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Measurement of Radium Equivalent Activity from Natural Occurring Radionuclides in Soil in the East Coast of Libya

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Highlights

- **The measurement of the concentration of background radionuclides in soil in the East Coast of Libya indicated that the levels of the average activity to be within world average.**
- **It is observed that the concentrations of naturally occurring radionuclides increase with increasing altitude of the sample site locations.**
- **There is good correlation between soil structure and radioactivity content especially grain size.**
- **Radioactivity from natural occurring radionuclides is present everywhere at different levels, which could be attributed to geological and geographical conditions.**

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ABSTRACT

The technological development, using atomic, and nuclear energy in industry, agriculture, nuclear medicine, nuclear wars and tests may increase environmental pollution with noticeable concentrations of man-made radionuclides in the environment. This experimental work aims at the determination of radium equivalent activity from the soil samples collected from sites extending from Benghazi city to the Libyan-Egyptian borders, along 600 km. Samples collected from fifty chosen sites, kept for four weeks to get a secular equilibrium between ^{226}Ra and ^{232}Th and their corresponding daughters. The result indicated that the value of radium equivalent (Ra_{eq}) ranged from 208.919 to73.881 Bq/kg, with an average of 117.587 Bq/kg

1. Introduction

Industry and all form of life on earth have been unavoidably exposed to radiation from all kind of sources. Exposer to natural sources vary little from year to year and involves the whole world population to almost the same extent. The exposure dose from natural sources depends mainly on the place of residence, and altitude. For most world population, the range of individual effective dose from natural sources is between one-half and two times the average global value at sea level which is 2.4 *mSv per year* (UNSCEAR, 1988).

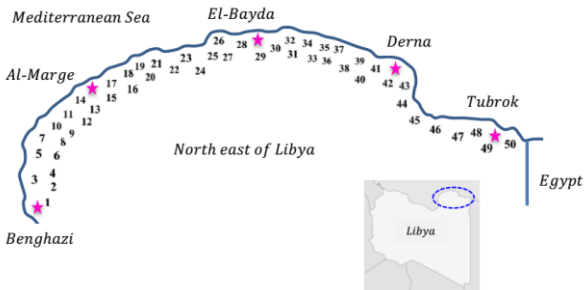

Fig. 1. Shows the sites of collected samples in the area extended from Benghazi city to the Libyan-Egyptian borders

Study of natural radiation background and exposure of human beings are of great importance, not only for practical reasons but also for the radiological impact of nuclear activities. Radioactivity is present everywhere due to geological and climate conditions. The activities of mankind may also enhance the level of radioactivity in our world. Radiation comes from different sources; mainly, electromagnetic rays such as gamma-ray emitters in soils, water, food, building materials, and air. Levels of radionuclide distribution in the environment have been studied providing essential radiological information. Soils may contain a significant amount of radioactivity. Several studies worldwide have measured the activity concentration of natural radionuclides in soil and gave valuable information about the levels of contamination (Quinds *et al.*, 1994; Taiwo *et al.*, 2014). A number of human activities contribute to our natural radiation environment and may result in the production of radioactive nuclides (Scholten *et al.*, 2005; Malik, 1994). Ingesting and inhaling such levels of radionuclides contribute significantly to the radiation dose that people receive (Saleh, *et al.*, 2007).

2. Sampling Procedures

Soil samples were collected from the fifty chosen sites shown in Fig. 1, using template a 25 cm×25 cm area sample was cut out using the template for guidance to a depth of 5 cm. Each sample was air-dried to avoid loss of radionuclides (IAEA, 1989). The dried samples each were thoroughly ground to ensure equal representation of samples. The samples were transferred to plastic Marinelli beakers (100 or 1000 ml capacity) made to fit on the high purity germanium detector. Each sample was sealed with adhesive tape and left for 21 days for the short-lived radionuclide to allow radon and its short-lived progenies attain secular equilibrium. Samples were analyzed by high-resolution gamma-ray spectroscopy using high purity germanium detector type Tennelec model CPCVS 30-30195 (active volume 155cc) with 30% photo peak efficiency and 1.95 keV FWHM for 1.33 MeV of Co-60 gamma transition connected

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to an Ortec series multichannel analyzer (MCA). The gamma-ray spectrometer is coaxial of vertical configuration and consists of a preamplifier, a linear amplifier, an analog-to-digital converter (ADC).

3. Radium Equivalent Activity Calculations

To assess the radiological hazard of possible changes of soil due to various geological processes or any artificial influences, it is useful to calculate an index called radium equivalent Ra_{eq} expressed in Bq/kg. The radium equivalent Ra_{eq} is defined according to the estimation that 10 Bq/kg of ^{226}Ra, 7 Bq/kg of ^{232}Th and 130 Bq/kg of ^{40}K produce the same ɤ-ray dose. (Beretka *et al.*, 1985; El-Tahawy *et al.*, 1992). The radium equivalent (Ra_{eq}) expressed in Bq/kg was calculated using the following equation:

$$Ra_{eq}(Bq.kg^{-1}) = A_{Ra} + 1.43\, A_{Th} + 0.077\, A_K$$

Where A_{Ra}, A_{Th} and A_K are the activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K, respectively, in this calculations we used ^{238}U for (^{226}Ra), ^{232}Th and ^{40}K radionuclides. (Girigisu *et al.* 2013; Darwish *et al.*, 2015). The results are shown in Table 1 where maximum and minimum values are shown in bold.

Table 1.

Concentration of radionuclide in soil Bq/kg and Radium equivalent

Site No.	^{40}K	^{238}U	^{232}Th	Radium equivalent (Ra_{eq}Bq/kg)
1	660.9±21.9	29.4±1.4	31.9±2.3	125.906
2	638.6±32.5	32.5±1.1	43.9±1.5	144.449
3	780.3±25.6	41.7±2.2	48.2±2.6	170.709
4	754.1±11.9	44.1±0.8	50.1±0.8	173.809
5	744.0±47.5	47.5±2.2	49.2±2.8	175.144
6	725.8±14.4	43.9±1.2	48.5±1.5	169.142
7	644.1±25.9	42.7±2.8	51.7±2.9	166.227
8	688.0±14.4	41.9±1.2	50.1±1.6	166.519
9	845.0±33.6	46.9±3.3	67.8±4.3	**208.919**
10	830.0±37.0	48.7±3.3	61.2±1.8	200.126
11	858.7±32.7	44.0±3.4	60.2±3.6	196.206
12	807.1±12.7	38.0±0.8	58.8±1.1	184.231
13	669.6±28.9	43.8±2.6	43.4±3.5	157.421
14	714.0±15.2	46.4±1.3	52.8±1.7	176.882
15	714.6±13.6	48.3±1.2	51.8±1.5	177.398
16	711.0±14.3	47.0±2.1	50.1±1.3	173.390
17	223.4±8.1	42.0±1.3	28.2±1.2	99.528
18	234.3±7.5	39.8±1.4	30.3±1.5	101.170
19	213.5±7.1	38.9±1.0	24.5±1.1	90.375
20	198.2±6.6	36.4±1.0	25.5±1.0	88.126
21	475.4±19.3	29.2±1.9	29.3±2.5	107.705
22	483.8±26.6	23.6±2.5	29.1±2.9	102.466
23	485.0±25.6	26.7±2.1	29.4±2.8	106.087
24	488.8±11.2	26.6±0.9	27.8±1.2	103.992
25	452.4±20.9	27.5±2.1	24.6±2.2	97.513
26	475.2±23.9	23.6±1.9	26.0±2.5	97.370
27	462.3±22.2	24.3±2.3	26.9±2.9	98.364
28	392.5±10.6	25.2±0.9	21.3±1.0	85.882
29	475.4±19.3	27.5±2.1	24.5±1.1	99.141
30	483.8±26.6	23.6±1.9	25.5±1.0	97.318
31	475.0±25.6	26.6±0.9	29.3±2.5	105.074
32	234.3±7.5	23.6±2.5	29.1±2.9	83.254
33	457.4±20.9	26.7±2.1	29.4±2.8	103.962
34	475.4±19.3	26.6±0.9	23.8±1.2	97.240
35	383.8±26.6	27.5±2.1	23.6±2.3	90.801
36	385.0±25.6	23.6±1.9	26.0±2.5	90.425
37	388.8±11.2	24.3±2.3	24.9±2.8	89.845
38	352.4±20.9	24.2±0.9	21.3±1.0	81.794
39	383.8±26.6	27.5±2.1	24.5±1.1	92.088
40	385.0±25.6	23.6±0.9	22.5±1.0	85.420
41	388.8±11.2	23.5±2.1	28.3±2.5	93.907
42	252.4±20.9	23.6±1.9	29.1±2.2	84.648
43	235.4±19.3	22.3±2.3	29.4±2.8	82.468
44	383.8±26.6	22.2±0.9	25.8±1.2	88.647
45	385.0±25.6	22.5±2.1	24.4±2.2	87.037
46	298.8±11.2	21.6±1.9	26.5±2.5	82.503
47	252.4±20.9	21.3±2.3	24.2±2.9	75.341
48	283.8±26.6	22±0.9	21.3±1.0	74.312
49	285.0±25.6	20.5±2.1	22.9±2.9	75.192
50	288.6±11.2	21.2±0.9	21.3±1.0	**73.881**

4. Results and Discussion

The efficiency calibration of HpGe-detector was achieved using ^{226}Ra source and KCl solutions of different concentrations (El-Tahawy *et al.* 1992) and reference materials (RM) obtained from the Analytical Quality Control Service (AQCS) of the International Atomic Energy Agency (IAEA).

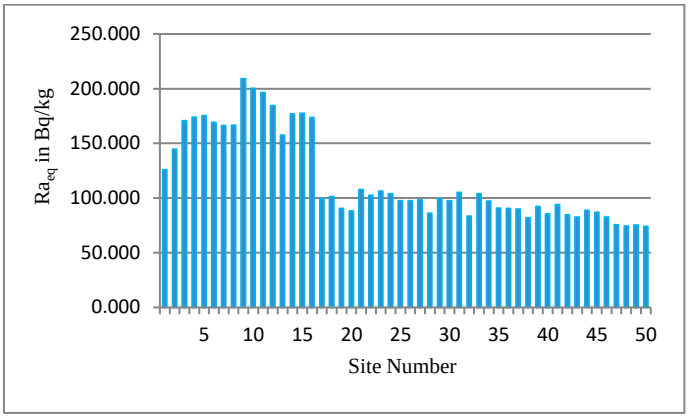

Fig. 2. The Radium Equivalent Activity and their Respective Site Locations

Fig. 2. Radium equivalent activity plotted against the site number. It is observed that the calculated radium equivalent in soils is lower than the allowed maximum value of 370 Bq/kg.

5. Conclusion

The calculated radium equivalent activity in fifty (50) soil samples collected from the East Coast of Libya have been investigated as part of the radiological impact of natural radionuclides. These in addition to man-made radionuclides behave differently in environmental samples according to sample type, and nature; for example in soil their behavior depends mainly on the rocks from which soil is formed (IAEA, 2003). Furthermore, the increase in the value of radium equivalent in samples from 1 to 9 can be attributed to the type of soil in that area. Samples from 9 to 16 have higher values than all other samples which may be due to the relative abundance of rocks from which soil is formed since this area is the Green mountain area the reason is that potassium-40 and radionuclides of uranium and thorium series contribute most of the naturally occurring radioactivity in rocks (Zebracki *et al.*, 2015).

Distribution of uranium and thorium depends upon the geological history of the rock, and the abundance of radioactive elements. From our measurements, it was found that the maximum value for the radium equivalent activity is 208.919 Bq/kg which was obtained from sample 9 as shown in Fig. 2 and tabulated in Table 1, and it is within the maximum allowed world average value of 370 Bq/kg. This study could be used as baseline data for a radiological map for the East Coast of Libya.

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