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STUDY OF RADON EXHALATION RATES IN COAL FLY ASH SAMPLES COLLECTED FROM ROSA THERMAL POWER PLANT (RTPP) SHAJAHANPUR BY USING SSNTD TECHNIQUE

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In the present study radon exhalation rates in terms of mass and area have been measured in coal fly ash samples collected from Rosa Thermal Power Plant, Shahjahanpur (U.P.) by using cylindrical Sealed Can Technique (SCT) based on LR-115, type II nuclear plastic track detector. In the present work radon activity concentration was found to vary from 145.35Bqm^{-3} to 290.70Bqm^{-3} with an average and average value of 191.15Bqm^{-3}. Radon exhalation rate in terms of mass was found to vary from 8.70 mBq$Kg^{-1}h^{-1}$ to 17.41mBq$Kg^{-1}h^{-1}$ with an average value of 11.44 mBq$Kg^{-1}h^{-1}$ where as radon exhalation rate in terms of area was found to vary from 280.35 mBq$m^{-2}h^{-1}$ to 544.19 mBq$m^{-2}h^{-1}$ with an average of 272.09 mBq$m^{-2}h^{-1}$. The observed values of radon exhalation rates in coal fly ash samples in the present study were found below the average value of 57.6Bq$m^{-2}h^{-1}$ as recommended by International Commission on Radiation Protection (IRCP). Thus the result shows that the study area is safe as for as far the health hazard effects of radon activity concentration and radon exhalation rate are concerned.

Introduction

Coal is the main energy source for electricity generation in the world. In India, a large amount of energy generation comes from coal combustion in thermal power plant (TPP). This combustion process generates large amounts of fly ashes. In recent years due to the use of fly ash in building materials, it has become a subject of worldwide interest. Radon exhalation rate is most important for the measurement of radiation risk in coal and fly ash. The radon exhaling properties of porous materials, both naturally occurring like soil, coal and rocks and man-made like mining wastes, fly ash and many building materials etc. have been the object of several investigations. Coal is important material for power generation. Coal contains trace quantities of naturally occurring primordial radionuclides which acts as a source of radon isotopes Rn-222 and its daughter products are considered to be the main sources of inhaled alpha-activity resulting from coal burning in industrial cities. Considerable work has been undertaken to investigate radon exhalation as well as well as other hazards from coal combustion by-products (Ingersoll, 1981; Stranden, 1983; Nakaoka *et. al*, 1984, 1985 and Karamdoost *et al,* 1988). The measurements carried out by Tufail *et al*., (1988) show that the radon concentration inside the coal mines is about 5-10 times greater than that of radon levels outside the mines. Coal combustion results in the emission of its particulate byproduct-flyash into the atmosphere. Fly ash may contain much higher concentration of radionuclides in the uranium and throrium series (UNSCEAR. 1977; Pensko *et al.*, 1978). The collected fly ash is used in the manufacture of concrete for building purposes and for the filling of underground cavities. Because of its relatively high radionuclide contents, it may possess a potential hazard to the population through its radon exhalation and gamma activity. The radiation exposure of the average member of the public is dominated by radon and its decay products. Building materials constitutes the second most important source of radon in a reference house (UNSCEAR, 1988). In some countries, some building blocks are made almost entirely of flyash and measurements in houses build of this material show enhanced radon concentration (Blaton-Albicka and Pensko 1981). It has been shown by Straden (1983) that when flyash is the main component of a building material, it may result enhanced exposure both to gamma radiation and radon daughters. So before promoting coal-fired plants, it is necessary that dose assessments be carried out to determine the effects on the public which is exposed to radiation from microamounts of radionuclides contained in the flyash released by the operation of a coal- fired power plant. The surrounding soil, vegetation, milk and flesh should be checked as radionuclide contents due to precipitation of coal ash in the nearby areas. Attention should also be paid to the buildings in which coal ash has been used as a building material. Radon exhalation is important parameter for the estimation of radiation risk from various materials.

Study Area

Rosa thermal power plant is one of the largest thermal power plants in the central part of the Uttar Pradesh in India, which is owned and operated by Reliance Power. It is a 1,200 MW (2 units, each unit of 600 MW capacity) of coal based generation capacity at Rosa village in Shahjahanpur, Uttar Pradesh. It is Situated 160 km away in west from capital Lucknow. Four ash ponds are present which operates alternately throughout the year. The neighboring area is Shahjahanpur city (head quarter of the District) having high population density residing in localities present very close from the ash ponds. In figure 1 & 2, purple and red colour location shows the study area and head quarter of the district respectively where as figure 3 shows the location of Rosa thermal power plant.

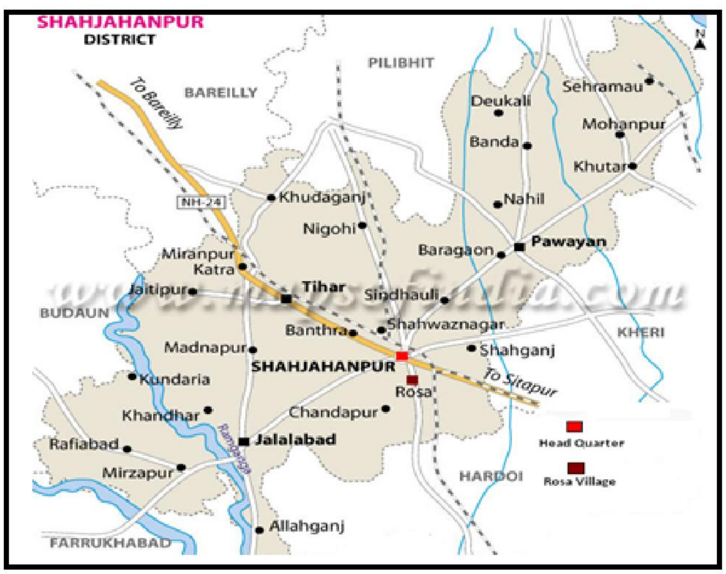

Fig. 1. Map showing Shahjahanpur District and study area

Fig. 2. Rosa Thermal power plant

EXPERIMENTAL TECHNIQUE

Sealed Can Technique has been used for the study of radon exhalation rates from coal fly ash samples collected from Rosa thermal power plan Shahjahanpur (Abbu-Jarad *et al* 1988, Khan *et al*., 1992, Kant *et al*., 2001, Ramola *et al*., 2003). In such measurement technique it is expected that the radon exhalation rates (both mass and area exhalation rates) depends upon material, its amount as well as on the geometry and dimension of the cane. The exhalation rate is the amount of radon emanated from a given sample per unit mass (for mass exhalation rate) or surface area (for surface exhalation rate) per unit time. With sealed can technique (Somogy *et al*., 1986) both area and mass exhalation rates for radon in the sample can be determined with reasonable accuracy. Fifteen (15) flyash samples were collected from the study area. A known amount (about 120gram) of the collected sample is kept in each plastic cylindrical can. LR-115, type II nuclear plastic track detector of size 2cm × 2cm was fixed on the bottom of the lid of each cylindrical can having dimension 8cm in total height and 7cm in diameter with tape such that the sensitive part of the detector always facing the sample so that it could record the alpha particles resulting from the decay of radon in the remaining volume of the cylindrical can and from ^{218}Po and ^{214}Po deposited on the inner wall of the cane. The can is then tightly closed from the top and sealed for a period of 90 days in order to get the equilibrium.

After the completion of exposure time, the detector was removed and subjected to a chemical etching process in 2.5N NaOH solution at 60°C for 70 minutes in a constant temperature water bath. The etched detectors are thoroughly washed and dried. The resulting alpha tracks on the exposed face of the detector were counted using the spark counter. From the track density the radon activity concentration C_{Rn} was obtained using the formula

$$C_{Rn} = \rho / KT$$

where ρ is the track density ($Track.cm^{-2}$), T is the exposure time (90 days) and K is the sensitivity factor (K= 0.056 Tracks $cm^{-2}d^{-1}Bqm^{-}3$) (Singh *et al*., 1997). The mass and area exhalation rate can be calculated respected by using the following formula (Kant *et al*., 2001):

$$E_M\,(BqKg^{-1}h^{-1}) = C_{Rn}V\,\lambda / M\,\{T - \frac{1}{\lambda}\left(1 - e^{-\lambda T}\right)\}$$

&

$$E_A\,(Bqm^{-2}h^{-1}) = C_{Rn}V\,\lambda / A\,\{T - \frac{1}{\lambda}\left(1 - e^{-\lambda T}\right)\}$$

where C_{Rn} is the radon activity concentration, V is the effective volume of the cylindrical can, λ is the radon decay constant in h^{-1}, M is the mass of the sample in Kg (120×10^{-3}Kg), A is the cross sectional area of the cylindrical can in square meter (38.46×10^{-4} m^2) and T is the effective exposure time in hour. The radon decay constant is given by

$$\lambda_{Rn} = \log_e 2 / T_{1/2}$$

where $T_{1/2}$ is the half life of radon in days ($T_{1/2}$ = 3.8 days).The experimental setup for the study of radon exhalation rate is shown in the figure 3.

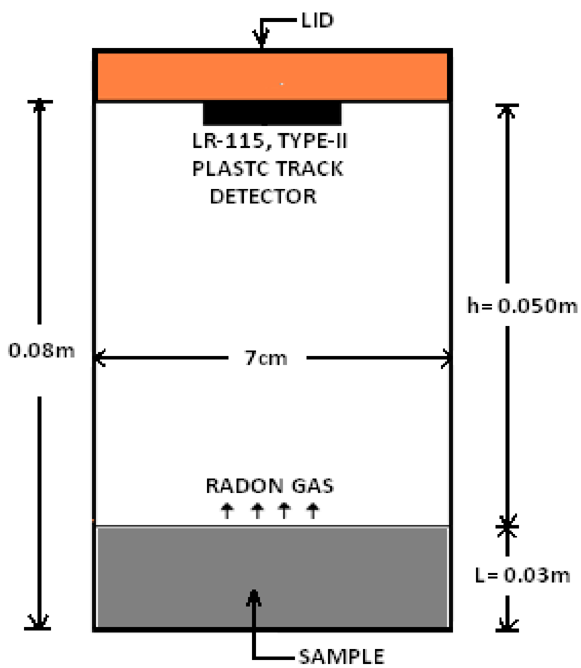

Fig. 3. Experimental setup for the measurement of radon exhalation rate

Result and discussion

The result of radon exhalation rate in coal and fly ash sample collected from Rosa thermal plant is reported in the table 1. It was found that the radon activity concentration and radon exhalation rate (both mass and area) in coal fly ash sample soil are different. This may be due to the parameters on which radon exhalation rates are depends. Radon flux density (*i.e.* ^{222}Rn exhalation rate) depends upon a number of parameters that behave in a stochastic and independent fashion, such as the radioactive disintegration of radium to produce radon, the direction of recoil of radon in the grain, the interstitial fly ash moisture condition in the vicinity of the ejected radon atom and its diffusion in the pore space (Lawrence *et al.*, 2009). It was found that the values of radon activity concentration in coal fly ash sample vary from 145.35Bq/m^3 to 290.70Bq/$m^3$with an average value of 191.15Bq/m^3. Radon exhalation rate in terms of mass was found to vary from 8.70 mBqK$g^{-1}h^{-1}$ to 17.41mBqK$g^{-1}h^{-1}$ with an average value of 11.44 mBqK$g^{-1}h^{-1}$ where as radon exhalation rate in terms of area was found to vary from 280.35 mBq$m^{-2}h^{-1}$ to 544.19 mBq$m^{-2}h^{-1}$ with an average of 272.09 mBq$m^{-2}h^{-1}$. The value of radon activity concentration, mass exhalation rate and area exhalation rate was found maximum in sample code FA13. Similarly the value of radon activity concentration, mass exhalation rate and area exhalation rate was found minimum in sample code FA15. The observed values of radon exhalation rate (both mass and area) in coal flyash samples collected from Rosa thermal power plant in the present study were below the average value of 57.6Bq$m^{-2}h^{-1}$ as recommended by International Commission on Radiation Protection (IRCP). Thus the result shows that the study area is safe as for as far the health hazard effects of radon activity concentration and radon exhalation rate are concerned. The variations of exhalation rates with number of samples are shown in figure 4 &5.

Table 1. Observed values of radon exhalation rates in coal fly ash samples

Sr. No.	Sample Code	Radon Activity concentration (Bq/m^3)	Mass Exhalation rate E_M (mBqK$g^{-1}h^{-1}$)	Area Exhalation rate E_A (mBq$m^{-2}h^{-1}$)
1	FA1	175.35	10.50	328.25
2	FA2	190.57	11.42	356.74
3	FA3	200.11	11.99	374.60
4	FA4	170.65	10.22	319.45
5	FA5	165.25	9.89	309.34
6	FA6	210.12	12.58	393.34
7	FA7	149.76	8.97	280.35
8	FA8	167.80	10.05	314.12
9	FA9	198.24	11.87	371.10
10	FA10	187.90	11.25	351.74
11	FA11	210.12	12.58	393.34
12	FA12	240.14	14.38	449.54
13	FA13	290.70	17.41	544.19
14	FA14	165.23	9.89	309.31
15	FA15	145.35	8.70	272.09
Average		191.15	11.44	357.83

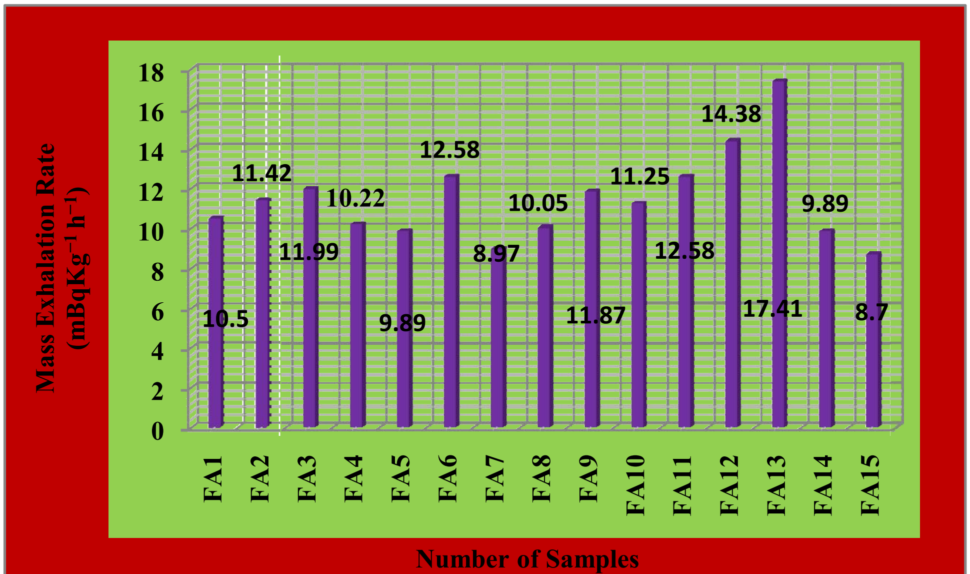

Figure 4: Variation of Mass Exhalation Rate with no. of samples

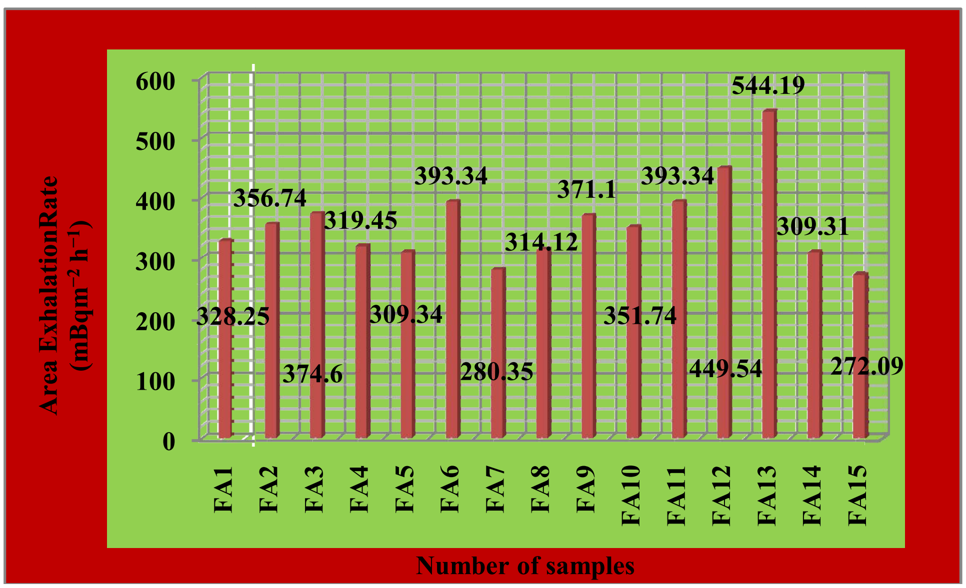

Fig. 5. Variation of Area Exhalation rate with no. of samples

Conclussion

The radon exhalation rates of the fly ash samples collected from Rosa thermal power plant are measured as radon an inert gas released from the decay of radium is an alpha emitter and can damage the lungs on inhalation. These are found to be lower than those from other thermal power plants but within the limit prescribed by Radiation Protection Agencies. The radon exhalation rates in the present study were also found below the world average value of 0.016 $Bqm^{-2}s^{-1}$(57.6 $Bqm^{-2}h^{-1}$).Therefore fly ash used in this region as building construction material give no significant radiation dose and pose no radiological risk to the population. The measurements of radon exhalation rate in fly ash samples collected from the study area are important from public health point of view. The motivation of work is to measure radiological health risk level of radon exhalation rates in study area which would be of great help for radiological database of country.

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