HOSTED BY

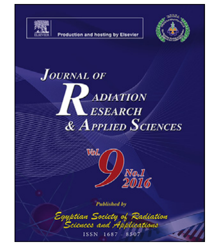
ELSEVIER

Available online at www.sciencedirect.com

ScienceDirect

Journal of Radiation Research and Applied Sciences

journal homepage: http://www.elsevier.com/locate/jrras



Radon exhalation rate for phosphate rocks samples using alpha track detectors

CrossMark

Hesham A. Yousef [a,*], **Gehad M. Saleh** [b], **A.H. El-Farrash** [c], **A. Hamza** [c]

[a] *Physics Department, Faculty of Science, Suez University, Suez, Egypt*
[b] *Nuclear Materials Authority, P.O. Box: 530 El-Maadi, Cairo, Egypt*
[c] *Physics Department, Faculty of Science, Mansoura University, Mansoura, Egypt*

ARTICLE INFO

Article history:
Received 10 June 2015
Received in revised form
23 August 2015
Accepted 1 September 2015
Available online 14 September 2015

Keywords:
Radon
Phosphate
Exhalation rate
SSNTDs
Passive technique

ABSTRACT

Solid state nuclear track detectors are used in very broad fields of technical applications and successfully applied in different areas of environmental physics and geophysics. Radon concentration and surface exhalation rate for phosphate samples from El-Sebaeya and Abu-Tartur, Egypt, were measured using nuclear tracks detectors from types CR-39 and LR-115. The average values of radon concentration are 12711.03 and 10925.02 Bqm^{-3} in El-Sebaeya area using CR-39 and LR-115 detectors, respectively. Also the average values of radon concentration are 15824.16 and13601.48 Bqm^{-3} in Abu-Tartur area using CR-39 and LR-115 detectors, respectively. From the obtained results we can conclude that the average values of radon concentration in Abu-Tartur are higher than El-Sebaeya. The present study is important to detect any harmful radiation which, can be used as reference information to assess any changes in the radioactive background level in the surrounding environment.

1. Introduction

There are three natural isotopes of the radioactive element radon ^{222}Rn originate in the ^{238}U decay series with a half-life of 3.82 days, thoron (^{220}Rn) is in the ^{232}Th chain with a half-life of 55.6 s, actinon (^{219}Rn) is in the ^{235}U series with a half-life of 4 s (IAEA, 2003). Radon can be considered to be of the most dangerous radioactive elements in the environment (Mansur et al., 2005). The most important mechanism of exposure is the inhalation of the short lived decay products of the principal isotope, ^{222}Rn with indoor air. Concentrations of ^{222}Rn and its progeny are usually higher in indoor air than in outdoor air, exceptions are in tropical regions, where ^{222}Rn concentrations in well ventilated dwellings are essentially the same as in outdoor air (UNSCEAR, 1993). When radon gas is inhaled, densely ionizing alpha particles emitted by deposited short-lived decay products of radon (^{218}Po and ^{214}Po) can interact with biological tissue in the lungs leading to DNA damage (WHO, 2009). The exposure to high level of radon gas through breathing of air increases the risk of lung cancer (Ramadan, 2012). Fertilizers are used for reclaiming the land and improving the properties of crops. Super phosphate is the fertilizer most commonly used in Egypt and it is manufactured from the reaction between sulfuric acid, phosphate rock and water (El-Zakla, Abdel-Ghany, & Hassan, 2007; Rehman,

* *Corresponding author.*
E-mail addresses: h_yosef2013@yahoo.com, h_yosef2003@hotmail.com (H.A. Yousef).
Peer review under responsibility of The Egyptian Society of Radiation Sciences and Applications.
http://dx.doi.org/10.1016/j.jrras.2015.09.002

Imtiaz, Faheem, & Matiullah, 2006). Using phosphate fertilizers over a period of decades could eventually increase the radium and uranium content of the soil, which would result in corresponding increasing of the dose from this source (Ashraf, Higgy, & Pimpl, 2004).

Phosphate deposit of sedimentary origin contains higher concentration of ^{238}U and its decay products than phosphate from volcanic or biological origin (Korkmaz & Turgut, 2005). The Egyptian phosphate is widely distributed in many localities on the Red Sea, Nile Valley (El-Sebaeya) and Western Desert. The deposits in the first two districts are relatively rich in phosphate and are exploited at several mines, but those of the Western Desert are of low grade except at Abu-Tartur mine (Ahmed, Abbady, El-Kamal, Steinhausler, & El-Arabi, 2001).

Abu-Tartur phosphate project is the largest phosphate mines in the Middle East. The mining area is located in the heart of the Western desert of Egypt (60 km from El-Kharga City, and 10 km from the main road between the two Oases El-Kharga and El-Dakhlah) (Ahmed, 2003; Ashraf, 2012), but El-Sebaeya area found in the south of Esna city (Luxor), Western Nile Valley.

The present work aimed to determine the values of radon concentration and surface exhalation rate for phosphate rocks samples from El-Sebaeya and Abu-Tartur areas, Egypt. The present study is important to detect any harmful radiation which, can be used as reference information to assess any changes in the radioactive background level.

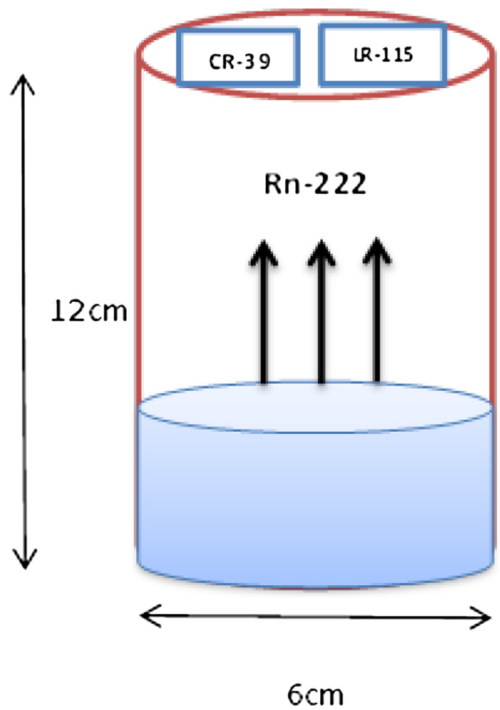


Fig. 1 – Plastic cylindrical container of the samples.

2. Materials and methods

Radon concentration and surface exhalation rate for phosphate rocks samples collected from El-Sebaeya and Abu-Tartur areas, Egypt were measured using solid state nuclear track detectors from types CR-39 and LR-115. Ten samples were collected from each region. The samples were crushed, dried in oven at 110 °C for 3 h, minced, sieved by 1 mm mesh, weight carefully and sealed for one month in cylindrical containers with dimensions of 6 cm in diameter and 12 cm in height. Each sample container was capped tightly to an inverted cylindrical plastic cover as shown in Fig. 1 in order to get equilibrium.

CR-39 (American Technical Plastic, Inc.) and LR-115 (Kodak Pathe, France) detectors of area 1.5 cm × 1.5 cm fixed at the bottom center of the inverted plastic cover. During the exposure time of α-particles from the decay of radon and their daughters bombard the detectors in the air volume of the cylindrical containers. After the exposure period CR-39 and LR-115 detectors were removed carefully from the Can. CR-39 detector etched in NaOH solution with condition 6.25 N at 70 ± 1 °C for 7 h. After etching CR-39 detectors were washed in distilled water and then dipped for few minutes in a 3% acetic acid solution, washed again with distilled water and finally dried (Zarrag, El-Araby, & Elhaes, 2012). In the case of LR-115 detector etched in 2.5 N of NaOH in water bath at 60 ± 1 °C for about one hour. After the chemical etching LR-115 detectors were washed in distilled water and then placed in a solution of (50 ml water + 50 ml ethyl alcohol) again washed using water and dried in air (Belafrites, 2008). After etching CR-39 and LR-115 detectors, the tracks were counted using an optical microscope with a magnification of 640×. The value of radon concentration in (Bqm^{-3}) at secular equilibrium given by the following equation:

$$C_{Rn} = \frac{\rho}{\eta\, T} \tag{1}$$

Where, C_{Rn} is radon concentration (Bqm^{-3}), ρ is the track density (track cm^{-2}), T is the exposure time (day) and η is the calibration coefficient of CR-39 and LR-115detectors in (tracks cm^{-2} day^{-1}/Bqm^{-3}) (Hafez, El-Farrash, & Yousef, 2011).

Radon surface exhalation rate given by the relation:

$$E_A = \frac{CV\lambda}{A\left[T + \frac{1}{\lambda}\left(e^{-\lambda T} - 1\right)\right]} \tag{2}$$

Where, E_A is the surface exhalation rate in ($Bqm^{-2}\,h^{-1}$), C_{Rn} is the radon concentration in ($Bqm^{-3}\ h^{-1}$), λ is the decay constant of radon (h^{-1}), V is the effective volume of the Can (m^3), A is the area covered by the can (m^2) and T is the irradiation time (Rehman et al., 2006; Barooah, Phukan, & Baruah, 2011).

3. Results and discussion

The values of radon concentration and surface exhalation rate for phosphate samples are listed in Table 1, which represents a comparison between the values of radon concentration and surface exhalation rate which were measured using CR-39 and LR-115 detectors. In El-Sebaeya area the values of radon