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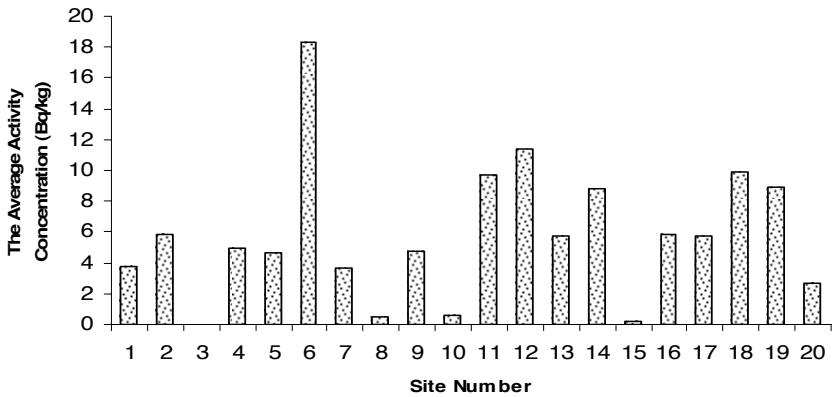

Figure 6. The Average Activity Concentration of Cs-137 in Soil Samples from Hebron Region at Different Depths.

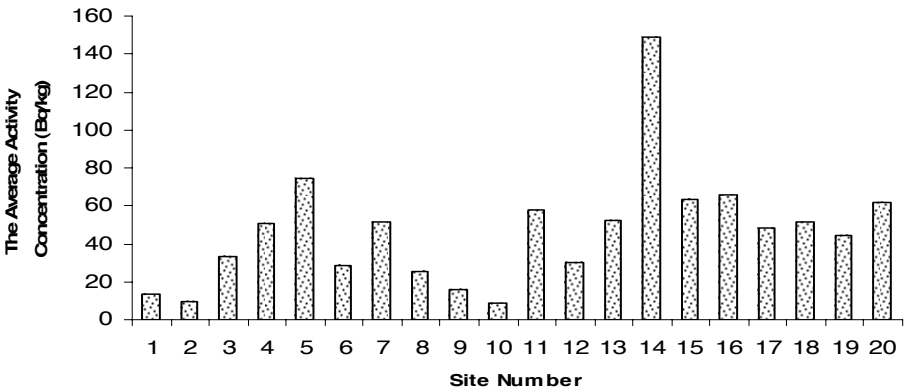

Figure 3. The Average Activity Concentration of U-238 Series in Soil Samples from Hebron Region at Different Depths.

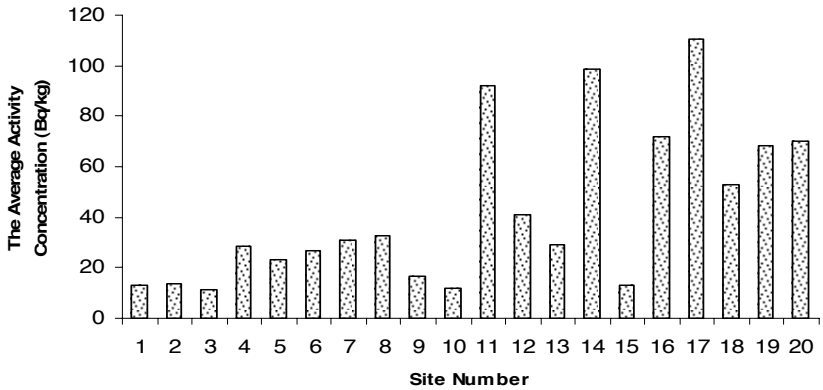

Figure 4. The Average Activity Concentration of Th-232 Series in Soil Samples from Hebron Region at Different Depths.

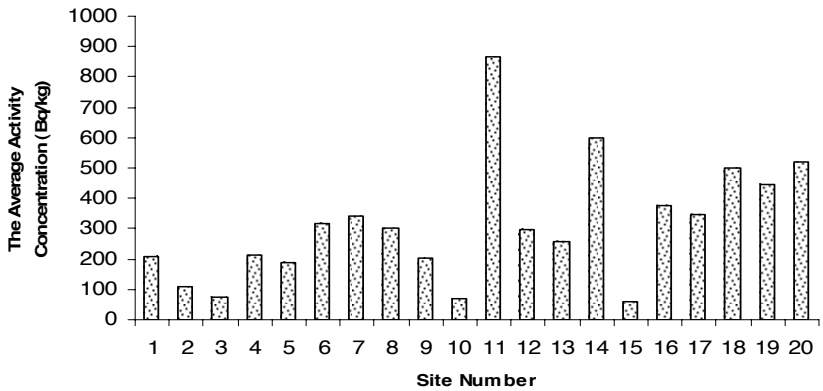

Figure 5. The Average Activity Concentration of K-40 in Soil Samples from Hebron Region at Different Depths.

Table 4. The dose rate, the external hazard index and the external gamma radiation of the soil sample at different depths in southern Hebron province

Site	Sample	Depth (cm)	Dose rate (nGy/hr)	Ra_{eq} (Bq/kg)	H_{ex}(mGy/yr)	I_γ
11	11SRIII	Surf.	137.60	292.88	0.79	2.11
		20	99.10	209.44	0.57	1.52
		40	136.15	277.89	0.75	2.10
		60	119.58	246.56	0.67	1.84
Average			**123.11**	**256.69**	**0.70**	**1.89**
12	12SRIII	Surf.	67.08	142.39	0.38	1.03
		20	50.38	107.55	0.29	0.78
		40	58.73	123.97	0.33	0.90
		60	34.56	71.72	0.19	0.53
Average			**52.69**	**111.41**	**0.30**	**0.81**
13	13SRIII	Surf.	86.40	189.41	0.51	1.34
		20	45.14	96.34	0.26	0.70
		40	41.20	88.15	0.24	0.64
		60	37.40	79.76	0.22	0.58
Average			**52.54**	**113.42**	**0.31**	**0.82**
14	14SRIII	Surf.	222.9	486.87	1.32	3.44
		20	145.68	319.49	0.86	2.25
		40	112.35	239.28	0.65	1.73
		60	125.26	269.64	0.73	1.92
Average			**151.55**	**328.82**	**0.89**	**2.34**
15	15SRIII	15 meter	38.36	86.83	0.24	0.60
16	16SRIV	Surf.	137.76	298.03	0.80	2.11
		20	104.96	277.35	0.61	1.61
		40	58.40	123.77	0.33	0.90
		60	66.82	142.17	0.38	1.03
Average			**91.99**	**210.33**	**0.53**	**1.41**
17	17SRIV	Surf.	173.65	376.99	1.02	2.66
		20	81.05	172.08	0.46	1.24
		40	116.39	248.51	0.67	1.77
		60	95.29	202.82	0.55	1.45
Average			**116.60**	**250.1**	**0.68**	**1.78**
18	18SRIV	Surf.	78.72	166.07	0.45	1.21
19	19SRIV	Surf.	83.56	176.88	0.48	1.28
20	20SRIV	Surf.	95.14	202.04	0.55	1.46
Total Average			**86.33**	**201.62**	**0.54**	**1.44**

Table 3. The dose rate, the external hazard index, and the external gamma radiation of the soil sample at different depths in northern Hebron province.

Site	Sample	Depth (cm)	Dose rate (nGy/hr)	Ra_{eq} (Bq/kg)	H_{ex}(mGy/yr)	I_γ
1	1SRI	Surf.	26.23	54.35	0.15	0.41
		20	23.44	48.29	0.13	0.36
		40	24.10	49.35	0.13	0.37
		60	24.21	50.77	0.14	0.37
Average			**24.50**	**50.70**	**0.14**	**0.38**
2	2SRI	Surf.	18.14	38.02	0.11	0.28
		20	28.66	60.34	0.16	0.44
		40	13.66	28.85	0.08	0.21
		60	11.68	24.75	0.07	0.18
Average			**18.04**	**38.0**	**0.11**	**0.28**
3	3SRI	15 meter	25.04	55.48	0.15	0.39
4	4SRI	Surf.	55.18	119.91	0.32	0.85
		20	51.33	111.41	0.30	0.79
		40	47.79	103.60	0.28	0.74
		60	44.87	97.29	0.26	0.69
Average			**49.80**	**108.05**	**0.29**	**0.77**
5	5SRI	Surf.	63.38	140.07	0.38	0.98
		20	59.16	130.74	0.35	0.92
		40	54.57	120.58	0.33	0.85
		60	43.71	96.82	0.26	0.68
Average			**55.21**	**122.05**	**0.33**	**0.86**
6	6SRI	Surf.	53.95	113.01	0.31	0.83
		20	43.97	92.52	0.25	0.68
		40	40.07	83.84	0.23	0.62
		60	36.17	75.41	0.20	0.56
Average			**43.54**	**91.20**	**0.25**	**0.67**
7	7SRI	Surf.	62.41	133.58	0.36	0.96
		20	56.72	121.10	0.33	0.88
		40	52.79	112.40	0.30	0.82
		60	56.96	121.46	0.33	0.88
Average			**57.22**	**122.14**	**0.33**	**0.89**
8	8SRII	Surf.	47.83	100.16	0.27	0.74
		20	45.92	96.23	0.26	0.71
		40	44.86	94.64	0.26	0.69
		60	55.13	116.26	0.31	0.85
Average			**48.44**	**101.82**	**0.28**	**0.75**
9	9SRII	Surf.	25.43	53.35	0.14	0.39
		20	22.29	45.94	0.12	0..34
		40	38.60	80.62	0.22	0.59
		60	19.28	40.16	0.11	0.30
Average			**26.40**	**55.02**	**0.15**	**0.41**
10	10SRII	15 meter	14.52	30.98	0.08	0.22
Total Average			**38.7**	**70.2**	**0.22**	**0.60**

Table 2. The activity concentration of ^{238}U-series, ^{232}Th-series, ^{40}K and ^{137}Cs in Bq/kg (dry weight) of the studied samples in southern Hebron province.

Site	Sample	Depth (cm)	^{238}U	^{232}Th	^{40}K	^{137}Cs
11	11SRIII	Surf.	64.9 ± 3.3	127.5 ± 6.4	592.1 ± 29.6	30.2 ± 1.5
		20	37.6 ± 1.9	94.6 ± 4.7	475.0 ± 23.6	5.3 ± 0.3
		40	64.9 ± 3.2	76.9 ± 3.8	1338.1 ± 66.9	2.8 ± 0.1
		60	64.7 ± 3.2	70.0 ± 3.5	1060.0 ± 53.0	0.3 ± 0.1
Average			**58.0 ± 2.9**	**92.3 ± 4.6**	**866.3 ± 43.3**	**9.7 ±0.5**
12	12SRIII	Surf.	39.0 ± 2.0	53.5 ± 2.7	349.1 ± 17.5	24.2 ± 1.2
		20	40.8 ± 2.0	31.6 ± 1.6	280.0 ± 11.0	17.8 ± 0.9
		40	26.9 ± 1.4	51.0 ± 2.6	313.5 ± 15.7	2.1 ± 0.1
		60	13.5 ± 0.7	27.2 ± 1.4	251.0 ± 12.6	1.3 ± 0.1
Average			**30.1 ± 1.5**	**40.8 ± 2.0**	**298.4 ± 14.9**	**11.4 ± 0.6**
13	13SRIII	Surf.	100.5 ± 5.0	45.1 ± 2.3	317.1 ± 15.9	12.4 ± 0.6
		20	38.5 ± 1.9	26.4 ± 1.3	260.9 ± 13.1	6.9 ± 0.4
		40	36.9 ± 1.9	23.3 ± 1.2	232.9 ± 11.7	2.2 ± 0.1
		60	32.9 ± 1.7	20.6 ± 1.0	226.0 ± 11.3	1.1± 0.1
Average			**52.2 ± 2.6**	**28.9 ± 1.5**	**259.2 ± 13.0**	**5.7 ± 0.3**
14	14SRIII	Surf.	236.9 ± 11.9	130.7 ± 6.5	819.1 ± 41.9	24.0 ± 1.2
		20	195.3 ± 8.3	80.6 ± 4.0	505.6 ± 25.3	6.0 ± 0.3
		40	67.7 ± 3.4	90.6 ± 4.5	545.7 ± 27.3	5.2 ± 0.3
		60	97.0 ± 4.9	92.0 ± 4.6	533.5 ± 26.7	0.0 ± 0.0
Average			**149.2 ± 7.1**	**98.5 ± 4.9**	**601.0 ± 30.1**	**8.8 ± 0.4**
15	15SRIII	15 meter	63.7 ± 3.2	12.8 ± 0.6	61.5 ± 3.1	0.2 ± 0.0
16	16SRIV	Surf.	88.5 ± 4.4	124.8 ± 6.2	403.5 ± 20.2	15.3 ± 0.8
		20	83.6 ± 4.2	80.6 ± 4.0	370.0 ± 18.5	4.3 ± 0.2
		40	43.9 ± 2.2	36.2 ± 1.8	365.0 ± 18.3	2.6 ± 0.1
		60	47.7 ± 2.4	46.2 ± 2.3	368.9 ± 18.4	1.0 ± 0.1
Average			**65.9 ± 3.3**	**72.0 ± 3.6**	**376.9 ± 18.8**	**5.8 ± 0.3**
17	17SRIV	Surf.	105.5 ± 5.3	152.7 ± 8.4	396.5 ± 19.8	11.0 ± 0.6
		20	31.0 ± 1.6	80.3 ± 4.0	340.9 ± 17.0	7.0 ± 0.4
		40	33.5 ± 1.7	131.7 ± 6.6	346.5± 17.3	4.9 ± 0.3
		60	21.8 ± 1.1	77.7 ±5.5	296.9 ± 14.8	00.0
Average			**48.0 ± 2.4**	**110.6 ± 6.1**	**345.2 ± 17.3**	**5.7 ± 0.3**
18	18SRIV	Surf.	51.6 ± 2.6	53.0 ± 2.7	502.3 ± 2.7	9.9 ± 0.5
19	19SRIV	Surf.	44.7 ± 2.2	68.4 ± 3.4	446.8 ± 22.3	8.9 ± 0.4
20	20SRIV	Surf.	61.8 ± 3.1	70.0 ± 3.5	520.8 ± 26.0	2.7 ± 0.1
Total Averge			**65.6**	**71.3**	**447.1**	**7.5**

Table 1. The activity concentration of ^{238}U-series, ^{232}Th-series, ^{40}K and ^{137}Cs in Bq/kg (dry weight) of the studied samples in northern Hebron province.

Site	Sample	Depth (cm)	^{238}U	^{232}Th	^{40}K	^{137}Cs
1	1SRI	Surf.	13.4 ± 0.7	17.2 ± 0.9	211.3 ± 10.6	7.9 ± 0.4
		20	15.1 ± 0.8	11.4 ± 0.6	220.6 ± 11.0	3.6 ± 0.2
		40	13.6 ± 0.7	12.3 ± 0.6	236.6 ± 12.0	2.2 ± 0.1
		60	12.3 ± 0.6	11.4 ± 0.9	155.6 ± 8.0	1.3 ± 0.1
Average			**13.6 ± 0.7**	**13.1 ± 0.7**	**206.0 ± 10.3**	**3.8 ±0.1**
2	2 SRI	Surf.	10.5 ± 0.5	12.6 ± 0.6	123.8 ± 6.2	7.1 ± 0.4
		20	11.5 ± 0.6	25.8 ± 1.3	154.9 ± 7.8	6.5 ± 0.3
		40	8.4 ± 0.4	9.8 ± 0.5	82.5 ± 4.1	5.8 ± 0.3
		60	8.7 ± 0.4	7.3 ± 0.4	72.7 ± 3.6	3.8 ± 0.2
Average			**9.8 ± 0.5**	**13.9 ± 0.7**	**108.5 ± 5.4**	**5.8 ± 0.3**
3	3 SRI	15 meter	33.2 ± 1.7	11.5 ± 0.6	75.2 ± 3.8	0.0 ± 0.0
4	4SRI	Surf.	55.2 ± 2.8	33.1 ± 1.7	225.4 ± 11.3	6.3 ± 0.4
		20	51.6 ± 2.6	30.0 ± 1.5	218.9 ± 10.9	5.5 ± 0.3
		40	48.0 ± 2.4	27.5 ± 1.4	211.7 ± 10.6	5.0 ± 0.3
		60	46.6 ± 2.3	24.4 ± 1.2	204.3 ± 10.2	3.3 ± 0.2
Average			**50.4 ± 2.5**	**28.8 ± 1.4**	**215.1 ± 10.8**	**5.0 ±0.3**
5	5 SRI	Surf.	81.5 ± 4.1	30.2 ± 1.5	198.7 ± 9.9	5.9 ± 0.3
		20	77.2 ± 3.9	27.1 ± 1.4	192.6 ± 9.6	5.8 ± 0.3
		40	71.2 ± 3.6	24.9 ± 1.2	178.4 ± 8.9	4.9 ± 0.3
		60	66.8 ± 3.3	11.5 ± 0.6	175.9 ± 8.8	2.1 ± 0.1
Average			**74.2 ± 3.7**	**23.4 ± 1.2**	**186.4 ± 9.3**	**4.7 ±0.3**
6	6 SRI	Surf.	35.1 ± 1.8	33.3 ± 1.7	393.3 ± 19.7	25.0 ± 1.3
		20	28.8 ± 1.4	28.7 ± 1.4	294.9 ± 15.0	20.7 ± 1
		40	26.3 ± 1.3	24.1 ± 1.2	299.5 ± 15.0	14.8 ± 0.7
		60	23.9 ± 1.2	20.5 ± 1.0	288.3 ± 14.4	13.2 ± 0.7
Average			**28.5 ± 1.4**	**26.7 ± 1.3**	**319.0 ± 16.0**	**18.4±0.9**
7	7 SRI	Surf.	57.6 ± 2.9	33.8 ± 1.7	359.1 ± 18.0	4.3 ± 0.2
		20	50.7 ± 2.6	31.0 ± 1.6	337.7 ± 16.9	4.2 ± 0.2
		40	46.6 ± 2.3	28.2 ± 1.4	330.1 ± 16.5	3.6 ± 0.2
		60	50.4 ± 2.6	31.1 ± 1.6	345.3 ± 17.3	2.8 ± 0.1
Average			**51.3 ± 2.6**	**31.0 ± 1.6**	**343.1 ± 17.2**	**3.7 ± 0.2**
8	8 SRII	Surf.	26.3 ± 1.3	33.9 ± 1.7	328.3 ± 16.4	0.9 ± 0.0
		20	24.5 ± 1.2	33.7 ± 1.7	306.5 ± 15.3	0.7 ± 0.0
		40	23.8 ± 1.2	35.6 ± 1.7	259.6 ± 13.0	0.3 ± 0.0
		60	27.4 ± 1.4	28.1 ± 2.3	312.2 ± 15.6	0.2 ± 0.0
Average			**25.5 ± 1.3**	**32.8 ± 1.9**	**301.7 ± 15.1**	**0.5 ± 0.0**
9	9 SRII	Surf.	14.6 ± 0.7	17.9 ± 0.9	170.7 ± 8.5	9.1 ± 0.5
		20	14.3 ± 0.7	10.9 ± 0.5	208.6 ± 10.4	7.5 ± 0.4
		40	22.0 ± 1.1	25.9 ± 1.3	280.9 ± 14.0	1.4 ± 0.1
		60	12.2 ± 0.6	11.3 ± 0.6	153.3 ± 7.7	1.2 ± 0.1
Average			**15.8 ± 0.8**	**16.5 ± 0.8**	**203.4 ± 10.2**	**4.8 ± 0.2**
10	10 SRII	15 meter	8.9 ± 0.4	11.8 ± 0.6	67.2 ± 3.4	0.6 ± 0.0
Total Average			**32.9**	**22.9**	**225.9**	**5.5**

Conclusion

The following concluding remarks are drawn from results of the present study: Firstly, the radionuclide concentration levels of most natural radioactive elements in the inspected areas are decreasing by increasing the soil depth. For ^{137}Cs, it is found that concentration levels decrease on going deeper in soil. Secondly, the radionuclide concentration levels for natural and artificial radioactive elements are higher for those areas located in the southen part of Hebron province. This might be attributed to some nuclear activities close to the inspected area such as the Israeli Demona nuclear reactor in Negev. Also, it is found that ^{137}Cs concentration is slightly higher around oil lube mineral in site (6) which may be due to chemical reaction taking place inside the oil lube mineral. Finally, all measurements and calculations performed in northen region are lower than the international assigned levels; while many measurements performed in southern Hebron region are higher than the international levels (UNSCEAR, 2000). Accordingly, the obtained results that are above the international assigned reference values are considered as a potential source of danger and as a radioactive polluted resources that could be hazarduoes to the inhabitants in the southern part. Our recommendation to the law makers is that the implementation of an environmental protection rules to reduce radiation pollution is of great importance.

The Radium equivalent for the collected soil was calculated according to the following equation *(Yu K et al., 1992; Van Dijk and De Jong, 1991)*:

$$\mathbf{Ra_{eq} = 1.43\ C_{Th} + C_{Ra} + 0.077C_K\ ,} \qquad \mathbf{(4)}$$

In defining Ra_{eq} activity, it has been assumed that an equivalent activity of 370 Bq/kg for ^{226}Ra or 259 Bq/kg for ^{232}Th or 4810 Bq/kg for ^{40}K can produce the same γ- dose rate (I_γ) reference. The maxium Ra_{eq} value should be 370 Bq/kg in order to keep the external dose 1.5 mGy/yr *(OECD, 1979)*.

(c) The external hazard index (H_{ex}):

The external hazard index H_{ex} due to the emitted gamma rays of the samples is calculated and examined according to the following inequality *(Van Dijk and De Jong, 1991; Ruixiang, 1986)*:

$$\mathbf{H_{ex} = C_{Ra}/370 + C_{Th}/259 + C_K/4810 \leq 1} \qquad \mathbf{(5)}$$

The value of H_{ex} must be lower than unity in order to keep the radiation hazard insignificat. The maximum H_{ex} value of unity corresponds to the limit of 370 Bq/kg for Ra_{eq}, after which the health hazard starts functioning.

(d) Radioactivity Level Index (I_γ)

This index can be used to estimate the level of gamma radiation hazard associated with the natural radionuclides . The radioactivity level index may be defined as *(Ruixiang, 1986)*:

$$\mathbf{I_\gamma = C_{Ra}/150 + C_{Th}/100 + C_K/1500} \qquad \mathbf{(6)}$$

The permissible value of the radioactivity level index (I_γ) is less than unity**.**

The calculated as well as the measured values of D_r, Ra_{eq}, H_{ex} and I_γ parameters of the samples collected from the northen side of Hebron province are shown in Table 3. The average value of all parameters in this region are found to be lower than international levels [D_r = 55 nG/ hr, Ra_{eq} = 370 Bq/kg, $H_{ex} < 1$ and $I_\gamma < 1$].

The different values of D_r, Ra_{eq}, H_{ex} and I_γ of the samples collected from the south part of Hebron province are reported in Table 4. The average values for the most parameters in this region are found to be higher than the assigned international levels .

province (Table 1), and is higher than the international limit and ranged from 61.5 to 1338.1 Bq /kg within an average 447.1 Bq /kg in the southern part of the province as it can be seen from Table 2.

The average concentration for ^{137}Cs were found to range from 0 to 25.0 Bq /kg within an average 5.5 Bq /kg in the northen side of the province (see Table 1), and it is ranged from 0 to 30.2 Bq /kg within an average 7.5 Bq /kg in the southern side of the province (see Table 2).

The average activity concentration levels of ^{238}U series, ^{232}Th series, ^{40}K and ^{137}Cs, measured for the inspected soil samples at different depths are shown in Figures 3, 4, 5 and 6, respectively.

(2) Assessment of Exposure Risk:

Exposures to radionuclides will be occurred either by external irradiation or internal irradiation following ingestion or inhalation of the radionuclides.

(a) The absorbed dose rate (D_r):

The gamma radiation doses for the population living in a rural area is due to the soil content of radionuclides which can be estimated by employing a half-infinite source of a homogenous distribution and by considering only the contribution D_r, from the natural radionuclides in the soil. The convenient formula is given by using the following equation: *(Yu K et al 1992).*

$$\mathbf{D_r = 0.427C_U + 0.662C_{Th} + 0.043C_K}\ \mathbf{,\ nGy/hr} \qquad \mathbf{(3)}$$

where C_U, C_{Th} and C_K are the activity concentration of uranium, thorium and potassium, respectively. The international recommended value for D_r is about 55 nGy/hr *(UNSCEAR, 2000).*

(b) Radium equivalent activity (Ra_{eq}):

The distribution of ^{226}Ra, ^{232}Th and ^{40}K in soil samples is not uniform. The uniformity with respect to radiation exposure has been defined in terms of radium equivalent activity (Ra_{eq}) in Bq/kg and it can be used to compare the specific activity of materials containing different amounts of ^{226}Ra, ^{232}Th and ^{40}K.

Results and Discussion

(1) The activity concentration of radionuclides

The radioactivity concentrations of different identified radionuclides was calculated by gamma rays spectrometry with the following simple regression *(El-Sayed et al, 1997).*

$$C = \frac{Net\ Area(c/s)}{I_\gamma\ \xi\ M}, \qquad Bq/kg. \qquad (2)$$

where C is the activity concentration of the gamma rays spectral line in Bq/kg and M is the mass of sample in kg.

The average values of activity concentration in each specific location in Hebron province are reported in Table 1 (northen region) and Table 2 (southen region). As it can be seen from Table 1, the average of ^{238}U is lower than the international recommended limit (35 Bq/kg) *(UNSCEAR, 1998; UNSCEAR, 2000)* and its concentration levels are found to range from 8.4 to 81.5 Bq /kg within an average 32.9 Bq /kg. On the contrary, as it can be seen from Table 2, the average concentration levels of ^{238}U are found to be higher than the international recommended limit and its concentration levels are found to range from 13.5 to 236.9 Bq /kg within an average 65.6 Bq /kg.

The obtained average concentration levels of ^{232}Th recorded in Table 1, are also found to be lower than the international limit (30 Bq /kg) *(UNSCEAR, 1998; UNSCEAR, 2000)* in the northen side of the province. These values were found to range from 7.3 to 35.6 Bq /kg within an average 22.9 Bq /kg. The concentration levels of ^{232}Th belonging to the southern side are found to be higher than the international limit and ranged from 12.8 to 152.7 Bq /kg within an average 71.3 Bq /kg as seen in Table 2.

The measured average concentration values reprted for ^{40}K have shown that the average concentration is lower than the international limit (400 Bq /kg) *(UNSCEAR, 1998; UNSCEAR, 2000)* and ranged from 67.2 to 393.3 Bq /kg within an average 225.9 Bq /kg in the northen part of the

1- ^{214}Pb (351.9 keV), ^{214}Bi (609.3, 768.4, 934.1, 1120.3, 1238.1 and 1764.8 keV), respectively, and ^{226}Ra (186.2 keV) for the uranium series.

2- ^{228}Ac (209.5, 338.5, 463.0, 911.1 and 2614.7 keV) and ^{214}Bi (727.2, 785.4 and 1620.6 keV) for the thorium series.

3- ^{40}K (1460.8 keV) for potassium.

4- ^{137}Cs (661.3 keV) for cesium.

The brancing ratio (photo peak density) of each peaks was taken into consideration in the activity calculation.

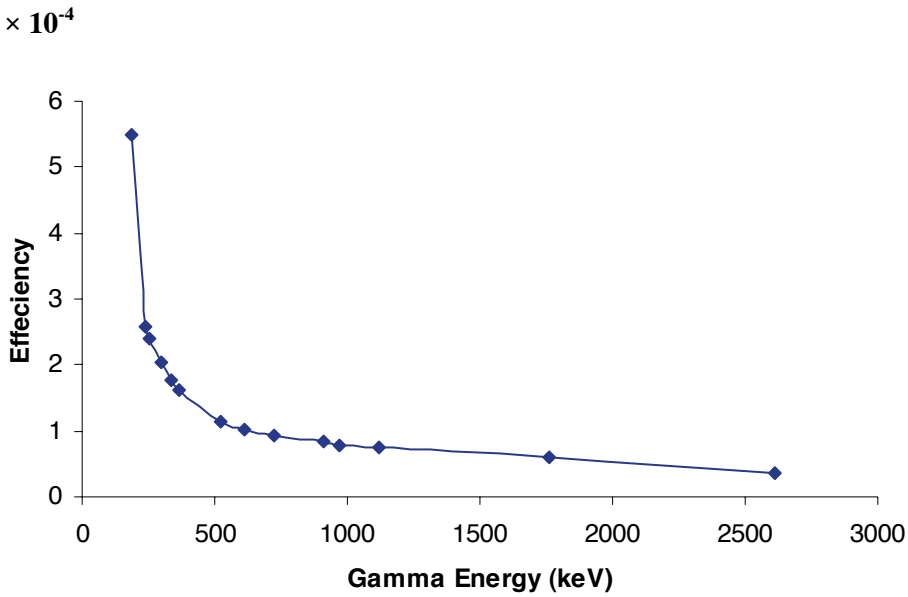

Figure 2: The Photopeak Efficiency of HPGe detector

preamplifier, amplifier, MCA, power supply and Oscilloscope *(Data in Science and Tech., 1991; Klaus and Richard, 1988).*

The detector was surrounded by a cylindrical lead shield to isolate it, with a fixed bottom and movable cover to reduce the gamma rays background from either cosmic rays or terrestrial radiation. The detector has a resolution (FWHM) of 0.9 keV at 122 keV gamma transition of ^{57}Co and 1.9 keV at 1.33 MeV of ^{60}Co gamma transition with Peak- to-Compton ratio of about 62.

The energy calibration of the HPGe detector was performed using the following gamma lines obtained from various gamma standard sources: ^{60}Co (1173.2 and 1332.5 keV), ^{241}Am (59.5 keV), Ra-226 (185.7, 241.92, 295.22, 351.99 and 609.70 keV), respectively, and ^{137}Cs (661.9 keV) *(Knoll, 2000; Helmer, 1982).*

The detection of absolute efficiency of the HPGe detector was determined by using standard ^{238}U with activity 2120.37 Bq (420 gm) and standard ^{232} Th with activity 1333.96 Bq (410 gm). Each of these standard sources was placed in identical polyethylene bottles with the same volume 350 cm^3. The absolute efficiency of the detector for the energy of each gamma rays energy was then calculated from the well known formula:

$$\xi = \frac{Net\ Area\,(c/s)}{A\,I_\gamma} \times 100\%, \quad cps/Bq \qquad (1)$$

where ξ is the photopeak absolute efficiency, Net Area represents the net counts per second (c/s) for the standard, A is the activity of the radionuclides in Bq, and I_γ is the absolute intensity of the gamma transition *(Knoll, 2000; Helmer, 1982; Venturini and Vanin, 1995).*

The calibration curve of the efficiency for HPGe detector by using standard sources of thorium and uranium is shown in Figure 2. The gamma ray transitions used to measure the concentration of the assigned nuclides in the series will be performed as follows *(EML, 1990)*:

Methodology

1- Sample Preparation

Two hundred and fifty-two soil samples, that might be representative of the environmental region of the province, were collected from different areas chosen radndomly around factories, farms, dwellings, old dwellings and breakers. The collected samples were obtained at different soil depths (see Figure 1.b). The collected samples represent various soil samples of different types such as sandy, red (clay soil), white and quarries. The samples were collected using a template 30 X 30 cm^2 in area from surface layer and at depths (20, 40, 60) cm, respectively *(Nancy et al., 1992)*.

Samples were prepared as follows: a sample of about 1kg is taken from a certain collected soil sample. This sample is mixed, homogenized and sieved through 1 mm mesh by a crushing machine *(Goet and Jennifer, 1997)*. The selected samples were then placed for drying at 110 ^0C for 48 hr to ensure the removal of moisture completely from tha sample. Then, samples were placed in polyethylene bottles of 350 cm^3 that were completely sealed and stored for more than one month. This period of time is sufficient to provide the establishment of radioactive equilibrium between ^{238}U and ^{232}Th and their progeny. This step is necessary to ensure that radon gas is confined within the volume and that the disintegrated daughters will also remain in the sample *(Data in Science and Technology, 1991)*. The individual samples were placed on the detector manually for 20 hrs to detect gamma energy lines produced during the disintegration processes of ^{238}U, ^{232}Th , ^{40}K and ^{137}C radionuclides.

2- Calibration

A high-resolution gamma rays spectrometer was used for gamma analysis. Basically, it is a hyper pure germanium detector (HPGe), model No. GMX-13185-P with study a serial No. 33-TNI0424A. The recommended voltage is (-) 3000 V DC. The system also contains the usual electronic components of

radioactive sources are of particular interest as it is the largest contributor to the external dose of the world population (UNSCEAR, 1998).

The aim of the present study is to initiate a radiological assessment program for Hebron province, which is located in the southern-middle of Palestine (see map in Figure1a). At 35 km south of Jerusalem and Hasan area of 1070 kilometers square. The area under consideration was divided into two main regions, namely the northen and the southern parts shown in Figure 1b. The ultimate aim of this study is the establishment of a baseline map of environmental radioactivity concentration levels for this part of the world that can be used as reference to detect any changes in the radioactivity background concentration levels due to any geological changes or natural nuclear activity processes.

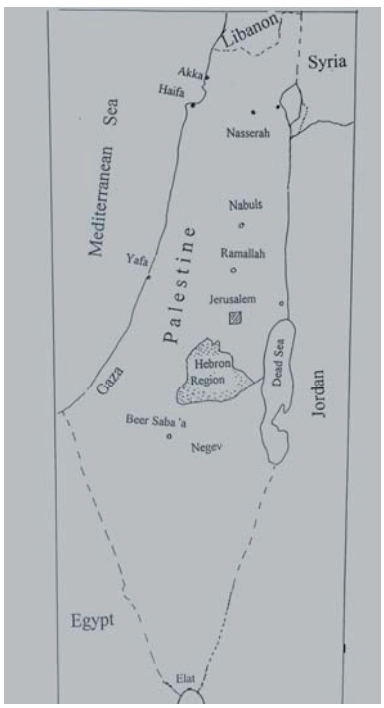

Figure 1.a: Palestine map indicating the location of Hebron province

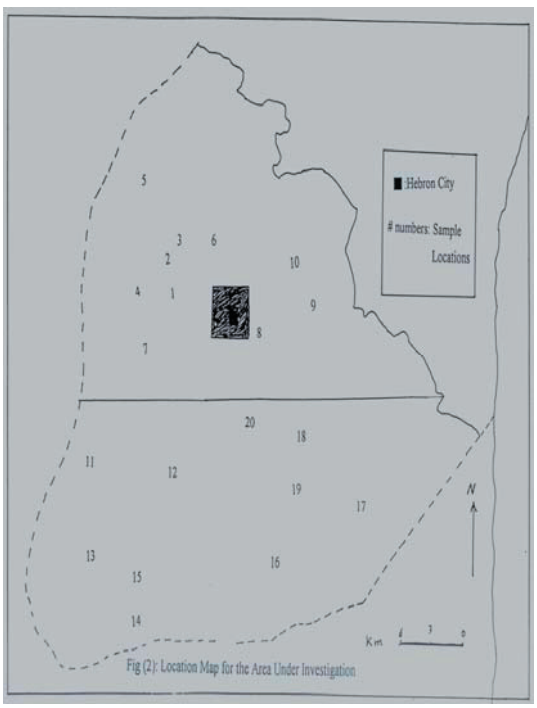

Figure 1.b: Location of the inspected areas

Introduction:

In the environment, natural radionuclides, such as ^{238}U, ^{232}Th and ^{40}K, are present in the earth's crust. Nuclides emitted gamma rays during the decay series of ^{238}U and ^{232}Th as well as the disintegration of ^{40}K. Therfore, composition material of the earth's crust such as soil, building materials and so on, are considered as a major source of external radiation exposure to humans in the environment (UNSCEAR, 1998).

The radioactive decay processes occur either naturally or artificially. The natural radioactivity may be due to cosmic radiation, terrestrial radiation (Uranium and Thorium and its series, Actinium series, and ^{40}K) and natural radioactivity in the human body. The artificial radioactivity may be due to different sources related to non-nuclear processes represented by industrial supply, medicine, nuclear weapons and nuclear technology *(Khan et al., 1992; Bodansky, 1987).*

The soil contains small quantities of uranium and thorium radioactive elements as well as their daughter products and potassium. The concentration of these elements varies considerably depending on the type of soil formation *(Eisenbud and Gesell, 1997).* The soil radioactivity may be diminished by means of the leaching action of moving water and diluted by increasing porosity. The dilution processes are attained by adding water and organic matter.

Calculations of environmental dose levels produced by naturally and artificially radionuclides are of great importance in providing a comprehensive data to be used as an assigned reference of the environmental dose received by humans due to external radiation originating from terrestrial radionuclides having natural origin *(IAEA, 1998; Eisenbud and Gesell, 1997).* Therefore, measurements of natural radioactivity in soil are required to determine any changes of natural background activity with time as a result of any nuclear activity *(IAEA, 1989).* Thus, the assessment of radiation doses from natural

ملخص

لقدتم قياس النشاطية الإشعاعية لعينات من التربة جمعت من عشرين موقعا ومن أعماق مختلفة في منطقة الخليل في فلسطين باستخدام مطيافية جاما. لقد وجد أن متوسط تركيز النويدات ذات النشاط الإشعاعي في هذه العينات لسلسلة اليورانيوم-٢٣٨، سلسلة الثوريوم-٢٣٢، نظير البوتاسيوم-٤٠ ونظير السيزيوم-١٣٧ هو ٩,٣٢، ٩,٢٢، ٩,٢٢٥ و٥,٥ بيكريل/ كغم بالتتابع لشمال منطقة الخليل، بينما وجد أن متوسط التركيز هو: ٦,٦٥، ٣,٧١، ١,٤٤٧ و٥,٧ بيكريل/ كغم بالتتابع لجنوب منطقة الخليل. لقد وجد أن متوسط التركيز في منطقة الشمال أقل من مستوى العالمي، بينما متوسط القياسات للعديد من العينات المأخوذة من جنوب منطقة الخليل أعلى من المستوى المسموح به عالميا، وبالتالي إعتبار هذه المناطق مناطق ذات نشاط إشعاعي مرتفع. كذلك تم تقدير الأضرار الإشعاعية الناجمة عن النشاط الإشعاعي الكلي (الناتج من مختلف النظائر المشعة) في عينات الدراسة، حيث تم حساب الجرعات الإشعاعية نتيجة التعرض الخارجي لإشعاعات جاما المنبعثة من المواد المشعة الطبيعية في التربة، كذلك تم حساب نشاط الراديوم المكافىء (Raeq) لجميع العينات، كما تم حساب معامل الأخطار الخارج (Hex) والذي يعكس مستوى التعرض الخارجي وأخيرا تم حساب معامل مستوى الإشعاع (I_γ) وذلك لتقدير مستوى إشعاع جاما المرتبط بالنويدات المشعة في العينات المدروسة. وبناء على ما سبق سيتم وضع خريطة إشعاعية للمنطقة محل الدراسة وبالتالي فإن ذلك يساعدنا على متابعة أي تغيير يحدث مستقبلا لمثل هذه الخلفية الإشعاعية والتنبؤ بأسبابها و دراسة طرق الوقاية منها. ويعزو سبب وجود تركيزات عالية للسيزيوم في تلك العينات هو نتيجة السقط النووي والناتج عن التجارب والصناعات النووية.

Abstract

The activity concentrations of naturally occurring and man-made radioactive materials in soil samples collected from 20 locations at different depths from the northen as well as the southern parts of Hebron province were measured using gamma-ray spectroscopy. The average of the measured concentrations for ^{238}U series, ^{232}Th series, ^{40}K isotope, and ^{137}Cs isotope in the northen region are found to be 32.9, 22.9, 225.9 and 5.5 Bq/kg, respectively; while in the southern region, the avearge of the mneasured concentration levels are 65.6, 71.3, 447.1 and 7.5 Bq/kg, respectivly. On one hand, the averge of the concentration levels for all inspected nuclides in the northen area are generally found to be lower than the assigned international radioactivity concentration levels. On the other hand, the concentration levels for most nuclides in the southen area are found to be higher than the assigned interntional concentration levels. The investigated zone areas may be classified as high to moderate natural concentration levels. The absorbed dose rates (D_r), the radium equivalent activity (Ra_{eq}), the external hazard index (H_{ex}), and the gamma level index (I_γ) for the soil samples are also investigated. The obtained results may be considered to be as reference values that can be used and as baseline data for drawing a radiological map of the regions under consideration. The presence of ^{137}C in the soil samples is mainly attributed to fall-out of the usage of technological nuclear aspects and artificial nuclear processes.

Key Words: Radioactivity Concentration; Environmental Pollution; Radiation Hazard Indices; Gamma Level; Absorbed Doze Rate.

Environmental Nuclear Studies of Natural and Man-Made Radioactivity at Hebron Region in Palestine

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