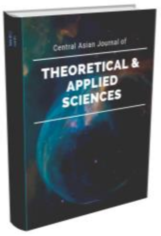

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Article

Estimation of levels of radioactivity and heavy metals in Al-Zahraa Preparatory School for Girls in Al-Kut City

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Abstract: The level of radioactivity concentrations was measured for samples from the soil of Al-Zahraa Preparatory School for Girls. Where 5 samples were taken at two depths 5 and 15cm.The samples were prepared for examination using theThallium-Activated Sodium IodideNaI (Ti) activated sodium iodide detector system. The results showed that the rate of Uraniumm (U) radioactivity was 24.72 Bq/kg, and that of the Thorium (Th) series was 16.8 Bq/kg. It was also found that the radioactivity rate of Potassium (K) was 229.71 Bq/kg. Also, the radium equivalent, the dose absorbed in the air, the internal and external hazard coefficients, and the annual effective dose were calculated. It was found that all the calculated values within the permissible limits. As for the heavy metals test, the concentrations of lead (Pb), (Zinc) Zn, (Manganese) Mn, (Copper) Cu, (and Cadmium) Cd, was reached 24.8ppm, 88.23ppm,4 02.45ppm, 23.83ppm and 0.98ppm respectively. The average concentrations of heavy elements that were found, and according to the concentrations set by the World Health Organization, all concentrations are considered normal and within the permissible limits.

Keywords: NaI (Tl) Detector, Gamma Radiation, Radium Equivalent, Radioactivity, Heavy Metals

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1. Introduction

One of the most hazardous forms of pollution to the environment is radioactive contamination. External and internal harm arises when radioactive materials enter the body's cells[1]. Natural sources of radioactive pollution include space radiation and radioactive gases rising from the earth's crust[2]. Man-made sources include nuclear power plants, atomic reactors, and radioactive isotopes used in industry, agriculture, and medicine [3].

Radioactive materials are present in the earth's crust to a large extent and are found in most of the rocks and soils that make up the earth's crust in varying proportions [4]. The concentration of natural radioactive isotopes in the sediment depends to a large extent on the type and nature of the composition of the soil components[5], and the radioactivity in the soil depends on the radioactivity in the rocks that The soil formed and the total activity that occurred for the formation of soil and air, and the radioactive background can be known by determining the concentrations of the most important radionuclides present in the studied soil, and that the most important of these nuclides, which are a natural source of radiation, are the uranium series (U-238) and thorium (Th-232) in addition to potassium)K- 40(which is found in nature singly[6, 7].

Depending on the type of rocks and the origin of the geochemical environment, geological formations can contain varying concentrations of natural radioactivity. When natural rocks decompose, radionuclides are transferred to the soil and sediments by rain and flows [8].

The concentration of uranium (U-238(in areas that contain sandstone and limestone is less than its concentration in flint. As for its concentration in volcanic rocks, it depends on the amount of silicates present in them. As for sedimentary rocks, when these rocks are broken, uranium transfers with the remnants of rocks or dissolves. In the water and in the form of carbon compounds in the sedimentary bottom, therefore, uranium is found in all types of soil [9].Thorium (Th-232) compounds, most of them are insoluble and do not dissolve in the remains of crumbled rocks, and that these natural radioactive materials are present in soil and rocks[10, 11] and the radiation emitted to the background of radioactive elements that the human body is exposed to [12]. The type of soil determines the potassium (K-40) content in the soil, and the application of phosphate fertilizers in certain agricultural areas causes a rise in this concentration [13].

N.K. Sethy et al. (2014) evaluated the naturally occurring radioactive elements present in the soil surfaces of the uranium mining region of Jaduguda, India. The levels of U-238, Th-234, and Ra-226, the absorbed dose, the internal and external danger indicators, the radium equivalent, and the annual effective dose were all measured in order to compare the results with results from other nations.[14].In 2017, Kamal Karim and Duha Bashir identified the natural radionuclide concentrations and radiation hazard index for the East Baghdad field, where the oil and gas production facility is located. as well as measuring the radiation levels in various samples using a pure germanium detector apparatus. The samples' concentrations were all found to be below internationally permitted bounds and to not be a radiation concern. Among the goals of the study are determining the natural radioactivity levels of the soil and computing certain variables associated with the existence of naturally occurring radionuclides and the consequences of those radionuclides on the environment and human health.[3].

The research aims to measure the radioactivity concentrations of natural nuclides of natural origin, represented by natural chains, including uranium, thorium, and the individual elements represented by potassium, and to find the values of the radium equivalent 〖(Ra〗_eq) the dose ratio absorbed in the air, and the hazard coefficients (H_in ,H_ex) for soil models using gamma ray spectroscopy with Sodium iodide detector Nal (TI) as well as calculating the concentrations of some heavy metals such as lead (Pb) , zinc (Zn), manganese (Mn), copper (Cu) and cadmium, (Cd)

2. Materials and Methods

The Geographical

With its area of approximately 2540 km³ between latitudes 32.5086651° N and 45.790801° E. Kut is regarded as one of the most significant agricultural cities in Iraq because of its fertile land, which contributes to the production of numerous agricultural crops, and its unique geographic location in central Iraq. Water comes mostly from the Tigris River, which flows right through the center of the city.

Preparing for the radiological measurement

The samples were prepared for radiological examination by collecting them and placing them inside plastic bags on which the information of each sample was written, grinding them well and exposing them to sunlight for (3) days until they homogenized, then placing one kilogram of the samples in a Marnelli container to measure the radioactivity of radium for a period of time of one hour.

Preparation for heavy metal measurements

0.5 g of the soil sample was put into a beaker and digested for 6 hours at 90 C using a concentrated HCl:HNO3 (3:1) mixture (8 ml) and concentrated HClO_4 (3 ml) solutions. After filtering, The residue was filtered and diluted to 25 ml with deionized water.

3. Results and Discussion

Table (1) shows the radioactivity of radionuclides in soil samples after calibrating the system in advance using standard elements. Where the highest value of U-238 was found in the sample B 5cm, where its value was 33.6 Bq/kg, and the minimum value was 20.8 Bq / kg in the sample C 15cm. The average values for U-238 was 24.72 Bq / kg, and it did not exceed the values of U-238 the global permissible limit of 35 Bq/kg according to UNSCEAR 2000 [15] as shown in figure(1).

Th-232 reached the highest value in the sample E 15cm, which had a value of 22.87 Bq/kg, and its minimum value was 7.12 Bq/kg in sample C 5cm, while the average values were 16.80 Bq/kg, and did not exceed Th - 232 the permissible global limits of 35 Bq/kg according to UNSCEAR 2000.

Potassium K-40 had values ranging from 128.47 Bq/kg in sample D 15cm to 360.82 Bq/kg in sample B 5cm, with average values of 229.71 Bq/kg. These values did not go above the permitted international limits which equals 350 Bq/kg in accordance with UNSCEAR 2000 and is depicted in the figure (3).

Table 1. The radioactivity concentrations of U-238, Th-232 and K-40 for the two depths 5 and 15 cm.

Sample's Code	U-238 (Bq/kg)	Th-232 (Bq/kg)	K-40 (Bq/Kg)
A 5 cm	20.96	13.05	298.37
A 15 cm	22.34	20.09	150.34
B 5 cm	33.6	15.97	360.82
B 15 cm	27.36	21.08	251.87
C 5 cm	24.52	7.12	208.63
C 15 cm	20.8	15.73	228.15
D 5 cm	21.33	15.93	241.02
D 15 cm	29.42	16.89	128.47
E 5 cm	24.89	19.3	247.92
E 15 cm	21.97	22.87	181.52
overall average	24.72	16.80	229.71
Standard	35.00	35.00	350.00

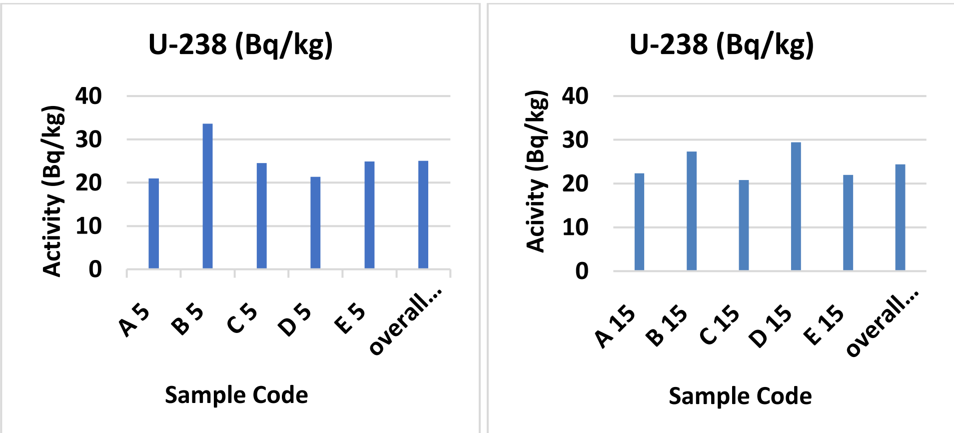

Figure 1. Concentration U-238 in samples for depth 5 and 15 cm.

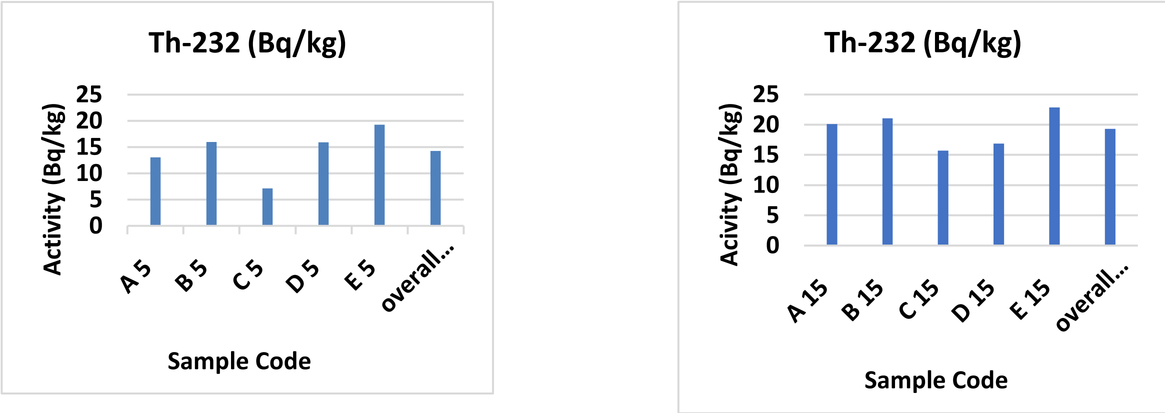

Figure 2. Concentration Th-232 in samplesfor depth 5 and 15 cm.

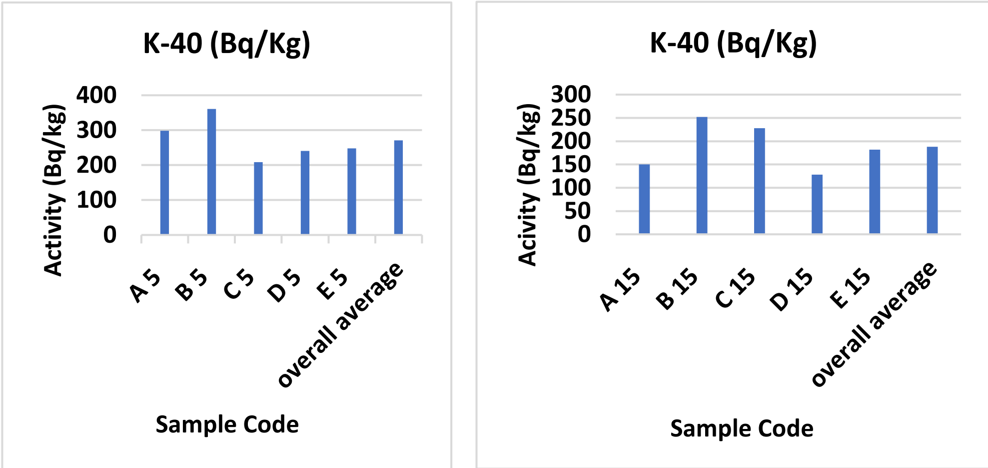

Figure 3. Concentration K-40 in samples for depth 5 and 15 cm.

Table (2) also shows the values of external and internal hazard coefficients, absorbed dose, effective dose and radium equivalent[16]. Where the lowest value of radium equivalent was 50.77 Bq/kg in the sample C 5cm and the maximum value was 84.22 Bq/kg in sample B 5cm. The radium equivalent values for the two depths 5 and 15 cm did not exceed the internationally permissible limits according to UNSCEAR 2000 as in figure 4.

Table 2. Radium equivalent levels, absorbed dose, internal and external hazard coefficients, annual effective dose, and gamma coefficient for both depths.

Sample's Code	Ra-eq (Bq/kg)	D (nGy/h)	H_{ex}	H_{in}	Ef in (mSv/y)	Ef out (mSv/y)	Iγr
A 5 cm	62.60	30.23	0.17	0.23	0.15	0.04	0.47
A 15 cm	62.64	29.07	0.17	0.23	0.14	0.04	0.45
B 5 cm	84.22	40.49	0.23	0.32	0.20	0.05	0.62
B 15 cm	76.90	36.23	0.21	0.28	0.18	0.04	0.56
C 5 cm	50.77	24.45	0.14	0.20	0.12	0.03	0.37
C 15 cm	60.86	28.89	0.16	0.22	0.14	0.04	0.45
D 5 cm	62.67	29.80	0.17	0.23	0.15	0.04	0.46
D 15 cm	63.46	29.44	0.17	0.25	0.14	0.04	0.45
E 5 cm	71.58	33.82	0.19	0.26	0.17	0.04	0.52
E 15 cm	68.65	31.92	0.19	0.24	0.16	0.04	0.50
overall average	66.43	31.43	0.18	0.25	0.15	0.04	0.49
Standard	112.00	52.50	0.30	0.40	0.26	0.06	0.82

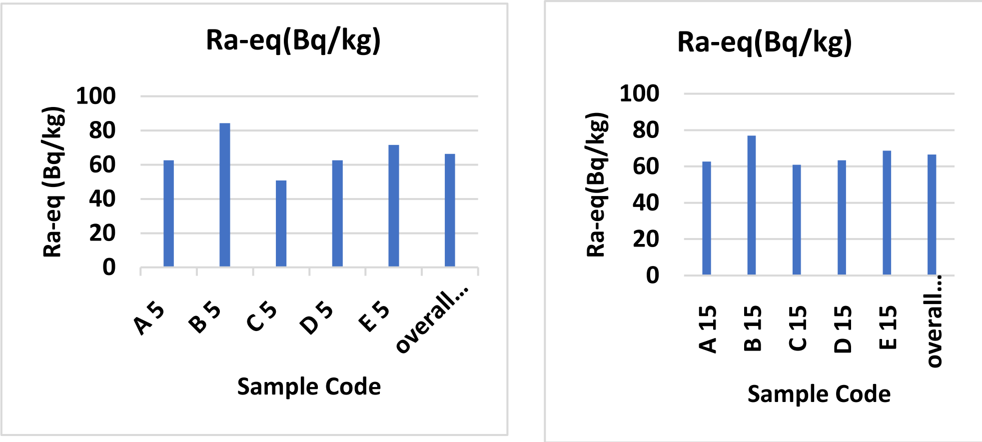

Figure 4. Radium equivalent concentration for depth 5 and 15 cm.

For the absorbed dose, its highest value was 40.49 nGy/h and the lowest value was 24.45 nGy/h. It was a natural and non-hazardous value because it was within the internationally recommended limit, as shown in figure 5.

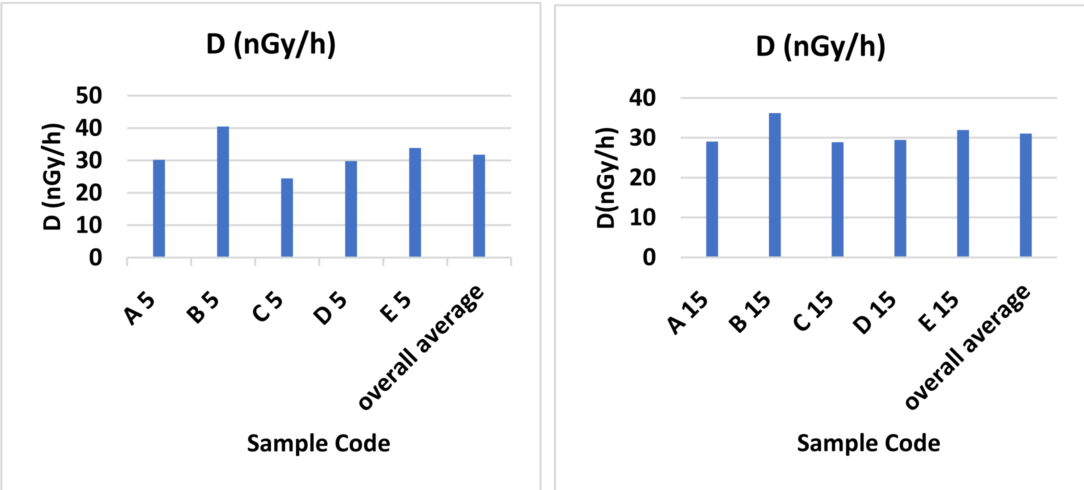

Figure 5. Absorbed dose levels for depth 5 and 15 cm.

As indicated in the two figures below, the exterior and internal danger coefficients for the two depths 5 and 15 cm did not exceed one, so they are considered normal values according to UNSCEAR2000 as shown in figure 6.

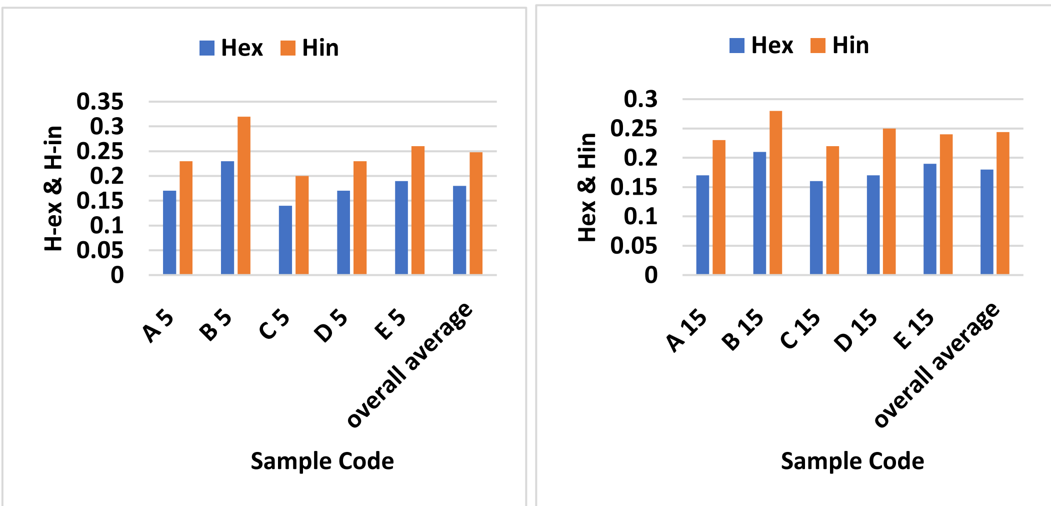

Figure 6. External and internal risk factors for depth 5 and 15 cm.

Indicated by table (2) and the figures 7 and 8, the internal and external yearly effective dose rates, as well as the gamma coefficient (efficacy concentration coefficient), were determined to be normal values.

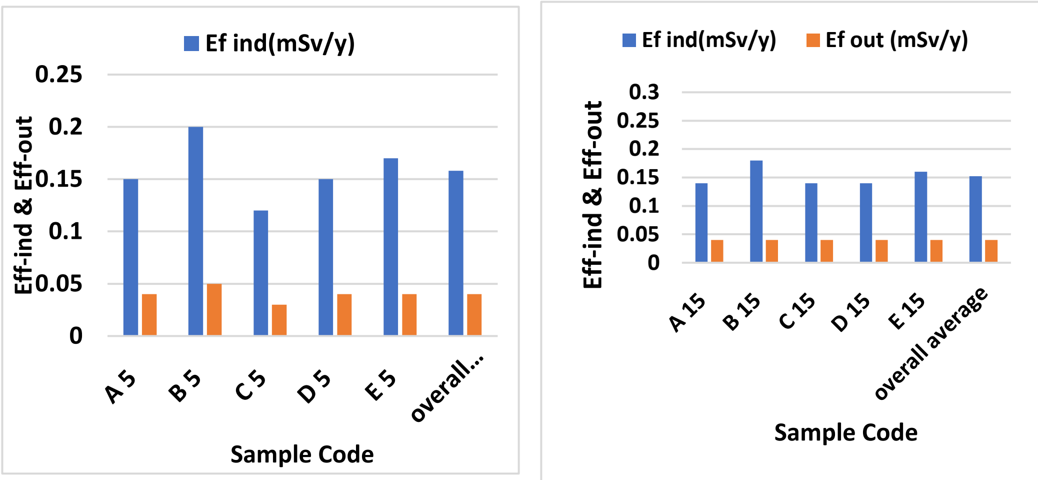

Figure 7. Internal and external annual effective dose rate for depth 5 and 15 cm.

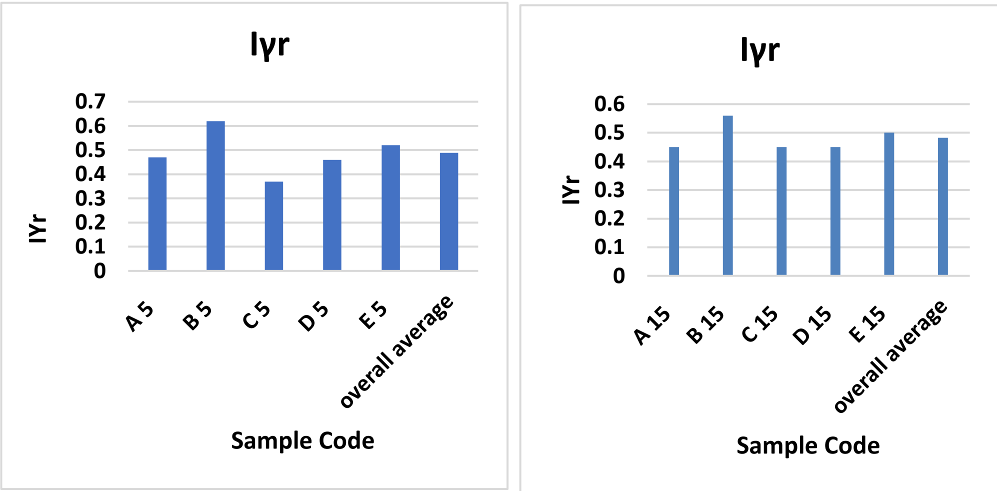

Figure 8. Gamma coefficient levels for depth 5 and 15 cm.

For the heavy elements, the two depths were dealt with by combining them together, and all results appeared within the permissible concentrations according to the World Health Organization (WHO)[17], so they do not pose a threat to the soil, according to table (3) and as shown in figure(9).

Table 3. Heavy metal concentrations.

Sample's code	Pb (ppm)	Zn (ppm)	Mn (ppm)	Cu (ppm)	Cd (ppm)
A	7.5	39	94.6	7.9	1
B	25	79.8	84.8	15.6	0.43
C	5	41.3	73.9	6.1	0.64
D	5	38.5	81.5	6.7	0.29
E	6.3	30.8	79.9	6.7	0.54
WHO	100	300	2000	100	3

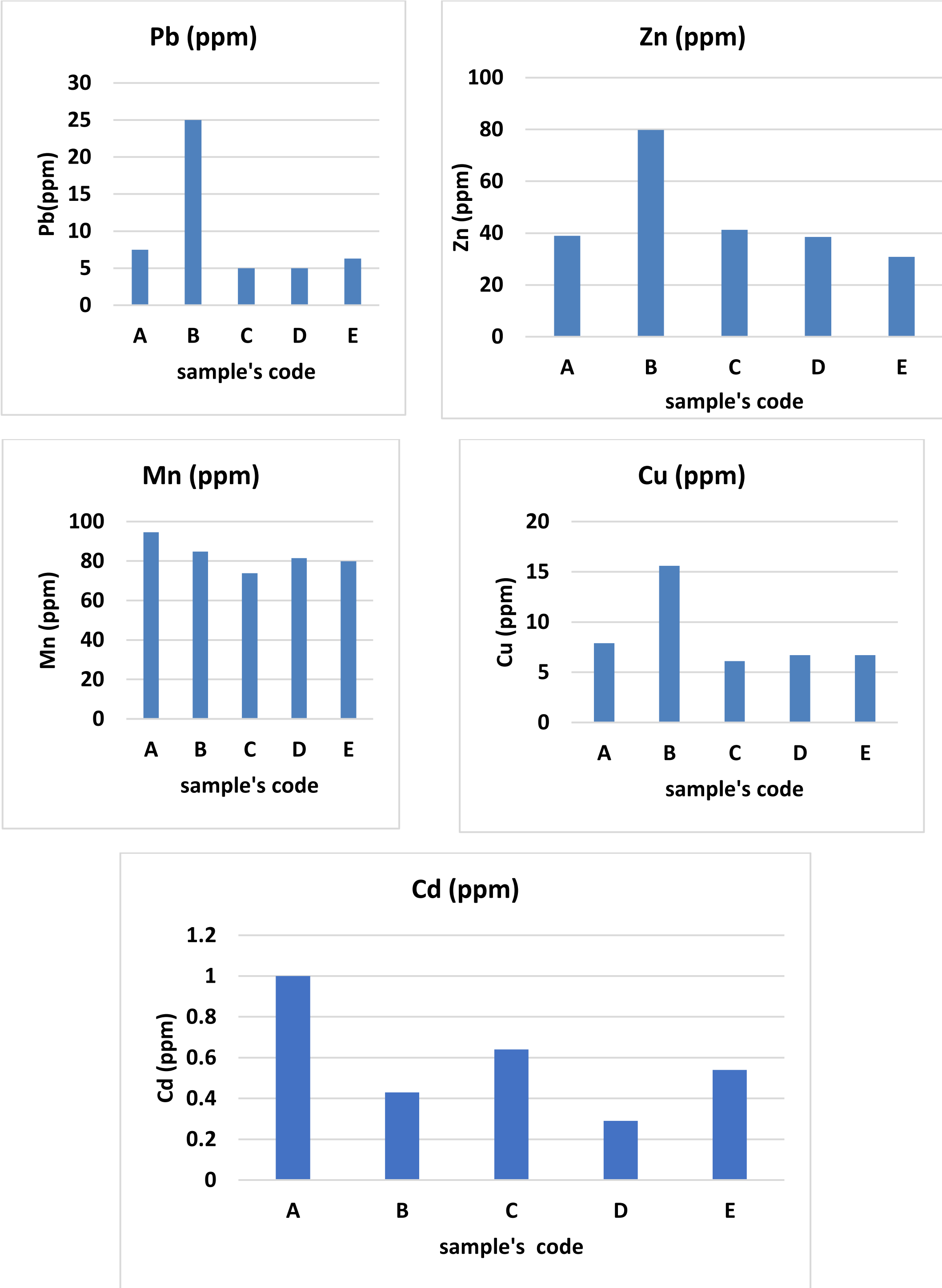

Figure 9. Concentration of heavy metals in the soil

4. Conclusion

Based on the study's findings and comparison with the highest limits of naturally occurring radiation, it is clear that the radioactivity levels for uranium, thorium, and potassium are within normal ranges and are not considered a health risk to humans. The same holds true for the heavy element concentrations, all of which fell within acceptable limits.

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