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Assessment of Natural Radioactivity and Gamma Dose Rate level round Dalanj area, South Kordofan - Sudan

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Abstract

This study was carried out to asses natural environmental radioactivity level and estimation gamma absorbed dose rates in soil and foodstuff samples collected round the Dalanj area, South Kordofan. By using (γ −spectroscopy)with NaI (Tl) detector, the activity distribution of radionuclides ^{238}U, ^{232}Th, ^{137}Cs and ^{40}K was to be22.08 Bqkg^{-1}, 28.99 Bqkg^{-1}, 1.38 Bqkg^{-1} and 319.16 Bqkg^{-1} in soil samples. On the other hand the activity distribution of radionuclide ^{238}U, ^{232}Th and ^{40}K fallout nuclide^{137}C in Foodstuff samples was to be 4.67Bqkg^{-1}, 4.49 Bqkg^{-1}, and 326 Bqkg^{-1} respectively. Evaluation of radiological absorbed dose rates and annual effective dose was determined. For the Soil sample were found in the range (26.78 to33.78) nGyh^{-1} with an average value of 31 nGyh^{-1}, and.(32.86 to 41.47) μSvy^{-1} with an average value of 39.81 μSvy^{-1} respectively. Corresponding for Foodstuff samples ranged from (4.08 to 8.48) nGyh^{-1} with an average value of 6.16 nGyh^{-1} and (5.01 to 10.37) μSvy^{-1} with an average value of 7.56 μSvy^{-1}respectively. However, the results indicate the radioactivity level in the surveyed area was less than the global data reported in the UNSCEAR publications for normal background areas soil and Food stuff.

Keyword: Natural radioactivity level, Soil, Food stuffs samples.

Introduction

Environmental radiation monitoring programs are usually consist of two phases the first is background radiation monitoring to establish baseline radiation level against changes arising from local and cross boundary radiation activities, and the second is on-going program for detecting long term changes in environmental radioactivity. Estimation and monitoring natural environmental radioactivity are great important for scientists, that it identify and determine gamma radiation from environmental media[1-3]. The radioactivity in food mainly comes from radioisotope elements of the uranium and thorium series and from potassium. Evaluation and assessment of radionuclide in environmental samples like soil, rock and foodstuffs are extremely important for controlling radiation levels and radiation dose exposure[4].

The programme of environment radioactivity has been taken seriously worldwide during the past fifty years, especially during the last decade and nowadays most of the countries have continuous monitoring programme for radioactivity, and evaluation doses[5-8]. In Sudan many researches were conducted to investigation and monitoring the radioactivity in soil and foodstuffs. This study will be helpful to establish a research baseline of the national programme on monitoring of environmental radioactivity to initiate creation of radiation map for the country and provide a useful reference for radiation Protection[5].

Geographic structure of Nuba Mountains as well as rocks that are rich in phosphate, granite and salt contain radionuclides like ^{238}U, ^{232}Th and ^{40}K, when rocks are disintegrated through natural processes radionuclides are carried to soil by rain and flows[8,9]. Also soil is used by the people to build their traditional clay brick and house sand earmarked for house.

Materials and Methods

Study area: The study area is located in the Northern part of the Nuba Mountains in the South Kordofan State, the section at north east of the coordinate lies between latitudes 29.39 and 30.20 º E latitudes and 11.15 and 12.36 º N.

Sample collection and Measurement: A total of 31 soils, were taken randomly from in eight districts (Kazgil, Tayba, showshaya, Dubaibat, Dalanj, Al Hamadi and El Dilema) within round Dalanj area. And 29 samples of Foodstuff samples were collected directly from various farms and markets districts

within the study area. Samples were thoroughly washed free of adhering soil particles, were first kept in the sun for several days and packed in fabric bags to minimize decomposition of organic matter. Then, About 500 grams of the powdered samples were weighed in a dry clean Marinelli beaker and stored for three weeks so as to allow in growth of gaseous ^{222}Rn and its short-lived decays products to reach secular equilibrium with long lived ^{226}Ra.

The radionuclide ^{238}U, ^{232}Th and ^{40}K in samples was measured by γ-spectroscopy with NaI (Tl) detector. The activity distribution of ^{238}U and ^{232}Th were determined from their progeny photopeaks: ^{214}Bi (609 Kev) and ^{214}Pb (352 Kev) and ^{212}Pb (238 Kev). The activity of ^{40}K was measured via 1460 Kev and the 662Kevgamma transition was used to determine ^{137}Cs concentration.

Results and Discussion

In Table-1 summarized the results of investigation of radionuclide ^{238}U, ^{232}Th, ^{137}Cs and ^{40}K in the soil samples. Activity distribution were came out to be 22.08Bqkg^{-1}, 28.99 Bqkg^{-1}, 1.38Bqkg^{-1} and 319.16Bqkg^{-1} respectively. The average of activity distribution of all radionuclide were lower as compared with global presented in UNSCEAR (2000) as 35, 30 and 400 Bqkg^{-1}, respectively. A little contamination due to the Fallout nuclide ^{137}Cs was encountered, very low concentration, was not detected at most of the places, also the highest activity concentration of ^{232}Th and ^{235}U were recorded in Kazgil and Dalanj town. The reason could be attributed to differences in their geological nature. This study is similar to early work that has been done by Nooreldin Fadol et at[10].

On other hand table-2 was noted the activity distribution of natural nuclides ^{238}U, ^{232}Th and ^{40}K fallout nuclide ^{137}Cs in Foodstuff samples in the investigated area was 4.67, 4.49 and 326 Bqkg^{-1} respectively, the result showed the highest activity concentration came mainly from ^{40}K with the highest value obtained in Maize, so the concentration may be high expected that the soil characteristics favor the mobilization.

In order to estimate the radiological impact of the investigated radionuclides, the absorbed dose rates (D) due to terrestrial gamma rays at 1m above the ground can be calculated using the followingrelationship[11,12] .

$$D = (0.462C_U + 0.602C_{Th} + 0.0417C_K)\, nGyh^{-1} \quad (1)$$

Where: C_U, C_{Th} and C_K are the activity concentrations (Bqkg^{-1}) of Uranium, Thorium and Potassium, respectively. Furthermore, estimate the absorbed dose rate in air (μSvy^{-1}) was converted into annual effective dose ($\bar{H}$) using the conversion formula:

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

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[11,12].

In Table-3 it is seen that the absorbed gamma dose rate in air at a height of 1m from the ground surface was evaluated from the investigated activity distribution of the radionuclide ^{238}U, ^{232}Th and ^{40}K in soil samples were found 10.54, 17.51 and13.3 nGyh^{-1}, respectively. The estimated of total absorbed dose in the study area was (26.78 to33.78) nGyh^{-1} with an average value of 31 nGyh^{-1}. Corresponding annual effective dose average value was (32.86 to 41.47)μSvy^{-1} with an average value of 39.81 μSvy^{-1}.

The detailed analysis of the results indicates that there is some degree of positive correlation between the absorbed gamma dose rate presented in earlier studies and the worldwide average value for annual dose from outdoor terrestrial gamma radiation is 70μSvy^{-1} as reported in UNISCEAR (1993, 2000)[5,13].

As shown in Table–4, the absorbed dose rate in air at height of 1 m above ground level nGyh^{-1} for ^{238}U, ^{232}Th and ^{40}Kin Food stuff was ranged between (1.7 to 2.65), with an average value of 2.16 nGyh^{-1}, (1.56 to 3.57), with an average value of 2.71 nGyh^{-1} and (7.98 to19.9), with an average value of 14.30 nGyh^{-1}, respectively and the total absorbed dose in the study area ranges from (4.08 to 8.45) nGyh^{-1} with an average value of 6.61 nGy h^{-1}. The corresponding annual effective dose average value ranged from 5.01 to 10.37μSvy^{-1} with an average value of 7.56 μSvy^{-1} respectively, a values are typical global average and lower than similar data reported UNISCEAR.

Conclusion

The study showed that the evaluation of the radio activity level in radionuclides uranium-238 and thorium-232, and Potassium, for 30 soil and 29 Foodstuff samples collected round Dalanjarea are typical of global fallout values. On other hand, the dose rate at 1 m above ground level for sample was lower the Goble average and with similar data reported from different geographical regions in Sudan such as Elgash area 37.5 nGyh^{-1}, Sinner 38.80nGyh^{-1}, Jabel Mun 200 nGyh^{-1}, Kurun 190 nGyh^{-1} and Uro1900 nGy h^{-1}[5,6,12].

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Table-1
Concentration of activity (Bqkg^{-1}) for ^{238}U, ^{232}Th, ^{40}K and ^{137}Cs in soil samples round Dalanj area, South Kordofan State

Location	Number of samples	^{238}U	^{232}Th	^{137}Cs	^{40}K
Kazqil	2	28.48±7.92	30.04±4.25	2.42±0.57	321.81±42.48
Tayba	2	22.27±4.60	30.04±1.27	0.81±0.57	296.07±18.20
Showshaya	3	21.54±2.73	24.23±15.33	ND	320.38±60.88
Krkraah	2	21.55±3.02	26.58±0.21	2.63±0.29	296.07±54.61
Dubaibat	5	21.5±2.73	30.34±2.07	1.45±1.05	310.65±104.65
Dalanj	8	25.29±4.85	31.58±8.31	1.26±1.36	330.39±56.55
Al Hamadi	3	23.12±2.80	30.94±1.83	1.62±0.81	346.12±44.04
El Dilema	6	18.39±4.18	28.19±2.42	0.88±0.65	331.82±73.35
Total Average ±STD	31	22.08±3.64	28.99±4.46	1.38±0.66	319.16±56.85
Min		18.93	24.37	0.71	253.16
Max		27.04	34.36	2.17	378.66

Table-2
Concentration of activity (Bq/kg) for $^{238}_{U}$, $^{232}_{Th}$ and $^{40}_{K}$ in Foodstuff samples round Dalanj area, South Kordofan State

Type of food	Number of samples	^{238}U	^{232}Th	^{40}K
Maize	5	4.61±0.42	4.78±2.86	530.02±168.59
Cordia Africana	*5*	3.87±0.96	3.90±1.94	319.48±160.66
Portuaca	5	4.46±0.94	4.70±0.95	301.82±116.28
Okra	5	5.40±1.14	4.94±1.04	348.93±164.31
Molokhia	5	4.51±0.58	4.54±0.53	295.93±156.19
Peanuts	4	5.14±1.22	4.08±1.00	161.95±15.90
Total Average ±STD	29	4.67±0.88	4.49±1.39	326.36±130.32
MIN		3.68	2.59	191.4
MAX		5.73	5.91	477.26

Table-3
Absorbed dose rates (nGyh^{-1}) due to gamma emitting nuclides from ^{238}U, ^{232}Th and ^{40}K as derived using UNSCEAR DRCFs and Annual effective dose (µSvy^{-1}) in soil samples round Dalanj area, South Kordofan State

Location	Number of samples	^{238}U	^{232}Th	^{40}K	nGy/h	µSv/y
Kazqil	2	13.36±3.66	18.14±2.57	13.42±1.77	35.77±1.68	43.90±2.07
Tayba	2	10.29±2.13	18.14±0.77	12.25±0.76	32.55±3.15	39.64±3.86
Showshaya	3	9.95±1.26	14.64±9.26	13.36±2.54	29.04±10.82	35.64±13.27
Krkraah	2	9.96±1.40	16.06±0.13	12.35±2.28	30.13±0.77	36.97±0.94
Dubaibat	5	9.93±1.26	18.32±1.25	12.95±4.36	32.58±3.64	39.98±4.46
Dalanj	8	11.68±2.24	19.07±5.02	13.78±2.36	35.35±5.78	43.38±7.09
Al Hamadi	3	10.68±1.29	18.69±1.10	14.43±1.84	34.18±2.73	41.95±3.35
El Dilema	6	8.50±1.93	17.02±1.46	13.84±3.06	30.13±2.62	36.98±3.21
Total Average ±STD	31	10.54±1.9	17.51±2.7	13.3±2.37	31±3.9	39.81±4.78
Min		5.92	15.06	8.59	26.78	32.86
Max		10.37	18.87	16.46	33.78	41.47

Table-4
Absorbed dose rates (nGyh^{-1}) due to gamma emitting nuclides from ^{238}U, ^{232}Th and ^{40}K as derived using UNSCEAR DRCFs and Annual effective dose (µSvy^{-1}) in Foodstuff samples round Dalanj area , South Kordofan state

Type of food	Number of samples	^{238}U	^{232}Th	^{40}K	nGy/h	µSv/y
Maize	5	2.13±0.19	2.89±1.73	22.10±7.03	9.04±2.49	11.09±3.06
Cordia Africana	*5*	1.79±0.44	2.36±1.17	13.32±6.70	5.82±2.56	7.15±3.14
Portuaca	5	2.06±0.43	2.84±0.57	12.59±4.85	5.83±1.71	7.15±2.10
Okra	5	2.50±0.53	2.98±0.63	14.55±6.85	6.68±2.65	8.19±3.25
Molokhia	5	2.09±0.27	2.74±0.32	12.34±6.51	5.72±2.28	7.02±2.79
Peanuts	4	2.37±0.56	2.47±0.60	6.75±0.66	3.86±0.18	4.74±0.22
Total Average ± STD	29	2.16±0.40	2.71±0.84	14.30±5.43	6.16±1.98	7.56±2.43
MIN		1.7	1.56	7.98	4.08	5.01
MAX		2.65	3.57	19.9	8.45	10.37

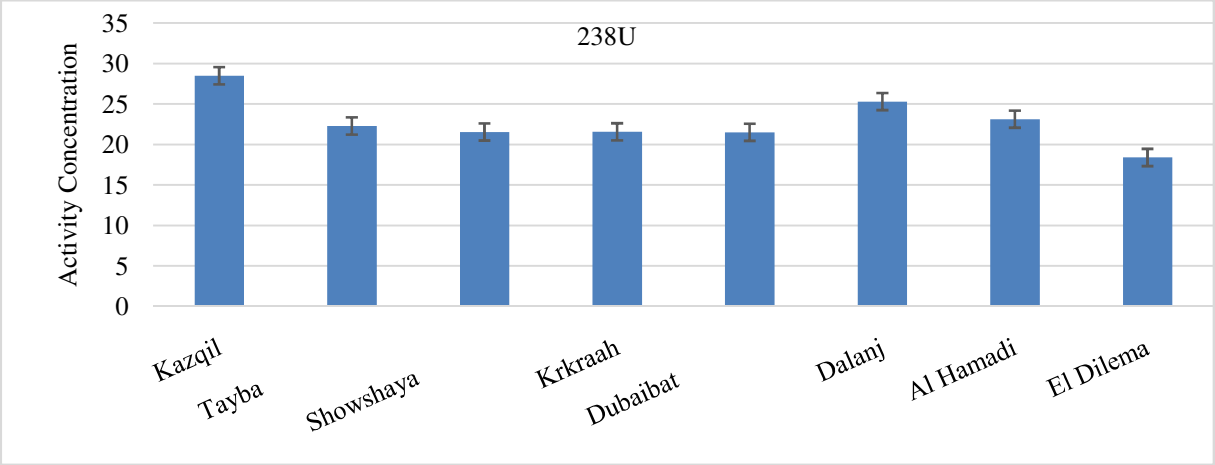

Figure-1
Activity concentrations of ^{238}U for soil samples round Dalanj area, South Kordofan State

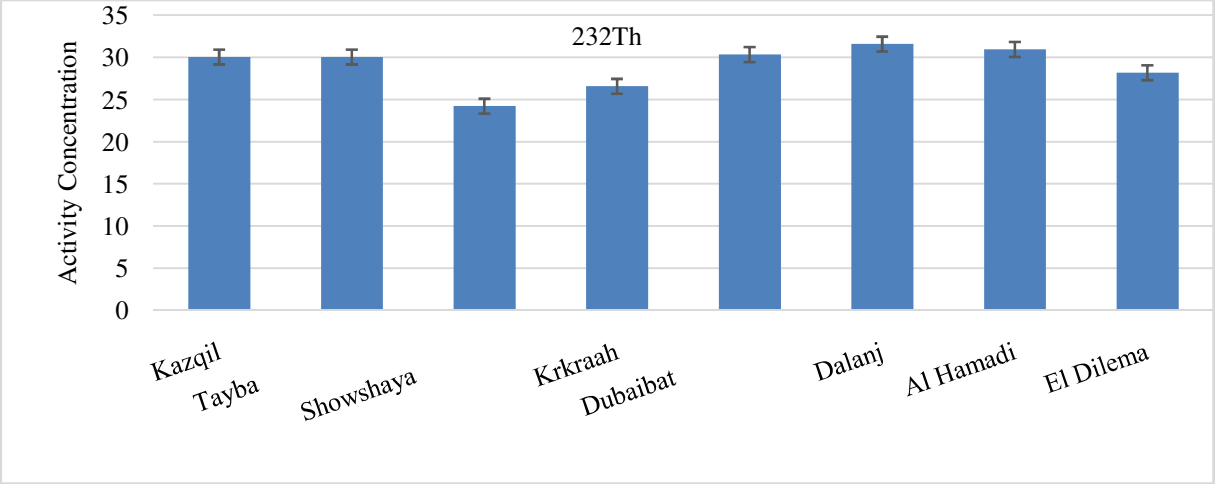

Figure-2
Activity concentrations of ^{232}Th for soil samples round Dalanj area, South Kordofan State

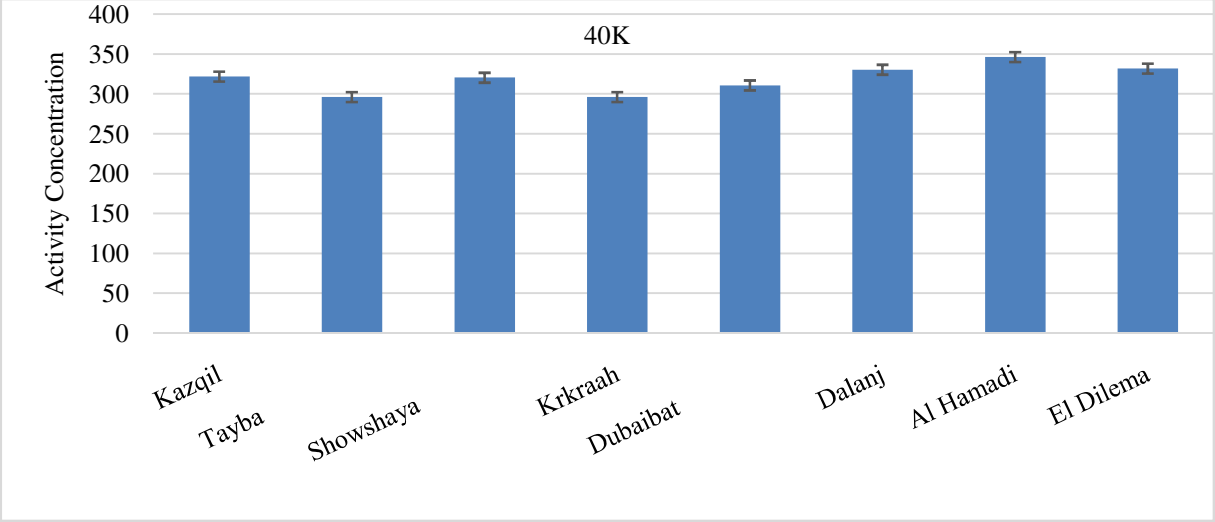

Figure-3
Activity concentrations of ^{40}K forsoil samples round Dalanj area, South Kordofan State

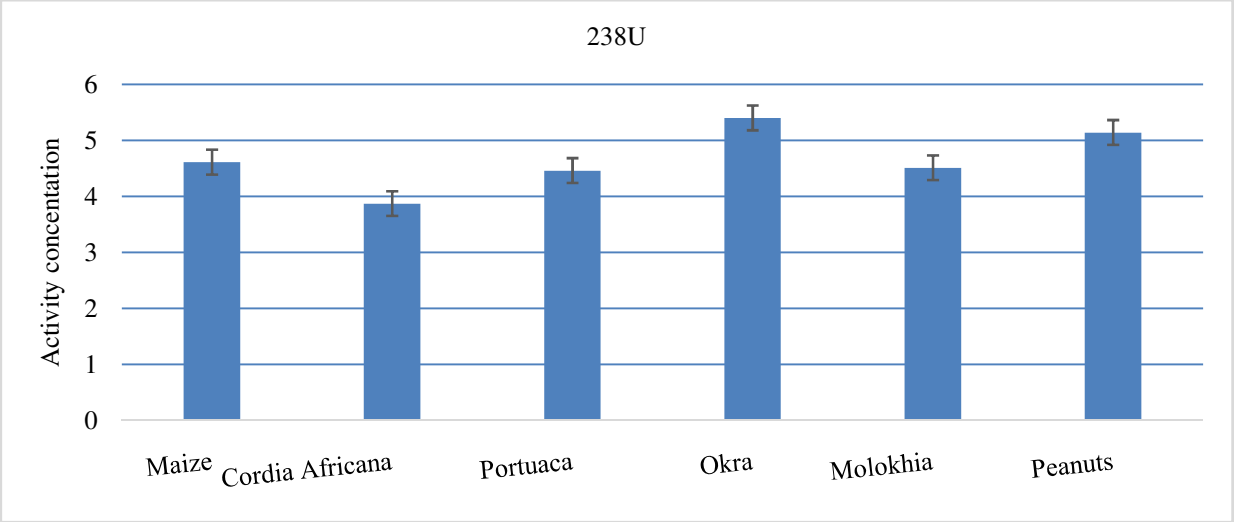

Figure-4
Activity concentrations of ^{238}U for Foodstuff samplesround Dalanj area, South Kordofan state

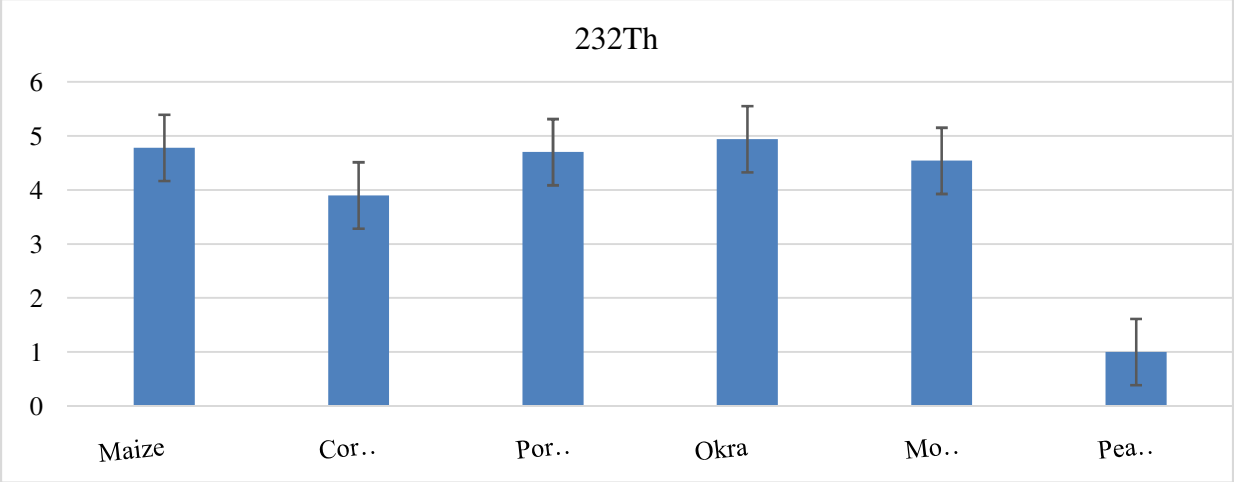

Figure-5
Activity concentrations of ^{232}Th for Foodstuff samplesround Dalanj area, South Kordofan state

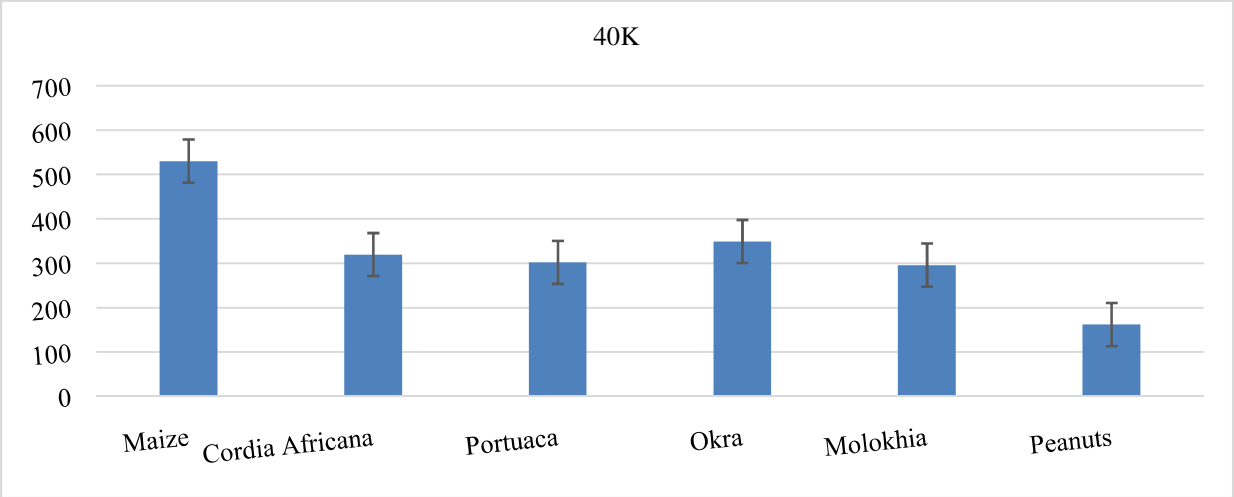

Figure-6
Activity concentration of ^{40}K for Foodstuff samples round Dalanj area, South Kordofan state

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