Measurement of radon and thoron concentrations of soil- gas in Al-Kufa city using RAD-7 detector

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Abstract

This work represents the set of measurements of radon and thoron concentrations levels of soil-gas in Al-Kufa city in Iraq using electric Radon meter (RAD-7). Radon and thoron concentration were measured in soil-gas in 20 location for three depth of (50, 100 and 150) cm.

The results show that the emanation rate of radon and thoron gas varied from location to anther, depending on the geological formation. The Radon concentration in soil has been found to vary from (12775±400) Bq/m^3 at 150 cm depth in location (sample K2) to (41.45±17) Bq/m^3, for depth 150 cm in location (sample K20). The thoron concentration in soil has been found to vary from (198±8.5) Bq/m^3 at 150 cm depth in location samples (K1 & K2) to undetected in the most location. These concentrations values are well below the allowed levels which it is range (0.4-40) KBq/m^3.

Key words

Radon soil-gas , Thoron, Al-Kufa city, RAD-7 detector.

Article info

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قياس تراكيز غازي الرادون والثورون للتربة في مدينة الكوفة باستخدام كاشف RAD-7

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الخلاصة

يمثل هذا العمل بمجموعة قياسات مستويات تراكيز الرادون والثورون لغاز التربةَ في 20 موقعٍ في مدينةِ الكوفة في العراق، باستعمال نظام المراقبة RAD-7 الأمريكي الصنع . وتم القياس لثلاثة أعماقَ مختلفةً لكل موقعٍ وهي 50 ، 100 و150 سنتيمتر.

أظهرت النتائج معدلات تركيز الرادون والثورون وتغيرها من موقع للآخر بالاعتماد على التركيب الجيولوجي .فقد وجد ان تراكيز الرادون في غاز التربة تتغيير من 400±2775بيكرل\م^3 عند العمق 150سم في الموقع نموذج K2 إلى 41.45±17 بيكرل\م^{3}عند العمق 150سم ، نموذج K20، اما قيم تراكيز الثورون في غاز التربة فتتراوح من 198 بيكرل\م^3 عند العمق 150سم في نماذج الموقعين K2 و إلى قيم قليلة جدا بحث لم تكشف من قبل الكاشف في بعض المواقع. إن قيم التراكيزللرادون والثورون في تربة مدينة النجف اقل من المستوى المسموح به والذي مداه 0.4-40 بيكرل\م^3.

Introduction

Radon is a natural inert radioactive tasteless and odorless gas, whose density is 7.5 higher than that of air [1, 2]. 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 [3,4]. There are three natural occurring isotopes of Radon; ^{222}Rn , a direct product of ^{226}Ra in the ^{238}U decay series with physical half-life 3.825 days, ^{220}Rn, a decay products of ^{232}Th, Thoron ^{220}Rn , half-life 55.6s for a radioactive noble gas exists in natural Radon gas, and ^{119}Rn, a decay product of ^{235}U, with half life of 3.6s. Among of 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 groundwater. Because it's relatively long half - life enabling it to migrate quit significant distance before decaying and can be found in the soil-gas.

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 [5]. Since Radon is a gas, it has much greater mobility than uranium and radium, which are fixed in the soil matter in rocks and soil.

There are some scientists modernly using RAD-7 detector and other techniques to measure Radon and Thoron concentrations in soil-gas. A. K. Hasan et al. in (2011)[6] studied the (^{222}Rn) concentration of soil for samples depths (5 , 25 , 35 and 60) cm in Al-Najaf city, using RAD-7 Radon monitoring system. The results suggested that the largest concentration was 9290±400 Bq/m^3 for 60cm depth at in Al-Amir district and the smallest concentration was 9±17 Bq/m^3 for 5cm depth at Al-Shoara district. In (2010) [7] Radon exhalation rate were estimated in soil samples that collected at the depth level of 30 cm inside 124 houses, using passive (CR-39 NTDs) and active (RAD-7) detecting method. The results show that the emanation rate for Radon gas was variation from location to other, depending on the geological formation.

Studied zone

In this study 20 regions were taken as fair distribution in Al-Kufa city. The locations were determined using (GIS) program. Fig.1 illustrates the map of Al-Kufa city and shows the distribution of studied locations, where it was drawn by GPS technical. Table1 shows location name, location symbol and coordinates for these zones.

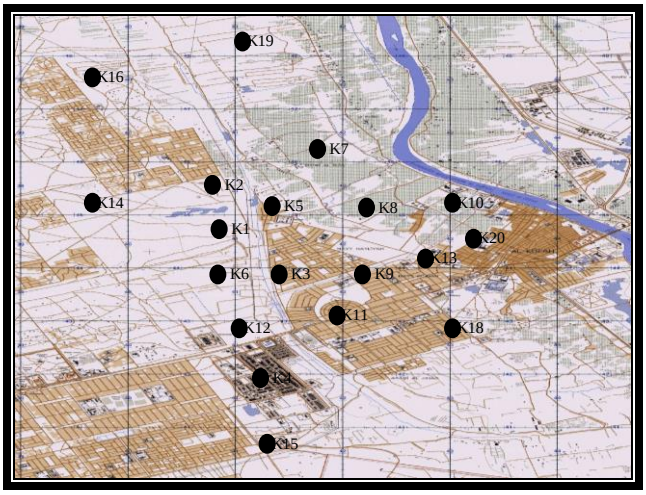

Fig. (1): The map shows the zone of Al-Kufa city which have been studied.

Measurement of Radon and Thoron in Soil-Gas samples

The RAD-7 can measure Radon via 3 different modes. The mode have been used for the soil-gas measurements is called the Grab sample protocol. The RAD-7 pumps the soil-gas for 5 minutes into the cell of the detector, and then waits for 5 minutes and only then counts for 5 minutes. ^{218}Po has a half-life of 3.05 min and it takes about 3-5 half-lives for the ^{218}Po activity to reach secular equilibrium, hence, in about 9-15 minutes. The decays of the ^{218}Po would then be counted after 10 mins (5 min of pumping

plus 5 min of waiting), in which time 95% of equilibrium would have been reached [8]. Finally, each set of readings includes four 5-min cycles that at last takes 30 min. There are a few types of soil-gas monitors that give real-time radon readings used the α-Probe 601 to complete a radon soil depth profile [3], where the RAD-7 used to measure the profile of the radon soil-gas.

Figure (2) shows the RAD-7 with the probe and a steel probe and shaft of length about 1.3m [8]. In this study, there are three different depths which (50 cm, 100 cm and 150 cm) which used to measure the concentration of radon and thoron concentration.

Table 1: Samples measurements of sites in Al-Kufa area .

No.	Location name	Location Symbol	Coordinates
1	Al.Motanaby	K1	44022/ 53.662// E , 3201/ 48.533// N
2	Al.Askary	K2	44022/ 52.701// E , 3202/ 7.472// N
3	Al.Shorta	K3	44023/ 21.377// E , 3201/ 40.2// N
4	Tamoz	K4	44023/ 19.438// E , 3201/ 2.182// N
5	Al.Jameah	K5	44023/ 21.377// E , 3201/ 40.2// N
6	Cenda	K6	44023/ 21.377// E , 3201/ 40.2// N
7	Al.Jemeah	K7	44023/ 32.435// E , 3201/ 16.483// N
8	Al.Jamhoriaa	K8	44023/ 57.168// E , 3201/ 59.881// N
9	Al.Moallemeen	K9	44023/ 37.175// E , 3201/ 47.986// N
10	Al.Sarria	K10	44024/ 10.902// E , 3202/ 16.906// N
11	Methamaltammar	K11	44023/ 38.578// E , 3201/ 18.738// N
12	Al.Saha	K12	44023/ 17.486// E , 3201/ 18.365// N
13	Al.Rashadiah	K13	44024/ 12.41// E , 3201/ 57.693// N
14	Al.Asatethah	K14	44021/ 51.843// E , 3202/ 30.579// N
15	Al.Shoarah	K15	44023/ 26.618// E , 3200/ 48.767// N
16	Messan 1	K16	44021/ 32.478// E , 3203/ 16.807// N
17	Meassan 2	K17	44022/ 2.231// E , 3203/ 15.717// N
18	Al.Forat	K18	44024/ 38.225// E , 3202/ 150.766// N
19	Alwatalfahal	K19	44022/ 59.216// E , 3203/ 17.863// N
20	Al.Jedada	K20	44024/ 21.563// E , 3202/ 25.565// N

Fig.2: The RAD-7 soil-gas setup, including the electronic Radon monitor

Results and Discussion

The values of radon and thoron concentrations in Bq/m^3 of soils gas samples was selected in location at depths 50, 100 and 150cm in Al-Kufa city as shown in Table 2.

Table 2 and Fig. 3 show that the radon activity in soil varied from 8835±513.703 Bq/m^3 in location K2 sample to 697.5±119.145 Bq/m^3 in location K20 sample with an average value 3630.05 Bq/m^3at depth 50 cm.

Table 2 and Fig. 4 show that the radon activity in soil varied from 12775±386.48 Bq/m^3 in location K2 sample to 178.75±25.303 Bq/m^3 in location K20 sample with an average value 4410.868 Bq/m^3 at depth 100 cm.

Table 2 and Fig. 5 show that the radon activity in soil varied from 9535.5±712.729 Bq/m^3 in location K2 sample to 41.45±16.500 Bq/m^3 in location K20 sample with an average value 4716.898 Bq/m^3 at depth 150 cm.

Table 2 and Fig. 6 show that there was no detection of thoron in these samples except at K1, K3, K4 and K13 samples the rate of a highest value at K3 sample of 65.8 Bq/m^3 and the lowest value at K4 sample of 64 Bq/m^3 with an average value 12.995 Bq/m^3 at depth 50cm.

Table 2 and Fig.7 show that there was no detection of thoron in these samples except at K1, K2, K4, K6, K10, K11, K13, K16 and K17 samples the rate of a highest value at K1, K2 sample of 65.4 Bq/m^3 and a lowest value at K10 sample of 64 Bq/m^3 with an average value64.8 Bq/m^3 at depth 100 cm.

Table 2 and Fig. 8 show that there was no detection of thoron in these samples except at K1, K2, K4, K11, K13, K16 and K17 samples the rate of a highest value at K1 sample of 198 Bq/m^3 and a lowest value at K4, K16 and K17 sample of 64.4Bq/m^3 with an average value 83.857 Bq/m^3 at depth 150 cm.

The spectra in Figs. 9-14 show the higher and lower concentration in locations of Al-Kufa city depths at 50 , 100 and 150cm respectively, these figures show the the relation between the count rate and the energy which consist of Radon daughters in A(^{218}po) , B(^{214}po) and thoron daughters D(^{216}po) , E(^{212}po).

The results of the average activity concentration of ^{222}Rn and ^{220}Rn of soil in Al-Kufa city is smaller than the accordable limit, usually ranges from 0.4 to 40 kBq. m^{-3} [9,10].

The radon concentration in soil increased with increasing the depth except in some soil with rich water. In comparison between the average radon concentration in Al-Kufa city/ Iraq; measured by RAD-7 at depth 60cm is 3273 ±245 Bq/m^3 [6] and in Jordan (west of Iraq), particularly in some region, the average radon concentration in soil air was reported to be about 15 kBq/m^3 in range from 4 to 21 kBq/m^3 [11].

The difference in soil radon gas concentrations at the studied areas is due to difference in the underlying bedrocks and the geology of the studied areas. The high anomalies may be due to holes falling exactly on covered fault lines in the earth crust, since Radon gas concentration in soil is taken as proportional to fracture opening. Large size of the fault lines serve as routes for soil ^{222}Rn gas, porosity of sandstone which is normally found mainly under the Togo formation and high out gassing rate at faulted zones where the gas permeability is relatively high also contributes. Also it may be attributed to ^{222}Rn gas coming from the earth's deep interior not from surrounding rocks only because the rocks found at both studied areas do not fall under major rocks containing naturally occurring radioactive materials (NORMS) [10,12].

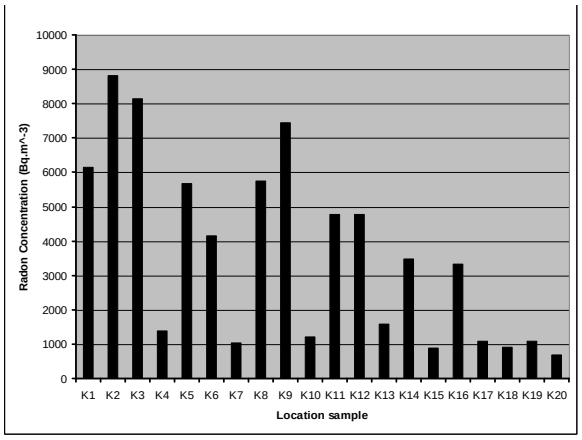

Fig.3: Radon concentration of soil at depth 50 cm in Al-Kufa city

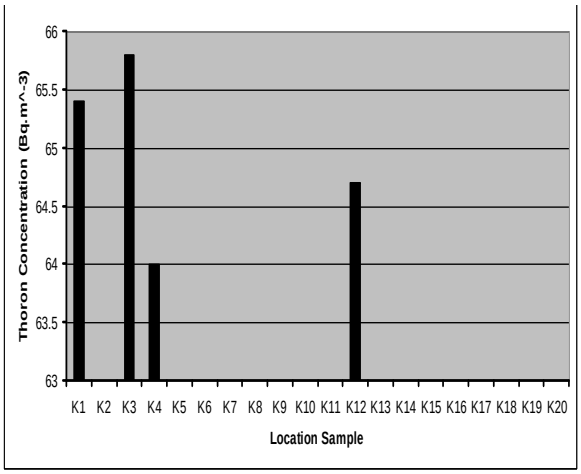

Fig.6: Thoron concentration of soil at depth 50 cm in Al-Kufa citv

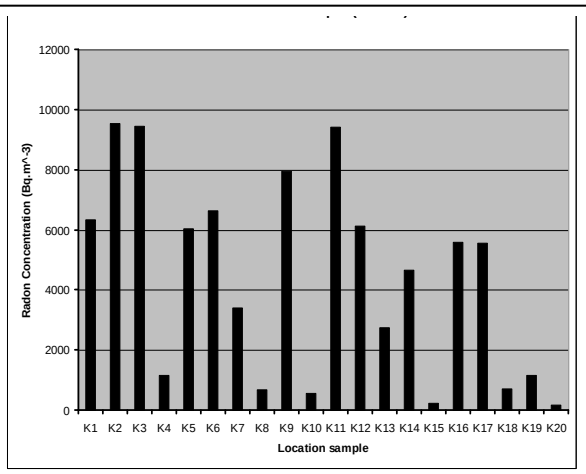

Fig.4: Radon concentration of soil at depth 100 cm in Al-Kufa city

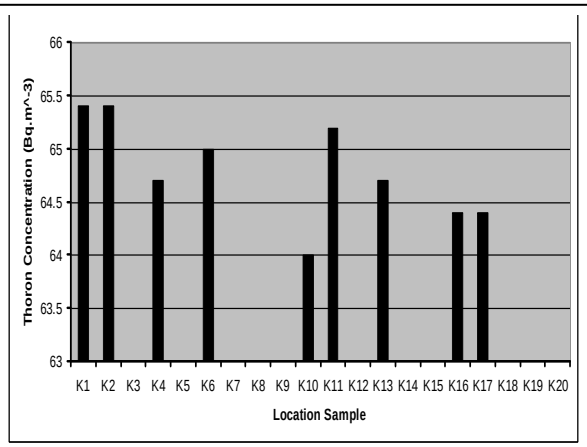

Fig.7: Thoron concentration of soil at depth 100 cm in Al-Kufa city

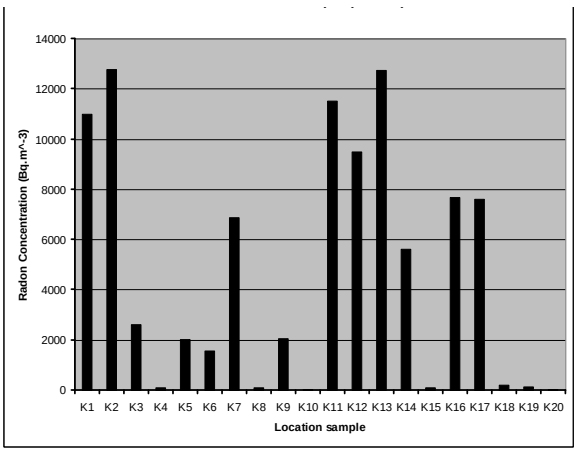

Fig.5: Radon concentration of soil at depth 150 cm in Al-Kufa city

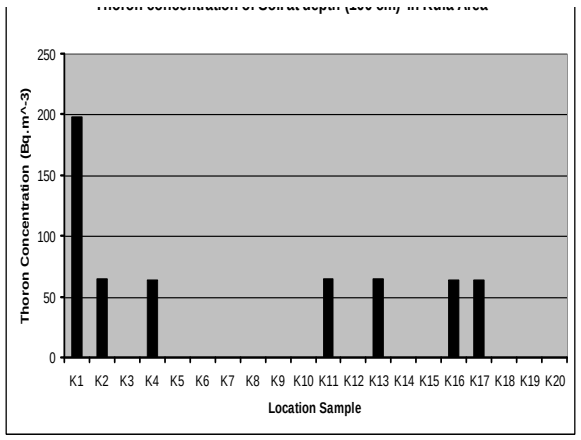

Fig.8: Thoron concentration of soil at depth 150 cm in Al-Kufa city

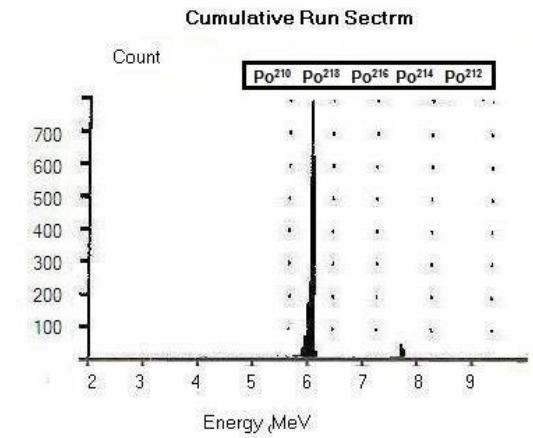

Fig. 9: Aalpha energy spectrum of location sample soil at depth50 cm for K2

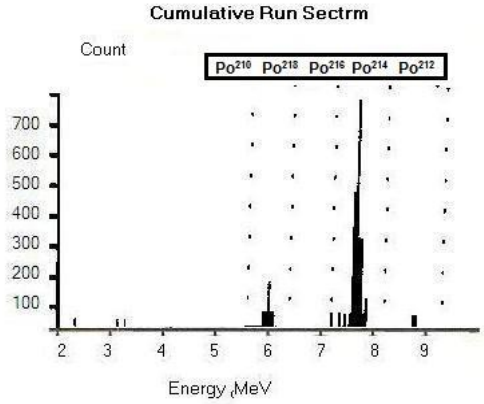

Fig.12: Alpha energy spectrum of location sample soil at depth 100 cm for K20

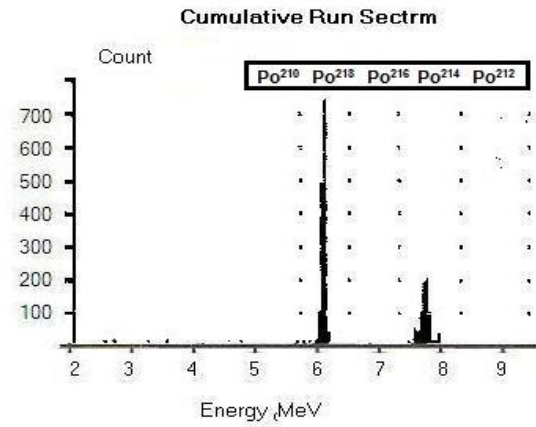

Fig.10: Alpha energy spectrum of location sample soil at depth 50 cm for K20

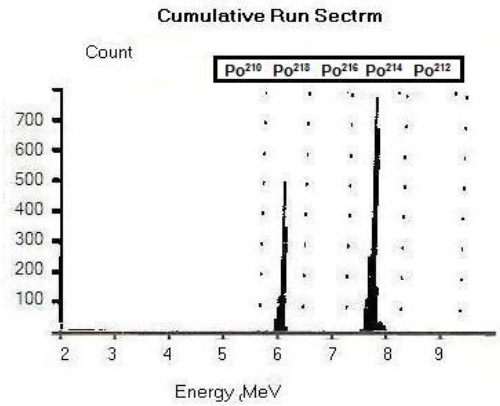

Fig.13: Alpha energy spectrum of location sample soil at depth 150 cm for K2

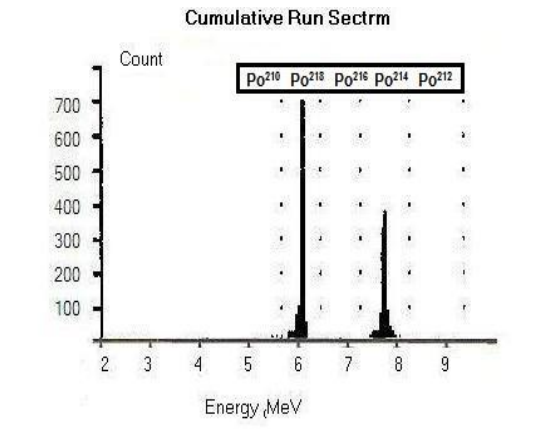

Fig.11: Alpha energy spectrum of location sample soil at depth 100 cm for K2

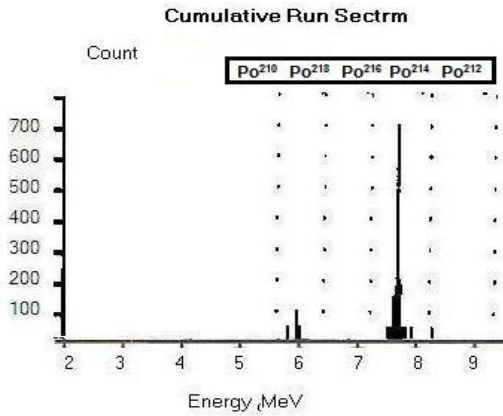

Fig.14: Alpha energy spectrum of location sample soil at depth 150 cm for K20

Conclusions

1. Radon concentration in soil increases with increasing the value of depth except for the water rich soil.
2. Thoron concentrations for some samples in this study undetected because the half-life of thoron equal55s
3. The maximum allowed concentration level in soil of radon is between 0.4 – 4 kBq/m^3, therefore all results that were obtained in this study are less than the maximum allowed concentration level.

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