Study of Radium and Radon Exhalation Rate in Some Sand Samples Using Solid State Nuclear Track Detectors

Amal Mohamed[1] Tarfa.H.Alsheddi[2] and Shaffa. Almansour[3]

[1] Department of physics, Faculty of Science, Zagazig University, Egypt.

[2] Department of physics, King Faisal University, Saudi Arabia.

Received: **Accepted:**

ABSTRACT

This study aims to assess the environmental hazards from radon exhalation rate in the sand samples in selected locations in Shaybah field in Saudi Arabia, using passive (CR-39NTD$_S$) and active (SSBD) detecting method. Radon concentration, effective radium content and radon exhalation rate were estimated in sand samples measurements. The ranges of the obtained results are as follows: 10.96 to 12.62(Bq.m^{-1}) for radon concentration active, 107.1 to 126.4(Bq.m^{-3}) radon concentration passive, 22.4 to 19.5 Bqkg^{-1} for radium content, and the values of E_A ranged from 6.19 to 31.1 (10^{-5}Bq.m^{-2}h^{-1}) and values of E_M range from 0.18 to 0.89 (10^{-5}Bq.m^{-2}h^{-1}). The results showed that there is a linear relationship between the ratio of radon concentration and the effective radium content in sand samples. A comparison between our results with that mentioned in international reports was done.

Keyword: Radium, Radon exhalation rates, CR-39, SSBD, sand samples.

INTRODUCTION

Radon is a naturally occurring radioisotope. Radon -222 is one of the elements in the long radioactive decay chain from uranium-238. The elements above radon in the chain are relatively long – lived and of less concern for radiation exposure, but radon and the elements immediately following it in the chain are short- lived and therefore more hazardous [(1)]. Whereas the predecessors to radon in the chain are sands and will not migrate far from their place in the sands, radon is a gas and can migrate through a few feet of earth, radon in the outside air is diluted rapidly, but if it enters through a basement floor, it can reach high concentrations, and therefore, more hazardous appear for poor ventilation rate [(2)]. Uranium is the proximate source of radium and radon in the sand, soil and rocks. Uranium present in the earth, is transferred to water, plants, food supplements and then to human beings. Uranium accumulated in humans may have a dual effect due to its chemical and radioactive properties. High intake of uranium and its decay products may lead to harmful effects in human beings. According to an estimate [(3)], food.

MATERIALS AND METHODS

This samples collected different region from Shaybah field is a major crude oil producing site in Saudi Arabia, this region is shifting sands Fig. (1). And is located approximately 40 km from the northern edge of Rub,Al- Khali/Empty Quarter desert. It is located about10 km south of the border to Abu Dhabi, United Arab Emirates, which is a straight line drawn in the desert, This samples were measured using two techniques. First technique CR-39 (Intercast, Italy) based radon exhalation; nuclear track detector with a thickness of 400 µm was used in this work. Samples were dried, pulverized, homogenized and placed in plastic containers. A piece of CR-39 detector with area 1x1 cm^2 was embedded in the sample in each container [8-10]. The containers were left at room temperature for one month exposure time. During this time α particles from the decay of radon, and their daughters bombard the CR-39 nuclear track detectors in the air volume of the container [(11-12)]. After exposure the detectors were etched chemically with 6.25 N NaoH solutions at 70 C^0 for 5.5h. The tracks were counted using an optical microscope of 400X magnification. The second technique; Silicon surface Barrier Detectors (SSBD) counts alpha particle emissions from Radon. This system is called Radon-Scout. It is provided with sensors to measure the temperature and relative humidity during radon measurement Fig. (2). the system outputs are available both in analog and digital display. Contributes about 15% of ingested uranium, while drinking water contributes about 85%. The measurement of radon exhalation rates of sand, soil and rocks are helpful to study radon health hazard [(4-7)]. The purpose of this study was to assess the radon concentration, radon exhalation rate and the radium content in sand samples in selected areas in Shaybah field Saudi Arabia using passive and active techniques type CR-39 NTDs and SSBD respectively to quantify the radon activity of sand samples.

Fig. (1): Shifting sands.

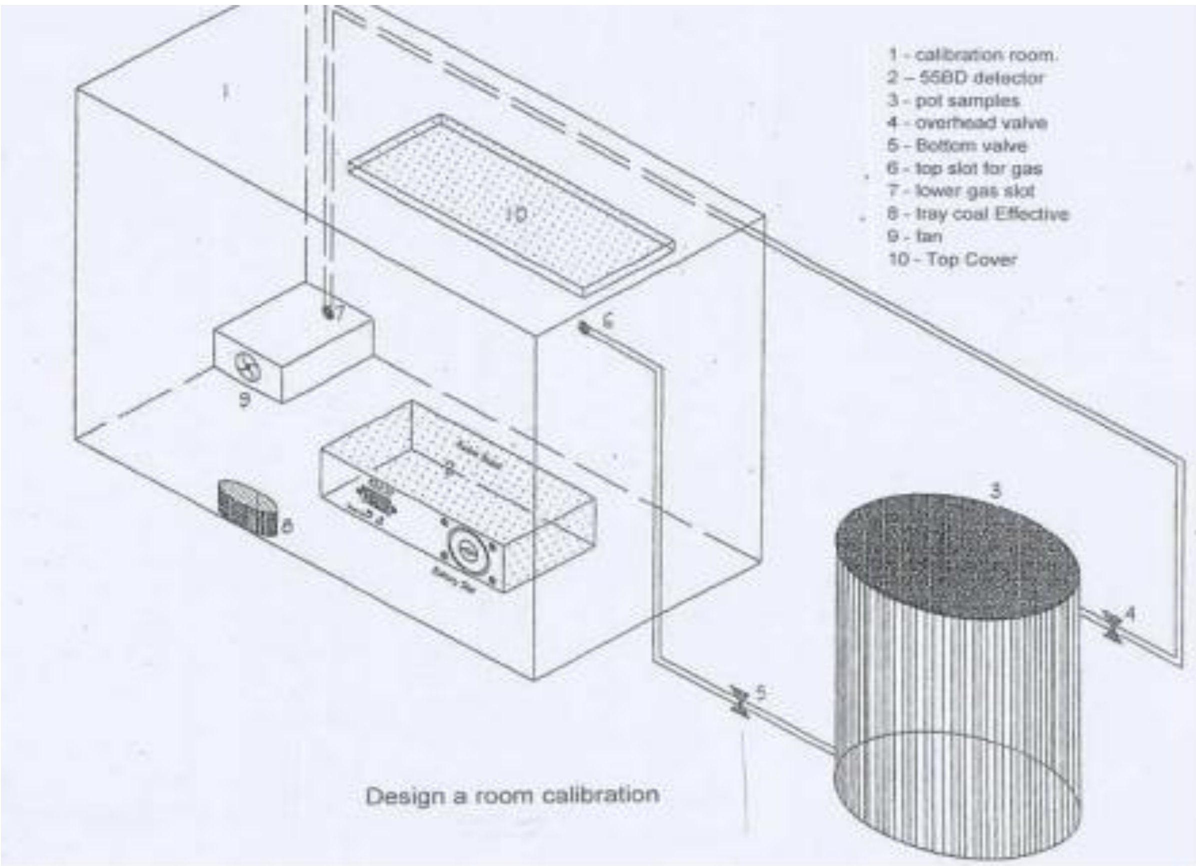

Fig. (2): Design room calibration to measure the temperature and relation humidity during radon measurement.

Determination of the Radon concentration, Radium content and Radon Exhalation rate.

A. Radon concentration (Bq.m-3).

Average radon concentration in the sand samples is calculated using the following formula (13).

$$c_{Rn}(Bq.m^{-3}) = \frac{\rho_{Rn}}{k_{Rn}t}$$

Where ρRn is the radon track density (track/cm2), KRn is the calibration factor for radon (=0.2083 track.cm-2 . d-1/Bq.m-3) which is calibrated in previous work (14), and this factor depended on the detector efficiency for detect alpha particles, which are emitted from radon and its progeny (15), and t is the exposure time(=30 days).

B. Radium Content and Radon Exhalation Rate.

The effective radium content of the samples was calculated using the formula (16)

$$C_{Ra} = C_{Rn}(Bq/m^{3})x\frac{hA}{MT_{e}}$$

Where M is the mass of the sample, A is the area of cross-section of the cylinder in m2, h is the distance between the detector and the tope of sand samples in meters, and Te is the effective exposure time, which is related to the actual exposure time T and decay constant λ for Rn222 by the relation.

$$T_{e} = [T - \frac{1}{\lambda}(1 - e^{-\lambda T})]$$

Where λ is the decay constant for radon (h-1) and T is the exposure time in (h). The radon exhalation rate in terms of area is calculated from the equation (17-18).

$$E_{s(Rn)} = \frac{CV\lambda}{AT_{e}} \quad , \quad E_{m(Rn)} = \frac{CV\lambda}{MT_{e}}$$

Where Es is the radon exhalation rate expressed in Bqm-2h-1, V is the effective volume of the bottle in m3, C is the integrated radon exposure as measured by CR-39 plastic track detector (Bq.m-3.hr). This formula was also modified to calculate the radon exhalation rate in terms of mass (Bq.kg-1. hr-1). Where Em is the radon exhalation rate in terms of mass (Bq.kg-1. hr-1) and M is the mass of the sample (1kg).

RESULT AND DISCUSSION

The result for radium activity and radon exhalation rate in sand samples belonging to some area of Shaybah field in Saudi Arabia, are presented in Table (1). The radium activity in sand sample varies from 22.4 to 19.5 Bqkg-1 with a mean value of 21 Bqkg-1. The radon exhalation values were calculated in terms of area EA and EM. The values of EA ranged from 6.19 to 31.1 (10-5Bq.m-2 h-1) and values of EM range from 0.18 to 0.89 (10-5Bq.m-2 h-1).

One observed that the radon concentration had high and low values in the location of Shaybah, because the geological formation of the locations was different, and this is clear in Fig.(3). In Fig.(4), one observed that there is a linear relationship a good correlation (R=0.89) between an effective radium content in the sand samples radon concentration. This mean that, sand radon is a good correlation (R=0.82) has been observed between the results of the passive and active detector for measure radon concentration in the soil samples in Fig.5. Slop of the linear relation is 9.43, this is due to the long and short measurements. For CR-39NTDs the measurements were for 1 month, and for SSBD the measurement was for 1 hour.

A comparison between our results about sand radon concentration, radon exhalation rate and effective radium content in sand samples in some location in Shaybah with that report in (Hafez et al., 2001). The values of radium activity determined are less than the permissible value 370 Bqkg-1, which is acceptable for safe use OECD, 1979. Thus, results reveal that the area is safe as far the health hazard effects are concerned.

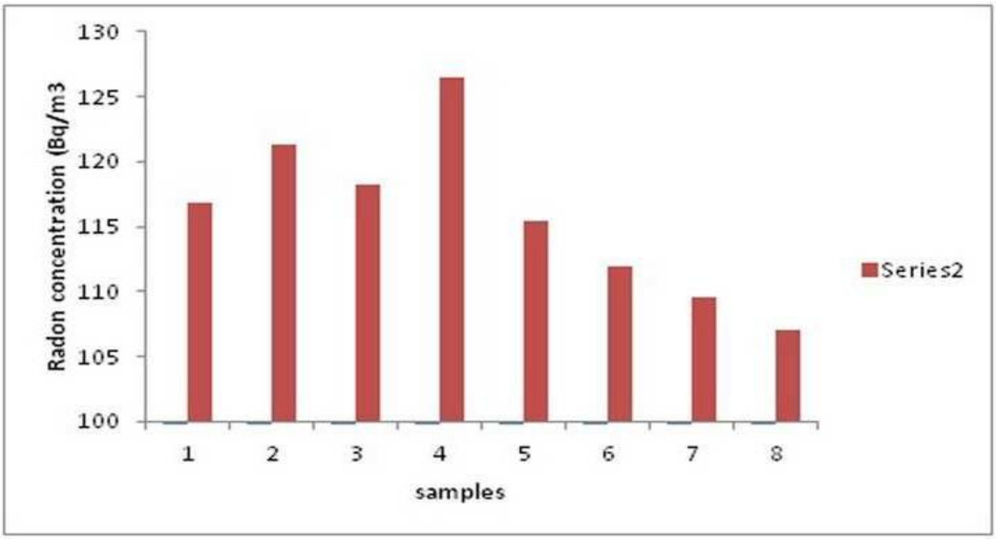

Fig. (3): Relation between the location and radon concentration.

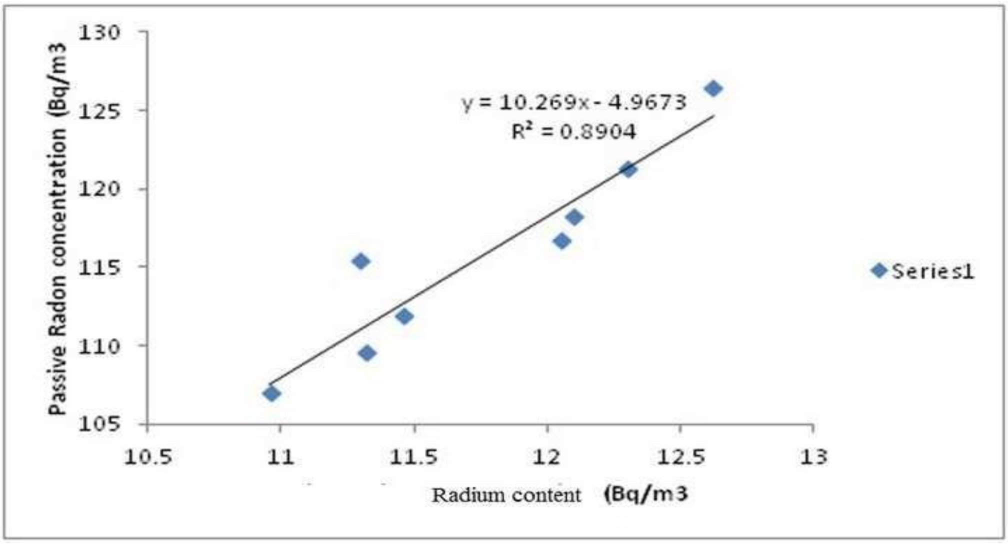

Fig. (4): Relation between the radium content and passive radon concentration.

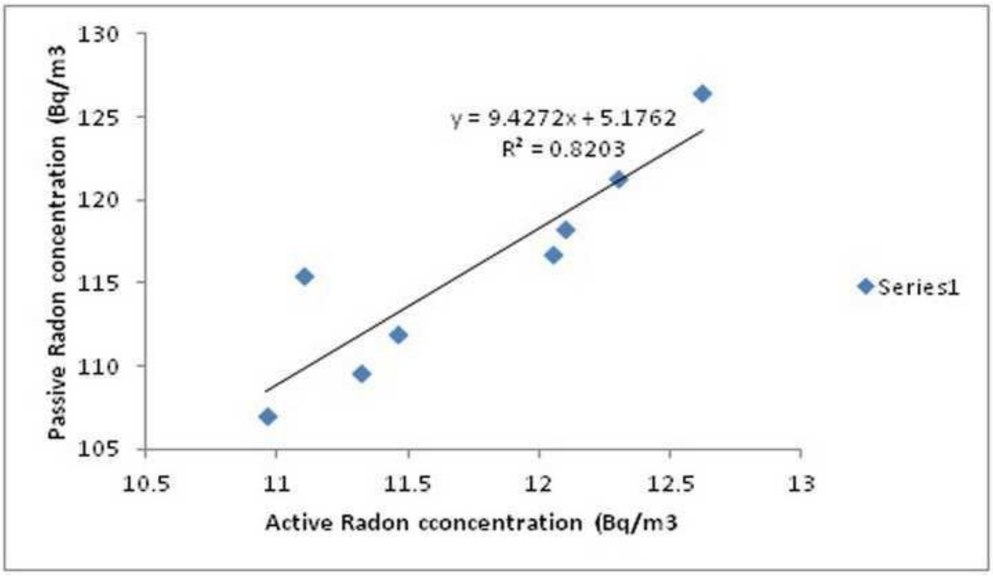

Fig. (5): Relation between active and passive radon concentration.

Table (1): Values of radium and radon exhalation rate in terms of area (E_A) and mass (E_M) in sand samples of different Shaybah field in Saudi Arabia.

Samples	Radium concentration in sand (Bq.kg^{-1})	Radon exhalation rate	
		E_A (10^{-5}Bq.m^{-2} h^{-1})	E_M (10^{-5}Bq.m^{-2} h^{-1})
1	21.38	8.71	0.25
2	21.83	7.21	0.21
3	21.47	6.19	0.18
4	22.4	6.47	0.19
5	20.05	31.1	0.89
6	20.34	18.16	0.52
7	20.09	12.87	0.37
8	19.45	9.47	0.27

REFERENCES

(1) J. Singh , H. Singh , S. Singh , B. Bajawa, Uranium, radium and radon exhalation studies in some soil samples using plastic track detectors, Indian J. Phys. 83 (8) 1147-1153(2009).
(2) S. Singh, D. Kumar, S.I Dher, Uranium, Radium and Radon measurements in the Environs of Nurpur Area, Himachal Himalayas, India, Environ Monit assess, 128, 301-309, (2007).
(3) Cothern CR, Lappenbusch WL: Occurrence of uranium in drinking water: US Hlth Phys,45:89-99, (1983).
(4) Eaton R S, Proc of workshop on radon and radon daughters in urban communities associated with Uranium mining and processing (Atomic Energy Control Board, Attawa),(1978).
(5) Cheng K C &Porrit JM M, CIM BULL: 74, 110 (1981).
(6) Khan A J, Prasad R & Tyagi R K, Nucl Tracks Radiat Meas, 20, 609 (1992).
(7) Jonsson G, Baixeras C, Devantier R & Treutles H C, Radiat Meas, 31, 29 (1999).
(8) Alter H W & Price P B, Patent U S, 3,665,194, Tarradex Corp USA (1972).
(9) Nageswara M V Rao, Bhatti S S, Seshu P & Reddy A R, Radiation Protection Dosimetry,63, 207 (1996).
(10) Somogyi G, Track detection methods of radium measurement, Atomki Pre Print, E/25 1-28, (1986).
(11) Azam A, Naqvi A H & Srivastava D S, Nucl Geophys, 9, 653 (1995).
(12) Abujarad F, Nucl Tracks Rad Meas, 15, 525 (1988).
(13) V. Z. Hamza, M. N. Mohankumar, Cytogenetic damage in human blood lymphocytes exposed in vitro to radon, Mutation Research, 661, pp.1-9,(2009).
(14) Ismail A. H., Jaafar M. S., Experimental Measurements on CR-39 Response for Radon Gas and Estimating the Optimum Dimensions of Dosimeters for Detection of Radon. Proceedings of the 3rd Asian Physics Symposium, Bandung, Indonesia, July 22-23, pp.407-411, (2009).
(15) Ismail A. H, Study of change in the efficiency of CR-39 after storage for different product companies by using TRACK_TEST program, Nuclear Instruments and Methods in Physics Research B 267, 3209-3213,(2009).
(16) Somogyi, G. The environmental behavior of radium. Technical reports series no. 310,vol. 1, IAEA, Vienna, 229-256, (1990).
(17) Abu-Jarad F. Application of nuclear track detectors for radon related measurements: Nuclear Tracks Radiat. Meas. 15, 1-4 (1998).
(18) R. P. Chauhan, Radon exhalation rates from stone and soil samples of Aravali hills. Radiat. Res.9(1), 57-61(2011).