



Measurement of alpha radioactive air pollutants in some coal fired industrial units of northern India

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Abstract: In various thermal power plants the combustion of coal results in the release of some natural radioactivity which consequently increases the radioactivity in soil, water and atmosphere around thermal power plants. As the radon in the atmosphere, soil, ground water, oil and gas deposits contributes the largest fraction of the natural radiation dose to populations, so tracking its concentration is fundamental for radiation protection, health and hygiene point of view. In the present study, measurements of radon concentration in the environment of some coal fired thermal power plants of north India have been made using Solid State Nuclear Track Detectors (SSNTD). The radon thoron twin dosimeter cups are being used for the study. Three pieces of LR-115 solid-state Nuclear Track detectors are fixed in the dosimeters and were suspended in the industrial units for three months during a season. One gives radon, thoron and progeny concentration, second gives radon and thoron concentration while the third gives only the radon concentration. The annual effective doses received by the workers in these plants have also been calculated. The results indicate that the fly ash and coal dust produced by grinding and burning of coal in thermal power plants cause an increase in radon concentration in and around thermal power plants.

Keywords: Radon; thoron; annual dose; lung cancer; health

I. Introduction

With the advancements in the industrial and technological growth and applications, a general awareness has also arisen regarding the deleterious side effects of the same and has a role to play as lifeline. In some industrial units coal, is used as fuel. The coal combustion in industrial units is associated with the dispersal of radionuclides in the environment. The activities of radionuclides discharged in the atmosphere from coal depend on a number of factors such as activity concentration in coal, ash content in coal, temperature of combustion and efficiency of the filtering systems etc. In the production of electric power, coal is burnt in furnaces operating at temperature upto 1700°C and by this process most of the mineral matter in the coal is fused into vitrified ash. A portion of ash and incompletely burnt organic matter drop to the bottom of the furnace as bottom ash or slag. The fly ash, however, is carried through the boiler along with the hot flue gases to the stack where some fractions are collected while the rest escape in to the atmosphere. Thermal Power Stations add to environmental degradation problems through gaseous emissions, particulate matter, fly ash and bottom ash. Ash content being in abundance in Indian coal, problem of fly ash and bottom ash disposal increase day by day. The fly ash generated in thermal power station causes many hazardous diseases like Asthma, Tuberculosis etc. The people living within 5 km radius of coal based power plant suffer from respiratory ailments. Initially, perceptions of objectionable effects of air pollutants were limited to those easily detected like odour, soiling of surfaces and smoke stacks. Later, it was the concern over long term/chronic effects that led to the identification of six criteria pollutants. These six criteria pollutants are sulphur di-oxide (SO₂), Carbon Mono-oxide (CO), Nitrogen oxide (NO₂), Ozone (O₃), suspended particulates and non-methane hydrocarbons (NMHC) now referred to as volatile organic compounds (VOC). In the later part Lead (Pb) was added to that list. There is substantial evidence linking them to health effects at high concentrations.

National Fertilizer plant at Panipat (Haryana) accords high priority to quality, environment and safety at all the points and is covered under ISO 9001[2000] standards. The production of the plant is about 1550 metric ton of urea per day. Coal and diesel are the main fuels used in the plant. 1600 metric ton of coal and 1000 kilolitres of diesel are used in the plant per day. About 950 workers are employed in the plant. In the last year the company registered Urea sale of 33.77lac metric ton and sale turn over of Rs 5127 crore. NFL is the 2nd largest producer of nitrogenous fertilizers in the country. KISAN UREA {46% N} is the brand product of the company. The %age share of NFL in the urea production in the country is 16.8% The company apart from producing nitrogenous fertilizers also produces products like Nitric acid, Ammonium nitrate, Sodium Nitrate, Liquid

oxygen, Carbon dioxide, Argon etc. Neem coated UREA developed as panipat results is 5-10% increase in yield in paddy and wheat crops. NFL in collaboration with Kribhco and RCF has formed a joint company venture named as "URVARAK VIDESH LIMITED" to explore investment opportunities abroad and within the country. In order to improve the accountability and giving higher autonomy to Public Sector undertakings, the company has signed MOU with the department of fertilizers and has been awarded excellent rating award.

The exposure of population to high concentrations of radon and its daughters for a long period leads to pathological effects like the respiratory functional changes and the occurrence of lung cancer (BEIR VI, 1999). The goal of the present investigations is the radon, thoron monitoring of the national fertilizer plant and thermal power plant. The annual effective dose received by the people working in these plants is being estimated. These investigations are important as the number of such studies available is not much and the use of fly ash as building construction material is being encouraged.

II. Experimental Techniques

For the measurement of concentration of radon, radon and thoron both, and total sum of radon, thoron and their progeny in the dwellings, the radon-thoron mixed field dosimeter popularly known as, 'Twin Chamber Radon-Thoron Dosimeter, developed by Bhabha Atomic Research Centre (BARC) has been employed. The specially designed twin cup dosimeter used in present study consists of two chambers of cylindrical geometry separated by a wall in the middle with each having a length of 4.5 cm and radius of 3.1 cm. This dosimeter employs three SSNTDs out of which two detectors were placed in each chamber and a third one was placed on the outer surface of the dosimeter. One chamber is fitted with glass fiber filter so that radon and thoron both can diffuse into the chamber while in other chamber, a semi permeable membrane made of latex or cellulose nitrate, having a thickness of 25 μm is used. The membrane mode measures the radon concentration alone as it can diffuse through the membrane but suppresses the thoron. The twin cup dosimeter also has a provision for bare mode enabling it to register tracks due to radon, thoron and their progeny in total. Therefore, using this dosimeter we can measure the individual concentration of radon, thoron, and their progeny at the same time (Fig.-1).

The dosimeters were suspended at a height of about 1.5 m in order to evaluate the annual average indoor radon levels. 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°C for 90 minutes. The detectors were washed and dried and the tracks produced by the alpha particles were observed and counted under an optical Olympus microscope at 600X. A large number of graticular fields of the detectors were scanned to reduce statistical errors.

The measured track density (Track/cm²/day) was converted into radon and thoron concentration using calibration factors (Eappen & Mayya, 2004). Radon and thoron progeny levels in mWL has also been calculated using indoor equilibrium factor as 0.4 for radon and 0.1 for thoron from UNSCEAR [3]. Annual dose received by the industrial workers in the unit under study in mSv was estimated using the relation (Sannappa et al., 2003, Mayya et al., 1998):

$$D = [(0.17 + 9 F_R) C_R + (0.11 + 32 F_T) C_T] \times 7000 \times 10^{-6}$$

Where, F_R = equilibrium factor for radon; C_R = radon concentration; F_T = equilibrium factor for thoron and C_T = thoron concentration

III. Results and Discussion

In the present investigations the measurements indicate moderate to some higher levels of radon, thoron and progeny concentration in the environment of the Industrial units under study.

The values of radon concentration in the atmosphere of fertilizer plant varied from 23 to 122 Bq m⁻³ with an average of 50 ± 8 Bq m⁻³ and the average annual effective doses have variation from 0.9 to 3.7 mSv with an average of 1.9 ± 0.2 (Table 1). The radon concentration in the atmosphere of thermal power plant varied from 46 to 122 Bq m⁻³ and the average annual effective doses have variation from 1.5 to 4.9 mSv (Table 2). In another power plant the values of radon concentration varied from 114 to 229 Bq m⁻³ with an average of 165 ± 16 Bq m⁻³ and the average annual effective doses have variation from 4.9 to 8.1 mSv with an average of 6.6 ± 0.5 (Table 3).

It may be seen from the data obtained that the levels are higher in coal handling area of the thermal power plant due to higher contents of uranium and radium in coal. In the present case study however, the annual effective dose is less than 20 mSv the recommended occupational dose (ICRP, 1993). The use of fly ash as building material should not be encouraged as it may enhance indoor doses from external irradiation besides inhalation of radon decay products may increase significantly. The information calls for necessary steps to be taken to minimize the emission of fly ash and coal dust produced in thermal power plants. The workers in thermal power plants are exposed to higher doses compared with other workers due to use of coal and production of fly ash in the plants

IV. References

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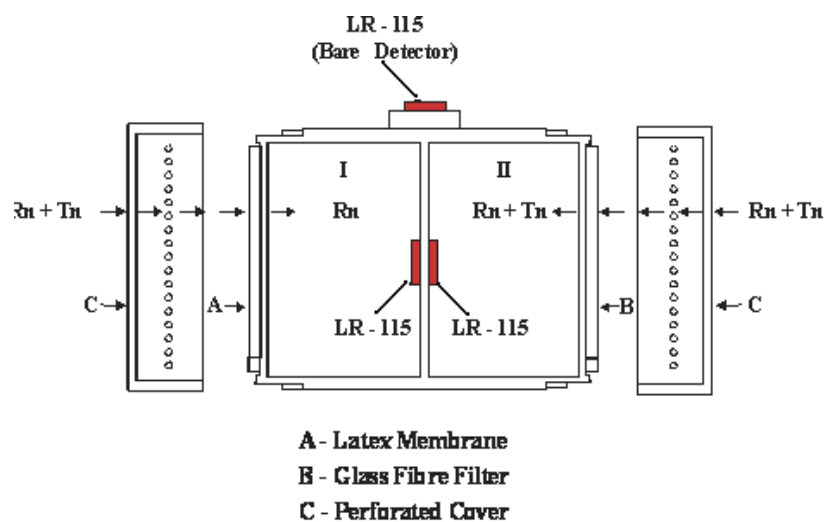


Fig.-1 Twin Chamber Radon-thoron dosimeter cups used in the present study

Table-1 Radon, thoron Levels and Annual Effective Dose Received by the workers at NFL plant PANIPAT, India

Location	Radon Conc. (Bq m ⁻³)	Thoron Conc. (Bq m ⁻³)	Radon Progeny (mWL)	Thoron Progeny (mWL)	Annual Effective Dose (mSv)
Urea Compressor Area	66	10	7.4	0.3	2.0
Amonia Plant Area	46	37	4.9	1.0	2.0
Carbon Dioxide Area	38	21	4.1	0.6	1.5
Central Lab Area	38	21	4.1	0.6	1.5
Efficient Treatment Plant	61	27	6.6	0.7	2.2
Electricity Gen. Area	30	5	3.3	0.1	0.9
Fly Ash Area	38	21	4.1	0.6	1.5
Bagging Area	23	31	2.5	0.9	1.3
Urea Plant Area	53	36	5.8	1.0	2.2
Sulphur Storage Area	122	21	13.1	0.6	3.7
Sulphur Recovery Area	38	30	4.1	0.8	1.7
AM ± SE	50 ± 8	24 ± 3	5.5 ± 0.9	0.7 ± 0.1	1.9 ± 0.2

Table-2 Radon, thoron Levels and Annual Effective Dose Received by the workers at Thermal Power Station Panipat, India

Location	Radon Conc. (C _R) (Bq/m ³)	Thoron Conc. (C _{Th}) (Bq/m ³)	Radon Progeny (mWL)	Thoron Progeny (mWL)	Annual Effective Dose(mSv)
Office	46	29	4.9	0.8	1.7
Boiling area	53	36	5.8	0.9	2.2
Fly ash area	114	89	1.2	2.4	5.1
Coal area	122	71	1.3	1.9	4.9
Near ent. gate	76	17	8.2	0.5	2.4
Turbine area	69	18	7.4	0.4	2.3
AM±SE	80 ± 13	43 ± 11	4.8 ± 1.2	1.1 ± 0.3	3.1 ± 0.7
TP-1 room	53	11	5.8	0.3	1.7
TP-2 room	46	12	4.9	0.3	1.5
TP-3 room	61	10	6.6	0.3	1.9
TP-4 room	46	20	4.9	0.6	1.7
AM±SE	52 ± 4	13 ± 2	5.6 ± 0.4	0.4 ± 0.1	1.7 ± 0.1

Table-3 Radon, thoron Levels and Annual Effective Dose Received by the workers at Thermal Power Station Yamuna Nagar, India

Location	Radon Conc. (C _R) (Bq/m ³)	Thoron Conc. (C _{Th}) (Bq/m ³)	Radon Progeny (mWL)	Thoron Progeny (mWL)	Annual Effective Dose(mSv)
Coal area	206	105	22	2.8	7.9
Boiler area	114	89	12	2.4	5.1
Office	122	71	13	1.9	4.9
Generation area	168	134	18	3.6	7.5
Near ent.gate	168	117	18	3.1	7.2
Store	146	61	16	1.6	5.2
Fly ash area	229	94	25	2.5	8.1
AM±SE	165 ± 16	96 ± 10	18 ± 2	2.6 ± 0.3	6.6 ± 0.5

Fig.-2 Comparison of Radon-thoron levels in different industrial units study

