Libyan Journal of Science & Technology 12:1 (2020) 194–196

Faculty of Science - University of Benghazi

Libyan Journal of Science & Technology

journal home page: www.sc.uob.edu.ly/pages/page/77

Radon concentration measurements by SSNTD from construction materials used in Benghazi–Libya

Ibrahim. S. Elyaseery[a], Nagi. A. Hussein[a], Yasin K. Abdalla[a], Abdallah F. Saad[b]

[a]*Department of Physics, Faculty of Science, University of Benghazi, Benghazi, Libya*

[b]*Department of Physics, Faculty of Science, University of Zagazig, 44519 Zagazig, Egypt*

Highlights

- **Samples of construction materials were collected from Benghazi**
- **Radon concentrations from construction materials were measured**
- **CR-39 Solid State Nuclear Track Detectors was used for radon gas detection**

ARTICLE INFO

Article history:

Received 11 December 2020
Revised 29 December 2020
Accepted 30 December 2020

Keywords:

Can technique, Construction Materials, CR-39, Radon Gas, SSNTD

**Address of correspondence:*

E-mail address: elyaseery@hotmail.com

I. S. Elyaseery

ABSTRACT

Materials that are used in the construction of buildings may contain radioactive elements that lead to the emission of dangerous radioactive radon gas. Radon is an alpha emitter and therefore a source of radiation occupational dose that affects immensely the general public and their environmental living conditions. A variety of construction materials, whether local or imported, are employed in Benghazi-Libya buildings and 24 samples of these construction materials were collected and their radon gas concentrations were measured by ''Can technique'' that involves the use of CR-39 Solid State Nuclear Track Detectors, SSNTD. Standardisation procedures of CR- 39 were carried out using a specially constructed standard size emanation chamber. Measurements showed that radon concentration varied from 66.7 to 625.8 Bqm^{-3} which are within the acceptable level set by the ICRP.

1. Introduction

Radon (^{222}Rn) is a radioactive gas whose half-life is 3.82 days. ^{222}Rn is a radionuclide product of the decay of ^{238}U and ^{232}Th series which are found in the crust of the earth. Radon gas is the main source of occupational dose in buildings since buildings are constructed from materials obtained from the earth's crust. Its concentration will vary from place to place depending on the nature of the building. Radon gas can emanate from the ground soil or from construction materials that make up the building. The former is dependent on the geological formation of the area that buildings were constructed on whereas the latter is due to materials that were brought from other sites, local or imported, to be used in the structure of the building itself.

Construction materials have wide applications within the household; some of them are concerned with building foundation such as gravel, bricks and cements others with an internal decoration of the building such as plasters, cement plastering, tiles, and some materials are used in the exterior of the building such as roofing. Cement and sand are involved in almost all aspects of buildings. Concentrations of radon gas due to construction materials were previously reported by recommended radon concentration limit called "action level" was set up by ICRP between 200-600 Bqm^{-3} (ICRP-65, 1993).

It is of dire importance to measure concentration and dose due to radioactive radon in order to give assurance to the general public of such radiation hazards, in addition to the surveying and consequently limit the use of certain construction materials that exceed the recommended level (European Commission (EC), 1999; WHO, 2005; Durani, 1993). Researchers in various countries have determined radon concentration from different materials used in construction (Abu–Jarad *et al.*, 1980; Mustonen, 1984; Al-Jarallah, 2001; Al-Jarallah *et al.*, 2001; Amin, 2015). Studies of radon in construction materials in Libya are therefore needed (Saad *et al.*, 2010; Saad *et al.*, 2014; Hussein *et al.*, 2020) and this project was undertaken to further meet this need.

2. Materials and Methods

2.1 Samples

24 samples of various materials that are used in building constructions were obtained from the local market in and around Benghazi city area. Those samples were then sorted, weighed, and labelled appropriately as shown in Table 1. The samples were left in the same original forms employed in the construction process. Some of the samples are powders such as cement, blocks such as bricks, or grains such as gravel. Some samples are similar in type but being collected from two different places as in samples number 2 and 18. Certain samples were obtained from the local area such as sample number 20. Other samples were obtained from within the country such as in sample number 17. However, some samples are imported either from neighbouring countries namely Egypt and Tunisia as in sample number 3 and sample number 5 respectively or from Europe such as Italian marble of sample number 13. Samples number 22 and 15 are soil samples, which one might wonder why it is being included as a construction material. The soil was considered to be a construction material since most modern buildings in Libya have empty space between foundational concrete networks are filled by layers of soil and then levelled by a layer of concrete to form the bottom surface of the building. Some samples are used as an additive to other materials for various reasons such as sample number 2. All the samples were loaded into a cylindrical stainless steel can of dimensions; 15 cm in height and 11 cm in diameter.

Table1

Classification of collected samples specifying their type, origin, and mass.

Sample *No*	Construction material	Description (Origin)	mass (gm)
1	Cement	normal/Benghazi	500
2	sand1	kuafia/Benghazi	500
3	Ceramic	Egypt	779.9
4	Gravel	Benghazi	1000
5	white cement	Tunisia	500
6	Gypsum	powder/Tunisia (CaSO4 2H2O)	500
7	cement bricks	Benghazi	524.8
8	Gypsum	solid/Tunisia	360.6
9	Granite	Egyptian/white	419.3
10	Granite	Egyptian/brown	531.9
11	white bricks	Benghazi	491.6
12	Marble	Egyptian	819.9
13	Marble	Italian	555.9
14	red roof tiles	solid/Egyptian	586.7
15	red soil	powder/Garyounis- Benghazi	500
16	red bricks	Benghazi	502.4
17	lime stone	Khomus	250
18	sand2	Shat Albaden	500
19	Kawalina	Alabiar	500
20	Gravel	small grain/Alabiar	1000
21	Granite	solid /Talmita	1098.1
22	soil 2	Redeem	1000
23	yellow kawalina	Benghazi	500
24	powdered red brick		500

2.2 Detection system

For the purpose of detecting radon gas, a simple passive detection system based on the "Can technique" (Fleischer *et al.*, 1980; Abu–Jarad *et al.*, 1980) was used. 24 Solid state nuclear track detectors SSNTD of type CR-39, square in shape of size 1.5 cm×1.5 cm and thickness of 1 mm were cut and labelled accordingly. These CR-39 SSNTDs, used in our survey, were purchased from Intercast Europe Co., Parma, Italy. Each labelled detector was then fixed onto the interior of the lid of the can containing the appropriate sample as shown in Fig. 1. The cans are then sealed shut using a strong adhesive and left for recording radon activity.

2.3 Counting

Detectors were removed from all cans after a recording period of 90 days. The detectors were first etched in a solution of NaOH (6.25 M) at a constant temperature of 70°C maintained by the water bath for a period of 8 hours. The detectors are then washed and dried to be ready for the counting process. Counting of each detector was done manually using an optical microscope at a magnification of 400x. Hundred random fields were select and counted for each detector in order to ensure good statistics and their mean values were obtained. The background was measured using an unused detector under the same etching condition and its value was subtracted for each detector.

2.4 Calculation

Track density is the average count of tracks per unit area (tr. cm^{-2}). It was calculated from the hundred-recorded field of views (FOV) for each sample using the following expression (Durrani and Ili'c, 1997):

$$\rho_{Rn} = \frac{\sum_i \frac{N_i}{n}}{FOV\ area}$$

Where:

$\sum_i \frac{N_i}{n}$ is the average number of total tracks, $\sum_i N_i$ is the total number of tracks in all FOV, and n is the total number of FOV, and FOV area is 1.589×10^{-3} cm^{-2}. A calibration factor of 0.239±008 (tr. cm^{-2})/(Bq m^{-3}) was then used to convert track density into radon concentration (Bqm^{-3}) using the following equation (Saad, 2008):

$$C_{Rn} = \frac{\rho_{Rn}}{T\ K_{Rn}}$$

Where: C_{Rn} is radon concentration (Bqm^{-3}), ρ_{Rn} is track density (tr. cm^{-2}), T is exposure time, and K_{Rn} is the calibration factor.

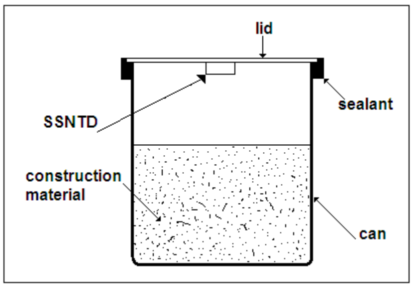

Fig. 1. A schematic diagram of the experimental setup

3. Results and discussion

Each sample's total tracks were counted for the hundred chosen FOV from which the track density and radon concentrations were calculated. The results obtained are shown in Table 2. Data from four samples (2, 15, 20, and 22) were unavailable for various reasons. Measurements showed that radon concentration varied from 66.7 to 625.8 Bqm^{-3}. Most of the tested samples gave radon concentration values that lie below the minimum action level recommended by ICRP (200-600 Bqm^{-3}). Five samples (10, 14, 16, 17, and 21) have values within the range of ICRP action level while the rest of the samples are below 200 Bqm^{-3}. Only one sample (sample No. 23) gave a slightly higher radon concentration (625.8 Bqm^{-3}) than the maximum ICRP action level limit.

Table 2

Radon concentration (Bq m^{-3}) was obtained for various materials used in construction in Benghazi-Libya.

Sample *No*	**Construction Material**	$\sum_i N_i$ **(Counts)**	ρ_{Rn} **(Tr. cm^{-2})**	C_{Rn} **(Bq m^{-3})**
1	Cement	272	1711.8	79.6±2.6
2	Sand1			NA
3	Cera±mic	228	1434.9	66.7±2.2
4	Gravel	348	2190.1	101.8±3.4
5	White Cement	474	2983.0	138.7±4.6
6	Gypsum	554	3486.5	162.1±5.4
7	Cement Bricks	352	2215.2	103.0±3.4
8	Gypsum	339	2133.4	99.2±3.3
9	Granite	281	1768.4	82.2±2.8
10	Granite	1038	6532.4	303.7±10.2
11	White Bricks	572	3599.8	167.4±5.6
12	Marble	506	3184.4	148.0±5.0
13	Marble	326	2051.6	95.4±3.2
14	Red Roof Tiles	1320	8307.1	386.7±12.9
15	Red Soil			NA
16	Red Bricks	1391	8753.9	407.0±13.6
17	Lime Stone	1292	8131.0	378.0±12.7
18	Sand2	303	1906.9	88.7±3.0
19	White soil	521	3278.8	152.4±5.1
20	Gravel			NA
21	Granite	810	5097.6	237.0±7.9
22	Soil 2			NA
23	Yellow Soil	2139	13461.3	625.8±21.0
24	Powdered Red Brick	391	2460.7	114.4±3.8

4. Conclusion

Measurement of radon concentration from some materials employed in construction in Benghazi Libya was accomplished using SSNTD and the Cup technique. The method may be cumbersome but it is well established and has good reliability in the scientific community. The radon concentration was found to vary in value with only one sample slightly over the action limit. This study forms the basis of a further survey for more construction materials from different parts of the country.

References

Abu–Jarad, F., Fremlin, J.H., Bull, R., (1980) 'A study of radon emitted from construction materials using plastic α-track detectors', *Phys. Med. Biol*., 25, pp. 483-694.

Amin, R. M. (2015) 'A study emitted from building materials using solid-state nuclear track detectors', *Journal of Radiation Research and Applied Science*' 8, pp. 516-522.

Al-Jarallah, M., (2001) 'Radon exhalation from granite used in Saudi Arabia', *J. Environ. Radioact.,* 53, pp. 91–98.

Al-Jarallah, M.I., Abu-Jarad, F., ur-Rehman, F. (2001) 'Determination of radon exhalation rates from tiles using active and passive techniques', *Radiat. Meas.*, 34, pp. 491–495.

Commission des Communautes Europeennes (1990) Recommendation de la commission Relative a la protection de la population Contre les Dangers Resultant de l' Exposition au Radon a l'Interieur des Batiments (Brussels: CEC).

Durrani, S.A. (1993) 'Radon as health at home: what are the facts?', *Nucl. Tracks Radiat. Meas*., 22, pp. 303-317.

Durrani, S.A. and Ili'c, R. (1997) Radon measurements by etched track detectors: Applications in radiation protection, Earth Science Environmental. Singapore: World Scientific.

European Commission (EC) (1999) 'Radiation Protection Unit. Radiological protection principles concerning the natural radioactivity of building materials', *Radiation Protection*, p. 112.

Fleischer, R. L., Giard, W. R., Mogro-Campero, A., Turner, L. G., Alter, H. W. and Gingrich, J. E. (1980) 'Dosimetry of Environmental Radon: Methods and Theory for Low-dose, Integrated Measurements', *Health Physics*, 39, pp. 957-962.

Hussein, N .A., Elyaseery, I.S., Abdalla, Y. K., Saad, A.F., (2020) 'Seasonal variation measurements of indoor radon concentrations in the city of Benghazi- Libya', *Libyan Journal of Science & Technology,* 11(1), pp. 01-04.

ICRP (International Commission on Radiological Protection) (1993) Protection against ^{222}Rn at Home and at Work. Report 65, Ann. ICRP 23 (2), Pergamon, Oxford.

Mustonen, R., (1984) 'NaturalradioactivityinandradonexhalationfromFinnish construction materials', *Health Phys*., 46, pp. 1195–1203.

Saad, A. F. (2008) "Radium activity and radon exhalation rates from Phosphate ores using CR-39 on-line with an electronic radon gas analyzer" Alpha GURAD', *Radiation Measurements*, 43, pp. S463-S466.

Saad, A.F., Abdalla, Y. K., Hussein, N. A., Elyaseery, I.S. (2010) 'Radon exhalation rate from building materials used on the Garyounis University campus, Benghazi, Libya', *Turk. J. Eng. Environ. Sci*., 34, pp. 67–74.

Saad, A. F., Hend H. Al-Awami, Hussein, N.A. (2014) 'Radon exhalation from building materials used in Libya', *Radiation Physics and Chemistry,* 10, pp. 15–19.

World Health Organization (WHO) (2005) Fact Sheet No.291: Radon and Cancer. Available at: ⟨http://www.who.int/media center/factsheets/fs291/en/index.html⟩.