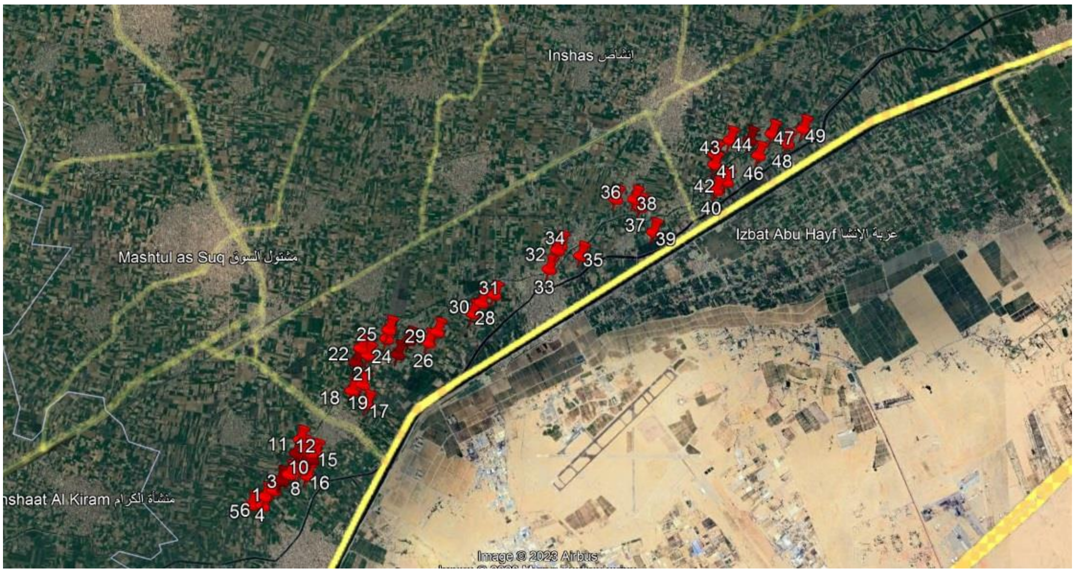

Fig. 1.: Schematic diagram shows that the distributions soil and plant samples irrigated with Nile water

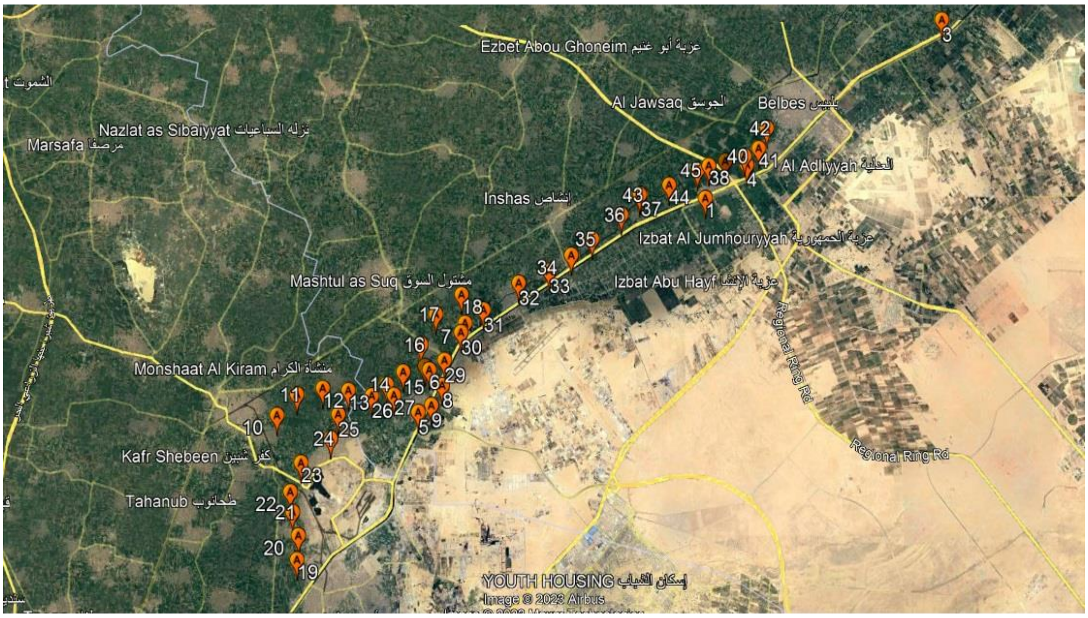

Fig. 2.: Schematic diagram shows that the distributions of soil and plant samples irrigated with sewage water

2.3. Study samples and influencing environmental factors

The survival period of plants in the soil, the number of irrigation times, as well as the method of irrigation was mentioned in table 1. Type of irrigation in all test samples are immersion and the survival periods for taro, Strawberry and corn are ranged from 10 to 12, 7.0 to 8.0 and 3.5 to 4.0 months, respectively table 1. shows all these factors.

Table (1) Environmental factors affecting the concentration of radionuclides

Sample	The survival periods in months	Irrigation method	Number of Irrigations in months
Taro	10 – 12	Immersion	11
Strawberry	7.0 - 8.0		7
Corn	3.5 - 4.0		4

3. Results and discussion

The use of sewage water in the irrigation process has significant upnormal effects on the environment, both in the short and long term, the values of natural radioactive isotopes affected by the sewage water irrigation process. They are transmitted to plants through the irrigation process and then transmitted directly or indirectly to humans. The concentration of natural radioactive elements (^{238}U, ^{226}Ra, ^{232}Th and ^{40}K) increase in the human body and result in internal and external radiation doses, and as is known, the negative effects of internal doses are much greater and more dangerous than external.

Irrigation with sewage water leads to a change in the physical and chemical qualities and properties of the soil, and this is directly reflected on plants and vegetables [21].

The study confirms that the activity concentration of natural radionuclides in soil and plants irrigated by the Nile River within the limits of the internationally proportions, but these values in soil and plants irrigated with sewage, are relatively high compared with irrigated by Nile water. The obtained results show that the mean activity concentrations of ^{238}U, ^{226}Ra, ^{232}Th and ^{40}K in soil irrigated by Nile water are 33, 10, 8 and 103 Bq/kg, respectively. But the values of these radionuclides in both taro, Strawberry and corn plants are 14, 10, 8 and 103 Bq/kg, 25, 17, 16, and 1852 Bq/kg and 20, 41, 24 and 541 Bq/kg for ^{238}U, ^{226}Ra, ^{232}Th and ^{40}K, respectively. While the activity concentrations of ^{238}U, ^{226}Ra, ^{232}Th and ^{40}K in Nile water are 16, 10, 7 and N.D Bq/kg, respectively, as shown in Fig. (3). But in case of the soil irrigated by sewage water, the activity concentrations of ^{238}U, ^{226}Ra, ^{232}Th and ^{40}K are 41, 10, 9 and 148, respectively. Also, the values of these radionuclides in both taro, Strawberry and corn plants which irrigated by sewage water are 19, 13, 18 and 2528 Bq/kg, 40, 23, 19, and 2175 Bq/kg and 80, 31, 23 and 508 Bq/kg, respectively. While the activity concentrations of ^{238}U, ^{226}Ra, ^{232}Th and ^{40}K in sewage water are 26, 11, 7 and 21 Bq/kg, respectively, as shown in Fig. 4. The obtained results show that the values of activity concentrations of ^{238}U, ^{226}Ra, ^{232}Th and ^{40}K are relatively high in both sewage water, soil and plants irrigated by sewage water compared with the same values in both Nile water, soil and plants irrigated by Nile water. The data obtained in figures (3,4) show that the values of ^{238}U, ^{232}Th and ^{40}K are relatively more than the limits which are 33,45 and 420, respectively, especially for the values of ^{40}K concentrations in some plant samples [6].

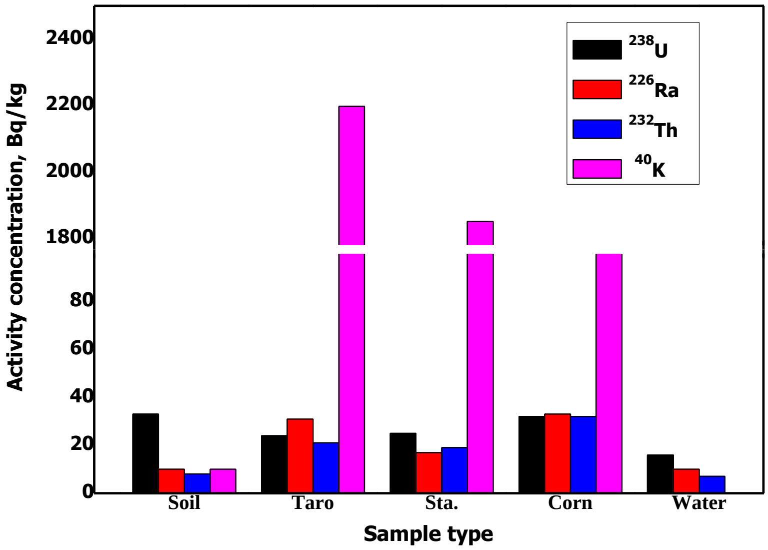

Fig. (3): Schemtic digrame show the distribution of ^{238}U, ^{226}Ra, ^{232}Th and ^{40}K in soil, taro, strrawberry and corn irrigated by Nile water as well as Nile water

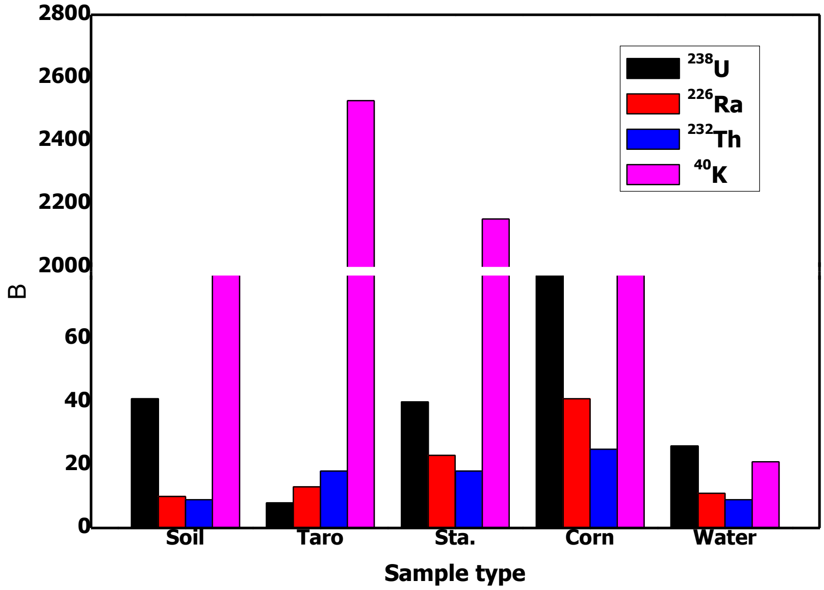

Fig. (4): Schemtic digrame show the distribution of ^{238}U, ^{226}Ra, ^{232}Th and ^{40}K in soil, taro, strrawberry and corn irrigated by Nile water as well as Nile water

3.1. Radiation hazardous parameters assessment

Depending on the values of activity concentrations, different radiation parameters were calculated as illustrated in Tables (3,4). In table 3. the different radiation parameters were calculated depending on the values of activity concentrations for ^{226}Ra, ^{232}Th and ^{40}K in soil, plant and water irrigated with Nile water in samples under study. The results showed that the calculated values of dose rates (D) at 1 m of the surface vary from 5.2 to 17.4, 84 to 161, 79.2 to 110.1 35.7 to 49.2 and 3.6 to 15.1 nG/h with a mean value of 14, 118, 95, 43.3 and 9 nGy/h for soil, taro Strawberry, corn and Nile water, respectively. While the results show that the values of radium equivalent activity Ra_{eq} ranged from 11 to 37, 171 to 314, 152 to 211, 73 to 102 and 8.3 to 34.1 Bq/kg for the same samples, respectively, with mean values 28.8, 230, 184, 89 and 19.8 Bq/kg, respectively. Also, there are many hazards parameters were calculated depending on the radiation doses like D_{abs}, H_{ex}, H_{in}, AGDE, and ELCR. The obtained results show that the all radiation hazards parameter in case of Nile water irrigation are under the limits values expect for the dose rate values which are relatively high. The permissible safe value of dos rate is equal 57 nG/h [6, 22]. The permissible values of Ra_{eq} and D_{ann} are 370 Bk/kg and 100 mSv in five year but the other values for different parameters are less than unity, [6].

Table (3): Radiation hazard parameters in soil and planet collected from ElSharkia governorate irrigated by Sewage water

Sample type	Radiation hazards parameters															
	Ra_{eq} (Bq/kg)		D (nGy/h)		D_{ann} (mSv/y)		AGDE (µSv/y)		AUI		H_{in}		H_{ex}		ELCR	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Soil	25-40	33	12-19	16	0.014-0.023	0.019	0.084-0.135	0.112	0.156-0.237	0.205	0.068-0.107	0.090	0.086-0.142	0.116	0.050-0.081	0.067
Taro	215-276	243	109-143	128	0.132-0.174	0.16	0.80-1.07	0.96	0.34-0.69	0.48	0.63-0.74	0.66	0.67-0.77	0.67	0.46-0.61	0.54
Strawberry	179-245	216	92-126	112	0.122-0.135	0.14	0.68-0.93	0.83	0.52-0.74	0.63	0.48-0.66	0.58	0.53-0.73	0.65	0.39-0.53	0.47
Corn	86-123	103	42-58	49	0.050-0.071	0.060	0.30-0.41	0.35	0.47-0.78	0.60	0.23-0.33	0.28	0.30-0.45	0.36	0.18-0.25	0.21
Water	16-32	23	7.3-15	10	0.009-0.017	0.010	0.05-0.10	0.07	0.16-0.27	0.19	0.04-0.13	0.06	0.066-0.13	0.09	0.03-0.06	0.04

* The number of test samples measured from each type of both soil, plants and water are 10 samples.

Also, different radiation parameters were calculated for soil, plants and sewage water as shown in Tables 4. In this table the different radiation parameters were calculated depending on the values of activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K in both soil, plant and irrigated by sewage water as well as sewage water in samples under study. The results showed that the evaluated values of dose rates (D) at 1 m of the surface vary from 12 to 19, 109 to 143, 92 to 126, 42 to 58 and 7.3 to 15 nG/h with mean values of 16, 128, 112, 49 and 10 nGy/h for soil, taro Strawberry, corn and sewage water, respectively. While the results show that the values of radium equivalent activity Ra_{eq} ranged from 25 to40, 215 to 276, 179 to 245, 86 to 123 and 16 to 32 Bq/kg in the same samples, respectively with mean values 23, 243, 216, 103 and 23 Bq/kg, respectively. Also, there are many hazards parameters were determined depending on the dose of radiation like D_{abs}, H_{ex}, H_{in}, AGDE, and ELCR. The obtained results show that the all radiation hazards parameter in case of sewage water irrigation are under the limits values expect for the dose rate values which are relatively high. Its known that the permissible safe value of dos rate is equal 57 nG/h, [6, 22]. The permissible values of Ra_{eq} and D_{ann} are 370 Bk/kg and 100 mSv in five year but the other values for different parameters are less than unity [6]. From comparison between the results of the radiation hazards parameters in both samples irrigated by Nile and sewage water the data showing that the values of sewage water are relatively more than in case Nile water.

3.2. Data Comparison with some others studies

The obtained results of Natural radionuclides ^{226}Ra, ^{232}Th and ^{40}K in soil in this study compared with other studies in Egypt as well as other countries table 4. The data in table (4) shows that there are relative agreements between these data and others in different countries. Also, our results found in Egypt and other countries are relatively more than the mean worldwide activity concentrations, which are 32, 45 and 412 for ^{226}Ra, ^{232}Th and ^{40}K, respectively [6].

Our obtained results of Dose rate (D) at 1 m above the sea and the absorbed dose equivalent D_{ann} as well as radium equivalent activity Ra_{eq} are compared with others in different countries table 5. Data comparison in table 5. show that all values of D, Ra_{eq} and D_{ann} are below the permissible values expect for some values of dose rate D is relatively more than the permissible value (57 nG/h).

Table 4.: Comparison of natural radionuclide activity concentrations in soil of the present

Table 2.: Radiation hazards parameters in soil, plants and water collected from ElSharkia governorate irrigated by Nile water

Sample type	Radiation hazards parameters															
	Ra_{eq} (Bq/kg)		D (nGy/h)		D_{ann} (mSv/y)		AGDE (μSv/y)		AUI		Hin		Hex		ELCR	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Soil	11.1-36.8	28.8	5.2-17.4	13.5	0.006-0.021	0.016	0.037-0.122	0.095	0.071-0.242	0.193	0.03-0.99	0.078	0.039-0.136	0.104	0.022-0.074	0.057
Taro	171-314	230	83.8-160.5	118.4	0.101-0.194	0.143	0.58-1.17	0.872	0.99-1.15	0.719	0.47-0.85	0.620	0.46-10.02	0.703	0.35-0.68	0.502
Strawberry	152-211	184	79.2-110.1	95.4	0.096-0.133	0.12	0.59-0.82	0.71	0.36-0.56	0.52	0.41-0.57	0.50	0.41-0.62	0.54	0.34-0.47	0.40
Corn	73-102	89	35.7-49.2	43.3	0.043-0.060	0.05	0.26-0.35	0.31	0.32-0.55	0.46	0.20-0.27	0.24	0.22-0.33	0.28	0.15-0.21	0.18
Water	8.3-34.1	19.8	3.6-15.1	8.8	0.004-0.018	0.01	0.03-0.10	0.06	0.09-0.30	0.17	0.03-0.09	0.05	0.03-0.14	0.08	0.02-0.06	0.04

* The number of test samples measured from each type of both soil, plants and water are 10 samples.

study with other country

Country	Activity concentrations (Bq/Kg)			References
	^{226}Ra	^{232}Th	^{40}K	
Perm Krai, Russia	17.0	11.0	298.0	[23]
China	1-360	2-960	9-1800	
USA	4-130	4-140	100-700	
Egypt	31-40	52-61	3149-3210	
Brazil	29.2	47.8	704.0	
Global Average Value	33.0	45.0	420.0	
Perm Krai, Russia	17.0	11.0	298.0	
ElSharkia, Egypt	10	8	103	Present study
mean worldwide activity concentrations	32	45	412	[6]

Table 5.: Comparison of radiation parameters in the present study with other in different countries

Country	Radiation hazardous parameters			References
	Ra_{eq} (Bq/kg)	D (nGy/h)	D_{ann} (mSv/y)	
Kuantan, Malaysia	24.92	11.16	0.014	[20]
Saudi Arabia	68.1	35.2	0.04	
Western Ghats, India	208	91.54		
Northern Pakistan	190.89	87.47	0.11	
Tehran city, Iran	143.6	69.1	0.08	
Eastern Sichuan, China	130	60	0.074	
Niger Delta, Nigeria	76	30	0.037	
West Bank, Palestine	185.8	88.2	0.11	
ElSharkia, Egypt	33	16	0.019	Present study

4. Conclusion:

The present study showed that the values of activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K in all test samples (soil and plants) in case of sewage water irrigation are relatively more than that in case of Nile water irrigation but these values are in the same range found in other countries. Also, our results obtained for different radiation hazards parameters were determined depending on the activity concentrations of the primordial radionuclides are in the range of average world values in most studied samples.

Recommendations

The process of irrigation by sewage water in term of the concentrations of the natural radionuclides is relatively safe. But, the cumulative and negative effects of this irrigation process increasing the concentration of radionuclides at the long time. Therefore, the process of irrigation by sewage water must be done under special control rules to avoid any direct negative effect on the plants and also, indirect effect on the human body. Also, recommended that the sewage water must be treated before using it in the irrigation process.

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