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An investigation of radon exhalation rate and estimation of radiation doses in coal and fly ash samples

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Abstract

Coal is a technologically important material used for power generation. Its cinder (fly ash) is used in the manufacturing of bricks, sheets, cement, land filling etc. Coal and its by-products often contain significant amounts of radionuclides, including uranium which is the ultimate source of the radioactive gas radon. Burning of coal and the subsequent atmospheric emission cause the redistribution of toxic radioactive trace elements in the environment. In the present study, radon exhalation rates in coal and fly ash samples from the thermal power plants at Kolaghat (W.B.) and Kasimpur (U.P.) have been measured using sealed Can technique having LR-115 type II detectors. The activity concentrations of ^{238}U, ^{232}Th, and ^{40}K in the samples of Kolaghat power station are also measured. It is observed that the radon exhalation rate from fly ash samples from Kolaghat is higher than from coal samples and activity concentration of radionuclides in fly ash is enhanced after the combustion of coal. Fly ash samples from Kasimpur show no appreciable change in radon exhalation. Radiation doses from the fly ash samples have been estimated from radon exhalation rate and radionuclide concentrations.

Keywords: Radon exhalation rate; Gamma ray spectroscopy; LR-115 type II detector; Radium equivalent activity; Gamma absorbed dose to air rates

1. Introduction

Thermal power generation contributes more than 70% of the power generation in India. Indian coal is of bituminous type with 55–60% ash content amounting to 100 million tons of fly ash per year (Vijayan and Behra, 1999). Like other natural materials, coal contains U, Th, and K radionuclides, which may be concentrated in the fly ash by thermal power plant combustion. Also, coal combustion may enhance the natural radiation in the vicinity of the thermal power plant through the release of the radionuclides and their daughters in the surrounding ecosystem such as the surface soil. Due to diverse uses of fly ash in building materials, as under ground cavity filling material and in the production of cement, etc., fly ash has become a subject of worldwide interest in recent years. Radon exhalation rate from fly ash is of prime importance for the estimation of radiation risk. Earlier studies (Mishra, 2004) on coal and fly ash have shown that Indian coals contained 1.8–6.0 ppm ^{238}U and 6.0–15.0 ppm of ^{232}Th. Recent studies have indicated as high as 50 ppm ^{232}Th and 10 ppm of ^{238}U in the pond ash generated from coal combustion (Mandal and Sengupta, 2003). Radiation risk from fly ash is of importance since if used in construction materials it may raise the concentration of airborne indoor radioactivity to unacceptable levels, especially in places having low ventilation rates (Rawat et al., 1991; Khan et al., 1992). In the present study, radon exhalation rates from the coal and fly ash samples collected from the thermal power stations at Kolaghat and Kasimpur situated in West Bengal and Uttar Pradesh states of India have been measured to estimate their enhancement in fly ash due to coal combustion. Also the activity concentrations of ^{238}U, ^{232}Th, and ^{40}K radionuclides in the samples of Kolaghat power station are measured using a low level NaI (Tl) gamma ray spectrometer (Mandal and Sengupta, 2003).

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Radiation doses and health risk have been estimated from the radon exhalation and ^{238}U, ^{232}Th, and ^{40}K concentrations.

1.1. Geology of study area

The Kolaghat thermal power plant is situated in the Midnapur district of West Bengal and near Mecheda railway station on the South-Eastern Railway route. It is 59 km away from Kharagpur in the ENE direction and 60 km WSW of Kolkata. Fig. 1 shows the location map of Kolaghat thermal power plant, West Bengal, India. The Kolaghat region falls within the Kasai delta of Contai formation of late Pleistocene age. The dominant lithotypes of the Contai formation are laterite, with mottled red and brown clays at the top. The major surface runoff in the region is the Denan–Dehati canal, which is the major outlet of the Rupnarayan River, and lies to the west of the thermal power plant. The Kasai River is the principal tributary of the Haldi River and enters the study areas from the north-west. The Denan–Dehati canal and a branch of the Kasai River are the major sources of portable water to about 100,000 people in the neighboring 200 villages of the Kolaghat, Delta and Panskura blocks in West Bengal. Kasimpur thermal power plant (KTPP) is situated in the plains of the state of Uttar Pradesh and the wastes are discharged into the upper Ganges canal.

2. Experimental method

2.1. Radon exhalation rate

Samples of coal and fly ash were collected from Kolaghat and Kasimpur thermal power plants. Coal samples were grinded. All the samples were dried and sieved through a 100-mesh sieve. Sealed Can technique was used for the radon exhalation measurements. In such measurements equal amount of each sample (100 g) was placed in the Cans (diameter 7.0 cm and height 7.5 cm) similar to those used in the calibration experiment (Singh et al., 1997). In each Can, an LR-115 type II plastic track detector (2 cm × 2 cm) was fixed at the top inside of the Can. Thus the sensitive lower surface of the detector is freely exposed to the emergent radon so that it is capable of recording the alpha particles resulting from the decay of radon in the Can. Radon and its daughters reach an equilibrium concentration after a week or more and thus the equilibrium activity of emergent radon could be obtained from the geometry of the Can and the time of exposure. The half life of thoron is very small and ^{220}Rn has lower exhalation rate/emanation factor. Also ^{232}Th concentration is low and is comparable with ^{238}U in the present case. Therefore, the tracks recorded in TE detector due to alpha particles may be attributed to ^{222}Rn escaping

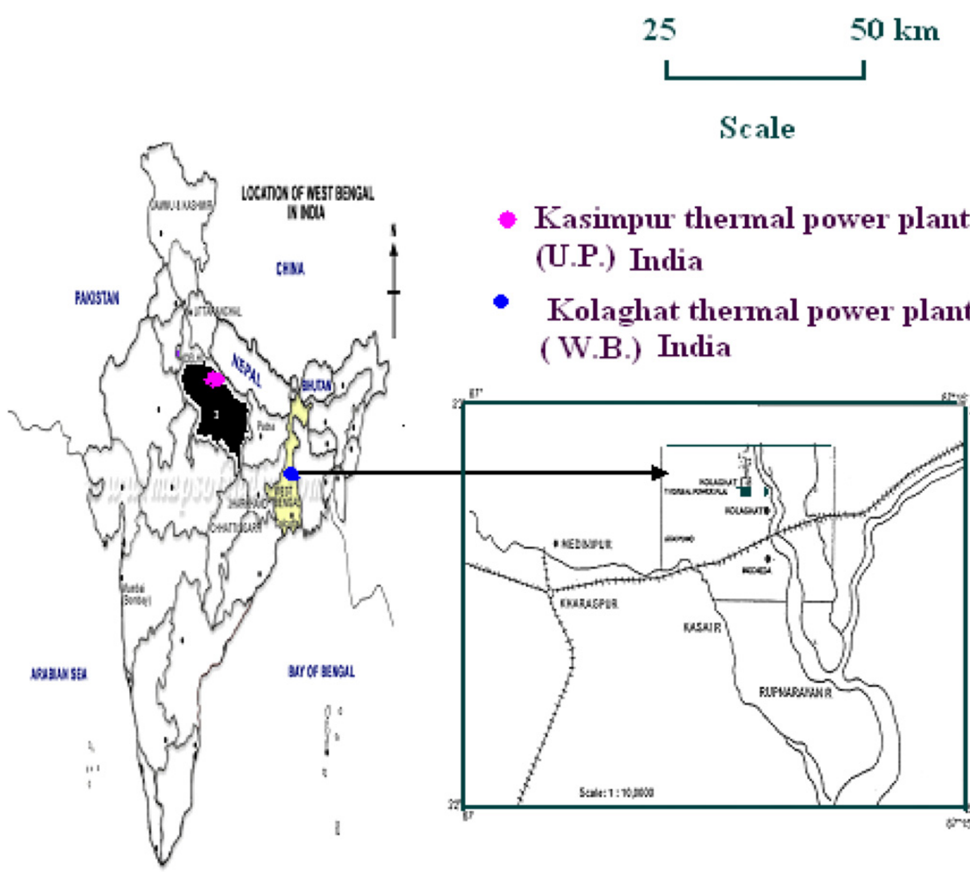

Fig. 1. Location map of Kasimpur thermal power plant (U.P.) and Kolaghat thermal power plant (W.B.), India.