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The concentrations of radon in the marine sediments of Ra's Al-Besha, Northern west of the Arabian Gulf

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Abstract - Pollution is the common problem in the biosphere and the pollution in the marine habitat was noticed more in the present scenario. There are two ways for the pollution marine habitats. They are Naturally Occurring Radioactive Material (NORM) and Artificially Radionuclides (TENORM). Methods used to estimate the concentration of radionuclides are passive (can technique) which use CR-39 and active with different ways. The passive and active methods are different in the exposure time for detectors. The study area Ra's Al-Beshais lie in the northern west of the Arabian Gulf. The obtained average value of radon concentration with arithmetic mean value of 400.7±198 Bq m^{-3} by the passive method. The mass exhalation rate in sediment samples under study with average value 0.1617 $Bq.kg^{-1}.h^{-1}$. This value was acceptable worldwide and safe to use.

Key words: Marine sediment, CR-39, Can technique, Radon concentration and Radium content.

Introduction

Ra's Al-Beshais is an important region and it lies at northern Arabian Gulf. It represents the entry path way for Iraq through Shatt Al-Arab river. Most of the radioactivity deposited on the surface sediment was washed by rain and drained through rivers to ocean. Part of the ground deposited activity was absorbed in the soils and percolates with the underground waters to the ocean. Radionuclides reaching the ocean become part of the marine ecosystem (water, sediments and biota) and many transfer through seawater, sediment and biota interface to human beings (Akram *et al.*, 2006).

Radon is noble gas with a lifetime, which is relatively longer than the breathing time, most of it is inhaled and exhaled without decay (Matiullah A., 2000). The melting point for Radon gas is (-71°C), boiling point is (-61.8°C), critical temperature is (104°C),it is soluble in cold water the solubility is about 0.5 at 0°C and it decreases to ~ 0.1 at 100°C (Lawrence Stein, 1983).

Radon decays into its daughters giving a tiny radioactive particles. When inhaled, these radioactive particles can damage the cells that line the lung. Long-term exposure to radon can lead to lung cancer, the only cancer is proven to be associated with inhaling radon (Yamada *et al.*, 2003).

The daughters are solid particles and when they are inhaled they release radiation (alpha and beta) into the lungs, which can potentially cause cancerous cell growth (in the lungs) (Al-Mosuwi, 2006). The measurement of radon flux from soil surface is a useful tool for the assessment of radon prone areas and monitoring of radon released from uranium mining (Onishchenko *et al.*, 2015), so it is necessary to study the transfer through porous soils (Catalano *et al.*, 2015).

The aim of the present study was to measure the effective dose due to radon exhalation. It is reasonable to use the higher values measured by the passive method to calculate the hazard indices of radon exhalation.

Material and Methods

Study Area:

Ra's Al-Besha region lies in the south of Fao city southern east of Basrah city about 100 km distance as shown in Figure (1). The deep water was between (0.5-2.0 m) in the area. Salinity value ranged between 32 part per thousand (ppt.) to 35 ppt. The tidal system represented by northern part of the Gulf, which was known as semidiurnal.

Area represented the high sedimentation rate to another region as a result of Caron, Tigris and Euphrates rivers. In both sides direction of region in Khor Abdullah and navigational channel of Shatt Al-Arab, it have high speed surface current, the maximum value of the surface current (0.91-1.5 m/s) (Al-Taei, 2010).

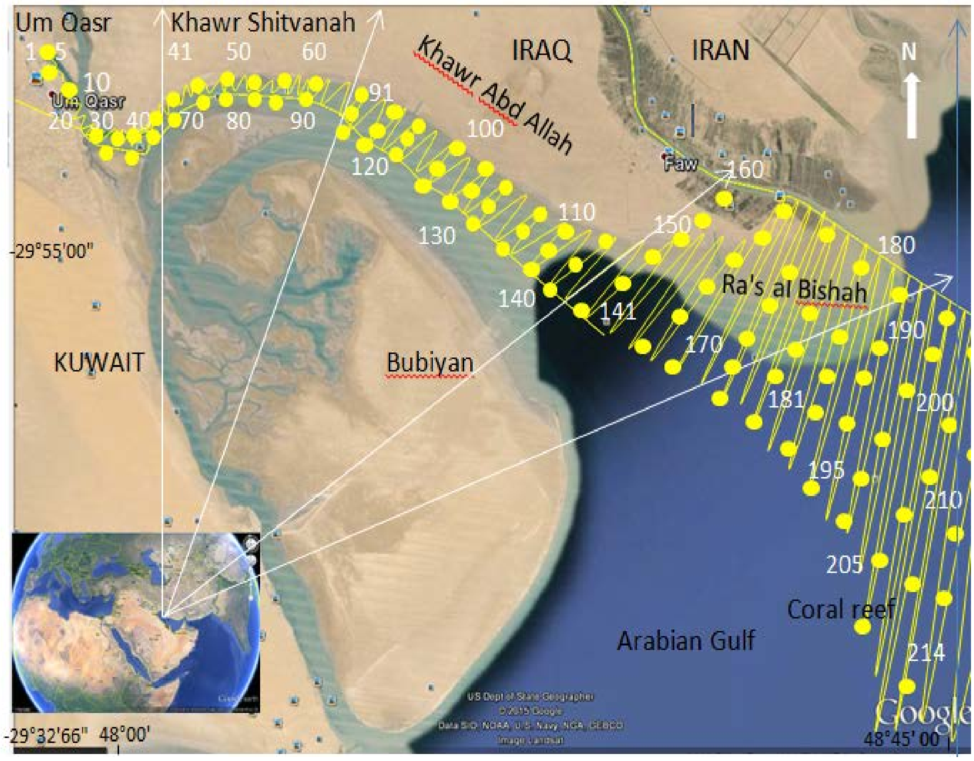

Figure 1. The area of study taken from Google earth.

The forty sediment samples investigated within this study were collected from this region. The samples were collected using Grab sample equipment. Then separated from the contamination materials and air-dried at room temperature for a week, then dried to 110 °C, milled and sieved through 0.2 mm sieve. The dried samples were put inside cylindrical can. The cans were sealed, gas-tight and stored for four weeks for secular equilibrium (Jebur, 2015).

Method of Measurements:

(a) Active Method:

The samples were put inside cans (7 cm x 15 cm) to produce 5 cm thickness. The schematic diagram of RAD7 connected online with the cylindrical can was shown in Figure (2). The alpha RAD7 detector was operated in grab mode for 1 to 2 days protocol, with cycle 1 hour and recycle 48 for 1 day protocol.

Ambient air was sucked in by a pump at rate of 1*l*/m and passes through a desiccant filter prior to interring the solid-state detector, which measures radon concentration. The solid-state silicon detector converts alpha radiation directly to an electrical signal discriminating the electrical pulses generated by α-particles from the polonium isotopes (^{218}Po, ^{216}Po, ^{214}Po, ^{212}Po) with energies of 6.0, 6.7, 7.7 and 8.8 MeV, respectively. Inlet filter at the top of RAD7 remove the progenies of ^{220}Rn and ^{222}Rn, so that only the concentration of the gas is measured.

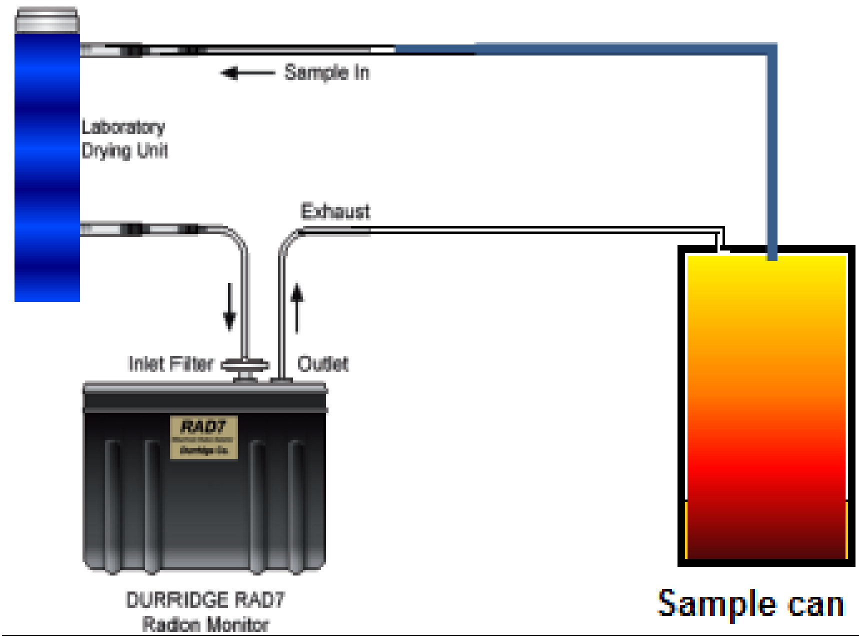

Figure 2. Schematic diagram of RAD7 instrument online with sample can.

(b) Passive Method:

Method illustrated earlier to measure the radon concentrations in the samples, laboratory "Can Technique" was used (Abu-Jarad, 1988; Khan *et al.*, 1992). The dried samples were grinded and sieved to produce a homogenous fine powder. About 150 g of the sample was placed at the bottom of a cylindrical emanation chamber (7.0 cm x 15 cm), shown in Figure (3).

The dosimeters were stored (closed) for four weeks to reach secular equilibrium between radium and radon. After this period, CR-39 plastic detector (1.5 cm x 1.5 cm), which was previously fixed by adhesive tape to the inside surface of a second identical cover was mounted quickly and closed the chamber.

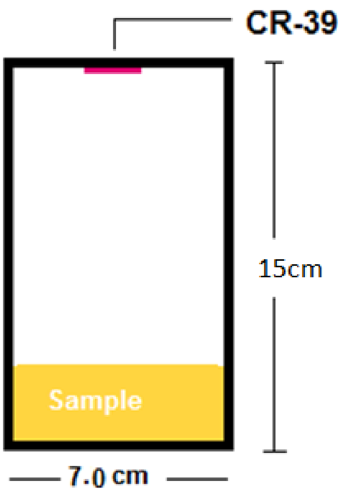

Figure 3. A schematic diagram of can used.

The detector expose to radon-222 for period of 105 days. After exposure time, all detectors were chemically etched using a solution of 6.25 N NaOH at 70 °C for 7 hrs. The tracks emerge on the surface of the detector were counted using microscope 400 x (Jeabur, 2015).

Radon gas concentration is given by Alzoubif *et al.* (2013) and Mansour *et al.* (2014).

$$A_{Rn} = \frac{\rho}{TK} \qquad (1)$$

Where ρ is track density in Tr/cm^2, T exposure time in day and K the calibration factor in Tr/cm^2.day/Bq.m^{-3}. The value of K depends on the radius of the measuring can. In the present measurement the value of K = 0.3420±0.0459 Tr cm^{-2} d^{-1} per Bq m^{-3} have been adopted (Subber *et al.*, 2015).

At the equilibrium state, the surface exhalation rate from the sample inside the can was given by Imme *et al.* (2014).

$$E_A = \frac{A_{Rn} TV\lambda / S}{T + \lambda^{-1}(e^{-\lambda T} - 1)} \qquad (2)$$

Where E_A is area exhalation rate in unit Bq m^{-2}.h^{-1}, A is radon concentration measured by CR39 detector in unit Bq m^{-3}, λ is radon decay constant, T is the exposure time, V the volume of the air space in the can and S is the surface area of the sample.

The mass radon exhalation rate is calculated from the relation:

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

Where E_M expressed in Bq kg^{-1}h^{-1} and M is the mass of the sample.

The effective radium content in the sample could be calculated from Sharma *et al.* (2003).

$$A_{Ra} = \frac{\rho V}{KMT_{eff}} \qquad (4)$$

Where $T_{eff} = T - \lambda^{-1}(1 - e^{-\lambda T})$

Results and Discussion

The area of study has high accumulation sediment with less depth approximately 0.5-2.0 m for another regions.

The correlation between two methods passive and active method were positive, according to Figure (4) for radon concentrations in sediments sample were measured with correlation factor R^2 = 91 %.

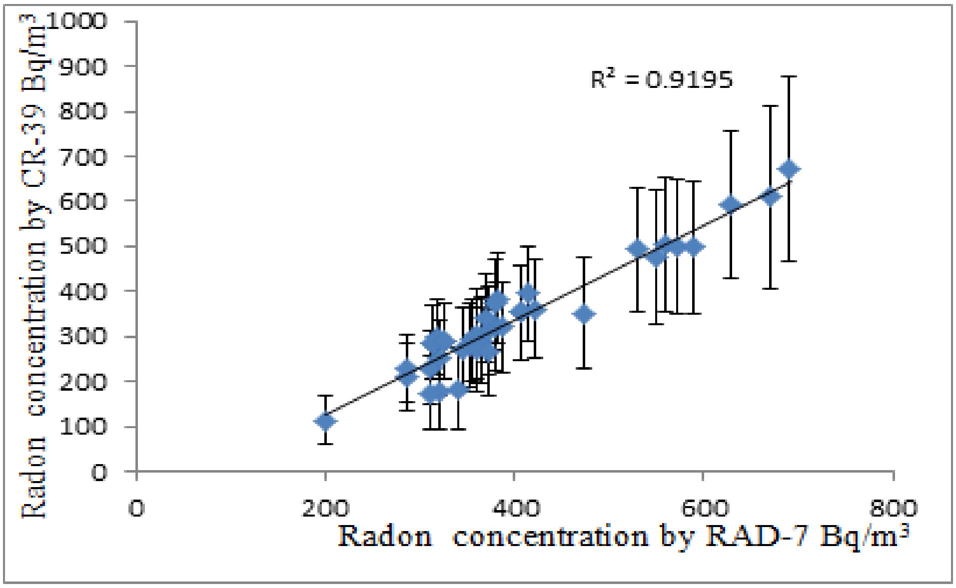

Figure 4. Compression between active and passive method.

The results of radon concentrations obtained in these measurements are shown in Table (1).

The results showed that the radon concentrations were varied from 201.37±52 Bq m^{-3} for sample number 21 to 690±205 Bqm^{-3} for sample number 11, with arithmetic mean value 400.7±198 Bq m^{-3} in the passive method. While in the active method radon concentrations varies from 113.2±11Bq m^{-3} to 671.3±36 Bq m^{-3}with average value 337.26±22 Bq m^{-3} for the number same sample. The values in many samples approximately closed in each methods although the short time for the active method measurements of the RAD7.

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

St. No.	Radon Conc. Bq/m^3 using (SSNTD)	Radon Conc. Bq/m^3 using RAD7	E_A in mBq/kg.h	E_m in mBq/kg.h	Effective Ra (Bq/kg)
1	365.09±95	291.0±18	6.62	0.15	0.87
2	320.88±83	252.4±14	5.82	0.12	0.70
3	354.72±92	292.3±18	6.43	0.13	0.76
4	311.06±81	230.0±15	5.64	0.12	0.66
5	360.17±93	291.1±17	6.53	0.14	0.80
6	371.63±96	312.0±20	6.74	0.15	0.87
7	380.37±99	321.2±21	6.89	0.14	0.78
8	407.65±106	352.34±23	7.39	0.14	0.82
9	313.24±81	286.31±17	5.68	0.13	0.74
10	325.25±84	288.715±16	5.90	0.12	0.71
11	690.0±205	671.3±36	12.51	0.30	1.93
12	285.96±74	210.0±14	5.18	0.12	0.68
13	560.0±148	503.8±33	10.1	0.22	1.24
14	353.08±92	284.0±16	6.40	0.13	0.76
15	318.7±83	294.3±17	5.78	0.12	0.68
16	415.0±106	392.95±24	7.52	0.16	0.91
17	573.01±149	498.0±33	10.39	0.24	1.34
18	629.21±163	593.4±38	11.41	0.23	1.29
29	387.46±101	324.0±22	7.02	0.14	0.77
20	382.55±99	380.15±24	6.93	0.16	0.91
21	201.37±52	113.2±11	3.65	0.08	0.44
22	368.91±96	341.33±21	6.69	0.16	0.90
23	421.3±110	360.2±22	7.64	0.18	1.00
24	379.82±95	373.3±25	6.88	0.15	0.83
25	530.44±139	496.1±27	9.62	0.20	1.14
26	550.0±149	475.0±26	9.97	0.21	1.22
27	473.68±124	351.2±23	8.59	0.19	1.05
28	345.0±93	272.0±19	6.25	0.14	0.85
29	320.88±85	176.87±11	5.82	0.11	0.65
30	340.0±94	185.67±12	6.16	0.12	0.71
31	313.06±80	176.66±11.7	5.64	0.13	0.74
32	360.17±92	270.0±18	6.53	0.14	0.79
33	371.63±93	264.7±17	6.74	0.16	0.91
34	360.0±99	304.92±20.2	6.53	0.15	0.91
35	405.65±109	351.34±23	7.39	0.16	0.89
36	318.24±84	287.31±19	5.68	0.12	0.67
37	320.25±84	286.71±19	5.90	0.12	0.69
38	670.0±206	609.0±41	12.15	0.27	1.76
39	283.96±72	226.89±16	5.18	0.12	0.66
40	592.0±171	493.0±32	10.70	0.21	1.16

Radon flux per unit area in unit Bq.m^{-2}h^{-1} was ranged from 12.516 Bq.m^{-2}. h^{-1} to 3.6528 Bq.m^{-2}. h^{-1}, with mean value 7.2701 Bq.m^{-2}. h^{-1}. The mass exhalation rate in sediment samples under study ranged from 0.3065 Bq.kg^{-1}.h^{-1} to0.0804 Bq.kg^{-1}.h^{-1} with average value 0.1617 Bq.kg^{-1}.h^{-1}. The effective radium responsible for radon emanation in the air varies from1.9384 Bq.kg^{-1} to 0.444 Bq.kg^{-1} with average value of 0.909 Bq.kg^{-1}. The correlation between radon concentration measured by passive method with the effected radium was shown in Figure (5) which has positive R^2 = 90 %.

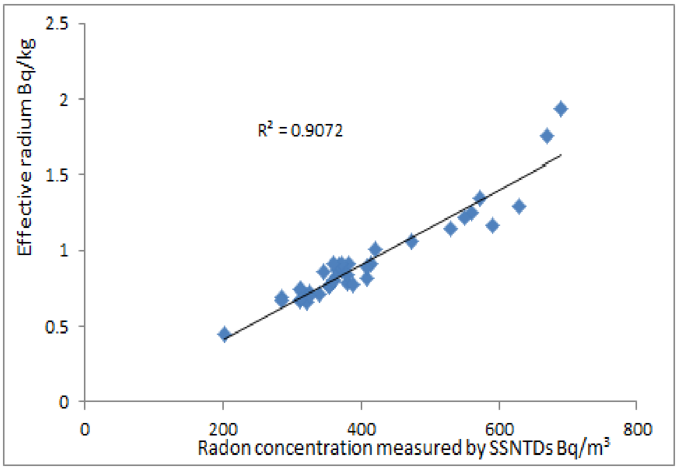

Figure 5. Correlation between radon concentration and effective radium.

Conclusion

The obtained values of radon concentration, radon flux and effective radium contents of the sediments collected from different locations in Ras Al-Bisha indicate the safe use as a building materials, etc and deal with. The can technique was reliable to estimate the effective radium content in solid samples. These finding and follow up research are expected to contribute to the radiological mapping of the Arabian Gulf.

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تركيز الرادون في الرواسب البحرية لمنطقة رأس البيشة شمال غرب الخليج العربي

مناف قاسم جابر[1] و نوري حسين نور الهاشمي[2] و عبد الرضا حسين صبر[2]

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المستخلص - هناك طريقتان لتلوث البيئة البحرية بالإشعاع، الأولى بواسطة الأنوية المشعة طبيعيا والثانية بواسطة الأنوية المشعة صناعيا. لقد أستخدمت طريقتان في قياس مستوى تركيز غاز الرادون المشع طبيعيا هما طرية طويلة الأمد باستخدام تقنية الأسطوانة المغلقة مع كاشف الأثر النووي من نوع CR-39 والطريقة الثانية الطريقة الفعالة القصيرة الأمد. إن الإختلاف بين الطريقتين هو في زمن تعرض الكاشف النووي إلى الأنويه المشعة. منطقة الدراسة في رأس البيشة تقع شمال الخليج العربي ولقد تم الحصول على معدل تركيز غاز الرادون بطريقة بعيدة الأمد 400.7 ± 198 Bq m^{-3} في حين كان معدل الانبثاق غاز الرادون 0.1617 Bq.kg^{-1}.h^{-1} وهذه القيمة مقبولة عالميا.