Comparative Study of Radioactive Content in Soils from Different Countries

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Abstract: The article presents the specific activities of natural radioactive nuclides in soil samples from Upper Egypt. The samples had been measured within the last ten years and the results were compared with others from some countries. The mean activity level of the natural radionuclides ^{226}Ra, ^{232}Th and ^{40}k is 21.4, 14.6 and 663.1 Bqkg^{-1}, respectively. These values agree with values reported elsewhere in the country and other countries. The paper includes available results of hazard indices values which indicate that there are no excessive exposures for inhabitants. These data are important for radiation protection purposes.
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1. Introduction

Since soil is one of the main contributors to background radiation, it is very interest to know the radioactivity content of the soil over the world.The natural radionuclides have been an essential constituent of the earth during its creation. Many radioactive elements goes back to the formation of our world, while the others are continuously produced through different human activities. Determination of naturally occurring radionuclides in soil have been performed in many parts of the world, mostly for assessment of the dose due to gamma radiation and the risk resulting from them (**Nellis 1990; Rudge et al., 1993; Clouras et al. 2001. Copplestone et al. 2001; Dowdall et al,2004 and El-Bahi et al. 2005).** It was observed that most of natural radioactive elements present in soil are primordial radinuclides from the uranium series, thorium series and potassium-40. Several radionuclides in the radioactive decay chains starting from ^{238} U and ^{232} Th are highly radiotoxic, in particular ^{228} Ra and ^{226} Ra. The radon gas produces from the disintegration of ^{228} Ra and ^{226} Ra in the earth's crust is considered the main source of exposure to ionizing radiation for humans representing 40% of the annual accumulated dose (**UNSCEAR, 1993).**

Measurements of ^{210}Pb in air and surface soils can help in uranium exploration and monitoring transfers of radionuclides of uranium series in soils and aquatic systems.Furthermore, ^{210}Pb and its grand-daughter radionuclides ^{210} Po are included in the group of most highly toxic radioisotopes and provide the major internal natural radiation doses to humans.

Natural environmental radioactivity and the associated external exposure due to gamma radiation depend primarily on the geological and geographical conditions, and appear at different levels in the soils of each region in the world [**Anagnostakis et al, 1996; Shender 1997 and Iqubal et al, 2000].** Abnormal occurrences of uranium and its decay products in rocks and soils and thorium in monazite sands have been identified in several areas of the world **[Al-Jundi et al 2003]**.

In the present investigation, the level of specific activities of ^{226} Ra, ^{232} Th and ^{40} K in soil samples, collected from different places in Egypt, measured by radiation protection laboratory in Faculty of Science Qena, have been compared with those in other countries. In addition, these data will be useful for sub-sequent evaluations of possible future environmental contamination due to any future activities.

Samples Classification and Preparation

The samples presented in this article were collected from different locations in Upper Egypt along the last few years. Preparations and collections had been done by the search group of radiation protection laboratory in physics department, Faculty of Science Qena. The sampling locations are classified as follows:

30 samples from Aswan governorate, 52 samples from W. Daeeb, W. Sarara and W. Hodein and 13 from different farms in Armant near Luxor.

All soil- samples taken from 0-30cm depth were dried up to 105c^{o} to eliminate any traces of water. Afterwards, the samples were ground to a fine grain size powder. Then the ground samples were shaked by electrical shaker to homogenize the samples and filled in 1000 ml marinelli beakers.

The prepared samples should be sealed tightly and were stored for one month at least to allow daughter products to come into radioactive equilibrium with their parents ^{226}Ra and ^{232}Th. The counting time ranged from 10 to 15 hours depending on the concentration of the radionuclidies.

Experimental Setup:

This method is based on the assessment of gamma rays emanated from radioactive nuclides in each sample under investigation for 10 hours at least with a gamma-ray spectrometer. The applied spectrometer consists basically of high pure germanium detector with 8192 multichannel analyzer housed inside a specific chamber with 4 layers :10 mm thick plexiglass; 30 mm copper,100 mm lead and finally 3 mm thick cadmium. This shield serves to eliminate different background radiations. The detector is coupling with pre-amplifier, linerar am plifier and the multichannel analyzer composed of 8192 channels. The specifications of detector were described in details elsewhere in publiched article by **Abd el-Mageed et al 2011**. The spectra were evaluated either with the computer software program Maestro (EG G ORTEC) or manually with the use of a spread sheet (Microsoft Excel) to calculate the natural radioactivity. ^{226} Ra activity of the samples was determined via its daughters (^{214}Bi and ^{214}Pb) through the intensity of 295.22 and 351.93 kev for ^{214}Pb and 609.3, 1120 and 1764.5 kev for ^{214}Bi gamma lines. ^{232}Th activity of the sample was determined from the daughters (^{228}Ac,^{212}Pb and ^{208}Tl). The ^{228}Ac gamma lines are 338.3,911.2 and 968.9 kev and 583.19 and 2614.5 kev for ^{208}Tl while one gamma line at 238.6 kev for ^{212}Pb.The gamma line of ^{40}K is 1460.7kev.

3.Results and Discussion

The results for 95 soil samples collected from different locations in Upper Egypt are presented in table (1).

Table 1 specific activities of radionuclides in soil samples at different locations in the area of Upper Egypt.

Location	Specific activity of radionuclides (Bq/kg)			
	^{226} Ra	^{232}Th	^{40}K	
W. Daeeb	20.9	13.5	477.0	Ref. Hashem2009
W. Sarara	27.8	17.8	735.3	
W. Hodein	20.3	12.0	664.2	
Armant	17.1	11.8	538.6	Ref.Maha 2007 Ref.Rashed 2013
Aswan	18.5	12.1	564.4	
Mean	20.9	13.4	595.6	

From the data, there is no obvious differences can be observed for the specific activity values in samples under investigation. These values are in the same range with the data listed in table2,except for potassium the value is twice higher.

Table 2 presents comparison of the average values of the specific activity of the radionuclides in some countries as given in **UNSCEAR 2000**. The concentrations of the radionuclides in soil is ranging from country to another.

Table 2 comparison of specific activity of radionuclides in soil samples in different countries as given by UNSCEAR 2000

Samples	Specific activity of radionuclides (Bq/kg)		
	^{226} Ra	^{232} Th	^{40}K
Egypt	17	18	320
United States	40	35	370
Argentina	-	-	650
Bangladesh	34	-	350
China	32	41	440
Hong Kong SAR	59	95	530
India	29	64	400
Japan	33	28	310
Islamic Rep. Iran	28	22	640
Denmark	17	19	460
Belgium	26	27	380
Luxemburg	35	50	620
Switzerland	40	25	370
Bulgaria	45	30	400
Poland	26	21	410
Romania	32	38	490
Greece	25	21	360
Portugal	44	51	840
Spain	32	33	470
Thailand	48	40	400
OAP data	172	211	511
Thailand	68	54	213

The distribution of ^{226} Ra, ^{232}Th and ^{40}k in soil is not uniform. Uniformity with respect to exposure to radiation has been defined in terms of radium equivalent activity (Ra_{eq}) in Bq/Kg to compare the specific activity of materials containing different amounts of ^{226} Ra, 232 Th and 40 K. It is calculated using the following relation **[Beretka and Mathew 1985]**.

$$Ra_{eq}=C_{Ra} + 1.43\ C_{Th} +0.07\ C_k \ldots\ldots(1)$$

Where C_{Ra}, C_{Th} and C_k are the activity concentrations of ^{226} Ra, ^{232} Th and ^{40}k in Bq/kg respectively. While defining Ra eq activity, it has been assumed that 370 Bq/kg of $^{226}_{Ra}$ or 259 Bq/kg of ^{232} Th or 4810 of ^{40} K produce the same gamma dose rate.The average values obtained for radium equivalent activity for soil samples from different countries are listed in table (3) and plotted as histogram fig1.

Table (3) Average Ra_{eq} for soils in different countries

Country	Ra_{eq} kg/Bq	References
China (Xiazhuang)	266	Zhuo et al 2001
Pakistan	173.6	Abdul, Ahad 2004
India (Yelagiri Hills)	168.9	Ravisankara et al 2012
Yemen (Sanaa)	160.97	Abd El-Mageed et al 2011
Brazil	150.3	Malanca et al.1996
Thailand	146.9	Prasong. et al 2008
Upper Egypt	92.7	Hashem 2009, Maha 2007 and Rashed 2012
Nigeria	76	Agbalagba and Onoja 2011
Saudi Arabia	47.8	Alaamer 2008

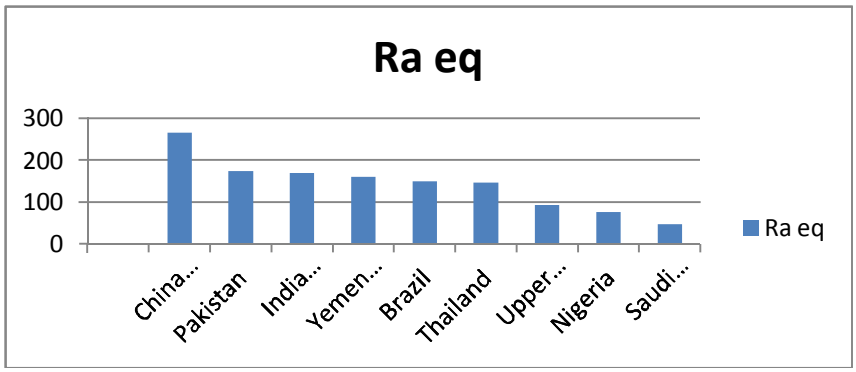

Fig.1 Radium equivalent activity in soils from different countries.

From the available data, it is clear that all values are less than the recommended limiting values of radium equivalent activity as 370 Bq/kg, which are acceptable for safe use. The maximum values is that of China soils while the minimum is the results of Saudi Arabia.

Air absorbed gamma radiation does rate

Effects of gamma radiation are normally expressed in terms of the absorbed dose rate in air, which originate from radioactive sources in the soil. The absorbed dose rate is mainly due to the natural radionuclides ^{226} Ra, ^{232} Th and ^{40} K in soil while the contribution due to other radinuclides is very little and can be neglected.

The absorbed dose rates D in outdoor air at 1m above the ground level to the population can be calculated from activities of terrestrial radionuclidies according to the following formula **(Kohshi et al 2001)**:

$$\mathbf{D=A_E\times C_F \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)}$$

Where A_E is the activity concentrations in $BqKg^{-1}$ and C_F is the dose conversion factor (absorbed dose rate in air per unite mass in units of n Gy h^{-1} per Bq kg^{-1}). The dose rate conversion factors are listed in **UNSCEAR2000** WHERE C_{Ra} = 0.462, C_{Th}=0.604 and C_k=0.042.

The acceptable value for external absorbed dose rate must be less than 59nGyh-1 **(UNSCEAR 2000).**

Annual effective dose

To estimate the annual effective dose, account must be taken of: (a) the conversion coefficient from absorbed dose in air to effective dose and (b) the indoor occupancy factor. The average

numerical values of those parameters vary with the age of population, according to **UNSCEAR 2000**, the conversion coefficient from absorbed dose in air to effective dose received by adults is 0.7 Sv Gy^{-1} and the fraction of time spent outdoors is 0.2. Then, the annual effective outdoors dose received by adults can be estimated as follows:

Annual effective dose = Dx24x356x0.7x0.2 ……(3)

The average dose rate and annual effective dose for soils in different countries are listed in table (4).

Table (4) Average dose rate and annual effective dose in soils from different countries

Country	Dose rate	Annual effective dose msvy-1	References
China	124	0.15	Yang et al 2005
Vietnam	124	0.15	Huy and Luyen 2006
Sana'a	78.6	0.0963	Shaban Harb 2012
Brazil	72.6	0.088	Malanca et al. 1996
Thailand	68	0.083	Prasong and Susaira 2008
Spain	53.3	0.065	Ajayi,2008
Mexico	44.9	0.055	
India	43.3	0.053	Patra et al 2006
Upper Egypt	42.8	0.052	Rashed 2013, Hashem 2009 and Maha 2007
Nigeria	37.2	0.045	
Saudi Arabia	23.3	0.028	Alaamer 2008
Cyprus	8.7	0.010	Tzortzis et al 2004

The comparison in table (4) reveals that the average dose rate as well as the annual effective dose of soils are less than the recommended worldwide values (59 nGy^{-1} and0.07$mSvy^{-1}$)respectively in most countries.In some countries,the values are higher than the recommended value and precise analysis must be carried for these soils.

Conclusion:

Natural radioactivity levels in soils of Upper Egypt have been measured using Gamma spectrometer. The obtained specific activities of ^{226}Ra, ^{232}Th and ^{40}k were in good agreement with the values of Egypt listed in **UNSCEAR 2000** except the average value of potassium.

The mean values of radium equivalent activities are less than worldwide value for all soil samples under consideration.

The average absorbed dose rate and consequently the annual effective dose are higher in soils of some countries than the acceptable levels reported by **UNSCEAR (1988).**

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