



Radioactivity levels in some urban areas of west of Iraq

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Abstract

The soil is one of the most important environmental sources for human, animals and plants. The activity of radioactive substances including (^{226}Ra , ^{228}Ac and ^{40}K), was investigated. Twenty surface soil samples were collected from different regions of Anbar province were collected during summer 2019. The soil sample was examined using gamma ray spectrometer based on a high counting efficiency NaI(Tl) scintillation detector. The results showed that the radioactivity of ^{40}K was 263.031 Bq/kg in sample S11 to 571.12 Bq/kg in S14; while the ^{232}Th series was 0.2886 Bq/kg in S13 to 3.737 Bq/kg in S1. The radioactivity of ^{238}U series were 0.1047 Bq/kg in S6 to 1.1737 Bq/kg in S7. However, ^{137}Cs activity was 0.4 Bq/kg in S2 to 7.5 Bq/kg in S8. The result confirms that the level of all radio activities was in acceptable range and never affected on the integrity of the environment. The obtained data revealed that the mean specific activity for ^{226}Ra , ^{228}Ac and ^{40}K in these samples were less than world thresholds average. But ^{40}K activity was 571.12 Bq/kg in S14; this disparity in the values may due to the different depths that are the soil sample extracted. The study aimed to investigate the impacts of military activities on soil radioactivity; and the safety level of soil in Anbar province.

Keywords: NaI(Tl) scintillation detector, Radioactive concentrations. Soil, Anbar province.

Introduction

Human being is continuously exposed to ionizing radiation from naturally occurring radioactive materials (NORM). Natural radioactivity is widely spread in the earth's environment and it exists in various geological formation e.g. soils, rocks, plants, water, air and in building materials.

Oil and gas deposit in geological formations also contain naturally occurring radionuclides. Geologists have identified their presence and Locations since the early 1930s and used them as a method for finding deposits. Some elements such as Uranium, Radium and Radon are found in naturally occurring radioactive materials that are dissolved into very low concentrations during normal reactions between water and rock or soil. The deposits of oil and gas and underground water that co-exist for extended periods may have unequal high concentrations of dissolved constituents build up in water/rock contact. NORM originated from the creation of earth, from cosmic rays and man-made activities and has many different path ways (Joga *et al.*, 2019). There are more than one main sources of radiation found in the environment; natural radioactivity

sources, symbolized NORM (which include terrestrial, cosmic rays, and cosmogenic), and man-made radioactivity sources, symbolized TENORM (which include medical, fallout, and nuclear power). The main bulk of internal and external exposure to the human body is comes by gamma radiation released by naturally occurring radioactive materials found in all waters and soil (UNSCEAR 2000). Specific anthropogenic activity highlighted to increase the levels of the radiation doses. The value of health physics is increasing as the need for population safety and protection from radiation exposure grows. Studies on the distribution of radionuclides in the atmosphere and their corresponding doses can be useful as radiological baseline data for developing radiation safety legislation (Karahan *et al.*, 2020) and (Ellender *et al.*, 2001) was measured an average human kidneys content of $0.13 \mu\text{g } ^{238}\text{U}$ from 12 New York City dwellers, aged 20–60. An average daily New York City diet of $1.3 \mu\text{g}$ yields a blood uptake of $0.026 \mu\text{g}$. The kidney-to-blood uptake ratio was estimated at 4 and the bone-to-blood uptake ratio. The aim of this research was to calculate the radioactivity in soil of Anbar governorate and

investigate of radiation hazard indicators of these naturally occurring radionuclides (^{226}Ra , ^{228}Ac and ^{40}K) in 20 soil samples in Anbar Governorate, Iraq using scintillation detector NaI(Tl).

Materials and Methods

Study area: Al-Anbar province is located in a plain desert environment of western Iraq, which occupies a surface area of 138,500 km² (Latitude 31°00' to

36°00' N, Longitude 39°00' to 44°00' E) that represent one-third of the total area of Iraq (Figure 1). The city is some of the vast deserts in the world, namely the Arabian Desert located in the central plain of the Arabian Peninsula.

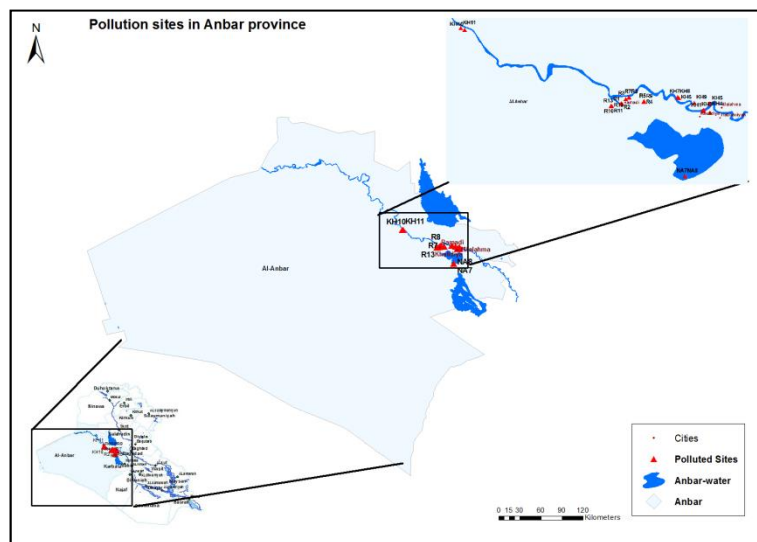


Figure (1): Soil sampling points the study area

In recent years, Al-Anbar province acquired ecological importance not only because of its large geographical area but also for the abnormal activity of sequence military actions that occurred in this region. After 2003, the survey region is exposed to long-term military events as part of the war against terrorism, where different kinds of military weapons were used.

Soil Sampling and Analysis: The survey region represents urban core area, including Ramadi (R), Al-Khalidya (KH), Fallujah and Hit (NA) districts of the Al-Anbar province (Latitude 33°34' to 33°63' N, Longitude 43°76' to 42°83' E), where different residential and commercial activities along with motorways are located. A total of 96 surface soil samples (0-20 cm) were collected from the survey region using a gridded sampling design. Each study area was divided into regular grids of 500x500 m,

and samples were collected surrounding each sampling point and then were mixed to form one composite sample. A composite (3 subsamples) soil sample was collected in each grid in residential gardens, school parks, health services sites, roadside fields and agricultural warehouses. At each sampling site, samples were screened to remove gravel-sized materials, residual roots and other unwanted materials and then stored in polyethylene film bags until analysis. The samples were air-dried, ground, passed through a sieve of 2 mm mesh size and homogenized. Each sample weighed about 1 kg. All soil samples were screened for radioactivity investigation. The NaI(Tl) scintillation detector has been used to investigate and study the soil sample. Table (1) shows the sampling sites of which testing samples were collected from Anbar province.

Table (1): The overall results of NORM of Soil Samples.

Local	Code No.	U/Ra Bq/kg	Th/ Ac-228 Bq/kg	K-40 Bq/kg	Ra _{eq} (Bq/kg)
Kidney wash	S1	0.1047	3.737	295.297	28.18648
Back yard garden	S2	0.1874	1.67	367.2	30.8499
Garbage	S3	0.45	0.952	418.61	34.04433
Apartment buildings	S4	0.63	1.536	430	35.93648
Neighbor garden	S5	0.106	2.222	366.166	31.47824
Ramadi hospitall	S6	0.48	1.348	395.8	32.88424
Heet secondary school	S7	0.4699	2.092	320.66	28.15228
Agricultural supplying	S8	0.29`86	1.3585	293.01	24.80303
General hospital of Heet	S9	0.2	0.409	282.955	22.57241
General hospital of Heet	S10	0.1469	2.784	304.74	27.593
General hospital of Heet	S11	0.5032	1.08	263.031	22.30099
Gartan region	S12	0.264	2.023	432.31	36.44476
Abo kanaan	S13	0.7037	0.2884	455.048	36.15481
Abo kanaan2	S14	0.565	1.335	571.12	46.45029
Abo kanaan2	S15	0.534	0.4997	385.187	30.90797
Khaldyiah island	S16	0.798	3.704	310.836	30.02909
Khaldyiah island	S17	0.1495	2.919	370.194	32.82861
Khaldyiah island	S18	0.7398	0.361	399.69	32.03216
Khaldyiah island	S19	1.108	2.489	493.9	42.69757
Khaldyiah island	S20	1.1737	1.395	417.906	35.34731
Average		0.45228	21.562	376.581	31.50924
World average		50	50	500	160

Sample Collection and Treatment: The sample preparation depends on type of samples under investigation. Clay dry and max soils sampled cleaning and make one piece with area about by placing each sample in an oven for drying at a temperature of 110 °C for one hour until complete removal of any residual moisture and ensuring that a constant weight was reached. After that; the dried samples were pulverized into a fine powder and passed through a standard 1 mm mesh size. The homogenized samples were filled into (1 \2) L Marinelli beakers to measure the radioactivity by NaI

(TI) (3x3) scintillation detector coupled to PC-MCA (4096 channel) and related accessories based on a high efficiency gamma spectrometry device with an overall efficiency of 60% and resolution of (6.5- 8.5). All samples were weighed using a fine balance \pm 0.01g error. For all samples, 1kg of sample mass was used and stored for at least one month prior to measurements in order to attain radioactive secular equilibrium between ^{226}Ra and ^{228}Ac and their short-lived progeny. Figure (2) shows the apparatus for sample preparation

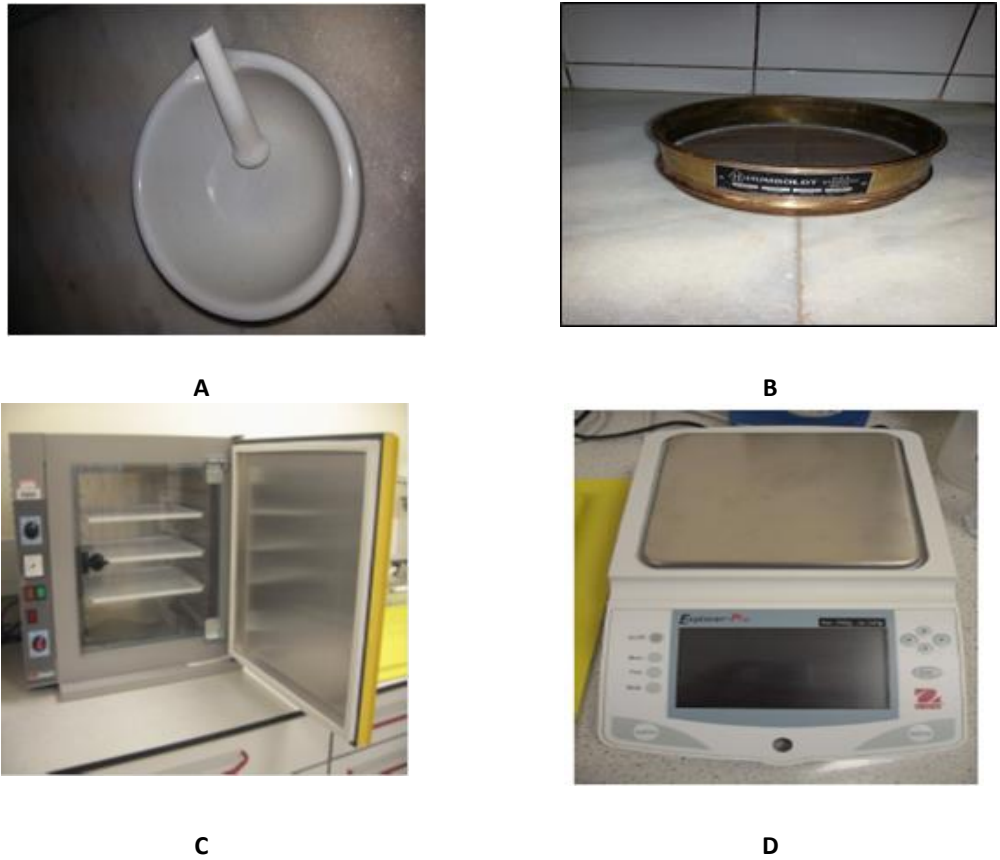


Figure (2): The apparatus for sample preparation (A) a mortar and pestle for crushing and homogenizing samples (B) a standard sieve of 1 mm mesh size (C) an oven for drying samples (D) a weighing scale

Calculations: Determine of hazard Indices in soil one of the important index that may be using to investigate the risk by metals of presenting the exterior exposing and named the Exterior Risk Index .Its calculation by (Hadi *et al.*, 2017):

$$HL_{ex} = \frac{A_{Ra}}{370} + \frac{A_{Th}}{259} + \frac{A_k}{4810} \quad \dots (1)$$

A_{Ra} , A_{Th} and A_k are activation of ^{232}Ra , ^{232}Th and ^{40}K On the other hand, the interior risk index that exposing to radon and written as (Diab *et al.*, 2008)

$$H_{in} = \frac{A_{Ra}}{185} + \frac{A_{Th}}{259} + \frac{A_k}{4810} \quad \dots (2)$$

The representative level index I_{γ} used to estimate the level of gamma- radiation hazard associated with the natural radionuclides in specific investigated samples is defined from the following equation.

$$I_{\gamma} = \frac{A_{Ra}}{150} + \frac{A_{Th}}{100} + \frac{A_k}{1500} \quad \dots (3)$$

2) The specific activity of radiation could be written as:

$$A = \frac{C_E}{\epsilon_{\gamma} P_r} \quad \dots (4)$$

Where A is the specific activity of the radionuclide in (Bq/kg) or in (Bq/l) , C_E is the count of net peak area per second at energy gamma ray , M is the mass soil sample in Kg , V is the volume of the sample in L , P_r is the the transition probability of gamma-decay at energy and ϵ_{γ} is the detector efficiency at energy. (2)

On the other hand ,the estimation of ^{232}Ra , ^{232}Th and ^{40}K the risk that connect with, and substance named Radium equivalent activity in (Bq/kg)and given by

$$Ra_{eq}(\text{Bq/kg}) = A_{Ra} + 1.43A_{Th} + 0.077A_K \quad \dots (5)$$

Where A_{Ra} , A_{Th} and A_k are the activity concentrations of ^{226}Ra , ^{232}Th and ^{40}K respectively. In eq. 2.2, it has been assumed that 10 Bq/kg of ^{226}Ra , 7 Bq/kg of ^{232}Th and 130 Bq/kg of ^{40}K produced equal gamma dose. The published

maximal admissible (permissible) Ra_{eq} is 370 Bq/kg (Silk et al., 1995).

3) dose rate , Due to gamma radiations in air at 1m above the ground surface for the uniform separation of the naturally occurring radionuclide's (^{226}Ra , ^{232}Th and ^{40}K) were calculated based on guidelines provided by (UNSCEAR, 2000) and the effective doses rate(nGy/h) are evaluated using (Rasheed et al., 2016).

$$D(nGy/h) = 0.462A_{Ra} + 0.621A_{Th} + 0.0417A_k \dots(6)$$

4) Annual effective dose: Annual radionuclide intakes and yearly influential effective doses of $Sv/year$ had been counting for Indoor effective dose by **Indoor effective dose:**

$$E_{ied}(mSv/y) = D(nGy/h) * 8760h * 0.8 * 0.7 Sv/Gy * 10^{-6} \dots(7)$$

Outdoor effective dose:

$$E_{oed}(mSv/y) = D(nGy/h) * 8760h * 0.2 * 0.7 Sv/Gy * 10^{-6} \dots(8)$$

(Hussein, 2017).

Result and Discussion

Investigated samples (local clay bricks), have been presented in table (1). The obtained data revealed that the mean specific activity for ^{226}Ra , ^{228}Ac and ^{40}K in these samples were less than the world average. The artificial radionuclide represented by ^{137}Cs was

observed in some samples and vary from <MDA to $7.5Bq.kg^{-1}$ in sample S9 with an average Value $3.842857 Bq.kg^{-1}$.area around the berms of site may attributed to the nuclear activities of this site or may be due to the nuclear accident (Chernobyl Catastrophe) which have been spread throughout a large area of the world including the samples locations were collecting. (Kamal and Shafik, 2017).

The important indices for testing the different soil sample such that were estimated to known how can effective on human health. The most important effective index is hazard index (H_{in}) that estimation using Eq.(2) and we show from table (2) the 0.151 mSv/y was minimum values that measured in S1 sample and the maximum value was 0.342mSv /y in S9 sample, whereas the overall average value was 0.261 mSv/y.

The figures (3), (4) were shows that the Radium equivalent activity and the effective doses rate at soil sample are large for both samples S9 and S7 and lowering for sample S1.

The radiological hazard parameters of absorbed dose Dy , annual effective (AEDE), Radium equivalent activities (Ra_{eq}), external hazard.

Table (2) Results Data of radiological testing for soil samples

Sample no.	D	H_{ex}	H_{in}	Eff_{in} (mSv/y)	Eff_{out} (mSv/y)	I_{yr}
S1	14.68293	0.082308	0.082297	0.072029	0.018007	0.234933
S2	16.43589	0.086068	0.086048	0.080628	0.020157	0.262749
S3	18.25513	0.093502	0.093454	0.089552	0.022388	0.291593
S4	19.17592	0.09958	0.099514	0.094069	0.023517	0.306227
S5	16.69796	0.088681	0.088669	0.081913	0.020478	0.267037
S6	17.56373	0.091027	0.090976	0.086161	0.02154	0.280547
S7	14.88775	0.079486	0.079436	0.073033	0.018258	0.237826
S8	13.2001	0.069224	0.069193	0.064754	0.016189	0.210916
S9	12.14561	0.061625	0.061604	0.059582	0.014895	0.19406
S10	14.50439	0.079124	0.079108	0.071153	0.017788	0.231979
S11	11.87155	0.062007	0.061954	0.058237	0.014559	0.189509
S12	19.40558	0.10176	0.101733	0.095196	0.023799	0.310197
13	19.47971	0.098099	0.098025	0.09556	0.02389	0.310941
14	24.90577	0.127634	0.127574	0.122178	0.030544	0.397863
15	16.61932	0.084283	0.084226	0.081528	0.020382	0.265348
16	15.63072	0.08723	0.087146	0.076678	0.01917	0.249584
17	17.31886	0.093484	0.093468	0.084959	0.02124	0.276983
18	17.23304	0.087088	0.08701	0.084538	0.021135	0.275002
19	22.6532	0.119419	0.119302	0.111128	0.027782	0.361543
AVERGE	18.83522	0.097757	0.097633	0.092398	0.0231	0.300379
World average	75	0.43	0.57	0.37	0.09	0.941

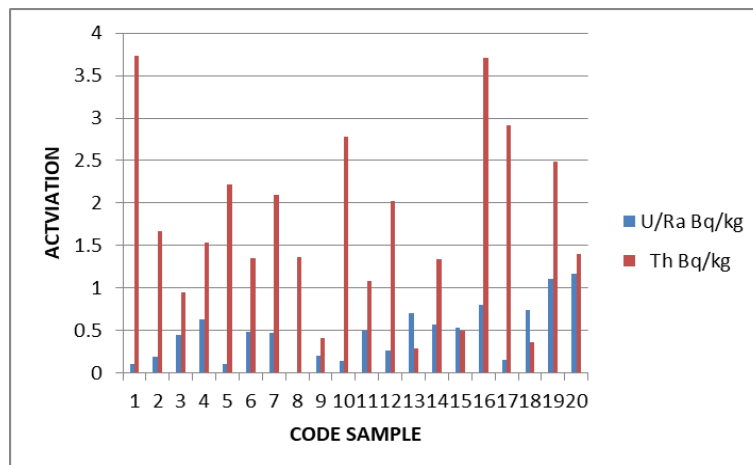


Figure (3): Activity Concentration of radiation for Ua and Th , soil sample

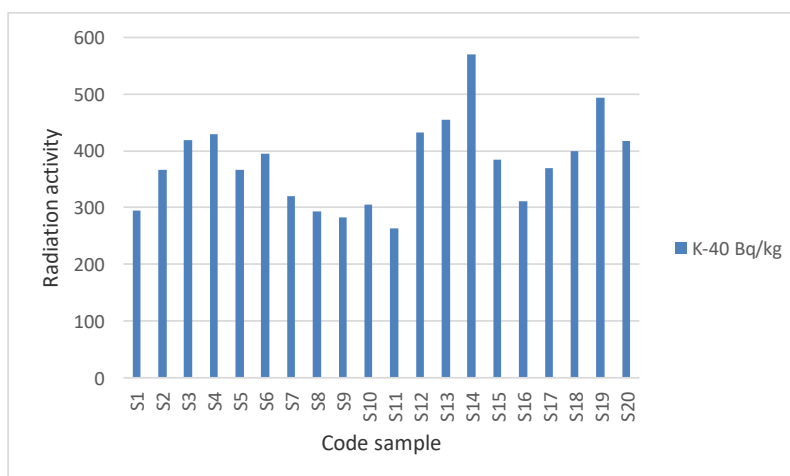


Figure (4): Activity Concentration of radiation for ⁴⁰K at soil sample

Conclusion

All the soil test shows that the level of radioactivity in Anbar soil was in acceptable level; more intensive study need to be adopted using ,ore advance equipment in order to ensuring the safety.

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