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ORIGINAL ARTICLES

Monitoring of Radon Concentrations in Jazan Beach Soil

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ABSTRACT

The concentration of radon activities and exhalation rate from sand was measured in collected sand samples from different locations in Jazan. In this study the solid state nuclear track detectors SSNTD are used to investigate the radioactive material in the collected sandsampes. The concentrations of radon and alpha emitters in 18 selected areas in Jazan were evaluated using CR-39 detector. The diffusion chamber is designed to set alpha emission distributions in volume and radon concentrations at the top shelf of a 9.0 cm height. The results show that the mean exhalation rate is 18.72 mBq /m^2.d and radon concentrations is 88.17 Bq/m^3. From the measured concentrations the calculated average annual effective dose to the general public of the regions was found to be 1.52 mSv/y. These values fall within the accepted level set by the International Committee for Radiation Protection (ICRP). The alpha concentrations varied from 55.56 to275.79 Bq/m^3 with an average of 97.22 Bq/m^3.

Key words: Jazan, Beach soil, Radon, Alpha particles, Solid state nuclear track detector.

Introduction

Uranium and thorium are present everywhere in the Earth’s crust in varying amounts. These radioactive elements are sources of three radioactive decay series. Radon gas is one of the decay products of these series. It consists of three isotopes, namely: ^{222}Rn (called radon, belongs to ^{238}U decay series); ^{220}Rn (called thoron, belongs to ^{232}Th decay series) and ^{219}Rn (called actinon, belongs to, ^{235}U decay series). ^{222}Rn has 3.82 days half-life, where as ^{220}Rn (55.6 s) and ^{219}Rn (3.96 s) have much shorter half-lives than ^{222}Rn. That is why ^{220}Rn and ^{219}Rn are given less importance in environmental studies. Scientifically, radon is known to be ^{222}Rn, the most abundant isotope of the element radon, Rafique, M., *et al*. 2011; Florea, N. and Duliu, O.G. 2012).

It is one of the heaviest substances that under normal conditions. It reaches the earth's surface by diffusion through soil layers and can then enter the atmosphere. Noble gas, Radon-222 plays an important role in transporting natural radioactivity from place to another. It breaks the natural decay series and carries its progenies to a new place depending on the climate. Because of its high mass density, it doesn’t diffuse to the upper atmospheric strata. Radon radioactivity, at high concentrations, may be harmful to human. It could be considered as the second reason for lung cancer after cigarette smoking, WHO, 2009; Al-jundi J. *et al.* 2011. Radon gas from natural sources can accumulate in buildings, especially in confined areas such as the basement.

Variations of ^{222}Rn concentrations in the air influence seasonal and diurnal variations of the ambient dose equivalent rate (ADER) depends on the intensity of ionizing radiation of radionuclides in the atmosphere and on the ground surface as well as on cosmic radiation. The value of ADER in the ground level air is mostly caused by ionizing radiation of 40K, Obed, R.I. *et al.,* 2005; Lebedyte, M., *et al.,* 2003. The ^{222}Rn exhalation is influenced by alteration of meteorological conditions: the snow-cover thickness; the freezing depth; the air and soil temperatures, their difference, the precipitation amount, etc., Sahoo, B.K., *et al*. 2011; Grasty, R.L. 1994. The ^{222}Rn concentration in the ground level atmosphere depends on the rate of the ^{222}Rn exhalation from soil and the intensity of turbulent air mixing. Its diurnal and seasonal variations depend on meteorological conditions, Merrile, E.A. and Akbar-Khanzaden**,** F., 1998**.** The International Commission on Radiological Protection (ICRP) has reviewed the available scientific information on the health effects attributable to radon and its decay products and has recently published a statement on radon, ICRP, 2009**.** The ICRP proposed that the same approach should be applied to exposure to radon and progeny as that applied to other radionuclides using the reference biokinetic and dosimetric models. The calculated dose coefficients for radon and its progeny will replace the dose conversion convention, ICRP, 1993a, which is based on the nominal value of radiation detriment derived from epidemiological studies.

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On the other hand, sediment and beach soil is a good indicator for marine pollution. River sediment was a topic of our previous spectroscopic analyses, Ibrahim, M. *et al.* 2008**,** Ibrahim, M. *et al.,* 2009. Molecular modeling was utilized to investigate metal interactions with organic acids mainly in the environment, Elhaes, H. *et al***.** 2011, Ibrahim, M., *et al.* 2009. A standardless method is developed to study river sediment with X-ray fluorescence (XRF) technique Shaltout, A. A., *et al***.** 2011. Jazan area is a promising Saudi area for different kinds of investment. Acordingly, monitoring environmental pollution in one hand and setting standards for radioactive decay on the other hand a must. Besides, these steps are important for setting strategy for environmental impact assessment (EIA). Based on the above considerations Solid State Nuclear Track Detectors (SSNTDs) are utilized to measure the concentrations of radon and alpha particles in beach soil collected from Jazan area on the Red sea. This detector has been chosen for its good sensitivity, stability against environment factors and high degree of optical clarity.

Materials and Methods

Sample collection and preparation:

Beach soil samples were collected from 18 sites in Jazan. Samples were chosen after and close to Jazan as described in table 1.

Table1: Description of the samples indicating the sample locations for the studied 18 samples.

Location		Description
(1-6) Jazan Shrimp farm	1	Before Jazan Robyan factory
	2	Water entry Jazan Robyan factory
	3	Inside Jazan Robyan factory
	4	Inside Jazan Robyan factory
	5	Water out of Jazan Robyan factory
	6	After Jazan Robyan factory
(7-15) Jazan sewage treatment station	7	Before Jazan sewage treatment station
	8	Close to Jazan sewage treatment station
	9	At Jazan sewage treatment station
	10	200 m after Jazan sewage treatment station
	11	500 m after Jazan sewage treatment station
	12	1000 m after Jazan sewage treatment station
	13	2000 m after Jazan sewage treatment station
	14	4000 m after Jazan sewage treatment station
	15	6000 m after Jazan sewage treatment station
Faculty of Medicine	16	Close to Faculty of Medicine
Jazan Stadium	17	Close to Jazan Stadium
Jazan Harbour	18	500 m after Jazan Harbour

200 grams of samples put in a chamber designed to measure radon and total alpha particles.

The specimen is placed at the bottom of the chamber. The alpha detector and then filter paper are placed over the sample as shown in figure 1. Radon detector is placed on a shelf at a distance of 9 cm from the filter paper.

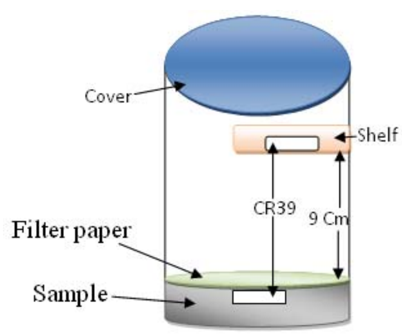

Fig. 1: The chamber designed to measure radon and total alpha.

Measurements:

The CR-39 (solid state nuclear track detector) is a polymer used for detecting energetic charged particles such as alpha–particles. The interaction of the energetic particles with the polymer results in the formation of latent tracks. These latent tracks can be made by chemical etching of the polymer. In the present work, the three-dimensional shape of these etch-pits were measured in much greater detail using a special type of microscope known as a laser scanning con-focal microscope. Using this technique, the efficiency of etching CR-39 using alcohol/water solutions of sodium-hydroxide was examined. CR-39 sheets of 25 cm x 30 cm surface area and 1mm thickness were cut into small detectors of area 1.2 cm x 1.5 cm each. The exposure time was 30 days (to reach secular equilibrium) for ^{222}Rn determination. After exposure the CR-39 detectors were etched in 6.25 Normal NaOH at 70^{o}C for 6 h and the track density was counted using the optical microscope

Radon concentration and exhalation rate:

The value of soil radon concentration (Bqm^{-3}) has been obtained from the expression, Singh, S., *et al*. 2005.

$$C = \rho / KT \tag{1}$$

Where C, is the radon concentration, ρ the sensitivity factor which is calculated by, Durrani, S. *et al***.** 1997, K = 0.168 tracks m^{-2} d^{-1}/Bqm^{-3} of radon and T is the effective exposure time.

The surface exhalation rate of the soil sample for the release of radon can be calculated by, Chen, J., N. *et al.* 2010; Keller, G., *et al.* 2001

$$E = \frac{C\,V\,\lambda}{A[T+\frac{1}{\lambda}(e^{-\lambda T}-1)]} \tag{2}$$

Where E are the radon exhalation rate in terms, A the area of can (m^{2}) , V effective volume of the can in m^{3}, λ decay constant for radon in h^{-1}, and T the exposure time in hours, respectively.

Results and Discussion

The average value concentration of radon activity is listed in table 2. Generally the values in table 2 exceed 50 Bq/m^{3}; the range of radon concentration varies from 49.11 Bq/m^{3} in the location 6 up to 151.79 Bq/ m^{3} in location 14 with the mean value of 88.18 Bq/m^{3}. These values were withen the accepted level set by the International Committee for Radiation Protection (ICRP). It is worth to mention that neither shrimp nor sewage station affects the level of radon in the studied samples.

The average effective doses in the studied samples are found to be within the order of the accepted level set by the International Committee for Radiation Protection (ICRP). The exhalation rate yielded values of 10.17 - 30.11 mBq/m^{2}.d with a mean value 18.27 mBq/m^{2}.d. It can be seen from table 2 that the radon exhalation rate varies appreciably from one location to another.

Table 2: The radon activity concentration in different locations.

Location	Conc. of radon Bq/m3	Dos from radon	Exhalation rate mBq /m^{2}.d
1	85.32	1.47	17.68
2	110.12	1.89	22.81
3	145.34	2.50	30.11
4	71.92	1.24	14.90
5	58.53	1.01	12.13
6	49.11	0.84	10.17
7	74.90	1.29	15.52
8	96.73	1.43	17.26
9	83.33	1.73	20.86
10	100.69	0.98	11.82
11	57.04	1.23	14.80
12	71.43	1.66	20.04
13	54.56	0.94	11.30
14	151.79	2.61	31.45
15	96.73	1.66	20.04
16	87.30	1.50	18.09
17	102.18	1.76	21.17
18	90.28	1.55	18.70
Average	88.18	1.52	18.27

The result for the average alpha concentration for the studied samples is reported in table 3. The average value of alpha concentration 97.22 mSv/y varies from 55.56 in location 18 to 257.79 Bq/m^{3} in location 3. The average alpha in all locations is found to be below the recommended action level.

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Table 3: The alpha activity concentration in different locations.

Location	Con. Of alpha Bq/m3	Dos from radon
1	125.99	2.17
2	103.67	1.78
3	275.79	4.74
4	99.70	1.71
5	63.99	1.10
6	58.04	1.00
7	64.98	1.12
8	62.5	1.08
9	109.13	1.88
10	121.03	2.08
11	92.76	1.60
12	82.84	1.42
13	77.88	1.34
14	96.73	1.66
15	66.96	1.15
16	90.28	1.55
17	102.18	1.76
18	55.56	0.96
Average	97.22	1.67

The variation of radon concentration could be attributed to different types of activities for space and different concentration of radioactive material in earth's crust. The variation between the different locations and radon concentration is shown in figure 2.

Figure 3 shows the variation of concentration of alpha at different locations. It is evident that the highest measured value is belongs to location 3 while lower one is close to location 16.

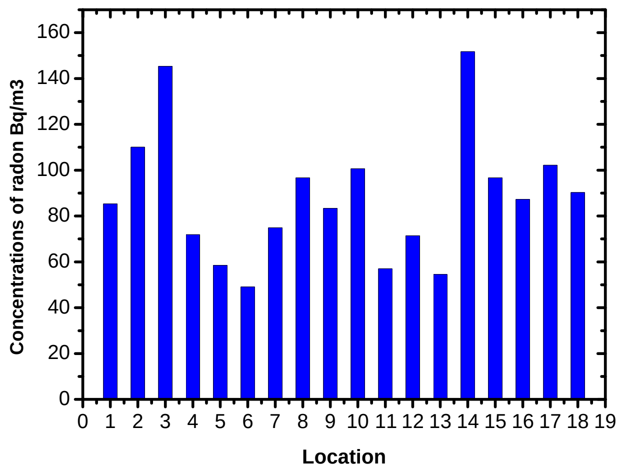

Fig. 2: The variation of concentrations of radon with different locations.

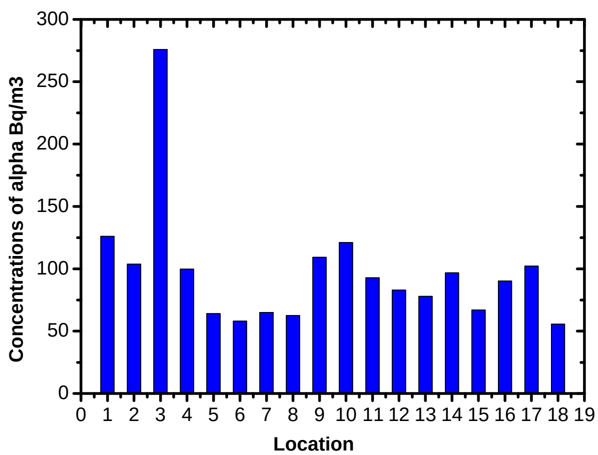

Fig. 3: The variation of concentrations of alpha particles with different location.

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Conclusions:

Monitoring the level of radon as well as alpha particles is a must in a promising community like Jazan. The existence of shrimp farm; sewage treatment, Jazan harbor are considered attractive sites besides of course the natural resources which has no set values. The studied levels are considered within the allowed international acceptable levels. The area close to shrimp farm is a little bit higher than others but still within acceptable levels. This study indicates the importance of continuous monitoring for radon as well as other pollutants and molecular structure in Jazan beach soil in light of the importance of this city for further investment. The present study verifies that the area under study is considered as safe and promising for further future investments.

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