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Radon exhalation rates from stone and soil samples of Aravali hills in India

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Background: The most popular building materials are soil bricks and different types of stones. Radon is released into ambient air from soil and stones due to ubiquitous uranium and radium in them, thus increasing the airborne radon concentration. The radioactivity in soils is related to radioactivity in the rocks from which the soil is formed. In the present investigation, the radon emanated from soil and stone samples collected from different locations of Aravali range of hills in the Haryana state of Northern India has been estimated. ***Materials and Methods:*** For the measurement of radon concentration emanated from these samples, alpha-sensitive LR-115 type II plastic track detectors have been used. The alpha particles emitted from the radon form tracks in these detectors. After chemical etching the track density of registered tracks is used to calculate radon concentration and exhalation rates of radon using required formulae. ***Results:*** The radon concentration in stone samples collected from Aravali range of hills varied from 729 Bq m^{-3} to 1958 Bq m^{-3} with an average of 1440 ± 134 Bq m^{-3} whereas it varied from 806 Bq m^{-3} to 1325 Bq m^{-3} with an average of 1040 ± 101 Bq m^{-3} in case of soil samples. Based upon the data, the mass and the surface exhalation rates of radon emanated from them have also been calculated. ***Conclusion:*** The measurements indicate normal to some higher levels of radon concentration emanated from the samples collected from Aravali range of hills of north India. **Iran. J. Radiat. Res., 2011; 9(1): 57-61**

Keywords: *Radioactivity, radon concentration, nuclear tracks, exhalation rates, stone, soil.*

INTRODUCTION

The radioactive decay of naturally occurring uranium in the earth's crust leads to radon in the environment, soil, ground water, oil and gas deposits. This way it contributes the largest fraction of the natural radiation dose to populations, and therefore tracking its concentration is fundamental for radiation protection. ^{222}Rn, one of three isotopes of radon- ^{219} Rn (actinon), ^{220}Rn (thoron) and ^{222}Rn (radon) is an a-emitter that decays with a half-life of 3.82 days into a series of radon progeny. Radon being eight times heavier than air, it travels low to ground and deposits its daughters in the form of a solid radioactive fallout on the vegetation, soil and water. These radioactive particles enter the food chain, ending up in fruits, the flesh of fish and animals and hence ultimately in the bodies of human beings. Also, the decay products of radon can attach to the surface of aerosols, dust and smoke particles which may be inhaled become deeply trapped in the lungs. Therefore, the exposure of population to high concentrations of radon and its daughters for a long period leads to pathological effects like the respiratory functional changes and the occurrence of lung cancer (1).

When a radon atom is produced inside a grain of a porous material it can escape from this grain by at least two mechanisms: i) Due to recoil, the radon atom receives a momentum, which enables it to travel a certain distance trough a material. ii) Radon atoms not escaping the grain by recoil may still be able to leave the material by diffusion. This involves diffusion through a solid structure for which diffusion coefficients will be small and only atoms close to the surface may stand a chance to escape. The radon released from the grain by recoil may be embedded in adjacent grains and may no longer be available for transport. The fraction of radon atoms generated in the soil grains and reaching the pore volume of the soil is known as the

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emanation coefficient. This coefficient depends basically on the soil grain size-distribution, the porosity and the water content. The geometry, the size of soil grains and the pores determine the 'static' emanation coefficient in the sense that they do not change with time. So the type of soil determines the general radon level in the soil.

The water content has a large impact on the emanation coefficient and on the soil transport parameters for radon gas and therefore affects the radon concentration in the soil. Another effect of moisture is that a sudden increase in humidity may result in a transient increase of radon emanation due to adsorption of water molecules on the grain surfaces, these molecules will compete with radon atoms for adsorption sites and thus lead to an increase in emanation. Besides moisture, temperature also has been reported to influence radon emanation. The amount of radon at the solid surface is determined by the interplay of adsorption and desorption. If the temperature of the material is increased, the probability of desorption will increase and thus the total amount of radon adsorbed will decrease. A sudden change in temperature may thus result in a short extra release of radon [(2)]. Emanation of radon in rocks is promoted by a geological process that form mylonites which is rock type textural that develops as a result of ductile shear in which temperature is above 250° C. During ductile shear the rock behaves plastically rather than by fracturing, which is considered brittle shear. The development of a mylonite involves changes in the microstructures, porosity, permeability and the chemical composition of the parent rock. These changes can influence the mobility and concentration of uranium and may promote the emanation of radon.

In the present work, we report on the estimation of radon emanated from stone samples collected from different parts of Aravali range of hills in the Haryana state of Northern India. Some soil samples were also collected from the stone crushing zones situated nearby area of Arvali hills to observe the effect of stone dust on the radioactivity of the soil. The radon concentration emanated from stone and soil samples has been reported. The aim of study is the possible health risk assessment in the area associated with the radon activity.

Geography of the area under study

As a geographical unit, Haryana is situated in India's northwest between 27^0 37´and 30^0 35´ Northern Latitude and 74^0 28´ to 77^0 36´ East Longitude. Haryana can be subdivided into two natural areas, sub-Himalayan terrain and the Indo-Gangetic planes. The plane is fertile and height above sea level is 700-900 ft. The slope is from north to south. The climate of Haryana is of pronounced character, very hot in summer and markedly cold in winter. The maximum temperature recorded in the month of May and June may be 46^0C while it goes even upto 48^0C in the area of study. The state is bounded north by Himachal Pradesh, east by Uttar Pradesh, south and west by Rajasthan and northwest by Punjab. Delhi forms an enclave on its eastern boundary. Mountain hills are Shivalik hills in the north and Aravali hills in the Southwest. Mines and minerals found in Haryana are Limestone, Slate stone, Dolomite, Building stone, China clay and marble. Granite and quartzite have also been found at several places. The present study is confined to Aravali range of hills of the state, situated along south west of the Haryana state and adjacent to the state of Rajasthan. The sample collection sites have been shown in figure 1.

MATERIALS AND METHODS

For the measurement of radon concentration, can technique have been used [(3)]. Different samples of stones and soils based on their different colours and physical appearance were collected from each site. A known amount (0.10 kg) of stone and soil

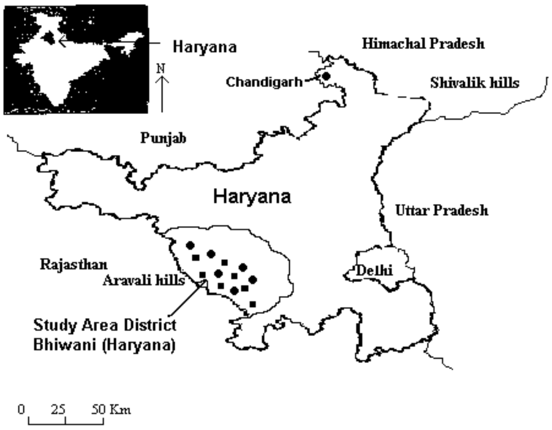

Figure 1. Stones and Soil samples collecting sites.

samples (crushed, filtered through a sieve and oven dried) were placed in plastic cans. LR-115 type-II plastic track detectors were fixed on the bottom of the lid of each can with tape such that sensitive side of the detector faced the specimen. The cans were tightly closed from the top and sealed. The geometrical parameters of the detectors were: LR-115 type- II plastic track detectors (1cm×1cm).

The exposure time of the detectors was 100 days. At the end of the exposure time, the detectors were removed and subjected to a chemical etching process in 2.5N NaOH solution at 60^0C for one and half-hour. The detectors were washed and dried. The tracks produced by the alpha particles, were observed and counted under an optical Olympus microscope at 600X. The measured track density (Track/cm^2/day) was converted into radon concentration in Bq/m^3 using calibration factor [4-5].

The equations used for exhalation rates are [6-7].

$$E_x = \frac{CV\lambda / M}{T + 1/\lambda(e^{-\lambda T} - 1)}$$ (Bq Kg^{-1} h^{-1}) for mass exhalation rate (1)

$$E_x = \frac{CV\lambda / A}{T + 1/\lambda(e^{-\lambda T} - 1)}$$ (Bq m^{-2} h^{-1}) for surface exhalation rate (2)

Where:

C = Integrated radon exposure (Bq m^{-3} h^1)
M = Mass of sample (Kg)
V = Volume of air in can (m^3)
T = Time of exposure (hrs)
λ = Decay constant for radon (h^{-1})
A = Area covered by the can or Surface area of the sample (m^2).

RESULTS AND DISCUSSION

The calculated values of radon concentration in stone samples collected from Aravali range of hills from the state of Haryana (North India) varied from 729 Bq m^{-3} to 1958 Bq m^{-3} with an average of 1440 ± 134 Bq m^{-3} (table 1). The values of radon concentration in soil samples varied from 806 Bq m^{-3} to 1325 Bq m^{-3} with an average of 1040 ± 101 Bq m^{-3} (table 2). In a similar study Gabin [8] found that the grinding of grains increases specific surface, decreasing specific radioactivity. The mass and the surface exhalation rates of radon were also calculated for all types of samples as shown in table 1 and 2. It can be seen from the results that the radon concentration varies appreciably in various samples. It is due to the fact that the soil and stone samples collected from various sites may have appreciably large uranium contents which results in higher radon emanation rates [9].

The measurements indicate normal to some higher levels of radon concentration emanated from stone and soil samples collected from Aravali range of hills of north India. The levels are higher in some granite diorite and granite samples compared with other white stones. It may be due to higher radium and uranium contents in them. In similar studies [10-12] radon activity and exhalation rates for different Indian samples and dwellings have been calculated. For stone samples, they reported the radon concentration from 472 Bq m^{-3} to 905 whereas in soil samples the variation was from 246 Bq m^{-3} to 453 Bq m^{-3}. In present study all the samples were collected from Aravali ranges and are showing some higher levels compared with earlier studies, which indicates the presence of higher uranium contents in the area.

Table 1. Radon concentration and exhalation rates in some stone samples from Aravali range of hills in India.

Samle codes	Geological names	Radon concentration (Bq m^{-3})	Mass exhalation rates (mBq kg^{-1} hr^{-1})	Surface exhalation rates (mBq m^{-2} hr^{-1})
ST-1	Granite Igneous rocks	1670	60.6	1327
ST-2	Granite with pheno crystal of orthpclobe	1843	66.0	1444
ST-3	Granite	1593	59.0	1292
ST-4	Granite weathered	1766	86.7	1517
ST-5	Granite diorite	1958	72.6	1587
ST-6	Quartzite	1497	56.6	1238
ST-7	Meta sand stone	729	27.6	609
ST-8	Granite coarse grain	1421	68.4	1197
ST-9	Syenite	845	31.3	685
ST-10	Mixture of stones	1075	37.8	828
	AM ± SE*	1440 ± 134	56.6 ± 6.0	1172 ± 110

Table 2. Radon concentration and exhalation rates in some soils and mixtures of stones from aravali range of hills in India.

Samle codes	Geological names	Radon concentration (Bq m^{-3})	Mass exhalation Rates (mBq kg^{-1} hr^{-1})	Surface exhalation Rates (mBq m^{-2} hr^{-1})
S-1	Surface soils	864	24.8	528
S-2		979	28.6	599
S-3		806	23.1	493
STM-1	Mixtures of soil and stones	1325	50.5	1106
STM -2		1228	46.0	1006
AM ± SE*		1040 ± 101	34.6 ± 5.7	746 ± 128

* SE (standard error) = s/√ N, Where s is SD (standard deviation) and N is the no of observations.

CONCLUSION

The measurements indicate normal to some higher levels of radon concentration emanated from stone and soil samples collected from Aravali range of hills of north India. Out of different samples under study the levels are higher in some granite diorite and granite samples compared with other white stones. The exposure of soil to stone dust also increases the activity of soil samples (figure 2).

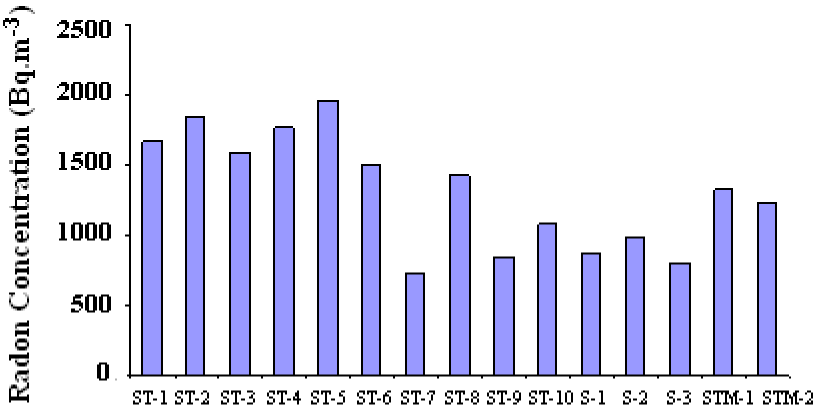

Figure 2. Radon levels in different types of stone and soil samples.

REFERENCES

1. BEIR VI, Report of the Committee on the Biological effects of Ionizing Radiation (1999) Health Effects of Exposure to Radon. *Natl. Res. Council. Natl. Acad. Press, Washington, DC.*
2. Mazur J, Kozak K, Horwacik T, Haber R, Zdziarski T (2004) Influence of meteorological conditions on radon measurements in soil-Preliminary results. *In the proceedings of NORM IV conference Szczyrk, Poland. 77-78.*
3. Abu-Jarad F (1988) Application of Nuclear Track Detectors for radon related measurements. *Nucl Tracks Radiat Meas, **15:** 525-534*.
4. Deka PC, Bhattachargee BK, Sharma BK, Goswami TD (2001) Measurement of Indoor Radon Progeny Levels in Some Dwellings of North Kamrup in Brahamputra Valley Regions of Assam. *Indian J Environmental Protection, **21:** 24-28.*
5. Jojo PJ, Rawat A, Prasad R (1994) Enhancement of trace Uranium in fly ash. *Nucl Geo Phys, **8:** 55-61.*
6. Abu-Jarad F, Fremlin JH, Bull R (1980) A Study of radon emitted from building materials using SSNTD. *Phys Med Biol, **25:** 683-694.*
7. Khan AJ, Tyagi RK, Prasad R (1992) Measurement of radon exhalation rates from some building materials. *Nucl Tracks Radiat Meas, **20:** 609-610.*
8. Gablin G (2004) Grain size in radiometric measurements of ground. *In the proceedings of NORM IV conference Szczyrk, Poland. 101-102.*
9. El-Bahi SM (2004) Assesment of radioactivity and radon exhalation rate in Egyptian cement. *Health Physics, **86:** 517-522.*
10. Chauhan RP and Chakarvarti SK (2002) Radon Exhalation rates from soils and stones as building materials. *Indian Journal of Pure & Applied Physics, **39:**491-495*.
11. Nain M, Chauhan RP, Chakarvarti SK (2006). Alpha radioactivity in Indian cement samples. *Iran J. Radiat Res*, **3**: *1 71-176.*
12. Kant K, Rashmi, Sonkawade RG, Sharma GS, Chauhan RP, Chakarvarti SK (2009) Seasonal variation of radon, thoron and their progeny levels in dwellings of Haryana and western Uttar Pradesh. *Iran J Radiat Res*, ***7:** 79-84.*