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Measurement of Natural radioactivity levels in Rock samples collected from Dallanj Mountains - South Kordofan State, Sudan

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ABSTRACT

This study was conducted primarily to monitoring and measure natural radioactivity level in rock samples were taken from Dallanj Mountains - South Kordofan State to establish background radiation level. Measurements were carried out using gamma-spectrometry equipped with Nal (TI) detector. Activity concentrations of radionuclides ^{226}Ra,^{232}Th and ^{40}K were found with mean value of 23.56±2.11, 29.57±4.33 and 330.58±37.06 Bq.kg^{-1}. The calculated absorbed dose rate in air at a height of 1 m and annual effective dose was around with mean value of 33.34±3.39nGyh^{-1} and 40.92±4.16µSvy^{-1}, respectively. The indicate that the radioactivity level in the surveyed Mountains lie within the global rang of normal background radiation.

Introduction

Various researchers in the word are taking interest in monitoring and measurement of natural radioactivity concentrations in the environment media, to build up guidelines background radiation level, its impact on the human's health [1]. Rocks radioactivity originates from a variety by one of three natural gamma-radiation: uranium, thorium and their daughter products and potassium [2]. These radionuclides are present in rocks in varying amounts, and they are easily mobilized into the environment. Radioactivity in soil results from the rock from which they were derived. The distributions of naturally occurring radionuclides depend on the distribution of rocks from which they originate and the processes which result to their removal from the soil and migrate them [3, 4, 5].Therefore, the natural radioactivity concentration mainly depends on geological and geophysical setting [5].So higher concentrations of radionuclide are associated igneous rocks such as granite and the lower are present sedimentary rocks [6]. The aim of this Study is to complement other some studies to establish a radiation map for country as reference in documenting due to anthropogenic activities.

Materials and Methods

Study area

Area under consideration is lie in Dallanj Mountains, Northern part of Nuba Mountains-South Kordofan State, Sudan. Coordinated between a latitudes 29.38 and 30.21ºE, and longitudes 12.03 and 13.04 ºN, as depicted in Figure-1. Geologically the area setting with granite rocks are exposed in the most Mountains.

Sampling and Measurement Technique

Background radiation level was monitoring and measured with bGeigie Nano (safe cast), survey meter, hand-held at one meter above the ground level recoded CPS and reading ambient dose rate (µSvy^{-1}).

Figure 1. Map showing the study area.

Thirty-one rock samples taken randomly from study area, and then crushed into fine powder using a mortar and pestle. Each sample was weighted 500g, and sealed in plastic containers, and left for more than a month before counting by gamma- ray spectroscopy allow secular equilibrium for radionuclide with their respective progeny. Radioactivity measurements were made using via γ-spectroscopy equipped with NaI (Tl) detector. Sample spectra were analyzed using winTMCA32 software package (provided by IAEA), is capable of energy spectra emitted by samples with 90% relative efficiency, situated in a well housing. The detector has best resolution achievable is about 6.7% for the 1332-keV gamma ray form ^{06}Co. The counting time for each samples as well as background was 10800second .Moreover the activity concentrations of ^{226}Ra was determined from the average of ^{214}Bi (609 Kev) and ^{214}Pb (352 Kev) decay products, and ^{212}Pb (238 Kev) was used to measure the specific activity of ^{234}Th. The activity concentration of ^{40}K was determined by using 1460 Kev gamma line.

Dose Calculation:

Different approaches are often used to quantify and express the radiation effects in air in terms of absorbed dose rate or exposure rate.

However here we have used the dose conversions factors adopted by UNSCEAR to convert the measured activity concentration of ^{226}Ra , ^{232}Th and ^{40}K into absorbed dose rate (nGyh^{-1}), was calculated using equation (1):

$$D\ (\mathrm{nGy\ h^{-1}}) = 0.427A_{Ra} + 0.662\ A_{Th} + 0.043A_K \qquad (1)$$

Where A_{Ra}, A_{Th} and A_K are the activity concentration of ^{226}Ra, ^{232}Th, and ^{40}K, respectively **[7].**

In order to estimate for the annual effective dose equivalent (E) to be received by the public, was calculated using formula (2):

$$E\ (\mathrm{\mu Svy^{-1}}) = D\ (\mathrm{nGyh^{-1}}) \times 24\mathrm{h} \times 365.25\mathrm{d} \times 0.2 \times 0.7\mathrm{SvGy^{-1}} \times 10^{-3} \qquad (2)$$

Where: 0.2 is the outdoor occupancy factor adopted by UNSCEAR (2000) and 0.7SvGy^{-1} is the conversion coefficient from gamma absorbed dose rate in air outdoors.

Results and Discussion

Table-1 presents result of monitoring radiation background at the sampling sites. The present survey shows that the ambient gamma dose was displayed between 0.03 to 0.48µGyh^{-1} .However, in the Northern parts of the study area were slightly lower than other parts of the region, the reason could be geological features,(show as Figure-2),and the highest measurement values of ambient dose rate was measured in Jabel Bela.

Activity concentration ^{226} Ra, ^{232}Th and ^{40}K measured in rock samples collected from various locations are lasted in tables -2, were varied from 20.15 to 25.76,with a geometric mean of 23.56±2.11 Bq.kg^{-1} for ^{226}Ra, 22.95 to 33.22,with a geometric mean of 29.57±4.33Bq.kg^{-1} for ^{234}Th and 278.04 to 375.87,with a geometric mean of 330.58±37.06 Bq.kg^{-1} for ^{40}K.The global average values for ^{226}Ra, ^{232}Th and ^{40}K activity concentration are 35 (range: 16-110), 30 (range: 11-64), and 400(range:140-850)Bq.kg^{-1} respectively [7,8]. In these measurements mean value, that the activity concentration of these radionuclides are slightly scattered which in turn indicates that the geological setting in the area under consideration are not much differ. There are significant correlation was found between activity concentration and ambient dose. However, the highest activity concentration of ^{226}Ra and ^{232}Th was met with Jabel Bela samples, the reason could be geological features, which are associated with younger and older granite.

The absorbed dose rate in air at height of one mater as evaluated using dos rate conversion factors for activity data of ^{226}Ra, ^{232}Th and ^{40}K is adopted in Table -2. The assessment of gamma radiation dose from natural sources is of particular importance as natural radiation is the largest contributor to the collective external dose of the world's population. Estimated exposure values was ranged from 28.27 to 36.21 with mean value of (33.34±3.39) nGyh^{-1}, this result was to slightly to be lower than 55nGyh^{-1}**,**the acceptable average outdoor exposure. On the other hand, the corresponding annual effective dose was varied from 34.69 to 44.44 with value mean (40.92±4.16) µSvy^{-1}.

In addition, the relative contribution to the external radiation dose rate from the radionuclide ^{226} Ra, ^{232}Th and ^{40}K comes from ^{232}Th (53.57%).This the present study has been proposed to cover and establish a base line data for the regional radioactivity.

Table –I: radiation Background at the sampling area using safecas at one meter above the ground level in counts/sec.

Area	CPS (counts/Sce)	Ambient Dose rate µSvy^{-1}	Area	CPS (counts/Sce)	Ambient Dose rate µSvy^{-1}
Hager gawad	53	0.19	Jabel Dish	41	0.15
	57	0.15		98	0.25
	72	0.16		81	0.32
	76	0.22		94	0.36
	80	0.47		97	0.16
Jabel Vracl	76	0.32		40	0.1
	76	0.24		49	0.11
	75	0.34		31	0.03
	77	0.29		87	0.3
	81	0. 52		86	0.19
	88	0.41		90	0.41
	87	0.36	Jabel Bela	81	0.27
Hagar Muk	85	0.4		85	0.36
	79	0.23		87	0.48
	75	0.22		88	0.43
	81	0.39		86	0.39
	82	0.42		92	0.45
	79	0.41		98	0.46
	76	0.32			

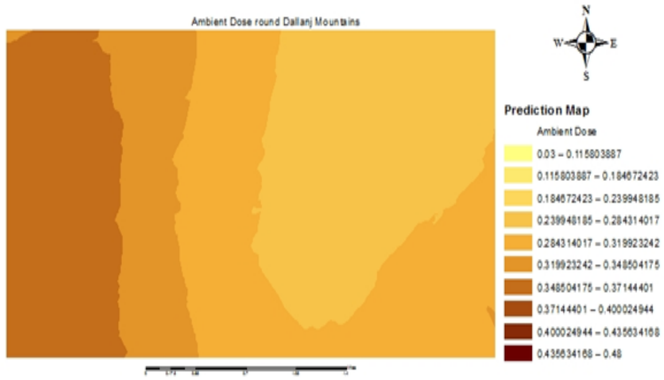

Figure -2: GIS predictive map showing ambient dose distribution in area under study.

Conclusion

Based upon the results obtained in this study the following concluding remarks can be drawn:

I. The radioactivity level calculated for ^{226}Ra, ^{232}Th, and ^{40}K in rock samples were below the recommended limits.

Table 2. Descriptive Statistical summary of ^{226}Ra, ^{232}Th and ^{40}K, absorbed dose level and annual effective dose calculated from rock samples.

Location	No	^{226}Ra	^{232}Th	^{40}K	nGyh^{-1}	µSvy^{-1}
Jabel Vracl	11	23.31±3.19	29.52±2.80	313.62±39.21	32.96±3.07	40.45±3.77
Jabel Bela	4	24.92±0.73	32.44±1.61	336.83±34.59	35.79±1.02	43.92±1.26
Hager gawad	4	21.21±3.16	24.11±14.77	330.39±51.25	28.95±9.79	35.53±12.01
Hagar Muk	5	23.87±1.55	31.36±1.67	331.25±19.76	34.58±1.39	42.43±1.71
Jabel Dish	7	24.50±1.94	30.42±0.81	340.81±40.47	34.43±1.66	42.26±2.04
Overall Avenge +STD	31	23.56±2.11	29.57±4.33	330.58±37.06	33.34±3.39	40.92±4.16
Min		20.15	22.95	278.04	28.27	34.69
Max		25.76	33.22	375.87	36.21	44.44
Contribution %		32.66	53.57	41.36		

No: Number of samples

II. Absorbed dose level in air at one meter above ground surface attributable to gamma-emitters from investigated radionuclide and the annual effective dose for all samples in areas are almost unity lower than the acceptable value.

III. The data obtained in this study will serve as baseline data for the proper assessment of radiation exposure of the dwellers.

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