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Natural Radioactivity level and the measurement of soil gas Radon ,Thoron concentrations in Hilla city

مستوى النشاط الإشعاعي الطبيعي وقياس تركيز غاز الرادون والثورون في تربة مدينة الحلة

Khalid Hussain Hatif [1] , Mohsin Kadhim muttaleb [2]
[1]Department of physics, college of Science, University of Babylon
[2]Department of physics, college of Science, University of Babylon
E-mail:Khalid hsen@yahoo.com or E-mail:mam50_24@yahoo

Abstract

Examine the level of natural radioactivity of radon concentration and thoron in the soil for ten important sites in the city of Hilla, by spectrometer gamma Na (Tl) system, and a focus for radon and thoron in the soil was defined using the detector solid state (RAD7), this study aims to identify the difference in the concentration of radon and thoron as well as assess the health risks associated with radioactivity natural, if any, and by the results found that the concentration of radon gas soil in the study area ranged between 34-15200 Bq/m^3, it was observed that the highest concentration of radon is in the depth and the lowest concentration measured in surface.The average concentration activity of uranium, thorium, and potassium found 14.079 ± 0.46, 12.326 ± 0.43 and 416.655 ± 2.86 Bq/m^3 respectively. Thus, the annual affecting radionuclide dose identified and analyzed, and found the calculated dose values is not too high and not exceeding the proposed radio-protection standards by international agencies.

Keywords: Radon, soil, natural radioactivity, Thoron, Hilla.

الخلاصة

قياس مستوى النشاط الإشعاعي الطبيعي وتركيز الرادون والثورون في التربة لعشرة مواقع مهمة في مدينة الحلة، بواسطة منظومة مطياف كاما (Na(Tl، والتركيز لرادون والثورون في التربة كان محدد باستخدام كاشف الحالة الصلبة (RAD7)، تهدف هذه الدراسة التعرف على الاختلاف في تركيز الرادون والثورون وكذلك تقيم المخاطر الصحية المرتبطة بالنشاط الإشعاعي الطبيعي إن وجدت ، ومن خلال النتائج وجد إن تركيز الرادون لغاز التربة في منطقة الدراسة تراوحت بين 34- 15200بيكرل/م^3 ،ولوحظ إن أعلى تركيز للرادون يكون في العمق وأدنى تركيز يقاس في السطح.أما متوسط تركيز النشاط لليورانيوم ،ثوريوم، والبوتاسيوم وجدت 0.46±14.079، 0.43±12.326 و2.86±416.655 بيكرل/م^{3}على التوالي .وهكذا فأن الجرعة المؤثرة السنوية للنويدات المشعة حددت وحللت، ووجدت قيم الجرعة المحسوبة ليست مرتفعة جدا ولا تتجاوز معايير الحماية
الراديوية المقترحة من قبل الوكالات الدولية

Introduction

There are two main contributors to natural radiation exposures: high-energy cosmic ray particles incident on the earth's atmosphere and radioactive nuclides that originated in the earth's crust present in soil, air, water, food and the body[1]. Naturally occurring radionuclides of terrestrial origin arises mainly from the primordial radionuclides that have long half-lives comparable with the age of the earth. These primordial radionuclides are ^{238}U, ^{232}Th and their decay products as well as the radioisotopes of ^{40}K . All of these spectrometric measurements indicate that the three components of the external radiation field, namely from the gamma-emitting radionuclides in the ^{238}U and ^{232}Th series and ^{40}K, make approximately equal contributions to the externally incident gamma radiation dose to individuals in typical situations both outdoors and indoors[2].

The knowledge of specific activities or concentrations and distributions of the radionuclides in these materials of the radionuclides in these materials are of interest since it provides useful information in the monitoring of environment radioactivity.Gamma radiation emitted from naturally occurring radioisotopes, also called terrestrial background radiation, represents the main external

source of irradiation of the human body. Natural environmental radioactivity and the associated external exposure due to gamma radiation depend primarily on the geological and geographical conditions, and appear at different levels in the soils of each region in the world . A significant part of the total dose contribution in the form of natural sources comes from terrestrial gamma radionuclides[5].

Radon (^{222}Rn), which is the member of ^{238}U decay series, is of special interest since Radon and its non-gaseous short-lived daughters namely, ^{218}Po and ^{214}Po are the most important radioactivity sources in air and they cause about half of the effective dose equivalent of all natural ionizing radiations. Exposure of person to high concentration of radon and its short-lived progeny for a long period leads to health problems, particularly lung cancer [1].

Radon gas and its radioactive isotopes have special attention among the other naturally radioactive materials, because it has the largest amount of total annual effective dose to humane. There are three natural occurring isotopes of Radon; Radon ^{222}*Rn* , a direct product of ^{226}Ra in the ^{238}U decay series with physical half-life 3.825 days, ^{220}Rn, decay products of ^{232}Th, Thoron ^{220}*Rn* , half-life 55.6s is a radioactive noble gas exists in natural radon gas as well, and ^{119}Rn, a decay product of ^{235}U, with half life of 3.6s. Among the three radioactive isotopes ^{222}*Rn* is the most significant. This isotope is found in soil-near air and soil-gas, and, surface water and ground water. Because it's relatively long half - life enabling it to migrate quit significant distance before decaying and can be found in the soil gas [3].

Their concentration levels depend strongly on geological and geophysical conditions, as well as on atmospheric influences such as barometric pressure and rainfall. Formed as a result of the natural radioactive series in the earth's crust they are free to move through soil pores and rock fractures; then to escape into the atmosphere. ^{222}Rn and/or ^{220}Rn exhaled from the earth's surface into the free atmosphere is rapidly dispersed and diluted by natural convection and turbulence. When a dwelling is present, they may migrate into this structure and accumulate indoors in sufficient quantities to pose a health hazard [2].

The major source of radon in the atmosphere (at least 80%) comes from emanation from soil's rocks. These rocks contain some Uranium, where the decay of ^{238}U through ^{226}Ra gives Radon. Certain types of rock, including granites, dark shale, light colored volcanic rocks, sedimentary rocks containing phosphate and metamorphic rocks derived from these rocks have higher average Uranium contents . Since Radon is a gas, it has much greater mobility than uranium and radium [4].

Exposures arise from the intake of terrestrial radionuclides by inhalation and ingestion. Doses by inhalation result from the presence in air of dust particles containing radionuclides of the ^{238}U and ^{232}Th decay chains. The dominant component of inhalation exposure is the short-lived decay products of radon. Doses by ingestion are mainly due to ^{40}K and to the ^{238}U and ^{232}Th series radionuclides present in foods and drinking water[6].

Theory Concepts

1. Geophysical-Chemical Properties of Radon

Radon is a form of chemical element with a chemical symbol Rn and atomic number 86. In nature, radon has three kinds of common radioactive isotopes (^{219}Rn, ^{220}Rn, and ^{222}Rn). Separation process of radon means that radon migrates from underground strata to surface and then spreads into the air. The whole separation process of radon can be divided into two stages of free radon generation and migration. In the first stage, radium atom in media lattice of underground strata will decay into radon atom by emitting -particle, and the radon atom will escape from media lattice under nuclear recoil and emanation effects, then possibly enter into the interconnected microfractures, and thus generate the free radon. In the second stage, the free radon will migrate to the surface under diffusion and convection effects from the media microfractures and then will eventually escape from the surface into the air. The mathematical model of radon migration in accordance with geological conditions of mining has been established; the general migration equation of radon has been deduced, and the distribution law of radon concentration has been obtained. The calculation results indicate that the distribution of radon concentration is affected by

both the properties of the strata and the depth of cover and the radon concentration law varies at different depths even in the same layer[7].

2. Calculation of Radiation Hazard Indices

To represent the activity levels of ^{226}Ra, ^{232}Th and ^{40}K by a single quantity, which takes into account the radiation hazards associated with each component, Radium equivalent (Ra_{eq}) is a common index used to compare the specific activities of materials containing ^{226}Ra, ^{232}Th and ^{40}K by a single quantity, which takes into account the radiation hazards associated with them . The activity index provides a useful guideline in regulating the safety standard dwellings. The radium equivalent activity represents a weighted sum of activities of the above mentioned natural radionuclides and is based on the estimation that 1Bq/kg of ^{226}Ra, 0.7Bq/kg of ^{232}Th, and 13Bq/kg of ^{40}K produce the same radiation dose rates. The Radium Equivalent activity (Ra_{eq}) which is defined mathematically by Eq.(1) .

$$Ra_{eq}=C_{Ra}+1.43C_{Th}+0.077C_k \quad \text{---------- (1)}$$

where C_{Ra}, C_{Th} and C_K are the activity concentration in $Bqkg^{-1}$ of ^{226}Ra, ^{232}Th and ^{40}K, respectively the use of a material whose (Ra_{eq}) concentration exceeds 370Bq/kg is discouraged to avoid radiation hazards[8].

3. The Absorbed Dose Rate in Air

The absorbed dose rate in air one meter above the ground surface express the received dose in the open air from the radiation emitted from radionuclides concentrations in water. This factor is important quantity to evaluate when considering radiation risk to a biosystem. The absorbed dose rate can be determined by using Eq.(2)

$$AD=0.4612\ C_{Ra}+0.623C_{Th}+0.0414C_k \text{--------(2)}$$

where 0.461, 0.623 and 0.0414 nGy h^{-1}/Bq kg^{-1} are the conversion factors of ^{226}Ra, ^{232}Th and ^{40}K, respectively[9].

4. Annual Effective Doses Equivalent

Annual estimated average effective dose equivalent received by member was calculated using factor of 0.7 SvGy-1, which was used to convert the absorbed dose rate to human effective dose equivalent with an outdoor of 20 % and 80% for indoor. The annual effective doses equivalent outdoor and indoor calculated using Eqs.3 and 4[8]:

$$\text{Outdoor (mSv/y)} = AD\ (nGyh^{-1}) \times 8760\ h \times 0.2 \times 0.7\ SvGy^{-1} \times 10^{-6} \text{---------- (3)}$$
$$\text{Indoor (mSv/y)} = AD\ (nGyh^{-1}) \times 8760\ h \times 0.8 \times 0.7\ SvGy^{-1} \times 10^{-6} \text{----------(4)}$$

5.Determination of Radiation Hazard Indices

Many of the radioactive materials decay naturally and when these materials decay produces external radiation field which exposed humans. In terms of dose, the principal primordial radionuclides are ^{232}Th, ^{226}Ra and ^{40}K. Thorium and uranium head series of radionuclides that produce significant human exposure. The external hazard index (H_{ex}) is calculated by Eq.(5).

$$H_{ex}= C_{Ra}/370+C_{Th}/259+C_k/4810 \leq 1 \text{----------(5)}$$

where C_{Ra}, C_{Th} and C_K, are the radioactivity concentrations in Bq/kg of ^{226}Ra, ^{232}Th and ^{40}K respectively. The value of this index must be less than unity for the radiation hazard to be negligible; H_{ex} equal to unity corresponds to the upper limit of Ra_{eq} (370Bq/kg). The internal hazard index (H_{in}) can be calculated by Eq.(6)

$$H_{in}= C_{Ra}/185+C_{Th}/259+C_k/4810 \leq 1 \text{----------(6)}$$

where C_{Ra}, C_{Th} and C_K, are the radioactivity concentrations in Bq/kg of ^{226}Ra, ^{232}Th and ^{40}K respectively. The value of this index must be less than unity for the radiation hazard to be negligible[8].

An additional hazard index so called representative (radioactivity) level index was calculated by using the formula Eq.(7)

$$H_\gamma = C_{Ra}/150 + C_{Th}/100 + C_k/1500 \leq 1$$

The value of $I\gamma$ must be less than unity in order to keep the radiation hazard insignificant[9].

The Study Location

Hilla is a city in central Iraq on the Hilla branch of the Euphrates River, 100 km (62 mi) south of Baghdad, Al Hillah's location inside Iraq Coordinates: 32°29′N 44°26′E. The population is estimated at 364,700 in 1998. It is the capital of Babylon Province and is located adjacent to the ancient city of Babylon, and close to the ancient cities of Borsippa and Kish. It is situated in a predominantly agricultural region which is extensively irrigated with water provided by the Hilla canal, producing a wide range of crops, fruit and textiles. Its name may be derived from the word "beauty" in Arabic. The river runs exactly in the middle of the town, and it is surrounded by date palm trees and other forms of vegetation enhancing the weather and reducing the harmful effect of dust and the desert winds[10].

In the present study (10) regions were chosen as fair distribution in Hilla City. The regions were determined using (GIS) as shown in Fig.(1), which was obtained the map sites of the city, drawn by using (GPS) technical. Table (1) and show the sites studied in city.The reason for the first elected to the high population density of the Second Industrial business which they are located.

Table(1): Samples measurements of sites in Hilla city **.**

No.	Location name	Location Symbol	Coordinates
1	Athar Babil	H1	$44^0\ 25'\ 03.2''$ E , $32^0\ 32'\ 29.5''$ N
2	Abu Ajaj Village-Aloulla	H2	$44^0\ 28'\ 33.3''$ E , $32^0\ 31'\ 38.3''$ N
3	Abu-Kistawi Aloulla	H3	$44^0\ 24'\ 21.8''$ E , $32^0\ 30'\ 25.7''$ N
4	Hay-Al- Jazaar Aloulla	H4	$44^0\ 26'\ 24.5''$ E , $32^0\ 30'\ 42.6''$ N
5	Al-Tenya- Althanya	H5	$44^0\ 22'\ 00.3''$ E , $32^0\ 29'\ 00.2''$ N
6	Al-Atayij Village -Aloulla	H6	$44^0\ 27'\ 21.8''$ E , $32^0\ 26'\ 57.8''$ N
7	Almohandseen Al-Thaltha	H7	$44^0\ 23'\ 43.2''$ E , $32^0\ 27'\ 11.1''$ N
8	Hay-Nadir Althaltha	H8	$44^0\ 25'\ 28.5''$ E , $32^0\ 26'\ 25.3''$ N
9	Al-Mamera Village -Aloulla	H9	$44^0\ 27'\ 38.2''$ E , $32^0\ 25'\ 57.0''$ N
10	Al-Imam Baker Village	H10	$44^0\ 23'\ 51.5''$ E , $32^0\ 24'\ 30.0''$ N

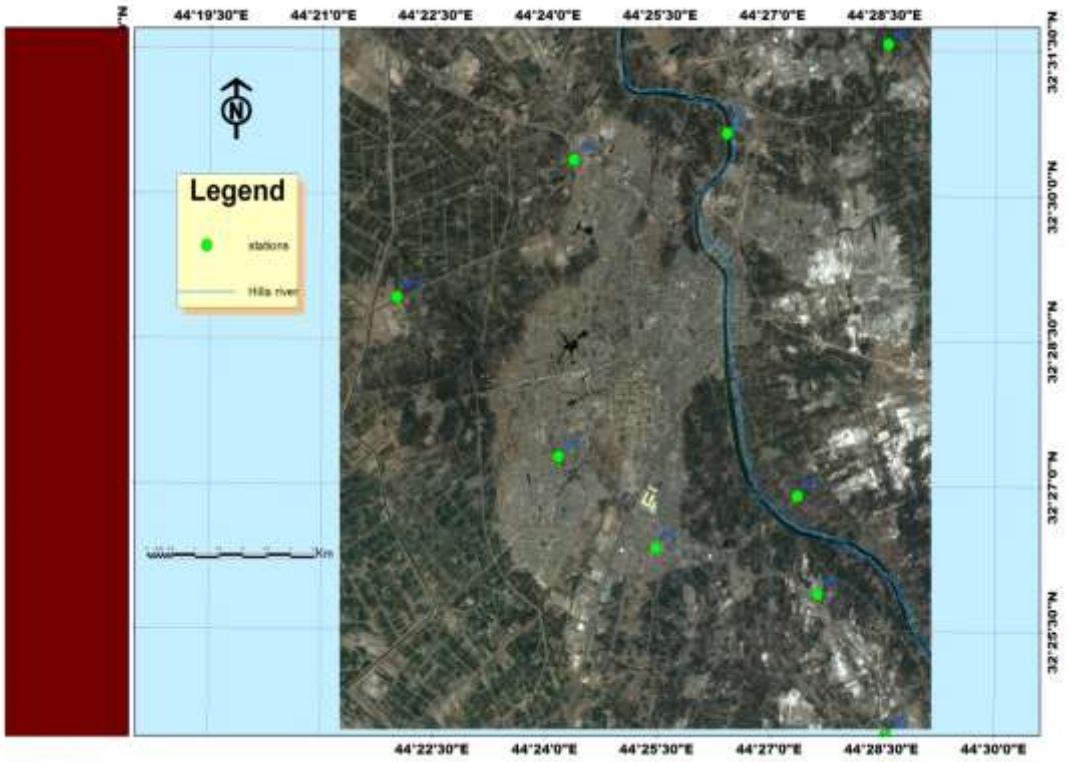


Fig. (1): The map shows the zone of Hilla city which have been studied**.**

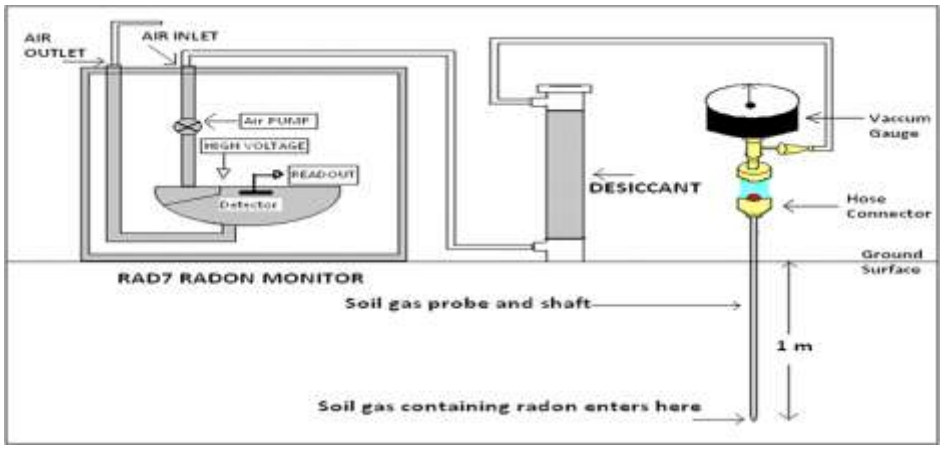
Experiments

1.Measurement of Radon and Thoron Parameters

The soil-gas radon concentration was measure dat 10 locations at each location the radon concentration was determined at three different depths (15, 30, and 45 cm). The measurements were performed by RAD7, an electronic radon detector manufactured by Durridge Company, USA. The RAD7 radon monitor apparatus uses an air pump and a solid state alpha detector which consists of a semiconductor material (generally silicon) that converts alpha radiation directly to an electrical signal. It has desiccant (CaSO4) tubes and inlet filters (pore size 1 μm) that block fine dust particles and radon daughters from entering the radon test chamber. The RAD7's internal sample cell is a 0.7 litter hemisphere, coated on the inside with an electrical conductor. The centre of the hemisphere is occupied by a silicon alpha detector. One important benefit of solid state devices is ruggedness. Another advantage is the ability to immediately differentiate radon from thoron by the energy of the alpha particle released. The RAD7 has also the ability to tell the difference between the new radon daughters and the old radon daughters left from previous tests. The equipment is portable and battery operated, and the measurement is fast. The soil-gas samples of each site were collected with the help of the stainless steel probe supplied by Durridge Company (USA), immersed in the soil to a specified depth, which was then connected to the RAD7 detector with a special accessory for the purpose. Figure 2 shows the schematic diagram of RAD7 soil-gas setup. The probe was penetrated in the soil with a rotating handle or immersed with gentle strokes of a hammer. The measurements were performed where the soil is uniform and generally free of rocks. The depth of the sampling point is determined by the length of the probe inserted into the ground, taking into consideration the location of the sampling points on the probe shaft. Before the counting process started, the hole was properly sealed in order to prevent mixing of soil-gas with air from atmosphere. The sniff protocol and grab mode were used for the soil-gas sampling on the RAD7 detector at each site. The measuring instrument was then attached to the probe for sucking the soil-gas from the deep soil. The soil was sucked through the tube pipe into the measuring instrument for 5 min pumping phase. The instrument waits another 5 min and then counts for four 5-min cycles. At

the end of the half-hour period, the RAD7will print out a summary of the measurement, including an average radon concentration in the soil-gas from the four 5-min cycle measurements.

This method gives a quick (half-hour) reading and uses the least amount of soil-gas (RAD7 Manual)[11].



Figure(2). The schematic diagram of the RAD7 soil-gas setup[11].

2. Measurement of Radionuclide Concentrations

Soil samples were collected during 2014 from 10 locations in the Hillah City. Sampling locations are marked in Fig. 1. After removing the stones and vegetation, all soil samples were dried up at room temperature, sieved, placed in the plastic 400 cm^3 containers and left for four weeks for the short-lived daughters of ^{226}Ra (in the^{238}U decay series) and ^{232}Th decay series to attain secular equilibrium with their long lived parent radionuclides [12]. Samples were taken from the surface layer soil of 30 cm depth. The homogenized samples were filled into Marinelli beakers and all samples were weighed (about 1000gm) by using a high sensitive digital weighing balance with a percent of ±0.01%. The samples were analyzed using a NaI(Tl) spectrometer. The ^{232}Th-series, ^{238}U-series, and ^{40}K activities were estimated, as were the amounts of these radionuclides that would enter the air from the soil. A 3 inch × 3 inch NaI(Tl) detector was used, with adequate lead shielding, which reduced the background by a factor of 95. The energies of interest were found using an International Atomic Energy Agency standard source and the appropriate geometry. The system was calibrated in terms of both the energy response and the counting efficiency and the counting time was 18,000s for each sample. The concentrations of the radionuclides of interest were determined using the counting spectrum for each sample. The peaks corresponding to 1.46 MeV (^{40}K), 1.76 MeV (^{214}Bi), and 2.614 MeV (^{208}Tl) were considered when evaluating the ^{40}K, ^{238}U-series, and ^{232}Th-series activities, respectively. The crystal detector resolution was 6% for ^{40}K, 4.4% for the ^{232}Th-series, and 5.5% for the ^{238}U-series. The gamma-ray spectrum activities for each soil sample were analyzed using dedicated software, and references were chosen to achieve sufficient discrimination[13].

Results and Discussion

1. Radon in soil

An average value of Radon Activity in Bq/m3 was calculated for each sampling point. All the results were listed in Tables(2), (3), (4) and the average Radon concentrations as a function of sample point number are shown in Figures(3),(4),(5). The radioactive level of ^{222}Rn for soil samples, as shown in Table(2), range from 9800±4280 Bq/m3 for sample H8 at in Hay-Nadir Althaltha district at depth 15cm under ground surface, to 187±220 Bq/m3 at Al-Tenya- Althanya district with the same depth , in Table(3) For depth 30 the concentration varied from 8520±1580 Bq/m3 at H3 to 43±17 Bq/m3 at H5. While in the depth 45cm in Table(4) the maximum Radon concentration is 15200±1200 Bq/m3 at H10 to 60±291 at H6 and The radioactive level of ^{220}Rn for

soil samples, as shown in Table(2), range from 11675±1823 Bq/m3 for sample H8 at in Hay-Nadir Althaltha district at depth 15cm under ground surface, to 1329±706Bq/m3 at Al-Tenya- Althanya district with the same depth in Table(3) For depth 30 the concentration varied from 7848±1500 Bq/m3 at H6 to 15±303 Bq/m3 at H8. While in the depth 45cm in Table(4) the maximum Thoron concentration is 6885±1428 Bq/m3 at H4 to 60±291 Bq/m3 at H6. Looking for the whole data in the tables, one can see that in the majority of locations there is linearity between the radon and thoron concentrations and the depth for the same sample point as shown in the samples of data in Figures. However large variation of Radon concentration in soil gas over a small depth is well known . Also it is worth to notice the sample point H10 has the maximum Radon concentration for all the three depths compared with other locations[14].

Table(2) Radon(Rn^{222}) and Toron (Rn^{220}) concentration in soil gas at depth (15cm) in Hilla city.

No.	Location Sample	Radon Concentration ($Bq.m^{-3}$)				Mean of radon concentration ($Bq.m^{-3}$)	Mean of thoron concentration ($Bq.m^{-3}$)
		1	2	3	4		
1	H1	304	952	1500	1190	986±506	1583±743
2	H2	304	1260	1610	1270	1110±560	4470±1157
3	H3	4140	10100	11600	12200	9520±3700	9205±1628
4	H4	846	918	1190	1360	1080±239	1538±739
5	H5	476	238	34	0.00	187±220	1329±706
6	H6	340	1190	816	1050	850±374	4325±1144
7	H7	1050	986	1090	1042	1042±371	4567±1173
8	H8	3700	10000	12000	13500	9800±4280	11675±1823
9	H9	479	718	821	855	718±170	7970±1520
10	H10	1290	3080	4790	6120	3820±2090	3470±1039

Table(3) Radon(Rn^{222}) and Toron (Rn^{220}) concentration in soil gas at depth (30cm) in Hilla city.

No.	Location Sample	Radon Concentration ($Bq.m^{-3}$)				Mean of radon concentration ($Bq.m^{-3}$)	Mean of thoron concentration ($Bq.m^{-3}$)
		1	2	3	4		
1	H1	2390	3830	4070	3520	3450±741	5105±1240
2	H2	1600	8040	7250	8050	6235±965	2533±910
3	H3	8090	10500	8850	6670	8520±1580	7410±1480
4	H4	1020	913	986	1050	992±60	30±285
5	H5	34	34	68	34	43±17	873±609
6	H6	1390	2720	3880	4060	3010±1230	7848±1500
7	H7	1190	2350	2750	2790	2270±747	2350±882
8	H8	6120	2020	1850	1330	2830±2210	15±303
9	H9	1290	2600	3620	2970	2620±983	7343±1453
10	H10	6530	9760	13400	14800	11100±3720	2040±838

Table(4) Radon(Rn^{222}) and Toron (Rn^{220}) concentration in soil gas at depth (45cm) in Hilla city.

No.	Location Sample	Radon Concentration ($Bq.m^{-3}$)				Mean of radon concentration ($Bq.m^{-3}$)	Mean of thoron concentration ($Bq.m^{-3}$)
		1	2	3	4		
1	H1	8490	9990	10700	10900	9110±2840	2898±858
2	H2	6390	9970	8690	10800	9820±886	2490±933
3	H3	4190	6150	10400	13200	8490±4070	46±355
4	H4	2500	8990	13600	15300	10100±5710	6885±1428
5	H5	34	102	34	34	51±34	3583±1057
6	H6	2550	2620	2960	3420	2890±397	60±291
7	H7	1430	3620	3450	3830	3080±1110	1803±801
8	H8	1680	9990	19600	23900	13800±9960	3129±990
9	H9	2450	4270	6770	7250	5190±2250	3433±1027
10	H10	16900	15200	14200	14500	15200±1200	2735±963

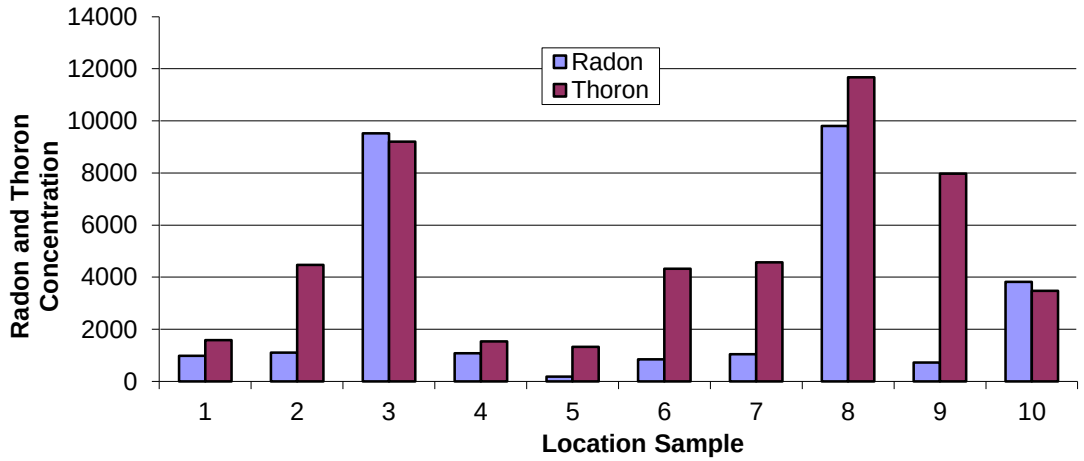


Fig.(3): Radon and Thoron concentration of soil at depth 15 cm in Hilla city.

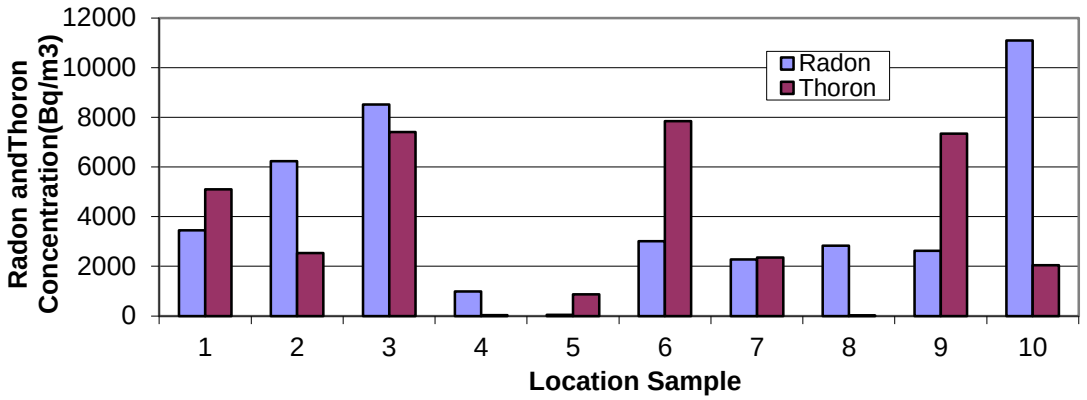


Fig.(4): Radon and Thoron concentration of soil at depth 30 cm in Hilla city

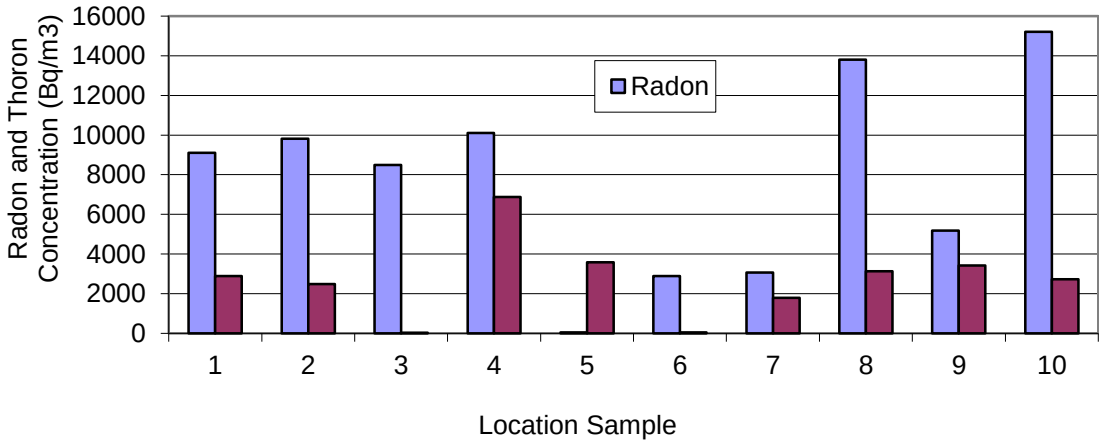


Fig.(5): Radon and Thoron concentration of soil at depth 45cm in Hilla city

2-The Activity Concentration

The results of analysis of activity concentration of ^{40}K, ^{238}U, ^{232}Th radionuclides in soil samples for different locations at surface (0-5cm) in Table (5). The activity concentration of ^{40}K was 336.600±2.60 to 426.363±2.73Bq·kg^{-1}, with an average value of 410.223±2.86 Bq·kg^{-1}. The range of measured activity of ^{238}U in the soil of Hilla City was 2.783±0.23 to 26.610±0.64 Bq·kg^{-1} with an average of 17.647±0.52 Bq·kg^{-1}. The minimum value obtained in sample H2 and a maximum for the sample H8. The differences are attributable to the geochemical composition and origin of soil types in a particular area. The range of measured activity concentration of ^{232}Th for the soil was 0.351±0.07 to 10.206±0.42 Bq·kg^{-1} with an average of 4.579±0.25 Bq·kg^{-1}. The minimum value obtained in sample H7 and a maximum for the sample H1. The differences are significant in all samples. The differences are attributable due to soil type in Hilla district which is sandy and clay soils. While in Table (6) at the depth 30 cm the activity concentration of ^{40}K, ^{238}U, ^{232}Th was 416.655±2.86, 14.079±0.46, 12.326±0.43 respectively.

Moreover, our obtained average values fall within the range of corresponding world values. The world average activity concentration of ^{238}U is 35 Bq·kg^{-1} with ranges of 17 - 60 Bq·kg^{-1}, ^{232}Th is 30 Bq·kg^{-1} with ranges of 11 - 64 Bq·kg^{-1} and ^{40}K is 400 Bq·kg^{-1} with ranges of 140 - 850 Bq·kg^{-1} [6]**.** We see from Table (5) that, the activity concentration of uranium is higher than thorium in all samples, which is evident from the fact that the average uranium is higher than that of the average thorium in earth's crust in this region. It is also observed that the measured activity concentration of ^{40}K exceeds markedly the values of both Uranium and Thorium, as it is the most abundant radioactive element under consideration. Moreover the excessive use of the Potassium containing fertilizers in the area adjacent to the sampling sites may contribute to the higher values of ^{40}K activity. The same Table (5**)** shows the radiological effects such as: the radium equivalent and the absorbed dose rate. Using equation (1), the radium equivalent activity found in the soil samples are shown in Table (5). The radium equivalent activity (Ra_{eq}) calculated for the same soil samples vary from 36.052 Bq·kg^{-1} to 70.217 Bq·kg^{-1} with an average value of 50.127 Bq·kg^{-1}. It is inferred that for all the soil samples analyzed, the radium equivalent activity value is well within and less the permissible limits of 370 Bq·kg^{-1}.While Table (6**)** shows the radium equivalent activity (Ra_{eq}) with an average value of 63.297 Bq·kg^{-1}. The calculated absorbed dose rate varied from 19.202 to 43.294 nGy·h^{-1}, with an average value of 28.989 nGy·h^{-1}. in Table (5) while Table (6) was 31.534 .Thus, the radioactive impact and the additional external radiation exposure for population due to radon flux from the soil, uptake by plants, natural alpha activity of food products must be minimal[15].

The calculated indoor and outdoor values are quoted in Table (7). The results of outdoor, indoor and average effective dose for Hilla district are 0.0355, 0.1422 mSv·y^{-1}, respectively.While in Table (8) was 0.0387, 0.1546 It can be seen that the above-mentioned values were lower than the corresponding worldwide values of 0.08, 0.42 mSv·y^{-1}, respectively [6].

The external hazard indexes (H_{ex}) were calculated in Table (7). from 0.0976 to 0.1921, with anaverage value of the 0.1450; the calculated average values were less than the acceptable value (1.5 mGy·y^{-1}). These radionuclides are a few sources of radon (^{222}Rn) and its radioactive progeny. The internal exposure by radon and its progeny is controlled by the internal hazard index H_{in}. H_{in} ranged between 0.1051and 0.2594 with an average value of the 0.1975and less than 1 is suggested for materials used for house construction.

The external hazard indexes (H_{ex}) were calculated in Table (8). from 0.1301 to 0.2275, with an average value of the 0.1685 **.** H_{in} ranged between 0.1424 and 0.3033 with an average value of the 0.2132**.** The calculated I_γ values for all the samples are presented in Table(7) the values range from 0.3659 to 0.5420 with an average of 0.4298 and in Table(8) the values range from 0.2963 to 0.6270with an average of 0.4698 . The calculated values for most samples were lower than the international values ($I_\gamma < 1$), which corresponds to an annual effective dose < 0.3 mSv/y[6].

Table **(**5 **):** Specific activities of radionuclides , Radium equivalent and absorbed dose of soil samples taken from the surface (0-5)cm .

Location	Activity Concentration [Bq/kg]			Radium Equivalent (Raeq) [Bq/kg]	Observed Dose(ERD) [nGy/h]
	^{40}K	^{238}U	^{232}Th		
H1	410.989±3.00	24.895±0.69	10.206±0.42	70.217	43.294
H2	415.269±3.01	2.783±0.23	0.965±0.13	36.052	19.202
H3	336.600±2.60	11.361±0.42	6.580±0.30	46.689	23.371
H4	426.363±2.73	8.921±0.37	2.862±0.20	45.844	23.057
H5	397.305±2.84	11.990±0.43	5.153±0.26	49.701	27.231
H6	464.426±3.18	24.685±0.69	1.420±0.16	52.349	31.653
H7	398.567±2.64	26.610±0.64	0.351±0.07	57.802	29.132
H8	416.684±2.70	26.183±0.63	5.373±0.27	65.951	32.809
H9	412.889±3.00	14.430±0.52	8.873±0.39	58.112	29.394
H10	423.142±2.88	24.610±0.62	4.004±0.27	58.554	30.747
Least value	336.600±2.60	2.783±0.23	0.351±0.07	36.052	19.202
Highest value	426.363±2.73	26.610±0.64	10.206±0.42	70.217	43.294
Mean	410.223±2.86	17.647±0.52	4.579±0.25	50.127	28.989

Table (6): Specific activities of radionuclides , Radium equivalent and absorbed dose of soil samples taken from the depth (5-30)cm .

Location	Activity Concentration [Bq/kg]			Radium Equivalent (Ra_{eq}) [Bq/kg]	Observed Dose(ERD) [nGy/h]
	^{40}K	^{238}U	^{232}Th		
H1	402.472±2.96	9.836±0.43	12.311±0.46	57.323	28.972
H2	417.431±3.02	23.370±0.67	19.290±0.58	81.361	40.183
H3	418.134±2.70	19.000±0.54	10.662±0.39	66.443	32.835
H4	418.134±2.70	1.693±0.16	19.809±0.53	62.216	30.520
H5	414.043±2.85	13.475±0.45	15.518±0.49	66.836	33.128
H6	446.475±3.12	4.537±0.29	6.488±0.34	47.609	24.743
H7	422.956±2.72	10.690±0.40	6.706±0.31	52.847	26.740
H8	399.511±2.64	28.029±0.65	17.803±0.50	84.250	40.665
H9	408.128±2.99	15.478±0.54	5.542±0.31	54.330	27.611
H10	419.268±2.87	14.684±0.47	9.135±0.37	59.759	29.940
Least value	399.511±2.64	1.693±0.16	5.542±0.31	47.609	24.743
Highest value	446.475±3.12	28.029±0.65	19.809±0.53	84.250	40.665
Mean	416.655±2.86	14.079±0.46	12.326±0.43	63.297	31.534

Table(7): Rate of annual effective dose and hazard indices of soil samples taken from the surface (0-5)cm .

Location	Effective Dose Rate(mSv.y $^{-1}$)		Hazard Index		Activity Concentration Index (I_γ)
	Outdoor	Indoor	External ($H_{ex} \leq 1$)	Internal ($H_{in} \leq 1$)	
H1	0.0531	0.2124	0.1921	0.2594	0.5420
H2	0.0235	0.0942	0.0976	0.1051	0.3050
H3	0.0287	0.1146	0.1261	0.1568	0.3659
H4	0.0283	0.1131	0.1238	0.1479	0.3734
H5	0.0334	0.1336	0.1349	0.1673	0.3966
H6	0.0388	0.1553	0.1688	0.2355	0.4388
H7	0.0357	0.1429	0.1561	0.2281	0.4466
H8	0.0402	0.1609	0.1781	0.2489	0.5061
H9	0.0360	0.1442	0.1591	0.1981	0.4602
H10	0.0377	0.1508	0.1655	0.2277	0.4629
Least value	0.0283	0.0942	0.0976	0.1051	0.3659
Highest value	0.0531	0.2124	0.1921	0.2594	0.5420
Mean	0.0355	0.1422	0.1450	0.1975	0.4298

Table(8): Rate of annual effective dose and hazard indices of soil samples taken from the depth(5-30)cm.

Location	Effective Dose Rate (mSv. y $^{-1}$)		Hazard Index		Activity Concentration Index (I_γ)
	Outdoor	Indoor	External ($H_{ex} \leq 1$)	Internal ($H_{in} \leq 1$)	
H1	0.0354	0.1417	0.1557	0.2074	0.4483
H2	0.0493	0.1971	0.2244	0.2876	0.6270
H3	0.0403	0.1611	0.1794	0.2308	0.5120
H4	0.0374	0.1497	0.1680	0.1726	0.2963
H5	0.0406	0.1624	0.1468	0.2246	0.4709
H6	0.0303	0.1214	0.1301	0.1424	0.3928
H7	0.0328	0.1312	0.1427	0.1716	0.4203
H8	0.0499	0.1995	0.2275	0.3033	0.6312
H9	0.0339	0.1354	0.1481	0.1899	0.4307
H10	0.0367	0.1468	0.1621	0.2018	0.4688
Least value	0.0303	0.1214	0.1301	0.1424	0.2963
Highest value	0.0499	0.1995	0.2275	0.3033	0.6270
Mean	0.0387	0.1546	0.1685	0.2132	0.4698

Conclusion

The activity concentration of terrestrial radionuclide (^{238}U, ^{232}Th, ^{40}K) and (^{222}Rn,^{220}Rn) in soil were measured in ten located in Region Hilla City. Based on ^{238}U, ^{232}Th, measurements, it can be said that the average activity concentration of these radionuclides are lower than world averages, expect ^{40}K. However, this value of ^{40}K concentration can be accepted to be normal because of the high usage of fertilizers those have potassium. The results of the present work indicate that the radionuclide activity concentrations of the soil samples varied within the study area due to the differences of geological structures. The mean absorbed dose rate and the average annual effective dose equivalent due to naturally occurring radionuclides in Region Hilla City were lower than the world averages. The soil gas radon levels also lie within normal levels compared to national values. It is possible to state that the low levels of radon concentration observed in all investigated

geothermal springs is a direct consequence of the geological structure of soils. The maximum radon concentration for soils is recorded during depth, whereas the minimum was observed in the surface.

In summary, all studies in Region Hilla City are radiology safe; none of them exceeds the recommended action level. This study would be useful for establishing base line data on the natural radioactivity levels in different areas of Hilla province**.**

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