Comparison the 222-Rn Gas and there Exhalation between Depth and Surface Formation Soil

A Case Study in Tawke,Duhok, North of Iraq

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*Abstract*—In this study,13 different location of surface soil of geological formation and 20 samples of mud companion oil extraction were collected during drilling, from one of the oil wells in the Kurdistan region of Iraq /Dohuk governorate / Zakho district / Tawky area. Samples are taken at different depth of well. For both samples used the RAD7 technique, for finding the radon concentration in both samples with comparison, the smallest value in depth soil and surface formation was 14.12±8.59 and 16±4.24 Bq/m3 while the highest value was 93.25+21.72 and 137±8.76 Bq/m3, finding there are difference in both the depth and surface formation, with shows that the all surface formation ratio over the depth ratio. The same thing with exhalation rate for both of samples, recorded value was higher than well depths layer. At last will compared with recommended researches and the “International Atomic Energy Agency” (IAEA) levels. Data shows it was less than the standards of IAEA.

Keywords: NORM, Surface geological formation, Oil well, 222-Radon gas, Exhalation rate, RAD7

1. Introduction

The natural radioactivity was more than background radiation, which clarified in oil with gas retrieval waste into the 1930s (Otto 1989). In 1980s and up some regulatory agencies going to have an action for paying attention to NORM subject related to hydrocarbon production (Smith 1992). Gamma radiation that comes from wastes has an extremely wide range[3][7]. The environment contamination with pose risks to the health of human comes from the activities that uncontrolled releasing and joined by enhanced of NORM levels. These kinds of risks can reduce by the adoption of checks to recognize the NORM source, with controlled NORM waste and polluted equipment whereas protecting workers. The 238U and 232Th are radi oactive material and they occurred hint concentration into a rock formation and soil organizes. This kind of unstable radioactive chemical element create other radionuclides, which have certain conditions as of (temperature, pressure, acidity, etc.) into the some surface layer and subsurface environment, they have mobile with a probability of transmitted from a reservoir to up surface during the extraction of crude oil products, from this research tries to find the radon gas and its exhalation in term of area and mass ratio in each hundred meters of depth even though the more than one sample during some hundred meters come from the same formation. In-contrast the other samples were collected from different location that have a spatial geologecal formation. The study of radon in Saudi-Arabia found radon concentration in the soil was ranged from 75 to 220 Bq/m3 [3], in another research found 4561 Bq/m3 as mean value in soil [4]. From the India study of radon gas in soil, the radon rated were 7.46 ± 0.69 kBq/m3 [5]. In the field of radon exhalation rate in Syria measured 9 Bq.m-2.s-1 as of area exhalation rate [6]. The aim of the current study is to find the concentration of radon by using RAD7 technique. A total of 13 formation samples from different location located in the North of Duhok governorate, and 20 mud samples were collected during drilling of the oil well. This is in one of the oil wells in the area of Tawky, located east of the Zakho district in Dohuk governorate. At different depths, the purpose of calculating the surface area and mass exhalation rate of radon to be compared them with surface formation and depth with other studies.

1. Study area information

The Both area was located in Iraq/ Northwest and North of Duhok governorate about 60 km far from the center of the city and about 20, 60 km east of Zakho district, it was one of the 51 wells locations that extracting the crude oil in it and the other surface formation soil, this well it located at the end of oil land at present time. GPS pint was 37.161985 latitude, 43.016341 longitude, the depth was 2200 m to be reached the layer of crude oil, so during the excavation, we can find different of geological formation. But the other list of data was form special locations that appear the formation soil on it.

1. Experimental preparation

Twenty samples of drilling mud from assorted depths (assorted formations) were gathered from Tawke (T-49) oil well. The well is located in Tawke oil field, which is located in north of Iraq, northeast of Duhok governorate. The formation with the depths, from the samples that collected, is listed into table (1) and the surface formation measurement explored in table (2) . The collected samples were dried by putting in oven 110oC one day for eliminate moisture, then milled to be a fine powder, then garbled with 0.2 mm mesh. This study was used as an active mod as a solid-state determination to find the activity concentration of radon gas. The setup of the experiment is shown by Figure (1) obviously, contain plastic-tube technique about ~one-liter volume manufactured of polyvinyl chloride (PVC) as a chamber to accumulation radon in it. The PVC-tube joined with vinyl tubing for drying the gas from humidity, because it contains desiccant (CaSO4) with the radon device monitor. A soil sample was put in the bottom of the tube as of radon exposure source, with closing both sides by PVC cover then the plastic-tube container isolated via two valves adjust at the different direction of sides of the container. The design has been measured after putting the samples and left in room temperature about one month. Throughout one month, it is sufficient to reach the equilibrium between both of radium with radon and also radon decay production been reached inner of tube chamber. When connected to the closed loop both valve where opened. The device pool air from the container, passing through desiccant then to inlet filter then to RAD7 device into measuring tube chamber. The air was departing from the outlet of RAD7 device. The radioactive element decays interior of the chamber, creating detected () alpha-particle that emitter progeny, especially polonium isotopes. There is high voltage is about 2218V, pot on chamber walls. The detector of Rad7 was converted () alpha-radiation right away to electrical sign by utilizing the alpha technique and able to separate the different electrical pulses produce from 214Po and 218Po with energies 7MeV and 6MeV correspondingly.



` Fig. 1. Active method of radon concentration measurement.

The testing is done under a dry situation. Humidity condition between, 4-8%, with a temperature of room between 20 to 31 oC.

When the equilibrium state, the flux (exhalation) of radon from each one of the sample inside the can in term of area and mass can be measured by the following model[7].

EA= (1)

EM = (2)

where EA is exhalation rate in term of area, unit (Bq.m-2.d-1) and EM is exhalation rate in term of mass, unit (Bq.kg-1.h-1), CRn is radon concentration calculated by RAD7 detector in a unit (Bq/m3), (⅄=7.56x10-3 h-1) is a constant of radon decay, T is the exposure time in hours (h), V is the volume of the can equal (0.001192 m3) and S is the surface area equal (0.003847 m2) of sample in the can.

The setup RAD7 on four-cycle mode, the data are stored in the internal memory via using starting protocol of 2-days test. The saved value depends on the average gas concentration of radon during each break time. A suitable data get out via the attachment unit of a printer to printout needed to be stored memory data.

1. Result and discussion

The statistics of the concentration of radon into different depths and formation of Tawke area location and the soil from different location that contain the formation layers, shows that in different depth have different ratios of the radioactive radon gas and the results with compared with surface formation location. In both data was sheered with same formation was upper and lower Faris which was the measurement near to each others, but the surface formation in general was recorded higher than the depth location. The high rate was recorded in the depth of (1100) meter named (Euphrates formation) and Khormala Formation , but the low ratio was recorded in the depth of (1900) meter named (Kolosh formation ) and Jurbi formation, by value 93.25±19.72, 137±8.76 and 14.12±8.59, 16±4.24 Bq.m-3, respectively. The mean of radon gets via RAD7 monitor, about to (44.53+9.52, 58.60±9.34 Bq/m3). Results of all data with chart displayed via Figure (2).There are many factors are be reasonable to be released radon from soil and rocks, as of permeability, moisture, porosity, content, CO2 concentration into the soil, temperature, and atmospheric affection as of pressure. Maybe each location include specific distinctive soil properties also the rocks, so the evaluated be accordingly[3]. Under the earth there is radon movement, this movement depends on compaction, brittle, lithology, porosity, and in tectonic skin as of faults, joints also thrust[8][9]. The raises of Radon gas emission caused by soil moisture, but if there is a saturation of soil pores, the emission will be inhibited. The carbon dioxide behaves is as of carrier gas for the radon into the soil, cause to enhance the 222-Rn concentration into the soil atmosphere[10]. In the studied samples demonstrate the maximum radon concentrate level acceptable into soil is (0.40 to 4.0 kBq.m-3 )[11].

Through the table (3) comparing this study results with the result of world radon concentration and exhalation, the present study shows that the radon rate was higher than the study done in Iraq- Kurdistan, Eygept and India, while less than the Iraq- Baghdad and Iraq-Erbil study, but with range of Sudi-Arabia, still this value lower than the acceptable level mentioned in EPA should be less than 300 Bq.m-3 [12], but as of mass exhalation rate in Osaka, Japan and Catania, Italy the value of exhalation rate was under the average of this study, but also with the range of Erbil, Iraq and India and the other was more than this study range, in general this results also less than mean world value which is (57600 mBq.m-2.h-1) [13]. In term of mass, this study results were near to India and Erbil, Iraq.

Fig. 2. Radon concentration in different depth and formation of soil Bq/m3.

Table. 1. The radon (222-Rn) concentration with its exhalation in different depth.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| # | Depth meters | Layer Name | Weight gram | 222Rn+SD  Bq/m3 | Radon area mBq.m-2.h-1 | Radon mass mBq.kg-1.h-1 |
| 1 | surface | Surface area | 126.34 | 62±15.25 | 177.8±43.73 | 5.41±1.33 |
| 2 | 400 | Upper Faris | 129.96 | 85.25±7.18 | 244.48±20.59 | 7.24±0.61 |
| 3 | 500 | Sandston-clayston-Upper Faris | 136.02 | 66.25±3.77 | 189.99±10.81 | 5.37±0.31 |
| 4 | 600 | Sandston-clyston- Upper Faris | 132.5 | 40.75±21.72 | 116.86±62.29 | 3.39±1.81 |
| 5 | 700 | Sandston-clyston- Upper Faris | 145.12 | 52.2510.17 | 149.84±29.17 | 3.97±0.77 |
| 6 | 800 | Lower Faris clayston | 136.34 | 57.5±10.87 | 164.9±31.17 | 4.65±0.88 |
| 7 | 900 | Euphrates | 145.1 | 40±16.79 | 114.71±48.15 | 3.04±1.28 |
| 8 | 1000 | Euphrates | 129 | 47±11.46 | 134.79±32.86 | 4.02±0.98 |
| 9 | 1100 | Euphrates | 137.8 | 93.25±19.72 | 267.42±56.55 | 7.46±1.58 |
| 10 | 1200 | Pelaspi | 126.8 | 69±8.98 | 197.88±25.75 | 6±0.78 |
| 11 | 1300 | Pelaspi | 142.2 | 63.5±12.15 | 182.1±34.84 | 4.93±0.94 |
| 12 | 1400 | Jurkes | 138 | 24±3.36 | 68.83±9.64 | 1.92±0.27 |
| 13 | 1500 | Jurkes | 126.04 | 29±8.44 | 83.17±24.2 | 2.54±0.74 |
| 14 | 1600 | Jurkes | 149.69 | 24.25±7.93 | 69.54±22.74 | 1.79±0.58 |
| 15 | 1700 | Jurkes | 150.6 | 23.75±5.85 | 68.11±16.78 | 1.74±0.43 |
| 16 | 1800 | Kolosh | 153.34 | 27.05±4.71 | 77.6±13.51 | 1.95±0.34 |
| 17 | 1900 | Kolosh | 129 | 14.12±8.59 | 40.52±24.63 | 1.21±0.73 |
| 18 | 2000 | Kolosh | 137.58 | 18.23±7.21 | 52.3±20.68 | 1.46±0.58 |
| 19 | 2100 | Kolosh | 137.15 | 23.01±1.32 | 65.98±3.79 | 1.85±0.11 |
| 20 | 2200 | Kolosh | 140.34 | 30.50±5 | 87.47±14.34 | 2.4±0.39 |
|  |  |  | Max | 93.25+21.72 | 267.42±62.29 | 7.46±1.81 |
|  |  |  | Min | 14.12±8.59 | 40.52±3.79 | 1.21±0.11 |
|  |  |  | Average | 44.53+9.52 | 125.08±26.45 | 3.52±0.74 |

Table. 2. The radon (222Rn) concentration with its exhalation in different surface formation.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| # | Formation Name | Weight gram | Radon Average & Stander division [Bq/m3] | Radon Area mBq.m-2h-1 | Radon MASS mBq.kg-1h-1 |
| 1 | Jurbi formation | 156.15 | 16±4.24 | 45.88 ± 12.16 | 1.13 ± 0.3 |
| 2 | Sludge after treatment | 165.85 | 16±5.66 | 45.88 ± 16.23 | 1.06 ± 0.37 |
| 3 | Soil before treatment | 165.35 | 66.5±11.27 | 190.71 ± 32.32 | 4.43 ± 0.75 |
| 4 | Lower Faris formation | 100.89 | 33.25±2.06 | 95.35 ± 5.91 | 3.63 ± 0.22 |
| 5 | Khormala Formation | 170.56 | 137±8.76 | 392.88 ± 25.12 | 8.86 ± 0.57 |
| 6 | Avana Formation | 128.07 | 39.5±13.87 | 113.28 ± 39.77 | 3.4 ± 1.19 |
| 7 | Waste Mud | 130.25 | 80±13.44 | 229.42 ± 38.54 | 6.77 ± 1.14 |
| 8 | Pelaspi formation | 160.1 | 47±4.24 | 134.78 ± 12.16 | 3.24 ± 0.29 |
| 9 | Bakhtyari Formation | 142 | 31±8.49 | 88.9 ± 24.35 | 2.41 ± 0.66 |
| 10 | Jurkes Formation | 134.27 | 55.5±6.81 | 159.16 ± 19.53 | 4.56 ± 0.56 |
| 11 | Upper Faris Formation | 154 | 57.5±7.14 | 164.89 ± 20.47 | 4.12 ± 0.51 |
| 12 | Qamchqa Formation | 161.25 | 123.25±17.34 | 353.45 ± 49.73 | 8.43 ± 1.18 |
| 13 | Sheranish Formation | 133.21 | 59.35±18.11 | 170.2 ± 51.93 | 4.91 ± 1.5 |
|  |  | Max | 137±8.76 | 392.88 ± 25.12 | 8.86 ± 0.57 |
|  |  | Min | 16±4.24 | 45.88 ± 12.16 | 1.13 ± 0.3 |
|  |  | Average | 58.60±9.34 | 168.06 ± 26.78 | 4.38 ± 0.71 |

Table. 3. The radon exhalation rate in term of area and mass.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Radon exhalation rate in term of area and mass | | | | |
| Country | 222-Rn concentration Bq/m3 | 222-Rn mBq.m-2.h-1 | 222-Rn  mBq.kg-1.h-1 | Reference |
| Tawky-T49 different soil of well depth,  Different Formation | 44.53+9.52  58.60±9.34 | 125.08±26.45  168.06 ± 26.78 | 3.52±0.74  4.38 ± 0.71 | Present study |
| India | 7.46±0.69 | 246.63–1100 | 7.17–31.98 | [5] [14] |
| Turkey |  | 1476 | - | [15] |
| Erbil, Iraq | 361.77 ± 3.79 | 67.962- 515.167 | 1.882- 12.630 | [16] |
| Iraq, Kurdistan | 15.638±7.38 | 5670-14020 | 536.09-1324.12 | [17] |
| Osaka, Japan | - | 10.8 | - | [18] |
| Island of Hawaii | - | 9.0±226 | - | [19] |
| Japan |  | 1260 | - | [20] |
| Germany | - | 7200-63000 | - | [21] |
| Catania, Italy |  | 43.1±6.7 | - | [22] |
| Baghdad, Iraq | 1337.55 | 1059.5 | 61.25 | [23] |
| Alexandria, Egypt | 7 | 464.4 | - | [24] |
| Saudi-Arabia | 75 - 220 |  |  | [3] |
| Mean world value | <300 | 57600 | - | [12][13] |

1. Conclusion

There are difference of the amount of Radon gas and its exhalation rate from the depth and the surface formation soil, over all the surfaces average was greater than the depth of soil as of 31.59 % radon and 34.36% exhalation per area then 24.43% exhalation per mass. The naturally decay of uranium producing the radon gas, RAD7 was the easiest way to find radon concentration in the soil. All the result shows that the rates less than mean world value.

Reference

[1] K. P. Smith, “Overview of Naturally Occurring Radioaiv Materials (NORM) in the Petroleum Industry,” Work, 1992.

[2] M. A. Hilal, M. F. Attallah, G. Y. Mohamed, and M. Fayez-Hassan, “Evaluation of radiation hazard potential of TENORM waste from oil and natural gas production,” J. Environ. Radioact., vol. 136, pp. 121–126, 2014.

[3] W. R. Alharbi, “Measurement of radon concentrations in soil and the extent of their impact on the environment from Al-Qassim, Saudi Arabia,” Nat. Sci., vol. 05, no. 01, pp. 93–98, 2013.

[4] S. Mittal, A. Rani, and R. Mehra, “Estimation of radon concentration in soil and groundwater samples of Northern Rajasthan, India,” J. Radiat. Res. Appl. Sci., vol. 9, no. 2, pp. 125–130, 2015.

[5] G. Prasad, Y. Prasad, G. S. Gusain, and R. C. Ramola, “Measurement of radon and thoron levels in soil, water and indoor atmosphere of Budhakedar in Garhwal Himalaya, India,” Radiat. Meas., vol. 43, no. SUPPL.1, pp. 375–379, 2008.

[6] R. Shweikani and M. Hushari, “The correlations between Radon in soil gas and its exhalation and concentration in air in the southern part of Syria,” Radiat. Meas., vol. 40, no. 2–6, pp. 699–703, 2005.

[7] J. Jebur and A. Subber, “Activity Concentration of 222Rn Gas,226Ra, 232Th and 40K in Crops and Soil Taken from Safwan Granges Using Active, Passive and Gamma Spectroscopy Techniques,” Br. J. Appl. Sci. Technol., vol. 11, no. 6, pp. 1–12, 2015.

[8] H. Pradesh, “Geology of Radon Occurrence Around Jari in Parvati,” vol. 34, no. 2, pp. 139–147, 1997.

[9] R. Mehra, “Measurement of soil-gas radon in some areas of northern Rajasthan, India,” J. Earth Syst. Sci., vol. 123, no. 6, pp. 1241–1247, 2014.

[10] T. K. Ball, D. G. Cameron, T. B. Colman, and P. D. Roberts, “Behaviour of radon in the geological environment: a review,” Q. J. Eng. Geol. Hydrogeol., vol. 24, no. 2, pp. 169–182, 1991.

[11] A. A. Al-hamidawi, Q. S. Jabar, A. H. Al Mashhadani, and A. A. Al Bayati, “Measurement of Radon and Thoron Concentrations of Soil- Gas in Al-Kufa City using RAD-7 Detector,” Iraqi J. Phys., vol. 10, no. 19, pp. 110–116, 2012.

[12] E. P. A. (EPA), “Health Specialists - Environmental Protection Agency (EPA,” Environ. Prot. Agency.

[13] W. E. C. and D. S. M. H. WILKENING, “Radon-222 Flux Measurements in Widely Separated Regions, in the Natural Radiation Environment,” Tech. Inf. Serv. Springf., p. II pp. 717-730.

[14] S. Singh, M. Kumar, and R. K. Mahajan, “The Study of Indoor Radon in Dwellings of Bathinda District, Punjab, India and its Correlation with Uranium and Radon Exhalation Rate in Soil,” Radiat. Meas., vol. 39, no. 5, pp. 535–542, 2005.

[15] O. Baykara, M. Doǧru, M. Inceöz, and E. Aksoy, “Measurements of Radon Emanation from Soil Samples in Triple-Junction of North and East Anatolian Active Faults Systems in Turkey,” Radiat. Meas., vol. 39, no. 2, pp. 209–212, 2005.

[16] H. H. Aziz, “A Study of Radon and Thoron Gases Release from Iraqi-Kurdistan Building Materials Using Passive and Active Methods,” vol. 2010, 2010.

[17] A. H. Ismail, M. S. Jaafar, and A. S. Collection, “Hazards Assessment of Radon Exhalation Rate and Radium Content in the Soil Samples in Iraqi Kurdistan Using Passive and Active Detecting Methods,” vol. 4, no. June 2009, pp. 638–641, 2010.

[18] K. Megumi and T. Mamuro, “Radon and Thoron Exhalation from the Ground,” J. Geophys. Res., vol. 78, no. 11, pp. 1804–1808, 2008.

[19] M. H. Wilkening, “Deep Soils are More Important than Lava Fields or Volcanoes,” Am. Assoc. Adv. Sci., vol. 183, no. 4123, pp. 413–415, 1974.

[20] N. M. HASSAN et al., “Simultaneous Measurement of Radon and Thoron Released from Building Materials used in Japan,” Prog. Nucl. Sci. Technol., vol. 1, no. 0, pp. 404–407, 2015.

[21] M. Keller, G and Schutz, “Radon Exhalation from the Soil,” Radiat. Prot. Dosimetry, vol. 24, no. 1–4, pp. 43--46, 1988.

[22] G. Immé, R. Catalano, G. Mangano, and D. Morelli, “Radon Exhalation Measurements for Environmental and Geophysics Study,” Radiat. Phys. Chem., vol. 95, pp. 349–351, 2014.

[23] S. A. Amin, A. H. Al-Obiady, and A. Alwan, “Radon Level Measurements in Soil and Sediments at Oil Field Area and Its Impact on the Environment,” Eng. Technol. J. Part B Technol. J. Part B, vol. 35, no. 1, pp. 1–7, 2017.

[24] A. F. Hafez, A. S. Hussein, and N. M. Rasheed, “A Study of Radon and Thoron Release From Egyptian Building Materials using Polymeric Nuclear Track Detectors,” Appl. Radiat. Isot., vol. 54, no. 2, pp. 291–298, 2001.