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Radon, Thoron and their progeny measurements in the environment

Nitin Gupta, Advanced Institute of Technology & Management, Palwal, India,
Maneesha Garg, YMCA University of Science & Technology, Faridabad, India,

Abstract— **Radon is an invisible, odourless, heaviest (9 times heavier than air) and radioactive gas. Radon, which is topic of public health concern, has been found to be a ubiquitous air pollutant in homes and in the environment of work stations. Risk projections imply that radon is the second leading cause of lung cancer after smoking. Measurement of radon, thoron and their progeny is important because the radiation dose to human population due to inhalation of radon and its progeny contribute more than 50% of the dose from all sources of the radiation. LR-115, type-II, plastic track detectors (SSNTDs) use to measure radon concentration.**

Keywords—***Radon, thoron, progeny, SSNTDs***

I. INTRODUCTION

We live in a milieu of radiation and are continuously exposed to ionizing radiation from natural and artificial sources. Natural radioactivity is wide spread in the earth's environment and it exists in various geological formations in soils, rocks, plants, water and air (Ibrahiem et al., 1993; Malance et al., 1996; Aly Abdo et al., 1999). 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 (BEIR VI, 1999). Radon, a topic of public health concern, has been found to be a ubiquitous radioactive air pollutant in homes and in the environment of certain workplaces (such as thermal power plants, gas turbine power plants, refineries and Liquid Petroleum Gas (LPG) bottling plants) to which all persons are exposed (Cole, 1993; Proctor, 1995; Kant and Chakarvarti, 2003; Kant et al., 2006; Marcia et al., 2006; Deka et al., 2006). Problem of radon is global and concerns the world population.

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, 1999). 222Rn, a progeny of 238U, formed from the radioactive decay of radium which occurs in trace amounts in rocks and soils all over the earth's crust, is an invisible, odourless, electrically uncharged noble but hazardous gas and emits alpha radiation. There are three isotopes of radon viz., actinon (219 Rn) with a half-life of 3.96 sec., thoron (220Rn) with a half-life 55.6 sec., and radon (222Rn) with a half-life 3.824 days, belonging to the decay chain of 235U, 232Th and 238U, respectively.

Although, the concentration of thoron in the indoor air is expected to be less than that of radon, even then there is rising interest in the dosimetry of thoron for risk evaluation (Steinhausler, 1993& 1996; Shang et al., 1997, Tokonami et al., 2004). Radon is generated from radium present in soil, building material and even in water. . it can be easily disperse into the atmosphere and can easily enter into the homes via soil, cracks, water, windows etc. as shown in fig. 1.

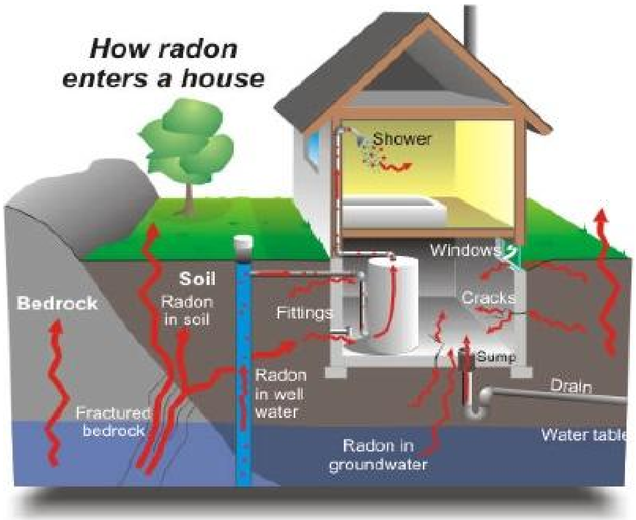

Fig. 1 Typical ways of entry of radon entry in dwellings

Radon can migrate and diffuse through different media. The migration of radon is dependent on its half- life and permeability of the medium. Radon is second most common cause of lung cancer after cigarette smoking. The environmental radioactivity build-up in the environment leads to the radiation exposure of both humans and biota (plants, animal etc.)

The exposure to alpha radiation emitted from radon-222 (222Rn), immediate daughter of Radium-226, poses grave health hazards not only to uranium miners but also to people living in normal houses and buildings and workplace like thermal power plants, nuclear power plants, refineries and

LPG bottling plants in which gas and oil processing operations are carried out, gas turbine power plants, fertilizer industry, granite industry, slate mines, cement manufacturing plants, industries using gypsum, asbestos, fly ash for making bricks, partition boards and asbestos sheets, coal fields and other related industries (ATSDR, 1999, 5-11, 13-19). Radon now has been identified as occupational respiratory carcinogen by International Agency for Research and Classified Cancer (IARC, 1987). As per ICRP recommendations, it becomes necessary to take remedial steps for the reduction of radon and its progeny if the level is found to be more than 200 Bq-m^{-3} for dwellings and more than 500 Bq m–3 for the work place (ICRP, 1993).

Measurement of radon, thoron and their progeny in dwellings, workplaces and building materials is important because the radiation dose to human population due to inhalation of radon and their progeny contribute more than 50% of the dose from all sources of the radiation both naturally occurring and manmade (UNSCEAR, 2000).

Various researchers have reported that exposure to high levels of environmental smoke at the workplace and in other public sector indoor settings are important risk factors for lung cancer risk in workers (Grey, 1991; Kreuzer et al., 2000). Radon daughter exposure, however, has been associated with an increased risk of lung cancer. For this reason, all exposures should be kept below recognized exposure standards for the general public and unnecessary exposure to radiation should be minimized. The estimated level of health risk associated with average indoor radon levels is much higher than those due to other environmental carcinogens (Nazaroff and Nero, 1988). It is quite important to make a systematic study of radon exposure from health and hygiene point of view, because a radiation dose to human population due to inhalation of radon and its progeny contribute more than 50% of the total dose from the natural sources (UNSCEAR, 1999). It has a direct relevance to the public in general and the workers in Industries in particular. Modern Buildings are liable to allow build-up of radon, because the building envelope is almost airtight while the foundation is leaky to soil gas. Based on the study, the annual effective doses received by the persons and health risk assessment would be made as per ICRP (International Council for Radiation Protection) Recommendations.

II. MEASUREMENT TECHNIQUES

A. *Twin Cup Dosimeter for Radon, Thoron and their progeny Measurements*

In Twin Cup Dosimeter for Radon, Thoron and their progeny Measurements, solid state nuclear track detectors SSNTDs can be used for recording the alpha charged particle tracks. (Frank and Benton, 1978; Fleischer et al., 1975; Kant et al., 2006; Nain et al., 2010)

The LR-115 type II (Kodak- Pathe: Cellulose Nitrate type II, Vincennes, France) plastic track detector used for radon measurements. It consists of a 10-13 µm thick alpha-sensitive layer of red dyed cellulose nitrate plastic deposited on a 100 µm thick insensitive and non-detachable polyester base. The film is sensitive to alpha particles with energies in the range of 1.7- 4.8 MeV emitted by radon in the surrounding air. LR-115 films are not affected by electrons or by radiations in the electromagnetic spectrum (such as gamma rays, X-rays, ultraviolet or infra-red). These can, therefore, be handled without risk where such radiations are present.

The track etching mechanism of LR-115 detectors has been studied at different temperatures ranging from 300C to 600C for different etching times and the calculated value of activation energy is 0.1845 eV (Paul and Bose, 1980). .Another suitable etch condition reported is 2.5 NaOH, 600C, 60 to 70 minutes with stirring (Costa-Riberio and Labao, 1975).

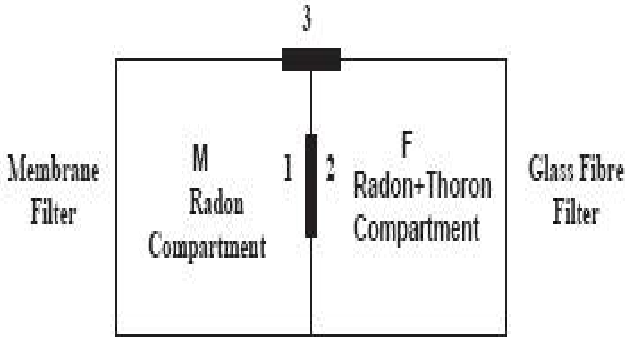

Fig-2 Twin Cup Chamber

The dosimeter which would be employed for the measurement consists of a twin chamber system with SSNTDs placed on the two sides of the central partition inside the cup and a bare film placed outside it, as shown in Fig. 2 (Eappen and Mayya, 2004).Each chamber has a length of 4.5 cm and a radius of 3.1 cm. The LR-115 films will be fixed in the dosimeter system and mounted at the same place.

The detectors will be exposed in the mixed field of radon-thoron in the environment of the dwellings and workplaces in three different modes:

- the bare mode, recording alpha tracks due to radon, thoron and their progeny
- the cup with filter paper mode, recording alpha tracks due to radon and thoron only
- the cup with filter paper and membrane mode, recording alpha tracks due to radon alone.

B. *Can Technique for Radon Exhalation Rates Measurements from Various Samples*

For the measurement of radon exhalation rates from material samples, the "Can technique" will be used (Kant et al., 2010; Rafique et al., 2011) The exhalation rate is the amount of radon emanated from a given sample per unit mass (for mass exhalation rate) or surface area (for surface exhalation rate) per unit time. A known amount of given sample is kept in plastic cans. The LR-115 plastic track detector is fixed on the bottom of the lid of each can with tape such that sensitive side of the detector faces the specimen. The can is tightly closed from the top and sealed as shown in fig. 3.

At the end of the exposure time (~100 days), the detectors will be removed and subjected to a chemical etching process in 2.5 N NaOH solution at 600C for 90 minutes. The etched detectors are thoroughly washed and dried and the alpha tracks are counted using an optical Olympus microscope with CCTV camera and a monitor at magnification 600 X. using some standard equations (Kant et al., 2010), radon exhalation rates are calculated.

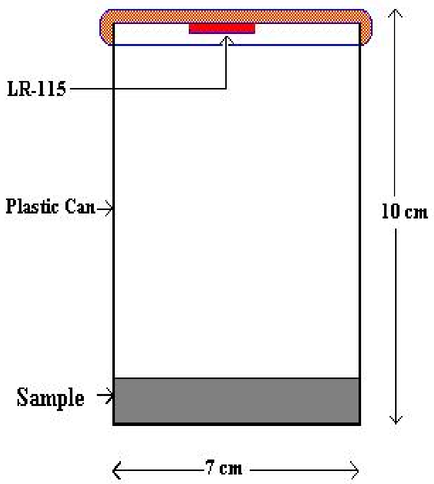

Fig.3 The can for the measurement of radon exhalation rates

III. CONCLUSION

The measurement techniques indicate moderate to high levels of radon/ thoron concentration at different locations in the environment. Measurement shows adverse effects on humans and Biotas. So, necessary steps should be taken to minimize the adverse effect on the environment from naturally occurring radioactive material exposure through monitoring, safe guidelines and handling of contaminated waters.

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