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Short Communication

Radon activity and the radiation dose levels in the slate mines in aravali range in India

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Radon activity measurements in slate mines in the aravali range in Haryana were carried out from radiation protection point of view of the occupational workers and general public. For the measurement, alpha sensitive LR-115 type II plastic track detectors (solid state nuclear track detectors) were used. Results of various measurements of the radon activity and inhalation dose received by the workers have been reported. The radon activity and the annual inhalation dose in the environment of various slate stone mines in Haryana varied from 21 Bq m^{-3} to 113 Bq m^{-3} with an average of 38.5 ± 5.8 Bq m^{-3} and 0.37 mSv to 1.94 mSv with an average of 0.66 ± 0.10 mSv respectively. Seasonal variation of radon activity has also been studied and reported.

Key words: Radon, inhalation dose, environment, mine, aravali range.

INTRODUCTION

Human population is always exposed to ionizing radiation from natural sources. Natural radioactivity is wide spread in the earth's environment and it exists in various geological formations in soils, rocks, plants, water and air (Ibrahiem et al., 1993; Aly et al., 1999; Malance et al., 1996). Natural radioactivity in the environment comes from soils which contain ^{238}U and ^{232}Th series and natural ^{40}K. The environmental radioactivity built up in the environment leads to the radiation exposure of both humans and biota (plants, animals, etc.). The radiation exposure of humans and biota may result in adverse health effects. Radon, a progeny of ^{238}U formed from the radioactive decay of radium, is a colourless, odourless, electrically uncharged noble but hazardous gas which is radioactive and emits alpha radiation has been found to be a ubiquitous air pollutant to which all persons are exposed (Cole, 1993; Proctor, 1995) and it has been estimated that the radon, largely in homes and at workplace, constitutes more than 50% of the dose equivalent received by general population from all sources of radiation, both naturally occurring and man-made (Beir, 1990). It is present in trace amounts almost everywhere (indoor and outdoor) on the earth and its concentration in the atmosphere varies, depending on the place, time, and height above the ground and meteorological conditions. It is well known that exposure of population to high concentrations of radon and its daughters for a long period lead to pathological effects like the respiratory functional changes and the occurrence of lung cancer (Beir, 1999). Alpha radiation emitted by radon being densely ionizing (high LET) has the potential to damage the DNA of the lung cells. The damage being localized to lung cells, the lung cancer is the only potential hazard posed by radon in indoor air. Measurement of Radon (^{222}Rn) and its progeny Concentration is fundamental as it poses grave health hazards not only to uranium miners but also people living in normal houses and buildings and at work place in mining and milling industry (Jakupi et al., 1997; Duenas et al., 1999).

In slate mines, mining of slate stone is being carried out since long and a large number of workers are involved in this industry. Slate stone is technologically important material being used in houses in flooring and on walls. It is also used as slate by school children for writing purpose. The increased interest in measuring radon concentration in the environment of slate mines is due to its health hazards and environmental pollution and is of concern with the control and minimization of such radiation exposure.

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Table 1. Radon activity and annual effective dose in the environment of slate mines in aravali range in Haryana (India).

Location of mine	Radon activity, EEC_{Rn} (Bq/m^3) Max Min AM ± SE*			Annual inhalation dose (mSv) Max Min AM ± SE*		
Mahu	95	24	46.7 ± 5.7	1.63	0.41	0.80 ± 0.10
Nahrika	101	21	43.2 ± 8.4	1.74	0.37	0.74 ± 0.14
Chitora	113	22	52.2 ± 6.4	1.94	0.38	0.90 ± 0.11
Ghimravat	88	33	38.5 ± 5.8	1.52	0.57	0.66 ± 0.10
Kheri Kalan	103	33	41.8 ± 4.5	1.78	0.58	0.72± 0.08

Table 2. Seasonal variation of radon activity in the environment of slate mines in aravali range in Haryana (India).

Slate Mine	Radon concentration (Bq/m^3) Average± SE*			
	(Nov-Feb)	(Feb-May)	(May-Aug)	(Aug-Nov)
Mahu	46.7 ± 5.7	41.1 ± 7.9	35.7 ± 6.4	42.1 ± 4.6
Nahrika	43.2 ± 8.4	39.8 ± 4.6	31.3 ± 4.6	41.3 ± 6.2
Chitora	52.2 ± 6.4	50.5 ± 5.0	39.2 ± 4.7	34.2 ± 7.3
Ghimravat	38.5 ± 5.8	32.3 ± 4.1	39.4 ± 4.1	35.1 ± 4.5
Kheri Kalan	41.8 ± 4.5	37.8 ± 9.4	39.7 ± 8.0	34.3 ± 9.6

*SE (standard error) = $\sigma/\sqrt{N}$, Where σ is SD (standard deviation) and N is the no. of observations.

exposure. In the present work we report on the estimation of radon activity and radiation dose levels in environment of slate-stone mines in the Aravali Range (Haryana), India (Table 1).

MATERIALS AND METHODS

For radon activity measurements in the environment of mines, LR-115 plastic track detectors (2 x 2 cm) sizes, (strippable) were exposed in the ambient air for 90 days at different locations. The detectors were fixed on microslides and the height of detectors was kept about 2 m from ground in most of the cases. To minimize the dust load, which could otherwise affect the radon progeny estimates, the bare mode exposure was carried out in a plane vertical to the ground. The exposed detectors were retrieved and etched in 2.5 N, NaOH (sodium hydroxide) solution in an etching bath with a magnetic stirrer at a temperature of 60 ± 1°C for a period of 75 min for developing the tracks recorded and registered in the films. The etching process removes a bulk thickness of 4 μm leaving a residual detector thickness of 8 μm and records alpha particles with 100% efficiency. The detectors are then washed in triple distilled water and deionized water in succession. During washing, Teflon coated long tweezers are used to handle these detectors. The detectors having a residual thickness of 8 μm after etching are peeled off from their plastic bases and the tracks are registered with spark counter. The spark counter is pre-sparked at a voltage of 900 V and is operated at 450 V. Its design characteristics are similar to the one discussed by Garakani (1989). The measured track density (Track/cm^2/day) was converted into radon activity (EEC_{Rn}) in Bq/m^3 by using a calibration factor of 0.02 tracks/cm^2/d/Bqm^{-3} (Eappen and Mayya, 2004).

The indoor equilibrium factor is 0.4 (UNSCEAR, 2000).

The annual inhalation dose from radon was calculated according to ICRP Publication (1993).

$D = (C \times K \times H) / (3700\ Bq/m^3 \times 170\ h)$, where:

D – Annual inhalation dose (mSv/y).

C – Equilibrium Equivalent Concentration, EEC_{Rn} (Bq/m^3).

K – ICRP dose conversion factor (5 mSv WLM^{-1} for occupational workers and 3.88 mSv WLM^{-1} for general public).

H – Annual occupancy at the location.

2160 h for workers and 7000 h for residents (80% of the total time)

170 is the exposure hours taken for WLM (ICRP, 1993).

RESULTS AND DISCUSSION

The radon activity and the annual inhalation dose in the environment of various slate stone mines in Haryana varied from varied from 21 - 113 Bq m^{-3} with an average of 38.5 ± 5.8 Bq m^{-3} and 0.37 - 1.94 mSv with an average of 0.66 ± 0.10 mSv respectively. In the measurements, we find that radon activity is moderate to high at various locations in the slate-stone mines. This indicates that at certain locations, the inhalation dose is almost 100% more than that the recommended safety limit for general public (ICRP 1993) and marginally below the global average value (UNSCEAR, 2000). Table 2 shows the seasonal variation of average values of radon levels measured in different slate mines. The measured radon and its progeny levels were higher in winter (November to February) than in summer (May to August). It is because of the lower exchange rate of air in winter, as the windows are kept closed. The decrease of radon concentration in monsoon season is due to the fact that the soil is saturated with water (Grasty, 1994). Necessary steps should be taken to minimize the adverse effects on the environment from slate stones and stone dust. In the light of these findings, the slate stones and stone dust may affect doses from external irradiation and the inhalation of radon decay products is significant from health point of view.

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