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Calculation of Uranium Concentrations in Tikrit University Soil Samples using Neutron Activation and CR-39 Detector

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Abstract: ***The aim of this work was to measure the concentrations of uranium in soil samples collected from the University of Tikrit, which located in the province of Salah al-Din, (180) km north of Baghdad, in this study 80 samples was collected from (14) college in Tikrit University. The samples were preperated with CR-39 for irradiation with thermal neutrons and compared the results with standrad samples, in order to measure uranium concentrations in soil samples. The results show that the highest uranium concentration was (7.31) ppm in sample (V1) college of arts which and the lowest concentration of uranium was (0.54) ppm in the sample (G1) which college Engineering and the weighted average of all samples was (3.48 ± 1.57) ppm, These values were within the universally accepted limit of (11.7) ppm.***

1. Introduction

Human body is usually exposed to radiation with vary rates, whether it is natural or industrial. The effect of the radiation in the environment may remain several years, that chang the genetic of humans and animals, leading to genetic mutations that appear in subsequent generations, the impact of contamination should not be neglected in soil and water that transfer from it to human and animal food . [1]

Uranium is a natural component of soil and water. Its concentration ranges approximately from (1_120) ppm and consists of a number of isotopes, ^{238}U, ^{235}U, and ^{234}U. Most of these isotopes emit (α or ß) particles and Gamma radiation.[2]

Therefore, there is a need to study the effect of radiation and detection the natural and industrial radiation activity, the extent of pollution of the environment and how to be treated, many researches calculated concentrations of radioactive materials in the soil, plant, building materials, water, air and others, and the indication of their impact on living organisms. [3]

For this purpose, different techniques were used, such as spectral measurements of gamma rays, neutron activation analysis, X-ray fluorescence, and solid state nuclear track detector. [4]

The purpose of this research is to calculate the concentrations of uranium in soil of University of Tikrit (as it attracts an increasing number of students).

2. Experimental Part

a) Collection of Samples

The University of Tikrit is located north of the city of Tikrit in the province of Salah al-Din and within the coordinates listed in Table (1), shown in Figure (1)

Soil samples were collected from 14 college in University of Tikrit at a depth of 5 cm and stored in special bags with 500 g for each sample. Six samples were taken from each college except the printing department only two samples, the distance between the sample and the specific building varies between (2-20)m. This process was carried out at 16/10/2017.

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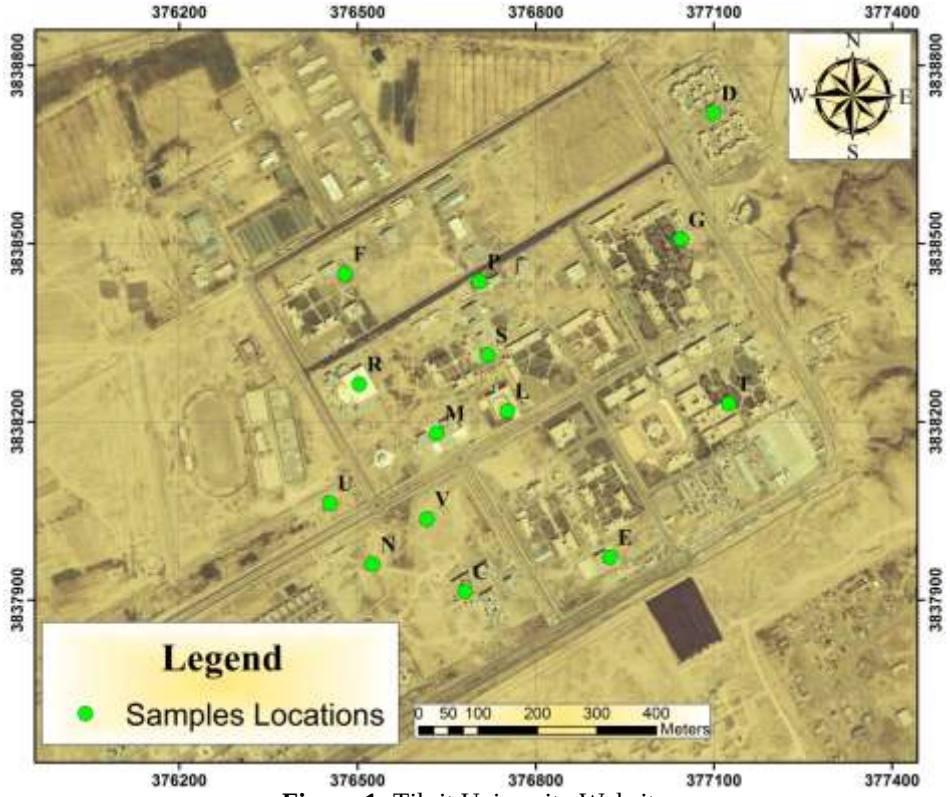

Figure 1: Tikrit University Website

Table 1: Location and (GPS) coordinates to study samples

No.	Location	Cod	Coordinates
1	College of science	$S_1 \rightarrow S_6 = S$	34°40'45.8"N→34°40'43.3"N 43°39'16.3"E→43°39'15.0"E
2	College of Education for Sciences of drainage and humanity	$T_1 \rightarrow T_6 = T$	34°40'43.6"N→34°40'47.4"N 43°39'26.0"E→43°39'26.3"E
3	College of Engineering	$G_1 \rightarrow G_6 = G$	34°40'52.6"N→34°40'50.0"N 43°39'25.3'E→43°39'17.0"E
4	College of Pharmacy	$P_1 \rightarrow P_6 = P$	34°40'50.3"N→34°40'44.6"N 43°39'15.9"E→43°39'16.7"E
5	The central Library	$L_1 \rightarrow L_6 = L$	34°40'44.1"N→34°40'41.5"N 43°39'15.8"E→43°39'16.0"E
6	College of Veterinary Medicine	$M_1 \rightarrow M_6 = M$	34°40'40.1"N→34°40'42.7"N 43°39'11.0"E→43°39'12.6"E
7	College of physical education	$R_1 \rightarrow R_6 = R$	34°40'42.3"N→34°40'44.8"N 43°39'07.8"E→43°39'04.7"E
8	College of Agriculture	$F_1 \rightarrow F_6 = F$	34°40'47.3"N→34°40'34.0"N 43°39'05.3"E→43°39'13.2'E
9	Internal Sections for Girls	$D_1 \rightarrow D_6 = D$	34°40'58.1"N→34°41'00.5"N 43°39'28.8"E→43°39'29.5"E
10	College of Administration Economics	$E_1 \rightarrow E_6 = E$	34°40'38.9"N→34°40'35.6'N 43°39'22.5"E→43°39'25.1"E
11	College of Dentistry	$C_1 \rightarrow C_6 = C$	34°40'38.0"N→34°40'47.4"N 43°39'05.3"E→43°39'05.2"E
12	College of Literature	$V_1 \rightarrow V_6 = V$	34°40'32.5"N→34°40'35.3"N 43°39'10.0"E→43°39'11.7"E
13	College of Islamic Sciences	$N_1 \rightarrow N_6 = N$	34°40'38.3"N→34°40'36.5"N 43°39'16.7"E→43°39'13.4"E
14	Printing	$U_1 \rightarrow U_2 = U$	34°40'33.9"N→34°40'33.6"N 43°39'11.7"E→43°39'14.1"E

b) Preparation of Samples

1) The samples were taken to the laboratory for drying by oven(German-made) and a with temperature of 80°C for 2h to get rid of moisture[5].
2) The samples were ground with a grinder(Turkish-made) (Retsch KG) and converted into a fine powder for homogeneity of the sample.
3) The homogenized samples was sieved by using a 75 µm (Retsch) made in Germany.
4) Weighted (0.5) g of each sample of soil using a sensitive balance (Kern) was made in German and then was compressed by pressure of 250 bar to made samples as disk with diameter of (1) cm and thickness of (2) mm by manual piston German-made (ENERPAC) of 5 tons.
5) The sample were fixed with use CR_39 detector of (1x1) cm^2 , by used sticker to covered with a tape which consisting of (25) samples as shown in Figure (2).

c) Irradiation Process

Place the tape inside a shield of paraffin wax (5 cm) from the neutron source (^{241}Am-^{9}Be) as shown in Figure (3) with flux of ($3x10^5$ n/cm^2.s) for(7) days to obtain the effects of fission fragments resulting from the fission of the uranium with thermal neutrons, the same procedure for standard source , then the CR -39 remove to chemical etching .

d) Chemical Etching

After irradiation process, CR-39 etched by NaOH solution with (6.25N) for 4 hours at 60°C [6] using water bath (type Memmert German-made) , then the detectors cleaned and wished by distal water, in order to measure the track density in CR-39.

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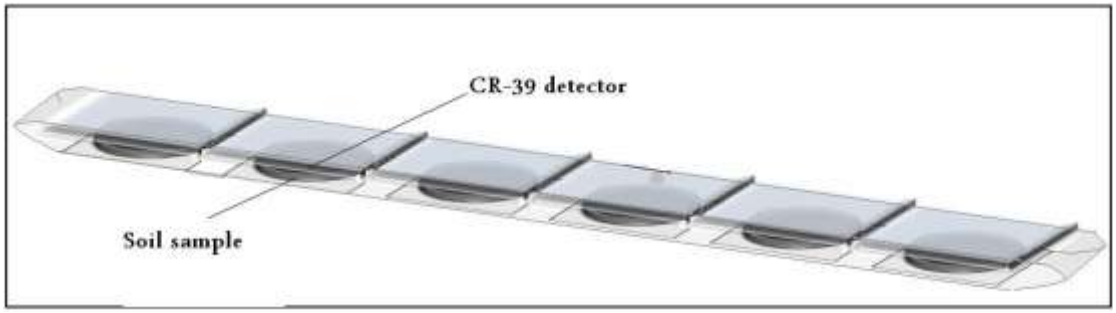

Figure 2: The tape which consists of 25 samples and detector (CR-39)

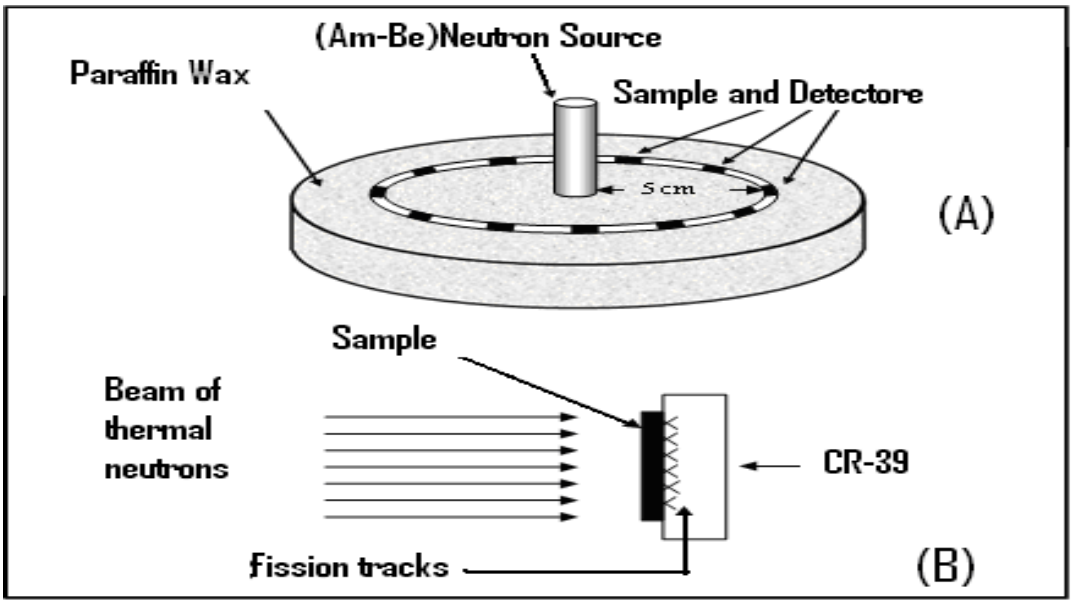

Figure 3: The irradiation tape which consists of (25) samples with the(CR-39) detector using Neutron source

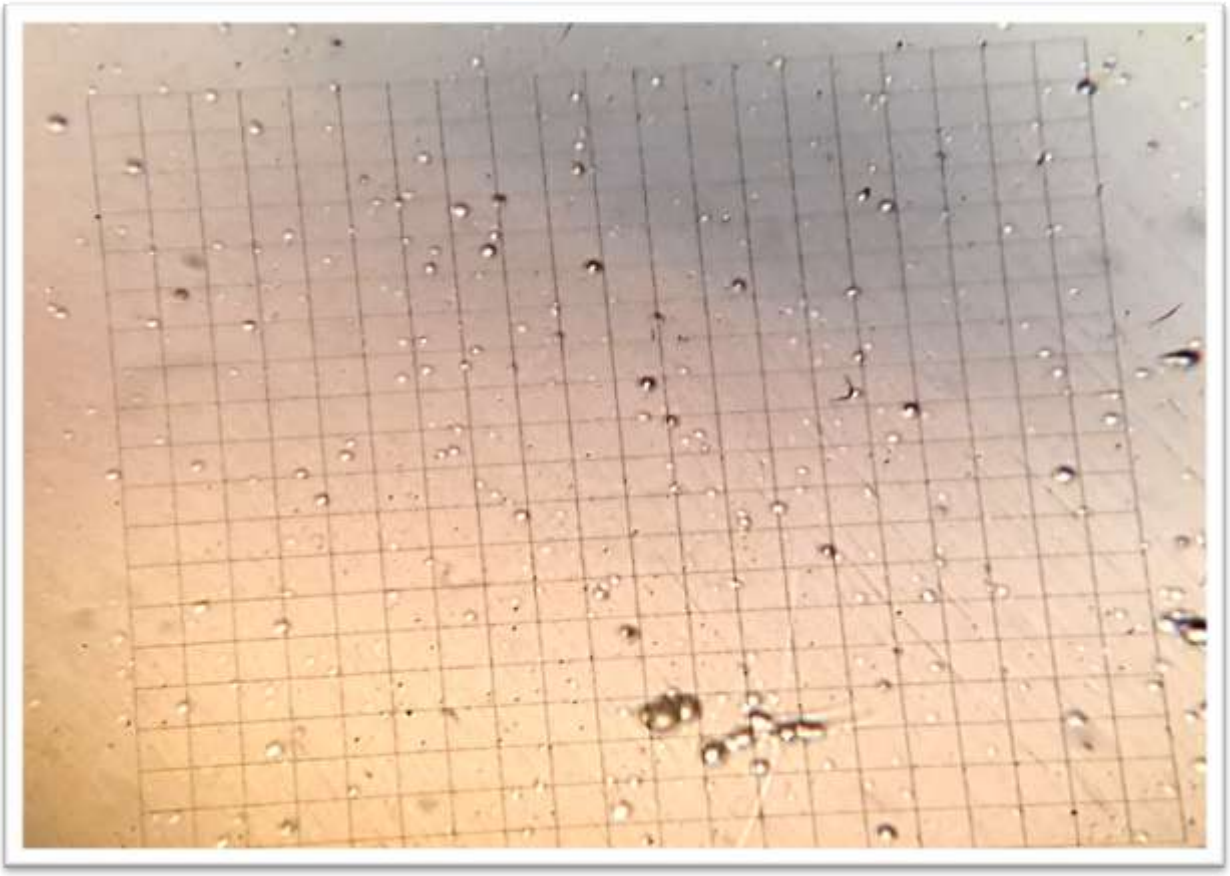

Figure 4: The track of Nuclear Fission Fragments in the Solid stat Nuclear detector type (CR-39)

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e) Measurement of uranium concentrations

The track density was measured by using microscope type (Novel) with a magnification power of (40x) using the following equation [7]:

Tracks density (ρ)=Nave/A ---------- (1)

Where:

ρ: Track intensity (Tracks / mm^2)

N_{ave}: Average total number of tracks (Track)

A: Aerea of the field vision (mm^2)

Figure (4) shows the track of nuclear fission fragments in the solid state nuclear detector type (CR-39).

The concentration of uranium is measured in soil samples by comparing the density of tracks that recorded by CR-39 for samples and for standard samples according to the following equation [7] :

$C_X=Cs(\rho_X/\rho_S)=\rho_X/slope$ ---------- (2)

Where:

C_X: Concentration of uranium in the unknown sample (ppm)

C_S: Concentration of uranium in the standard sample (ppm)

ρ_X: Track intensity in the unknown sample (Tracks / mm^2)

ρ_S: Trackt intensity in the standard sample (Tracks / mm^2)

The slope of the straight line for the track density and uranium concentration shown in Figure (5) [5].

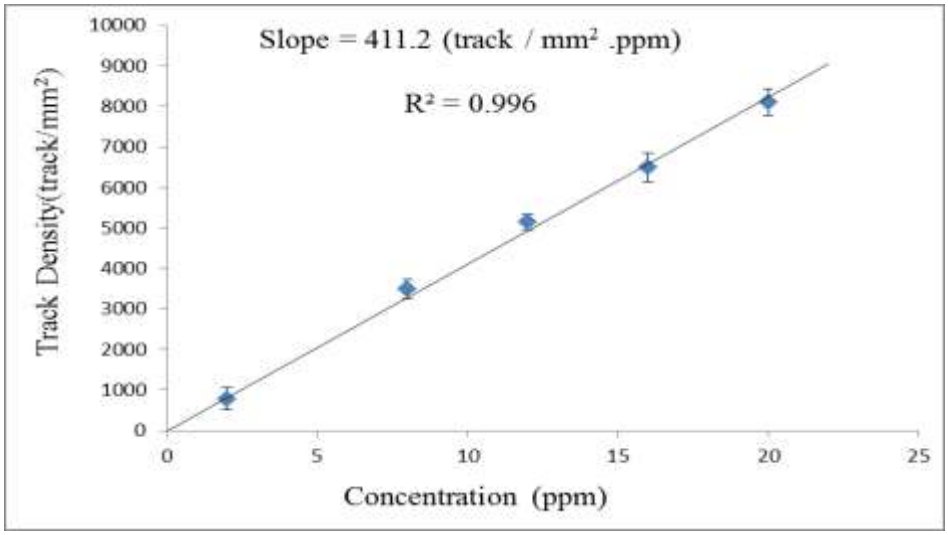

Figure 5: The relationship between the tracks density and the concentration of uranium (ppm) for standard soil samples.[5]

3. Results and Discussion

For monitering is necessary to measure the uranium concentration in soil of University of Tikrit , The monitoring at this time and in the future is very important to determined the risks that cause by this concentrations to ensure that its safety .

Table (2) shows the results of uranium concentrations in soil samples at the University of Tikrit. It is clear that the uranium concentration of the study areas ranges between (0.54 and 7.31)ppm. The highest concentration of uranium was (7.31ppm) in samples (V1) which was one of the samples from college of arts and the lowest concentration of uranium found in the samples (G1) from college of Engineering was (0.54) ppm. the weighted average of all samples was (3.48 ± 1.57)ppm, and these values were within the universally accepted limit of (11.7) ppm According to(UNSCEAR 2000) [8]. Figure (6) shows of the results that obtained from this study.

Table 2: Track density and concentration of uranium for all samples of soil and its locations

No.	Locations	Sample cod	Track density (track/mm^2)	Uranium Concentration (ppm)
1	College of Science	S1	2594.2±36.96	6.3
		S2	1924.2±30.57	4.67
		S3	945.7±18.42	2.29
		S4	2261.4±46.13	5.49
		S5	2142.8±43.11	5.21
		S6	1002.8±14.32	2.43
2	College of Education for Sciences of drainage and humanity	T1	1315.7±27.40	3.19
		T2	1591.4±24.75	3.87
		T3	1884.2±36.34	4.58
		T4	1322.8±22.26	3.21
		T5	1274.2±89.72	3.09
		T6	421.4±12.30	1.02
3	College of Engineering	G1	224.2±8.68	0.54
		G2	942.8±22.38	2.29
		G3	548.5±21.70	1.33
		G4	1540±23.81	3.74
		G5	860±15.34	2.09
		G6	1251.4±12.77	3.04
4	College of Pharmacy	P1	882.8±17.72	2.14
		P2	1244.2±58.21	3.02
		P3	830±22.68	2.01
		P4	384.2±17.26	0.93
		P5	1955.7±20.93	4.75
		P6	1178.5±12.88	2.86
5	The central Library	L1	2941.4±26.70	7.15
		L2	1647.1±19.96	4
		L3	1220±19.95	2.96
		L4	1012.8±11.51	2.46
		L5	1447.1±24.00	3.51
		L6	1481.4±53.08	3.6
6	College of Veterinary Medicine	M1	714.2±16.34	1.73
		M2	774.2±25.74	1.88
		M3	382.8±13.25	0.93
		M4	687.1±15.52	1.67

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		M5	722.8±6.72	1.75
		M6	1257.1±23.05	3.05
7	College of physical education	R1	1897.1±31.40	4.61
		R2	487.1±15.58	1.18
		R3	1185.7±40.54	2.88
		R4	2157.1±59.60	5.24
		R5	2047.1±26.16	4.97
		R6	1564.2±11.17	3.8
8	College of Agriculture	F1	1630±48.95	3.96
		F2	1410±23.91	3.42
		F3	2051.4±16.57	4.98
		F4	2651.4±34.72	6.44
		F5	958.57±39.35	2.33
		F6	1580±28.31	3.84
9	Internal Sections for Girls	D1	2107.1±12.08	5.12
		D2	1257.1±12.98	3.05
		D3	828.5±41.02	2.01
		D4	1287.1±41.95	3.13
		D5	2270±32.51	5.52
		D6	1804.2±24.20	4.38
10	College of Administration Economics	E1	1825.7±25.74	4.43
		E2	1560±13.71	3.79
		E3	2548.5±19.73	6.19
		E4	881.4±26.01	2.14
		E5	320±9.73	0.77
		E6	631.4±25.90	1.53
11	College of Dentistry	C1	2128.5±11.79	5.17
		C2	1887.1±29.10	4.58
		C3	1645.7±42.84	4
		C4	1314.2±24.58	3.19
		C5	1778.5±22.95	4.32
		C6	707.1±25.97	1.71
12	College of Literature	V1	3007.1±12.13	7.31
		V2	1194.2±34.37	2.9
		V3	571.4±12.64	1.38
		V4	1064.2±23.76	2.58
		V5	1778.5±19.80	4.32
		V6	2175.7±13.87	5.29
13	College of Islamic Sciences	N1	1914.2±28.51	4.65
		N2	1598.5±18.76	3.88
		N3	2375.7±15.43	5.77
		N4	1828.5±30.05	4.44
		N5	2110±30.03	5.13
		N6	520±10.38	1.26
14	Printing	U1	1324.2±21.61	3.22
		U2	1821.4±16.31	4.42
	Average		**1431.25±646.2**	**3.48±1.57**
	The acceptable limit [8]			**11.7ppm**

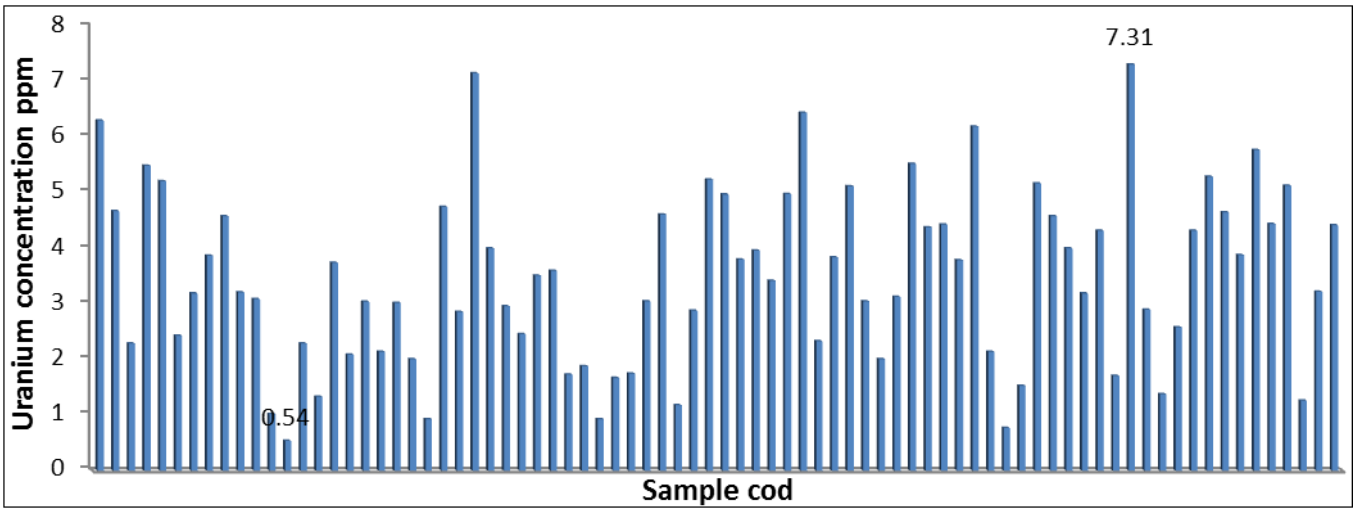

Figure 6: Concentration of uranium in soil samples

4. Conclusions

1) There is a clear contrast between the uranium concentrations in samples , which is attributed to the fact that some soils are transferred soils, especially in college of (arts and sports),that we concluded the may some soil are transfer from another places.
2) The current study found that the technique of counting the effects of fission fragments to calculate the concentration of uranium in soil samples using the nuclear track detector (CR-39) of the appropriate and good techniques to study the activity of radiation as it does not need an electronic system and electric energy.
3) The concentration of uranium in soil samples is found in sample (V1) and is equal to (7.31)ppm and this value is close to the permissible limit which is equal to (11.7 ppm) that we be leave future monitering those level is necessary.
4) It is recommended to use different and new methods and periodic and seasonal tests because radiation pollution is influenced by atmospheric factors and environmental variables in order to for monitor this places.

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