Gamma-ray measurements of natural radioactivity in cultivated and reclaimed soil, Upper Egypt

A. Abbady, A.M. El-Arabi, Adel G.E. Abbady and S. Taha

Physics department, Faculty of Science, South Valley University, Qena, Egypt
e-mail: mousa_19@yahoo.com

ABSTRACT

Specific activity of primordial radionuclides in soil samples from 10 different regions in Qena governorate and Wadi EL-Lagita were determined by gamma-ray spectrometry. A total of 50 soil samples were collected from different sorts of soil with depth ranged from 0 - 25 cm. The energy peaks used were: 352.0 keV of 214Pb and 609.3, 1120.3 and 1764.5 keV of 214Bi for 226 Ra. In the case of 232Th the energy peaks used were: 238.6 keV of 212Pb, 2615 of 208Tl and 911.1 keV of 228Ac. While the radioactivity of 40K was obtained from the single photopeak of this isotope at 1460.75 keV. The total uncertainty of the obtained values of the radioactivity was calculated from the systematic and the random error of the measurements. Concentrations of radionuclides in soils analyzed in this study ranged from 7.9±2.8 to 96.1±9.8 for 226Ra, 8±2.8 to 19 ±4.4 for 232Th and 85.2±9.2 to 302.5±17.4 Bq/kg for 40K.The results obtained were compared with those from other studies in the world and Egypt. The radiological health implication to the population that may result from these values is found to be low and almost insignificant, except in one case. No artificial radionuclide, however, was detected in any of the samples, hence, measurements have been taken as representing baseline values of these radionuclides in the soil in studying areas.

Key words: Natural radionuclides, under reclamation, reclaimed and cultivated soil, Upper Egypt.

INTRODUCTION

Gamma radiation emitted from naturally occurring radioisotopes, such as ^{226}Ra and ^{232}Th series and their decay products, and ^{40}K, which exist at trace levels in all ground formations represents the main external source of irradiation to the human body. More specifically, natural environmental radioactivity 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 (Tzortzis 2004, UNSCEAR 2000). The above-mentioned naturally occurring radionuclides and others are present in air, food, water, soil, bodies and in building materials such as local rocks, stone, sand, gravel, cement, concrete, brick, tile, gypsum, etc..(abbady 1994, Jibiri 1998).

Soils are naturally radioactive, because of their mineral content. The natural radioactivity may vary considerably from one type of soil to another. The sources of radioactivity in soils other than those of natural origin are mainly due to

• extensive use of fertilizers rich in phosphates for agricultural purposes.

• routine authorized low level radioactive effluent discharges or accidental release into the environment from nuclear fuel cycle installations, mineral extraction industries, industries working with mineral materials enriched in naturally radioactive elements,

(e.g. fertilizer factories) and various economic sectors in which naturally or artificially radioactive elements are used.
• fallout from past atmospheric explosions of nuclear devices and following nuclear accidents (ISO 2002).

MATERIALS AND METHODS

A total of 50 soil samples were collected from seven regions in Qena governorate (Nile valley) and three regions of Wadi EL- Lagita (Eastern Desert), Upper Egypt as shown in fig 1. The ten regions were categorized to three sorts of soils, cultivated, reclaimed and under reclamation. For more detailed descriptions. The soil sampling sites were randomly selected for the three types of soil, and samples were collected by a core method, in which cores of 10 cm diameter and 25 cm in depth were used to take soil samples (ASTM, 1986, 1983). Samples with large grain size were crushed to small pieces using mechanical crusher. Then they were dried at 110°C to eliminate any traces of water. Afterwards, the samples were ground to a fine grain size powder. Every powdered sample was mixed using electric shaker to obtain a homogeneous powdered sample.

The powdered samples were stored in tight plastic containers with (9 cm diameter ×8 cm height) more than one month to allow radioactive equilibrium to be reached. Under the assumption that secular equilibrium was reached between ^{232}Th and ^{226}Ra with their decay products, the concentration of ^{226}Ra was determined from the average concentrations of ^{214}Pb (352 keV) and ^{214}Bi (609, 1120 and 1765 keV), and that of ^{232}Th was determined from the average concentrations of ^{212}Pb (239 keV), ^{208}Tl (2615 keV) and ^{228}Ac (911 keV) in each sample under study. (1) Since ^{40}K is directly γ-emitter, so its activity concentration could be determined from its single photopeak at 1460 kev. Gamma-spectrometric measurements were performed with NaI (Tl) detector 3×3 inch with its electronic circuits. The detector had a photopeak efficiency of about 1.2×10^{-5} at 1332 keV and an energy resolution of 7.5 at 662 keV and operation bias voltage 800-1000 V dc.

RESULTS AND DISCUSSION

Activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K radionuclides in cultivated soil are shown in table (1), From the data of all soil samples it can be noticed that the average activity concentration ranged from 7.9±2.8 to 96.1±9.8 for ^{226}Ra, 8±2.8 to 19 ±4.4 for ^{232}Th and 85.2±9.2 to 302.5±17.4 Bq/kg for ^{40}K. The results of cultivated samples ranged from 3.4±1.9 to 26.4±5.1 Bq/kg for ^{226}Ra, 0.8 ±0.9 to 29.5±5.4 Bq/kg for ^{232}Th and 50.1±7.1 to 313.6±17.7 Bq/kg for ^{40}K as listed in table (1).

Table (1) activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K for cultivated soil samples.

Sample code	Soil depth (cm)	Radioactivity Concentration in Bq/kg		
		Ra-226	Th-232	K-40
	0 − 5	4.2±2	4.9±2.2	54.8±7.4
	5 − 10	7.9±2.8	2.1±1.5	50.1± 7.1
	10 − 15	7±2.7	0.8±0.9	76.5±8.7
(ES1)	15 − 20	3.4±1.9	2.6±1.6	73.2±8.6
	20 − 25	16.8±4.1	29.5±5.4	171.2±13.1
Average		7.9±2.8	8±2.8	85.2±9.2
	0 − 5	20.3±4.5	16±4	299.2±17.3
	5 − 10	9.7±3.1	10.6±3.3	223.7±15
(ES2)	10 − 15	14.8±3.9	20.5±4.5	223±14.9
	15 − 20	13.9±3.7	22.8±4.8	180.5±13.4
	20 − 25	19.8±4.5	12.5±3.5	211.1±14.5
Average		15.7±4	16.5±4.1	227.5±15.1
	0 − 5	26±5.1	17.4±4.2	313.6±17.7
	5 − 10	12.8±3.6	7.5±2.7	251±15.8
	10 − 15	13.7±3.7	14.6±3.8	162.1±12.7
SH	15 − 20	21.1±4.6	4.5±2.1	302.4±17.4
	20 − 25	9.3±3	12.4±3.5	86.3±9.3
Average		16.6±4.1	11.3±3.4	223.1±14.9
	0 − 5	19.8±4.4	25.4±5	282.9±16.8
	5 − 10	17.8±4.2	17.9±4.2	178.8±13.4
DN	10 − 15	8.8±3	18.5±4.3	223.8±15
	15 − 20	4.5±2.1	20.3±4.5	241.7±15.5
	20 − 25	6.6±2.6	13.2±3.6	213.4±14.6
Average		11.5±3.4	19±4.4	228.1±15.1
	0 − 5	16.4±4.1	9.9±3.1	90.2±9.5
	5 − 10	8.6±2.9	7.5±2.7	134.8±11.6
OD	10 − 15	26.4±5.1	16.1±4	245.6±15.7
	15 − 20	10.1±3.2	5.7±2.4	118.8±10.9
	20 − 25	9.8±3.1	12.1±3.5	119.4±10.9
Average		14.3±3.8	10.3±3.2	141.7±11.9

CONCLUSION

Gamma ray spectrometry was exploited to determine activity concentration due to naturally occurring ^{226}Ra, ^{232}Th and ^{40}K radioisotopes in three types of soil (cultivated, reclaimed, and under reclamation soil) from some areas in Qena Governorate, and Wadi EL- Lagita (Eastern Desert), Upper Egypt. Results show that reclaimed soil has the highest concentrations of ^{226}Ra, ^{232}Th and ^{40}K, and under reclamation soil has the lowest concentrations. In the present study, average activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K for cultivated soil samples are 13.2, 13 and 181.1 Bq/kg respectively. The corresponding values in second category are 41.1, 14.3 and 192.6 Bq/kg. In the last group values of ^{226}Ra, ^{232}Th and ^{40}K are 10, 9.1 and 102 Bq/kg respectively. These values fall within the lowest range of the world average values 30, 35 and 400 Bq/kg for ^{226}Ra, ^{232}Th and ^{40}K, respectively. Except the average value of ^{226}Ra (41.1 Bq/kg) for the reclaimed soil.

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