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Radon in harvested rainwater at the household level, Palestine

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ABSTRACT

The main objective of this study was to assess Radon concentration in the harvested rainwater (HRW) at the household level in Yatta area, Palestine. HRW is mainly used for drinking as it is the major source of water for domestic uses due to water scarcity. Ninety HRW samples from the household cisterns were collected from six localities (a town and five villages) and Radon concentrations were measured. The samples were randomly collected from different households to represent the Yatta area. Fifteen samples were collected from each locality at the same day. RAD7 device was used for analysis and each sample was measured in duplicate. Radon concentrations ranged from 0.037 to 0.26 Bq/L with a mean ± standard deviation of 0.14 ± 0.06 Bq/L. The estimated annual effective radiation doses for babies, children and adults were all far below the maximum limit of 5 mSvy^{-1} set by the National Council on Radiation Protection and Measurements.

1. Introduction

Many localities in Palestine suffer from water shortage due to regular failures of the water supply systems and insufficient supplied water, mainly during the summer season, further restricted by the Israeli control on the main water sources. Therefore, the use of rainwater harvesting (RWH), water tankers and water from supply networks are commonly practiced in the West Bank of Palestine, mainly in Hebron district in the southern part (Lange et al., 2012). Almost all of households of Hebron district have their own reinforced concrete cisterns to collect rainwater from the roofs of their houses during the rainy season to use it during the dry seasons (Al-Salaymeh et al., 2011).

Yatta has been connected to a water network since 1974, serving nearly 85% of the households. The water network is old and inadequate to meet current population needs. Despite the annual maintenance of the water network, the major problems are water losses due to deficiencies in the network, reduction of pumped water from the source, and the uneven distribution within the network which does not satisfy the population's needs. About 25–30% of the town's neighborhoods are not connected to the municipal water network, which creates a large demand on water distribution tankers. The tankers provide water with a lower quality than that of municipal water while costs reach up to 400% of the price of municipal water. As a result, people tend to depend on rainwater harvesting (RWH) cisterns, and almost all households in Yatta area have between 1 and 4 RWH cisterns as water quantities from the network is estimated to be around 20 L per capita per day (Al-Batsh, 2016). It is worth mentioning that the harvested rainwater in Yatta area is used mainly for drinking, in addition to other domestic uses.

The decay of ^{238}U results in the production of gaseous radon (^{222}Rn) which is soluble in water. Water supply behaves as a vector for the entrance of radon to homes. This helps to increase the concentration of radon, especially in enclosed places, especially during the cold seasons. So radon emitted from the water to indoor air constitutes an important and effective source of exposure to internal radiation (Nevinsky et al., 2015). Typically radon enters the human body through inhalation of air from the closed areas or drinking water (Mittal et al., 2016). This accounts for around 50% of all radiation of exposure (ICRP , 1993). The radon gas itself does not constitute a health concern, but its decay products include short-lived daughter α emitters (Cross et al., 1985). A large amount of energy is discharged in connection with α-particle emission. This energy and α- particles have propensity to destroy tissue and has a long term effect on the DNA, becoming a significant role in the end in the incidence of gastric cancer and lung cancer (USEPA, 1991; Ravikumar and Somashekar, 2014; Todorovic et al., 2012;

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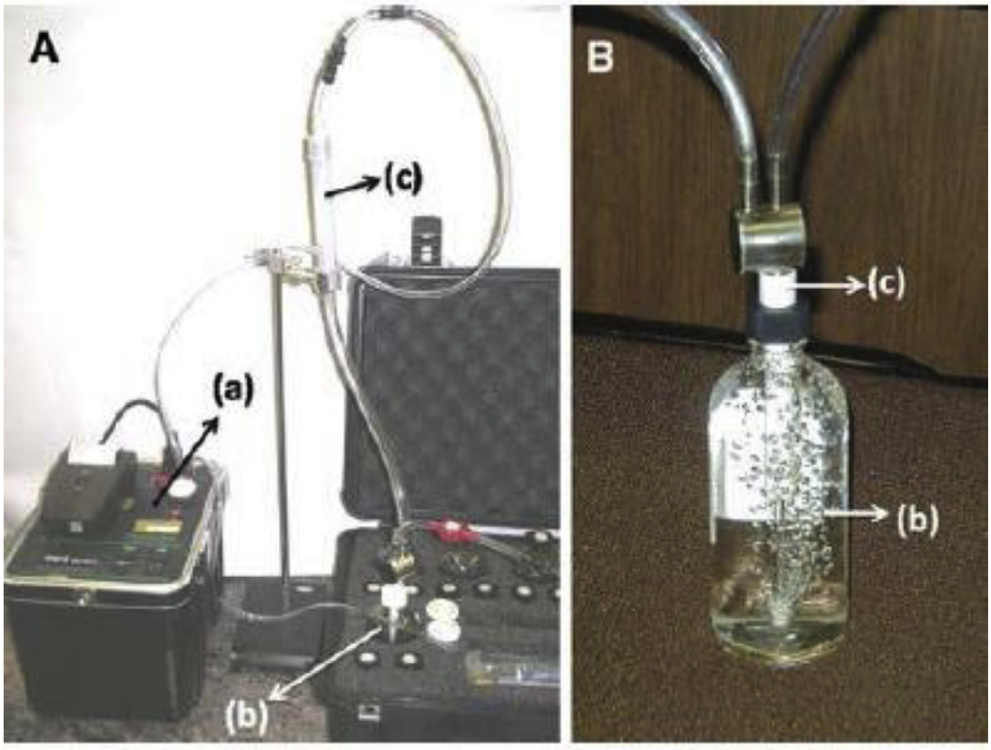

Fig. 1. Radon-in-air monitor RAD-7. Adapted from reference (DURRIDGE Company Inc., 2015) with permission.

Fonollosa et al., 2016).

In a study conducted in Calcutta, India, it was noted that the maximum radon activity could be associated with scant and isolated rainfalls. The radon activity rapidly diminished with the amount of rainfall. It was also noted that for equivalent rainfalls the radon activity of nocturnal rain was usually less than that of diurnal rains, confirming the diurnal variation of the radon content in the atmosphere (Banerji and Chatterjee, 1964).

Rainwater can be intensely radioactive due to high levels of radon and its decay progenies ^{214}Bi and ^{214}Pb. The highest levels of radon in rainwater occurs during thunderstorms, and it is hypothesized that radon is concentrated in thunderstorms on account of the atom's positive electrical charge (Yamazawa et al., 2008; Greenfield et al., 2008).

At the level of the world, it is estimated that the average annual effective dose is 1.2 mSv due to inhalation of thoron, radon and their decay products (Ahmad et al., 2014, 2015; UN, 2000).

Measurements of radon in HRW are seldom performed or presented in the literature, as most of developed countries do not use HRW for drinking, while researchers in underdeveloped countries may not have access to active radon measurements (RAD7). This paper presents the results of a survey on the concentrations of radon in harvested drinking water in rainfed cisterns at the household level in Yatta area, southern West Bank of Palestine. The primary objective of the survey was to determine the range of radon levels in the harvested rainwater and thereby establish whether or not there is an increased exposure to radon in Yatta area compared to the permissible exposure limits.

2. Materials and methods

2.1. Study area

The Yatta area includes Yatta town and many villages surrounding it. Yatta town is located in the Hebron governorate, 9 km south of Hebron city in the southern part of the West Bank of Palestine. The town is located on a mountainous area at an elevation of 793 m above sea level, with a mean rainfall of 303 mm, an average annual temperature of 18 °C, and average annual humidity of 61% (ARIJ, 2009). The 270,000,000 m^2 (270,000 dunums) are the total estimated area of Yatta town, of which 14,000,000 m^2 are classified as 'built up' area; whilst 115,000,000 m^2 are agricultural,

Table 1
Activity concentrations of ^{222}Rn in harvested rainwater in cisterns in Yatta area, Palestine.

Locality	Number of samples	^{222}Rn Concentration (Bq/L)	
		Mean ± SD	Range
Kheroshewesh Wal Hadedeyah	15	0.14 ± 0.06	0.04–0.22
Al Heila	15	0.17 ± 0.06	0.04–0.25
Om Ashoqhan	15	0.12 ± 0.04	0.04–0.21
Yatta	15	0.10 ± 0.04	0.04–0.19
Khallet Salih	15	0.15 ± 0.06	0.04–0.26
Om Al Amad (Sahel Wadi Elma)	15	0.16 ± 0.05	0.05–0.22
Total	90	0.14 ± 0.06	0.04–0.26