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Transfer Factors of Radionuclides from Soil to Wheat Grains

A. M. A. Mostafa, M. A. M. Uosif, Reda Elsaman*, Elsayed Moustafa
Department of Physics, Faculty of Science, Al-Azhar University, Assiut Branch, 71542 Assiut, Egypt

Abstract— Sixty samples of soil and wheat grains were collected from four different soil types (silt clay loam, sandy clay loam, clay loam and sandy) in EL-Mynia, Egypt. The samples were measured by NaI(Tl) gamma spectrometer to determine the activity concentrations of natural radionuclides (^{226}Ra, ^{232}Th and ^{40}K). The values of activity concentrations for soil varied from 9±0.4 to 34±2, 5±0.2 to 18±0.9 and from 77±4 to 283±14 $Bqkg^{-1}$ for ^{226}Ra, 232Th and ^{40}K respectively, while in case of the wheat grains the activity concentrations for ^{226}Ra, ^{232}Th and ^{40}K respectively, ranged from 3±0.3 to 11±1, 2±0.1 to 9±0.5 and from 204±8 to 355±20 $Bqkg^{-1}$. Transfer factor (TF) of ^{226}Ra, ^{232}Th and ^{40}K from all soil types to wheat grains were calculated and ranged from 0.11 to 2, from 0.14 to 1 and from 1.18 to 3.72 for ^{226}Ra, ^{232}Th and ^{40}K respectively. These values are higher than the default values 0.04, 0.05 and 1 for ^{226}Ra, ^{232}Th and ^{40}K respectively, suggested by IAEA.

Index Terms - Soil, Wheat grains, Silt, Loam, Clay, Sandy, Natural radionuclides and Transfer factor.

1 Introduction

Natural radioactive nuclides such as ^{226}Ra, ^{232}Th and ^{40}K can enter the human body via the food chain and increase the radiation burden for many years so analysis of these radionuclides in foodstuff is an important part of the environmental monitoring program. The important one of the parameters used to estimate the concentrations of radionuclide in plants is Soil-to-plant transfer factor (TF), and defined as the ratio of radionuclide concentrations in plant and soil [1]. Some of the numerous factors that affect the transfer of radioactivity from soil to plants are type of radionuclide, the chemico-physical characteristics of the soil, the type of plant and fertilization [2]. Wheat was selected as a crop grown over large areas of Egypt, and representing a major portion of human diet there is a considerable range of soil types on which wheat is grown in Egypt. The aim of present study was focused on calculation the transfer factor (TF) of ^{226}Ra, ^{232}Th and ^{40}K from different soil types to wheat grains in EL-Mynia governorate, Upper of Egypt.

2 Materials and Methods

2.1 Soil collection and characteristics

Thirty sample of agricultural soil have been collected from five regions; these regions are divided into ten location figure (1):

- West and East Bank of Bahr Yusef Canal (WY and EY), this regions irrigated from Bahr Yusef Canal, and this regions is divided into three locations coded by (WY1, WY2, EY1).
- West and East Bank of Nile River (WN and EN), this regions irrigated from Nile River, and this region is divided into four locations coded by (WN1, EN1, EN2, EN3).
- Reclaimed Soil (RS), this region irrigated from Ground water, and this region is divided into three locations coded by (RS1 to RS3).

The chemico-physical characteristics of agricultural soil under study such as: hydrogen Ion (PH), quantity of organic matter and texture of soil were performed by (PH meter, Walkley - Black method and Particle size distribution by Pipette method) respectively, and presents in table (1). While figure (2) shows the comparison between hydrogen ion concentrations (pH), quantity of organic matter (O.M) and soil texture.

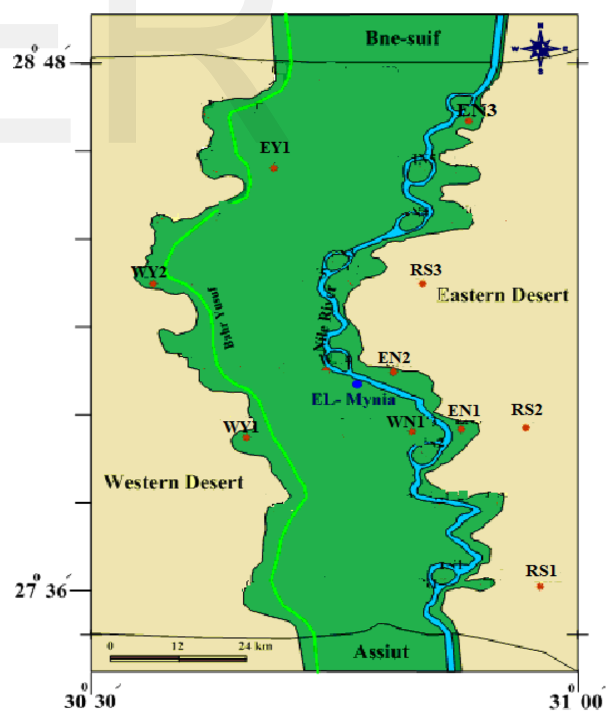

Fig. (1) Samples Location Map of the studied area.

* Corresponding author:
PH: +2 01013302376, E-mail: reda_m8282@yahoo.com

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TABLE 1.
The chemico-physical characteristics of soil under study.

Region Code	Soil Texture	pH	O.M (m %)
WY	Silt Clay Loam	7.6	1.7
EN	Silt Clay Loam	7.8	1
WN	Sandy Clay Loam	7.8	1.4
EY	Clay Loam	7.8	1.9
RS	Sandy	6.8	0.7

2.2 Wheat grains collection and characteristics

Thirty sample of wheat grains were collected at harvest time from the same locations of agricultural soil samples. The types of studied wheat samples were (Sohag1, Sohag2, Sohag3, seeds 1 and Sakha 69). The wheat plant has long, slender leaves, stems that are hollow in most types of wheat plants, and heads that have many kinds of flowers, from 20 to 100.

2.3 Samples preparation

All samples were dried in an oven at about 110^{o}C for 24 h to ensure that moisture is completely removed, while wheat grains samples were oven dried at 70^{o}C. All samples were crushed, homogenized, and sieved through a 200 μm, which is the optimum size enriched in heavy minerals , in case of wheat samples sieved through 555-μm sieve. Samples were placed in polyethylene beaker, of 250 cm^3 volume each and weighted. The beakers were completely sealed for 4 weeks to reach secular equilibrium radium and thorium, and their progenies [3].

2.4 Measuring system

The spectrometer system used in this study consists of sodium iodide detector 3×3 inch (NaI (Tl) model (802) with a 2048 multichannel analyzer (MCA). Its hermetically sealed assembly which includes NaI (Tl) crystal, photomultiplier tube, an internal magnetic / light shield, aluminum housing and a14 pin connector, Preamplifier, main amplifier, analogue to digital convert and Canberra Multichannel Analyzer (MCA) with Genie 2000 software [4]. The measurement time of the activity or background was 43,200 s. The background spectra were used to correct the net peak area of the gamma rays of the measured isotopes. The lower limit of detection (LLD) in case of soil samples were 2.4, 1.4 and 5.8, where for wheat grains were 1.2, 1.3 and 5 (Bq kg^{-1}) for ^{226}Ra, ^{232}Th and ^{40}K respectively.

3. Results and Discussion

3.1 Activity concentrations

The concentrations of ^{226}Ra, ^{232}Th, and ^{40}K of the collected samples have been listed in table (2). The values of activity concentrations in soil varied from 9±0.4 to 34±2, 5±0.2 to 18±0.9 and from 77±4 to 283±14 Bqkg^{-1} for ^{226}Ra, ^{232}Th and ^{40}K respectively, these values were within the world average ranges which are 35, 35 and 370 Bqkg^{-1} for ^{226}Ra, ^{232}Th and ^{40}K respectively [5].

TABLE 2.
Activity concentrations of soil, wheat grains and transfer factor (TF) from soil to wheat grains

Location code	Sample Code	Activity in soil (BqKg^{-1})			Activity in Wheat (BqKg^{-1})			TF		
		^{226}Ra	^{232}Th	^{40}K	^{226}Ra	^{232}Th	^{40}K	^{226}Ra	^{232}Th	^{40}K
WY1	1	34± 2	10±0.5	270±13	7±0.5	4±0.3	318±16	0.21	0.40	1.18
	2	28±1	8±0.4	283±14	3±0.3	4±0.2	352±18	0.11	0.5	1.24
	3	25±1	14±0.7	266±13	6±0.8	2±0.1	355±20	0.24	0.14	1.33
WY2	4	17±2	6±0.3	103±5	11±1	6±0.3	273±14	0.65	1	2.65
	5	22±1	6±0.3	122±6	8±0.7	3±0.2	236±12	0.36	0.5	1.93
	6	16±0.8	9±0.5	125±6	10±1	5±0.3	279±14	0.63	0.56	2.23
EN1	7	17±1	8±0.4	103±5	9±1	6±0.5	270±13	0.53	0.75	2.62
	8	22±2	5±0.2	122±6	10± 1	4±0.3	258±13	0.45	0.8	2.11
	9	16±0.8	6±0.3	125±6	7±0.7	5±0.4	237±11	0.44	0.83	1.9
EN2	10	26±1	18±0.9	165±8	6±0.5	5±0.2	237±12	0.23	0.28	1.44
	11	25±1	7±0.3	159±8	7±0.7	6±0.3	282±13	0.28	0.86	1.77
	12	29±1	14±0.7	153±8	10±0.9	7±0.4	270±14	0.34	0.5	1.76
EN3	13	23±1	7±0.3	172±9	10±1	6±0.3	204±8	0.43	0.86	1.19
	14	19±0.9	7±0.4	160±8	8±0.6	4±0.2	207±8	0.42	0.57	1.29
	15	17±0.9	10±0.5	152±8	7±0.5	5±0.2	213±9	0.41	0.5	1.4
Mean		22.4±1	9±0.5	165±8	7.9±0.8	4.8±0.3	266.1±13	0.38	0.60	1.74
RS1	16	10±0.5	10±1	82±4	8± 1	7±0.4	305±15	0.8	0.7	3.72
	17	13±2	7±0.4	106±5	8± 1	7±0.4	269±14	0.62	1	2.54
	18	12±0.3	6±0.2	77±4	6±1	4± 0.3	277±14	0.50	0.67	3.6
RS2	19	19±0.9	7±0.3	91±5	6± 0.3	6± 0.4	283±14	0.32	0.86	3.11
	20	18±0.9	7±0.4	99±5	8± 0.9	7± 0.3	272±16	0.44	1	2.75
	21	13±0.7	7±0.4	103±5	7± 0.6	4±0.3	263±14	0.54	0.57	2.55
RS3	22	11±0.6	6± 0.3	123±6	7± 0.4	4± 0.3	236±13	0.64	0.67	1.91
	23	9±0.4	5±0.2	123±6	8±0.3	5± 0.3	267±13	0.89	1	2.17
	24	10± 0.5	5± 0.2	111±6	7±0.4	4± 0.2	305±15	0.78	0.8	2.74
Mean		12.7±0.8	6.7±0.4	101.7±5	7.9±0.7	5.3±0.3	275.2±14	0.62	0.81	2.79
WN1	25	17±0.9	10± 0.5	160±8	9± 1	4±0.2	244±12	0.53	0.4	1.53
	26	26±1	8±0.4	153±8	9± 1	7±0.4	258±13	0.35	0.88	1.69
	27	20±1	16± 0.8	155±8	7± 0.5	3±0.2	340±17	0.35	0.19	2.19
Mean		21±1	11± 0.6	156±8	8.3±0.8	4.7±0.3	280.7±14	0.41	0.49	1.8
EW1	28	17±0.9	10± 0.4	154±8	7± 0.8	9±0.5	298±15	0.41	0.9	1.94
	29	13±0.7	8± 0.4	154±8	6± 0.3	8±0.4	298±13	0.46	1	1.94
	30	15±0.7	10± 0.5	163±8	7± 0.3	6±0.3	336±17	0.47	0.6	2.06
Mean		15±0.8	9± 0.4	157±8	6.7±0.5	8±0.4	310.7±15	0.45	0.83	1.98

In case of the wheat grains the activity concentrations for ^{226}Ra, ^{232}Th and ^{40}K respectively, ranged from 3±0.3 to 11±1, 2±0.1 to 9±0.5 and from 204±8 to 355±20. ^{40}K has the highest values in all the wheat samples despite having the lowest activity concentrations in soil samples. This may be attributed, in part, to the heavy use of chemical fertilizers by farmers to improve crop yields on the farms in the area [6]. In addition, ^{40}K activities tend to decrease deep layers from agricultural soil. The decreasing ^{40}K in depth due to the effect of irrigation water in dissolving thorium and potassium compounds, the solutions move under the effect of heating by the sun towards the surface and are deposited by evaporation [7].

3.2 Transfer factor (TF)

Transfer factors (TF) of ^{226}Ra, ^{232}Th and^{40}K were calculated from the ratio of activity concentration measured in wheat grains and the soil. The values of transfer factor (TF) for the wheat grains ranged from 0.11 to 0.89, from 0.14 to 1 and from 1.18 to 3.72 for ^{226}Ra, ^{232}Th and ^{40}K respectively as shown in table (2). These values are higher than the default values 0.04, 0.05 and 1 for ^{226}Ra, ^{232}Th and ^{40}K respectively, suggested by IAEA [8]. The lowest average value of TF for ^{226}Ra and ^{40}K in wheat grains collected from silt clay loam soil, this is may be

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due to these soil is alkaline pH is (7.6), where in alkaline soils insoluble precipitates may be formed with carbonate, hydroxyl, phosphate or sulfide ions. These insoluble precipitates reduce the availability of radionuclides for plants [9], or may be due to organic matter content of the soil [10]. While the highest average value of TF for ^{226}Ra, ^{232}Th and ^{40}K in wheat grains collected from sandy soil. This is may be due to the sandy soil containing a low pH (6.7) this is acid soil, so hydrogen replace the adsorbed cations which become more available to plants, consequently high absorption of radioactive materials in the plant [9], or this is may be due to organic matter content of the soil [10] .

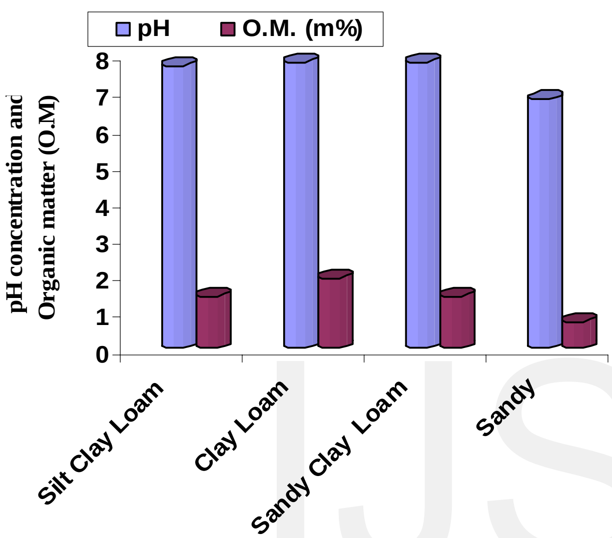

Fig. (2): The comparison between hydrogen ion concentration (pH), quantity of organic matter (O.M) for soil and soil texture.

4 Conclusion

As shown from the result agricultural soil has low natural radioactivity so it is safe for farmers, population living and can be used as a raw building materials or other human activities without any radiological risk. Also the results, does not prefer to wheat cultivation in sandy soil because of the high transfer factor of radioactive material from these soil to the wheat grains. While others preferred the wheat cultivation in silt clay loam soil due to the low transfer factor of radioactive material from these soil to the wheat grains. The results would be useful for establishing of the database in the area under consideration and represent a basis to assess any future changes in the radioactivity background levels due to various geological processes or any artificial influences around the area.

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