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A study of radon emitted from building materials using solid state nuclear track detectors

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ABSTRACT

Radon is a natural radioactive gas derived from geologic materials. Inhalation of the short-lived decay products of radon has been linked to an increase in the risk of developing lung cancers if present at elevated levels. Accurate knowledge of exhalation rate plays an important role in characterization of the radon source strength in some building materials.

For this purpose, in this study the Can Technique using CR-39 plastic track detectors was used to measure radium content and exhalation rates of radon in building samples collected from Jizan districts-a province in southern Saudi Arabia. The values of effective radium content are found to vary from 0.21 to 2.2 Bq kg^{-1} with a mean value of 0.92 Bq kg^{-1} and a standard deviation of 0.81. All the values of radium content in all samples under test were found to be quite lower than the permissible value of 370 Bq kg^{-1} recommended by Organization for Economic Cooperation and Development. The values of mass exhalation rates of radon vary from 1.6 to 16.7 mBq kg^{-1} h^{-1} with a mean value of 6.9 mBq kg^{-1} h^{-1}, while the surface exhalation rates vary from 29.7 to 998.9 mBq m^{-2} h^{-1} with a mean value of 219.6 mBq m^{-2} h^{-1}. Alpha index and annual effective doses have also been estimated.

1. Introduction

It is well known that most natural materials such as sand, soil, cement and rock, etc., used as building materials for construction of houses and buildings, etc originate from different rocks and earth's crusts. Such materials are often rich in different naturally occurring radioactive elements. Concentrations of radionuclides present in building materials vary depending upon the local geological conditions (Iqbal, Tufail, & Mirza, 2000; Tennisseen, 1994). The building industry also uses large amounts of waste from other industries (UNSCEAR, 1982). These construction materials may cause radioactivity to be significantly higher than background levels (OECD, 2009; UNSCEAR, 1982). Long exposures to low levels of ionizing radiation can seriously increase health risks to humans (ICRP, 1990). The study of alpha activity in building materials is very important because alpha radiation is 1000 times more carcinogenic than gamma radiation (Ghosh, Deb, Bera, Sengupta, & Patra, 2008). Knowledge of the natural radioactivity in building materials as a main continuous source of indoor radiation exposure is essential in the assessment of population exposures because 80%of their lifetime is spent in

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indoor air (Stoulos, Manolopoulou, & Papastefanou, 2003; Zikovsky & Kennedy, 1992).

Radon-222 formed from radium (^{226}Ra), is a noble gas with a half-life of 3.8 days, may be released from ground, rocks and also from building materials, and accumulate (Rawat, Jojo, Khan, Tyagi, & Rajendra Prasad, 1991), with its short lived progeny in the atmosphere inside of the dwellings. Inhalation of ^{222}Rn and its short lived daughters has been linked to lung cancer in humans. When radium decays in soil grains, the resulting atoms of the radon isotope escape from the mineral grains to the atmosphere. The rate at which radon escapes or emanates from the soil is termed the radon emanation rate or the radon exhalation rate. Radon exhalation is a complex phenomenon depending upon a number of parameters such as radium content in soil, soil morphology, soil grain size, soil moisture, temperature, atmospheric pressure, and rainfall (Khan, Srivastava, & Azam, 2012). Such studies can be useful for the assessment of public radiation dose and performance of epidemiology as well as for keeping reference data records, to ascertain changes in the environmental radioactivity due to industrial, nuclear and other human activities (Singh, Singh, Singh, & Bajwa, 2009). With the above important points in mind, a study was undertaken for the assessment of natural distribution of radium content, alpha index and radon exhalation rates (both surface exhalation and mass exhalation rate) of the building samples collected from the southwestern part of the regions of Saudi Arabia. The surveyed area is located in the region of Jizan in the south west of KSA as shown in Fig. 1. This is situated between 16°53′N latitude and 42°34′E longitude and lays on the Red Sea. Jizan experience the following two seasons: A hot and humid summer (May–October) and moderate winter seasons (November–April).

Studying the radon emanation from building materials with electronic equipment may be difficult and expensive; because of the low level of emanation from the material long term measurements are essential and very few can be made in a reasonable time, so the method based on the use of solid state nuclear tracks detectors (SSNTD) is probably the most widely applied for long term radon measurements. In the present study, the Can-technique was used to measure the exhalation rates of radon, the radium contents, the alpha index and the annual effective dose of some building materials used locally in Saudi Arabia.

2. Materials and methods

Twenty one samples of building materials were collected from the study area containing 11 slab samples and 10 powder samples. A passive method using CR-39 plastic detector, as a solid state alpha-track detector was developed for measurements of radon exhalation rate of samples of building materials. The CR-39, having a thickness of about 500 μm, is a very useful material for the registration of alpha particles (Maged & Ashraf, 2005). The tracks detected by these plastic detectors are not directly visible and have to be enlarged by adequate chemical processing. CR-39 was cut into 1.5 × 1.5 cm^2 pieces and adhered to a plastic can of known dimension (7 cm diameter and 11 cm height) (Chen, Weng, & Chu, 1993; Somogyi, 1986). Two types of experiments for measurements of radon exhalation rates of building materials were used:

(1) The can was placed on some building parts, such as marble, red brick, tiles, concrete block and ceramic

Fig. 1 – Map showing the study area in Jizan province.