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# Estimation of Seasonal Variation of Radon, Thoron and Their Progeny Levels in Some Textile Industrial Units of Panipat, Haryana

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***Abstract*—Radon and its progeny are the major contributors in the radiation dose received by general population of the world. Keeping this in mind the environmental radon, thoron and their progeny level measurements have been carried out in some Textile Industrial Units Of Panipat, Haryana. The radon-thoron twin cup dosimeters designed by environmental assessment division of Bhabha Atomic Research Centre (BARC) Mumbai, India have been used for the study. Three pieces of LR- 115 Solid-State Nuclear Track Detectors are fixed in the dosimeters and are suspended 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 different industrial units covered during present study are Bharti Udyog Panipat, P. P. International Panipat, Gupta Carpets Panipat, Shivam Textiles Panipat, Shingla Textile Panipat. To observe the effect of environmental conditions, the measurements have been carried out during different seasons of the year. The radon-thoron progeny levels and annual dose received by the inhabitants in the Industrial units under study have also been calculated. The levels are found to be higher during winter season as compared to other seasons of the year.**

***Index Terms*— Radon, Thoron, Industrial Units, Annual effective dose, LR-115.**

## I. INTRODUCTION

The natural sources such as cosmic radiation, terrestrial radiation and exposure to radon, thoron and their progeny gives rise to about 90% of radiation exposure to human. Various studies have been made on exposure to many forms of natural radiation [1]. These studies have shown that more than half of annual exposure to humans is from radon and its daughter products. Also it is a well known that the radiations from the naturally occurring radioactive material originating from the earth's crust are the major contributors to the total background exposures to the human populations which includes external gamma radiations exposures and inhalation exposures, the latter being due to radon, thoron and their progeny [2]. The major inhalation dose is contributed by the radon progeny nuclides. All building materials shows various amounts of radioactivity as most of these are derived from rocks and soil which contains uranium-238 and thorium-232 series and the radioactive isotope of potassiurn-40. All these can be sources of both internal and external

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radiation exposure. Internal exposure takes place through the inhalation of radon gas and external exposure occurs through the emission of penetrating gamma radiationsl3l. The problem of radon is an important global problem of radiation hygiene. Radon is a radioactive gas of natural origin, is produced by the disintegration of uranium. Radon mainly comes from granitic and volcanic subsoil as well from construction materials. In general, there are three main mechanisms responsible for entry of radon in a building [3], via convection access points, cracks and opening, diffusion from soil via the pore space of the building material and emanation from building materials. High indoor radon concentration is usually due to penetration from the surrounding soil. Radon levels can fluctuate from day to day, depending upon the level of radon in the soil, type of soil, airflow through the soil- openings of building and ventilation. Outdoor radon concentrations are low but indoors this gas may accumulate in high concentrations emitted from the soil and from building materials when the building is not properly ventilated. Radon emanation from the soil depends upon its radium content and also upon mineralogy, porosity, grain size, moisture content and permeability of host rock and soil [4-5]. Radon gas decays overtime into radioactive particles that can be inhaled and trapped in the lungs as these daughter products remain air borne for a long time. When radon decays, it forms its progeny $^{218}$Po and $^{214}$Po, which are electrically charged and can attach themselves to tiny dust particles, water vapours, oxygen, trace gases in indoor air and other solid surfaces. These daughter products remain air-borne for a long time and can easily be inhaled into the lung and can adhere to the epithelial lining of the lung, thereby irradiating the tissue. Bronchial stem cells and secretion cells in airways are considered to be the main target cells for the induction of lung cancer resulting from radon exposure. The 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 [6]. Based upon current knowledge about health effects of inhaled radon and its progeny, ICRP has made recommendations for the control of this exposure in work place [7]. Keeping this in mind the environmental monitoring of radon, thoron and their progeny in some textile industrial units of Haryana has been carried out using radon-thoron cup dosimeters. Haryana is basically situated in India's northwest between $27^0 37'$ and $30^0 35'$, northern latitude and 36' east longitude. Haryana can be subdivided into two natural areas, sub-Himalayan terrain gangetic planes. The plane is fertile and height above sea level is 700-900 ft with south slope. The climate of Haryana is of pronounced character, very hot in summer and very cold in winters. The maximum temperature is recorded in month of may and June gas above $40^0$C. The industrial units in Panipat (IUP) under study are Bharti Udyog Panipat (IUP-1), P. P International Panipat (IUP-2), Gupta Carpets Panipat (IUP-3), Shivam Textiles Panipat (IUP-4), Shingla Textile Panipat (IUP-5).

## 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 industrial units, 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 fibre 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 and thoron 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 $60^0$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/cm$^2$/day) was converted into radon and thoron concentration using calibration factors [2]. Radon and thoron progeny levels in mWL have also been calculated using indoor

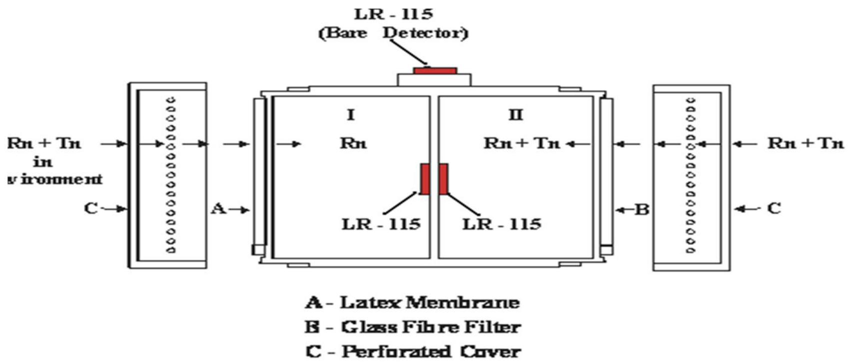


Figure. l: Twin Chamber Radon-thoron dosimeter cups used in the present study

equilibrium factor as 0.4 for radon and 0.1 for thoron from UNSCEAR [3]. Annual dose received by the inhabitants in the industrial units under study in mSv was estimated using the relation [4-5]

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

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 Industrial units of Panipat.The results of the measurements on indoor radon and thoron from some industrial units of Panipat, Haryana are listed in Tables 1, 2 and 3.

TABLE I. RADIOACTIVITY LEVELS AND ANNUAL EFFECTIVE DOSE RECEIVED BY THE INHABITANTS OF INDUSTRIAL UNITS IN PANIPAT, HARYANA (RAINY SEASON) AM (ARITHMETIC MEAN); *SE (STATISTICAL ERROR)

| Industrial unit in Panipat | Radon Conc.($C_R$) (Bq/m$^3$) | Thoron Conc. ($C_{Th}$) (Bq/m$^3$) | Radon Progeny (mWL) | Thoron Progeny (mWL) | Annual Effective Dose (mSv) |
|---|---|---|---|---|---|
| IUP-1 | 53 | 11 | 5.8 | 0.3 | 1.7 |
| IUP-2 | 53 | 11 | 5.8 | 0.3 | 1.7 |
| IUP-3 | 46 | 20 | 4.9 | 0.6 | 1.7 |
| IUP-4 | 53 | 11 | 5.8 | 0.3 | 1.7 |
| IUP-5 | 61 | 10 | 6.6 | 0.3 | 1.8 |
| AM±SE* | 53±2 | 13±1 | 5.8±0.2 | 0.3±0.1 | 1.7±0.1 |

TABLE II. RADIOACTIVITY LEVELS AND ANNUAL EFFECTIVE DOSE RECEIVED BY THE INHABITANTS OF INDUSTRIAL UNITS IN PANIPAT, HARYANA (WINTER SEASON) AM (ARITHMETIC MEAN); *SE (STATISTICAL ERROR)

| Industrial unit in Panipat | Radon Conc.($C_R$) (Bq/m$^3$) | Thoron Conc. ($C_{Th}$) (Bq/m$^3$) | Radon Progeny (mWL) | Thoron Progeny (mWL) | Annual Effective Dose (mSv) |
|---|---|---|---|---|---|
| IUP-1 | 61 | 10 | 6.6 | 0.3 | 1.9 |
| IUP-2 | 53 | 11 | 5.8 | 0.3 | 1.7 |
| IUP-3 | 53 | 20 | 5.8 | 0.5 | 1.9 |
| IUP-4 | 61 | 18 | 6.6 | 0.5 | 2.0 |
| IUP-5 | 76 | 17 | 8.2 | 0.5 | 2.4 |
| AM±SE* | 61±3 | 15±1 | 6.6±0.3 | 0.4±0.1 | 2.0±0.3 |

- Tables I, II and III infer that the indoor radon and thoron concentration from the various industrial units of Panipat were found to be high in winter as compared to other season. This can be accounted by poor ventilation rate of ventilation in winter season. The doors are usually closed in winters in order to maintain the thermal comfort, while the use of ceiling and exhaust fan in summer cause good intermixing of air and air exchange rates of industries.

TABLE III. RADIOACTIVITY LEVELS AND ANNUAL EFFECTIVE DOSE RECEIVED BY THE INHABITANTS OF INDUSTRIAL UNITS IN PANIPAT, HARYANA (SUMMER SEASON) AM (ARITHMETIC MEAN); *SE (STATISTICAL ERROR)

| Industrial unit in Panipat | Radon Conc.($C_R$) (Bq/m$^3$) | Thoron Conc. ($C_{Th}$) (Bq/m$^3$) | Radon Progeny (mWL) | Thoron Progeny (mWL) | Annual Effective Dose (mSv) |
|---|---|---|---|---|---|
| IUP-1 | 53 | 03 | 5.8 | 0.1 | 1.5 |
| IUP-2 | 46 | 4 | 4.9 | 0.1 | 1.3 |
| IUP-3 | 46 | 12 | 4.9 | 0.3 | 1.5 |
| IUP-4 | 46 | 20 | 6.6 | 0.6 | 1.7 |
| IUP-5 | 61 | 2 | 7.4 | 0.1 | 1.7 |
| AM±SE* | 50±4 | 8±1 | 5.9±0.3 | 0.2±0.1 | 1.5±0.1 |

- Also the thoron levels in all the industries are found to be smaller than that of the radon. This may be accounted due to short half life of thoron. The diffusion length of thoron in air have a value just few cm from the source in absence of air convective flow. Thus the probability that a thoron produced from the source and registers a track on dosimeter system is very small and hence the measured results. However the increase in ventilation rate in summer cause increase in diffusion length of thoron but dilution of thoron dominates at higher ventilation.

The measured radon and thoron concentration are found to be slightly more than the world average (40 Bq/m$^3$ from radon and 10 Bq/m$^3$ for thoron in UNSCEAR Reports) but less than the safe limit (100 Bq/m$^3$ for radon) recommended by report of International Commission on Radiation protection.

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