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Investigation of Natural Radioactivity levels in Soil Samples from North Kordofan State, Sudan

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Abstract

The aim of this study is to assess of the natural radioactivity level in the soil samples around North Kordofan State. The radioactivity concentration of ^{238}U, ^{232}Th, ^{40}K and ^{137}Cshave been determined using γ-ray spectrometry NaI (Tl) detector moreover, the absorbed dose rates and annual effective dose were calculated. The average value of ^{238}U, ^{232}Th, ^{40}K and ^{137}Cswere found to be 22.83, 25.11, 284.31and 0.28Bq.k^{-1} respectively. The obtained results were found to be lower than UNSCEAR reported data. The absorbed dose rates and annual effective dose were determined and found to be in range of 25 to 29.61 nGy h^{-1} and 30to 41μSvy^{-1} respectively. The overall annual effective dose were lower than allowable limit set by ICRP 1mSvy^{-1}.

Keywords: Natural radioactivity levels, Soil, North Kordofan, Sudan.

Introduction

Natural radioactivity in soil constitute one of the most component of the background radiation exposure to population[1]. Human beings always exposure to ionizing radiation owing to primordial radionuclide such as ^{238}U decay series and ^{232}Th series and ^{40}KW w that are found in the earth's crust, and to cosmic ray secondaries[2-4] ,always each of us is exposed to naturally occurring quantities of radiation[5-7].This study is a part of major program conducted by different institute for radiation in order to build up baseline data on radioactivity concentration to be used as a reference in the case of any radiation accident. Therefore numerous studies have been reported on radioactivity and radiation dose of public exposure have been carrying out in different regions in Sudan for instances in Northern area ,the absorbed rate dose ranged from 44 to 53 nGy and the annual effective dose ranged from 53 to 65 μSvy^{-1} [8]. Moreover, another study was found that absorbed dose rate ranged 7.1 to 84.6 nGy h^{-1} and annual effective dose ranged from 8.7 to 103.7 μSvy^{-1}[9]. In Eastern Sudan absorbed rate dose was ranged 24 to 48 with an average value of 38 nGy h^{-1} [10]. At Central Sudan., estimated that the absorbed dose rate in air at a height of 1 m ranges from 31 to 47 nGy h^{-1}and annual effective dose was 6 to 47.8μSvy^{-1}[11]. In western Sudan, a nationwide programme on environmental radioactivity monitoring has been Surveyed as the absorbed dose found ranges from 500 to 7000 nGy h^{-1} [12,13]. In south Kordofan State (Miri Lake in Nuba Mountains) was Surveyed environmental radioactivity, the study indicated that the average annual effective dose was 39.55 μSvy^{-1}[14].The purpose of the current study it to measure radioactivity concentration in soil sample from western part of the Sudan.

Material and Methods

Study area: The area of interest is found in North Kordofan State, Sudan, (see the map Figure-1) and lies between latitudes 29.60- 30.38 ºE, latitudes and 12.42-13.43ºN.

Sample collection and preparation: A total of 85 Soil samples were taken randomly from 14 locations around North Kordofan State using grab soil-sampler 20 cmat a depth from the ground surface to get the natural soil. Sampling locations were determined using GPS. Samples were sealed in a 500 ml Marinelli beakers for one month to get secular equilibrium between ^{238} U and ^{232}Th and their daughters.

Gamma-spectrometric analysis: ^{238}U, ^{232}Th and ^{40}K in Soil samples were measured via γ-spectroscopy equipped with NaI (Tl) detector. Soil. The samples were counted for three hours. Sample spectra were analyzed using win TMCA32 software package (provided by IAEA). $^{238}U$was determined by means of its progeny photo peaks: ^{214}Bi (609 Kev) and ^{214}Pb (352 Kev). $^{232}Th$was analyzed through its daughter photo peak ^{212}Pb (238 Kev). The activity concentration of ^{40}K and ^{137}Cs was determined by using 1460 Kev and 662Kev gamma line, respectively.

Dose Calculation: The absorbed dose rate (nGyh^{-1})$\overline{D}$ was calculated from ^{238}U, ^{232}Th and^{40}K activity concentration using different dose rate conversion factors (DRCFs) as given in table-1[8]. The absorbed dose rate was computed using the equation (1), and the annual effective dose equation (2):

$$\overline{D} = A \times \text{DRCFs} \quad (1)$$

Where: $\overline{D}$= absorbed dose rate, A = radioactivity Concentration in Bq kg^{-1}

DRCFs = dose rate conversion factors (nGyh^{-1} per Bqkg^{-1}) as given in table -1

The evaluation *absorbed* dose rate in air (μSvy^{-1}) was converted into annual effective dose ($\overline{H}$) using the conversion formula:

$$\overline{H}(\mu\text{Svy}^{-1}) = \overline{D}(nGyh^{-1}) \times 24\,h \times 365.25\,d \times 0.2 \times 0.7\,(Sv\,Gy^{-1}) \times 10^{-3} \quad (2)$$

Where: 0.7 SvGy^{-1} is the conversion coefficient from absorbed dose in air to effective dose received by an individual, and 0.2 for the outdoor occupancy factor [15, 16].

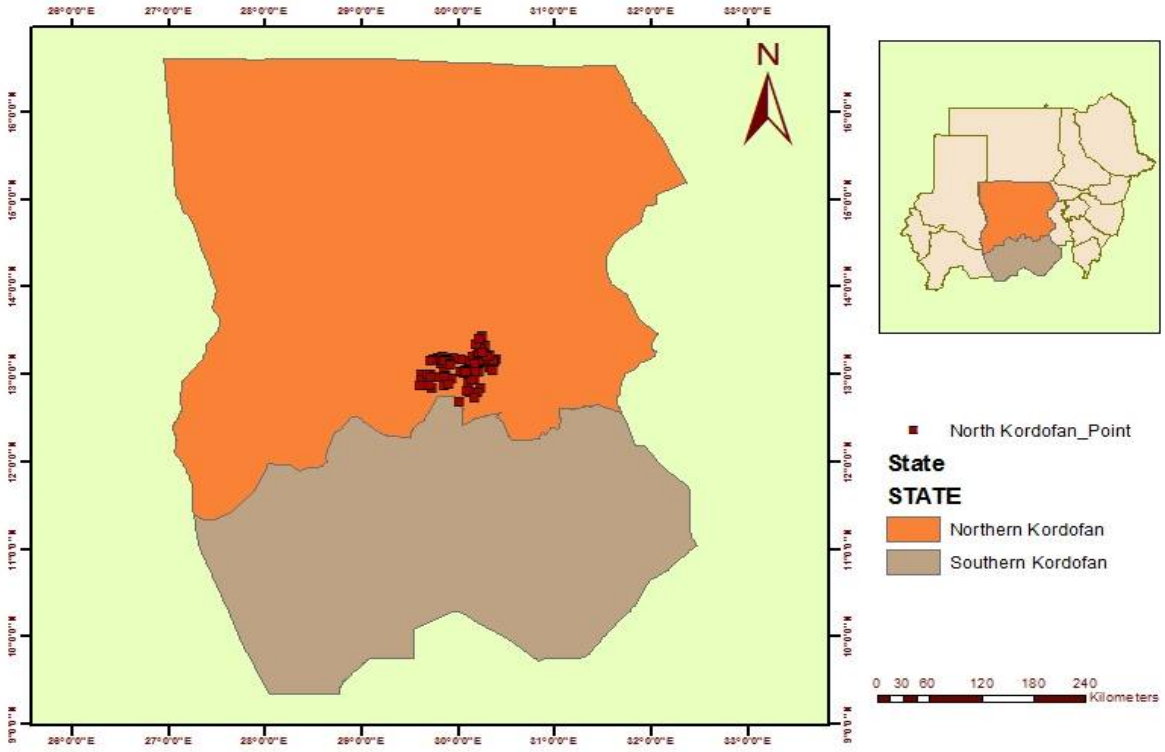

Figure-1
GIS mapping indicate the sampling location

Table-1
Dose rate conversion factors for some radionuclide used for calculation of absorbed dose (nGy h^{-1}) [17]

Nuclide	MC	MCNP	GEANT	UNSCEAR
^{238}U Series				
^{214}Pb	0.04413	0.0415	0.0434	0.462
^{214}Bi	0.34156	0.3385	0.3555	
Total	0.38668	0.3809	0.3999	
^{232}Th Series				
^{212}Pb	0.0193	0.017	0.0192	0.604
Total	0.5239	0.5168	0.5437	
^{40}K	0.0381	0.0378	0.03995	0.0417

Table-2
Activity concentration (Bqkg^{-1}) of ^{238}U, ^{232}Th, ^{40}Kand ^{123}Cs in soil samples North Kordofan State

Location	Number of sample	^{238}U	^{232}Th	^{123}Cs	^{40}K
Hashaba	2	21.24±2.44	21.11±1.72	ND	313.23±42.48
Kazail	8	23.88±3.29	25.88±3.37	ND	308.94±35.83
Banjadid	3	29.79±5.48	30.72±5.92	0.67±1.17	297.50±34.68
JableKordofan	3	28.33±5.24	21.79±18.52	ND	449.10±146.73
Elobied	12	21.44±3.25	22.67±6.21	0.34±1.17	227.41±66.92
Khortaget	9	22.17±1.26	23.82±2.24	ND	340.40±131.27
MosfaEl Obied	10	18.11±3.10	18.47±4.17	0.36±1.02	245.43±63.73
El eyarh	7	23.32±2.96	30.57±9.22	0.46±1.05	283.19±82.16
Abouharaz	13	20.86±3.06	28.83±4.16	0.28±0.73	266.69±93.18
Anumair	3	22.92±3.19	21.11±3.61	ND	234.56±176.15
Wad mkashvi	2	20.53±3.40	22.74±1.15	ND	179.38±109.23
Om bauid	7	18.92±4.44	24.77±1.17	0.75±1.41	245.19±30.48
Elgaka	3	23.07±0.59	26.93±1.31	1.08±1.87	283.19±44.59
Hilla sad	3	25.00±2.25	31.81±6.70	0.04±0.70	306.08±68.83
Average±STD	85	**22.83±4.03**	**25.11±4.96**	**0.28±0.65**	**284.31±80.45**
Min		**18.94**	**19.08**	**0.04**	**187.57**
Max		**26.53**	**31.41**	**1.62**	**385.56**

ND: Not detectable

Results and Discussion

Table -2 presents the level of ^{238}U, ^{232}Th, ^{40}K and^{137}Cs in soil samples around North Kordofan .The level ^{238}U, ^{232}Th, ^{40}K and^{137}Cs ranged from (18.94 to 26.53), (19.08 to 31.41),(187.57 to 385.56) and (0.04 to1.62) with average value of (22.83), (25.11), (284.31) and (0.28) respectively . The average level ^{238}U, ^{232}Th, ^{40}K are lower than international data 35, 30 and 400 Bq kg^{-1}, respectivelypublished by UNSCEAR 2000. The main factor influencing the level of primordial radionuclide in soil is the corresponding concentration in the soil forming rocks. Based on table-2 and figure-2 to 4,it is clear that an observed results Banjadid and Jable Kordofan has the highest concentration of ^{238}U. The highest value of ^{232}Th were recorded in Hilla sad, Banjadid and Eleyarh. While the highest level of ^{40}K was observed in Jable Kordofan when compared with the concentrations of all the other samples. The reason could be attributed to differences in their geological nature. Comparing the range of ^{137}Cs level with data from Libya 0.9 to 1.7 Bq·kg^{-118}, Spain10 to 60 Bq·kg^{-119}, Jordan 1.5 to 2.6 Bq.kg^{-120}, Egypt1.6 to 19.1 Bq·kg^{-1} [21] , Yugoslavia1.5 to 28.4 Bq·kg^{-122}, Greece3.73 to1307 Bq. kg^{-123}, Sudan2 to 26 Bq·kg^{-18} ,Central Sudan0.2 to0.9Bq. kg^{-1} and Northern Sudan0.14 to 6.72 Bq. kg^{-18}.obviously the level of ^{137}Cs seem to be very low. The absorbed dose ranged from 25.26 to 29.61nGyh^{-1}**.**On the other hand, the corresponding annual effective dose average value ranged from 30.99 to 41.72μSvy^{-1} as shown in Table-3. The worldwide average value of annual effective dose is 70μSvy^{-1}as reported in UNISCEAR (1993, 2000).Comparison of absorbed dose rate in air obtained in this study with similar data, it was found that the obtained values are far below the reported data, from different geographical regions in Sudan such as Elgash area 37.5 nGy h^{-110}, Sinnar 38.80 nGy h^{-111}, Jabel Mun 200 nGy h^{-1} [24], Kurun190 nGy h^{-1} [13] and Uro1900 nGy h^{-1} [13]. Also in other Countries, Egypt 32nGyh^{-1}, Syrian Arab Republic 59 nGyh^{-1}, Malaysia 92 nGyh^{-1} and Canada 63 nGyh^{-1} [16,] It is apparent that absorbed dose in air in North Kordofan is below world-wide average characteristics for normal background areas.

Table-3
Distractive statistic of ^{238}U, $^{232}Th$and ^{40}K absorbed dose rate (nGyh^{-1}) and the annual effective dose (μSvy^{-1})

DRCF	^{238}U	^{232}Th	^{40}K	nGyh^{-1}	μSv y^{-1}
MC					
Mean ±STD	8.83±1.22	13.08±2.60	11.66±3.06	25.60±4.03	31.20±4.95
Range	7.33-10.26	9.99-16.45	7.11-15.01	20.87-30.59	25.68-37.55
Contribution %	34.49	51.09	45.55		
MCNP					
Mean ±STD	8.70±1.20	12.97±2.56	10.80±3.04	25.26±3.97	30.99±4.89
Range	7.21-10.19	9.86-16.23	7.09-14.57	20.59-30.2	25.25-37.06
Contribution %	34.44	51.35	42.76		
GANT					
Mean ±STD	9.11±1.25	13.64±2.70	11.41±3.21	26.57±5.40	32.60±5.13
Range	7.57-14.17	10.38-17.08	7.5-15.4	21.51-31.76	26.58-38.99
Contribution %	34.29	51.34	42.94		
UNSCEAR					
Mean ±STD	10.55±1.46	15.15±3.74	11.9±3.36	29.61±4.64	41.72±6.71
Range	8.75-12.25	11.57-18.97	7.82-16.08	24.23-35.34	33.79-49.79
Contribution %	35.63	51.17	40.19		

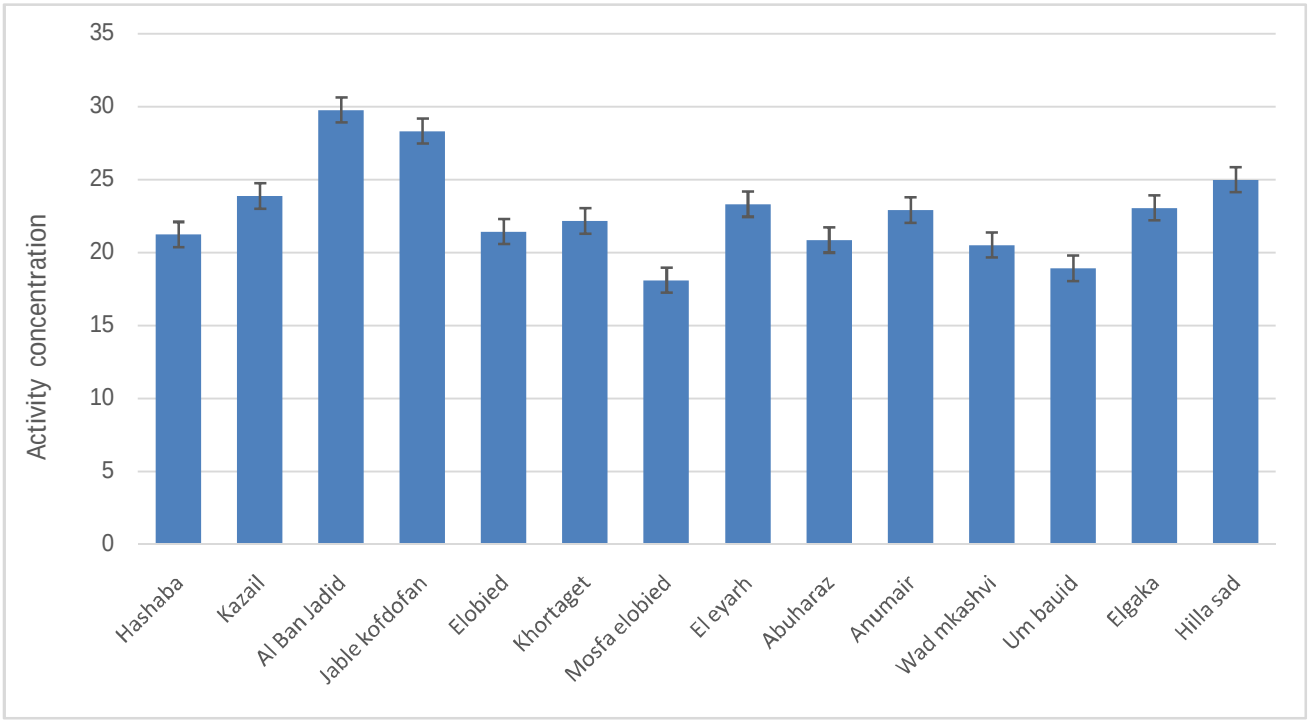

Figure-2
Activity distribution of ^{238}U in soil sample difference location, North Kordofan state

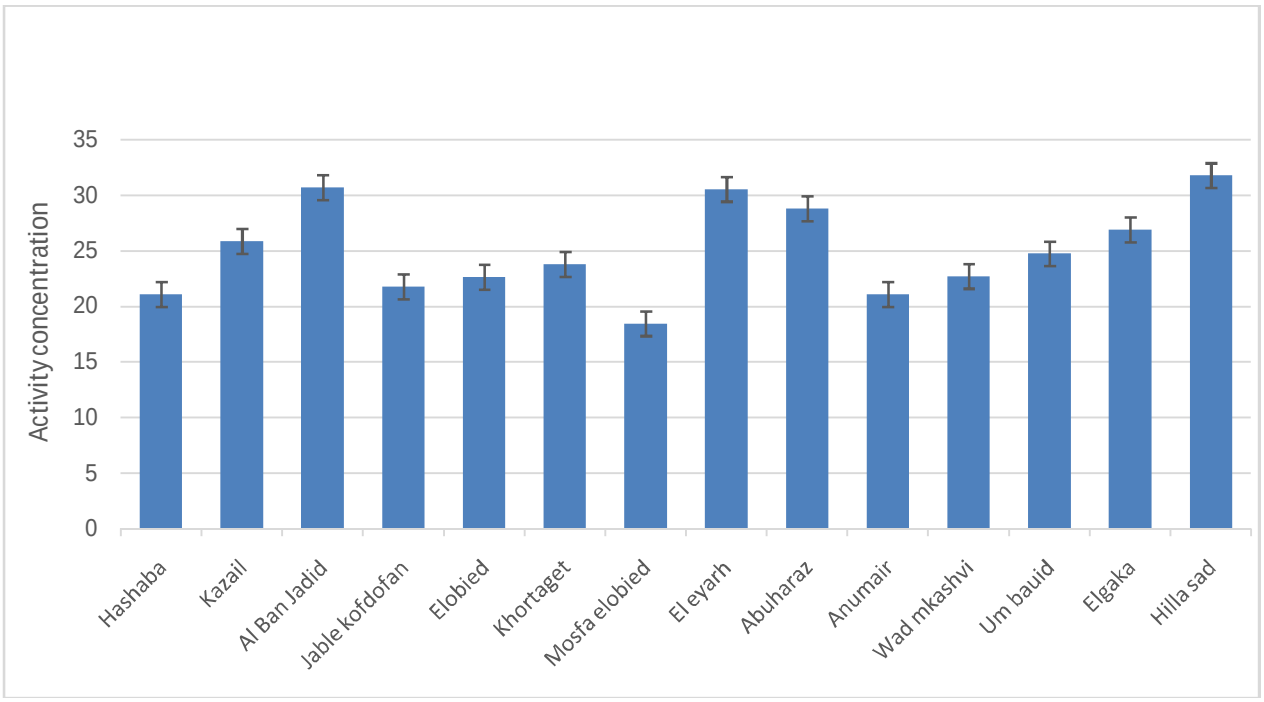

Figure-3
Activity distribution of ^{232}Th in soil sample in difference location, North Kordofan state

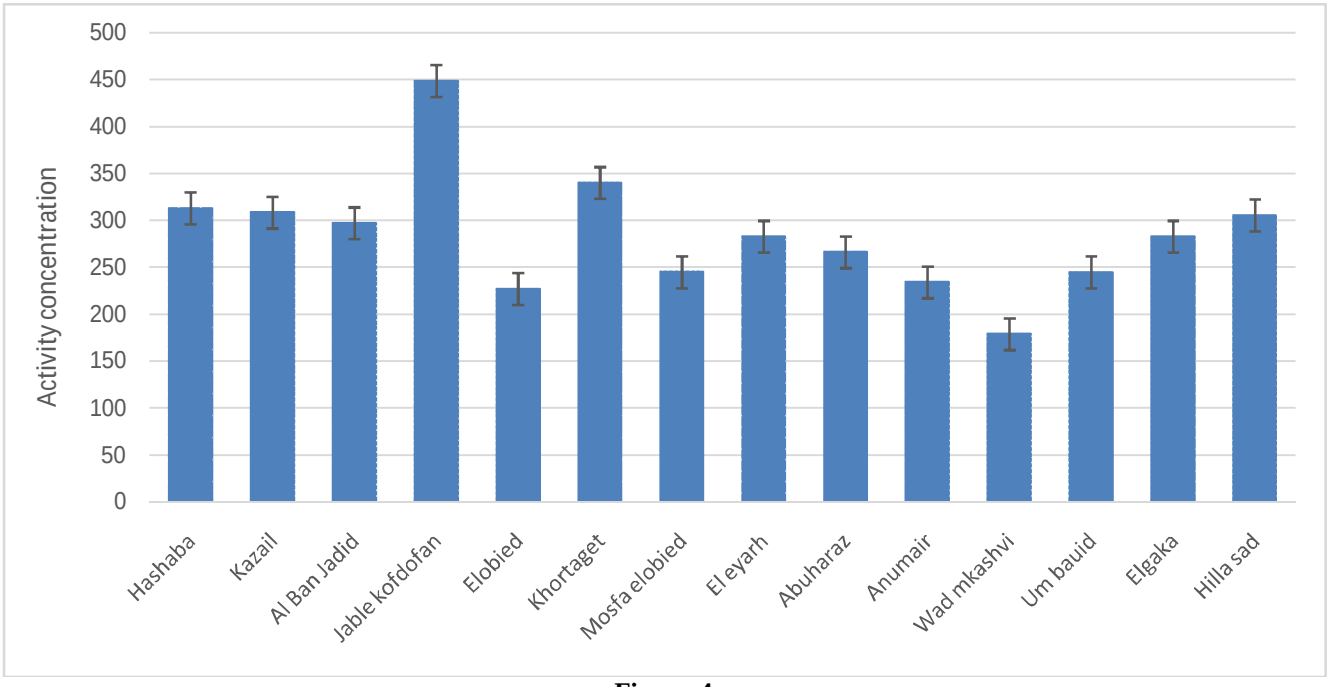

Figure-4
Activity distribution of^{40}K in soil sample in difference location, North Kordofan state

Conclusion

To sum up the fallowing conclusion can be drown, i. The average level ^{238}U, ^{232}Th, ^{40}K are lower than international data published by UNSCEAR (2000). ii. The highest value of ^{232}Th were recorded in Hilla sad, Banjadid and Eleyarh. iii. The highest level of ^{40}K was observed in Jable Kordofan when compared with the activity concentrations of all the other samples. iv. absorbed dose rate in air obtained in this study with similar data, far below the reported data, from different geographical regions in Sudan such as Elgash area 37.5 nGy h^{-1},

Sinnar 38.80nGy h^{-1}, Jabel Mun 200 nGy h^{-1}, Kurun 190 nGy h^{-1} and Uro1900 nGy h^{-1}

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