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Radon Concentrations in the Marine Sediments of Khor-Abdulla Northern West of the Arabian Gulf

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Abstract Radon-222, a naturally occurring radioisotope with a half-life 3.8 days was used to estimate the amount of radium and uranium in the marine and coastal sediments of Khor-Abdullaha bay, part of Arabian Gulf. The method used to estimate radon concentration in sediments was the SSNTDs techniques using closed can technique and RAD7 electronic instrument. The obtained average value of radon flux was 304.3 ± 79.4 Bq m^{-3}. The maximum and minimum values were; 606.8± 157.3 Bq m^{-3} and 78.6±21.3 Bq m^{-3} respectively. These values are much lower than the reported worldwide limit which indicates the safe use of these sediments as building materials and other uses. The closed can technique is suitable to estimate the radium content in solid samples.

Keywords: *marine sediment, CR-39, can technique, radon concentration, radium content*

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1. Introduction

Northwestern Arabian Gulf is an important passage for oil industry in Iraq. The analysis of radon gas in marine sediments offers important information: a) the distribution of ^{226}Ra and ^{238}U,b) radon gas exhalation across the air-sea interface, c) the exchange rate of radon between the deep water and sediments.

Uranium is a heavy element presents $1.6x10^{-4}$ of the earth's crust and it is found mostly as urinate. The combination of uranium with oxygen makes it less dense than the magma and it tends to rise to the surface. Uranium deposits are therefore often found on the outer rock surfaces and along cracks in the rock material.

Radon gas formed from the decay process of uranium, with several intermediate progenies. Radium is one of uranium daughters it decays to form ^{222}Rn(from ^{226}Ra) and ^{220}Rn (from ^{228}Ra). Radium is a solid radioactive, alpha emitter, element under ordinary conditions of temperature and pressure with half-life equal to 1620y. Since radium presented in relatively low levels in natural environment, everyone has some level of exposure to its radiation. Radium is particularly hazardous due to the continuality of radon production. Immigration of radon gas out of the rocks and soil is influenced by the amount and location of the uranium underground, and passageways for radon movement to the surface to combine with deep water.The amount of radon dissolved in ground water depends on the permeability of the rocks and soil. Sandy stones soil is more permeable than silt, clay soil, granites or shell.

Radon-222 is naturally radioactive gas used to estimate the radioactive hazard due to water, soil and sediment [1]. It is also used to estimate the amount of discharge ground water to the surface water [2]. Radon-222 produced primarily in sediment by the decay of Ra-226. A fraction of the radon which is produced in sediments will escape to the overlying water column, leaving a deficiency of radon in sediments, so that the activity ratio of radon to radium in less than one. Once radon is in water column, it is mixed vertically and will either decay there or escape to the atmosphere [3].

In the present investigations, radon concentration, radon flux and radium concentration have been estimated for sediments samples collected from different location at the Khor-Abdullah bay.

2. Experimental Methods

2.1. Area of Study

Khor Abdullah and Khor Al-Zubair are tidal flats represent an interesting area to investigate the nature of sedimentlogical aspect of northwestern coast of the Arabian Gulf. The daily variation in the salinity and sediment participation come from the Shutt Al-Basrah canal in the northwest of the study area as shown in Figure 1. Khor-Abdullah bayis a semi-closed funnel shape, the lower part has a width 17 km while, and the upper width is 6.5 km. The Iraqi coast has a mild decline relative to high decline at Kuwaiti coast. The average depth is 10m in the area. The longitudinal hub (bevel) of the channel is 40km in the direction of the Arabian Gulf with a width between (6-17)km [4,5]. Salinity value between 32‰ to 38‰ is regarded as a saline lagoon. The tidal system is the same as in the northern part of the Gulf, which is named as semidiurnal; the tidal range value is (2-3)m at spring tide. The maximum value of the surface current, in the downstream, is greater than it is like in the root, in both phases (spring & neap tide). The reversible situation is in the upstream and the value was 1.5m/s in the root. Geological properties of some tidal flat sediment of Khor-Abdullah coast the studied sediment are classified as silty clay sediments with high percentage of clay (~75%), and also with a high natural moisture contents.

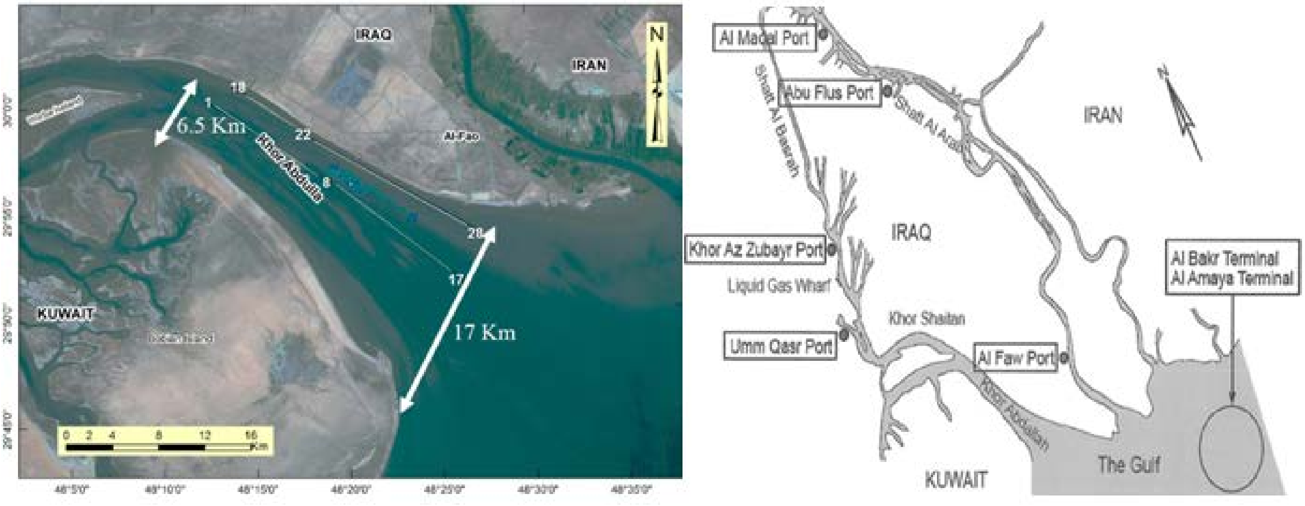

Figure 1. The area of study

Twenty eight sediment samples used for this study were collected from the Iraqi part of the bay. The samples were collected using Sample Grab equipment, shown in Figure 2. The sediments samples were separated from the contamination materials and air-dried at room temperature for a week, then dried to 100°C, milled and sieved through 0.2 mm. The dried samples were put inside cylindrical can. The cans were sealed, gas-tight and stored for four week for secular equilibrium.

Figure 2. The sample grabs equipment

2.2. Radon Measurements

(i) Active method

RAD7 (DURRIDGECompany USA)analyzer is an active, high performance, continuous radon- measuring technique was used to measure radon exposure from the sediment samples. The RAD7 radon monitor apparatus uses an air pump and solid state alpha detector which consist of a semiconductor material. The samples wereputinsidecan (7cmx15cm) to produce 4cm depth and the can sealed with silicon. The chamber made of polyvinyl chloride (PVC) and radon accumulation inside 7 cmx 11 cm chamber. The schematic diagram of RAD7 connected online with the cylindrical can is shown in Figure 3.The can connected to the RAD7 through the laboratory drying unit using plastic tubes to produce a closed loop configuration. The chamber and the system purged for 20min to reduce the humidity to less than 10%. The instrument draws air from the accumulation chamber, through the desiccant and an inlet filter in a rate 1*l*/m, into the measured chamber. The air is then returned to the enclosure from the RAD7 outlet. A high voltage of 2500 V is applied to the measuring chamber wall. The alpha RAD7 detector was operated in grab mode for1 to2days protocols, with cycle 1h and recycle 48 for 1 day protocol.

The solid-state silicon detector inside RAD7 detection unit 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.The experiments were performed under dry condition (relative humidity ~6%) and room temperature from 21°C to 28°C.

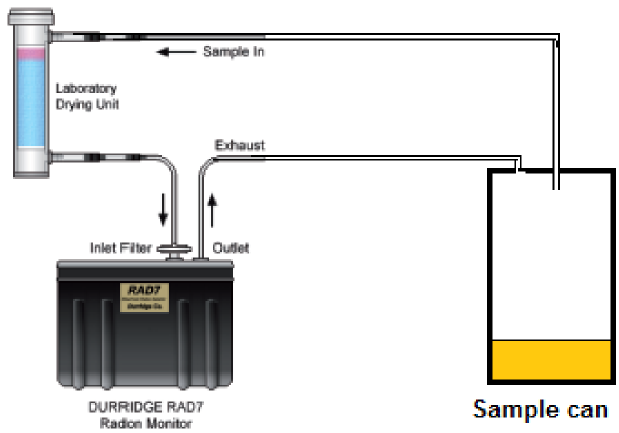

Figure 3. Schematic diagram of RAD7 instrument online with sample can

(ii) Passive Method

To measure the radon concentrations in the samples, laboratory "Can Technique" was used [6,7]. The dried samples were grinded and sieved to produce a homogenous fine powder. About 150gm of the sample was placed at the bottom of a cylindrical emanation chamber (7.0 cm x 11 cm), shown in Figure 4. 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, is mounted quickly and closed the chamber. The detector expose to radon-222 for period of 105 days. After exposure time, all detectors were removed carefully and then; chemically etched using a solution of 6.25 N NaOH at 70°C for 7 h. The detectors then; washed continuously by distilled water. The tracks emerge on the surface of the detector were counted using microscope 400x.

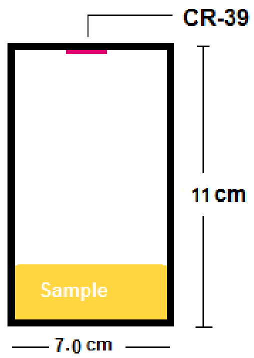

Figure 4. A schematic diagram of the dosimeter used in present work

In this technique, the radon level of a soil placed in an emanation container can be monitored with a passive radon dosimeter based on CR-39 solid- state nuclear track detector SSNTD. The radon concentration which emanated from sample inside the closed can calculated using the following relation [8,9];

$$A_{Rn} = \frac{\rho}{TK} \tag{1}$$

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} has been adopted [10].

At the equilibrium state, the surface exhalation rate from the sample inside the dosimeter is calculated by [11];

$$E_{ex} = \frac{A_{Rn} TV\lambda / S}{T + \lambda^{-1}\left(e^{-\lambda T} - 1\right)} \tag{2}$$

where E_x 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 which is equal to 0.181d^{-1}, 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;

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

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 [12];

$$A_{Ra} = \frac{\rho V}{KMT_{eff}} \tag{4}$$

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

3. Results and Discussions

Radon concentrations in sediments sample were measured by two methods and the two methods were positively correlated according to Figure 5, with correlation factor R^2= 90%. Since the aim is 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.

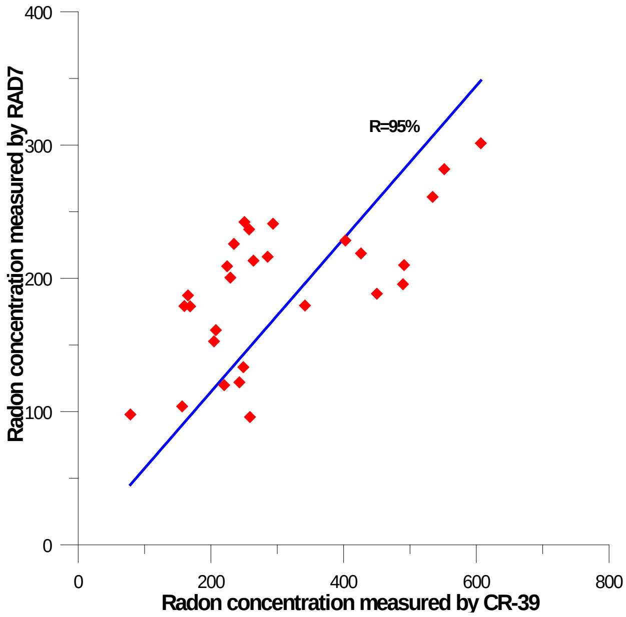

Figure 5. Correlation between active and passive method

The results of radon concentrations obtained in these measurements are shown in Table 1. The results show that radon concentrations varies from 78.6± 21.3Bq m^{-3} to 606.8± 157.3Bq m^{-3} with arithmetic mean value 304.3±79.4 Bq m^{-3} in the passive method. While in the active method radon concentrations varies from 95.6 Bq m^{-3} to 301.6 Bq m^{-3} with average 192.6 Bq m^{-3}, which is approximately half of the passive method and this is due to the effect of short time measurements of the RAD7.

Radon flux per unit area in Bq.m^{-2}h^{-1} is range from 0.069 Bq. m^{-2}h^{-1} to 0.531Bq.m^{-2}h^{-1}, with mean value 0.267Bq.m^{-2} h^{-1}. The mass exhalation rate in sediment samples under study ranged from 1.77mBq.kg^{-1}.h^{-1}to 13.70 mBq. kg^{-1}h^{-1}, with arithmetic mean value of 6.87mBq. kg^{-1}h^{-1}. The effective radium responsible for radon emanation in the air varies from 0.235 Bqkg^{-1} to 1.814 Bqkg^{-1} with average value of 0.910 Bq kg^{-1}. In comparison between values of effective radium measured by can technique and radium concentrations in the same sediment samples measured by gamma ray spectroscopy in previous experimentusing NaI (full detailed of gamma spectroscopy four the same samples may found in reference No.13), we found the two values of the radium contents were positively strong correlated (correlation factor 78%) as shown in Figure 6.

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

S. N.	Rn-222 concentration in Bq/m^3 by SSNTD	Rn-222 concentration in Bq/m^3 by RAD7	E_A in Bq/m^2. h	E_m in mBq/kg.h	Effective Ra in Bq/kg
1	293.6± 76.7	241.0±15.3	0.257	6.63	0.878
2	285.4± 74.6	216.2±14.5	0.250	6.44	0.853
3	168.6± 44.5	179.0±11.3	0.148	3.81	0.504
4	234.7± 61.5	225.9±14.8	0.205	5.30	0.701
5	159.9± 42.2	179.2±12.3	0.140	3.61	0.478
6	250.5± 65.6	242.3±16.8	0.219	5.65	0.749
7	224.3± 58.8	209.0±14.1	0.196	5.06	0.670
8	264.1± 69.1	213.2±13.1	0.231	5.96	0.789
9	165.4± 43.6	187.2±13.2	0.145	3.73	0.494
10	257.6± 67.4	236.7±14.6	0.226	5.81	0.770
11	229.2± 60.1	200.5±14.0	0.201	5.17	0.685
12	242.8± 63.6	122.0±10.3	0.213	5.48	0.726
13	219.9± 57.7	119.9±11.2	0.193	4.96	0.657
14	156.6± 41.4	103.9±10.3	0.137	3.53	0.468
15	204.6± 53.8	152.7±11.8	0.179	4.62	0.612
16	207.4± 54.5	161.1±13.8	0.182	4.68	0.620
17	258.7± 67.7	95.9±7.3	0.227	5.84	0.773
18	450.2± 117.0	188.4±11.3	0.394	10.16	1.346
19	534.3± 138.7	261.1±16.8	0.468	12.06	1.597
20	606.8± 157.3	301.5±21.3	0.531	13.70	1.814
21	426.2± 110.8	218.7±16.4	0.373	9.62	1.274
22	402.7± 104.8	228.4±15.8	0.353	9.09	1.204
23	551.7± 143.2	281.9±19.8	0.483	12.45	1.649
24	491.1± 127.5	209.9±14.1	0.430	11.09	1.468
25	489.5± 127.1	195.6±14.1	0.429	11.05	1.463
26	78.6± 21.3	97.8±6.6	0.069	1.77	0.235
27	248.8± 65.1	133.3±7.8	0.218	5.62	0.744
28	341.6± 89.0	179.6±8.9	0.299	7.71	1.021

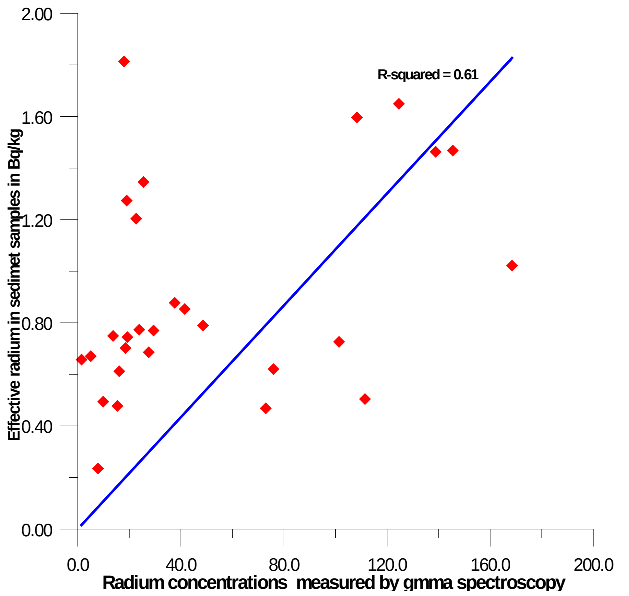

Figure 6. Correlation between radium concentration measured in gamma spectroscopy and effective radium measured by can-technique

4. Conclusion

The obtained values of radon concentrations, radon flux and effective radium contents of the sediments collected from different locations in Khor-Abdullahcanal indicated the safe use for construction as building materials. The values of radon concentrations, area radon exhalation rate and mass exhalation rates in the sediment samples of the study area are quit lower than international limit. The average values of effective radium content in sediment samples taken from locations in the study area are comparable to the global average value of radium in soil. The closed can technique is reliable method to estimate the effective radium content in solid samples and compare it with the gamma spectroscopy finding of radium contents. Positive correlation has been observed between effective radium contents and radium measured in gamma spectroscopy. All results reveal that the area is safe as far as the health hazard effects of radium and radon flux are concerned. These finding and follow up research are expected to contribute to the radiological mapping of the Arabian Gulf.

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References

[1] Schmidt, A., J. J.Gibson, I. R.M.Sandos,M.Schubert, K.Tattrie and H Weiss., 2010. The contribution of groundwater discharge to the

overall water budget of two typical Boreal lake in Alberta/ Canada estimated from radon mass balance. Hydrol. Earth Syst. Sci., 14, 79-89.

[2] Peterson, R. N., W. C. Burnett, M. Taniguchi, J. Chen, I. R. Santos and T. Ishitobi, 2008. Radon and radium isotope assessment of submarine groundwater discharge in the Yallow River delta, china. Journal of Geophysical Research, 113, C09021, 1-14.

[3] Hammond, D. E. and C. Fuller, 1979. The use of Rn-222 to estimate Benthic Exchange and Atmospheric Exchange Rate in San Francisco Bay. Pacific Division of the American for the advancement of Science, California Academy.

[4] Darmoian, S. A. and K. Lidqvist, 1988. Sediments in the estuarine environment of Iraq; Arabian Gulf. Geo. J., 23, 15-37.

[5] Reynolds, R. M. 1993. Physical oceanography of the Gulf, Strait of Hormuz, and the Gulf of Oman (Results from the Mt. Mitchell expedition). Mar. Pollut. Bull., 27, 35-59.

[6] Abu-Jarad, F., 1988. Application of nuclear track etch detector for radon related measurements.Nucl. Tracks Radiat. Measur., 15, 525-534.

[7] Khan, A. J., R. Prasad and R. K Tyagi,1992. Measurement of radon exhalation rate from some building materials.Nucl. Tracks Radiat. Meas., 20(4), 609-610.

[8] Alzoubif, Y., K.M. Al-Azzam,M.K. Alqadi,HM Al-Khateeb, ZQ Ababneh and A.M.Ababneh,2013. Radon concentration level in the historical city of Jarash, Jordon. Radiation Measurements, 49: 35-38.

[9] Mansour, H.L, N.F. Tawfiq and M.S.Karim, 2014. Measurements of radon-222 concentration in dwelling of Baghdad governorate. Indian journal of Applied Research, 4(2), 1-4

[10] Subber, Abdul R.H., Noori H.N. Al-Hashimi, Ali Farhan Nader, Jabbar H. Jebur and M. K. Khodier, 2015,Construct as a simple Radon Chamber for Measurement of Radon Detectors Calibration Factors, Pelagia research library, advanced applied science research, 6(2),128-131.

[11] Imme, G., R. Catalano, G. Mangano and D. Morelli, 2014. Radon Exhalation measurement for environmental and geophysics study. Radiation Physics and Chemistry, 95, 349-351

[12] Sharma, D.K.,A. Kumar, M. Kumar and S. Singh, 2003. Study of uranium, radium and radon exhalation rate in soil samples from some areas of Kangra district. Radiation Measurements, 36, 363-366.

[13] Jaber M. Q., Abdul. R. H. Subberand Noori H.N. Al-Hashmi, 2015. Natural radioactivity in marine sediment of Khor- Abdulla Northern west of the Arabian Gulf, Journal of Advances in Physics, 9(15), 2340-2347.