

## **Determination of Absorbed Dose Rates One Meter Above Ground Expressed in nGy/h from Average Activity Concentration of $^{40}\text{K}$ , $^{238}\text{U}$ -Series and $^{232}\text{Th}$ -Series in Soil from the North-East Region of Libya**

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### **ABSTRACT**

**For many insoluble radionuclides the primary exposure pathway to the general population is by inhalation. The resuspension of transuranic elements has received considerable attention their measurement in soil is one means of establishing compliance with environmental protection (EPA) guidelines on exposure to transuranic elements.**

**In this work the values of absorbed dose rates one meter above ground for each soil samples site expressed in nGy/h from average activity concentration of K-40, U-238 series, Th-232 series in soil were calculated. These values ranged from 40.4 nGy/h to 101.3 nGy/h with an average of 59.36 nGy/h.**

**The Cs-137 activity was not taken into account because of the limited contribution to the total exposure rate (Julus and Van Donegan, 1985).**

***Keywords: Absorbed dose; Radioactivity; Gamma spectroscopy***

### **INTRODUCTION**

Soil sampling provides useful information for many purposes such as: establishing radiological maps, plant uptake studies, total inventory of various radionuclides in soil due to atmospheric nuclear tests and accumulation of radionuclides as a function of time .And also to assess the radiological hazard of possible changes of soil due to various geological processes or any artificial influences. The presence of long lived radionuclides such as K-40, U-238 decay series, Th-232 decay series in soil results in transfer of these radionuclides to human either directly or by transferring them to plants, thereby enter directly the food chain of animals and indirectly enter the body of human beings through meat and/or milk. Therefore, calculation of absorbed dose rates from soil is essential. This work is the first of its kind in this particular area.

### **EXPERIMENTAL**

#### **Sampling and sample preparation**

Fifty soil samples were collected from the area located about 600 km along the eastern coast of Libya from Benghazi city to the Libyan-Egypton borders as shown on the map. Soil samples were collected by either template or corer method. In corer method two types of corers, with 10.5cm or 7.3cm diameter and 7cm or 25cm in depth were used to take soil samples. Some of the soil samples were made up of four sub-samples when ever possible; the

sub-samples were taken at four corners of 10 m side square. In the template method a 25cmx25cm area sample was cut out using a template for guidance to a depth of 5cm.

Samples of both methods of collection were weighed individually, oven dried at 110°C for 48 hours (Julus and Van Donegan 1985, Chu, Weng, Lin 1989 and Aulay, and Moran, 1988), and weighed again to determine the water content, then the samples were pulverized, homogenized, and sieved to pass through 2mm mesh. The meshed soil samples were transferred to marinelli beakers (100 or 1000 ml capacity) for gamma activity analysis. Each soil sample was weighed and carefully sealed for four weeks to reach secular equilibrium between Ra-226 and Th-232 and their respective progeny (Julus and Van Donegan 1985, Mollah, Kodlus and Husain, 1987 and UNSCEAR, 1993).

The activity of Bi-214 and Pb-214 in equilibrium with their parents was assumed to represent the U-238 activity. While the activity of Ac-228 was assumed to represent the activity of Th-232.

### Gamma spectroscopy measurements

Measurement of radioactivity of the samples was carried out using gamma spectrometric techniques. A high resolution gamma ray spectrometer was used. This measuring system is composed of hyper-pure germanium detector Tennelec model CPCVS 30-30195 (active volume 155cc) with 30% photopeak efficiency and a 1.95 keV FWHM for 1.33 MeV of Co-60 gamma transition.

Gamma transitions of 351.9 keV ( $^{214}\text{Pb}$ ) 609.3 keV 768.4 keV 1120.3 keV and 1764.5 keV ( $^{214}\text{Bi}$ ) were used to represent  $^{238}\text{U}$ -series concentration. While the gamma transition of 338.4 keV ( $^{228}\text{Ac}$ ) 583.1 keV ( $^{208}\text{Ti}$ ) 795.0 keV 911.1 keV ( $^{228}\text{Ac}$ ) and 968.0 keV ( $^{228}\text{Ac}$ ) were used to represent  $^{232}\text{Th}$  and their respective progeny (Marouf, Mohamad, Taha and Al-Haddad 1992).

The 1460 keV gamma transition was used to represent  $^{40}\text{K}$  concentration and 661.66 keV gamma transition was used to represent the  $^{137}\text{Cs}$ .

## RESULTS AND DISCUSSIONS

### a. Specific activity

Soil samples were collected from locations shown in figure (1). The determined values of activity concentration in Bq/kg dry weight for the analyzed soil samples are summarized in table (1).

The activity concentration of K-40 in soil ranged from a low value of 198.2 Bq/kg to a high one of 858.7 Bq/kg with an average of 535.9 Bq/kg dry weight of soil. The activity concentration of U-238 series in soil ranged from a low value of 21.0 Bq/kg to a high one of 48.7 Bq/kg with an average of 31.9 Bq/kg dry weight of soil.

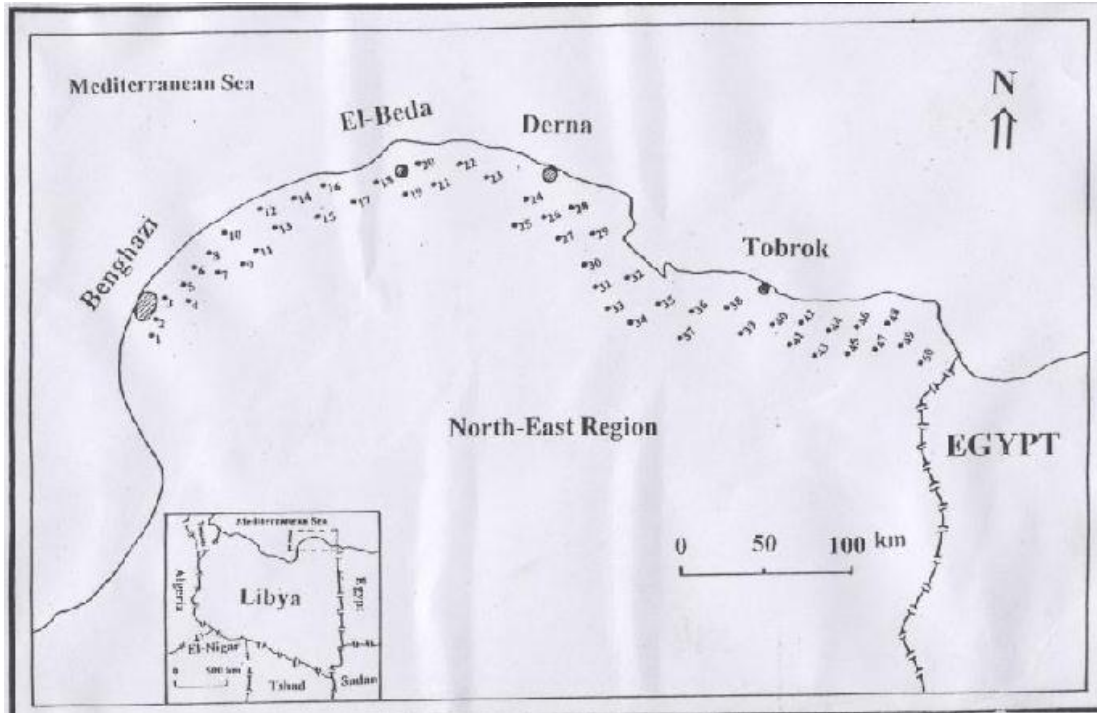


Figure (1): Map of soil samples location sites

The activity concentration of Th-232 series in soil ranged from a low value of 18.7 Bq/kg to a high one of 67.8 Bq/kg with an average of 33.6 Bq/kg dry weight of soil.

**b. absorbed dose rates**

The values of absorbed dose rates one meter above ground for each soil sample site expressed in nGy/h from average activity concentration of K-40, U-238 series and Th-232 series in soil were calculated using the following equation:-

$$D = R_k C_k + R_u C_u + R_{th} C_{th}$$

Where,

D is the absorbed dose rate;  $R_k$ ,  $R_u$ , and  $R_{th}$  are the conversion factors, expressed in absorbed dose rate unit per activity unit per mass unit. Conversion factors for absorbed dose rate are given in table (2) ( Mollah, Kodlus and Husain, 1977).

$C_k$ ,  $C_u$  and  $C_{th}$  are the concentrations of K-40, U-238 series and Th-232 series respectively, expressed in Bq/kg dry weight of soil.

The calculated values of absorbed dose rates ranged from 40.4 nGy/h to 101.3 nGy/h with an average of 59.36 nGy/h these values are presented in table (3) and illustrated in figure (2).

TABEL (1): Concentration of radionuclides in soil Bq/kg

	<sup>40</sup> K	<sup>238</sup> U	<sup>232</sup> Th	<sup>137</sup> Cs
1	660.9±21.9	29.4±1.4	31.9±2.3	10.4±1.0
2	638.6±32.5	32.5±1.1	43.9±1.5	9.6±0.4
3	780.3±25.6	41.7±2.2	48.2±2.6	9.7±0.9
4	754.0±11.9	44.1±0.8	50.1±0.8	9.3±0.3
5	744.0±47.5	47.5±2.2	49.2±2.8	9.2±0.9
6	725.8±14.4	43.9±1.2	48.5±1.5	8.5±0.4
7	644.1±25.9	42.7±2.8	51.7±2.9	9.4±1.1
8	688.0±14.4	41.9±1.2	50.1±1.6	9.8±0.5
9	845.0±33.6	48.7±3.3	61.2±1.8	9.3±0.9
10	830.0±37.0	48.7±3.3	61.2±1.8	9.3±0.9
11	858.7±32.7	44.0±3.4	60.2±3.6	5.9±1.0
12	807.1±12.7	38.0±0.8	58.8±1.1	5.4±0.2
13	669.6±15.2	43.8±2.6	43.3±3.5	10.36±1.1
14	714.0±15.2	46.4±1.3	52.8±1.7	10.8±0.5
15	714.6±13.6	48.3±1.2	51.8±1.5	8.9±0.4
16	711.0±14.3	47.0±2.1	50.1±1.3	7.4±0.4
17	223.4±8.1	42.0±1.3	28.2±1.2	13.1±0.6
18	234.3±7.5	39.8±1.4	30.3±1.5	9.6±0.6
19	213.5±7.1	38.9±1.0	24.5±1.1	11.6±0.5
20	198.2±6.6	36.4±1.0	25.5±1.0	13.6±0.5
21	475.4±19.3	29.2±1.9	29.3±2.5	6.4±0.7
22	483.8±26.6	23.5±2.5	29.1±2.9	7.3±1.0
23	485.0±25.6	26.7±2.1	29.4±2.8	8.4±1.0
24	488.8±11.2	26.6±0.9	27.8±1.2	7.8±0.4
25	452.2±20.9	27.5±2.1	24.6±2.2	12.4±1.0
26	475.2±23.9	23.6±1.9	26.0±2.5	12.0±1.0
27	462.3±22.2	24.3±2.3	26.9±2.9	11.5±0.9
28	392.5±10.6	25.2±0.9	21.3±1.0	10.5 ± 0.5
29	34211±23.33	28.9±3.33	26.63±2.50	10.74±0.54
30	380.2±9.00	26.3±1.2	23.0±1.1	9.3±0.4
31	463.6±27.8	22.4±3.4	22.9±3.41	13.8 ±1.5
32	433.6 ±21.8	25.0± 2.0	20.5± 2.1	12.8±1.0
33	430.0 ±22.0	21.0± 3.2	19.5±2.3	10.2±0.9
34	486.2 ±24.50	26.8±2.20	18.7±2.0	9.6±0.9
35	506.70±15.2	25.3±1.4	22.0±1.7	13.4±0.7
36	520.3±14. 1	26.2±1.6	22.7±1.9	12.5±0.9
37	510.4±16.6	23.9±1.9	24.3±1.6	13.6±0.5
38	495.6±18.3	27.2 ± 2.4	24.2±1.8	11.7±1.1
39	502.3±24.3	22.7±2.3	20.8±1.9	11.9±1.1
40	510.4±16.3	24.0±2.01	26.1±1.4	12.4±0.9
41	508.5±22.3	23.2±2.0	25.9 ±2.30	11.42±0.9
42	506.7±15.2	25.2±1.4	22.0±1.7	13.4±0.7
43	713.4±11.9	27. 3±0.8	33.9±1.1	13.1± 0.3
44	522.9±11.4	23.9±0.9	24.8±1.0	17.8±0.5
45	545.3±12.4	28.0±1.21	29.6±2.6	16.2 ±0.8
46	515.3±1.2	23.5±1.8	23.6±1.6	19.1±0.9
47	534.9±11.4	24.8 ± 2.2	24.2±1.0	19.7±0.6
48	446.8±18.0	23.8±1.6	25.3±1.7	13.3±0.7
49	539.2±8.4	23. 8±0.6	24.8 ±0.6	19.8±0.4

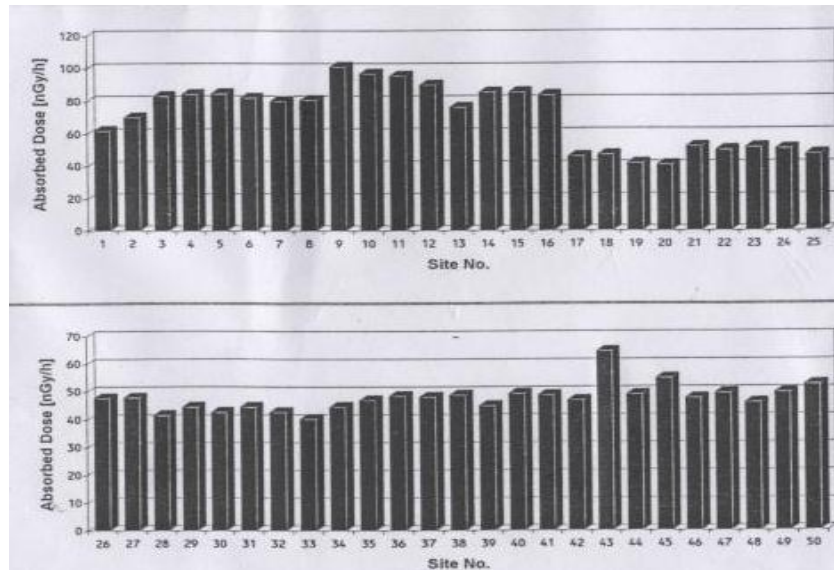
50	513.7±38.9	21.1±3.1	32.6±4.3	19.0±2.1
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TABLE (2): CONVERSION FACTORS FOR ABSORBED DOSE RATES IN AIR 1m ABOVE THE GROUND SURFACE.

Radionuclide or decay series	Dose rate $10^{-10}\text{ Gy h}^{-1}$ per $\text{Bq kg}^{-1}$	Average concn. in soil ( $\text{Bq kg}^{-1}$ )	Absorbed dose rate in air ( $10^{-8}\text{ Gy h}^{-1}$ )
K-40	0.43	370 (100-700)	1.6 (0.43-3.0)
U-238	4.27	25 (10-50)	1.1 (0.4-2.1)
Th-232	6.62	25 (7-50)	1.7 (0.5-3.3)

TABLE (3): ABSORBED DOSE RATE (nGy/h) OF SOIL SAMPLES.

Site No.	Absorbed Dose	Site No.	Absorbed Dose
1	62.1	26	47.7
2	70.4	27	48.1
3	83.3	28	41.8
4	84.5	29	44.7
5	84.8	30	42.8
6	82.1	31	44.7
7	80.1	32	42.9
8	80.7	33	40.4
9	101.3	34	44.7
10	97.02	35	47.1
11	95.58	36	48.6
12	89.9	37	48.2
13	76.3	38	48.95
14	85.5	39	45.1
15	85.6	40	49.5
16	83.8	41	48.9
17	46.2	42	47.1
18	47.2	43	64.9
19	42.1	44	49.2
20	40.9	45	55.0
21	52.3	46	47.8
22	50.1	47	49.6
23	51.7	48	46.1
24	50.8	49	49.8
25	47.5	50	52.7



**Figure (2): Average values of the absorbed dose rates 1 m above ground for soil samples sites**

### REFERENCES

- B.A Marouf, A.S. Mohamad, J.S. Taha and K. Al-Haddad (1992): "Population doses from environmental gamma radiation in Iraq" *Health physics* vol. 62 No.5 pp 443-444.
- Chu T.C., P. W. Weng and Y. m. Lin (1989) : "Changes in Capita and collective dose equivalent due to natural radiation in Taiwan (1950, 1985) " *Health physics* vol. 56 pp 201-217.
- Mc. Aulay I. R, and Moran D.(1988) "Natural radioactivity in soil in the republic of Ireland " *Radiation Protection Dosimetry* 24(1/4) ,47 - 49.
- Mollah S. Rahman, N. M. Kodlus and M. A. Husain (1987): "Measurement of high natural background radiation levels TLD at Cox & Bazar coastal areas in Bangladesh" *Radiation protection dosimetry*, 18(1): 39-41.
- Julus H.W and Van Dongan R. (1985): "Radiation doses to the population in the Netherland, due to external natural sources" *Sci. Total Environ.* vol. 45 pp 449-458.
- UNSCEAR (1993) "Exposure from Natural Sources of Radiation – United Nation Scientific Committee of Effects of Atomic Radiation", Report to General Assembly.