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RESEARCH ARTICLE

MEASUREMENTS OF RADON EXHALATION RATE FROM FLY ASH SAMPLES COLLECTED FROM KOLAGHAT THERMAL POWER PLANT WEST BENGAL, INDIA

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ABSTRACT

"Sealed Can technique" with LR-115 type II plastic track detector was used for the measurement of radon exhalation rate in the fly ash samples. Uranium concentrations have been measured through low level gamma ray spectroscopy. Activity concentration of uranium is found to vary from 5.6 to 11.0 ppm. Radon activity was found to vary from 182.9 ± 18.6 to 262.9 ± 22.3 and the exhalation rate lies in the range 62.3 ± 6.2 to 95. ± 8.0 mBq m^{-2} h^{-1} whereas the radon mass exhalation rate varied from 2.1 ± 0.2 to 3.6 ± 0.3 mBq $kg^{-1}h^{-1}$. There seems a positive correlation between uranium concentration and radon exhalation rates. Results are compared with our earlier studies of different thermal power plants in India.

INTRODUCTION

Coal is important material for power generation. In India more than 72% power generation contributes by thermal power generation (Kumar *et al*., 2005). Indian coal is of bituminous type with 50-60% ash content amounting to 100 million tons of fly ash per year (Vijayan and Behra, 1999). Fly ash finds applications in building construction materials, production of aggregates and more recently for agriculture (Brian *et al*., 2003) etc. 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 (Jonassen, 1983; Karmadoost *et al*., 1988). In our previous measurements (Mahur *et al*., 2013, 2008 a,b; Jojo *et al*., 1993) fly ash has been found to contain enhanced levels of uranium as compared to coal. Previous studies (Mishra *et al*., 1991) on coal and fly ash have shown that Indian coals contained 1.8– 6.0 ppm ^{238}U.

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Gamma radiations are emitted from naturally occurring radionuclides from the ^{238}U and ^{232}Th series and their decay products. There should be proper information regarding the radiation levels and radionuclide distribution in the environment, as these informations are necessary in understanding human exposure from natural and man-made sources of radiation and also necessary in establishing rules and regulations regarding the radiation protection (Gupta *et al*., 2013). Estimates of total radiation dose to the world population have shown that about 96% is from natural sources while 4% is from artificial sources (Chougankar *et al*., 2003). In the present study, radon exhalation rates have been measured in fly ash samples obtained from Kolaghat thermal power plant, is one of the largest thermal power plants in eastern India.

Measurement techniques

Samples collected from around a Kolaghat thermal power plant in Eastern India were dried and sieved through a 100 mesh sieve. For the measurement of radon exhalation rate, "Sealed can technique" was used. Equal amount of samples (100 gm) were placed in the "Cans" (diameter 7.0 cm and height 7.5 cm) as shown in Fig. 1 similar to those used in the calibration experiment (Singh *et al*., 1997). LR-115 Type II solid state nuclear track detector (2 cm × 2 cm) was fixed on the top

inside of the "Can". Sensitive lower surface of the detector is freely exposed to the emergent radon so that it could record the tracks of alpha particles resulting from the decay of radon in the remaining volume of "Can". Radon and its daughters reach an equilibrium concentration after 4 hours and hence the equilibrium activity of emergent radon can be obtained from the geometry of "Can" and time of exposure. After the exposure for 95 days, the detectors were etched in 2.5 N NaOH at 60^0 C for a period of 90 minute in a constant temperature water bath. The resultant alpha-particle tracks were counted using an optical microscope at a magnification of 400 ×. From the track density the radon activity was obtained using a calibration factor of 0.056 track cm^{-2} d^{-1} $(Bqm^{-3})^{-1}$ obtained from an earlier calibration experiment (Singh *et al*., 1997).

Surface exhalation rate 'E_A' is obtained from the following expression (Mahur *et al*., 2013, 2008 a,b).

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

This formula is also modified to calculate the mass exhalation rate 'E_M"

$$E_M = \frac{CV\lambda}{M\left[T+\frac{1}{\lambda}\left\{e^{-\lambda T}-1\right\}\right]} \quad \ldots\ldots\ldots\ldots\ldots..(2)$$

where, E_A is measured in Bq m^{-2} h^{-1} and E_M in Bq kg^{-1} h^{-1}; C is the integrated radon exposure as measured by LR -115 solid state nuclear track detectors (Bq m^{-3} h); V is the effective volume of can (m^3); λ is the decay constant for radon (hr^{-1}); T is the exposure time (hr); A is the area of the can (m^2) and M is mass of the sample.

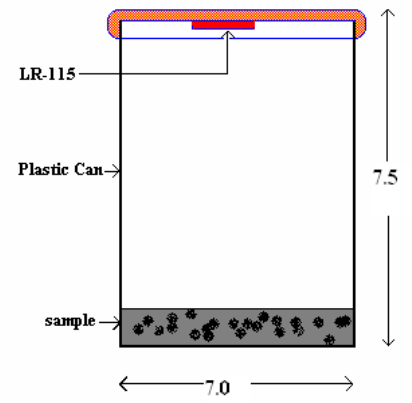

Fig. 1. Experimental set up for measurement of radon exhalation rate

Study area

Kolaghat thermal power plant is one of the largest thermal power plants in eastern India. Situated 60 km WSW of Kolkata, the plant's installed capacity is 1260 MW (6units, each unit of 210MW capacity). Four ash ponds are present which operates alternately throughout the year. Figure 2 shows the study area map.

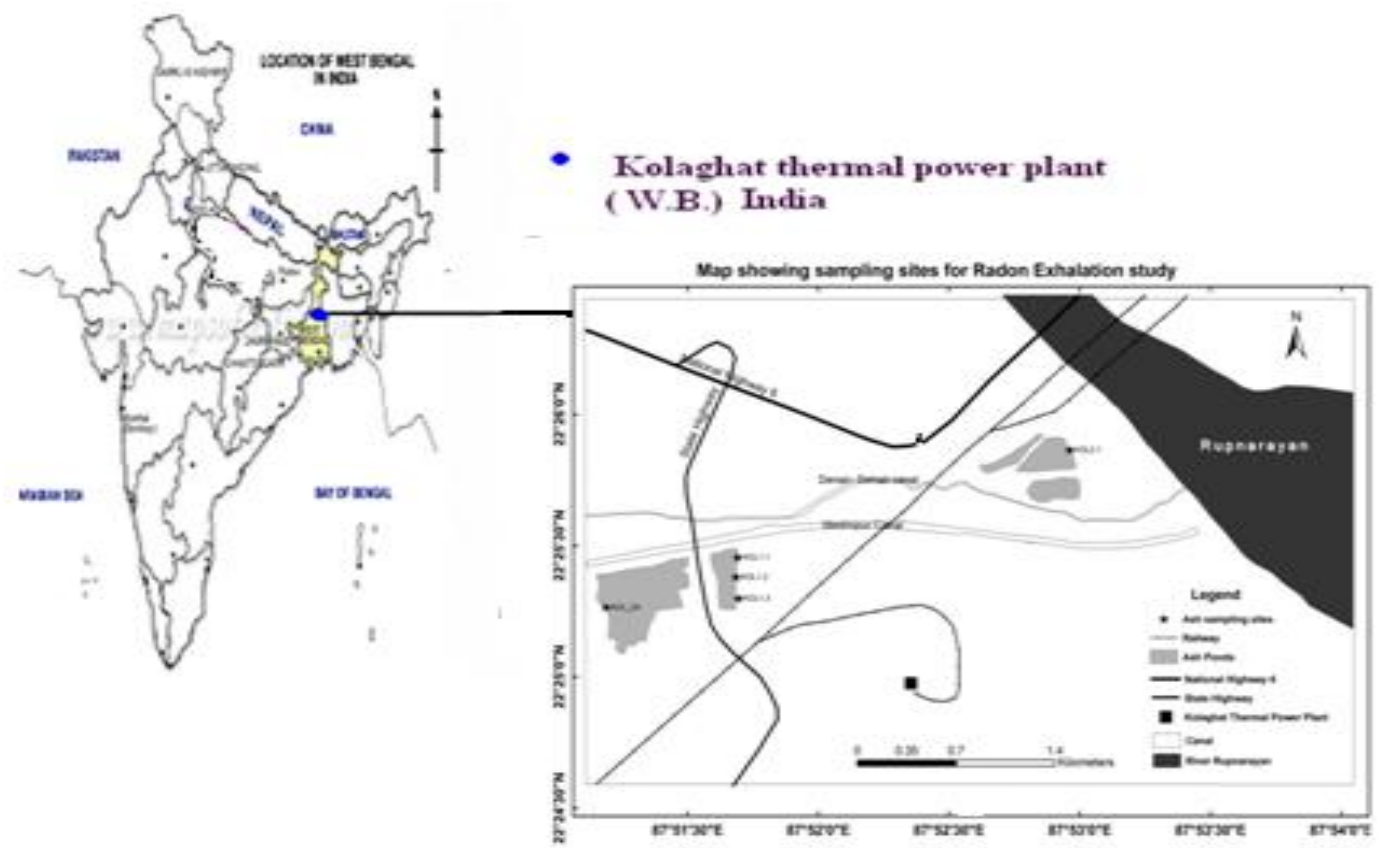

Fig. 2. Location map of Kolaghat Thermal Power Plant (W.B.) India

The neighbouring area is having high population density residing in localities present within a radius of few meters from the ash ponds.

RESULTS AND DISCUSSION

The results of the radon activity, radon surface exhalation rates, radon mass exhalation rates and concentration of uranium from the fly ash samples are given in Table 1. Radon activity has been found to vary from 182.9 ± 18.6 to 262.9 ± 22.3 Bq m^{-3} with an average value of 211.9 ± 20.8 Bq m^{-3}.

Radon surface exhalation rate vary from 62.3 ± 6.2 to 95.0 ± 8.0 mBq m^{-2} h^{-1} with a mean value of 75.7 ± 7.1 mBq m^{-2} h^{-1} whereas mass exhalation rate is found to be vary from 2.1 ± 0.2 to 3.6 ± 0.3 mBq kg^{-1} h^{-1} with an average value of 2.8 ± 0.2 mBq kg^{-1} h^{-1}. The activity concentration of uranium (^{238}U) has been found to vary from 5.6 to 11.0 ppm with an average value of 7.3 ppm. Figure 3 shows the variation of uranium concentration and radon exhalation rate in these fly ash samples. It seems positive correlation.

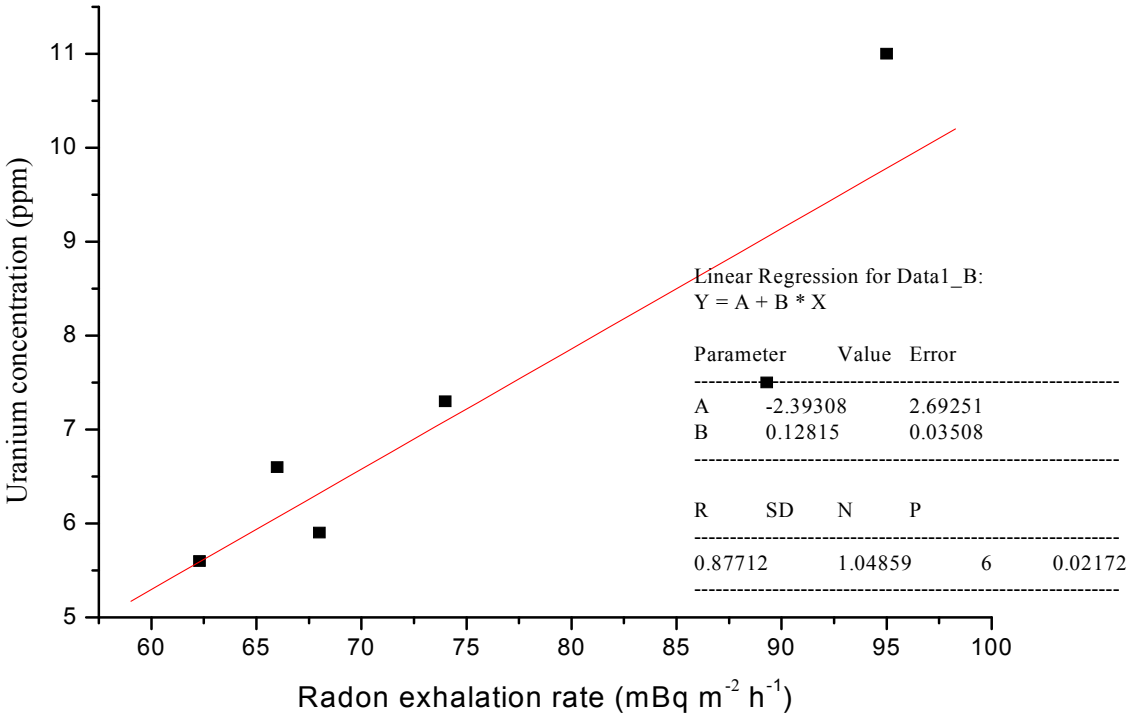

Figure 3. Correlation between activity concentration of uranium and radon exhalation rate

Table 1. Radon activity, exhalation rate, and activity concentration values for ^{238}U, in samples collected from the sun dried ash used as disposal ponds by Kolaghat Thermal Power Plant

Sample	Radon Activity (Bq m^{-3})	Radon Exhalation (mBq m^{-2} h^{-1})	Mass Exhalation (mBq kg^{-1} h^{-1})	Radon effective dose (μSv y^{-1})	^{238}U (ppm)
Kol_Slr	182.9 ± 18.6	66.0 ± 6.7	2.5 ± 0.2	7.7 ± 0.7	6.6
Kol_1.1	248.6 ± 21.7	89.3 ± 7.8	3.4 ± 0.3	10.5 ± 0.9	7.5
Kol_1.2	262.9 ± 22.3	95.0 ± 8.0	3.6 ± 0.3	11.1 ± 0.9	11.0
Kol_1.3	188.6 ± 18.9	68.0 ± 6.8	2.6 ± 0.2	7.9 ± 0.8	5.9
Kol_2.1	205.7 ± 19.7	74.0 ± 7.1	2.8 ± 0.2	8.7 ± 0.8	7.3
Kol_2.2	183.2 ± 15.3	62.3 ± 6.2	2.1 ± 0.2	6.9 ± 0.7	5.6
Avg.value	211.9 ± 20.8	75.7 ± 7.1	2.8 ± 0.2	8.8 ± 0.8	7.3
Max.	262.9 ± 22.3	95.0 ± 8.0	3.6 ± 0.3	11.1 ± 0.9	11.0
Mini.	182.9 ± 18.6	62.3 ± 6.2	2.1 ± 0.2	6.9 ± 0.7	5.6

Table 2. Average radon exhalation rate in fly ash samples from different thermal power plants in India

Thermal power plant	Average radon exhalation rate (mBq m^{-2} h^{-1})	Reference
NTPC, Dadri (U.P.)	155.5	Gupta *et al*. (2013)
Parichha, Jhansi (U.P.)	257.6	
Obra, Mirjapur (U.P.)	239.9	
Durgapur (WB)	406.2	Mahur *et al. (*2008a,b)
Kolaghat (WB)	75.7	Present study

Conclusion

The radon exhalation rates of the fly ash samples collected from Kolaghat 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. However the concentration of ^{238}U is higher than the world figure.

There seems to be positive correlation between activity concentration of uranium and radon exhalation rate. Therefore fly ash used in this region as building construction material may give significant radiation dose and pose radiological risk to the population.

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