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Radon levels in drinking water and soil samples of Jodhpur and Nagaur districts of Rajasthan, India

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HIGHLIGHTS

- Radon Concentration was studied in water and soil samples.
- All the samples were characterized by RAD7.
- Total annual effective dose for the studied water samples were within safe limit.
- Radon risk estimation of soil varies with permeability and radon concentration of soil.

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ABSTRACT

Radon causes lung cancer when it is trapped inside the lungs. Therefore it is very important to analyze the radon concentration in water and soil samples. In the present investigation, water and soil samples collected from 20 different locations of Jodhpur and Nagaur districts of Northern Rajasthan, India have been studied by using RAD7. The measured radon concentration in water samples varies from 0.5 to 15 Bq l^{-1}. The observed values lie within the safe limit as set by UNSCEAR, 2008. The total annual effective dose due to radon in water corresponding to all studied locations has been found to be well within the safe limit of 0.1 mSv y^{-1} as recommended by World Health Organization (WHO, 2004) and European Council (EU, 1998). The measurements carried out on radon concentration in soil samples reveal a variation from 1750 to 9850 Bq m^{-3}. These results explore that the water of Jodhpur and Nagaur districts is suitable for drinking purpose without posing any health hazard but soil hazards depend upon its permeability and radon concentration.

1. Introduction

The radon (^{222}Rn) isotope is one of the byproduct of U-238 decay process which is commonly present in soil and water. The radon (^{222}Rn) is observed in gaseous state, which becomes a source of internal and external exposure. The radon can easily enter in our homes by means of soil and water supplies, which elevates radon level in indoor air. But as compared to water, the soil is a major factor by which the radon enters our home through cracks, holes in the floor and walls. So radon emitted from soil is the main cause of health problem. The radon released from water and soil to indoor air is an effective source of internal radiation exposure. It usually enters human bodies by ingestion of drinking water or by inhalation from indoor air. According to International commission of radiation protection report it is about 55% of all type of exposure (ICRP, 1993).

The radon gas in its as such state do not causes any health risk (Cross et al., 1985) till it decays to short lived daughter products by emitting α-partial. But if radon gas enters in lungs/stomach by inhalation/ingestion and resides with in the body for a time longer than its half life, it decays to short live solid progenies. During the radon decay and by further decay of solid progenies a large amount of energy is released in association with α-particle emission. This energy and α-particles have tendency to damage tissues and may causes long term effect on DNA, it finally becomes a vital reason of lung and stomach cancer (USEPA, 1991).

The diffusion of radon from the soil to air depends on natural radionuclides (uranium and radium) concentration present in soil and rocks. In the Jodhpur and Nagaur districts of Northern Rajasthan, India the high activity concentration of natural radionuclides has been reported (Rani et al., 2015). The concentration of radon in soil and water is observed proportional to radium

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concentration at a particular place. Hence the measurement of radon concentration in water and soil samples of Jodhpur and Nagaur districts of Marwar region of Northern Rajasthan, India assumes significance. Such study will be helpful in determining whether the soil and water of these districts can be used for construction and drinking purposes without posing any health hazard to the inhabitants. However literature survey shows no attempt has been made towards the measurement of radon concentration in water and soil in Jodhpur and Nagaur districts of Northern Rajasthan, India. In the present study, radon concentration in water and soil from Jodhpur and Nagaur districts of Marwar region of Northern Rajasthan, India has been investigated systematically.

2. Geology of the area

Rajasthan is located in North-West part of India. It lies between 23°30′ and 30°11′ north latitude and 69°29′ and 78°17′ east longitude. Fig. 1 shows the geographic location of Rajasthan in India, as well as the location of the sampling sites.

The Jodhpur district in the present work is located in western part of Rajasthan and is enclosed between 26°00′ and 27°37′ latitude and 72°55′ and 73°55′ longitude. It shares common border with five districts namely Bikaner, Jaisalmer in north and north-west, Banner and Pali in South West and South East and Nagaur in East-North. This area is covered by Hillocks rocks, Luni-Jawa Plains, Sukri and Jojri rivers. The rocks of the area contain sandstone, limestone and granite. The major minerals found in this district are Jasper, Dolomite and Ball clay. The geological configuration of Jodhpur district is represented by rocks ranging from Pre-Cambrian to recent in age. The lithounits consist of igneous, sedimentary and metamorphic units (CGWB Jodhpur, 2013a).

The Nagaur district falls almost in the central part of Rajasthan. The district is expanded between latitudes 26°02′ and 27°37′ and longitudes 73°05′ and 75°24′ and comprises a major part of Thar Desert, India. The boundary of this region is shared by seven districts of Rajasthan viz.-Jaipur, Ajmer, Pali, Jodhpur, Bikaner, Churu and Sikar. This district is well known over the world map owing to producing the Makrana marble. It is covered by the Delhi super group rocks, Erinpura granite, Malani igneous suite, Marwar super group rocks and Jogira fuller's Earth/Kuchera Khajuwana series rocks. Moreover, the lake containing highest content of salt; the Sambhar Lake is also located in Nagaur District. The minerals

Fig. 1. The map showing the sample locations in Northern Rajasthan.

abundantly found in this region are limestone, lignite, gypsum and marble. The soil found in these two districts is mostly comprised of clay, clay loam, sandy loam and sandy soil (CGWB Nagaur, 2013b).

3. Experimental detail

The radon concentration in water and soil samples of 20 different locations in Jodhpur and Nagaur districts of Northern Rajasthan has been measured with active RAD7 radon detector by using it in different modes (RAD7 User Manual, 2013). The capacity of internal sample cell of RAD7 was 0.7 l hemisphere shape which was coated inside with an electrical conductor. A solid state silicon semiconductor alpha detector has been placed at the center of the hemisphere to convert the alpha radiation directly in to an electrical signal. The inside of the conductor has been charged to a very high potential of 2000–2500 V with the help of high voltage power circuit, relative to the detector which created a very high electric field throughout the volume of the cell. The created electric field propels positive charge particle onto the detector, henceforth the alpha particle has been detected by detector.

The RAD7 is equipped with desiccant ($CaSO_4$) to control the relative humidity. Moreover, an inert filter with pore size 1 μm has been used to block the fine dust particles and all radon daughters from entering the RAD7 test chamber. The instrument was calibrated according to Environmental Protection Agency (EPA) recommendations.

3.1. Measurement of radon concentration in water

Fig. 2 shows the schematic diagram of RAD7-H_2O assembly. It is connected to RAD7 electronic radon detector for the measurement of radon in water samples. The water samples collected in a radon tight regent bottle having 250 ml capacity has been henceforth attached with RAD7 detector through a bubbling kit. The bubbling kit has ability to degas the radon from water samples and makes a close loop circulation of radon gas between the RAD7 detector and regent bottle. A glass blub containing $CaSO_4$ desiccant is connected in between which helps to absorb moisture and reduces the relative humidity. To find the accurate results a total of four observations each for 5 min have been carried out through the RAD7-H_2O assembly. The WAT 250 protocol and grab mode of the instrument were used for this measurement.

3.2. Measurement of radon concentration in soil

Fig. 3 shows the schematic diagram of RAD7 soil gas setup. For the measurement of ^{222}Rn concentration in soil gas, a pilot iron rode was firstly driven into the soil with strokes of hammer up to the sampling site of specific depth of one meter. Thereafter, it was removed by leaving a hole in the soil. An assembly of stainless steel probe having iron rode within it, has been inserted with in this hole by gentle hammering up to the specific depth of one meter. After successfully insertion the iron rode was removed and the probe was then connected to RAD7 detector through desiccant tube containing $CaSO_4$. The soil gas was now sucked by RAD7 from the deep soil through the hole present at the tip of the stainless steel probe. The hole was properly sealed around the probe so that the soil gas could not mix with the fresh air. The soil gas sucked is allowed to pass through the instrument for 5 min observation. A total four such cycles were run each for 5 min to obtained accurate results. Sniff protocol and grab mode were used for the analysis of the radon concentration in the soil samples.