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Concentration of Radon Released from Marine Sediment Around Hajjam Island, Southern Iraq, North West Arabian Gulf, Using CR-39 Detector

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Abstract Hajjam Island lies in the lower reaches of Khor Al-Zubair southern of Iraq, it is the unity island in the Iraqi marine water. 15 sediment samples were collected from sites around the island and transferred to the lab in Marine Science Centre for radiological investigation. Two methods were adopted, Active and Passive, for determination of Radon in which an environmental radon monitoring system comprising a radon-cup, an etching system, and a track counting system, was constructed. The radon cup is a cylindrical chamber with a radius of 3.5 cm and a height of 15 cm in combination with a CR-39 detector. The effected radium concentrations from sediment samples were found to range from 0.0013 to 0.0049 with an average value of 0.0028 Bq/Kg. Concentrations of radon measured by passive method were 132±34 to 414±108 with average value 287±45 Bq/m^3 and by active method were 401±26 to 145±9 with average value 263±20 Bq/m^3. The area and mass exhalation rates were found to be 0.1 to 0.31 with average value of 0.220 Bq/m^2/h and 0.002 to 0.006 with average value 0.004 Bq/kg/h respectively. The values are found to be safe for sediment use.

Keywords Radium; Area exhalation rate; Mass exhalation rate; CR-39 detectors; Can technique

Background

During the 2nd and 3rd Gulf war, Basrah as a part of Southern Iraq exposed to a radiation attacks due to the usage of DU weapon against military troops and vehicles. Radiological results were detected within Basrah Governorate (Saadon et al., 2016). Moreover, Soils and Sediments from Southern part of Iraq is characterized by the existence of natural occurring radioactive materials (NORM), mostly are ^{40}K, ^{212}Pb,^{214}Pb, ^{214}Bi, and ^{228}Ac (Bashar et al., 2015).

Radioactive pollutants were spread over all Basrah Land (Al-Imarah and Ali, 2009). The radioactive materials are transferee from land towards waterways from where they move towards oceans and seas and accumulated in the water column, then they undergoes sedimentation to the bottom of the waterways, once they reach bottom bed they became a part of the ecosystem, water, sediments, and biota (Akram, 2005).

Radium is a decay product of uranium within the naturally occurring uranium series. When radium decays in soil, the resulting atoms of radon isotopes first escape from the mineral to air-filled pores. The rate at which radon escapes from soil into the surrounding air is known as radon exhalation rate of the soil. This may be measured by either per unit area or per unit mass of the soil. The measurement of radon exhalation rate in soil and building materials is helpful to study radon health hazard (Al-Yani, 2008; Pressyanov, 2012). Among many factors affecting radon exhalation, one of the most important is radium content of the bedrock or soil (Singh and Singh, 2006). Being aware of the hazardous effects of radon exhalation on human health, it was necessary to conduct measurements of radium content in the soil. Higher values of Ra-226 in soil contribute significantly in the enhancement of environmental radon. However, radon exposure shows an extreme variation from location to location and depends primarily on the exhalation rate of radon from the soil. Since radium present in the soil is the main source of indoor radon, the estimation of radium content along with the radon exhalation rate in the soil was carried out.

Radon arises from trace concentrations of radium in the earth's crust. It exists in three isotopes ^{219}Rn, ^{220}Rn, and ^{222}Rn with different half-lives, 4 s, 56 s, and 3.8 days respectively, the largest and most important isotope is ^{222}Rn. It is formed in the decay of ^{226}Ra within the decay chain of ^{238}U, it is an α emitter, and due to its relative high solubility in water it makes radon existence in all types of water (Al-Shamsi, 2014). Typical activity concentrations of ^{222}Rare n 2-20 Bq/m^3 in outdoor air, 10-100 Bq/m^3 in indoor air, 1-10 Bq/m^3 in underground cavities, and 5-50 k Bq/m^3 in soil gas (USEPA, 2013).

Radon is decays to relatively short lived (less than 30 min) radionuclides ^{218}Po, 3-11 min, ^{214}Pb, 26.8 min, ^{214}B, 19.9 min, and ^{214}Po, 164 μs. They all likely to decay to the stable isotope ^{210}Pb with half-life 22.3 y (USEPA, 2013). Concentrations of indoor radon gas have been measured by using time independant passive radon dosimeter solid state nuclear track CR-39 technique detection (Al-Alawy and Fadhil, 2016). ^{222}Ra was estimated as an average value of 1386, 36 Bq/m^3 in soil samples from Al-Nasiriah Province /southern Iraq to the north of Basrah Governorate, by using the CR-39 technique (Kadhim, 2014).

Concentrations of radon gas in samples of soil from Ras Tanurah and Saudi Arabia were measured by can technique containing CR-39 and found as an average to be 120 Bq/m3 (Al-Shahri et al., 2017).

Recent studies conducted for determination of radon concentrations in the marine sediments from nearby sites, measurements were done for Khor Abdullah the extended water way of Khor Al-Zubair, and Jaber et al. (2015) adopted two techniques, the SSMTDs and RAD7 and reported values were in the range 78 to 606 Bq/m^3 and 97 to 301 Bq/m^3 respectively.

Scientists overall the world are still probing the earth's crust and continuing to measure the radiation levels and quantify the hazards and doses affecting people, animals, plants and all kinds of life (Darwish et al., 2015).

1 Aim of the Study

In the present study investigations have been carried out to measure the radiological parameters in sediment samples collected from water ways around Hajjam island by using can technique containing SSNTDs of type CR-39.

2 The Study Area

Khor Al-Zubair is one of the main outlet water ways from Iraq to the Arabian Gulf, it is an estuarine lagoon environment (Emery and Stevenson, 1957; Al-Ramadan, 1986) situated south west of Basrah (Figure 1), which is connected to Al-Hammar marsh through Shatt Al-Basrah canal. Hajjam Island is located in the lower part of Khor Al-Zubair as a unity island in the beach of Iraq with locations (N: 30°00'54". 3, E: 47°57'02". 1), as shown in Figure 2, Hajjam Island has a length of 3.5 km and a width of 0.45 km, water and sediments around the island are effected heavily by the discharge from Khor Al-Zubair which is covered with fine muddy sediments where sandy deposits is restricted to the narrow zone of the shallow part near the shore and around the island slopes (Afaj, 2004).

3 Materials and Methods

Sediment were collected by means of Van veen Grab sampler from 15 sites around the island (Figure 2). Samples dried overnight, grinded, and powdered. For the determination of Radon concentrations two methods were adopted, passive and active.

3.1 Passive method

Within the passive method, can Technique was adopted (Abu-Jarad, 1988). About150-250 gm of the sample is kept inside the can as shown in Figure 3.

Equation 1 was used for the estimation of radon concentration (Khan et al., 1992; Al-Zoubi et al., 2013; Mansour et al., 2014):

$$A_{Rn}=\frac{\rho}{KT} \quad (1)$$

Figure 1 Hajjam island located (Location of Hajjam Island and sampling sites)

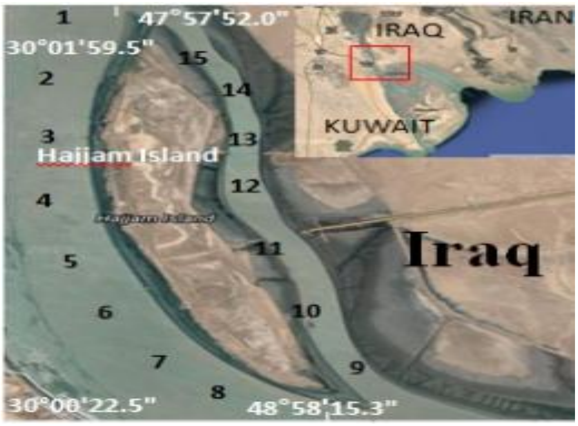

Figure 2 Hajjam Island and sampling sites

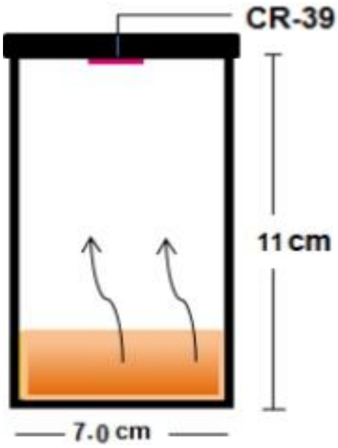

Figure 3 A schematic diagram of the dosimeter used in present work

Most of the emanation radon produced from marine sediment remains within the grain under water and many of fraction of radon escapes to the pore spaces and water, so it dissolves through the water which is depending on the grain size and location of its parent in grain (Duenas et al., 1997). The ^{226}Ra decays to ^{222}Rn by emitting an Alpha particle, the main mechanism of escape turns back energy of its atoms during the decay of ^{226}Ra and diffusion through grain or water as shown in Figure 4.The exhalation rate is defined as the rate at which radon escapes from soil into the surrounding air. This may be measured by either per unit area or per unit mass of sample.

The surface exhalation rate from the sample inside the dosimeter is calculated by equation 2 (Imma et al., 2014):

$$E_{ex} = \frac{A_{Rn} T V\lambda / S}{T + \lambda^{-1}(e^{-\lambda T})} \quad (2)$$

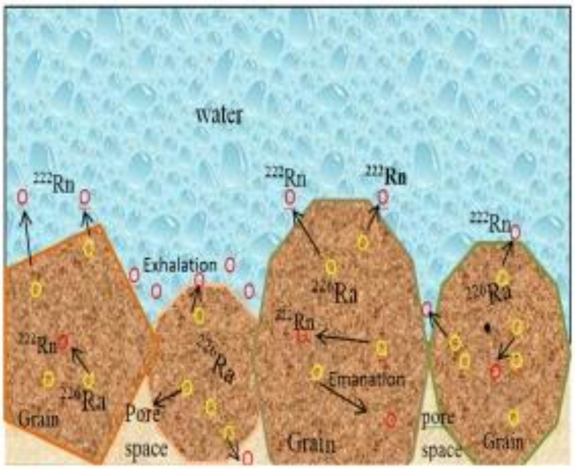

Figure 4 Exhalation, emanation of radon

The exhalation rate per unit mass is calculated by equation 3:

$$E_M = \frac{A_{Rn} T V\lambda /M}{T+\lambda^{-1}(e^{-\lambda T})} \quad (3)$$

While the effective radium content in the sample is calculated by equation 4 (Sharma et al., 2003):

$$A_{Ra} = \frac{\rho V}{K M Teff} \quad (4)$$

3.2 Active method

RAD7, Durridge Company USA analyzer as shown in Figure 5 was used which has a measurement chamber containing an electrostatic field overnight. When radon atoms enter the RAD7 from sample and decay, polonium-218 (^{218}Po) atoms are deposited onto the surface of the RAD7's Canberra Passivity Ion-implanted Planar Silicon Alpha Detector. Alpha particles from subsequent steps along the decay chain are counted and their energy recorded to memory. The spectrum of the RAD7 can allow for energies from 0-10 MeV. Specific interest is shown in the 5-9 MeV region, since most of the radon and thoron decay produce alpha particles in that range. The first window has the energy range 5.00 MeV, hence, alpha particle with energy 5.23 MeV from the ^{210}Po decay will fall in this region. Window A covers the energy range of 5.40-6.40 MeV, so clearly the alpha particle with energy 6.00 MeV from the ^{218}Po decay will fall in this region. All the counts detected in the region divided by the lifetime (duration of the time that it took to collect the data), give the count rate.

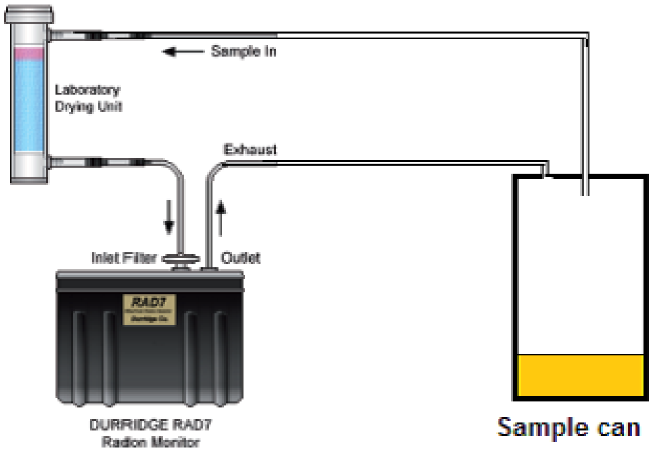

Figure 5 Schematic diagram of RAD7 instrument online with sample can

4 Results and Discussion

During this study results were obtained through short term measurements using the RAD7 accessories and long term measurement using the SSNTDs. Hence, the values of radon, radium concentrations and radon exhalation rates per unit area and mass were determined in 15 sediment samples collected from different locations around of

Hajjam island. Results are listed in Table 1.

Table 1 Radon contrition measure in active, passive methods, radon flux and effective radium values

Site No.	Passive Bq/m^3	C_{Rn} ctive Bq/m^3	EA Bq/m2.h	E_M Bq/kg. h	Eff. Ra Bq/kg
1	354±90	321±15	0.26	0.004	0.00347
2	296±76	200±13	0.22	0.005	0.00272
3	241±62	201±12	0.17	0.004	0.00190
4	180±46	202±13	0.14	0.003	0.00140
5	301±77	255±15	0.22	0.005	0.00186
6	203±55	161±8	0.16	0.003	0.00216
7	412±117	401±26	0.31	0.005	0.00457
8	361±95	370±21	0.26	0.004	0.00447
9	414±108	320±20	0.31	0.005	0.00490
10	361±90	304±19	0.26	0.006	0.00304
11	231±64	261±17	0.18	0.003	0.00233
12	264±67	224±16	0.20	0.004	0.00256
13	257±69	242±12	0.20	0.003	0.00262
14	132±34	145±9	0.10	0.002	0.00131
15	346±90	321±20	0.25	0.005	0.00361
Max	414±108	401±26	0.31	0.006	0.0049
Min	132±34	145±9	0.1	0.002	0.0013
Avr.	287±45	263±20	0.22	0.004	0.0028

In the present work, the results show that radon concentrations calculated by passive method varies from 132±34 Bq/m^3 to 414±108 Bq/m^3 with arithmetic mean value 287±45 Bq/m^3. The offshore sample 9 reported the highest value due to geological nature, while in the active method radon concentrations varies from 145±9 Bq/m^3 to 401±26 Bq/m^3 with average 263±20 Bq/m^3. The difference between the values estimated by the two methods could be due to the different measurements time. The positively correlation between passive and active method R^2=0.7947 which explain in Figure 6.

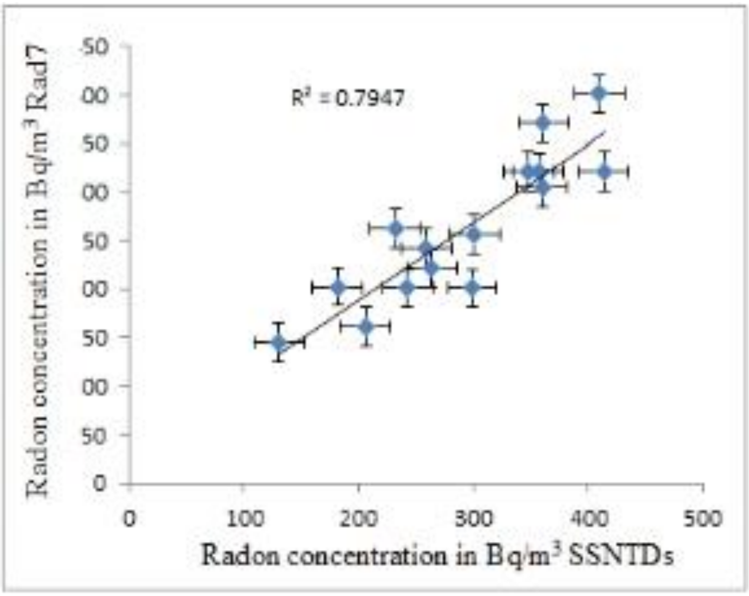

Figure 6 Radon correlation between passive method and active method

The E_A in B/m^2/h is range from 0.1 to 0.31, with mean value of 0.22, while E_M in unit of mBq/kg/h ranged from 0.002 to 0.006, with arithmetic mean value of 0.004.

Sediments samples has an effective radium varies from 0.0013 Bq/kg to 0.0049 Bq/kg with an average value of 0.0028 Bq/kg. The radium distribution of the soil is one important parameter governing radon emanation. Radon emanation from mineral grain or matter depends on where the atoms are situated in the grain, the texture and the size of grain, the permeability of the grains and the temperature and pressure. The emanation of radon from the measured soil samples indicates an important point in which the radon emanation from samples should be taken into consideration when measuring radium or uranium content with gamma spectroscopy, by using gamma lines emitted from radon daughters. Figure 7 explains the relation between effective radium in Bq/kg and radon concentration in Bq/m^3.

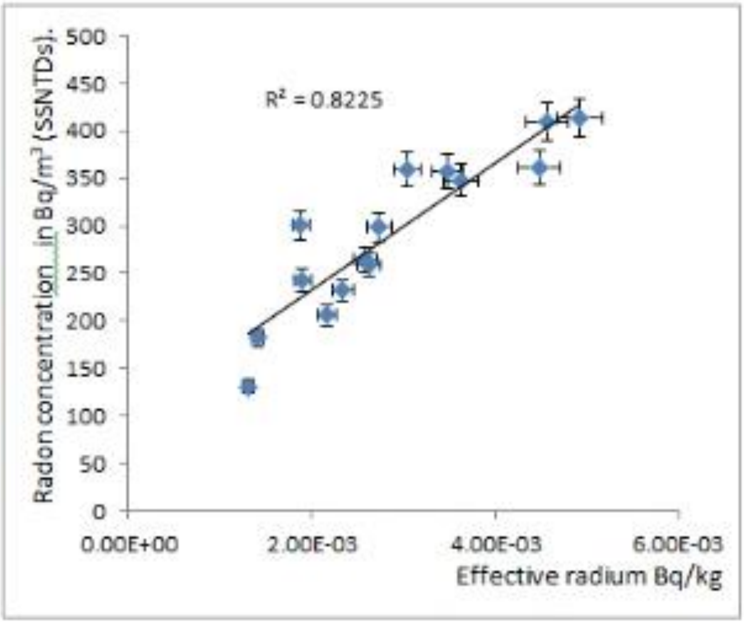

Figure 7 Relation between radon concentration by SSNTDs and effected radium

For comparison the levels of radon concentrations recorded for sediments within this study were lower or comparable to values recorded for soil/sediments over all the world as well as to standard levels as shown in Table 2.

Table 2 Comparison between levels of radon concentrations in soil/sediments estimated world wide as well as nearby areas with our findings

No.	Location	^{222}Rn in Bq/m^3	Reference
1	Pakistan	376	Munza et al.,(2008)[a]
2	Turkey	3.4 - 138	Muslim et al., (2011)[a]
3	Southern Lebanon	1774.291	Kobaissi et al., (2008)[a]
4	Baghdad	7.11	Saeed (1998)[a]
5	Central and Northern Iraq	33-100	Al-Ani (2000)[a]
6	Southern Iraq, Karmat Bani Said	1146.227	Mahsur (2009)[a]
7	Kut Eastern Iraq	583.594	Jabar (2001)[a]
8	Nasiriayh	1386.236	Kadhim (2014)
9	Ras Tanurah/Saudi Arabia	120	Al-Shari et al., (2017)
10	Khor Abdullah/Iraq	606	Jaber et al., (2015).
11	Marine sediments Iraq	288	This study
12	Standard	800	WHO[a]

5 Conclusion

The specific activity of radon in the study area (Hajjam island) is acceptable, and there are a positive correlation has been observed between effective radium contents and radon, as well as positive correlation between the passive and active which are acceptable.

Authors' contributions

FJM is the team leader analysis of results and paper writing. MQJ is responsible for field investigations, processing, seating the experimental dosimeter and conducting the radiological measurements. AJB is responsible for sample collection.

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References

Abu-Jarad F., 1988, Application of nuclear track etch detector for radon related measurements. Nucl. Trac. Rad. Meas., 15: 525-534 https://doi.org/10.1016/1359-0189(88)90195-1

Afaj A.H., 2004, Some sedimentilogical aspects of Khor Al-Zubair, Northern Arabian Gulf. J. Geological Soc, Iraq. 32: 55-67

Akram M., Qureshi R.M., Ahmad N., and Solaija T.J., Gamma-emitting radionuclides in the shallow marine sediments off the Sindh coast, Arabian Sea. Radiat. Protect. Dosim. 118(4), 440–447

Al-Alawy I.T., and Fadhil H.R., 2016, Measurements of radon concentrations and dose assessments in chemistry department/Science College/Al-Mustansiriyah University, Baghdad- Iraq. Int. J. Sci. Res. Sci. Tech., 2(4): 72-82

Al- Ani D.F., 2000, Measuring the radioactivity of radon emitted from some components of building materials, M.Sc Thesis, University of Baghdad

Al-Battat M.Q.J., 2016, Determination of NORM in the Iraqi marine environment, Ph. D. Tdesis, College of Education for Pure Science, Basrah University, pp126

Al-Imarah F.J.M., and Ali, M.A., 2009, Evaluation of some radioactive elements in the ecosystem of Tigris, Euphrates, Shatt Al-Arab rivers, Main Outlet Drainage and southern Iraqi marshes. Proceedings of 3rd Scientific Conference for Rehabilitation of Marshland. Marine Science Centre, Basrah, 13-15 April 2009, pp83-90

Al-Khafajy B.Y., Al-Imarah F.J.M., and Mohamed A.R.M., 1997, Trace Metals in Water, Sediments and Green Back Mullet (Liza subviridus) from Shatt Al-Arab Estuary. Marine Mesopotamica, 12(1): 7-23

Alshahri F., El-Taher A., and Elzain Ae.A., 2017, Characterization of Radon Concentration and Annual Effective Dose of Soil Surrounding a Refinery Area, Ras Tanura, Saudi Arabia J. Environ. Sci. Technol., 10(6): 311-319 https://doi.org/10.3923/jest.2017.311.319

Al-Shamsi D.M., 2014, Natural radioactivity in ground water recks and sediments from some areas in the UAE: Distribution, sources, and environmental impact. Ph. D. Thesis, United Arab Emirates University, pp146

Al-Yami S.H.M.A., 2008, Measurement of radon concentration in houses in Najran Region (Saudi Arabia). M.Sc. Thesis, King Saud Universiy

Alzoubif Y., Al-Azzam K.M., Alqadi M.K., Al-Khateeb M.M., Ababneh Z.Q., and Ababneh A.M., 2013, Radon concentration level in the historical city of Jarash, Jordon. Rad. Meas., 49: 35-38 https://doi.org/10.1016/j.radmeas.2012.12.005

Bashar A.J., Al-Muhyi A.A., Al-Tememi M.K., and Al-Alwan N.K.K., 2015, Determination of specific activity for the natural radioactive isotopes (^{40}K, ^{212}Pb, ^{214}Pb, ^{214}Bi, and ^{228}Ac) in soils and sediments for selected areas of the marshes Southern Iraq, Basrah Province and the Northern Arabian Gulf. Marsh Bull., 10(2): 102-111

Darwish D.A.E., Abul-Nasr K.T.M, and El-Khayatt A.M., 2015, The assessment of natural radioactivity and its associated radiological hazards and dose parameters in granite samples from South Sinai, Egypt. J. Rad. Res. Appl. Sci., 8: 17-25 https://doi.org/10.1016/j.jrras.2014.10.003

Duenas C., Fernandez M.C., Carretero J., Liger E., and Perez M., 1997, Release of ^{222}Rn from some soils. Geoph., 15: 124-133 https://doi.org/10.1007/s00585-997-0124-0

Emery K.O., and Stevenson R.E., 1957, Estuaries and Lagoons in Treatis on Marine Ecology and Paleocology, (Hedgpeth, J.W., ed). The Geol. Soc. America, New York, Memoir., 67: 673-750

Imme G., Catalano R., Mangano G., and Morelli D., 2014, Radon Exhalation measurement for environmental and geophysics study. Rad. Phys. and Chem., 95: 349-351 https://doi.org/10.1016/j.radphyschem.2013.02.033

Jabar Sh.J., 2011, Find Concentrations of Uranium and Radon, and some heavy metals in the soil of the city of Kut. M.Sc, Wh6 2011

Jaber M.Q., Subber Ar.H., and Al-Hashimi N.H.N., 2015, Radon Concentrations in the Marine Sediments of Khor-Abdulla Northern West of the Arabian Gulf. International Journal of Physics, 2015, Vol. 3(6): 239-243

Kadhim I.A., 2014, The use of the nuclear detector effect (CR-39) in determining the concentration of radon in samples of the Nasiriya City soil, South of Iraq. International Journal of Research in Applied, Natural and Social Sciences, 2(11): 103-110

Khan A.J., Prasad R., and Tyagi R.K., 1992, Measurement of radon exhalation rate from some building materials. Nucl. Trac. Rad. Meas., 20(4): 609-610 https://doi.org/10.1016/1359-0189(92)90013-L

Kobeissi M., Samad O., Zahraman K., Milky S., and Abumurad K.M., 2008, Natural radioactivity measurement in building materials in Southern Lebanon. J. Envir. Rad., 99(8): Cited in Kadhim I.A., 2014. https://doi.org/10.1016/j.jenvrad.2008.03.007

Mahsur H.B., 2009, Determine effectiveness of Radon Concentration and Anavach Water and Sediments in the Marshes of Iraq using Solid Reagents for the effects of a nuclear device and Alemmanumitr, M.Sc., Basrah University.

Mansour H.L., Tawfiq N.F., and Karim M.S., 2014, Measurements of radon-222 concentration in dwelling of Baghdad governorate. Ind. J. Appl. Res., 4(2): 1-4

Munazza Faheem and Matiullh, 2008, Radon exhalation and its dependence on moisture content from samples of soil and building materials", Rad. Meas., 43(8):1458-1462.

Muslim M., Harmansah C., Camgos B., and Sozbilir H., 2011, Radon Monitoring as the Earthquake Precursor in Fault Line in Western Turkey, 20 (79):Cited in Kadhim I.A., 2014.

Pressyanov D.S., 2012, Radiological problems related to radon and new methods for their investigation. PhD. Thesis, Sofia University

SaadonW.T., Subber Ar.H., and Hussain A. Hussain, 2016, Assessment of natural radioactivity of soil samples in selected locations of Basrah Governorate. Int. J. Phys. 4(2): 32-36

Saeed B.M., 1998, Define Concentrations of Radon in Blinding Using Nuclear Detector effect (CR-39). M.Sc., Baghdad University

Sharma D.K., Kumar A., Kumar M., and Singh S., 2003, Study of uranium, radium and radon exhalation rate in soil samples from some areas of Kangra district. Rad. Meas., 36: 363-366
https://doi.org/10.1016/S1350-4487(03)00152-5

Singh R.M.S., and Singh K., 2006, A study of uranium, radium, radon exhalation rate and indoor radon in the environs of some areas of the Malwa Region, Punjab. Indoor and Built Environment, 15: 499
https://doi.org/10.1177/1420326X06069053

Subber Abdul R.H., Al-Hashimi N.H.N., Nader A.F., Jebur J.H., and Khodier M.K., 2015, Construct as a simple Radon Chamber for Measurement of Radon Detectors Calibration Factors. Pelagia research library, Adv. Appl. Sci. Res., 6(2): 128-131

U.S. Environmental Protection Agency 2013, A Citizen's quide to Radon. retrieved from http://www.epa.gov/radon/citquide.html

WHO, 1993, World Health Organization. Guidelines of Drinking–Water Quality. 2^{nd} Ed, Geneva