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Radon monitoring in gas turbine and thermal power station; A comparative study

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ABSTRACT

Background: In this study, measurement of indoor radon and its progeny levels was carried out in Gas Turbine Power Station in Haryana (India), where natural gas is used as fuel. For comparison, the results of a study carried out in thermal power plant in Haryana are also presented. Radon being a ubiquitous air pollutant has global impact and its monitoring in the environment at work places is essential from health and hygiene point of view.
Materials and Methods: LR-115, Type- II (Kodak Pathe, France), plastic track detectors commonly known as solid state nuclear track detectors (SSNTDs) were used to measure the radon concentration over long integrated times. Alpha particles emitted from radon cause radiation damage tracks, which were subsequently revealed by chemical etching in NaOH. These alpha tracks registered were counted by optical microscope at suitable magnification and converted into radon concentration.
Results: The radon levels measured at various locations were moderate to high and thus unsafe from health point of view. The potential alpha energy concentration (PAEC), radon levels (EEC), annual exposure, annual effective dose in the Gas Turbine Power Plant varied from 4.14 mWL to 26.7 mWL, 38.3 Bq m^{-3} to 247.6 Bq m^{-3}, 0.17 WLM to 1.10 WLM and 0.66 mSv to 4.25 mSv respectively.
Conclusion: In gas turbine power plant, the radon levels were found to be lower as compared with thermal power plant. In thermal power plant a lot of coal is being burnt which contains radionuclides. Coal fired plants release more radioactive waste which is hazardous into the air than gas power plants of equivalent capacity. *Iran. J. Radiat. Res., 2003; 1(3): 133 - 137*

Keywords: *Radon, gas power station, health, environment, SSNTDs.*

INTRODUCTION

Problem of radon is global and concerns the world population. Radon (^{222}Rn), a progeny of ^{238}U, is a colourless, odourless, ubiquitously present but noble gas which is radioactive and poses grave health hazards not only to uranium miners but also people living in normal houses and buildings and at work place in industry. The increased interest in measuring radon (^{222}Rn) concentration in thermal power plants and gas turbine power stations is due to its health hazards and environmental pollution. It is well known that exposure of population to high concentrations of radon and its daughters for a long period lead to pathological effects like the respiratory functional changes and the occurrence of lung cancer (BEIR VI). The target organ for the radon exposure is the epithelial lining of the lung. As radon accounts for about half of our total exposure from air so measuring its concentration is very important for radioprotection.

With the global energy scene worsening with each passing day, we would need to wean ourselves off oil and other fossil fuels sooner than anticipated. With the exponential increase in demand of electricity, India will require 2,40, 000 MW of

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installed power generation capacity by 2012. There is a growing concern over pollution and global warming caused by conventional power plants, which can adversely affect atmospheric processes that regulate the global energy and heat balance. This in turn may have serious implications for the stability of life on the earth. Although, about 72% of electricity needs are being met by thermal generation in India, but a part of the electricity need is met with the electricity generated in gas turbine power stations. About 72 persons die per gigawatt of power each year when coal-burning plants are used for power (Beckmann 1989). It has been reported by several researchers (Nikl and Vegvari 1992, Bodizs *et al.* 1992) that the concentrations of the isotopes ^{238}U and ^{226}Ra become 3-5 times more than those in the coal itself in the coal slag and fly ash obtained by burning the coal in coal fired power plants. Several researchers have reported radon levels in thermal power plants (Bodizs *et al.* 1992, Rawat *et al.* 1991, Nikl and Vevgari 1992, Papastefanou and Charalanbous 1979, Kant *et al.* 2001). Keeping in view the environmental pollution caused due to the burning of coal in thermal power stations, there is an upsurge in the establishment of nuclear and gas turbine power stations in recent times. An increased share of gas and nuclear in power generation could lead to lower emissions. Also, considerable emphasis is being laid on developing non-polluting and renewable energy sources like water, air, solar energy and others. The contribution of different sources to power generation in India in 2002 is shown in figure 1 and that of total world consumption of energy in figure 2. From the figure 1 it can be seen that thermal power plants contribute around 72% followed by Hydel with about 25% (TEDDY 2002).

In the present study radon monitoring has been carried out in gas turbine power plant in Haryana, India. In this plant electric power is generated using natural gas as fuel. Natural gas is a better fossil fuel than coal as it burns completely and does not leave any residue and has high calorific value (25-30) kJ/g. It mainly consists of methane (CH_4) 95%, with small quantities of ethane and propane. For comparison the results of a study of radon monitoring carried out in thermal power plant in Haryana, India are also presented.

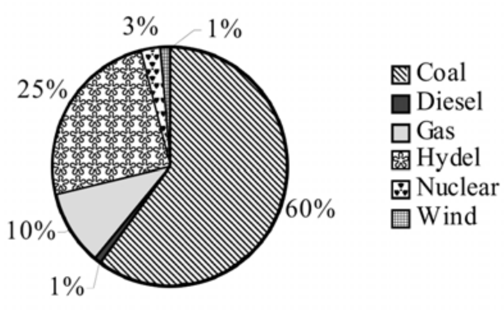

Figure 1. Contribution of different sources in power generation in India as on 31-03-2002 [Source: TEDDY, 2002]

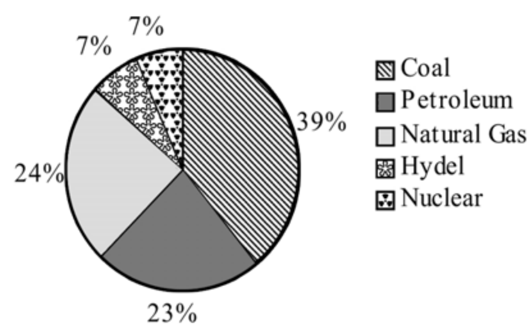

Figure 2. Total world consumption of energy: contribution of various sources[Source: IEA]

MATERIALS AND METHODS

For the measurement of environmental radon and its progeny concentration, track etch technique was used which is simple and inexpensive in the conditions that prevail in the power plants. It is time integrated passive technique that not only gives the average value of long-term exposure, but also gives comparatively low uncertainties due to randomness of radioactive decay. LR-115, type II plastic track detectors (1cm x 1cm) were fixed at thirteen different locations in Gas Turbine Power Station such that the sensitive side of the detector faced the environment. The detectors were kept away from the walls to avoid direct alpha emission from building materials. The exposure time of the detectors was three months. Proper arrangements were made to avoid settling of dust on the detectors, which could otherwise affect the radon concentration. At the end of the exposure time, the detectors were removed and subjected to a chemical etching process in 2.5 NaOH solution at 60 °C for one and half- hour. The tracks produced by the alpha particles, were observed and counted under an optical Olympus microscope at magnification 600 ×. Large number of graticular fields of the detectors were scanned to reduce statistical errors.

The measured track density (Track/cm^2/day) was converted into potential alpha energy concentration (PAEC) in mWL and then into radon concentration (EEC value) in Bq/m^3 (Jojo *et al.* 1994). The annual effective dose estimated from radon levels measured at various locations in the gas turbine power station was calculated following ICRP Publication (ICRP 1993):

$X = (C \times 5\ \text{mSv WLM}^{-1} \times 2160\ \text{h}) / (3700\ \text{Bq/m}^3 \times 170\ \text{h})$, for occupational workers, where:

X – Annual effective dose (mSv/Year)

C – Integrated radon concentration (EEC value) in Bq/m^3

5 mSv WLM^{-1} are the ICRP dose conversion factor for occupational workers

Annual exposure for occupational workers was calculated by using

1 Bq/m^3 = 0.00445 WLM = 1.72 × 10^{-2} mSv

RESULTS AND DISCUSSION

The radon concentration in gas turbine power plant varied from 38.3 Bqm^{-3} to 247.6 Bqm^{-3} with an average of 97.11 ± 15.78 Bqm^{-3} and the annual effective dose received by the workers varied from 0.66 mSv to 4.25 mSv with an average of 1.67 ± 0.27 mSv as shown in table 1. The radon concentration in thermal power plant varied from 103.6 Bqm^{-3} to 397.4 Bqm^{-3} with an average of 282.13 ± 30.56 Bqm^{-3} and the annual effective dose received by the workers varied from 1.78 mSv to 6.83 mSv with an average of 4.85 ± 0.52 mSv as shown in table 2. The radon concentration values in thermal power plant are in agreement with the values (47.07 to 850.40 Bqm^{-3}) reported in earlier study (Rawat *et al.* 1991) and from 558 ± 40 Bq m^{-3} to 682 ± 60 Bq m^{-3} (Chauhan *et al.* 2002). The average annual inhalation dose in thermal power plant is significantly higher than the global average value (UNSCEAR 2000). However, the dose levels observed in these power plants are marginally below the ICRP recommendations (ICRP 1993).

Table 1. Radon concentration, annual exposure, annual effective dose and lifetime fatality risk in Gas Turbine Power Station in Haryana (India).

S. No.	Location	PAEC (mWL)	Radon concentration (Bq/m^3)	Annual exposure (WLM)	Annual effective dose (mSv)
1	GP-1	6.74	62.3	0.28	1.07
2	GP-2	5.87	54.3	0.24	0.93
3	GP-3	9.77	90.4	0.40	1.55
4	GP-4	5.11	47.2	0.21	0.81
5	GP-5	4.14	38.3	0.17	0.66
6	GP-6	4.14	38.3	0.17	0.66
7	GP-7	5.87	54.3	0.24	0.93
8	GP-8	4.66	43.1	0.19	0.74
9	GP-9	26.7	247.6	1.10	4.25
10	GP-10	7.64	70.8	0.32	1.21
11	GP-11	12.8	118.3	0.53	2.03
12	GP-12	4.14	38.3	0.17	0.66
13	GP-13	7.64	70.8	0.32	1.21
14	AM ± SE*	8.09± 1.7	97.11 ±15.78	0.43 ± 0.07	1.67 ± 0.27

*SE (standard error) = σ/√N, Where σ is SD (standard deviation) and N is the no. of observations.

Table 2. Radon concentration, annual exposure, annual effective dose and lifetime fatality risk in Thermal Power Plant in Haryana (India).

S. No.	Locations in Thermal	PAEC (mWL)	Radon concentration (Bq/m^3)	Annual exposure (WLM)	Annual effective dose (mSv)
1	Coal area	42.9	397.4	1.77	6.83
2	Fly-ash area	41.1	380.1	1.69	6.53
3	Water treatment plant	28.0	259.1	1.15	4.45
4	Chlorination plant	35.5	328.2	1.46	5.64
5	Boiler area	24.2	224.4	0.99	3.86
6	Near entrance gate	11.2	103.6	0.46	1.78
7	AM ± SE*	30.48±3.30	282.13±30.56	1.25±0.13	4.85±0.52

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

CONCLUSIONS

The measurements indicate moderate to high levels of radon concentration at different locations in the environment of various power plants. In gas turbine power plant, the radon levels were found to be lower as compared with thermal power plant, as in thermal power plant a lot of coal is being burnt which contains naturally occurring primordial radionuclides. It may be seen from the data obtained that fly ash and coal dust produced by grinding and burning of coal in various thermal power plants causes an increase in radon concentration in and around thermal power plants, though the annual effective dose is less than 10 mSv recommended as occupational dose (ICRP 1993). Coal fired plants release more radioactive waste into the air than gas power plants of equivalent capacity. The information calls for necessary steps to be taken to minimise the emission and consequent adverse effects on the environment from the coal fired power plants.

As the natural gas burns completely and there is no SPM (suspended particulate matter), the environment is cleaner in gas turbine power stations as compared to thermal power plants. In thermal power plants the finer particles of coal and fly ash are suspended in the air that are inhaled and cause conjunctivitis and other respiratory problems.

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