Evaluation of Natural Radioactivity in Different Regions in Sudan

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Abstract: The aim of this study is to evaluate and describe Natural Radioactivity In Different Regions in Sudan.In this work the concentration of radioactive and trace elements is determined in different regions, having different locations, basements, morphology as well as climates. Soil analysis was made by Gamma spectrometer, while Laser Flourimetry was utilized for uranium (U) and for trace elements Inductive Coupled Plasma (ICP) is used. The analysis indicates that the concentration of radioactive elements is high at Mountains except in the Middle of the Sudan. The radiation dose rates in air are at the normal level except at Nubian areas (south of the central Sudan). The results obtained from the present work provide additional data on the Natural Radioactivity In Different Regions in Sudan. The dose rate in air in northern and central regions of Sudan is in arranged which is recommended by IAEA and WHO. At east and south of the Sudan are observed high radioactivity and radiation background.

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1. Introduction

After the discovery of radioactivity in 1896 by A. H. Becquerel (Allisy., 1996), the science of radioactivity is extensively studied. Radionuclides are the sources of radioactivity and emit nuclear radiations, which have become a part of our daily lives.

The most common forms of ionizing radiation are alpha particles, beta particles and gamma rays(Lilley., 2001),. The properties of radiations have been widely applied to various purposes such as medicine, biology, industry, agriculture, and electric power generation (Eisenbud, and Gesell., 1997). Because of the different applications of radiation in human life, humans can be exposed to the radiation emitted from different radioactive sources depending upon their activities and surroundings (Klement., 1982), . However, not all of the population is subjected to all the various sources of radiation exposure. For instance, patients who are treated with medical irradiation or members of staff who work in the nuclear industries may receive higher radiation exposure levels than members of public Watson, et al .,2005).

The most obvious radiation sources to which all individuals are exposed (both in working and public environments) are the ionizing radiation arising from radionuclides in the earth's surroundings and the interaction of cosmic rays on the earth's atmosphere(UNSCEAR., 2000). According to the National Council on Radiation Protection and Measurements Report (NCRP) No.45, the most significant source of radiation exposure to humans is due to natural radiation in the environment (NCRP., 1975),. This exposure to naturally occurring radiation also accounts for up to 85% of annual exposure dose received by the world population,(World Nuclear Association., 2011),. The International Atomic Energy Agency (IAEA) reports that the exposure from natural radiation is, in most cases, of little or no concern to the public, except those working with mineral ores and naturally occurring radioactive material (*NORM*). Nevertheless, the World Nuclear Association (WNA) states that any dose of radiation involves a possible risk to human health . In order to protect the general public health against the radiation risk originating from naturally occurring radiation, the measurement of radioactivity in the environment needs to be considered to assess the biological effect on the human. This has also become the focus of greater attention by the IAEA in recent years (IAEA., 2005).

Apart from the exposure from direct cosmic rays and cosmogenic radionuclides, natural exposures arise mainly from the primordial radionuclides that spread widely and present in almost all geological materials in the earth's environment(Wilson., 1994).

The majority of naturally occurring radionuclides belong to the radionuclides in the 238U and 232Th series, and the single decay radionuclide, 40K (IAEA., 2003).

The specific levels of the radioactivity of various soils are related to the nature of the parent rock from which the soils are derived and the process of soil formation (NCRP., 1977),.

The aim of this study was to evaluate and describe Natural Radioactivity

In Different Regions in Sudan

2. Material and Methods

2.1Region Selection:

To give realistic picture to the whole country, the samples are taken from Dongola that represent the northern, as well as desert region of Sudan. El-Burkal area also stands for the north, but the basement, unlike in Dongola is dominated by rocks and hills. In the middle of Sudan Jabel El-Awlia area is dominated by hills, while El-Jazira region is a valley dominated by mudy soil.

The middle area also represents tropical region. The equatorial region as well as west sector is represented by three different places Jabel Mernna, Jabel Kurrun and Ouro area in which crust is dominated by rocks and hills.

All samples are analyzed in Cairo at National Atomic Energy Authority labs. The time elapsed between samples collection and performing measurements ranges from 20-50 days. The Gamma spectrometer was utilized to measured U-235 and K-40 activity in soil.

2.2Experimental Work:

The aim of this work is to find the concentration of radioactive nuclides. To perform this task, samples are collected from different regions having different locations, basement, morphology and climates. This very special selection choice was made to give a more realistic picture about radiation and concentration in Sudan.

3. Results

The aim of this work is to evaluate and describe Natural Radioactivity in Different Regions in Sudan. The samples were prepared and stored prior to measurement. The radioactivity measurement was then performed.

Table(1) Shows radioactivity concentration levels that are for 226Ra, (^{238}U) series, ^{232}Th series and ^{40}K

Sample No.	Radioactivity (Bq /kg)		
	Th	U	K
1	23.22± 1.7	16.03 ± 1.9	412.5 ± 4.0
2	23.28 ± 3.9	17.22 ± 3.8	323.36 ± 13.4
3	18.82 ± 10.5	14.71 ± 1.54	302.3 ± 10.3
4	11.6 ± 4.6	11.44 ± 1.8	305.5 ± 13.6
5	30.45 ± 4.2	23.95 ± 3.6	365.11 ± 15.9
6	10.6 ± 2.9	7.38 ± 3.9	246.8 ± 13.6
7	20.71 ± 2.1	22.71 ± 1.7	317.3 ± 12.6
8	18.65 ± 4.5	14.2 ± 3.0	287.9 ± 10.7
9	11.5 ± 3.2	7.8 ± 1.4	253.8 ± 10.0
10	17.36 ± 2.7	12.97 ± 2.5	219.7 ± 7.0
11	13.04 ± 2.7	15.25 ± 4.2	210.95 ± 6.7
12	14.11 ± 1.38	10.22 ± 2.2	180.13 ± 4.9
13	6.2 ± 2.1	31.88 ± 5.9	11.3 ± 3.8
14	39.18 ± 1.8	19.19 ± 2.0	21.77 ± 4.6
15	10.38 ± 6.0	9.65 ± 7.6	< D.L
16	24.34 ± 4.4	16.62 ± 6.5	18.25 ± 7.2
17	70.5 ± 9.7	23.2 ± 8.9	1253.3 ± 24.7
18	17.11 ± 7.6	30.68 ± 3.5	1214.5 ± 32.7
19	25.65 ± 9.8	316.84 ± 18.2	173.73 ± 15.4
20	14.2 ± 3.1	32.6 ± 8.7	66.0 ± 8.7
21	< D.L.	652.37 ± 6.42	75.61 ± 8.64
22	< D.L.	459.89 ± 4.55	115.57 ± 6.27
23	< D.L.	1411.51 ± 7.34	< D.L.
24	< D.L.	1154.36 ± 10.58	45.55 ± 11.87
25	73.39 ± 4.2	32.6 ± 8.7	66.0 ± 8.7
26	< D. L.	25.5 ± 2.2	1061.92 ± 20.4
27	17.13 ± 3.4	79.43 ± 4.4	176.3 ± 5.96
28	34.82 ± 4.14	155.43 ± 4.5	291.54 ± 9.9
29	24.59 ± 4.7	140.27 ± 5.9	281.21 ± 13.8
30	11.25 ± 1.3	16.94 ± 1.4	277.7 ± 13.7
31	18.14 ± 5.02	16.73 ± 2.9	325.4 ± 16.5
32	13.4 ± 2.0	10.2 ± 1.5	336.8 ± 4.4
33	3.32 ± 0.3	17.48± 2.8	33.84 ± 3.3
34	15.489 ± 2.82	15.52 ± 5.66	< D.L.
35	48.94 ± 2.4	11.50 ± 1.78	924.75 ± 9.5
36	35.1 ± 2.11	21.4 ± 2.9	661.7 ± 9.9

Figures (1-10) show radioactivity concentration levels which are for 226Ra (^{238}U) series, ^{232}Th series and 40K.

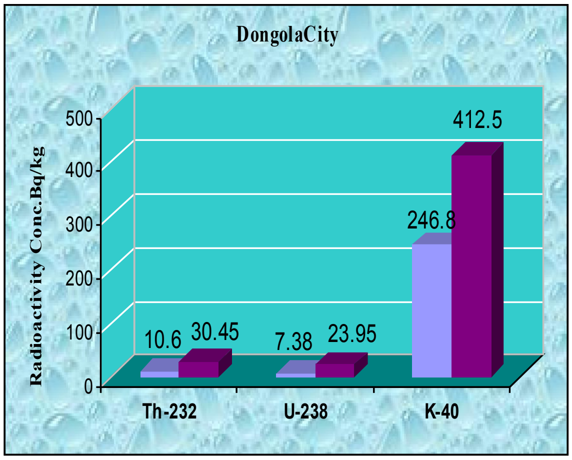
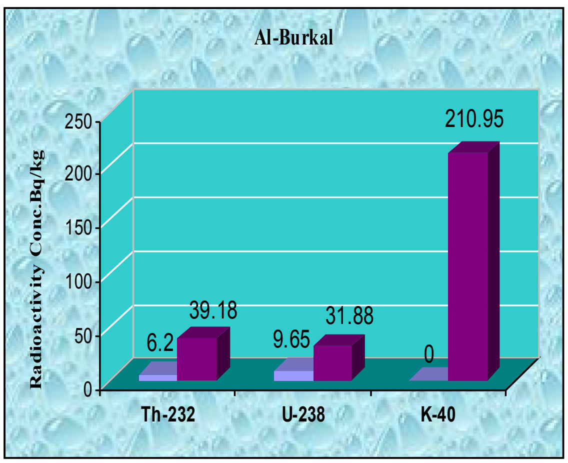


Fig.(1)



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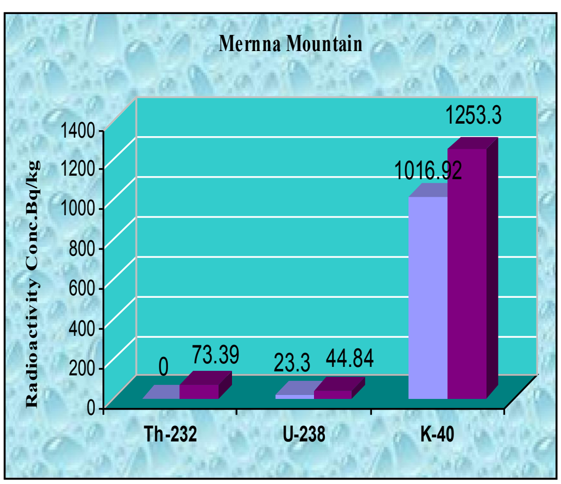

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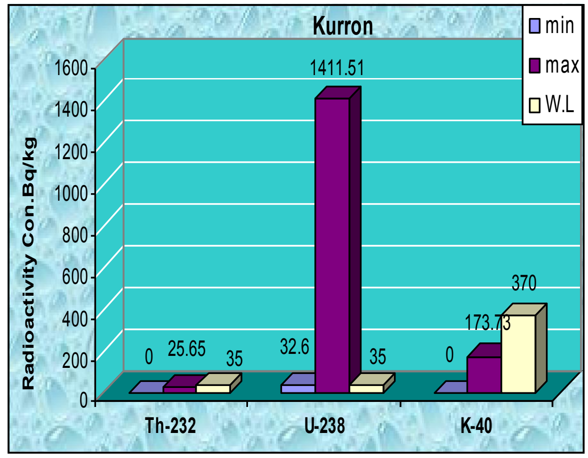

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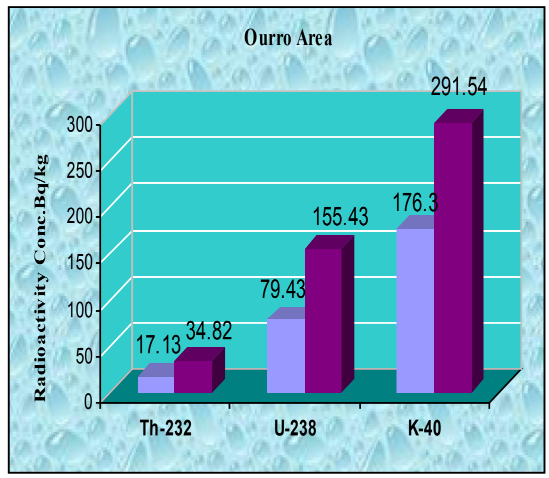

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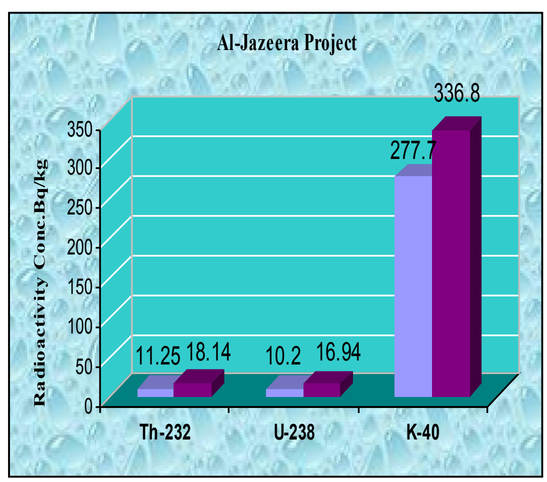

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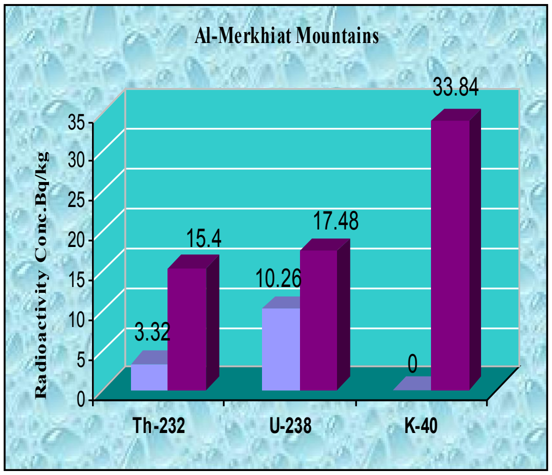

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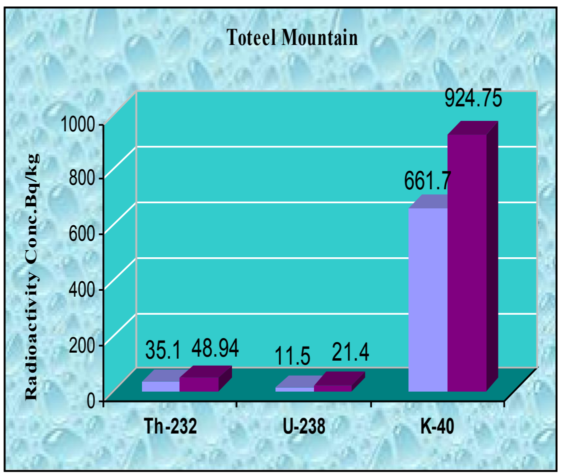

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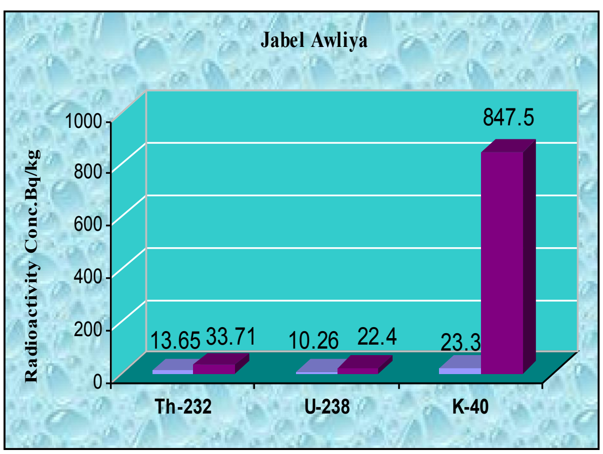

Fig.(9)

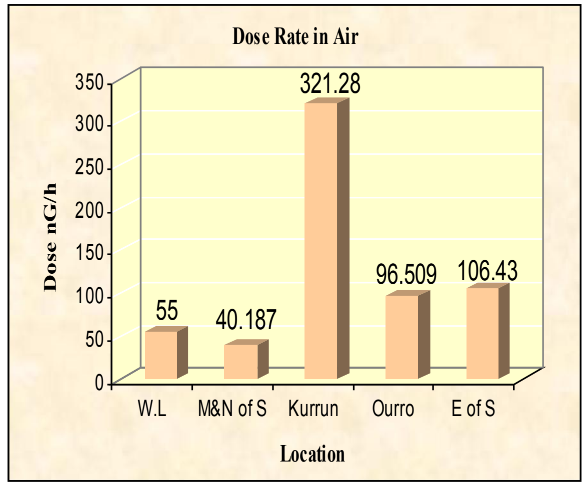

Fig.(10)

4. Discussions

This study revealed that the radioactivity concentration of ^{232}Th series, ^{226}Ra (^{238}U) and ^{40}K series are from 10.6Bq/kg to 30.45 Bq/kg, and from 7.38 Bq/kg to 23.95 Bq/kg, and from 246.8 Bq/kg to 412.5 Bq/kg dry weight respectively for soil collected from Dongola city (north of the Sudan), Fig.(1). From 6.2 Bq/kg to 39.18 Bq/kg, and from 9.65 Bq/kg to 31.86 Bq/kg, and from < D.L.? Bq/kg to 210.95 Bq/kg dry weight respectively for soil collected from Al-Burkal city and mountain (north of the Sudan), Fig. (2). From < D.L. Bq/kg to 73.39 Bq/kg, and from 23.2 Bq/kg to 44.84 Bq/kg, and from 1061.92 Bq/kg to1253.3 Bq/kg dry weight respectively for soil collected from Mernna mountains (south of Abojbiaha city- south of the Sudan), Fig.(3). From < D.L. Bq/kg to 25.65 Bq/kg, and from 32.6 Bq/kg to 1411.51 Bq/kg, and from <.D.L. Bq/kg to 173.73 Bq/kg dry weight respectively for soil collected from Kurrun mountains (East of Abojbiaha city- south of the Sudan), Fig.(4). From 17.13 Bq/kg to 34.82 Bq/kg, and from 79.43 Bq/kg to 155.43 Bq/kg, and from 176.3 Bq/kg to 291.54 Bq/kg dry weight respectively for soil collected from Ourro area (north of Abojbiaha city- south of the Sudan), Fig.(5). From 11.25 Bq/kg to 18.14 Bq/kg, and from 10.2 Bq/kg to 16.94 Bq/kg, and from 277.7 Bq/kg to 336.8 Bq/kg dry weight respectively for soil collected from AL-Jazeera project (middle of the Sudan), Fig.(6). From 3.32 Bq/kg to 15.4 Bq/kg, and from 10.25 Bq/kg to 17.48 Bq/kg, and from < D.L. Bq/kg to 33.84 Bq/kg dry weight respectively for soil collected from AL-Merkhiat mountains (north of Omdurman city-Khartoum state), Fig.(7). From 35.1 Bq/kg to 48.94 Bq/kg, and from 10.2 Bq/kg to 21.4 Bq/kg, and from 661.7 Bq/kg to 924.75 Bq/kg dry weight respectively for soil collected from Toteel mountains (Kasala city-East of the Sudan), Fig.(8). From 13.65 Bq/kg to

33.71 Bq/kg, and from 10.26 Bq/kg to 22.4 Bq/kg, and from 23.3 Bq/kg to 847.5 Bq/kg dry weight respectively for soil collected from Japel Awliya mountain (south of Khartoum state), Fig.(9).

Comparison of the radioactivity concentration for all the collected soil samples with National and International radioactivity concentration levels which is 35, 35 and 370 Bq/kg for 226Ra (^{238}U) series, ^{232}Th series and 40K respectively. And comparing the world average of dose rate in air 55nGy/h (NCRP 94., 1987).with that calculated from the equation below,(UNSCEAR .,1998):

$$D_{Air} = (0.462C_U + 0.621C_{Th} + 0.0917C_K)\ \mathrm{nGy/h}$$

C_U, C_{Th}, C_K is the concentration of U, Th and K respectively.

We can observe that the radioactivity concentrations are normal in Northern and Middle of the Sudan with average 40.187 nGy/h. But the highest radioactivity concentration and dose rate in air found in South of the Sudan with average 120.355 nGy/h and that means it is greater two times than the world level. And the average of radioactivity concentration of ^{232}Th, ^{238}U and ^{40}K is 53.66 Bq/kg, 31.05 Bq/kg and 1157.55 Bq/kg respectively, Fig.(10).

In Kurrun Mountain the average of the dose rate in air is 321.528 nGy/h, and the average of radioactivity concentration of 232Th, 238U and 40K is 19.925 Bq/kg, 671.26 Bq/kg and 95.29 Bq/kg respectively. In Ourro area the average of the dose rate in air is 96.509 nGy/h, and the average of radioactivity concentration of 232Th, 238U and 40K is 25.513 Bq/kg, 125.04 Bq/kg and 249.68 Bq/kg respectively. In Eastern of the Sudan the average of the dose rate in air is 106.43 nGy/h, and the average of radioactivity concentration of 232Th, 238U and 40K is 42.02 Bq/kg, 16.45 Bq/kg and 793 Bq/kg respectively, Fig.(10).

The obtained results and discussion above showed that the dose rate in air in northern and central of Sudan is in a range that recommended by IAEA and WHO. At east and south of the Sudan, the observed dose rates are high due to much radioactivity and high radiation background.

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