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Radionuclide Concentration in Different Environmental Samples Collected from Middle Delta Region, Egypt.

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ABSTRACT

This work is performed to evaluate the activity concentration levels in soil and water samples in Gharbia governorate, Egypt. Forty soil and thirty three water samples were collected and treated properly in order to evaluate the specific activity of ^{226}Ra , ^{232}Th (^{228}Ra) and ^{40}K in them using gamma spectroscopy technique based on a HpGe detector. Three districts and five irrigation canals were chosen in the area of study. For soil samples, the mean values of activity concentrations of ^{228}U, ^{232}Th and ^{40}K in the three districts are found to be less than the populated worldwide mean values. For water samples, the five selected irrigation canals in the area were investigated to evaluate their radioactivity content. The obtained results reveal that the mean values of the specific activities of ^{226}Ra ,^{228}Ra and ^{40}K are found to be far from the state of being hazardous. The present work also examined some radiation hazard indices where the mean values obtained are for absorbed dose rate 26.67 $nGyh^{-1}$, annual effective dose equivalent outdoor (AEDE) 33.74µSv $year^{-1}$, radium equivalent activity (Ra_{eq}) 58.58 Bq/kg, external hazard index (H_{ex}) 0.172 Bq/kg, internal hazard index (H_{in}) 0.211 Bq/kg, gamma index (I^{γ}) 0.222 mSv $year^{-1}$ and annual gonadal dose equivalent (AGDE) 192.93 $^{\mu}$Sv $year^{-1}$. Therefore, the investigated soils provide no significant radiation health hazard to the population if it is used as a building material. Moreover, the investigated water is radiologically safe for domestic and industrial use.

Keywords: Radioactivity concentrations , Soils ,Water ,Health hazards ,HpGe detector.

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INTRODUCTION

Natural radioactivity from naturally occurring radioactive materials is widely spread in the earth environment and it exists in various geological formations such as soil ,rocks, and water ,sediment, air and building materials. Artificial radionuclides are from nuclear weapon tests, nuclear accidents, medical and industrial applications. About 87% of the radiation doses received by humans are from natural radiation sources , which come from the naturally occurring radioactive isotopes ^{238}Uand ^{232}Thand their progenies as well as ^{40}K[1]. The contribution of radiation from sediment to human exposure can either be whole body due to external radiation originated directly from primordial radionuclides present in sediment or internal due to inhalation[2] . The internal exposure to radiation , affecting the respiratory tract , is mainly due to radon and its decay products which emanate from soil , sediment and building matrials[3] . long term exposure to radioactivity and inhalation for radionuclides have serious health effects such as chronic lung cancer and leukemia[4] .

The study area has many industries such as chemical , organic fertilizers and construction materials on both sides of the irrigation canal . The discharge wastes and toxic materials from such industries and living residents are directly let out into the canal. The Nile river has supported many civilization of Egypt throughout history and continues to play a vital role in supplying precious water for drinking, irrigation and industry. It plays an essential role in Egyptian life. The study of the natural radioactivity of the water , soil and sediment from its banks and those of the irrigation canals is very important and the assessment of natural dose rates deserves great interest to regional health. Also the Nile is a major north – flowing river in north – eastern Africa, generally regarded as the longest river in the world. It is 6650 km long. It runs through ten countries. These countries are Sudan, South Sudan, Burundi, Rwanda, The democratic Republication Congo, Tanzania, Kenya, Ethiopia, Uganda and Egypt.

The aim of the present work is to reinvestigate the radioactivity concentration in water and soil collected from the irrigation canals that take their water from the river Nile in the vicinity of Al_Mahalla Alkubra city. The health hazard parameters are to be accurately extracted and discussed.

MATERIALS AND METHODS

Study area

Al Mahallah Al Kubra city is a large industrial and agricultural city in Egypt, located in the middle of the Nile Delta on the western bank of the Damietta branch. It is known for its dominant textile industry. It is the largest city of Gharbia Governorate and in the Nile Delta, producing cotton, rice and wheat. In addition, it is home of several industrial activities, especially textile, oils, soap, packing, freezing vegetables and several other activities.

The present study covered an area around Al Mahallah Al Kubra city in Al Gharbia governorate from Bishbesh village (31°6'58"N ; 31°11'31"E) to Bolqina village (30°56'54"N ; 31°07'65"E) . Fourty soil and thirty three water samples were collected . Soil samples included 3 districts ; district 1 includes 2 villages :Bishbesh village (6 samples), Damro village (6 samples) ; district 2 includes 2 villages : Mehalet Hassan village (6 samples) and Al Amria village (6 samples) ;districts 3 icludes : Al Hayatem village (6 samples), Shobra Babel village (6 samples) ,andBolqina village (4 samples) while water samples included 5 irrigation canals in 5 villages ,Bishbesh irrigation canal (6 samples), Damro irrigation canal (6 samples) , Mehalet Hassan irrigation canal (6 samples) , Alamria irrigation canal (6 samples)and Alhaytim irrigation canal (9 samples) from different places .

Sample collection and preparation

Soil and water samples were collected from different sites of the selected study area. These samples were identified by their longitude and latitude axes using global positioning system(GBS).

Soil samples were taken from depths10 to 30 cm while water samples were collected from Almahallah Alkubra between May 2012 to October 2012 . The soil samples were manually collected with the help of a plastic spade in polyethylene bags. Soil samples were oven dried at temp 110 °C for 24 hours and sieved

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through 200 mesh . The dried samples were transferred to polyethylene Marinelli beakers of 350-cm^3 capacity .Each soil sample was left for at least 4 weeks to reach secular equilibrium between the radium and thorium and their progenies, while Water samples were collected from different locations at depth (3 - 5) m from the irrigation canals in 10-L capacity linear polypropylene bottles by means of subsurface electric pump connected directly into polypropylene bottles with 10-L capacity .

All samples of water were acidified with 10 M of HCl at the rate of 10 ml per liter of sample as soon as possible after sampling to prevent sorption of radionuclides in the bottles . In order to analyze the water samples, 10 liters of it were evaporated to 1 liter , and put into 1-L Marinelli beakers. These Marinelli beakers were previously washed, rinsed with a dilute sulfuric acid and dried to avoid contamination. Hereafter, they firmly sealed for at least four weeks to ensure that no loss of radon occurs thereby ensuring a state of secular equilibrium to be reached between radium isotopes and their respective daughters .

Radioactivity measurements:

For gamma measurements, a closed end-coaxial horizontal ORTEC-type HPGe detector having 62.3 cm^3 effective volume with 40% relative efficiency and 2keV energy resolution at 1.33 MeV photons of ^{60}Co. This detector is shielded by 4 mm Pb, 1mm Cd and 1 mm Cu .

The activity of ^{226}Ra and ^{228}Ra were obtained indirectly from the gamma-rays emitted by their progenies which are in secular equilibrium with them while^{40}K was estimated directly by its gamma-line of 1460.8 keV .^{226}Ra activities were determined using the gamma-lines 295.2 keV from ^{214}Pb , 609.3 and 1120.3 keV from ^{214}Bi. ^{232}Th activities were determined using gamma-lines 583.1 and 2614.4 keVfrom^{208}TL and 338.7 and 911.2 keVfrom ^{228}Ac .

RESULTS AND DISCUSSION

Radioactivity analysis

The activity concentrations of the detected radionuclides (^{226}Ra **,**$^{232}Th$and^{40}K) in the soil samples are given in (Table 1) .The average activity concentrations varied from location to location, because the canal bottom can exhibit large variations in chemical and mineralogical properties and rare-earth elements [5]. The ^{40}K activity concentration dominated over that of the $^{226}Ra$and ^{232}Thelemental activities ; as normally happens in soil . The activity concentration is based on the following equation :

$$A = \frac{N}{I \times \varepsilon \times t \times m} \qquad (1)$$

Where **A** is the activity concentration in Bq/kg , **N** is the net area (count per second) , **I** is the intensity of the Y-line in a radionuclide , **ε** is the measured efficiency for each Y- line , **t** is the detection real time, **m**is the mass of the sample in kilograms .

The uncertainty U(A) can be calculated by the following equation[6]**:**

$$\frac{U^2(A)}{A^2} = \frac{U^2(N_P)}{N_P^2} + \frac{U^2_{(I)}}{I^2} + \frac{U^2_{(m)}}{m^2} + \frac{U^2_{(\varepsilon)}}{\varepsilon^2} \qquad (2)$$

Table 1: Activity concentration of ^{226}Ra, ^{232}Th and ^{40}K in the soil samples

Location	^{226}Ra (Bq Kg^{-1})	^{232}Th (Bq Kg^{-1})	^{40}K (Bq Kg^{-1})
	District 1		

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Bishbesh	21.3 ± 0.98	10.3 ± 1.38	113.0 ± 9.5
	19.2 ± 0.77	8.90 ± 1.08	111.6 ±8.2
	17.1 ± 0.56	7.5 0± 0.78	110.2 ± 6.9
	23.2 ± 1.06	10.0 ± 1.35	115.4 ± 9.7
	21.1 ± 0.85	8.60 ± 1.05	114.0 ± 8.4
	19.0 ± 0.64	7.20 ± 0.75	112.6 ± 7.1
Damro	16.9 ± 0.08	9.60 ± 1.29	100.1 ± 8.6
	14.8 ± 0.38	8.20 ± 0.99	98.70 ± 7.3
	12.7 ± 0.38	6.80 ± 0.69	97.30 ± 6.0
	21.8 ± 1.00	10.9 ± 1.45	110.6 ± 9.4
	19.7 ± 0.79	9.50 ± 1.15	109.2 ± 8.1
	17.6 ± 0.75	8.10 ± 0.85	107.8 ± 8.0
Average	18.7 ± 0.75	8.80 ± 1.06	108.4 ±8.0
	District 2		
Mehalet hassan	21.7 ± 1.21	19.2 ± 2.29	228.3 ± 18.0
	20.3 ± 0.82	17.1 ± 2.08	226.9 ± 16.7
	18.9 ± 0.52	15.0 ± 1.87	225.5 ± 15.4
	25.7 ± 1.29	19.1 ± 2.28	234.1 ± 18.5
	24.3 ± 0.99	17.0 ± 2.07	232.7 ± 17.2
	22.9 ± 0.69	14.9 ± 1.86	231.3 ± 15.9
Alamria	23.4 ± 1.19	18.9 ± 1.83	236.7 ± 18.7
	22.0 ± 0.89	16.8 ± 2.04	235.0 ± 17.4
	20.6 ± 0.59	14.7 ± 1.83	233.9 ± 16.1
	24.9 ± 1.25	22.6 ± 2.71	291.0 ± 22.7
	23.5 ± 0.95	20.5 ± 2.50	290.9 ± 21.4
	22.1 ± 0.65	18.4 ± 2.29	288.9 ± 20.1
Average	22.5 ± 0.91	17.9 ± 2.14	246.3 ± 18.2
	District 3		
Alhaytim	31.2 ± 1.30	23.2 ± 2.77	323.0 ± 25.1
	29.8 ± 1.20	21.9 ± 2.67	320.9 ± 23.7
	28.4 ± 1.10	20.6 ± 2.57	318.8 ± 22.4
	24.0 ± 1.02	17.2 ± 2.02	213.8 ± 16.9
	22.6 ± 0.92	15.8 ± 1.92	211.7 ± 15.6
	21.2 ± 0.83	14.4 ± 1.82	209.6 ± 14.3
Shobra babel	37.1 ± 1.55	29.2 ± 3.49	409.4 ± 31.4
	35.7 ± 1.45	27.8 ± 3.39	407.3 ± 30.1
	34.3 ± 1.35	26.4 ± 3.29	405.2 ± 28.8
	23.9 ± 1.01	17.5 ± 2.06	225.9 ± 17.8
	22.5 ± 0.91	16.1 ± 1.96	223.8 ± 16.5
	21.1 ± 0.81	14.7 ± 1.86	221.7 ± 15.2
Bolqina	22.3 ± 0.90	8.30 ± 1.02	126.2 ± 9.30
	21.9 ± 0.89	7.80 ± 0.95	113.5 ± 8.40
	16.8 ± 0.68	7.30 ± 0.89	25.30 ± 1.90
	17.7 ± 0.72	10.8 ± 1.31	143.0 ± 9.90
Average	24.4 ± 1.04	17.4 ± 2.12	243.7 ± 17.9

The Population worldwide average concentrations of the radionuclides ^{226}Ra,^{232}Th, and ^{40}K, are 35, 30, and 400 Bq kg-1, respectively[7]. Our results show that the average activity concentrations of ^{226}Ra ,^{232}Th, and ^{40}K in our samples are less than that of the worldwide average.

Evaluation of radiological hazard effects

Absorbed dose rate

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Calculating the absorbed dose rate is the first major step for evaluating the health risk with regard to biological effects. The radiological and clinical effects are directly related to the absorbed dose rate[5]. The measured activity concentrations of ^{226}Ra, ^{232}Th, and ^{40}K are converted into doses by applying the conversion factors 0.462, 0.604, and 0.0417 for radium, thorium, and potassium, respectively[7]. These factors are used to calculate the total dose rate (D) (nGy h^{-1}) using the following equation[7]:

$$D = 0.462\ C_{Ra} + 0.604\ C_{Th} + 0.0417\ C_K\ (nGyh^{-1}) \quad (3)$$

Where c_{ra}, c_{th} and C_k are the activity concentrations ($BqKg^{-1}$) of ^{226}Ra, ^{232}Th, and ^{40}K in the soil samples respectively. The calculated values for the samples are presented in Table(2). The average absorbed dose rate for the soil samples in district 1, district 2,and district 3 is lower than the world average value (57 nGy h^{-1}) [7].

The annual effective dose equivalent

Annual estimated average effective dose equivalent (AEDE) received by an individual was calculated using a conversion factor of 0.7 SvGy , which was used to convert the absorbed rate to the human effective dose equivalent with an outdoor occupancy of 20% [8]. The annual effective dose is determined using the following equation:

$$AEDE\ (outdoor)(\mu Sv\ year^{-1}) = (nGy\ h^{-1}) \times 8760\ h \times 0.7\ Sv\ Gy^{-1} \times 0.2 \times 10^{-3} \quad (4)$$

The calculated values of the outdoor AEDE for soil samples in different locations are presentedin (table 2).

Table 2: Dose rates,AEDE(outdoor) and Ra_{eq} for the investigated samples.

Location	Dose rates (nGy h^{-1})	AEDE Outdoor (µSv $year^{-1}$)	Ra_{eq} (Bq Kg^{-1})
District 1			
Bishbesh	20.77	25.47	44.73
	18.89	23.16	40.52
	17.02	20.87	36.31
	21.57	26.45	46.38
	19.69	24.14	42.17
	17.82	21.85	37.96
Damro	17.78	21.80	38.33
	15.90	19.49	34.13
	14.03	17.20	29.91
	21.26	26.07	45.90
	20.29	24.88	41.69
	17.51	21.47	37.48
Average	18.54	22.74	39.63
District 2			
Mehalet Hassan	31.14	38.19	66.73
	29.16	35.76	62.22
	27.19	33.35	57.71
	33.17	40.67	71.03
	31.19	38.25	66.52
	29.21	35.82	62.01
Alamria	32.09	39.35	68.65
	30.11	36.92	64.11
	28.15	34.52	59.63
	37.28	45.72	79.62
	35.36	43.36	75.21

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	33.37	40.92	70.65
Average	28.95	38.57	66.76
District 3			
Alhayatim	41.89	51.37	89.25
	40.37	49.50	85.82
	38.85	47.65	82.40
	30.39	37.27	65.05
	28.81	35.33	61.49
	27.23	33.39	57.93
Shobra Babel	51.85	63.58	110.4
	50.26	61.63	106.8
	48.68	59.70	103.3
	31.03	38.06	66.31
	29.45	36.12	62.75
	27.87	34.17	59.19
Bolqina	20.57	25.22	43.88
	19.56	23.98	41.79
	13.22	16.21	29.19
	20.66	25.34	44.15
Average	32.54	39.91	69.35

From the table it is clearly shown that all the obtained AEDE valuefor all soil samples are far or below the population worldwideaverage (70 µSv/y)

Radium equivalent activities

The results were evaluated in terms of the radiation hazard by means of the Ra equivalent activity (Ra_{eq}). It is a widely used hazard index and is calculated through the relation given by Krieger (1981)[10]. It is assumed that 370BqKg^{-1} of^{226}Ra , 259Bq Kg $^{-1}$ of^{232}Thand 4810Bq Kg $^{-1}$ of ^{40}K produce the same gamma-ray dose rate :

$$Ra_{eq}(Bqkg^{-1})=C_{Ra}+1.43\ C_{Th}+ 0.077\ C_K \qquad (5)$$

Where c_{ra} ,C_{Th} , and $C_K$are the activity concentrations of ^{226}Ra,^{232}Th , and ^{40}K in Bq kg^{-1} respectively. The range of Ra_{eq} was estimated for the collected samples and is given in Table 2. The estimated average values are lower than the recommended maximum value of 370 Bq kg^{-1}.

Hazard indices

Krieger (1981)[10]defined twoindices that represent external and internal radiation hazards.The external hazard index (H_{ex}) is calculated using the following equation:

$$H_{ex} = (C_{Ra}/370 + C_{Th}/259+ C_K/4810)\ 0 \le 1 \qquad (6)$$

Where C_{Ra} ,C_{Th} , and C_K are the activity concentrations of ^{226}Ra, ^{232}Th , and ^{40}K in Bqkg^{-1}, respectively. H_{ex} must not exceed the limit of unity for the radiation hazard to be negligible. On the other hand, the internal hazard index (H_{in}) gives the internal exposure to carcinogenic radon and its short-lived progeny [5], and it is given by the following formula [10,11]:

$$H_{in} = (C_{Ra}/185+C_{Th}/259+C_K/4810)0 \le 1 \qquad (7)$$

Where C_{Ra} ,$C_{Th.}$, and C_K are the activity concentrations of ^{226}Ra, ^{232}Th, and ^{40}K in Bqkg^{-1} , respectively. The value of H_{in} must also be less than unity to have negligible hazard effects of radon and its short-lived progeny to the respiratory organs.The predictions of our calculations are given in Table 3.

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Table 3: Hazard indices(H_{ex} ,H_{in} , I^{γ} and AGDE) for the investigated samples

Location	Hazard indices			
	Hex	Hin	I^{γ} (mSv year $^{-1}$)	AGDE
District 1				
Bishbesh	0.120	0.178	0.160	144.35
	0.109	0.161	0.146	131.57
	0.089	0.144	0.131	118.79
	0.125	0.188	0.165	149.72
	0.114	0.170	0.115	136.94
	0.103	0.153	0.136	124.16
Damro	0.104	0.149	0.137	123.78
	0.092	0.132	0.123	110.99
	0.080	0.115	0.109	98.210
	0.123	0.183	0.164	147.65
	0.113	0.165	0.149	134.87
	0.101	0.148	0.135	122.09
Average	0.106	0.157	0.142	128.59
District 2				
Mehalet Hassan	0.180	0.239	0.244	218.99
	0.168	0.222	0.228	205.45
	0.156	0.206	0.213	191.91
	0.191	0.261	0.259	232.75
	0.179	0.245	0.243	219.21
	0.167	0.229	0.228	205.67
Alamria	0.185	0.248	0.250	225.63
	0.173	0.232	0.235	211.99
	0.161	0.217	0.220	198.54
	0.215	0.282	0.293	262.78
	0.263	0.266	0.278	249.64
	0.190	0.250	0.262	235.91
Average	0.224	0.266	0.271	221.53
District 3				
Alhayatim	0.241	0.325	0.327	294.80
	0.231	0.312	0.315	284.38
	0.222	0.299	0.303	273.96
	0.175	0.240	0.237	213.19
	0.166	0.227	0.244	202.35
	0.156	0.210	0.212	191.51
Shobra Babel	0.298	0.398	0.406	365.24
	0.288	0.384	0.393	354.40
	0.278	0.372	0.381	343.57
	0.179	0.243	0.242	217.93
	0.169	0.230	0.230	207.09
	0.159	0.216	0.218	196.26
Bolqina	0.118	0.179	0.157	143.22
	0.113	0.172	0.149	135.91
	0.078	0.124	0.101	90.370
	0.119	0.090	0.160	144.74

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Average	0.186	0.251	0.254	228.68

From the table it is clear that the average values of the external and internal health hazards are less than unity.

Gamma index

Another radiation hazard, called the gamma activity concentration index (I^{γ}) has been defined by the European Commission [12,13] and it is given as follows :

$$I^{\gamma} = (C_{Ra}/300 + C_{Th}/200 + C_k/3000) \quad (8)$$

Where C_{Ra} ,C_{Th} , and C_K are the activity concentrations of ^{226}Ra, ^{232}Th, and ^{40}K in Bq/kg^{1} respectively.

I^{γ} is correlated with the annual dose rate due to the excess external gamma radiation caused by superficial material values of $I^{\gamma} \leq 2$ correspond to a dose rate criterion of 0.3 mSv year^{-1} , whereas $I^{\gamma} < 6$ corresponds to a criterion of 1 mSvyear^{-1} [12,14]. Thus, I^{γ} should be used only as a screening tool for identifying materials that might be of concern to be used as construction materials, though materials with I^{γ} >6 should be avoided [15] since these values correspond to dose rates higher than 1 mSvyear^{-1} [12], which is the highest value of the dose rates recommended for humans [7].

The distribution ofI^{γ} values for the irrigation canals and soilsamples are presented in Table (3). The average values ofI^{γ} in the soil samples varied between 0.3 and 0.6. All I^{γ} values are<1. Therefore, the annual effective dose delivered by the soil samples is smaller than the annual effective dose constraint of l mSv year^{-1} . Hence, these soils can be used as a building materials.

Annual gonadal dose equivalent

The bone marrow activity and the bone surface cells are considered as organs of interest [16]. Therefore, the annual gonadal dose equivalent (AGDE) due to the specific activities of ^{226}Ra,^{232}Th,and^{40}K were calculated using the following formula [17]:

$$AGDE\ (\mu Sv\ year^{-1}) = 3.09\ C_{Ra} + 4.18\ C_{Th} + 0.314\ C_K \quad (9)$$

The obtained AGDE values are listed in Table (3). The average AGDE values varied from128.59 to 228.68 µSv year^{-1}.

Table(3) shows that the highest average AGDE value is 228.68 µ.Sv year^{-1} in district 3, which is less than the world average value 300 mSv/year [18].

Radioactivity concentration in water

The present obtained results of mean activity concentrations for ^{226}Ra,^{228}Ra and ^{40}K in water over five locations (Bishbesh canal , Damro canal ,Mehalet Hassan canal , Alamria canal and Alhayatem canal)are presented in Table (4).The difference in concentrations for ^{226}Ra and ^{228}Ra is probably due to the fact that the consequent differences in radionuclides solubilities and mobilities. The great difference of chemical characteristics and especially the important difference of solubility between the two elements (U, Th) imply that the equilibrium is not often achieved in water sincethorium is particularly insoluble element in natural water and is usually found associated with solids hence it has no disposition for transition with the water in

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contrary with uranium element which has distribution with the water affected by some factors such as temperature and salinity.

Table 4: The mean Activity concentration inBq/L for^{226}Ra , ^{228}Ra and ^{40}K in the water samples

Location	^{226}Ra(Bq L^{-1})	^{228}Ra(Bq L^{-1})	^{40}K(Bq L^{-1})
Bishbesh canal	0.034 ± 0.002	0.031± 0.006	2.27 ± 0.358
	0.032± 0.002	0.029± 0.006	2.25 ±0.356
	0.031 ± 0.001	0.027± 0.006	2.23 ± 0.354
	0.041± 0.002	0.017± 0.005	0.91 ± 0.070
	0.039± 0.002	0.016± 0.004	0.89± 0.068
	0.037± 0.002	0.013± 0.004	0.87± 0.066
Average	0.036± 0.002	0.021± 0.005	1.57 ± 0.212
Damro canal	0.061± 0.003	0.065± 0.003	2.71 ± 0.202
	0.060± 0.003	0.056± 0.003	2.69 ± 0.200
	0.057± 0.002	0.055± 0.002	2.67 ± 0.198
	0.029± 0.002	0.027± 0.001	1.67 ± 0.126
	0.027± 0.001	0.029± 0.001	1.65 ± 0.124
	0.025± 0.001	0.028± 0.001	1.63± 0.123
Average	0.043± 0.002	0.043 ± 0.002	2.17± 0.162
Mehalet Hassan Canal	0.051± 0.002	0.028± 0.004	6.85 ± 0.495
	0.049± 0.002	0.026± 0.004	6.83 ± 0.493
	0.047± 0.001	0.024± 0.003	6.82 ± 0.491
	0.031± 0.001	0.034± 0.005	0.62± 0.035
	0.029± 0.008	0.032± 0.004	0.59 ± 0.033
	0.029± 0.006	0.030 ± 0.004	0.58± 0.031
Average	0.039± 0.003	0.029± 0.004	3.72± 0.263
Alamria canal	0.118± 0.005	0.026± 0.004	5.77 ± 0.415
	0.116± 0.004	0.024± 0.003	5.75 ± 0.413
	0.114± 0.004	0.023± 0.003	5.73 ± 0.411
	0.055 ± 0.002	0.032± 0.004	1.96 ± 0.135
	0.053± 0.002	0.030± 0.004	1.94 ± 0.133
	0.051± 0.002	0.028± 0.004	1.92 ± 0.131
Average	0.085 ± 0.003	0.027± 0.004	3.85± 0.273
Alhaytim canal	0.057± 0.004	0.013± 0.001	5.29 ± 0.168
	0.055± 0.004	0.016± 0.002	5.27 ± 0.167
	0.053± 0.004	0.009± 0.002	5.25 ± 0.166
	0.024± 0.002	0.027± 0.004	4.87 ± 0.154
	0.022± 0.001	0.025± 0.003	4.86 ± 0.144
	0.020± 0.001	0.023± 0.003	4.84 ± 0.142
	0.031± 0.002	0.023± 0.004	0.38 ± 0.036
	0.030± 0.002	0.021± 0.003	0.36 ± 0.034
	0.028± 0.002	0.019± 0.003	0.34 ± 0.032
Average	0.036 ± 0.002	0.020± 0.003	3.49 ± 0.116

Annual effective dose equivalent

The obtained results of the annual effective dose equivalent in water are presented by making use of the activity concentrations(Table 4)and ingestion dose conversion factors for ^{226}Ra,^{228}Raand ^{40}K . The mean concentrations for ^{226}Ra,^{228}Raand ^{40}Kthatobtained in the present work (Table 4) are to great extent comparable with the results of some investigators such as that obtained for Brazilian Mineral water [19] ,Tunisian thermo-mineral springs in particular that for Ain Oktor spring [20],natural water in Morocco [24] ,

The surface water of Ebro river basin north spain,surface water in Istanbul [22] , the water in Canada [23] , the ground water around Buraydah in Saudia Arabia [24] ,Black sea [25] and drinking water samples that collected from North East Libya [26] .

The value obtained for the sum of the activity concentrations of both ^{226}Ra and ^{228}Ra in water is below the safety value recommended for ^{226}Ra in water which obtained by Surbeck (1Bq/L) [27], also it is below the maximum acceptable concentrations for ^{226}Ra (0.6 Bq/L) that obtained by (HECS) [28].

To compute the dose received from the consumption of the investigated water in the study area we have used the dose conversion factors publishedby the International Commission of Radiological Protection [29].

The conversion factors are 2.8×10^{-7} , 6.7×10^{-7} and 6.2×10^{-9} Sv/Bq for ^{226}Ra, ^{228}Ra and ^{40}K respectively.

Calculations using an estimated consumed quantity at 2 L of water per day resulted in an annual effective dose equivalent for irrigation canal water from 0.016 to 0.063mSv/Year with a total average value 0.036mSv/year as shown in table (5). These results represent about 36% of the level recommended by the World Health Organization [30]for the effective dose due to water consumption(0.1 mSv/year).

Table 5: Effective Dose Equivalent in canals water (mSv/year) .

Location Sample No.	Bishbesh canal	Damro canal	MehaletHassan canal	Alamria canal	Alhaytim canal
1	0.032	0.057	0.055	0.063	0.042
2	0.032	0.052	0.053	0.061	0.043
3	0.030	0.051	0.052	0.060	0.049
4	0.021	0.016	0.026	0.035	0.040
5	0.020	0.027	0.024	0.034	0.039
6	0.018	0.023	0.023	0.033	0.037
7	-	-	-	-	0.017
8	-	-	-	-	0.018
9	-	-	-	-	0.016
Total mean average	0.036				

CONCLUSION

The present work is devoted to determine the natural radioactivity levels of ^{228}U (^{226}Ra) , ^{232}Th and ^{40}K in soil and water samples from three nominated districts and five irrigation canals located in the vicinity of Al Mahalla Alkubra city in Gharbia governorate using gamma ray spectroscopy technique. The overall results have clearly showed low activity concentration across the study area. The mean activity concentrations of ^{228}U (^{226}Ra) ,^{232}Th and ^{40}K for soil samples are found to be ($21.86 \pm o.9$) , (14.7 ± 1.77) and (199.46 ± 14.72)Bq / kg respectively while the corresponding values for water samples are (0.048 ± 0.002), (0.028 ± 0.004) and (2.96 ± 0.205) Bq/Lrespectively. All these values are less than the populated international mean value. The associated health hazards for both soil and water samples have been estimated and found to be less than the populated world averages. Therefore, the obtained results reveal that the investigated soil can be savely used as building material while the water is to great extent save for use in domestic and industrial purposes. Furthermore, the obtained results represent a radiological data base which can be utilized to accurately determining any future activities.

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