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Radium and radon exhalation studies of soil

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Background: Everyone is exposed to radon because it is present everywhere with varying concentrations. Radon and its progeny are well established as lung carcinogenic. *Materials and Methods:* Track etch technique using LR-115 plastic track detectors has been used to measure the effective radium content and radon exhalation rates in soil samples collected from urban area of Etah district of Uttar Pradesh province in Northern India. *Results:* The values of effective radium content are found to vary from 27.87 to 45.14 $Bq.kg^{-1}$ with a mean value of 34.98 $Bq.kg^{-1}$. The mass exhalation rates of radon vary from 2.38×10^{-6} to 3.86×10^{-6} $Bq.kg^{-1}.d^{-1}$ with a mean value of 2.99×10^{-6} $Bq.kg^{-1}.d^{-1}$. The surface exhalation rates of radon have been found to vary from 6.19×10^{-5} to 10.03×10^{-5} $Bq.m^{-2}.d^{-1}$ with a mean value of 7.77×10^{-5} $Bq.m^{-2}.d^{-1}$. *Conclusion:* Radon exhalation study is important for understanding the relative contribution of the material to the total radon concentration found inside the dwellings. The values of radium and radon exhalation rates are found to be below the safe limit recommended by OECD, 1979. **Iran. J. Radiat. Res., 2011; 8(4): 207-210**

Keywords: *Radium content, radon exhalation rates, LR-115 plastic track detectors, can technique.*

INTRODUCTION

Radon is naturally occurring gas produced by the decay of radium which is found in all type of rocks, building materials and soils.

It is carcinogenic to humans (1, 2) and responsible for the main natural radiation exposure for human beings (1, 3). The radon isotope Rn^{222} has its half-life of 3.82 days that is long enough to allow it to migrate through the soil and enter the atmosphere, thus, reaching the human environment. Among many factors affecting radon exhalation, one of the most important is radium content of the bedrock or soil (1-4). Being aware of the hazardous effects of radon exhalation on human health, it was necessary to conduct in situ measurements of radium content in the soil.

Radium is present everywhere in the earth's crust so radon is found everywhere in varying quantity. It can move freely from the place of its origin through pores in soil and cracks in walls. Radon transportation is mainly due to diffusion and forced flow. Radon continuously undergoes radioactive decay spontaneously into four solid short lived radionuclides, viz., ^{218}Po, ^{214}Pb, ^{214}Bi and ^{214}Po, in which polonium isotopes are alpha emitters. The dose due to inhaled radon progeny accounts for more than 50% of the total radiation dose to the public from natural sources (5).

Radium is one of the radionuclide of concern. This mainly enters the body in food and tends to follow calcium in metabolic processes to become concentrated in bones. The radiation given off by radium bombards the bone marrow and destroys tissue that produces red blood cells. It also can cause bone cancer. Radium is chemically similar to calcium and is absorbed from soil by plants and passed up the food chain to humans. The radium content of a sample also contributes to the level of environmental radon as radon is produced from ^{226}Ra through alpha decay. Higher values of ^{226}Ra in soil contribute significantly in the enhancement of environmental radon. In the present study investigations have been carried out to measure the effective radium content and radon exhalation rates in soil samples collected from urban area of Etah

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district of Uttar Pradesh province in Northern India.

MATERIALS AND METHODS

The soil samples were collected from different places of urban area of Etah district by the grab sampling method. Geology of Etah district of Uttar Pradesh lies between 78°11´ & 79°17´ East longitudes and 27°18´ & 28°2´ North latitudes. The experimental arrangement is shown in figure 1. Dried samples (100g) were placed at the bottom of the plastic cans of size 10 cm height and 7 cm in diameter. The mouth of the can was sealed with a cover fixed with LR-115 type II plastic track detector in such a way that the sensitive surface of the detector faced the material. The detector records the tracks of α-particles emitted by radon gas produced through α-decay of radium. It is necessary that for this value of *K*, the etching is carried out to reduce the thickness of the LR-115 type detector about 5 µm [(6)], which is obtained by 1.5 hours etching of the detector in 2.5 N, NaOH solution at (60±1)°C in a constant temperature water bath to reveal the tracks. Subsequently, α-tracks were counted using an optical microscope at a magnification of 100X.

The track density ρ (in track.cm^{-2}) is related to the radon activity concentration C_{Rn} (in Bq.m^{-3}) and the exposure time T by the formula [(6)]:

$$\rho = K\, C_{Rn}\, T \qquad (1)$$

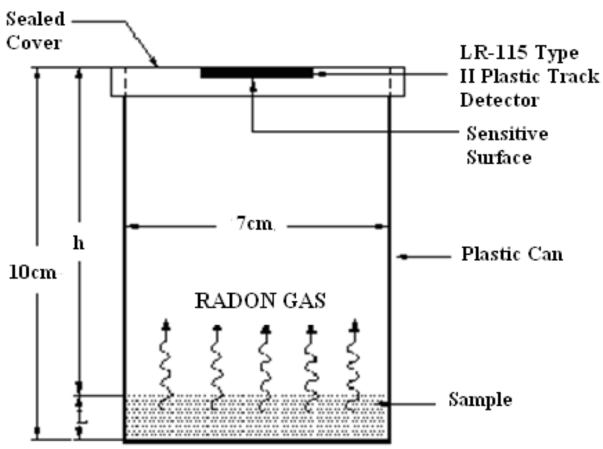

Figure 1. Experimental setup for measurements of effective radium content and radon exhalation rates in soil samples.

Where K is the sensitivity factor of LR-115 plastic track detector with an uncertainty of about ±15% [(6)]. The value of K will depend on the height and radius of the measuring can [(6)].

Since the half-life of ^{226}Ra is 1620 years and that of ^{222}Rn is 3.82 days, it is reasonable to assume that an effective equilibrium (about 98%) for radium-radon members of the decay series is reached in about three weeks. Once the radioactive equilibrium is established, one may use the radon alpha analysis for the determination of steady-state activity concentration of radium. The activity concentration of radon begins to increase with time T, after the closing of the can, according to the relation:

$$C_{Rn} = C_{Ra}\left(1 - e^{-\lambda_{Rn} T}\right) \qquad (2)$$

Where C_{Ra} is the effective radium content of the sample. Since a plastic track detector measures the time-integrated value of the above expression i.e. the total number of alpha disintegrations in unit volume of the can with a sensitivity K during the exposure time T, hence the track density observed is given by:

$$\rho = K C_{Ra} T_e \qquad (3)$$

where T_e denotes, by definition, the effective exposure time given by:

$$T_e = \left[T - \lambda_{Rn}^{-1}\left(1 - e^{-\lambda_{Rn} T}\right)\right] \qquad (4)$$

Referring to figure 1 it is clear that the "effective radium content" of the solid sample can be calculated using the formula:

$$C_{Ra}\,(\mathrm{Bq.kg^{-1}}) = \left(\frac{\rho}{KT_e}\right)\left(\frac{hA}{M}\right) \qquad (5)$$

Where M is the mass of the soil sample in kg, A is the area of cross-section of the can in m^2; h is the distance between the detector and top of the solid sample in meter.

The mass exhalation rate of the sample for release of the radon can be calculated by using the expression:

$$E_X(M)\,(\mathrm{Bq.kg^{-1}.d^{-1}}) = C_{Ra}\left(\frac{\lambda_{Ra}}{\lambda_{Rn}}\right)\frac{1}{T_e} \qquad (6)$$

The surface exhalation rate of the sample for release of radon can be calculated by using the expression:

$$E_X(S)(\text{Bq.m}^{-2}.\text{d}^{-1}) = \left[C_{Ra} \left(\frac{\lambda_{Ra}}{\lambda_{Rn}} \right) \frac{1}{T_e} \right] \frac{M}{A} \quad (7)$$

$$E_X(S)(\text{Bq.m}^{-2}.\text{d}^{-1}) = E_X(M)\ x \left(\frac{M}{A} \right) \quad (8)$$

RESULTS AND DISCUSSION

Table 1 depicts the values of effective radium content of soil samples collected from urban area of Etah district of Uttar Pradesh province in Northern India. It is clear from the table that the values of effective radium content vary from 27.87 to 45.14 Bq.kg^{-1} with a mean value of 34.98 Bq.kg^{-1}. These values are higher than the values found for Indian soil [(7)]. One reason for higher values in this area may be due to the fact that northern part of India is having high geochemical distribution of ^{238}U as revealed by the radioactivity profile map of India [(8)]. Table 1 also presents the value of mass exhalation and surface exhalation rates of radon of soil samples. The mass exhalation rate has been found to vary from 2.38 × 10^{-6} to 3.86 × 10^{-6} Bq.kg^{-1}.d^{-1} with a mean value of 2.99 × 10^{-6} Bq.kg^{-1}.d^{-1} and a standard deviation of 0.47. The surface exhalation rate has been found to vary from 6.19 ×10^{-5} to 10.03 × 10^{-5} Bq.m^{-2}.d^{-1} with a mean value of 7.77 × 10^{-5} Bq.m^{-2}.d^{-1} and a standard deviation of 1.20. The values of radium content reported in table 1 corresponds with the values reported by many researchers [(9, 2)]. The values of effective radium content are less than the permissible value of 370 Bq.kg^{-1} as recommended by Organization for Economic Cooperation and Development [(10)]. Hence, the result shows that this urban area is safe as for as the health hazards of radium are concerned.

CONCLUSION

Radon exhalation study is important for understanding the relative contribution of the material to the total radon concentration found inside the dwellings. The values of radium and radon exhalation rates are found to be below the safe limit recommended by OECD, 1979.

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Table 1. Effective radium content, mass exhalation and surface exhalation rates of radon in soil samples.

S. No	Detector Code	Corrected Track Density (tracks.cm^{-2})	Effective Radium Content (Bq.kg^{-1})	Exhalation rates	
				Mass Exhalation (Bq.kg^{-1}d^{-1}) Ex (M) ×10^{-6}	Surface Exhalation (Bq.m^{-2}d^{-1}) Ex (S) ×10^{-5}
1	S-06	22781.25	27.87	2.38	6.19
2	S-03	24406.25	29.48	2.52	6.55
3	S-05	25218.75	30.08	2.57	6.68
4	S-04	27093.75	31.49	2.69	6.99
5	S-12	26656.25	31.79	2.72	7.06
6	S-10	27531.25	32.84	2.81	7.30
7	S-08	29093.75	34.70	2.97	7.71
8	S-02	29906.25	36.13	3.09	8.03
9	S-07	30718.75	37.11	3.17	8.24
10	S-13	33218.75	39.62	3.39	8.80
11	S-09	36906.25	43.46	3.72	9.65
12	S-01	37843.75	45.14	3.86	10.03
Mean			34.98	2.99	7.77
Standard deviation			5.50	0.47	1.20

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REFERENCES

1. Ielsch G, Thieblemont D, Labed V, Richon P, Tymen G, Ferry C, Robe MC, Baurbon JC, Bechennec F (2001) Radon (^{222}Rn) level variations on a regional scale: influence of the basement trace element (U, Th) geochemistry on radon exhalation rates. *J Environ Radioact, **53:** 75-90.*
2. Sharma DK, Kumar A, Kumar M, Singh S (2003) Study of uranium, radium and radon exhalation rate in soil samples from some areas of Kangra district, Himachal Pradesh, India using solid-state nuclear track detectors. *Radiat Meas, **36:** 363-366.*
3. Wiegand J (2001) A guideline for the evaluation of the soil radon potential based on geogenic and anthropogenic parameters. *Environ Geol, **40:** 949-963.*
4. Ramola RC and Choubey VM (2003) Measurement of radon exhalation rate from soil samples of Garhwal Himalaya, India. *J Radioanal Nucl Chem, **256:** 219-223.*
5. Narayanan KK, Krishnan D, Subba Ramu MC (1991) BARC report.
6. Somogyi G (1986) Track detection methods of radium measurements. ATOMKI Preprint E/25.
7. Mishra UC and Sadasivan S (1971) Natural radioactivity levels in Indian soil. *J Sci Indus Res, **30:** 59-62.*
8. Sankaran AV, Jayaswal B, Nambi KSV, Sunta CM (1986) U, Th and K distribution inferred from regional geology and the terrestrial radiation profiles in India, BARC, *Technical Report.*
9. Singh S, Kumar A, Singh B (2002) Radon level in dwellings and its correlation with uranium and radium content in some areas of Himachal Pradesh, India. *Environment International, **28:** 97-101.*
10. OECD (1979) Organization for Economic Cooperation and Development. Report by a group of Experts of the OECD, Nuclear Energy Agency, OECD, Paris.