Chapter Five

Results and discussion

5.1 Introduction

Soil quality can be defined as the capacity of the soil to function within environmental quality and promote plant, animal and human health [141].Naturally occurring radionuclide's (NOR) are present in many natural resources. Human activities that exploit these resources lead to enhanced concentrations of radionuclides and potential radiation exposure such as phosphate fertilizers manufacture and its agricultural applications. As there are a considerable quantity of NOR and heavy metals in phosphate fertilizers and soil [142] For dose estimations, the behavior of long-lived radionuclides in soil is of particular importance since, once contaminated, the soil acts as a potential long term source for radionuclides in food and feed [143].

5.2 Activity concentration of radionuclide's in soil samples and analysis

Contamination of metals in soil has been well documented in recent years and more numerous studies are being carried out in different parts of the world [144].

The analysis of potentially contaminated by x-ray florescence (XRF) methods often takes some weeks due to sample preparation and can be expensive. For management, instant analysis of contaminated soil, sediments or geoprospecting may be required to guide further analysis and mapping of the area. The evolution of XRF application needs to be reengineered to improve the sensitivity in more accurate and precise analysis. The advantages of using the XRF for in situ analysis of soil are

the minimal requirement of sample preparation, easy to operate instrument and training, and the rapid resultant data.

At study area (Nyala city) soil samples were collected and analyzed using XRF to determine the levels of heavy metals and activity concentration of radionuclide's for ^{238}U, ^{232}Th and ^{40}K .

5.3 X-ray florescence (XRF) analysis

Heavy metals and the ratio of activity concentration using XRF techniques for some selected soil samples from Nyala city are given in table 5.1. Concentration of ^{238}U, ^{232}Th and ^{40}K in (ppm), and calculated leachable activity concentration of ^{238}U, ^{232}Th and ^{40}K in Bq/kg , in soil samples of study area by XRF are given in table 5.4.

The results from XRF were correlated with those produced with R^2 in table 5:3 [145].

Their statistical summary (Mean, standard deviation, standard error, Minimum, Maximum, Range (average), variance and Geometric Mean) are in table 5.4.the world average values are given in table 5.2[146].

The study average values for surface and subsurface are shown in figure (5.5) and figure(5.6), the Leachable activity concentration ratio of $^{238}U/^{232}Th$, $^{238}U/^{40}K$ and $^{232}Th/^{40}K$ are given in table 5.5, The activity concentrations average of heavy metals for all soil samples in (ppm) are found to be (0.002 , 0.004 , 0.008 , 0.006 , 0.003 , 0.001 , 1.603, 282.148 , 16.594 ,72.812 , 48.132 , 8.898 , 106.841, 8.957 and 393.221) respectively. The activity concentrations of radioactive elements and calculated leachable activity concentration of ^{238}U, ^{232}Th and ^{40}K ,(in Bq/kg) for ^{238}U= 39.19950 Bq/kg, for ^{232}Th = 43.74466 Bq.kg and for ^{40}K = 67.77642 Bq/kg, respectively.

The average activity concentration ratio (range) of $^{238}U/^{232}Th$, $^{238}U/^{40}K$ and $^{232}Th/^{40}K$ was (0.9767Bq/kg, 0.6619Bq/kg and 0.6952Bq/kg) respectively, less than one.

This gives an indication that the activity concentration of ^{228}Ra(or ^{232}Th) in the rock (parent material of soil), from which the soil was formed, is higher than ^{226}Ra (or ^{238}U) , because both radium isotopes have the same chemical and environmental behavior.

Grandparent isotopes of ^{226}Ra and ^{228}Ra, ^{238}U and ^{232}Th respectively, could have the same pattern of activity ratio in some types of rock.

For example, average activity concentration ratio of $^{238}U/^{232}Th$ in soil samples were 0.9767Bq/kg [147].

The natural concentrations of ^{238}U and ^{232}Th are 2.9 and 9.6 in ppm, which are equivalent to activity concentrations in Bq/kg are 35.960 and 44.160 $Bq.kg^{-1}$, respectively.

Uranium is often found in deficit with respect to thorium in the solid surface environment because uranium 4+ oxidation state is soluble [148].

The average activity concentrations of ^{238}U and ^{232}Th fall within the world average that are higher than the world average but they fall within the world range, but the results of potassium ^{40}K less than the world average and reported data as given in table 3.1 [149].

The second point is the slope of the fitting line, which indicates the average variation of activity concentrations in soil. Slopes equal to one or less than one or greater than one indicate the variation in activity concentration in soil due to agricultural activities such as soil washing and preparation, and soil fertilization ,the results of fitting line slopes were 0.026 for fig5.2,0.34 for fig5.3 and 0.009 for fig5.4, respectively.

Generally that indicates the enhancement of natural radionuclides in cultivated soils and soil activities of study area.

The enhancement of ^{226}Ra (or ^{238}U) and its daughters could be due to their accumulation in soil due to the application of fertilizers, where compound fertilizers (NPK- Nitrogen, Phosphate, and Potassium) it have activity concentration [151].

The enhancement of ^{40}K in soil is clearer than other radionuclides where the slope of the fitting line, figure 5.4 , even with the considerably high solubility of potassium that lead to its possible leaching from the upper soil layer. This indicates the excessive application of fertilizers and other chemicals containing potassium compounds for cultivated soils.

Also the physical and chemical properties of soil play a significant role in radionuclides accumulation, leaching and partitioning [152].

The concentration of heavy metals elements for Nyala area from 24 selected soil samples are presented in table below:

Table 5.1: Heavy metals concentration (in ppm) using XRF techniques for some selected soil samples from Nyala city.

No	Sample	Cr	Ni	Cu	Zn	Pb	Co	Fe	Zr	Y	Rb	V	Ga	Sr	Nb	Ba
1	S01E	0.012	0.007	0.008	0.033	0.008	0.007	2.880	372.820	25.660	92.290	61.590	13.495	169.300	14.046	462.547
2	S02E	0.022	0.003	0.005	0.011	0.008	0.000	1.314	198.401	10.165	89.321	65.321	5.211	71.678	4.904	327.792
3	S05E	0.016	0.008	0.007	0.013	0.007	0.000	3.048	200.231	11.289	85.320	60.215	6.909	131.071	8.475	289.533
4	S06E	0.028	0.002	0.002	0.004	0.003	0.000	1.023	154.254	13.967	88.321	55.321	9.207	112.523	6.900	399.019
5	S09E	0.019	0.007	0.007	0.005	0.001	0.000	0.842	198.879	14.212	83.001	50.214	8.001	118.004	7.0654	302.213
6	S10E	0.023	0.003	0.004	0.009	0.002	0.000	1.373	198.458	15.154	88.321	27.675	9.235	109.212	8.007	351.584
7	S01W	0.015	0.007	0.004	0.004	0.002	0.000	2.471	343.733	17.146	90.812	41.761	10.425	124.831	8.428	589.450
8	S02W	0.017	0.003	0.007	0.004	0.003	0.000	1.212	200.215	14.121	55.658	41.762	10.002	119.987	8.006	400.235
9	S05W	0.023	0.001	0.002	0.001	0.000	0.000	1.119	197.666	10.089	51.085	39.698	6.980	92.304	5.609	344.445
10	S06W	0.017	0.004	0.001	0.001	0.000	0.000	1.084	315.635	12.980	4.713	44.226	6.656	83.138	7.439	281.123
11	S09W	0.025	0.000	0.003	0.001	0.000	0.000	1.119	105.514	9.666	8.0756	41.666	7.029	97.215	3.432	453.059
12	S10W	0.013	0.003	0.006	0.001	0.003	0.007	2.684	198.401	11.200	154.321	36.108	8.598	100.251	5.326	452.215
13	S01S	0.016	0.000	0.001	0.004	0.002	0.000	0.059	105.514	13.808	114.300	31.178	7.891	88.954	6.985	398.298

14	S02S	0.019	0.003	0.002	0.004	0.004	0.000	0.847	198.401	15.128	77.326	29.640	7.976	72
15	S05S	9.726	3.106	0.852	0.167	0.000	0.000	29.18	171.760	13.422	68.617	39.698	7.165	64
16	S06S	0.024	0.003	0.012	0.003	0.002	0.000	1.182	263.028	15.545	69.604	42.783	7.520	63
17	S09S	0.023	0.000	0.051	0.001	0.001	0.000	1.017	213.277	14.321	48.759	29.640	7.998	70
18	S10S	0.015	0.002	0.053	0.002	0.002	0.000	1.671	699.122	28.543	56.325	43.175	12.601	10
19	S01N	0.014	0.006	0.006	0.021	0.007	0.000	2.791	442.841	29.556	95.088	69.071	14.422	17
20	S02N	0.027	0.008	0.002	0.004	0.002	0.000	1.892	295.127	18.947	74.986	52.745	9.684	10
21	S05N	0.019	0.005	0.004	0.004	0.002	0.000	1.267	215.350	16.001	56.325	69.071	8.585	10
22	S06N	0.018	0.007	0.004	0.004	0.000	0.004	2.894	298.218	17.923	69.084	70.604	11.189	15
23	S09N	0.026	0.004	0.001	0.001	0.002	0.000	1.541	858.960	31.22	65.324	52.908	7.029	97
24	S10N	0.031	0.003	0.000	0.002	0.003	0.000	1.542	215.35	15.020	56.325	50.654	8.021	99
Average		0.020	0.004	0.008	0.006	0.003	0.001	1.603	282.148	16.594	72.812	48.132	8.898	1

Table 5.2: Descriptive Statistics of Heavy metals concentration (in ppm) for some selected so

Elements	Range	Minimum	Maximum	Mean	Std. Deviation	V

	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	S
Cr	9.714	0.012	9.726	0.425	0.404	1.981	
Ni	3.106	0.000	3.106	0.133	0.129	0.633	
Cu	0.852	0.000	0.852	0.044	0.035	0.173	
Zn	0.166	0.001	0.167	0.013	0.007	0.034	
Pb	0.008	0.000	0.008	0.003	0.001	0.002	
Co	0.008	0.000	0.008	0.001	0.001	0.003	
Fe	29.119	0.059	29.178	2.752	1.160	5.684	
Zr	753.446	105.514	858.96	277.548	35.762	175.198	3
Y	21.554	9.666	31.220	16.462	1.252	6.136	
Rb	149.608	4.713	154.321	72.638	6.268	30.709	9
V	42.929	27.675	70.604	47.780	2.684	13.148	1
Ga	9.211	5.211	14.422	8.826	0.461	2.260	
Sr	115.503	63.158	178.661	105.061	6.180	30.276	9
Nb	15.199	3.432	18.631	8.829	0.751	3.681	
Ba	432.149	248.339	680.488	387.184	21.032	103.036	1

Table 5.3: Correlations of heavy metals concentration (in ppm) using XRF techniques for soil samples from Nyala city.

Elements	Cr	Ni	Cu	Zn	Pb	Co	Fe	Zr	Y	Rb	V	Ga
Cr	**1**	-.043	.997**	.975**	-.23	-.091	.990**	-.129	-.106	-.029	-.131	-.158
Ni	-.043	**1**	-.051	-.054	-.06	-.090	-.032	.020	.085	.017	.080	.081
Cu	.997**	-.051	**1**	.971**	-.24	-.091	.987**	-.105	-.085	-.039	-.149	-.137
Zn	.975**	-.054	.971**	**1**	-.05	-.011	.982**	-.109	-.021	.042	-.028	-.034
Pb	-.230	-.056	-.235	-.054	**1**	.204	-.167	.078	.239	.459*	.447*	.275
Co	-.091	-.090	-.091	-.011	.204	**1**	-.030	.018	.100	.385	.110	.272
Fe	.990**	-.032	.987**	.982**	-.17	-.030	**1**	-.088	-.056	.018	-.058	-.082

Zr	-.129	.020	-.105	-.109	.078	.018	-.088	**1**	.874**	-.073	.226	.368	
Y	-.106	.085	-.085	-.021	.239	.100	-.056	.874**	**1**	.077	.322	.683**	
Rb	-.029	.017	-.039	.042	.459*	.385	.018	-.073	.077	**1**	.017	.238	
V	-.131	.080	-.149	-.028	.447*	.110	-.058	.226	.322	.017	**1**	.291	
Ga	-.158	.081	-.137	-.034	.275	.272	-.082	.368	.683**	.238	.291	**1**	
Sr	-.289	-.021	-.299	-.136	.421*	.209	-.190	.226	.480*	.250	.568**	.777**	
Nb	-.171	.020	-.143	-.080	.285	.080	-.106	.770**	.905**	.039	.401	.758**	
Ba	-.288	-.029	-.267	-.266	.127	-.020	-.249	.520**	.531**	.134	.040	.561**	

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 5.4: concentration of ^{238}U, ^{232}Th and ^{40}K in (ppm), and calculated leach concentration of ^{238}U, ^{232}Th and ^{40}K in Bq/kg , in soil samples Nyala area by XR

Ser.No	*Location	Code	Activity concentration **					
			^{238}U ppm	^{232}Th ppm	K %	^{238}U Bq/kg	^{232}Th Bq/kg	^{40} Bq/
1.	1E	S01E	3.7320	13.0210	2.4010	46.2768	59.8966	76.8
2.	2E	S02E	1.2840	6.1500	2.3810	15.9216	28.2900	76.1
3.	5E	S05E	2.1100	8.2280	2.0750	26.1640	37.8488	66.4
4.	6E	S06E	2.3360	8.1160	1.9510	28.9664	37.3336	62.4
5.	9E	E09E	2.0210	9.0020	1.8530	25.0604	41.4092	59.2
6.	10E	S10E	2.6500	9.8580	1.9130	32.8600	45.3468	61.2
7.	1W	S01W	2.8000	15.5480	2.7590	34.7200	71.5208	88.2
8.	2W	S02W	1.9550	6.0230	2.5610	24.2420	27.7058	81.9
9.	5W	S05W	1.9060	5.7240	1.1750	23.6344	26.3304	37.6
10.	6W	S06W	1.6950	7.4660	1.5820	21.0180	34.3436	50.6
11.	9W	S09W	1.5820	4.5140	2.6270	19.6168	20.7644	84.0
12.	10W	S10W	1.6500	5.9800	2.1250	20.4600	27.5080	68.0
13.	1S	S01S	2.0780	6.2400	2.4730	25.7672	28.7040	79.1
14.	2S	S02S	1.7230	8.6180	2.3710	21.3652	39.6428	75.8
15.	5S	S05S	2.1500	4.6870	0.3760	26.6600	21.5602	12.0
16.	6S	S06S	2.5360	7.1710	1.9030	31.4464	32.9866	60.8
17.	9S	S09S	2.0320	8.9400	2.7890	25.1968	41.1240	89.2
18.	10S	S10S	2.3160	11.9170	2.9380	28.7184	54.8182	94.0
19.	1N	S01N	4.7250	14.0700	2.2230	58.5900	64.7220	71.1
20.	2N	S02N	3.1000	9.8630	2.0260	38.4400	45.3698	64.8
21.	5N	S05N	8.0100	8.0540	2.2650	99.3240	37.0484	72.4
22.	6N	S06N	13.3830	8.9520	1.8710	165.9492	41.1792	59.8
23.	9N	S09N	3.8460	30.4110	2.2150	47.6904	139.8906	70.8
24.	10N	S10N	4.2500	9.6800	1.9790	52.7000	44.5280	63.3
Average			3.16125	9.50971	2.11800	39.19950	43.74466	67.72

* sample location Inside and outside: soil samples.

1 ppm **U = (12.4 Bq/kg ^{238}U) , 1ppm **Th** = (4.6 Bq/kg ^{232}Th) , 1ppm **K** = (32Bq/kg

Table 5.5: Leachable activity concentration ratio of ^{238}U/^{232}Th, ^{238}U/^{40}K and ^{232}Th/^{40}K

(Surface samples)

Ser. No	Location	Depth(cm)	Code	Activity concentration in bq/kg		
				^{238}U/^{232}Th	^{238}U/^{40}K	^{232}Th/^{40}K
1.	01E	0	S01E	0.7726	0.6023	0.7796
2.	05E	0	S05E	0.6913	0.3940	0.5700
3.	09E	0	E09E	0.6052	0.4226	0.6983
4.	01W	0	S01W	0.4855	0.3933	0.8101
5.	05W	0	S05W	0.8976	0.6286	0.7003
6.	09W	0	S09W	0.9447	0.2334	0.2470
7.	01S	0	S01S	0.8977	0.3256	0.3627
8.	05S	0	S05S	1.2365	2.2158	1.7919
9.	09S	0	S09S	0.6127	0.2823	0.4608
10.	01N	0	S01N	0.9053	0.8236	0.9098
11.	05N	0	S05N	2.6809	1.3704	0.5112
12.	09N	0	S09N	0.3409	0.6728	1.9736
Average				0.9226	0.6971	0.8180

Table 5.6: Leachable activity concentration ratio of $^{238}U/^{232}Th$, $^{238}U/^{40}K$ and $^{232}Th/^{40}K$
(Sub-surface samples)

Ser. No	Location	Depth(cm)	Code	Activity concentration in bq/kg		
				$^{238}U/^{232}Th$	$^{238}U/^{40}K$	$^{232}Th/^{40}K$
1.	02E	5	S02E	0.5628	0.2090	0.3713
2.	06E	5	S06E	0.7759	0.4640	0.5980
3.	10E	5	S10E	0.7246	0.5368	0.7408
4.	02W	5	S02W	0.8750	0.2958	0.3381
5.	06W	5	S06W	0.6120	0.4152	0.6784
6.	10W	5	S10W	0.7438	0.3008	0.4045
7.	02S	5	S02S	0.5389	0.2816	0.5225
8.	06S	5	S06S	0.9533	0.5164	0.5417
9.	10S	5	S10S	0.5239	0.3055	0.5831
10.	02N	5	S02N	0.8473	0.5929	0.6998
11.	06N	5	S06N	4.0299	2.7717	0.6878
12.	10N	5	S10N	1.1835	0.8322	0.7031
Average				0.9476	0.6268	0.5724

Table 5.7: Report of calculated leachable activity concentration of ^{238}U, ^{232}Th and ^{40}K in samples Nyala area .

Statistic	**^{238}U** (Bq/kg)	**^{232}Th** (Bq/kg)	**^{40}K** (Bq/kg)
Mean	39.1995	43.7447	67.7764
Std. Deviation	32.2969	24.2406	17.4742
Std. Error of Mean	6.5926	4.9481	3.5669
Minimum	15.9200	20.7600	12.0300
Maximum	165.950	139.8900	94.0200
Range	150.030	119.1300	81.9800
Variance	1043.092	587.6050	305.3460
Geometric Mean	32.8001	39.6952	64.0824

Table 5.8: Summary of the activity concentration of ^{238}U (^{226}Ra), ^{232}Th (^{228}Ra) and ^{40}K (

samples worldwide [154].

Location		^{238}U (or ^{226}Ra)	^{232}Th (or ^{228}Ra-)	^{40}K	Note
Africa	Algeria	5-27	7-27	93-412	Sand
	Egypt	3-101	2-117	16-1379	National range
	Libya	8.7-12.8	7.6-9.7	265-282	Tripoli
	Namibia	45-49	3-38	42-1,100	
Asia	Bangladesh	37.2 (15-94)	60 (28-129)	438 (200-772)	Coastal
	China	18.2-79.7	2.33-225	281-891	
	Hong Kong	30-110	1.9-243	59-851	
	India	20-62	14-48	61-317	Coastal
	India	11.1[b]	8.9	108	Mangalore
	Jordan			156-544	
	Kuwait	11.8 (1.8-28)	10 (1.5-16)	332 (4-497)	
	Oman	29.7	16	225	
	Saudi	9.3	7.4	369	Jeddah area
	Syria	22.2 (1-40)	18.4 (11-25)	247 (100-378)	
	Taiwan	11-33	14-44	148-814	
Europe	Canary Island	7.3-104	12-111	142-1489	
	Greece	7-310	3-190	30-1440	All provinces

	Ireland		3-60	40-800	
	Italy Norway	57-71 43.3 (12-137)	73-87 21.1 (4-52)	580-760 283 (31-564)	Costal
	Serbia	21-29	25-43	348-441	
	Spain	8-310	5-258	31-2040	Rio Grande
America	Brazil	29.2(10-137)	47.8(12-191)	704(56-1972)	Rio Grande
	Canada	15.6(3.3-36)	12.3(1.5-28)	416(153-817)	Northem
	Costa Rica	10	8	175	Rainforest
	USA	41	82	930	New Jersey
	Global average	25 (10-50)	25 (7-50)	370 (100-700)	

[b] Geometrical mean & [c] Approximate values

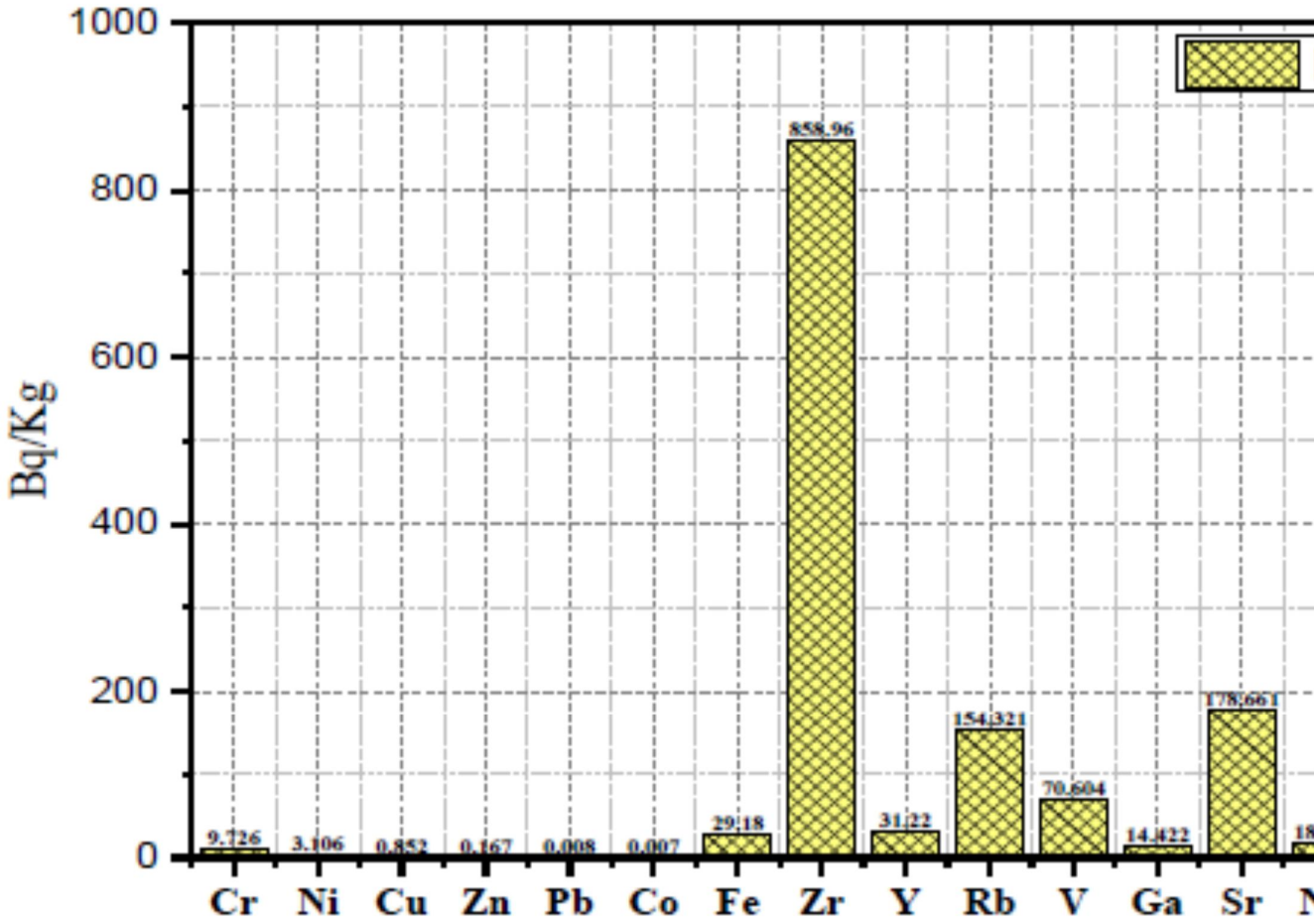

Figure 5.1: Heavy metals for soms soil samples in study area and their activity concentration values Bq/kg

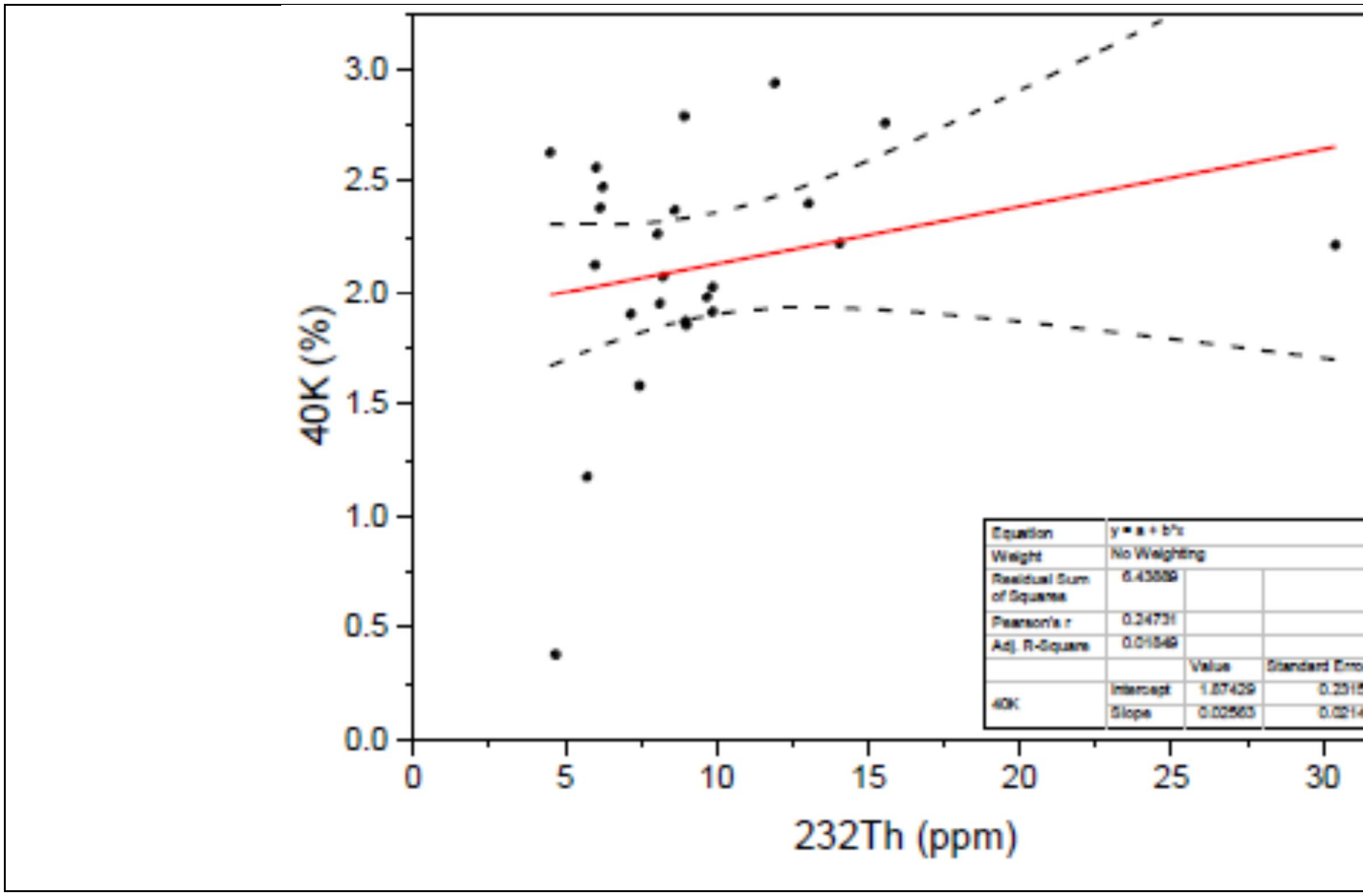

Figure 5.2: Correlation between activity concentration of ^{232}Th and ^{40}K in all s

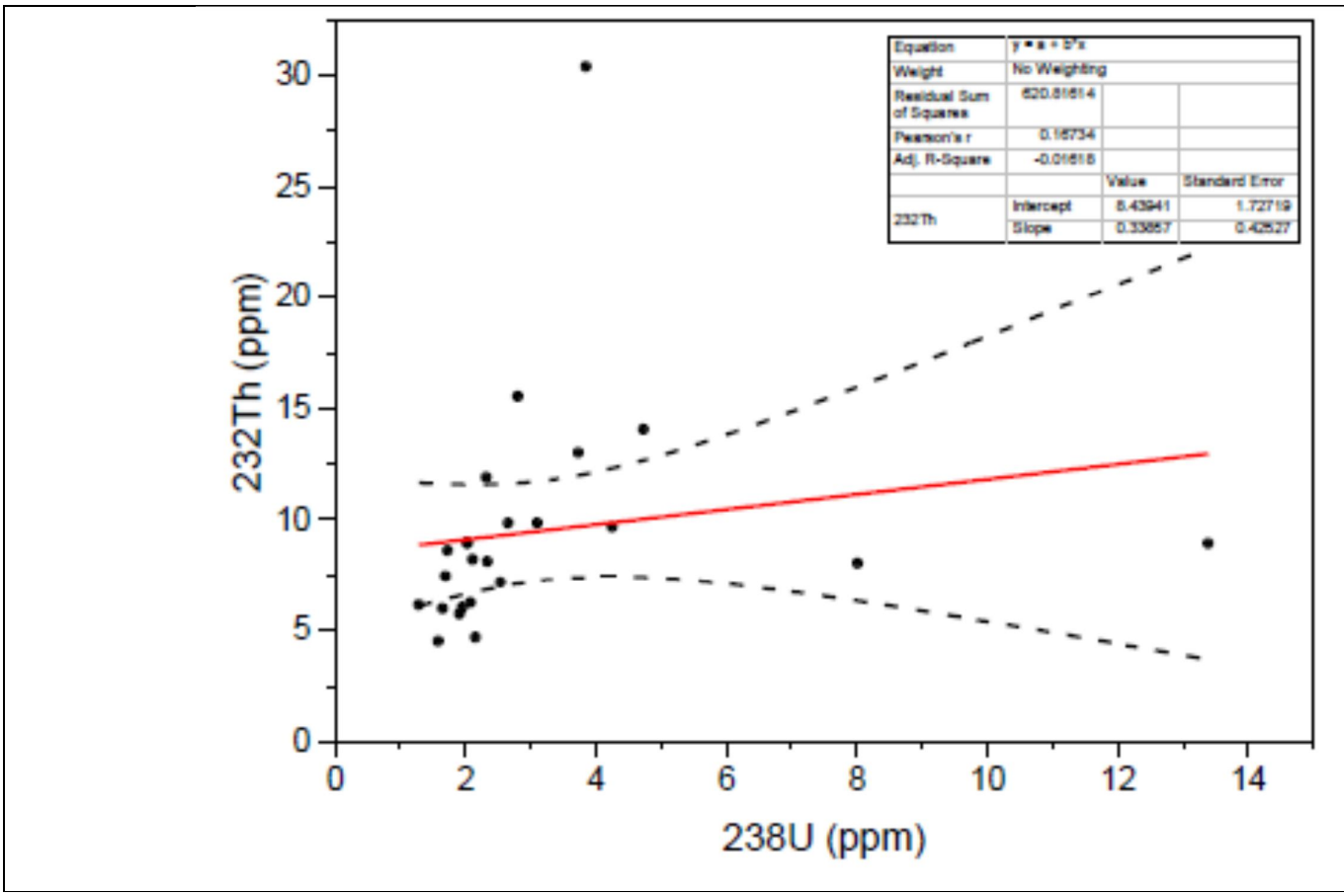

Fig. 5.3: Correlation between activity concentration of ^{232}Th and ^{238}U in all soil samp

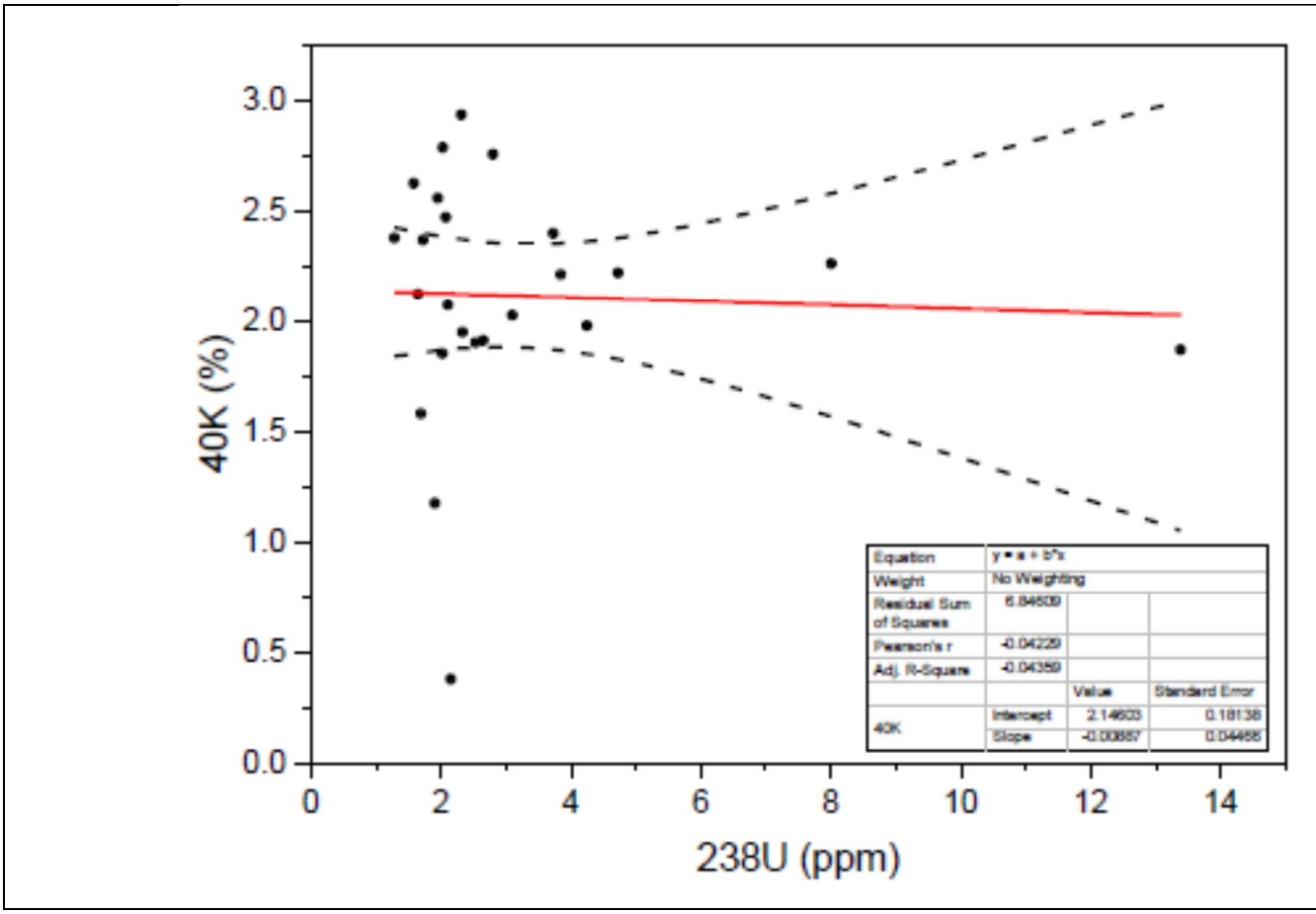

Fig. 5.4: Correlation between activity concentration of ^{238}U and ^{40}K in all soil sample

5.4 Surface and Sub-Surface Samples

A comparison between the surface soil samples and soil samples that taken at depth of (5) cm was conducted in order to investigate the correlation between the distribution of the radionuclide's ^{238}U, ^{232}Th and ^{40}K and layer depth. A topsoil sample and deeper soil sample were collected from 4 sampling points from the north, west, south and east of study area (see Figure 4.1 in Chapter 4 for sample locations). table 5.4 shows the mean of the activity concentration for the individual activities as deduced from the observed X-ray florescence (XRF) transitions associated with the direct decays . The activity concentration levels of ^{238}U decay products, ^{232}Th decay products and ^{40}K in the surface and deep soil samples were similar as in table (5.5 -5.6)[182]. For specific details on the activity concentration levels of ^{238}U, ^{232}Th and ^{40}K in the measured samples see Appendix A tables(5.9-5.19).

5.5 Soil properties

Soil is a dynamic layer in which many chemical, physical and biological activities are going on constantly. All soils contain mineral particles, organic matter, water and air. The combinations of these determine the soil properties It is not a lifeless zone but an active system having inputs and outputs of energy and matter. In soils, metals and radionuclide can be dissolved in solution, or ions exchanged in reaction, or complexed with soil organics or precipitate as pure or mixed solids. Soluble contaminants are subject to migration with soil water, uptake by plants or aquatic organisms or loss due to volatilization [183].

Soil samples were collected from different locations in Nyala city. Activity concentration of ^{238}U, ^{232}Th and ^{40}K were measured by using X ray

florescence spectrometry (XRF). Leachable and total concentration of, uranium, thorium and potassium in soil samples were measured.

The average activity concentrations of ^{238}U and ^{232}Th fall within the world average, while that ^{40}K activity concentrations are slightly less than the world average, for potassium results we need to measure more times to accurate the results of ^{40}K samples.

To evaluate the impact of agricultural activities on the activity concentration of natural radionuclide's, activity concentration ratios I/O [inside/outside soil samples] of ^{238}U, ^{232}Th and ^{40}K were calculated which indicate qualitatively the enhancement of natural radionuclide's in inside soils in comparison to outside soils. This indication was based on the average ratios.

The average concentration of leachable and total concentrations of uranium, thorium and potassium did not show any variation in inside and outside soil. It was obvious that with increasing the activity concentration of natural radionuclide's. Therefore, the chance to note the enhancement of natural radionuclide's, especially uranium content due to soil activities and continuous application in soil, will increase in low activity concentration range.

5.6 Recommendation and Future work

Physical and chemical properties of soils are playing a key role that affects the behavior of different metals and radionuclide's. In soils, metals and radionuclide can be dissolved in solution or complexed with soil organics or precipitate as pure or mixed solids. Agricultural activities affected the physical and chemical properties of soils with different patterns, while the correlation between these properties and radionuclide's activity

concentrations were varied even within the same parameter and the same soil (surface or subsurface soils).

Uranium concentrations in soil samples were found to be less than the United States Environmental Protection Agency (USEPA) maximum contaminant level (MCL) for uranium in soil which is 39.19950Bq/kg [184].

a recommendation for further future work we suggest the following:

a) Since the (XRF) X ray Florence spectroscopy results using one sample from each location indicate that radioactivity levels of soil samples for ^{238}U and ^{232}Th of study area are slightly higher than the world acceptable average, it is recommended that further studies which involve large representation of samples should be conducted.
b) To investigate the variation pattern of natural radionuclide's and activity concentration of ^{238}U, ^{232}Th and ^{40}K of soils from different locations in Nyala city using Hyper Pure Germanium spectroscopy (HPGe) system, beside X ray fluorescence spectrometry (XRF).
c) It will be very useful to perform the same study on other areas in Sudan with similar soil pattern in order to have a complement and concrete conclusion for the findings in our study. It is extremely significant to conduct further study on the vertical distributions of the natural radionuclide's on soil.

5.7 Conclusion:

Different soil samples were collected from study area in Nyala city Sudan.

XRF technique has been employed in order to reveal their mineral

composition to evaluate the pollution of soil with heavy metals.

The concentrations of studied elements (Cr, Ni, Cu, Zn, Pb , Co, Fe, Zr , Y, Rb, V, Ga , Sr ,Nb and Ba) in Nyala city area were determined.

Values including ^{238}U, ^{232}Th and ^{40}K activity concentration and heavy metals were determined for each sample of this study and summarized in Tables (5.2) to table (5.5).

The activity concentration of heavy metals which observed in all samples in this study is below the minimum detectable limit. This implies that the soil samples studied are free from artificial radionuclides.

All of the obtained values indicate that the area under investigation has a normal level of natural background,

A soil pollution assessment becomes very complex when different sources of contamination are present and their products are variably distributed with time assembling and become toxic. As a result of existance of all these elements, which are not pollutants.

the measurement of heavy metals in study area are within acceptable levels and doesn’t possess any biological risks. The results of this study can be used as a data baseline for preparing a radiological map of the study area, especially at the chosen sites. Existance of toxic elements with different values caused many diseases if reached to human bodies with high ratio [185]. For example, Cr caused carcinoma; Cu caused cirrhosis, nausea, vomiting and diarrhea.

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Study of Some Heavy Metals and Radioactive Element from Soil Samples, Nyala Area -Sudan

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Abstract:

In this work X-ray fluorescence (XRF) technique was used to evaluate the soil pollution with heavy metals for 40 surface and subsurface soil samples (0–5 cm in depth) from various locations to cover the area of Nyala city. Sudan. Concentrations of eight elements Cr, Ni, Cu, Zn, Pb, Co, Fe and K were determined. It also aims to establish the data baseline to the major and minor trace elements from study area that has not been investigated before. The elemental concentrations were compared with the normal values and other studies in different locations from the world. The correlation between elements appears that no pollution inside the investigated results from different sources of contamination in side them. The results indicated that all the samples analyzed are safe in general for the toxicity levels. The results establish a database reference of radioactivity background levels for the study around Nyala city.

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Study of Natural Radioactivity for Some Building materials used in Al Kharj Area

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Abstract: **The aim of this study is to determine the radioactivity content of different types for building materials. Twenty four samples, from both local and foreign product were collected and measured using gamma spectrometry system. The activity concentrations have been determined for radium (226Ra), thorium (232Th) and potassium (4OK) in each sample. The samples were crushed and dried in controlled furnace for around twenty four hours, and then stored for four weeks in plastic Marinelli beakers. From the measured gamma-ray spectra, activity concentrations of marble building materials 238U (0.72– 43.2Bq/kg), 232Th (0.20 –33.10 Bq/kg), 226Ra (0.43–33.1 Bq/kg) and 40K (0.70–897.2 Bq/kg) for granite 238U (0.04–315.3 Bq/kg), 232Th (0.02–186.1 Bq/kg), 226Ra (0.03–147.2 Bq/kg) and 40K (0.30 – 1482.6 Bq/kg) The results are compared with the published data of other countries and with the world average limits. It is concluded that the measured radioactivity of building materials are within acceptable levels and does not poses any risk from radiation protection point of view. The results indicated that all the samples collected used as building materials in Alkharj area are safe in general for the radioactivity levels.**

Keywords: **Radioactivity concentration, building materials, Radium Equivalent, Radiation Hazard, Annual dose.**