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Low-Level Radiation Exposure to Some Industrial Workers

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The industrial workers in units like thermal power plants, gas power plants, LPG bottling plant etc. are exposed everyday to varying amounts of low-level ionizing radiation emitted from radon and its progeny in the environment. These radiations are spontaneously emitted by naturally occurring radioactive material like 238U and 232Th, ever since their existence on earth. The radioactive radon in the atmosphere (indoor and outdoor), soil, ground water, oil and gas deposits contributes the largest fraction of the natural radiation dose to populations, enhanced interest exhibited in tracking its concentration is thus fundamental for radiation protection. In the present work, the annual effective doses received by the industrial workers working in some industrial units have been estimated. For these measurements we have used the alpha sensitive solid-state nuclear track detectors (SSNTDs). The concentration of radon and annual effective doses has been calculated using recommendations from International commission on radiological protection (ICRP).

Key Words: Low-level radiation, Radon, Dose, Industrial units

INTRODUCTION

The exposure to low-level alpha radiation emitted from radon poses health hazards to workers at industrial units like thermal power plants, coal fields and oil fields. Radon being an inert gas can easily disperse into the atmosphere immediately on its release. The solid alpha active decay products of radon like ^{218}Po and ^{214}Po become airborne and get themselves attached to the aerosols, dust particles and water droplets suspended in the atmosphere. When inhaled during breathe, these solid decay products along with air may get deposited in the tracho-bronchial and pulmonary region of lungs resulting in the continuous irradiation of the cells which may be the cause of lung cancer[1]. Coal fired plants release more radioactive waste into the air than nuclear power plants of equivalent capacity. Fly ash, being promoted as cheap building material is an end product of coal burning. It is an incombustible residue formed from 90 % of inorganic matter in coal and escapes (0.5-2%) into atmosphere and biosphere[2]. The largest part of coal radioactivity remains with the ashes. In India the coal ash produced is about 90 million tones per year. It has been reported by several researchers[3] that the concentrations of the isotopes ^{238}U and ^{226}Ra become 3-5 times more than the coal itself in the coal slag and fly-ash obtained by burning the coal in coal fired power plants. In the present study, measurements of radon concentration have been made in environment of three industrial units of Northern India and the annual effective doses received by workers have also been calculated.

EXPERIMENTAL

Solid state nuclear track detectors have been used for the measurement of radon concentration. In each Industrial unit LR-115 type- II detectors (1 cm x 1 cm size) were exposed for 100 days in bare mode at different locations. The height of detectors was kept about 1.5 m from ground in most of the cases. The sensitive side of the bare detectors was exposed to the environment facing down so that dust may not settle on it. At the end of the exposure time, the detectors were removed and subjected to a chemical etching process in 2.5N NaOH solution at 60^0C for one and half-hour. The detectors were washed and dried. The tracks produced by the alpha particles, were observed and counted under an optical Olympus microscope at 600X. The measured track density (Track/cm^2/day) was converted into radon concentration in Bq/m^3 using calibration factors[4-5]. The annual effective dose from radon was calculated according to ICRP Publication[6] as follows:

$$D = (C \times K \times H) / (3700 \text{ Bq m}^{-3} \times 170 \text{ h}) \qquad (1)$$

Where, D = Annual effective dose (mSv/yr), C = EEC of Rn (Bq/m^3)

K = ICRP dose conversion factor which is 3.88 mSv WL M^{-1} for general public and 5.0 mSv WLM^{-1} for occupational workers.

H = Annual occupancy at location (7000 hours for residents), i.e. 80% of total time. 170, is taken as exposure time in hours for WLM.

RESULTS AND DISCUSSION

The radon levels at different locations of coal fired thermal power plant and annual effective doses received by workers are shown in table 1. The results indicates that the levels are higher in coal and fly ash handling areas which may be due to higher radium and uranium contents present in coal and fly ash. The radon levels at different locations of gas turbine power plant and annual effective doses received by workers are shown in table 2 while the radon levels at different locations of LPG bottling and annual effective doses received by workers are shown in table 3. The annual effective doses received by industrial workers have been calculated using equation (1). In an Indian case study[7] an air-borne radon activity in the coal fired plant was found to vary from 47.07 to 850.40 Bq m^{-3}. Average radon concentration in various coal fired thermal power plants in Punjab (India), have been reported[8] as 79.2 Bq m^{-3}.

The present study shows that the radon concentration levels in coal fired and gas turbine power plants are within the recommended safety limits for industrial workers and the annual effective dose is less than the recommended occupational dose by ICRP[6].The average radon levels in thermal power plants are found to be more compared with other industrial units. The information calls for necessary steps to be taken to minimize the emission and consequent adverse effects on the environment from fly ash and coal ash produced in thermal power plants.

Table-1 Radon levels and annual effective doses received by workers in a coal fired thermal power plant.

S. No.	Locations in Thermal Power Station	Radon concentration (Bq/m^3)	Annual effective dose (mSv)
1	Boiler area	230	4.0
2	Chlorination plant Area	211	3.6
3	Fly ash area	256	4.4
4	Coal Area	288	5.0
5	Water treatment plant	182	3.2
6	Administrative block	83	1.4
7	Near entrance gate	67	1.2
	AM ± SE*	188 ± 31	3.3 ± 0.5

Table 2: Radon concentration and annual effective doses received by workers in Gas Turbine Power plant.

S. No.	Locations in Gas Turbine Power Station	Radon concentration (Bq/m^3)	Annual effective dose (mSv)
1	Boiler area	262	4.6
2	Stack area	288	5.0
3	Water treatment plant	96	1.6
4	Chlorination plant	115	2.0
5	Water tank area	134	2.3
6	Turbine area	154	2.8
7	Main control room	57	1.0
	AM ± SE*	158 ± 29	2.8 ± 0.5

Table 3: Radon concentration and annual effective dose in the environment of LPG bottling plant.

S. No.	Locations in LPG filling Station	Radon concentration (Bq/m^3)	Annual effective dose (mSv)
1	Administrative block	57	1.0
2	Canteen	134	2.3
3	Generator room	134	2.3
4	Store	96	1.6
5	Fire pump house	134	2.3
6	LPG comp.house-I	211	3.6
7	LPG comp.house-II	192	3.3
8	Near entrance gate	57	1.0
9	Air compressor house	154	2.8
	AM ± SE*	130 ± 18	2.2 ± 0.3

*SE (standard error) = $\sigma/\sqrt{N}$, Where σ is SD (standard deviation) and N is the no of observations

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