ACTIVITY CONCENTRATION FOR SURFACE SOIL SAMPLES COLLECTED FROM ARMANT, QENA, EGYPT

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Thirty four surface soil samples were collected from four directions in Armant area. Qena, Egypt to measure their natural radioactivity concentrations due to Ra-226, Th-232 and K-40 radionuclides. Soil samples were analyzed by using low-level gamma-spectrometric analysis. The average activity concentration for Ra-226 was found to be 27.3±3.2, 11.4±1.09, 10.6±1.2, and 11.4±1.02 (Bq/kg) while the average value for Th-232 was 15.1±1.4, 11.1±0.77, 10.8±0.72 and 11.1±0.8 (Bq/kg) for soil samples from North, South, West and East. The corresponding average values for K-40 were 521.4±16.8, 463±14.8 488.9±15.6 and344.5± 10.7(Bq/kg), respectively. Based on radionuclides concentration in soil samples the radiological effects were assessed.

Keywords: *Natural radionuclides; Gamma spectrometric; Radiological effects.*

1. INTRODUCTION

The world is naturally radioactive, and around 90% of human radiation exposure arises from natural sources such as cosmic radiations, exposure to radon gas, and terrestrial radiations. The naturally occurring radionuclides present in soil include Ra-226, Th-232 and K-40[1, 2, 3]. Since these radionuclides are not uniformly distributed, the knowledge of their distribution in soils and rocks play an important role in radiation protection and measurement [4] Some of the exposures are fairly constant and uniform for all individuals everywhere, for example, the dose from ingestion of potassium-40 in foods. Other exposures vary widely depending on location. Cosmic rays, for example, are more intense at higher altitudes and concentrations of uranium and thorium in soils are elevated in localized areas. High levels of uranium and its decay products in rock and soil and thorium in monazite sands are the main sources of high natural background areas that have been identified in several areas of the world, e.g., Yangjiang in China, Rasmar in Iran, Kerala coast of India, etc. [5, 6, 7]. Therefore, measurements of natural radioactivity in soil are of a great interest for many researchers throughout the world, which led to worldwide national surveys in the last two decades [8]. All of these spectrometric measurements indicate that the three components of the external radiation field, namely from the γ -emitting radionuclides in the U-238 and Th-232 series and K-40, made approximately equal contributions to the externally incident γ -radiation dose to individuals in typical situations both outdoors and indoors. Since 98.5% of the radiological effects of the uranium series are produced by radium and its daughter products, the contribution from the U-238 and the other Ra-226 precursors are normally ignored [9]. The paper aimed to measurement of natural radioactivity (Ra-226, Th-232 and K-40) of surface soil from Armant area and estimated of the radiation hazard .

2. EXPERIMENTAL WORK

2.1. Sample Collection and Preparation

Soil samples were collected from four directions in Armant area, (9 soil samples from north armant, 9 soil samples were collected from south armant, 16 soil samples were collected from east and west armant area(8 samples from each direction). After collection, samples were dried at about 100 °C to remove moisture and crushed to fine powder. And then the homogenized samples were packed in 7.5 × 8 cm bottle and sealed tightly with cap kept aside for about month allow for Radium and its short-lived progenies to reach secular radioactive equilibrium.

2.2. Detection Technique

Gamma spectrometer with a scintillation detector 2 × 2 inch NaI(Tl) from EG&G Ortec, was used determine the activity concentration of U-series, Th-series as well as K-40. The detector was calibrated using standard source QCY48 from Physikalisch Technische Bundesanstalt PTB, Germany; which has ten radionuclides with twelve γ-ray emitters ranged from 230 to 1836 keV, the efficiency calibration has been calculated (Fig 1). The detector is surrounding by a lead shield to reduce the background of the system.

2.3. Calculation of Activity Concentrations

The activity concentrations for the natural radionuclides in the measured samples were computed using the following relation [10, 11]

$$C_f = C_a / (\varepsilon P_\gamma M) \quad (Bq/kg) \tag{1}$$

where Ca is the net counting rate of γ-ray (counts per second), ε is the detector efficiency of the specific γ-ray, P_γ the absolute transition probability of γ-decay and M the mass of the sample (kg).

The analysis of Ra-226 and Th-232 depends upon the peaks of the decay products in equilibrium with their parent nuclides. Ra-226 was estimated through the γ-energies 351.92 keV of Pb-214 and 609.32 keV of Bi-214. Th-232 activity was determined from the γ-peaks of 238.6 keV from Pb-212 and 911.2 from Ac-228. K-40 was determined by its characteristic emission at 1460 keV.

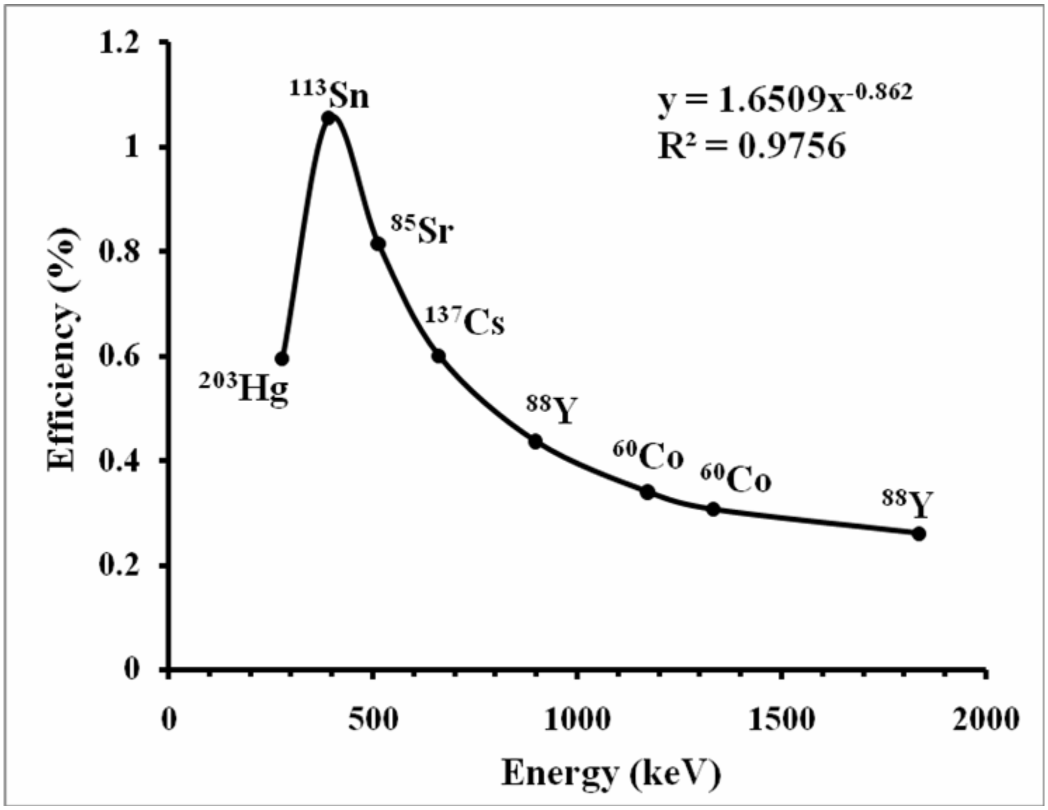


Figure 1. Full energy peak efficiency as a function of gamma ray energy for a typical NaI (Tl) detector

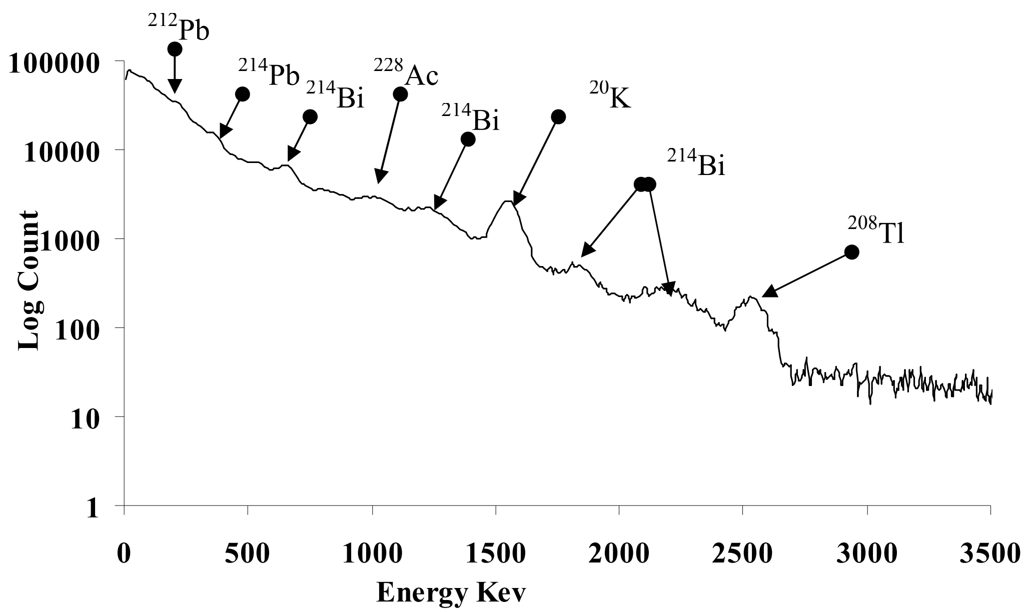


Figure 2. The energy spectrum recorded for soil sample by scintillation detector NaI(Tl)

2.4. Radiation Hazard Indices.

The absorbed dose rates (D) due to gamma radiations in air at 1m above the ground surface for the uniform distribution of the naturally occurring radionuclides (Ra-226, Th -232 and K-40) were calculated based on guidelines provided by UNSCEAR 2000. We assumed that the contributions from other naturally occurring radionuclides were insignificant. Therefore, D can be calculated according to [12].

$$D\ (nGy.h^{-1}) = 0.462\ A_{Ra} + 0.621\ A_{Th} + 0.0417\ A_K \qquad (2)$$

where A_{Ra}, A_{Th} and A_K are the activity concentrations of Ra-226, Th-232 and K -40, respectively

To estimate the annual effective dose rates, the conversion coefficient from absorbed dose in air to effective dose ($0.7 Sv.Gy^{-1}$) and outdoor occupancy factor (0.2) proposed by UNSCEAR 2000 are used. Therefore, the annual effective dose rate ($mSv.yr^{-1}$) was calculated by the following formula:

Effective dose rate ($mSv.yr^{-1}$) = D ($nGy.h^{-1}$) × 8760 $h.yr^{-1}$ × 0.7 × (10^3 mSv /10^9) nGy × 0.2 =D × 1.21 × 10^{-3} ($mSv.yr^{-1}$) (3)

A widely used hazard index (reflecting the external exposure) called the external hazard index H_{ex} is defined as follows:

$$H_{ex} = (A_{Ra}/370) + (A_{Th}/259) + (A_K/4810) \qquad (4)$$

In addition to external hazard index, radon and its short-lived products are also hazardous to the respiratory organs. The internal exposure to radon and its daughter products is quantified by the internal hazard index (H_{in}), which is given by the equation.

$$H_{in} = A_{Ra}/185 + A_{Th}/259 + A_K/4810 \qquad (5)$$

The values of the indeces (H_{ex}, H_{in}) must be less than unity for the radiation hazard to be negligible.

3. RESULT AND DISCUSION

The specific activity concentrations of U-238 series (Ra-226), Th-232 series (Th-232), as well as K-40, expressed in Bq/kg for samples obtained from North, South, East and west Armant area present in Table 1. From obtained results the range of Ra-226 values was 22.5±2.5 to 32.1±3.4, 7.4±0.7 to 17.1±0.7, 7.3±0.6 to 16.4±1.6 and 9.4±0.7 to 17.1±1.7, respectively. The values for Th-232 were 13.5±1.3 to17.6±2.2, 8.5±0.3 to 13.9±0.6, 6.7±0.3 to 16.5±0.9 and 7.9±0.3 to14.5±1.6 for the same sites while it was ranged from 294.9±9.4 to 632±20.2, 276±8.8 to 619.2±19.8, 231±7.4 to 554.6±17.8 and 276±8.8 to 619.2±19.8 for K-40 for North, South, East and west, respectively.

From table 1 it can be noticed

- The average value of Ra-226 at north Armant higher than its values in other directions this is may be due to irrigation water which contain for (P_2o_5) as the waste of sugar factory. While the average values of Th-232 and K-40 at all direction were closed.

- The activity concentrations of Ra-226, Th-232 and K-40 in all area under study are lower than the values that recorded by [13].
- The average values of Ra-226 and Th-232 are lower than world value and Egypt value 30, 35 and 17, 18Bq/Kg, respectively, (UNSCEAR 2000) in all area under investigation except the value of Ra-226 at north direction its value is higher than that reported for Egypt. While the values for K-40 in all directions were higher than Egypt and world values 320, 400 Bq/Kg respectively, (UNSCEAR 2000).

Table 2 show the average values of absorbed dose rate, annual effective dose, external hazard index and internal hazard index of the studied soil samples. The gamma dose rates due to naturally occurring terrestrial radionuclides Ra -226, Th-232 and K-40 were calculated based on their activities in soil samples, determined by gamma-ray spectrometry. The absorbed gamma dose rate due to these radionuclides were 48.5, 31.8, 33.5, 34.3 $nGyh^{-1}$ for North, South, East, and West of Armant, respectively. The estimated mean annual effective dose was 0.05, 0.03, 0.04 and 0.04 mSv for the same site. The external hazard index (H_{ex}) was calculated the mean value was 0.24, 0.17, 0.15 and 0.15 for North, South, West and East Armant area respectively. The internal hazard index (H_{in}) was also calculated, the value was 0.3, 0.2, 0.18 and 0.24 for North, South, West and East Armant area.

From table 2 it can be observed that:

- The values of absorbed dose rate in all area under study were lower than its values in Egypt farm soil which recorded 67.3 $nGyh^{-1}$ [14]
- Values of annual effective dose were lower than the values which reported in soil from Qena [15].The values of absorbed dose rate and annual effective dose were lower than world wide values [57 $nGyh^{-1}$,0.07 mSv, respectively] which reported in UNSCEAR 2000
- Values of H_{ex} and H_{in} in present work are lower than unity.

Finally , from the obtained results, we can concluded that the area under investigation have a normal background radiation and may be not pose radiological risks to the population owing to harmful effects of ionizing radiation from the naturally occurring radionuclides in soil .

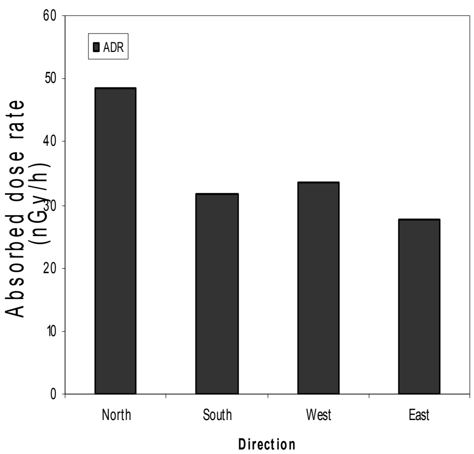
Figure 3 shows the average values for absorbed dose rate, annual effective dose, external and internal hazard index in all samples under investigation, respectively.

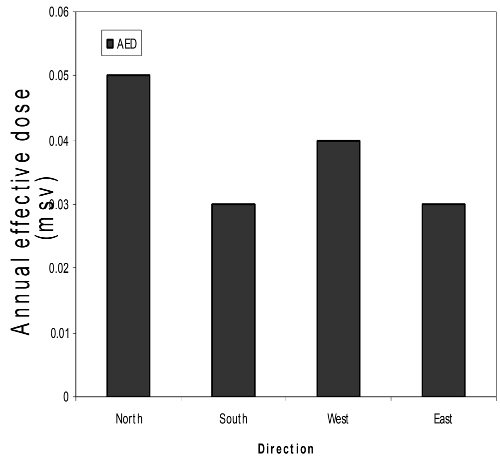
Table 1. The activity concentrations in Bq/kg of 226Ra, 232Th and 40K for soil samples from North, South, West and East Armant Area, Qena, Egypt.

Location	**Sample Code**	**Activity concentration in Bq/Kg**			**Sample Code**	**Location**	**Activity concentration in Bq/Kg**		
		Ra-226	**Th-232**	**K-40**			**Ra-226**	**Th-232**	**K-40**
North Armant	Ns1	26.1±4.12	14.2±1.6	371.5±11.9	South Armant	Ws1	16.4±1.6	13.5±0.8	363.7±11.6
	Ns2	23.3±2.4	13.5±1.3	294.9±9.4		Ws2	4.9±0.3	6.7±0.3	468.4±14.9
	Ns3	22.5±2.5	17.1±1.4	597±19.7		Ws3	13.4±2.3	9.9±0.9	501±23.9
	Ns4	26.4±2.9	14.4±1.3	584.6±18.9		Ws4	10.2±1.2	10.8±0.5	404.02±12.9
	Ns5	32.1±3.4	13.1±0.7	632±20.2		Ws5	9.5±1.5	11.5±0.9	554.6±17.8
	Ns6	28.6±3.5	15.7±1.9	626.3±20.5		Ws6	11.02±1.2	8.4±0.7	546.9±17.5
	Ns7	31.5±3.5	17.6±2.2	543.1±17.4		Ws7	14.1±1.4	12.1±1.0	500.9+±16
Average		27.2±3.2	15.1± 1.5	521±17.6		Ws8	8.9±0.7	7.7±0.5	496.3±15.9
						Ws9	7.3±0.6	16.5±0.9	231±7.4
South Armant	Ss1	15.6±0.9	13.9±0.6	402±12.9	Average		10.6±1.2	10.8±0.72	394±13.9
	Ss2	7.4±0.7	9.3±0.9	594±19.0	East Armant	Es1	15.6±0.9	14.5±1.6	598.8±19.2
	Ss3	13.5±1.2	12.03±0.9	447.5±.14.3		Es2	9.4±0.7	9.3±0.9	594±19.0
	Ss4	11.8±1.7	10.6±1.3	344.2±11.01		Es3	13.5±1.2	12.03±0.9	447.5±.14.3
	Ss5	11.3±0.9	9.7±0.7	393.4±12.6		Es4	11.8±1.7	10.6±1.3	344.2±11.01
	Ss6	17.1±0.7	12.8±0.9	304.3±9.7		Es5	13.3±1.1	9.7±0.7	393.4±12.6
	Ss7	12.7±1.1	12.1±0.8	619.2±19.8		Es6	17.1±1.7	13.8±0.9	304.3±9.7
	Ss8	11.7±1.9	9.8±0.5	397±12.7		Es7	12.7±1.1	12.1±0.8	619.2±19.8
	Ss9	11.4±0.7	8.5±0.3	276±8.8		Es8	14.1±1.4	9.8±0.5	593.9±19.0
	Average	11.4±1.09	10.9±0.77	463.5±14.8		Es9	11.4±0.7	7.9±0.3	276±8.8
					Average		13.2±1.1	11.1±0.8	344.5±10.8

Table 2. The average value of absorbed dose rate, annual effective dose rate, External and Internal hazard index

Location	Absorbed dose rate (nGy/h)		Annual effective dose (mSv)		External hazard index		Internal hazard index	
	Range	Average	Range	Average	Range	Average	Range	Average
North	35.3-56.8	48.5	0.040.07	0.05	0.17-0.29	0.24	0.23-0.37	0.31
South	20-42.5	31.8	0.020.05	0.03	0.10-0.22	0.15	0.13-0.27	0.2
West	20.2-50.8	33.5	0.020.06	0.04	0.09-0.21	0.15	0.1-0.26	0.18
East	19.8-35.4	27.6	0.020.04	0.03	0.11-0.19	0.15	0.13-0.24	0.18





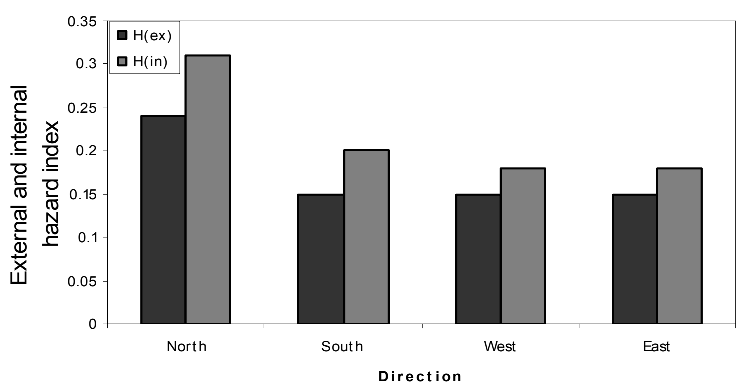


Figure 3. The average value of absorbed dose rate, annual effective dose, external and internal hazard index in all area under investigation

4. CONCLUSION

1-The obtained results illustrate the following important observation: the radium concentration at north of Armant area is higher than other direction this may be due to irrigation water which contain for (P_2o_5) as are the waste of sugar factory.

2- The average value for Ra-226 and Th-232 in all area under investigation are lower than the world wide values reported at UNSCEAR 2000.

3-The results indicate that average value for absorbed dose rate and annual effective dose for all samples under investigation are lower than the world values and the mean value for external and internal hazard index are less than unity for all samples under study. So the radiation risk from these soils can be negligible.

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