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An analysis of naturally occurring radioactive materials in the selected areas of Kashmir

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Abstract
The present study was intended to explore the naturally occurring radioactive materials in the selected areas of Kashmir Division. The study was carried out in with the help of experimental method. SSNTDs in track etch technique has been used in the present study due to their simplicity, low cost, non-destructive, small size, and having integrating capability for large scale studies for the measurement of radon activity, and radon exhalation rates studies in various samples. In the present investigations the observed values of mass exhalation rate and surface exhalation rate in soil and sand samples are usually less, comparable with other Indian studies reported for soil and sand samples of nearby areas, except for Rajpora area which shows high mass exhalation rate.

Keywords: Radioactive materials, Kashmir

Introduction
Radioactivity in the environment is the biggest concern for the human beings. Due to unawareness about it, this becomes a potential risk for living things. In 1956 a term "Radiation Ecology" came into existence to denote this area of the broad field of ecology concerned with the assessment of radioactivity in the environment. The development and subsequent expansion of nuclear energy for military and peaceful purposes has been accompanied by environmental problems. The problems are primarily concerned with the ecological effects of radionuclides released into the environment, effects of ionizing radiation on man, his domesticated plants and animals. The major environmental problems introduced by the atomic age may be grouped into several areas of scientific and public concern. The radioactivity can be described as natural radioactivity due to existence of naturally-occurring radioactive elements and artificial radioactivity due to man-made sources of radiation in the environment. Natural radioactivity is common in the rocks, soil, water, oceans that make up our planet and in our building materials. The world is naturally radioactive, and around 90% of human radiation exposure arises from natural sources such as cosmic radiations. The naturally-occurring radionuclides of interest are uranium, thorium, actinium series elements ^{40}K and ^{14}C. These radionuclides are of main concern due to their relative long half-lives and are principal sources of exposure of natural radiation. Since these radionuclides are not uniformly distributed, the knowledge of radionuclides distribution and radiation levels in the environment is important for assessing the effects of radiation exposure to human beings. Natural radioactivity is widespread in the earth's environment and it exists in various geological formations in soils, rocks, plants, water and air (Ibrahiem *et al*., 1993; Aly Abdo *et al*., 1999) [9]. Some of the radionuclides from these sources may be transferred to human beings through food chain or inhalation. The reports on radioactivity levels of soil and rocks is limited in India (Chauhan RP. (2011) [25], Catelinois O. (2007) [24], Bochicchio F. (2005) [20], Badhan K, Mehra R, Sonkawade RG. (2012) [14] and Alter HW (1981) [8] and hence the present study was undertaken to determine radioactivity levels at different locations and materials used in Pulwama of J&K UT districts and to evaluate the radiological risk to inhabitants. Systematic studies on the natural radiation level and radionuclide distribution in the environment of Pulwama district of Kashmir division have been carried out under following objectives.

Objectives of the research

The present study would have the following objectives:-

1. To find out the naturally occurring radioactivity metals in district Pulwama of J&K UT.
2. To identify the Geographical areas based on extent of Radioactivity.
3. To identify the safe and unsafe area in district Pulwama of J&K UT based on Radioactivity status.

Methodology and procedure

SSNTDs in track etch technique has been used in the present study due to their simplicity, low cost, non-destructive, small size, and having integrating capability for large scale studies for the measurement of radon activity, and radon exhalation rates studies in various samples.

Analysis of the data

Radon Exhalation Rates for Soil Samples

a) Awantipora area: The equilibrium radon concentration in various soil samples of Awantipora varied from 25.5 Bqm^{-3} to 51.9 Bqm^{-3} with an average of 38.8±1.9 Bqm^{-3}. The radon mass exhalation rates from the soil samples varied from 0.9 to 1.9 mBq/kg/h with an average of 1.39±0.1mBq/kg/h and radon surface exhalation rates varied from 20.7 to 42.3 $mBq/m^2/h$ with an average of 31.8±1.5 $mBq/m^2/h$. The radon mass and surface exhalation rates of the soil of Awantipora were lower than that of the world wide average. These values are calculated using Eqs. (4.1-4.2) and are shown in table 4.1.

b) Pampore area: The equilibrium radon concentration in various soil samples of Pampore area of district Pulwama of J&K UT varied from 12.9 Bqm^{-3} to 83.1 Bqm^{-3} with an average of 37.8±15.6 Bqm^{-3}. The radon mass exhalation rates from the soil samples varied from 0.46 to 3.0 mBq/kg/h with an average of 1.4±0.6 mBq/kg/h and radon surface exhalation rates varied from 10.5 to 67.6 $mBq/m^2/h$ with an average of 30.7±12.7 $mBq/m^2/h$. These values are calculated using Eqs. (4.1-4.2) and are shown in table 4.2.

Table 1.1: Equilibrium radon concentration, radon mass and surface exhalation rates from soil samples of Awantipora in District Pulwama of J&K UT

S. No.	Location	Equilibrium Radon conc. (Bq/m^3)	Mass exhalation rate (mBq/kg/h)	Surface exhalation rate ($mBq/m^2/h$)
1.	AW-01	34.0	1.3	30.5
2.	AW-02	49.8	1.7	40.5
3.	AW-03	29.4	1.0	23.9
4.	AW-04	31.6	1.1	25.7
5.	AW-05	40.0	1.4	32.5
6.	AW-06	35.3	1.3	28.7
7.	AW-07	25.5	0.9	20.7
8.	AW-08	42.1	1.5	34.3
9.	AW-09	33.2	1.2	27.0
10.	AW-10	42.6	1.5	34.7
11.	AW-11	48.7	1.8	39.7
12.	AW-12	51.9	1.9	42.3
13.	AW-13	40.7	1.5	33.2
14.	AW-14	43.2	1.6	35.2
15.	AW-15	36.4	1.3	29.7
16.	AW-16	36.9	1.3	30.1
AM±SE		38.8±1.9	1.39±0.1	31.8±1.5

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

*AM (arithmetic mean); SE (standard error) = $\sigma/\sqrt{N}$, Where σ is SD (standard deviation) and N is the no. of observations Where as, (PMP=Pampore)

Sr. No.	Location	Codes	Equilibrium Radon conc. (Bqm^{-3})	Mass exhalation rate ($mBqkg^{-1}h^{-1}$)	Surface exhalation rate ($mBqm^{-2}h^{-1}$)
1.	Pampore	PMP-1	12.9	0.46	10.5
2.		PMP-2	83.1	3.0	67.6
3.		PMP-3	31.4	1.1	25.6
4.		PMP-4	23.6	0.85	19.2
AM □ SE			37.8 ± 15.6	1.4 ± 0.6	30.7 ± 12.7

c) Tral area: The equilibrium radon concentration in various soil samples of Tral area of district Pulwama of J&K UT varied from 14.3 Bqm^{-3} to 40.4 Bqm^{-3} with an average of 28.8 ±4.2 Bqm^{-3}. The radon mass exhalation rates from the soil samples varied from 0.51 to 1.5 mBq/kg/h with an average of 1.0 ± 0.2 mBq/kg/h and radon surface exhalation rates varied from 11.6 to 32.9 $mBq/m^2/h$ with an average of 23.4 ± 3.5 $mBq/m^2/h$. These values are calculated using Eqs. (4.1-4.2) and are shown in table 4.3.

d) Pulwama town: The equilibrium radon concentration in various soil samples of Pulwama of J&K U. varied from 23.6 Bqm^{-3} to 38.4 Bqm^{-3} with an average of 29.8±1.8 Bqm^{-3}. Whereas mass exhalation rates from the soil samples varied from 0.85 to 1.4 mBq/kg/h with an average of 1.1±0.1 mBq/kg/h and radon surface exhalation rates varied from 19.2 to 31.3 $mBq/m^2/h$ with an average of 24.3±1.5 $mBq/m^2/h$. These values are calculated using Eqs. (4.1-4.2) and are shown in table 4.4. The radon mass and surface exhalation rates of the soil of district Pulwama of J&K UT were lower than that of the world wide average.

Table 1.2: Equilibrium radon concentration, radon mass and surface exhalation rates from soil samples of site Tral in District Pulwama of J&K UT

Sr. No.	Location	Codes	Equilibrium Radon conc. (Bqm^{-3})	Mass exhalation rate ($mBqkg^{-1}h^{-1}$)	Surface exhalation rate ($mBqm^{-2}h^{-1}$)
1.	Tral	TRL-1	26.8	0.96	21.8
2.		TRL -2	31.3	1.1	25.4
3.		TRL -3	40.4	1.5	32.9
4.		TRL -4	14.3	0.51	11.6
5.		TRL -5	31.1	1.1	25.3
AM ± SE			28.8 ± 4.2	1.0 ± 0.2	23.4 ± 3.5

*AM (arithmetic mean); SE (standard error) = $\sigma/\sqrt{N}$, Where σ is SD (standard deviation) and N is the no. of observations, Where as, (TRL =Tral)

Table 1.3: Equilibrium radon concentration, radon mass an surface exhalation rates from soil samples of Pulwama Town of J&K UT

Sr. No	Location	Equilibrium Radon conc. (Bq/m^3)	Mass exhalation rate (mBq/kg/h)	Surface exhalation rate ($mBq/m^2/h$)
1.	PLW-01	27.5	0.99	22.4
2.	PLW -02	29.8	1.1	24.3
3.	PLW -03	33.8	1.2	27.5
4.	PLW -04	37.1	1.3	30.2
5.	PLW -05	34.3	1.2	27.9
6.	PLW -06	23.8	0.85	19.3
7.	PLW -07	23.6	0.85	19.2
8.	PLW -08	24.5	0.88	19.9
9.	PLW -09	25.4	0.91	20.7
10.	PLW -10	38.4	1.4	31.3
AM ± SE		29.8 ± 1.8	1.1 ± 0.1	24.3 ± 1.5

AM (arithmetic mean); SE (standard error) = $\sigma/\sqrt{N}$, Where σ is SD (standard deviation) and N is the no. of observations Whereas, (PLW = Pulwama of J&K UT).

e) Rajpora

The equilibrium radon concentration in various soil samples of Rajpora area varied from 47.1 Bqm^{-3} to 88.3 Bqm^{-3}. Whereas mass exhalation rates from the soil samples varied from 1.2 to 3.31 mBq/kg/h and radon surface exhalation rates varied from 22.4 to 40.9 $mBq/m^2/h$. These values are calculated using Eqs. (4.1-4.2) and are shown in table 4.5. The radon mass and surface exhalation rates of the soil of Rajpora area were higher than that of the world wide average.

Table 1.4: Equilibrium radon concentration, radon mass and surface exhalation rates from soil samples of Rajpora

Sr. No.	Location	Equilibrium Radon conc. (Bq/m^3)	Mass exhalation rate (mBq/kg/h)	Surface exhalation rate ($mBq/m^2/h$)
1.	RJP-01	65.5	2.1	22.4
2.	RJP-02	76.8	1.99	37.3
3.	RJP-03	83.8	2.24	28.5
4.	RJP-04	47.1	3.31	30.2
5.	RJP-05	88.3	1.2	40.9

AM (arithmetic mean); SE (standard error) = $\sigma/\sqrt{N}$, Where σ is SD (standard deviation) and N is the no. of observations Whereas, (RJP =Rajpora)

The average equilibrium radon concentration, mass exhalation rates and surface exhalation. A comparative graph of radon concentration and exhalation rates in soil samples. The radon mass and surface exhalation rates of the soils of these districts were lower than that of the world wide average.

Conclusion and Discussion: Following important conclusions had been drawn from the study:

- For Awantipora the minimum mass exhalation rate was found to be 0.9 mBq/Kg/h for sample no. AWA-07 and the maximum mass exhalation rate was found to be 1.9 mBq/Kg/h for sample no. AWA-12.
- For Tral the minimum mass exhalation rate was found to be 0.51 mBq/Kg/h for sample no. TRL-04 and the maximum mass exhalation rate was found to be 1.5 mBq/Kg/h for sample no. TRL-03.
- For Pulwama, the minimum mass exhalation rate was found to be 0.85 mBq/Kg/h for sample no. KAK-07 and the maximum mass exhalation rate was found to be 1.4 mBq/Kg/h for sample no. KAK-10.
- For Pampore, the minimum mass exhalation rate was found to be 0.46 mBq/Kg/h for sample no. PMP-1 and the maximum mass exhalation rate was found to be3.2 mBq/Kg/h for sample no. PMP-2.
- For Rajpora area, the minimum mass exhalation rate was found to be 1.2 mBq/Kg/h for sample no. RJP-4 and the maximum mass exhalation rate was found to be 3.31 mBq/Kg/h for sample no. RJP-5.
- The equilibrium radon concentration, mass exhalation rate and surface exhalation rate are found to be minimum in the soil samples of Tral Area.
- The equilibrium radon concentration, mass exhalation rate and surface exhalation rate are found to be maximum in the soil samples of Rajpora area in comparison to the study of the other regions.
- The minimum mass exhalation rate was found to be 1.01 mBq/Kg/h (RJ-2) for sand sample of Pulwama of J&K UT and the maximum mass exhalation rate was found to be 1.29 mBq/Kg/h (MNJ-2) for sand sample of Tral.
- The radon exhalation rates of soil sample collected from the study area are nearly the same having not much

difference. The radon exhalation rates from soil samples are less than the world wide average (UNSCEAR, 2000), however the Radon exhalation rate of soil samples of Rajpora area are significantly much more than world-wide average (UNSCEAR, 2000).

- Due to less radon exhalation rate compared to worldwide average data (UNSCEAR, 2000), the 4 mentioned sites namely Tral, Pulwama, Pampore and Awantipora are safe (Least risky) for inhabiting, Agriculture purpose, Industrial setup, however the 5th site namely Rajpora, shows high radon exhalation rate thus unsafe for inhabiting, Agriculture purpose and other setups.
- The measurements indicate normal levels of natural radioactivity in sand samples of the study area with little hike in Rajpora area.
- In the present investigations the observed values of mass exhalation rate and surface exhalation rate in soil and sand samples are usually less, comparable with other Indian studies reported for soil and sand samples of nearby areas, except for Rajpora area which shows high mass exhalation rate, as shown in the table 5.1 on next page.

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