International Journal of Technical Research and Applications e-ISSN: 2320-8163,
www.ijtra.com Volume 4, Issue 3 (May-June, 2016), PP. 118-125

COMPARATIVE STUDY OF INDOOR RADON, THORON AND THEIR PROGENY INSIDE KASIMPUR THERMAL POWER PLANT AND ITS NEIGHBOURING REGIONS

Dr. Meena Mishra
Assistant Professor, Sanskriti Group of Institutions, Mathura, U.P., India
meenaapd@yahoo.co.in

Abstract— **In the present study, concentration of radon- thoron and their progeny levels inside the kasimpur thermal power plant, Ukhalana and Sunamai villages were measured using the twin chamber solid state nuclear track detector (SSNTD) based dosimeters using 12 μm thick cellulose nitrate based pelliculable LR-115 type II detectors. Twin chamber dosimeter cups fitted with LR-115 type II films were placed at 10 places inside the Kasimpur thermal power plant, 10 places in the dwellings of ukhalana village and 8 places in the dwellings of sunamai village. Radon concentration inside Kasimpur Thermal Power Plant vary from 16 ± 2.9 Bq m^{-3} to 61± 5.6 Bq m^{-3} whereas thoron concentration varies from 6 ± 0.7 Bq m^{-3} to 56 ± 5.1 Bq m^{-3}. Radon and thoron PAEC values are found to vary from 1.73 ±0.31 mWL to 6.59 ±0.61 mWL and 0.16 ± 0.02 mWL to 1.51 ± 0.4 mWL. The annual effective dose from radon, and thoron is found to vary from 0.05 mSv y^{-1} to 0.95 mSv y^{-1}. The life time fatality risk factor was also estimated and it varies from 0.01×10^{-4} to 0.24 × 10-^{4}. Radon concentration in the dwellings of Ukhalana village is found to vary from 13 ± 2.54 Bq m^{-3} to 42± 4.66 Bq m^{-3} whereas thoron concentration varies from 11 ± 1.27 Bqm^{-3} to 39 ± 4.08 Bq m^{-3} . Radon and thoron PAEC values vary from 1.41 ±0 .27 mWL to 4.54 ±0 .5 mWL and 0.29 ±0 .03 mWL to 1.05 ± 0.11 mWL. The annual effective dose from radon, and thoron is found to vary from 0.063 mSv y^{-1} to 0.183 mSv y^{-1}. Estimated life time fatality risk factor varies from 0.19×10^{-4} to 0.55×10^{-4} . The inhalation dose is found to vary from 0.64 mSv y^{-1} to 1.57 mSv y^{-1}. The Radon concentration in the dwellings of Sunamai village is found to vary from 14 ± 2.67 Bq m^{-3} to 58± 5.51 Bq m^{-3} whereas thoron concentrations varies from 3 ± 0.27 Bq m^{-3} to 57 ± 4.97 Bq m^{-3}. Radon and thoron PAEC values vary from 1.51 ± 0.29 mWL to 6.27 ± 0.59 mWL and 0.08 ± 0.007 mWL to 1.54 ± 0.13 mWL. The annual effective dose from radon, and thoron is found to vary from 0.066 mSv y^{-1} to 0.229 mSv y^{-1}. The life time fatality risk factor was also estimated and varies from 0.19×10^{-4} to .69 × 10^{-4}.These values are below the recommended action levels.**

Index terms- **LR-115 type II dector, Twin chamber dosimeter cups, Effective Dose, Kasimpur thermal power plant, Ukhalana and Sunamai villages.,**

I. INTRODUCTION

About 90% of radiation exposure to human arises from natural sources such as cosmic radiation, terrestrial radiation and exposure to radon, thoron and their progeny [1]. Radon, thoron and its (alpha- emitting) decay products is naturally occurring in the environment in the form of ionizing radiation. Indoor radon, thoron and its decay products is assumed to be health hazardous for human [2]. Radon pollution is an important global problem of radiation hygiene. Radon and its progeny are the major contributors in the radiation dose received by general population of the world [3]. Short-lived radon and its decay products are the most important sources of radiation from natural sources which effect human beings [4]. Short-lived radon and its decay products are the most important sources of radiation from natural sources which effect human beings [5]. Radon is a radioactive gas which makes the primary contribution to the natural radiation to which people are exposed [6].There are over 30 known isotopic forms of radon. Most of these have very short half-lives in comparison to radon-222. due to their very short half-lives they cannot migrate far from their origins and consequently are of no radiological health significance. One of them, however, is radon-220 (usually called thoron) and despite its short half –life (55.6sec) may be present in indoor air at a sufficiently high concentration to be of some radiological significance [7]. Radon and thoron are invisible, odorless, heavy and radioactive gases which are obiquitously present in dwellings and in the environment [8].

Radon, thoron and their progenies as a natural radiation hazards to human health is well known [9].

The behavior of ubiquitous radon and its progeny in the indoor atmosphere generally reflects a complex interplay between a number of processes, the most important of which are radioactive α- decay, ventilation, attachment to aerosols and deposition on the surfaces. Indoor Rn exposure depends in a complex way on the characteristics of the soil, the type and details of the building structure, meteorology, ventilation conditions and occupant behavior. The measurements of time integrated concentration of indoor radon and its daughters are important since indoor radon and its progeny is responsible for more than half of the total yearly radiation dose to human beings. Study of radon and its progeny in air is indispensable, as these deliver the highest radiation dose to human beings among all natural radioactive sources. It has been estimated that inhalation of short–lived radon progeny accounts for more than half of the effective dose from natural sources [10]. Airborne concentrations of radon and its progeny vary from time to time, depending upon the meteorological conditions, such as temperature, relative humidity, wind speed, rainfall etc. Among all sources of background radiation that deliver significant doses to the tissues or cells of respiratory tract, The inhaled radon progeny are dominant and is about 55% of the total doses. There is increasing concern about exposure to radon and its progeny due to their detrimental effects on the health of inhabitants [11]. For an individual person exposed to radon gas for a long time, there is, from medical point of view, an increase in the risk for growth of a lung cancer [12,13], although low dose radiation lower the risk of cancer [14]. The seventh generation decay product of Uranium, radon, in indoor environment, contributes some what more than one half of the collective dose received by human population from all sources of exposure. Precisely, out of 98% of average radiation dose received by man from natural sources, about 52% is due to breathing of radon, thoron and their progeny present in the dwellings [15]. . The main contributions of indoor radon are: (i) diffusion from building elements, 21%; (ii) diffusion from subjacent earth, 15%; (iii) advection from subjacent earth, 41%; (iv) infiltration by outdoor air, 20% (v) de-emanation from water supply, 2% (vi) consumption of natural gas, 1% [16-18]. There has been increasing interest in indoor radioactivity measurements motivated by the concern about the possible consequences of long time exposure to higher concentrations of ^{222}Rn and ^{220}Rn and their progeny [19]. While indoor radon exposure has received wide public attention vis-a-vis lung cancer risk due to inhalation, not much information is known about the levels and risk associated with thoron (^{220}Rn) in indoor air because of its short half life. However, half-lives of its daughter products ^{212}Pb (10.6h) and ^{212}Bi (60. 6 min.) are comparable with biological elimination rate. The inhalation lung dose is relatively smaller than that from radon progeny. Radiation exposure due to inhalation of thoron progeny is estimated to be of the order of 10-20% compared with short-lived radon progeny [20]. Radon contributes to a large part of the radiation exposure to the general public [21] and it might produce lung cancer if inhaled in high concentration for long period [22-24]. This high exposure level may be harmful for people residing in the region.

Measurement of radon, thoron and their progeny is important because of the radiation dose to human population due to inhalation of radon, thoron and their progeny. As the radon progeny contributes a major part of natural radiation dose to general population, attention has been given to the large scale and long term measurement of radon and its progeny. Thoron and its progeny contribute little for the radiation dose in normal background region due to its small half life. Thoron, ^{220}Rn, is a natural decay product of thoron series. It has a half life of 55.6 seconds and decays through alpha particles. It is assumed that the inhalation dose to the human beings from thoron and its progeny is negligible although some studies in many countries have revealed that this may not be entirely correct [25].

II. EXPERIMENTAL DETAILS

Concentration of radon- thoron and their progeny were measured using the twin chamber solid state nuclear track detector (SSNTD) based dosimeters using 12 μm thick, LR-115 type II pelliculable, cellulose nitrate based SSNTDs, manufactured by Kodak Pathe, France. The dosimeter has been developed at Bhabha Atomic Research Centre (BARC) [26] and is shown in Fig. 1. Each cylindrical chamber has a height of 4.1 cm and a radius of 3.1 cm. one piece of the detector film (SSNTD) of size 3cm × 3cm, placed in compartment M measures radon only which diffuses into it from the ambient air through a semipermeable membrane of 25 μm thickness having diffusion coefficient in the range of 10^{-8} to 10^{-7} cm^{-2} s^{-1} [27]. It allows the build up of about 90% of radon gas in the compartment and suppresses thoron gas concentration by more than 99%. The mean time for radon to reach the steady-state concentration inside the cup is about 4.5 hours. Glass fiber filter paper and thickness of 0.56 mm in the compartment R allows both radon and thoron gases to diffuse into it and hence the tracks on second piece of the detector film placed in this chamber are related to the concentration of both the gases. Third piece of the detector film exposed in bare mode (placed on the outer surface of the dosimeter) registers alpha tracks attributed to both the gases and their alpha emitting progeny, namely ^{218}Po, ^{216}Po and ^{212}Po. LR-115 detectors do not develop tracks originating from the progeny alphas, deposited on them [28-31] and, therefore, are ideally suited for radioactive gas concentration study. The exposed films were etched in 2.5 NaoH solution at 60% ^{o}C for 90mins. in a constant temperature water bath. The etching processes removes a bulk thickness of 4 μm, leaving a residual detector for thickness of 8 μm. The detectors are pre-sparked using spark counter [32] at a voltage of 900V to fully develop the partially etched track holes. The tracks are then counted at the voltage corresponding to the plateau region of the counter (450V). The concentrations of radon, thoron and progeny are computed from the observed track densities using appropriate calibration factors. The calibration factors depend upon various parameters such as membrane and filter characteristics as well as the energy of the alpha particles for the cup mode exposure, the parameters of the etching process and spark counting characteristics.

From the track density, concentration of radon (C_R) and thoron (C_T) were calculated using the sensitivity factor determined from the controlled experiment [33].

$$C_R\ (\text{Bq m}^{-3}) = T_m/d \times S_m \quad (1)$$

$$C_T\ (\text{Bq m}^{-3}) = T_f - d \times C_r \times S_{rf} / d \times S_{tf} \quad (2)$$

where

C_R = Radon concentration

C_T = Thoron concentration

T_m = Track density in membrane compartment

T_f = Track density in filter compartment

d = Exposure time

Sensitivity factor for membrane compartment is

(S_m) = 0.019 ± 0.003 trc m^{-2} d^{-1}/Bq m^{-3}

Sensitivity factor for radon in filter compartment is

(S_{rf}) = 0.020 ± 0.004 trc m^{-2} d^{-1}/Bq m^{-3}

Sensitivity factor for thoron in filter compartment is

(S_{tf}) = 0.016 ± 0.005 trc m^{-2} d^{-1}/Bq m^{-3}

The inhalation dose (D) in mSv y^{-1} is estimated using the relation:

$D = [(0.17 + 9 F_R) C_R + (0.11+32F_T) C_T] \times 7000 \times 10^{-6}$----------------(3) where F_R and F_T are equilibrium factor for radon and thoron respectively. The values are taken as 0.4 and 0.1 for radon and thoron [34].

The life time fatality risks were also calculated from the values obtained for radon and thoron and their daughters concentrations in terms of potential alpha energy concentration (PAEC) in mWL extracted from bare detector exposure. Measured radon/thoron concentrations were converted into equilibrium equivalent concentration (EEC) which was further converted into potential alpha energy concentration (PAEC) using the relation:

C_R or C_T = PAEC (WL) × 3700/F-------------------------------(4)

where, F is the equilibrium factor and its value is 0.4 and 0.1 for radon and thoron respectively . PAEC is converted into annual effective dose by using dose conversion factors. Radon daughter dose conversion factor for the population is given as 3.9 mSv per WLM whereas the effective dose equivalent for thoron is 3.4 mSv per WLM . The life time risk associated with the exposure due to indoor radon and its progeny was computed by using 1 WLM = 10×10^{-6} case/year. If the risk persists for 30 years, life time fatality risk is 3×10^{-4} case/WLM .

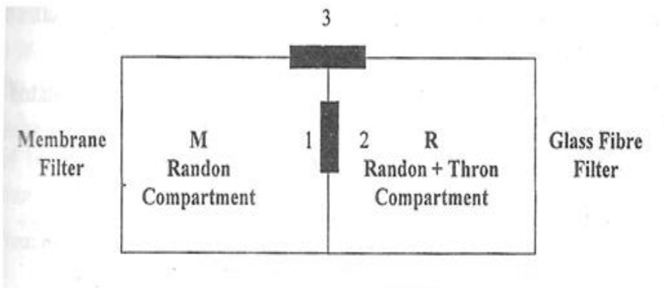

Fig 1 Radon-Thoron mixed field dosimeter system

III. Results and Discussion

The values of radon and thoron concentration and inhalation dose obtained are presented in Table 1,2 and 3. The results of the life time fatality risks are given in Table 4,5 and 6. Radon concentration inside Kasimpur Thermal Power Plant vary from 16 ± 2.9 Bq m^{-3} to 61± 5.6 Bq m^{-3} whereas thoron concentration varies from 6 ± 0.7 Bq m^{-3} to 56 ± 5.1 Bq m^{-3}. Radon and thoron PAEC values are found to vary from 1.73 ±0.31 mWL to 6.59 ±0.61 mWL and 0.16 ± 0.02 mWL to 1.51 ± 0.4 mWL. The annual effective dose from radon, and thoron is found to vary from 0.05 mSv y^{-1} to 0.95 mSv y^{-1}. The life time fatality risk factor was also estimated and it varies from 0.01×10^{-4} to 0.24 × 10-[4]. Radon concentration in the dwellings of Ukhalana village is found to vary from 13 ± 2.54 Bq m^{-3} to 42± 4.66 Bq m^{-3} whereas thoron concentration varies from 11 ± 1.27 Bqm^{-3} to 39 ± 4.08 Bq m^{-3} . Radon and thoron PAEC values vary from 1.41 ±0 .27 mWL to 4.54 ±0 .5 mWL and 0.29 ±0 .03 mWL to 1.05 ± 0.11 mWL. The annual effective dose from radon, and thoron is found to vary from 0.063 mSv y^{-1} to 0.183 mSv y^{-1}. Estimated life time fatality risk factor varies from 0.19×10^{-4} to 0.55×10^{-4} . The inhalation dose is found to vary from 0.64 mSv y^{-1} to 1.57 mSv y^{-1}. The Radon concentration in the dwellings of Sunamai village is found to vary from 14 ± 2.67 Bq m^{-3} to 58± 5.51 Bq m^{-3} whereas thoron concentrations varies from 3 ± 0.27 Bq m^{-3} to 57 ± 4.97 Bq m^{-3}. Radon and thoron PAEC values vary from 1.51 ± 0.29 mWL to 6.27 ± 0.59 mWL and 0.08 ± 0.007 mWL to 1.54 ± 0.13 mWL. The annual effective dose from radon, and thoron is found to vary from 0.066 mSv y^{-1} to 0.229 mSv y^{-1}. The life time fatality risk factor was also estimated and varies from 0.19×10^{-4} to .69 × 10^{-4}. The wide variation in the concentration of both radon and thoron and their daughters may be attributed to theVariation in radioactivity in the region, the soil beneath the house, the ventilation, construction material and the type of construction etc.. Thoron may contribute a little towards the radiation dose. The inhalation dose and radon and thorn concentration are within the permissible limits.

Table 1

Radon and Thoron Concentration and Inhalation dose inside Kasimpur Thermal Power Plant

Location	T_m (Tr cm^{-2})	T_f (Tr cm^{-2})	C_R (Bq m^{-3})	C_T (Bq m^{-3})	D (inhalation dose) (mSv y^{-1})
Oil cooler	73.00	110.00	38 ± 4.4	21 ± 2.0	1.48
Water treatment plant	54.35	118.75	28 ± 3.8	39 ± 3.6	1.64
Control room	62.25	132.56	32 ± 4.1	42 ± 3.6	1.82
Office	57.81	123.63	30 ± 3.9	39 ± 3.5	1.69
Near L.P heater	44.66	57.00	23 ± 3.4	6 ±0 .7	0.75
Turbine hall 4	62.00	138.00	32 ± 4.1	46 ± 3.9	1.91
BMD store room	59.00	108.75	31 ± 4.0	29 ± 2.8	1.52
Near stair case	31.33	122.17	16 ± 2.9	56 ± 5.1	1.71
Mechanical workshop	116.8	135.25	61 ± 5.6	8 ± 0.7	1.79
Near induced draft fan	112.6	132.5	59 ± 5.6	9 ±0 .8	1.77
Minimum	31.33	57.00	16 ± 2.9	6 ±0 .7	0.75
Maximum	116.8	138.00	61 ± 5.6	56 ± 5.1	1.91
Average value	67.38	117.86	35 ± 4.18	29.5 ± 2.67	1.61
S.D.	27.33	23.66	14.43±.85	17.69± 1.55	0.33

Table 2

Radon and Thoron Concentration and Inhalation dose in Ukhalana village

Location	T_m (Tr cm^{-2})	T_f (Tr cm^{-2})	C_R (Bq m^{-3})	C_T (Bq m^{-3})	D (inhalation dose) (mSv y^{-1})
Drawing room	25.13	82.21	13.0 ± 2.59	35.0 ±3.86	1.15
Courtyard	30.83	85.17	16.0 ± 2.88	33.0 ± 3.58	1.19
Store room	51.33	97.67	27.0 ± 3.78	27.0 ± 2.73	1.34
Bed room	81.25	116.00	42.0 ± 4.66	20.0 ± 1.86	1.57
Kitchen	28.00	91.33	14.0 ± 2.65	39.0 ± 4.08	1.27
Drawing room	26.12	48.33	13.0 ± 2.54	13.0 ± 1.87	0.64
Kitchen	28.35	72.00	14.0 ± 2.63	27.0 ± 3.18	0.99
Bed room	55.50	75.67	29.0 ± 3.89	11.0 ± 1.27	1.02
Shop store	31.28	75.00	16.0 ± 2.86	26.0 ± 3.00	1.02
Varandah	29.00	58.33	15.0 ±2.78	17.0 ± 2.23	0.79
Minimum	25.13	48.33	13.0 ± 2.54	11.0 ± 1.27	0.64
Maximum	81.25	116.00	42.0 ± 4.66	39.0 ± 4.08	1.57
Average value	38.68	80.17	19.9 ±3.13	24.8 ± 2.77	1.09
S.D.	18.34	19.29	9.7±0.72	9.4±0.94	0.27

Table 3

Radon and Thoron Concentration and Inhalation dose in Sunamai Village

Location	T_m (Tr cm^{-2})	T_f (Tr cm^{-2})	C_R (Bq m^{-3})	C_T (Bq m^{-3})	D (inhalation dose) (mSv y^{-1})
Bath room	28.5	44.00	15 ± 2.81	8 ± 1.21	0.58
Bath room	64.2	124.00	33 ± 4.12	36 ± 3.23	1.70
Courtyard	27.5	67.5	14 ± 2.67	24 ±2.92	0.93
Store room	82.33	113.5	43 ± 4.74	17 ± 1.59	1.53
Stair case	38.65	131.81	20 ± 3.22	57 ±4.97	1.85
Varandah	40.7	125.33	21 ± 3.29	52 ± 4.65	1.76
Bed room	110.67	121.45	58 ± 5.51	3 ± 0.27	1.60
Kitchen	57.67	85.00	30 ± 3.95	15 ± 1.63	1.14
Minimum	27.5	44.00	14 ± 2.67	3 ±0.27	0.58
Maximum	110.67	131.81	58 ± 5.51	57 ± 4.97	1.85
Average value	56.28	101.57	29.25± 3.79	26.5 ± 2.56	1.39
S.D.	28.92	32.23	15.21±.98	19.98± 1.67	0.45

Table 4

Radon and Thoron daughters, annual exposure (WLM), life time fatality risk factor inside Kasimpur Thermal Power Plant

Location	Radon daughters (mWL)	Thoron Daughters (mWL)	Annual Exposure (radon + Thoron) WLM	Life time fatality risk factor x10^{-4}	Effective dose (mSv y^{-1})
Oil cooler	4.10 ±0 .48	0.57 ± 0.05	0.149	0.45	0.58
Water treatment plant	3.02 ± 0.41	1.05 ± 0.09	0.147	0.44	0.55
Control room	3.45 ±0 .44	1.14 ± 0.09	0.165	0.49	0.62
Office	3.24 ± 0.43	1.05 ±0 .09	0.154	0.46	0.58
Near L.P heater	2.48 ±0 .37	0.16 ±0 .02	0.014	0.04	0.05
Turbine hall 4	3.45 ± 0.44	1.24 ±0 .1	0.169	0.51	0.64
BMD store room	3.35 ±0 .44	0.78 ±0 .08	0.149	0.44	0.57
Near stair case	1.73 ± 0.31	1.51 ± 0.14	0.117	0.35	0.43
Mechanical workshop	6.59 ± 0.61	0.22 ± .02	0.238	0.71	0.95
Near induced draft fan	6.38 ± 0.60	0.24 ± 0.02	0.238	0.72	0.93
Minimum	1.73 ± 0.31	0.16 ± 0.02	0.014	0.04	0.05
Maximum	6.59 ± 0.61	1.51 ±0 .14	0.238	0.72	0.95
Average value	3.78 ±0.45	0.79 ± .07	0.154	0.46	0.59
S.D.	1.56 ±0 .93	48 ± 0.04	0.063	0.19	0.25

Table 5

Radon and Thoron daughters, annual exposure (WLM), life time fatality risk factor in Ukhalana Village

Location	Radon daughters (mWL)	Thoron Daughters (mWL)	Annual Exposure (radon + Thoron) WLM	Life time fatality risk factor x10^{-4}	Effective dose (mSv y^{-1})
Drawing room	1.41 ±0 .28	0.95 ± 0.10	0.085	0.25	0.31
Courtyard	1.73 ± 0.31	0.89 ± 0.09	0.094	0.28	0.35
Store room	2.92 ± 0.41	0.73 ± 0.07	0.131	0.39	0.49
Bed room	4.54 ± 0.50	0.54 ± 0.05	0.183	0.55	0.70
Kitchen	1.51 ± 0.29	1.05 ± 0.11	0.092	0.28	0.34
Drawing room	1.41 ± 0.27	0.35 ±0.05	0.063	0.19	0.24
Kitchen	1.51 ±0 .28	0.73 ± 0.09	0.081	0.24	0.30
Bed room	3.14 ± 0.42	0.29 ± 0.03	0.124	0.37	0.48
Shop store	1.73 ± 0.31	0.70 ± 0.08	0.088	0.26	0.33
Varandah	1.62 ± 0.30	0.46 ± 0.06	0.075	0.22	0.28
Minimum	1.41 ± 0.27	0.29 ± 0.03	0.063	0.19	0.24
Maximum	4.54 ± 0.5	1.05 ± 0.11	0.183	0.55	0.7
Average value	2.15 ± 0.34	0.67 ± 0.07	0.102	0.30	0.38
S.D.	1.05 ± 0.08	0.26 ± 0.03	0.035	0.11	0.14

Table 6

Radon and Thoron daughters, annual exposure (WLM), life time fatality risk factor in Sunamai Village

Location	Radon daughters (mWL)	Thoron Daughters (mWL)	Annual Exposure (Radon + Thoron) WLM	Life time fatality risk factor x10^{-4}	Effective dose (mSv y^{-1})
Bath room	1.62 ± 0.30	0.22 ± 0.03	0.066	0.19	0.25
Bath room	3.57 ±0 .45	0.97 ±0 .09	0.163	0.49	0.62
Courtyard	1.51 ± 0.29	0.65 ± 0.08	0.078	0.23	0.29
Store room	4.65 ± 0.51	0.46 ± 0.04	0.184	0.55	0.71
Stair case	2.16 ± 0.35	1.54 ± 0.13	0.133	0.39	0.49
Varandah	2.27 ±0 .36	1.41 ± 0.13	0.132	0.39	0.49
Bed room	6.27 ± 0.59	0.08 ±0 .007	0.229	0.69	0.89
Kitchen	3.24± 0.43	0.41 ± 0.04	0.131	0.39	0.50
Minimum	1.51 ± 0.29	0.08 ±0 .007	0.066	0.19	0.25
Maximum	6.27 ±0 .59	1.54 ± 0.13	0.229	0.69	0.89
Average value	3.16 ±0 .41	0.72 ±0 .068	0.139	0.42	0.53
S.D.	1.65 ± 0.10	0.54 ±0 .046	0.053	0.16	0.21

The percentage frequency distribution of radon in 10 dwellings is shown in Fig. 2. The percentage frequency distribution of thoron and the percentage frequency distribution for dose rates in these dwellings are shown in Figs. 3 and 4 respectively.

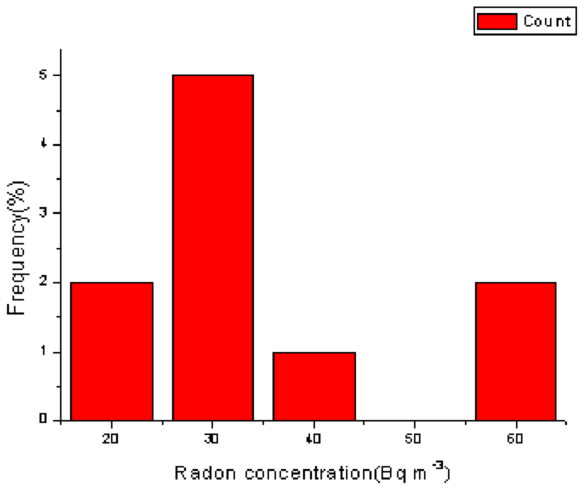

Fig 2 frequency distribution of radon in 10 dwellings inside of Kasimpur thermal power plant.

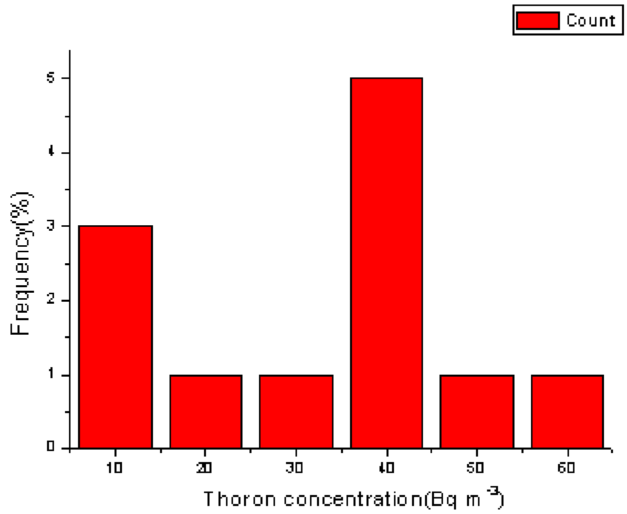

Fig 3 Frequency distribution of thoron in 10 dwellings inside of Kasimpur thermal Power plant

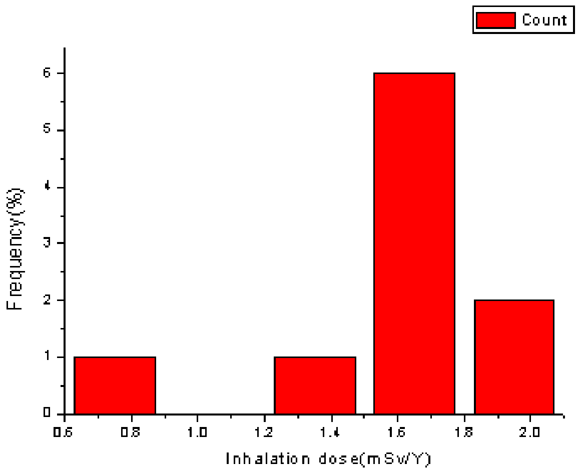

Fig 4 Frequency distribution of inhalation dose in 10 dwellings inside of Kasimpur thermal power plant.

As can be seen the maximum frequency of radon concentrations of radon, thoron and inhalation dose lie between 25 Bq m^{-3} to 35 Bq m^{-3} and 35 Bq m^{-3} to 45 Bq m^{-3} and 1.5 mSv y^{-1} to 1.8 mSv y^{-1} respectively.

The percentage frequency distribution of radon in the dwellings of Ukhalana village is shown in Fig.5. It is clear from the figure that majority of dwellings monitored, have radon values lying between 10 Bq m^{-3} to 15 Bq m^{-3}.. For thoron the percentage frequency distribution is shown in Fig. 6. Majority of dwellings monitored, have thoron values lying between 27.5 Bq m^{-3} to 35 Bq m^{-3}. Frequency distribution for dose rates as shown in Fig. 7 indicates that majority of dwellings have dose rate values lying between 1 mSv y^{-1} to 1.2 mSv y^{-1}.

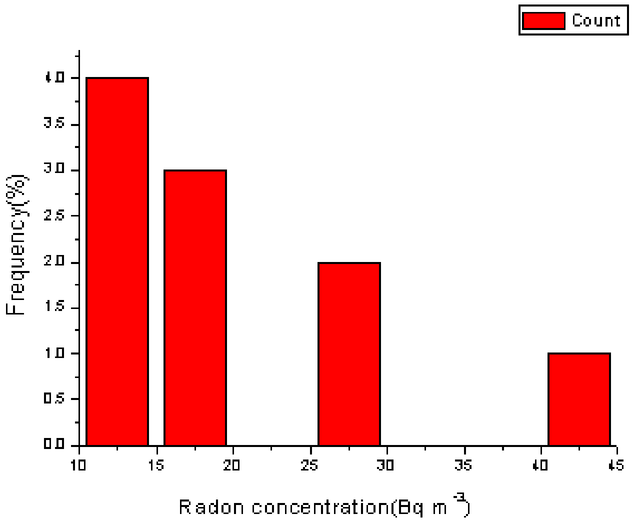

Fig 5 Frequency distribution of radon in dwellings of Ukhalana village

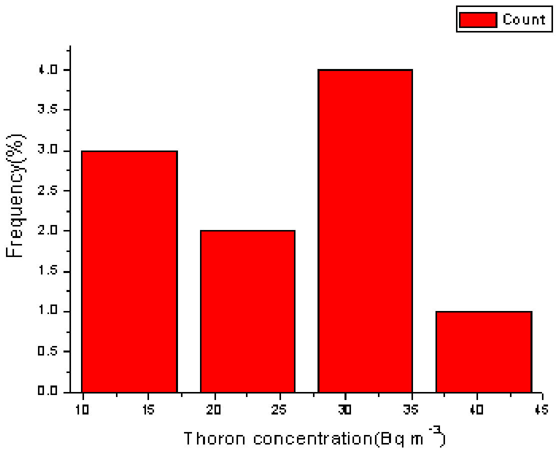

Fig 6 frequency distribution of thoron in dwellings of Ukhalana village

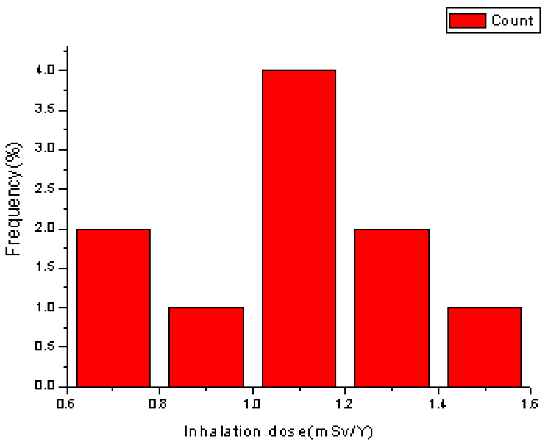

Fig 7 Frequency distribution of inhalation dose in dwellings of Ukhalana village

The percentage frequency distribution of radon, thoron and inhalation dose in the dwellings of Sunamai village are shown in Figs. 8,9 and 10.

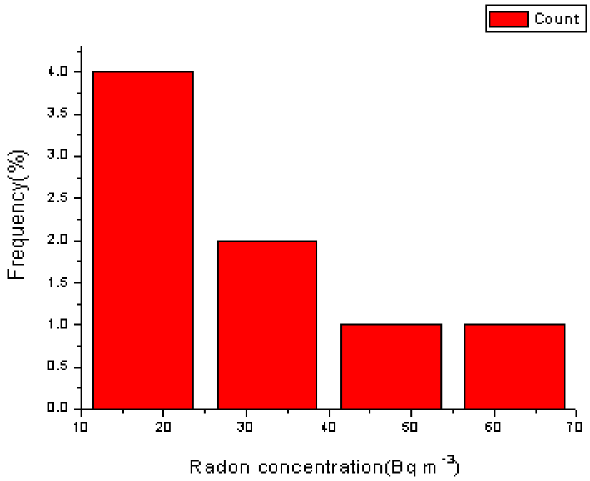

Fig 8 frequency distribution of radon in 8 dwellings of Sunamai village.

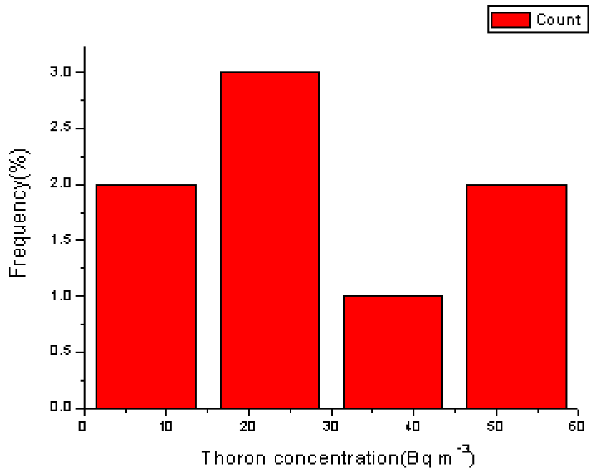

Fig 9 frequency distribution of thoron in 8 dwellings of Sunamai village

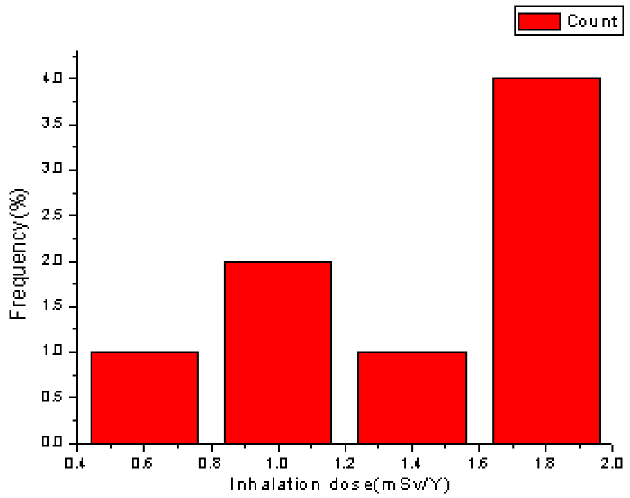

Fig 10 frequency distribution of inhalation dose in 8 dwellings of sunamai village.

It is clear from the Figures that majority of dwellings monitored, have radon values lying between 10 Bq m^{-3} to 25 Bq m^{-3} and Majority of dwellings monitored, have thoron values lying between 15 Bq m^{-3} to 30 Bq m^{-3} and majority of dwellings have dose rate values lying between 1.6 mSv y^{-1} o 2.0 mSv y^{-1} .

IV. Conclusion

In the measurement of Radon/Thoron and their progenies by twin cup dosimeter Radon and Thoron concentrations in Kasimpur power plant, Sunamai and Ukhalana village decrease slightly with the distance from the power plant. The twin cup dosimeters fitted with track detectors, filters and membranes always give better representation Radon/Thoron and their progeny concentrations. It can thus be concluded that twin cup dosimeters should be used for getting reliable values of Radon/Thoron and their progeny concentrations.

References

[1] Chauhan, R.P., 2010.Monitoring of radon, thoron and their progeny in dwellings of Haryana. Indian Journal of Pure & Applied Pysics,vol. 48, pp. 470-472.

[2] Zubair, Mohd., Shakir Khan, M., Verma, Deepak., 2011. Assessment of indoor radon, thoron and their decay products in the surrounding areas of Firozabad, Uttar Pradesh, India. Scholars Research Library, Archives of Applied Science Research, 3(1) : 77-82.

[3] Saini, R.S., Nain, Mahabir., Chauhan, R.P., Kishore, Nawal., and Chakaravarti, S. K., 2009. Radon, thoron and their progeny levels in some dwellings of Northern Haryana, India using SSNTDs. Indian J. Phys. 83 (8) 1197-1200.

[4] Sivakumar, R., 2010. A study on radon and thoron progeny levels in dwellings in South India. Iran. J. Radiat. Res., 8 (3) : 149-154.

[5] Sathish, L.A., Ramanna, H.C., Nagesh, V., Nagaraja, K., Shobha, S., Sundareshan, S., Ramachandran, T.V., 2010. Effective radiation dose due to indoor radon and thoron concentrations in Bangalore city, India. The Arabian Journal for Science and Engineering, volume 35. Number 2A.

[6] Singh, Joga., Singh, Harmanjit., Singh, Surender., and Bajwa, B.S., 2010. Measurement of soil gas radon and its correlation with indoor radon around some areas of upper Siwaliks, India. Journal of Radiological Protection, volume, 30, Number 1, 30 63.

[7] Mc Laughlin, James., Murray, Michael., Currivan, Lorraine., Pollard, David., Smith, Veronica., Tokonami, Shinji., Sorimachi, Atsuyuki., Janik, Miroslaw., 2010. Thoron and its Airborne Progeny in Irish dwellings. Proceedings of Third European IRPA congress, 14-18, Helsinki Finland.

[8] Kant, K., Rashmi., Sonkawade, R.G., Sharma, G.S., Chauhan, R.P., and Chakarvarti, S. K., 2009. Seasonal variation of radon, thoron and their progeny levels in dwellings of Haryana and western Uttar Pradesh. Iran. J. Radiat. Res., 7 (2) : 79-84.

[9] Rohmingliana, P. C., Vanchhawng, Lalmuanpuia., Thapa, R.K., Sahoo, B.K., Mishra, R., Zoliana, B., Mayya, Y.S., 2010. Measurement of indoor concentrations of radon and thoron in Mizoram, India.Original Research, sci vis 10(4), 148-152.

[10] UNSCEAR, (United Nations Scientific committee on the effect of Atomic Radiation) 1993 . Source Effect of Ionizing Radiation, United Nations New York.

[11] Durrani, S.A., 1993. Radon as a health hazard at home: what is the facts? Nucl. Tracks Radiat. Meas. 22, 303-317.

[12] ICRP,1981. Limits for inhalation of radon daughters by workers ICRP publication 32, Annals of ICRP 6 (1). Pergamon Press, Oxford.

[13] ICRP, 1987. lung cancer risk from indoor exposure to Radon daughters, report 50, Vol. 17, No. 1.

[14] Toth, E., Lazar, I., Selmeczi, D., Marx, G., 1998. Lower risk in medium high radon pathol. Oncol. Res. 4/2, 125-129.

[15] United Nations Scientific Committee on the Effects of Atomic Radiations (UNSCEAR), 1988. Sources and effects of ionizing radiation. UNSCEAR. No. A/Ac 82 R- 441.

[16] Deka, P.C., Sarkar, Subir., Bhattacharjee, B., Goswami, T.D., Sarma, B.K., Ramachadran, T.V., 2003. Measurement of radon and thoron concentration by using LR-115 type II plastic track detectors in the environ. Of Brahmaputra Vally, Assam, India. Radiation Measurement 36, 431-434.

[17] Dwivedi, K.K., Mishra, R., Tripathy, S.P., Kulshreshtha, A., Sinha, D., Srivastava, A., Deka, P., Bhattacharjee, B., Ramachandran, T.V., Nambi, K.S.V., 2001. Simultaneous determination of radon, thoron and their progeny in dwellings; Radiation Measurements 33, 7-11.

[18] Dwivedi, K.K., Mishra, R., Tripathy, S.P., 2005. An extensive indoor ^{222}Rn/^{220}Rn monitoring in North-East India, Radiation Measurements, 40, 621-624.

[19] Subba Ramu, M.C,. Shaikh, A.N., Muraleedharan, T.S., Ramachandran, T.V., 1991. Current science.

[20] Nambi, K.S.V., 1994. Radon Theron Exposures in high back ground radiation areas-bulletin of radiation protection 17, 49-52.

[21] Metters, J. 1992. Radon in context. Radiat. Prof. Dosim. 42 (3), 159-164.

[22] ICRP, 1993. Protection against radon-222 at home and at work, ICRP publication 65, Annuals of the ICRP 23 (2). Pergamon Press, Oxford.

[23] Lubin, J.H., Boice Jr., J.D., 1997. Lung cancer risk from residential radon. Meta-analysis of eight epidemiological studies. J. Nat. cancer Inst. 89, 49-57.

[24] BEIRVI, 1999. National Research Council; Health effects of exposures to radon, National Academy Press, Washington, D.C.

[25] Steinhauser, F., Hofman, W., Lettner, H., 1994. Thoron Exposure to manz a negligible issue Radiat. Prot. Dosim. 56, 1-44.

[26] Mayya Y.S., Eappen, K.P., Nambi, K.S.V., 1998. Methodology for mixed field inhalation in monazite areas using a twin- cup dosimeter with three- track detector. Radiat. Prot. Dosim. 77 (3) 177-184.

[27] Eappen, K.P., Mayya, Y.S., 2004. Calibration factors for LR-115 (type II) based radon thoron discriminating dosimeter. Radiation Meas. 385-17.

[28] Durrani S.A., 1997. Alpha particle etched detectors. In. Durrani, S.A., Ilic, R. (Eds), radon measurement by etched track detectors. Application in radiation protection, earth sciences and the environment. World scientific Singapore, PP. 77-101.

[29] Sonakawade , R.G., Ramola R.C., Kanjilal, D.K., Dhiaryawan, M.P., Gupta, P., 2005. Dosimeter in the environment of 15 UD Pelltron Accelerator using plastic Track Detectors, Proc. 27th IARP Conference.

[30] Singh, Kulwant., Singh, Manmohan., Singh, Surinder., Sahsta, H.S., Pupp, Z., 2005. Variation of radon (^{222}Rn) progeny concentration in outdoor air as a function of time, temperature and relative humidity.

[31] Nikolaev. V.A., Ilic. R., 1999. Etched Track radiometers in radon measurements: a review. Radiat. Meas. 30, 1-13.

[32] Cross, W.G., Tommasino, L., 1970. Rapid reading technique for nuclear particle damage tracks in thin Foils. Radiat. Eff. 5, 85-89.

[33] Sannapa, J., Chandrashekara M.S., Sathish, L.A., Paramesh L., Venkataramath P., 2003. Study of back ground radiation dose in musore city, Karnatka State, India: Radiat. Meas. 37, 55-65.

[34] UNSCEAR, 2000. United nations scientific committee of the effect of Atomic Radiation, Sources, Effects and risks of ionizing radiations, United nations, New York.