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Variation of radon exposure in Damascus dwellings

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ABSTRACT

In the present work, activity concentrations of ^{222}Rn in air and ^{222}Rn and ^{226}Ra in drinking water were measured in Damascus city covering its old and modern parts.

It was found that the average air radon activity concentration in the old part was higher than in the modern part, and in drinking water, radon was found to be 60 ± 3 Bq/l, and less than 0.13 Bq/l for radium, which were lower than the recommended levels set by WHO.

1. Introduction

The most important contributors to human exposure from natural sources are radon and its short-lived decay products in the atmosphere. About one-third of the total radiation dose to humans is due to the inhalation of short-lived radon progeny in the indoor atmosphere. It is well known that inhalation of the short-lived decay products of radon and its subsequent deposition along the walls of the various airways of the bronchial tree, provide the main pathway for radiation exposure to the lungs (International Commission on Radiological Protection (ICRP), 1993; United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), 1993).

The activity concentrations of radon and its progeny are largely influenced by factors such as type of house construction, building materials, temperature, pressure, humidity, ventilation, wind speed, and even the life style of the people living in the house (Jonassen, 1975; Martz et al., 1991; Nazaroff and Doyle, 1985; Ramola et al., 1998, 2000; Segovia and Cejudo, 1984; Subba Ramu et al., 1988). To estimate the annual average equivalent dose, a number of indoor radon surveys have been carried out around the world (UNSCEAR, 1993).

In addition, the contribution of drinking-water to the total exposure is typically very small and is due largely to naturally occurring radionuclides in the uranium and thorium decay series. Radionuclides from the nuclear fuel cycle and from medical and other uses of radioactive materials may, however, enter drinking-water supplies. Therefore, radioactive constituents of drinking-water can result from (World Health Organization (WHO), 2004):

- naturally occurring radioactive species (e.g., radionuclides of the thorium and uranium decay series in drinking-water sources), in particular $^{226}Ra/^{228}Ra$ and a few others;
- technological processes involving naturally occurring radioactive materials (e.g., the mining and processing of mineral sands or phosphate fertilizer production);
- radionuclides discharged from nuclear fuel cycle facilities;
- manufactured radionuclides (produced and used in unsealed form), which might enter drinking-water supplies as a result of regular discharges and, in particular, in case of improper medical or industrial use and disposal of radioactive materials;
- past releases of radionuclides into the environment, including water sources.

Solid state nuclear tracks detectors (SSNTDs) have been utilized for studying radon activity concentration in dwellings in addition to many other applications related to radon measurements such as radon emanation from building materials (Oufni, 2003). But, the widest usage of these detectors is to measure the average radon activity concentration in homes as integral detectors.

In this work the average concentrations of radon in Damascus City (old and modern parts) were measured using CR-39 SSNTD. In addition ^{222}Rn, ^{226}Ra, and gross alpha/beta activity concentrations in the drinking water were also determined using liquid scintillation counter.

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2. Methods and measurements

2.1. Radon activity concentration in houses

The capital Damascus was divided into two parts old and modern. The old part involved houses close to each other made of soil and have special architecture designs, while, the modern part consists of normal multistory buildings.

The old part of Damascus was considered to be the houses within the ancient city wall, while the modern part was considered to be the modern houses surrounding the old part. Fig. 1 shows a map of the studied area. The chosen houses covered old and modern houses and different levels in the multi-story building.

Passive radon detectors carrying SSNTDs (CR-39) were distributed in the two parts in a way that 10 detectors per one square kilometer to be distributed randomly in the old part, while one to two detectors per square kilometer to be distributed randomly in the modern part. About 20 old houses were chosen in the old part and more than 50 multi-story building in the modern part (at least one detector in each level up to the third level). All measurements were performed in the spring season (from March to June) were the weather was moderate and the average temperature was around 20 °C.

The detectors were collected after about 3 months exposure and the alpha tracks were developed by chemical etching and counted using an optical microscope (Durrani and Ilic, 1997). From the average track densities on the detectors, radon activity concentrations were determined (Shweikani et al., 1995; Shweikani and Raja, 2005).

In addition, radon activity concentration in open air was also measured in different areas within the ancient city wall and outside using the Lucas cell technique (Shweikani and Raja, 2005).

2.2. Radon and radium in drinking water

Tap water samples were collected from the studied houses and radon activity concentrations were determined using the bubbling techniques (Durrani and Ilic, 1997), while ^{226}Ra activity concentrations and gross alpha/beta were determined using liquid scintillation counter (Sanchez-Cabesa and Pujol, 1995; Tinker and Smith, 1996; Al-Masri et al., 2007).

3. Results and discussion

Fig. 2(a) shows the statistical distribution of the radon activity concentration in both parts. It is clear that the average arithmetical mean is equal to 28 ± 33 Bq m^{-3}, while the geometric mean is equal to 20.5 ± 11.6 Bq m^{-3}. Two high values were measured, one in the old part (185.6 Bq m^{-3}) and another in the modern part (199.7 Bq m^{-3}). By excluding the radon measurements lower than 10 Bq m^{-3} and the two high values the statistical distribution become as in Fig. 2(b).

The houses, in which the two high values were obtained, were studied and found that they do have Chinese showpieces containing traces of uranium. The concentrations in these two houses were reduced to acceptable levels (around 50 Bq m^{-3}) by just advising to use the natural ventilation in the measurement rooms.

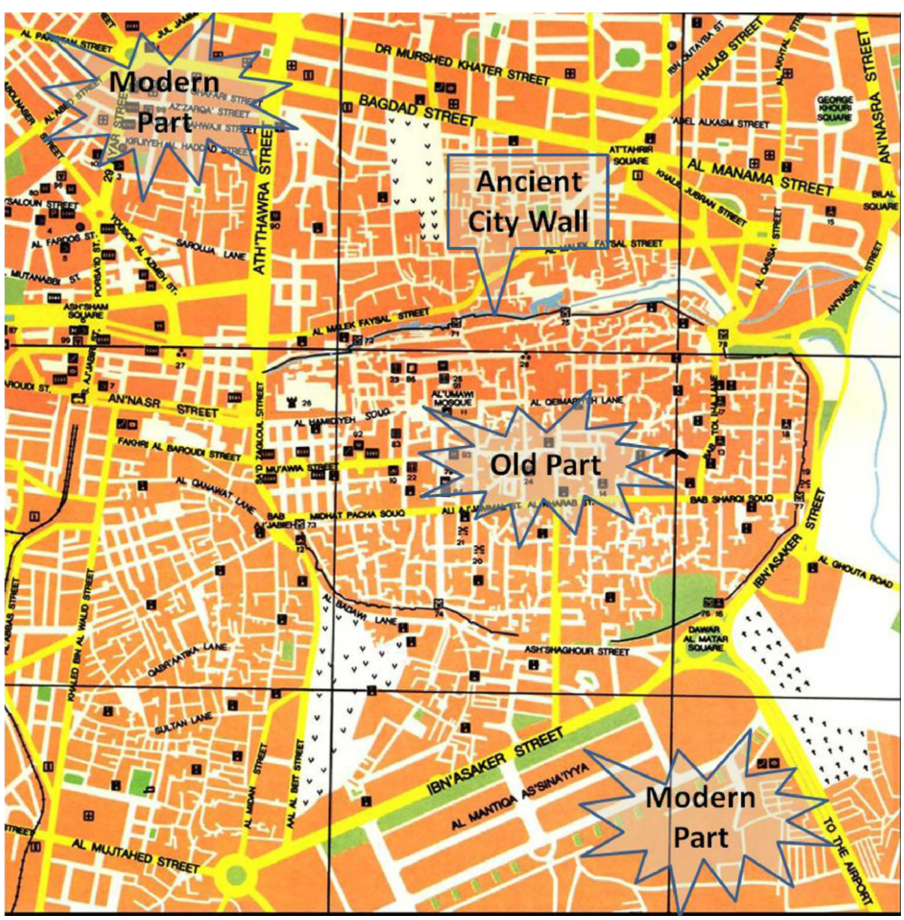

Fig. 1. Map shows the studied areas: the old and modern parts of Damascus.