INDOOR ASSESSMENT OF RADON, THORON AND THEIR PROGENY LEVELS IN THE DWELLINGS NEAR THE FLY ASH DUMPING SITES SITUATED IN FARIDABAD (HARYANA) INDIA

Environmental Science

KEYWORDS: radon, thoron, dwellings, dumping sites, dose, ventilation conditions

Nitin Gupta	Department of Humanities and Applied Sciences, AITM, Palwal, Haryana,
Krishan Kant	Aggarwal College Ballabgarh, Faridabad, Haryana
Maneesha Garg	Department of Humanities and Applied Sciences, YMCAUST, Faridabad, Haryana

ABSTRACT

The thermal power plants generate fly ash as naturally occurring product of coal combustion contains uranium which is an ultimate source of radon. Radon is second most common cause of cancer. So, from health point of view radon, thoron and their progeny levels were estimated in the dwellings near the fly ash dumping sites. For measurement, twin cup dosimeters were employed for a season of a year. Measurements show that the concentration of radon and thoron varied from 12.78±1.08Bqm^{-3} to 133.10±3.05Bqm^{-3} and 5.42±0.95Bqm^{-3} to 72.23±3.96Bqm^{-3} respectively. PAEC due to radon and thoron varied from1.38±0.12mWL to 14.38±0.33mWL and 0.14±0.02mWL to 1.95±0.11mWL respectively. Inhalation dose varied from 0.46mSv/y to 5.21mSv/y. However annual exposure due to radon and thoron and annual effective dose varied from 56.94x10^{-3}WLM to 592.82x10^{-3}WLM, 6.03x10^{-3} WLM to 80.42x10^{-3}WLM and 0.23mSv to 2.52mSv respectively. As recommended by various regulatory bodies the observations are below the safety levels. The maximum value of133.10±3.05Bqm^{-3} inside the cave of a temple as there is no ventilation. Variation in the various observations is because of different types of walls, floors and ventilation conditions of dwellings. Results shows that the concentration of radon decreases as the distance between dwellings and dumping sites increases.

INTRODUCTION

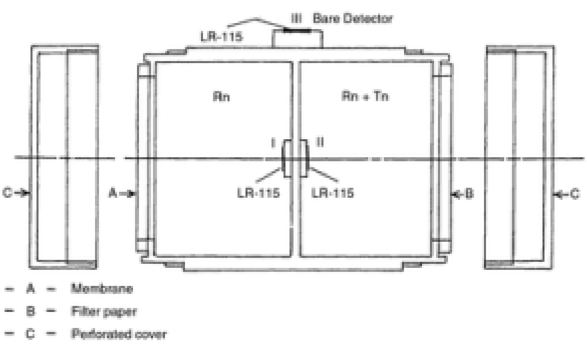
Coal contains radionuclides like uranium, thorium and potassium. Coal combustion results in the emission of its by-product named as fly ash into the atmosphere (D.C Adriano et al., 1980). Previous measurements show that, because of small size and large surface area fly ash contains enhanced uranium level than coal itself (A.K. Mahur et al., 2008). The ash produced in thermal power plants can cause all three environmental risks - air, surface water and groundwater. Growing demand of electricity generation results in the massive production of fly ash and need land for its disposal (dumping sites) (Gökhan Baykal et al., 2011). Presently, the annual production of fly ash is estimated nearly equal to 112 million tones which cannot be ignored and expected to cross 225 million tons by the year of 2017. Such a huge production of fly ash needs land for its safe disposal and upmost care for the safety of social life and environment.

Environment in the vicinity of these dumping sites is highly affected, because fly ash contains relatively high radionuclides content. It may raise the concentration of indoor activity through its radon emanation.Risk projections imply that radon is the second leading cause of lung cancer after smoking (Melloni et al., 2000). The presence of radon gas in the environment (indoor and outdoor) contributes largest radiation dose to the population(B.S. Bajwaa et al.,2008). The contribution of thoron is negligible because of their short half-life (55.6 s).

In the present study indoor assessment of radon, thoron and their progeny levels has been estimated in the dwellings near the fly ash dumping sites situated in Faridabad (Haryana) India.

EXPERIMENTAL TECHNIQUE

Twin chamber dosimeters were employed for the measurement of radon, thoron and their progeny levels, developed at the (BARC) and is reported elsewhere (Mayya et al., 1998; Eappen and Mayya, 2004). The strippable detector, LR-115 (TYPE II) cellulose nitrate films cut into the 2.5cmx2.5cm pieces of 12 μm thickness were fixed inside the dosimeters. The dosimeter provides two modes with central partition of 5.5cm length of each and one bare mode outside the dosimeter as shown in the fig. below These dosimeters provide three modes i.e. bare mode to detect the radon, thoron and their progeny, filter mode which allow the entry of both radon and thoron and membrane mode which allow the entry of radon only. The dosimeters were mounted in the dwellings near the fly ash dumping sites at different location selected with varying distances from the dumping sites for a season of a year. After the exposure of a season the detectors were retrieved from the dwellings. Now, the films were etched with constant temperature bath in 2.5N NaOH solution at 60oc for 90 minutes. Then these films were washed dried and stripped from thick polyester base for observations. Then visible tracks were counted using spark counter.



RESULT AND DISCUSSION

The radon (C_R) and Thoron (C_T) concentrations were calculated by using the following relations (Sannappa J. et al; 2003):

$$C_R\,(Bq\,m^{-3}) = T_m/d \times S_m$$

$$C_T\,(Bq\,m^{-3}) = T_f - d\,C_R \times S_{rf}/d \times S_{tf}$$

Where, C_R -Radon concentration; C_T - Thoron concentration; T_m- Track density in membrane compartment; T_f - track density in filter compartment and d - Exposure time.

S_m- Sensitivity factor for membrane compartment, whereas S_{rf} and S_{tf} - sensitivity factor for radon and thoron in filter compartment respectively.

The inhalation dose in mSv/y and PAEC in WL were estimated using the following relations (Khan and Azam2012):

$$D_{in} = \{(0.17 + 9F_R)\,C_R + (0.11 + 32F_T)\,C_T\} \times 7000 \times 10^{-6}$$

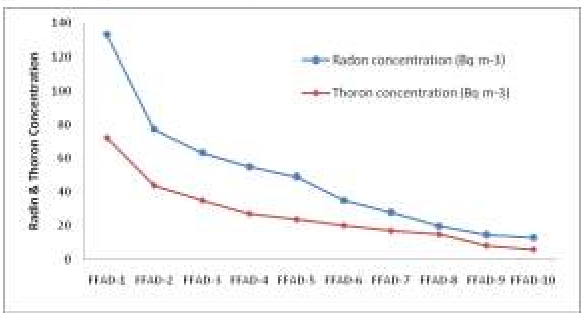
C_R or $C_T(Bq/m^3) = PAEC\,(WL) \times 3700/F$

Where F is equilibrium factor and its value is 0.4 and 0.1 for radon and thoron respectively (UNSCEAR, 2000).

Concentration of radon and thoron calculated using the formulation are shown in table 1. Results shows that concentration of radon and thoron varies from 12.78±1.08Bqm^{-3} to 133.10±3.05 Bqm^{-3}, 5.42±0.95 Bqm^{-3} to 72.23±3.96 Bqm^{-3} respectively. The PAEC value due to radon and thoron varied 1.38±0.12mWL to 14.38±0.33mWL, 0.14±0.02mWL to 1.95±0.11mWL respectively. The highest value of radon concentration is 133.10±3.05 Bqm^{-3} inside the cave of a temple, where there is no provision for the exchange of air.

Table 1: Radon and thoron concentration, progeny level in the dwellings near the fly ash dumping sites

Location	Radon concentration (Bq m^{-3})	Thoron concentration (Bq m^{-3})	PAEC (Rn) (mWL)	PAEC (Th) (mWL)
FFAD-1	133.10±3.05	72.23±3.96	14.38±0.33	1.95±0.11
FFAD-2	77.35±7.80	43.76±6.72	8.36±0.84	1.18±0.18
FFAD-3	63.23±5.55	34.76±7.81	6.83±0.60	0.94±0.21
FFAD-4	54.85±7.37	26.84±5.58	5.93±0.80	0.73±0.15
FFAD-5	49.03±8.86	23.47±3.17	5.30±0.96	0.63±0.09
FFAD-6	34.83±5.09	19.81±2.01	3.76±0.55	0.54±0.05
FFAD-7	27.79±2.99	16.73±2.14	3.00±0.32	0.45±0.06
FFAD-8	19.42±2.43	14.57±0.65	2.10±0.26	0.39±0.02
FFAD-9	14.49±0.79	7.84±0.42	1.56±0.08	0.21±0.01
FFAD-10	12.78±1.08	5.42±0.95	1.38±0.12	0.14±0.02



Graph 1: Variation of radon and thoron concentration in the dwellings near the fly ash dumping sites

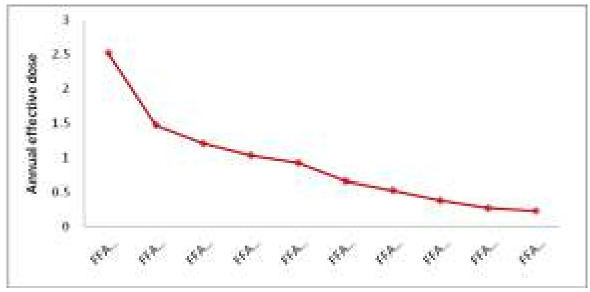
The above graph shows the variation in concentration from FFAD-1 to FFAD-10 is according to the locations selected at varying distances from the dumping sites. As the distance between the dwellings and dumping site increases radon and thoron concentration decreases.

Radon and thoron annual exposure, inhalation dose and annual effective dose in the dwellings near the fly ash dumping sites are shown in table 2: It shows that annual exposure due to radon and thoron varies from 56.94x10^{-3}WLM to 592.82x10^{-3}WLM, 6.03x10^{-3}WLM to 80.42x10^{-3} WLM respectively. Inhalation dose and annual effective dose varies from 0.46mSv/y to 5.21mSv/y, 0.23mSv to 2.52mSv respectively.Variation of annual effective dose with the different locations selected is shown in graph 2.

Table 2
Radon and thoron annual exposure, inhalation dose and annual effective dose in the dwellings near the fly ash dumping sites

Location	Annual exposure (Rn) (WLMx10^{-3})	Annual exposure (Th) (WLMx10^{-3})	Annual exposure (Rn+Th) (WLMx10^{-3})	Inhalation dose (mSv/y)	Annual effective dose (mSv)
FFAD-1	592.82	80.42	673.24	5.21	2.52
FFAD-2	344.50	48.72	393.22	3.07	1.47
FFAD-3	281.62	38.70	320.32	2.48	1.20
FFAD-4	244.30	29.89	274.19	2.08	1.03
FFAD-5	218.39	26.13	244.52	1.84	0.92
FFAD-6	155.11	22.05	177.16	1.38	0.66
FFAD-7	123.78	18.63	142.41	1.12	0.53
FFAD-8	86.49	16.22	102.71	0.85	0.38
FFAD-9	64.53	8.72	73.25	0.56	0.27
FFAD-10	56.94	6.03	62.97	0.46	0.23
Av±SE*				1.91±1.38	0.67±0.10

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



Graph 2. Variation of annual effective dose in dwellings near the fly ash dumping sites

CONCLUSION

Huge production of fly ash as a by-product of coal combustion poses the challenging problems of its safe management, health hazardous and environment. Results indicate that radon and thoron concentrations are within permissible levels as recommended by various regulatory bodies. The highest value of radon concentration was found to be 133.10±3.05Bqm-3, inside the cave of a temple where there is no any provision for the exchange of air. Variation in the concentrations is because of different type of house structure and their distances from the dumping sites.

REFERENCE

[1] Adriano D.C., Page A.L., Elseewi. A.A., Chang A.C., Straughan I.(1980), "Utilization and Disposal of Flyash and Other Coal Residues in Terrestrial Ecosystems: A Review", Journal of Environmental Quality, 9, 333–344 | [2] Bajwaab.S.,Singha H, Singha J., S. Singha, Waliab V (2008), "A combination study of indoor radon and gamma radiation levels in Tusham ring complex",Radiation Measurements, 43, 475–478 | [3]Eappen, K.P., Mayya Y.S. (2004),"Calibration factors for LR-115 (typeII.) based radon thoron discriminating dosimeter", Radiation Measurement, 38, 5-17 | [4] Gökhan Baykal, AltugSaygılı (2011), "A new technique to reduce the radioactivity of fly ash utilized in the construction industry", Fuel, 90,1612–1617 | [5] Kant K., Sonkawade R.G.,Chakarvarti S.K. (2008), "The radiological impact of the presence of radon, thoron and their progeny in the environment of a liquid petroleum gas bottling plant"Int. J. Low Radiation, 5, No. 3, 228-236 | [6] Khan MS, Azam A (2012) Depth dependent study of radon, thoron and their progeny in tube-wells. J RadioanalNuclChem 294:289–293 | [7] Mahur A.K. , Kumar R., SenguptaD., Rajendra Prasad (2008), "Estimation of radon exhalation rate, natural radioactivity and radiation doses in fly ash samples from Durgapur thermal power plant, West Bengal, India" Journal of Environmental Radioactivity, 99, 1289–1293 | [8] Mayya Y.S., Eappen K.P., Nambi K.S.V., (1998)"Methodlogy for mixed field inhalation in monazite areas using a twin-cup dosimeter with three- track detectors", Radiat. Prot. Dosim, Vol, 77, No. 3, pp177-184 | [9]Melloni B., Vergnenegra A., Lagrange P. and Bonnaud F. (2000).Radon and domestic exposure.Rev. Mal. Respir., 17(6): 1061-1071. | [10] UNSCEAR (2000), "Sources, effects and risks of ionizing radiation", United Nations scientific committee on the effects of atomic radiation, report to the general assembly, United Nations Publication, New York | [11] SannappaJ. Chandrasekhar M.S.,Sathish L.A., Paramesh L.,Venkataramaiah P. (2003), "Study of background radiation dose in Mysore city, Karnataka State, India", RadiatMeas,37, 55-65