Measurement of radium concentration and radon exhalation rates of soil samples collected from some areas of Bulandshahr district, Uttar Pradesh, India using plastic track detectors

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Background: Radon is an odourless, colourless and tasteless gas and it is the first cause of lung cancer among non- smokers. The assessment of the level of radium in building materials helps in understanding the radiological implications. It has been observed that everyone has some levels of exposure to them. Therefore measurement of radium and radon in the soil samples are important from public health point of view. *Materials and Methods:* In the present work, radon exhalation rate and radium from soil samples have been measured through "Sealed Can technique" using LR-115 type II plastic track detector. Twenty two samples were collected from industrial area of Bulandshahr, Hapur and Meerut districts of Uttar Pradesh (India). *Results:* The radium concentration ranges from 9.2 to 18.7 $Bqkg^{-1}$ with an average value of 14.1 $Bqkg^{-1}$. The area exhalation rate for radon ranges from 394.1 to 798.3 $mBqm^{-2}$ h^{-1} with an average value of 600.7 $mBqm^{-2}$ h^{-1} and mass exhalation rate ranges from 15.1 to 30.7 $mBqkg^{-1}h^{-1}$ with an average value of 23.1 $mBqkg^{-1}h^{-1}$. A strong correlation coefficient has been observed between radium concentration and radon exhalation rate. *Conclusion:* The values of radium concentration in all the soil samples were found to be lower than the limit 370 $Bqkg^{-1}$ as recommended by OECD, 1979. Hence, there is no matter of concern to the population living in this region. **Iran. J. Radiat. Res., 2012; 10(2): 83-87**

Keywords: *Soil, plastic track detectors, radium concentration, radon exhalation rates.*

INTRODUCTION

Radon, a gaseous product of uranium decay series, is odourless, colourless and tasteless. Soil is the prime source of uranium and it forms a major component of building materials. As a result radon reaches us through these building materials. Radon (^{222}Rn) is a decay product of radium (^{226}Ra) which decays after completing its half life (3.83 days) directly into radon. Radon varies in different quantities in different materials and place to place, because radon is chemically unreactive with several materials, it freely moves between particles of building materials (like soil, rock and sand etc) to the soil surface (1). Radon has carcinogenic effect, infact; it is the first known cause of lung cancer among non smokers(2). It is responsible for about 2900 deaths of those people who have never smoked in the world (2). Radon becomes airborne with the attachment of dust particle and pollution, after inhalation it becomes deeply trapped in the lung. Therefore the exposure of population to high concentration of radon and its daughters for a long period leads to pathological effects like the respiratory function changes (3). According to several researchers, breathing low level of radon may increase the possibility of lung cancer(4, 5). Radon occurs through advection and diffusion process from some building construction materials like soil and rock and enter the environment (6, 7). Uranium also occurs in every natural and edible material (8). In the present work "Sealed Can Technique" is used by using LR-115 type II plastic track detectors. The radon exhalation rate and radium is being measured for the first time in Bulandshahr,

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Hapur and Meerut districts of Uttar Pradesh according to the best of our knowledge. The motivation of work is to measure radiological health risk level of radon exhalation rates and radium in this area. A distance of 60 km had been covered in this study performed.

Geology of the area

The Bulandshahr district is in Meerut region of Uttar Pradesh. This is situated between 28.4° south and 28.0° north latitude and between 77° and 78° longitude. The River Ganga is the east separates this District from Moradabad and Badaun district and in the west river Yamuna separated it from Haryana state and Delhi. In the north of district is Ghaziabad and in south east are the borders of Aligarh district.

Meerut is the 16th largest metropolitan city in India and the 17th largest city in India (India's national census of 2001). Meerut is also the fastest developing city of Uttar Pradesh after Noida and Ghaziabad. Meerut district is the part of upper Ganga Yamuna Doaab, which lies 28° 47′ and 29° 18′ in north direction and 77° 7′ and 78° 7′ in east direction. In shape, it is roughly rectangular. study area shown in figure1.

The study area is a part of Indo-Gangatic plain, which has been formed by collision of Indian & Asian plate (continent-continent collision). The study area falls in the Ganga-Yamuna Doaab which is a part of the central Ganga plain, where quaternary sediments comprise sands of various grades, silt and clay often intercalated with calcareous concentrations in varying proportions. The aquifers are generally lenticular in nature and there are rapid alternation and gradations between granular and clayey horizons. The near surface groundwater occurs under unconfined while deeper aquifers generally contain water under semi-confined to confined conditions.

The district is 237.44 meters above sea level. The climate of the area is extremely cold in winter and very hot in summer. The area falls under sub-tropical climatic zone where during summer the temperature o ften rises to 45˚ C while during winter it touches 4˚ C. The average relative humidity ranges from 32 to 82%. The monsoon usually breaks in the last week of June every year causing heaviest rain during July and August, average annual rainfall of this region is 618.97mm [9]. This region has plain landscape, vast forest, agricultural land and very fertile, alluvial soils produced by the silt brought through by numerous rivers [3]. Three types of soils have been found which are as follows:

1. Sandy loam
2. Sandy loam to loam
3. Loam to clay loam.

Figure 1. The map showing the study area.

MATERIALS AND METHODS

Twenty two soil samples were collected from different places of industrial area of Bulandshahr, Hapur and Meerut districts of Uttar Pradesh (India) by grab sampling method. Sealed Can technique has been used [10]. Experiment has been performed in the month of summer. The experimental arrangement is shown in figure 2. The tracks were observed and counted by using microscope with a magnification of 400×. The track density and radon activity was obtained through calibration factor of 0.056 tracks $cm^{-2}d^{-1}$ (Bqm^{-3}) (11). The details of the method are the same as reported earlier (12).

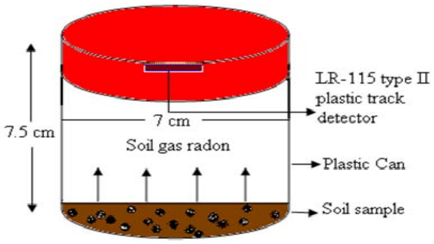

Figure 2. Experimental setup for measurements of radium concentration and radon exhalation rates in soil samples.

The radium concentration were found by using this formula:

$$C_{Ra} = \frac{\rho h A}{K T_e M} \quad (1)$$

Where, ρ is track density (track /cm^2), A is surface area of the sample in cm^2, h is distance between the detectors and top of the sample in cm, K is the sensitivity factor (tracks cm^{-2} d^{-1} per Bq m^{-3})

Exhalation rates in terms of area and mass were calculated from the following equation which was earlier used by various researchers (13, 14).

Area exhalation rate

$$E_A = \frac{CV\lambda}{A[T + \lambda^{-1}(e^{-\lambda T} - 1)]}\left(Bqm^{-2}h^{-1}\right) \quad (2)$$

Mass exhalation rate,

$$E_M = \frac{CV\lambda}{M[T + \lambda^{-1}\left(e^{-\lambda T} - 1\right)]}\left(Bqkg^{-1}h^{-1}\right) \quad (3)$$

Where, C is radon exposure ($Bqm^{-3}h$), V is volume of Can (m^3), T is Time of exposure (hrs), M is Mass (kg) of the sample in Can, λ is the decay constant for radon (h^{-1}).

RESULTS AND DISCUSSION

The values of radon exhalation rate in terms of area and mass and radium in soil samples from industrial areas of Bulandshahr, Hapur and Meerut districts of Uttar Pradesh, India, are depicted in table 1. The soil of this area is commonly using in brick manufacturing. In the present investigation, the area exhalation rate for radon ranges from 394.12 to 798.34 $mBqm^{-2}h^{-1}$ with an average of 600.74 $mBqm^{-2}h^{-1}$ and a standard deviation of 110.35. The values of mass exhalation rate for radon ranges from 15.1 to 30.7 $mBqkg^{-1}h^{-1}$ with an average of 23.1 $mBqkg^{-1}h^{-1}$ and a standard deviation of 4.26. The values of radon exhalation rate in soil samples observed with safe limit and higher than the global value of radon exhalation rate from soil is in the range of 0.02 - 0.05 Bq m^{-2} h^{-1}. Northern part of India is having high geochemical distribution of U^{238} as revealed by the radioactivity profile map of India (15). Radium concentration ranges from 9.2 to 18.7 Bq kg^{-1} with an average of 14.1 Bq kg^{-1} and a standard deviation 2.59. It is evident from the table 2 that the average values of radium concentrations and radon exhalation rates observed in soils of Bulandshahr district are comparable to those reported for other parts of India.

The observed values of radium concentration in soil samples in the present study are less than the recommended action level 370 Bq kg^{-1} (16) and also lower than the average global value of 35 Bq kg^{-1}. The soil of this area is advisable to use in brick manufacturing for building construction. The correlation between the radium concentration and the radon emanation potential of the source material is required for radon risk. A positive correlation has been observed between radium concentration and area exhalation rate in soil of the study area (figure 3).

CONCLUSION

1. The average values of radium content in the study area are comparable to the global average value of radium in soil.
2. The values of radon exhalation rate in soil samples of the study area are quite lower than the areas known for Uranium mineralization nevertheless is higher

from the global value. Therefore the use of soil of this area in Brick manufacturing for building construction is considered to be safe.

3. Highest activity was found in soil number 4. These results reveal that radon gas is chemically unreactive with soil sample. Radium concentration was found with safe limit recommended by a group of experts of the OECD. The results reveal that the area is safe as far as the health hazard effects of radium and radon exhalation rate are concerned.
4. Strong positive correlation has been observed between radium content, area exhalation rate and mass exhalation rate.

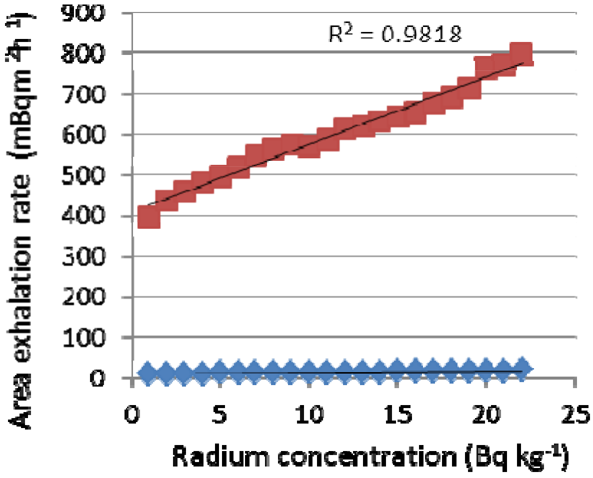

Figure 3. Showing the correlation between radium concentration and area exhalation rate.

Table 1. Values of radium concentration and radon exhalation rate in soil sample.

Sr. No	Sample code	Radon exhalation rates		Radium Concentration
		E_A (Bq. m^{-2}h^{-1}) x10^{-3}	E_M (Bq. kg^{-1}h^{-1}) x 10^{-3}	C_{Ra} (Bq.kg^{-1})
1	Soil-1	518.15	19.9	12.1
2	Soil-2	633.29	24.3	14.8
3	Soil-3	642.89	24.7	15.1
4	Soil-4	798.34	30.7	18.7
5	Soil-5	479.76	18.4	11.2
6	Soil-6	498.96	19.2	11.8
7	Soil-7	613.49	23.6	14.4
8	Soil-8	573.64	22.1	13.4
9	Soil-9	438.64	16.8	10.3
10	Soil-10	546.21	21.0	12.7
11	Soil-11	563.54	21.6	13.2
12	Soil-12	655.28	25.2	15.4
13	Soil-13	587.72	22.6	13.7
14	Soil-14	678.77	26.1	15.9
15	Soil-15	695.16	26.7	16.3
16	Soil-16	394.12	15.1	9.2
17	Soil-17	764.06	29.4	17.9
18	Soil-18	457.87	17.6	10.7
19	Soil-19	769.55	29.6	18.1
20	Soil-20	620.27	23.8	14.5
21	Soil-21	714.31	27.5	16.7
22	Soil-22	572.28	22.0	13.4
Minimum		394.12	15.1	9.2
Maximum		798.34	30.7	18.7
Mean		600.74	23.1	14.1
S. D.		110.35	4.26	2.59

Table 2. Comparison of the average radon exhalation rates and radium (Bq kg^{-1}) in soil samples in different part in India.

S. No.	Location	Exhalaltion rates		Radium	References
		Area exhalation rate	Mass exhalation rate		
1	Margherita Thrust area	362.0	10.9	-	17
2	Kangra (H. P)	806.1	24.3	18.5	18
3	Villages of Haryana and Himachal Pradesh States, India	524.9	12.8	14.8	19
4	Aravali hills in India	540.0	25.5	-	20
5	Jamtara district	642.9	18.9	15.7	5
Present study		600.7	23.1	14.1	-

ACKNOWLEDGMENT

The Authors are grateful to Prof. Alim Husain Naqvi, Chairman D / O Applied Physics, Aligarh Muslim University, Aligarh and Dr. Ameer Azam, D / O Applied Physics, Aligarh Muslim University, Aligarh for providing all necessary facility for carried out this work.

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