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Concentrations of Natural and Manmade Radionuclides for Wadi Al Numan Area in Makkah Al-Mukarramah Province

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Abstract. Umm al Qura University buildings are situated in Wadi Al Numan area in Makkah ALMukarramah province. Therefore, a detailed study of this area is of great importance in future. The study area was divided to 15 parts and soil samples were sampled from each part. *In situ*, gamma Scout system was applied during sampling, to give the dose rate μSv/h at each point, which ranged from 0.08 to 0.22. For determination of radioactivity concentrations of the ^{226}Ra, ^{232}Th series and ^{40}K, an in situ gamma spectrometer based on NaI(Tl) crystal crystal detector was applied. The concentrations (in ppm) ranged from ND to 2.4 , from 1.4 to 6.9 f, and from 1.7% to 3% for ^{226}Ra, ^{232}Th series, and ^{40} K respectively. An XR-D spectrometer was used for the mineral compositions analysis of the soil samples and Atomic Absorption Spectrometer was used for measuring mineral concentrations of K, Al, Bi, Pb, and Th in both percentage and (ppm). The mineral concentrations percentage ranged from 7.66% to 8.49% for Al and from 1.77% to 2.81% for K. The concentrations (in ppm) ranged from < 10.0 to 21.81 for Bi, from 15.54 to 25.88 for Pb, and from <1.0 to 5.5 for Th. For measuring radioactivity concentrations of collected soils in Bq/kg for ^{226}Ra, ^{232}Th series, and ^{40} K, prepared dry weight samples were analyzed by a gamma spectrometer based on HPGe crystal detector. Soil samples collected are divided into two groups, sandy mud (silty sand) and a mixture of sand and clay (sand clay mixture). For silty sand the concentrations in Bq/kg dry weight ranged from 9.2 to 14.1 with average value 11.6, from 9.5 to 15.2 with average value 12.5, and from 378.2 to 557.8 with average value 481.3 for ^{226}Ra,^{232}Th series, and ^{40}K respectively. The surface concentrations

in Bq/m^2 for ^{137}Cs ranged from LDL to 31.4 with average value 26.9.For sand clay mixture the concentrations in Bq/kg dry weight ranged from 10.1 to 18.1 with average value 13.3, from 11.1 to 22.6 with average value 15.6, and from 454 to 592 with average value 5143 for ^{226}Ra, ^{232}Th series, and ^{40}K respectively. The surface concentrations in Bq/m^2 for ^{137}Cs ranged from LDL to 164.1 with average value 83.3. The concentrations were compared with concentrations of isotopes of the same types of soil of similar research previously published.

Keywords: Atomic absorption, gamma spectrometry, natural radioactivity, absorbed dose.

Introduction

Umm Al Qura university buildings are situated in Wadi Al Numan area in Makkah Al-Mukaramah province so a detailed study of this area is of great importance. The study area were divided to 15 parts, soil samples were collected from each part. A global positioning system (GARMIN GPS 45) was used to point the sampling axes, (longitude, latitude, altitude). The importance of the area is due its commercial value and for the huge building materials found in this area*.

Study of radioactivity levels and concentrations of natural and man-made radionuclides have been done all over the world. In Egypt, Ibrahiem *et al* [1] gave a base map for the radioactivity in the Delta and middle Egypt, by HPGe gamma system they measured the absorbed dose one meter above the ground in each point. They studied sediments and surface area of Naser lake area by both neutron activation analysis and gamma spectroscopy techniques. Amaral[2] in Portogal studied gamma spectrum and dose rate In Situ, also studied the type and composition of the different rocks, as well as the mechanical, chemical and biological properties for each type of soil. Melo *et al*[3] studied the severe internal dose in Brazil from the high radioactivity concentrations due to the concentrations of uranium and thorium in this area. Morton *et al*[4] measured the natural radioactivity concentrations, $^{238}\mathrm{U} - {}^{226}\mathrm{Ra}$, ^{232}Th series and ^{40}K , as well as the man made ^{137}Cs. Also they studied the salinity level in the soil from the series of the black plateau resulting from the flood of Virgin River, south-east of Nevada state USA. They analyzed the samples by EDS electron dispersion spectrometer in addition X-ray diffraction spectrometer for the soil composition. Wu[5] studied the accumulation of radioactive concentrations owing to the long period of irrigation according to the Yucca Mountain program of Nevada state

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USA to point out, time needed to reach equilibrium, the suitable time for irrigation, study of agricultural areas irrigated for long time and the change of concentrations of radioactive nuclides in water. Florou *et al*[6] studied the effect of the external dose intake for areas of high radioactivity levels in three islands from Greece of volcanic origin. In these areas many geothermal springs give gases as carbon monooxide, carbon dioxide as well as radon. Study was done by In Situ NaI(Tl) spectrometer, also concentrations of natural radio nuclides in soil, spring water, sea water and sediments, also they calculated the dose rate as well as the external risk also the quality assurance of the ecosystem.

The aim of this work is to make base line map for the study area, to be compared with future studies for any environmental or geological changes. Study of the relation between type of soil and the radioactivity level, measurements of dose rate for population in this area, also relation between the geological composition of the soil and the dose rate.

Geology of the Study Area

It lies east of the Red sea between 210 15’ 00” and 210 30’ 00” latitude north , 390 45’ 00” and 400 00’ 00” longitude east and elevation between 282 and 326m above the sea level. Rate of rain between 28mm to 273.9mm per year, average of 115.6mm (from the year 1980 to 1995). Fig.(1) Represents sample sites.

Four types of rocks are found in the study area :

1- Metamorphic rocks.
2- Mafic rocks.
3- Felsic rocks.
4- Quaternary deposits

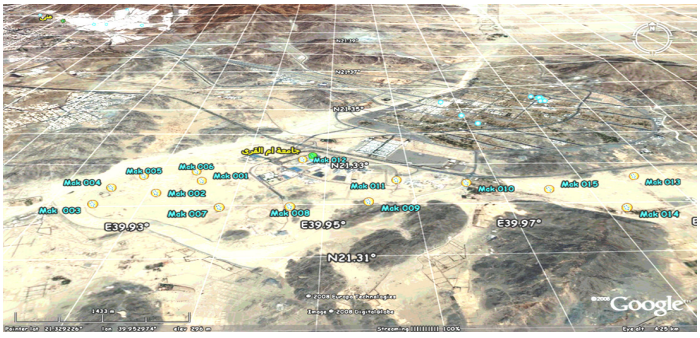

Fig. 1. Represents samples site.

Sampling and Sample Preparation

Sampling was done from 0-5 cm by a template 25x25x5 cm. Samples were mechanically analyzed for the type of soil, clay, sandy, loamy, or a combination of them by selecting the particle size using a system of sieves during the sampling. They were collected in polyethylene bags, then labeled. Remains of plants, weeds and rocks were removed from soil samples and were ground, sieved with a 1mm x 1mm mesh sieve, mixed for homogeneity. Samples were dried to 80 ^{O}C not to lose the volatile 137Cs or the natural polonium. 10 gm of the dried samples were used for XRD for the chemical and mineral composition, also 10 gm of the dried samples were used for the analysis by atomic absorption for the K, Al, Bi, Pb, and Th concentrations. A 640 cc sample was weighed then stored for one month in a polyethylene Marinelli beaker, for gamma spectrometry, to reach secular equilibrium between ^{226}Ra and ^{232}Th and their progenies. Sampling was done obeying methods adopted by RADREM[7].

Measurements

An X-ray diffraction spectrometer was applied for the chemical and mineral composition. Also an inductively coupled plasma atomic absorption spectrometer was used for measuring the activity concentrations of Th, Pb and Bi ppm and K and Al %. In Situ NaI(Tl) detector was used during the sampling to measure the concentrations of ^{226}Ra and ^{232}Th series as well as ^{40}K from the gamma energy transitions 1764, 2615, and 1460 keV respectively. In the same time a GAMMA – SCOUT dose meter was applied for the dose rate nGy/h in every sampling point. A gamma ray spectrometer based on a HPGe crystal of the vertical type was applied for the activity concentrations of ^{226}Ra, ^{232}Th series, and ^{40}K as well as the manmade ^{137}Cs. Energies (keV) of 295.2 (20.1) and 351.9 (38.3) ^{214}Pb and 609.3 (49.9), 1120.3 (16.2), and 1764.5 (16.0) ^{214}Bi were obtained for the ^{226}Ra series. 338.4(13), 911.16(30.3), and 968.97 (18.3) ^{228}Ac and 727.25(8.1) ^{212}Bi, also 583.02(33.2) and 2614.48(35.9) ^{208}Tl for the ^{232}Th series. 1460.8(10.7) for the ^{40}K and 661.65(89.9) for the ^{137}Cs[8].

Results and Discussion

The mechanical analysis for the soil classification shows that soil type is two categories: silty sand and sand clay mixture.

Table 1 represents XRD analysis results, it shows the major and minor minerals. The major and minor minerals are the quartz (SiO_2), the next is albite

($NaAlSi_3O_8$), pargasite ($NaCa_2[(MgFe^{2+})_4Al(Si_6Al_2)O22(OH)_2]$, and microline ($KAlSi_3O_8$).

Table 1. The mineral contents by XR-D Spectrometer.

Sample code	Type	Major	Minor	Trace
Makk-1	silty sand	quartz ,albite , pargasite,	microcline	
Makk-3		quartz,albite ,pargasite,	microcline	
Makk-4		quartz,albite ,pargasite,	miocrocline	
Makk-6		quartz,albite , richterite	microcline	biotite
Makk-9		quartz,albite , pargasite, microcline		vermiculite
Makk-11		quartz,albite , pargasite, microcline		clinochlore
Makk-2	sand-clay mixture	quartz , albite , pargasite , microcline		augite
Makk-5		quartz,albite ,pargasite,	gypsum , miocrocline	vermiculite ,biotite
Makk-7		quartz,albite , pargasite, microcline	clinochlore	biotite
Makk-8		quartz,albite , pargasite, microcline		vermiculite ,clinochlore
Makk-10		quartz,albite , pargasite, microcline	clinochlore	biotite
Makk-12		quartz,albite , pargasite, microcline		clinochlore , biotite
Makk-13		quartz,albite , pargasite	microcline	clinochlore , muscovite
Makk-14		quartz,albite , pargasite, microcline		clinochlore , biotite
Makk-15		quartz,albite , pargasite, microcline		clinochlore , biotite

Table 2 gives concentrations of Al and K % ,Bi ,Pb and Th ppm by atomic absorption analysis. Thorium concentrations range from DL to 5.55 ppm an average of 3.0. The stable lead (^{208}Pb, ^{206}Pb, and ^{207}Pb) from 12.4 to 25.9 ppm with an average 18.4. Bismuth (^{209}Bi) from DL (<10 ppm) to 21.8. Potassium from 1.4 to 2.8 % with an average of 2%. Aluminum from 7.7 to 8.2 %. with an average of 7.95%.

Table 2. Concentrations of Al,K,Bi,Pb,&Th Measured by Atomic Absorption Analyzer.

Elements Units		Th ppm	Pb ppm	Bi ppm	K%	Al%
Sample no.	**DL.**	1.00	7.50	10.00	0.05	0.05
Mak 1	**Concentrations**	1.97	19.52	<10.0	2.00	8.48
Mak		3.09	17.13	<10.0	2.10	8.31
Mak3		1.89	21.11	<10.0	1.99	8.49
Mak 4		2.98	18.72	<10.0	1.77	8.24
Mak 5		2.75	15.54	<10.0	1.42	7.97
Mak 6		2.82	17.13	<10.0	1.96	8.21
Mak 7		<1.00	20.31	<10.0	1.82	8.72
Mak 8	**Concentrations**	2.57	18.72	<10.0	1.90	8.28
Mak 9		2.76	18.72	<10.0	2.21	8.08
Mak 10		2.85	21.11	21.81	2.15	7.90
Mak 11		2.26	12.35	10.18	2.81	7.66
Mak 12		2.50	14.74	19.95	1.94	8.06
Mak 13		3.55	15.54	19.27	1.97	8.28
Mak 14		4.42	25.88	12.03	2.02	8.08
Mak 15		5.55	19.52	16.49	1.94	7.89

DL.:detection limit

Table 3 shows the results of the In Situ measurements (^{226}Ra, ^{232}Th, and ^{40}K as well as the dose rate μSv/h Measurements of in situ are relative and not absolute. Where there is dispersion of gamma rays depends on the distance between the source and detector according to the type of material between them and the density. Background radiation as well as the variable density of soil or sediment change, in addition to the interference of radiation from the soil and rocks in the vicinity, which increases the area under the peak, and the percentage of moisture changes the density of the source ^{226}Ra series concentrations ranged from ND to 2.4 ppm with an average 1.1ppm.^{232}Th series concentrations ranged from 1.4 ppm to 6.9 with an average of 4.0.^{40}K concentrations ranged from 1.7% to 3% with an average of 2.3%. The dose rate above the earth surface directly was from 0.08 to 0.22 μSv/h. with an average of 0.14 μSv/h.

Table 4 represents Results of gamma spectrum by the HPGe system Bq/kg dry weight for the silty sand, ^{226}Ra concentrations, Bq/Kg dry weight, ranged from 9.2 to 11.6 with an average of 11.6, it is lower than the average, 35 Bq/kg, given by UNSCEAR 2000.

^{232}Th series concentrations Bq/kg dry weight, ranged from 9.5 to 15.2 with an average of 12.5, which is lower than the average 35 Bq/kg, given by UNSCEAR 2000[9].

Table 3. In Situ., sample axes (elevation –longitude - latitude) and concentrations of ^{226}Ra,^{232} Th series ppm , and ^{40}K% in addition to the dose µSv/h.

Sample Code	Elevation (m)	Longitude (E)	Latitude (N)	^{226}Ra (ppm)	^{232} Th (ppm)	^{40}K %	Dose rate {µSv/h}
Mak001	292	39.93548	21.326	1.8	6.9	1.9	0.08
Mak002	288	39.93095	21.32307	1.7	2.1	2.6	0.11
Mak003	284	39.92477	21.32058	0.3	3.1	2.1	0.13
Mak004	281	39.92545	21.32442	1.5	2.9	1.9	0.13
Mak005	286	39.92826	21.32742	1.1	4.5	1.7	0.15
Mak006	291	39.93428	21.32854	1.2	1.4	2.2	0.12
Mak007	291	39.93874	21.31957	1.4	2.2	1.7	0.15
Mak008	306	39.94633	21.31961	2.4	2.8	2.4	0.15
Mak009	305	39.95486	21.32035	0.5	6.1	2	0.13
Mak0010	319	39.96634	21.32485	1.9	3.6	2.8	0.15
Mak0011	308	39.95832	21.32571	0.6	1.5	3	0.22
Mak0012	293	39.94696	21.3317	0.1	2.3	2.2	0.13
Mak0013	326	39.98647	21.32631	1.5	6.7	2.2	0.15
Mak0014	319	39.98235	21.31875	N D	6.9	2.7	0.19
Mak0015	311	39.97542	21.32312	0.3	6.9	2.6	0.18

^{40}K concentrations, Bq/kg dry weight, ranged from 378.2 = 13% to 557.8 =19% with an average of 481.3 =16% , which is more than the average 370 Bq/kg given by UNSCEAR 2000[9].

^{137}Cs (fallout) concentrations, Bq/m2, ranged from LDL to 31.4 with an average of 26.9.

For sand clay mixture Table 5 shows that ^{226}Ra series concentrations, Bq/kg dry weight, ranged from 10.1 to 18.1 with an average of 13.3 less than 35 given by UNSCEAR 2000[9].

^{232}Th series concentrations, Bq/kg dry weight, ranged from 11.1 to 15.6, average 15.6 less than 35 given by UNSCEAR 2000[9].

^{40}K concentrations, Bq/kg dry weight, ranged from 454 =15% to 592.6=20% more than 370 the value given by UNSCEAR 2000[9].

Table 4. Concentrations of isotopes Bq/kg and in percent dry weight for silty sand soil.

Sample Code	concentration Bq/kg			concentration Bq/m²
	Ra-226 series	Th-232 series	K -40	Cs-137
Mak001	10.7 ± 0.58	9.5 ± 1.1	514.6 ± 4.38	31.1 ± 20.12
Mak003	12.0 ± 0.74	10.5 ± 1.39	488.2 ± 5.59	20.7 ± 9.67
Mak004	12.6 ± 0.55	15.2 ± 0.95	435.6 ± 4.42	31.4 ± 17.16
Mak006	14.1 ± 0.64	14.4 ± 0.88	513.1 ± 4.40	24.3 ± 20.48
Mak009	9.2 ± 0.66	10.1 ± 1.25	378.2 ± 4.83	LDL
Mak011	11.1 ± 0.50	15.0 ± 0.85	557.8 ± 4.14	LDL
Average Concentrations	11.6 ± 0.25	12.5 ± 0.44	481.3 ± 1.90	26.9 ± 9.7

Table 5. Concentrations of isotopes Bq/kg & K in percent dry weight for sand clay mixture soil.

Sample Code	concentration Bq/kg			concentration Bq/m²
	Ra-226 series	Th-232 series	K -40	Cs-137
Mak002	13.1 ± 0.73	14.4 ± 2.08	527.8 ± 5.18	LDL
Mak005	12.3 ± 0.55	12.9 ± 1.45	454 .0 ±4.31	LDL
Mak007	10.1 ± 0.56	11.1 ± 0.65	461.8 ± 3.94	76.8±16.90
Mak008	12.8 ± 0.71	14.1 ± 1.16	504.4 ± 5.06	118.0±24.26
Mak010	12.5 ± 0.46	15.1 ± 1.26	592.6 ± 3.92	164.1±22.67
Mak012	11.9 ± 0.59	16.1 ± 1.75	486.9 ± 4.82	89.1 ± 22.44
Mak013	14.5 ± 0. 48	16.4 ± 0.87	546.2 ± 4.29	38.4 ± 16.32
Mak014	14.5 ± 0.46	17.4 ± 0.81	538.1± 4.13	31.9 ± 16.48
Mak015	18.1 ± 0.39	22.6 ± 1.18	522.6 ± 4.15	65.1 ± 19.42
Average Concentrations	13.3 ± 0.18	15.6 ± 0.44	514..9 ± 1.48	83.3 ± 7.57

LDL: Lower than Detection Limit.

Radium Equivalent and Absorbed Dose

Radium equivalent is calculated from equation (1) [10].

$Ra_{eq} = A_{Ra} + (A_{Th} \times 1.43) + (A_k \times 0.077)$ (1)

Where A_{Ra} ,A_{Th} and A_K are concentrations (Bq /kg) for the ^{226}Ra, ^{232}Th series and ^{40}K respectively.

Equation (1) was applied to convert concentrations (Bq/kg) to absorbed dose , using factors given by (Qunidos et al[11].

$$D = C_{Ra} A_{Ra} + C_{Th} A_{Th} + C_K A_K \quad (2)$$

Where D is the absorbed dose at one meter above the earth level nGy/h,

C_{Ra},C_{Th} and C_K are conversion factors (Bq/kg) to nGy/h for Radium, Thorium and K series respectively.

While A_{Ra}, A_{Th} and A_K are concentrations Bq/kg for ^{226}Ra, ^{232}Th series and ^{40}K respectively.

Table 6 shows sample no. mass in Kg,for dry weight, radium equivalent Bq/kg, dose at distance 1m above the earth in nGy/h for silty sand samples.

Table 6. Sample no. ,mass in g,dry weight, radium equivalent Bq/kg, dose at distance 1m above the earth in nGy/h for silty sand samples.

Sample	Mass wight dry (Kg)	Radium equivalent activity Ra_{eq} (Bq/kg)	Dose at distance 1m in nGy/h
Mak001	0.9522	63.9 ± 2.49	32.5 ± 1.09
Mak003	0.9464	64.6 ± 3.16	32.5 ± 1.39
Mak004	1.0263	67.9± 2.25	33.3± 0.99
Mak006	0.9664	74.20 ± 2.24	36.8 ± 0.99
Mak009	1.0326	52.8 ± 2.82	26.3 ± 1.24
Mak011	1.0623	75.5 ± 2.03	37.7 ± 0.90
Average	0.9977	66.5 ± 1.03	33.2 ± 0.45

Table 7. shows sample no mass in Kg for dry weight, radium equivalent Bq/kg, dose at distance 1m above the earth in nGy/h for sand-clay mixture samples.

Table 7. Sample no. ,mass in Kg for dry weight , radium equivalent Bq/kg , dose at distance 1m above the earth in nGy/h for sand-clay mixture samples.

Sample	Mass wight dry (Kg)	Radium equivalent activity Ra_{eq} (Bq/kg)	Dose at distance 1m in nGy/h
Mak002	0.9468	74.3 ± 4.10	37.0 ± 1.77
Mak005	0.9645	65.7 ± 2.96	32.6 ± 1.28
Mak007	0.9713	61.5 ± 1.79	30.9 ± 0.80
Mak008	0.9765	71.8 ± 2.76	35.7 ± 1.22
Mak010	1.0910	79.7 ± 2.56	39.9 ± 1.11
Mak012	0.9802	72.4 ± 3.46	35.7 ± 1.50
Mak013	1.0152	80.0 ± 1.57	39.6 ± 0.69
Mak014	1.0263	80.8 ± 1.94	39.8 ±0.86
Mak015	1.0480	90.7 ± 2.40	43.8 ±1.04
Average	1. 0022	75.2 ± 0.91	37.2 ±0.40

Table 8 represents a comparison between ^{40}K and ^{232}Th concentrations measured by atomic absorption spectrometer and gamma spectrometer. Gamma measurements in the laboratory showed ^{232}Th series concentrations in Bq/kg of dry weight, less concentration was 9.5 (sample no.1 is clay soil silty sand) and the highest concentration was 22.6(sample no. 15 is a mixture of sand clay mixture) and for ^{40}K concentrations ranged from 1.3% (sample no. 9 silty sand) to 2.0%(sample 10 sand clay mixture). From the results of analysis of the atomic absorption, ^{232}Th series concentrations in Bq/kg were <DL(sample no. 7 sand clay mixture) and 22.6 (sample no. 15 sand clay mixture) and for ^{40}K concentrations ranged from 1.42% (sample no. 5 sand clay mixture) to 2.81%(sample 11 siltysand).. Comparing the results of the atomic absorption with gamma results found to be close and the difference is simply due to the possible non-homogeneity of the sample (within the limits of error).

Table 8. Comparison between K-40 & Th-232 concentrations measured by atomic absorption spectrometers & gamma spectrometer.

Elements	[1]Th-232	[2]Th-232	K-40[1]	K-40[2]
Unit / No. of sample	Bq/kg	Bq/kg	%	%
Mak1	8.0	9.5	2.0	1.7
Mak2	12.6	14.4	2.1	1.8
Mak3	7.7	10.5	1.99	1.7
Mak4	12.1	15.2	1.77	1.5
Mak5	11.2	12.9	1.42	1.5
Mak6	11.5	14.4	1.96	1.7
Mak7	<DL	11.1	1.82	1.6
Mak8	10.5	14.1	1.9	1.70
Mak9	11.2	10.1	2.21	1.3
Mak10	11.6	15.1	2.15	2.0
Mak11	9.2	15.0	2.81	1.9
Mak12	10.2	16.1	1.94	1.7
Mak13	14.4	16.4	1.97	1.9
Mak14	17.9	17.4	2.02	1.8
Mak15	22.6	22.6	1.94	1.8

[1] Atomic absorption spectrometer.
[2] Gamma spectrometer.

Table 9 represents comparison between ^{226}Ra, ^{232}Th series and ^{40}K concentrations and dose measured, by gamma spectrometry, In Situ and laboratory. The results didn't match in both, the reason for the difference that in the case of in situ measurement, there is a background radiation dose from the surrounding medium (rocks and soil) and from cosmic rays which are higher at this altitude (326-280) above the sea surface, and the measurements in situ was on the surface directly, while the concentrations obtained in the laboratory were calculated on 1 meter from the surface of the earth, in addition, these samples contain moisture, while the samples in lab. were dried and sieved, also, radiation shield surrounding the detector was used to protect the system from the background radiation.

Table 9. Comparison between Th-232 , Ra-226, K-40 concentrations and dose measured, by gamma spectrometry, in Situ & laboratory.

Sampleno.	Measurements in situ				Measurements in lab.			
	Th-232 Bq/kg	Ra- 226 Bq/kg	K-40%	Dose at 0m µSv/h	Th-232 Bq/kg	Ra-226 Bq/kg	K-40 %	Dose at 1m µSv/h
Mak1	28.1	22.2	1.9	0.08	9.5	10.7	1.7	0.023
Mak2	8.5	21.0	2.6	0.11	14.4	13.1	1.8	0.023
Mak3	12.6	3.7	2.1	0.13	10.5	12	1.7	0.023
Mak4	11.8	18.5	1.9	0.13	15.2	12.6	1.5	0.023
Mak5	18.3	13.6	1.7	0.15	12.9	12.3	1.5	0.023
Mak6	5.7	14.8	2.2	0.12	14.4	14.1	1.7	0.026
Mak7	9.0	17.3	1.7	0.15	11.1	10.1	1.6	0.022
Mak8	11.4	29.6	2.4	0.15	14.1	12.8	1.70	0.025
Mak9	24.8	6.2	2.0	0.13	10.1	9.2	1.3	0.018
Mak10	14.7	23.4	2.8	0.15	15.1	12.5	2.0	0.028
Mak11	6.1	7.4	3.0	0.22	15	11.1	1.9	0.026
Mak12	9.4	1.2	2.2	0.13	16.1	11.9	1.7	0.025
Mak13	27.3	18.5	2.2	0.15	16.4	14.5	1.9	0.028
Mak14	28.1	ND	2.7	0.19	17.4	14.5	1.8	0.028
Mak15	28.1	3.7	2.6	0.18	22.6	18.1	1.8	0.031

Table10 Shows conversion factors nGy/h per Bq/kg used in the present work and that obtained by Amaral[2].

Table 10. Conversion factors nGy/h per Bq/kg used in the present work & that obtained by Amaral[2].

Dose rate (nGy/h per Bq/kg)	Amaral 2000	Qunidos *et al* ., 2004
Ra-226 series	0.4500	0.4551
Th-232 series	0.6680	0.5835
K -40	0.0424	0.0429

Al-Kusayer & Al-Haj[12] measured and calculated the level of background radiation in the city of Riyadh, concentrations of radioactive isotopes in Bq/ kg for ^{226}Ra,^{232}Th series, and ^{40}K were higher than that in the present work and for ^{137}Cs was even more higher. This is due to the that fact their measurements took place in 1987, a year after the Chernobyl accident.

Abulfaraj & Abdul-Majid[13] determined the concentrations of radioactive isotopes in natural soil from different parts of Jeddah, Saudi Arabia, the average concentrations Bq/ kg of dry weight were higher than that in the present work. It is possible that due to the fact that the soil in Jeddah area is often sand.

Table 11. The percentage contribution of nuclear series and K-40, related to the type of soil.

	Soil origin	Ra-226 series	Th-232 series	K -40
(Amaral, 2000)	intrusive	25.9% ± 6%	45 % ± 7%	30 % ± 5%
	sedimentary	22% ± 4%	32 % ± 5%	46 % ± 5 %
	metamorphic	22% ± 9%	42% ± 8%	36% ± 13%
Present work	silty sand	15.9% ± 0.3%	22 % ± 0.8%	62.2% ± 0.2%
	sand-clay mixture	16.3% ± 0.2%	24.5% ± 0.7%	59.4% ± 0.17%

Table 12 Represents comparison of isotopes concentrations (Bq/kg dry weight) in the present work and some published results .

Table 12. Comparison of isotopes concentrations in Bq/ kg dry weight concentrations in the present work & some published results .

Nuclide -Series	Ra-226	Th-232	K-40	Cs-137
Al-Kusayer and AlHaj [12]	26	23	315	14
Abulfaraj and Abdul-Majid [13]	9.25	7.4	369	0.32
Present work	12.5	14.1	498.1	0.8

Conclusion

The results of the In Situ measurements (^{226}Ra, ^{232}Th, and ^{40}K as well as the dose rate μSv/h) can't be considered accurate results because of the interference of the background of the surrounding of soil and rocks. Results of gamma spectrum by the HPGe system Bq/kg dry weight for the silty sand and sand clay mixture show that, for ^{226}Ra, ^{232}Th series, and ^{137}Cs concentrations are lower than that given by UNSCEAR 2000[9]. While the concentrations of ^{40}K are more than those given by UNSCEAR 2000[9]. There is a small difference between the two types of sandy soil component, silty sand and sand clay mixture, because both of them contain Quartz. The concentrations of radioactive materials from sand clay mixture were slightly higher for the two series (^{226}Ra, ^{232}Th series), as well as ^{40}K and ^{137}Cs.

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دراسة تفصيلية عن تركيزات العناصر المشعة الطبيعية والصناعية بوادي النعمان بمنطقة مكة المكرمة

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المستخلص. دراسة منطقة وادي النعمان بمنطقة مكة المكرمة ذات أهمية خاصة لوجود كليات وإنشاءات جامعة أم القرى بها، ويتوقع أن تزيد بها الكثافة السكانية و كذلك المناطق المجاورة لها. تم تحليل خمس عشرة عينة من التربة بمنطقة وادي النعمان بمكة المكرمة إشعاعيًا لجمع العينات تم استخدام جهاز تحديد المواقع عن طريق الأقمار الصناعية لتحديد إحداثيات كل نقطة لجمع العينات منها. تم استخدام مطياف جاما المحمول المتكون من كاشف أيوديد الصوديوم المنشط بالثاليوم لتعيين تركيزات النظائر المشعة في الموقع (سلسلة الراديوم وسلسلة الثوريوم كذلك تم تعيين الجرعة الإشعاعية باستخدام جهاز جيجر– ميللر. وكذلك البوتاسيوم الطبيعي).

جهزت العينات التي تم جمعها لتحليلها باستخدام مطياف جاما المكون من كاشف الجرمانيوم فائق النقاوة لتحديد تركيزات كل من سلسلتي الراديوم والثوريوم بالإضافة إلى البوتاسيوم بوحدة

البيكرل لكل كيلو جرام للوزن الجاف، وتم تحليل العينات بمطياف الامتصاص الذري لتحديد تركيزات النظائر (مثل الرصاص والبزموث والبوتاسيوم والألمنيوم والثوريم) في الجزء في المليون أو النسبة المئوية واستخدام مطياف حيود الأشعة السينية لتعيين نوع المعادن بالتربة. كما تم تحديد نوع التربة (رملية، أو طفلية، أو طينية) ميكانيكيًا.

نلاحظ من النتائج أن الاختلاف قليل بين نوعي التربة (التربة الطينية الرملية والتربة الطفلية الرملية) لأن المكون الرملي مشترك بينهما(الرمال) ويكون تركيز المواد المشعة الطبيعية فيها من أقل أنواع التربة ومع ذلك فإن التركيزات في التربة الرملية الطفلية أعلى قليلا بالنسبة وكذلك لسلسلتي الراديوم الثوريوم. ^{137}Cs و ^{40}K.