INVESTIGATION OF RADON/THORON LEVELS AND NATURAL RADIOACTIVITY IN ENVIRONMENT

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Abstract

The exposure of human beings to ionizing radiation from natural sources is a continuing and inescapable feature of life on earth. For most individuals, this exposure exceeds that from all man-made sources combined. There are two main contributors to natural radiation exposures: high-energy cosmic ray particles incident on the earth's atmosphere and radioactive nuclides that originated in the earth's crust and are present everywhere in the environment, including the human body itself. Radon is a noble gas in the uranium decay series with a fairly long half life of 3.8 days. Being an inert gas it can easily disperse into the atmosphere as soon as it is released. The solid alpha active decay products of radon (^{218}Po, ^{214}Po) become airborne and attach themselves to the dust particles, aerosols and water droplets in the atmosphere. When inhaled, these solid decay products along with air may get deposited in the trachea-bronchial (T-B) and pulmonary (P) region of lungs resulting in the continuous irradiation by α-particles of the cells which may cause lung cancer. Radon is the problem in all types of homes, including old homes, new homes, drafty homes, insulated homes, homes with basements and homes without basements.

Measurements of indoor radon are of importance because the radiation dose to human population due to inhalation of radon and its daughters contributes more than 50% of the total dose from natural sources and large scale studies have been carried out worldwide. On the other hand there exist only a few studies relating to passive measurements of thoron. It is assumed that the inhalation dose to the human beings from thoron and its progeny is negligible although recent studies in many countries have revealed that this may not be entirely correct.

It is well known that 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. In homes the predominant source of radon in indoor air is the soil beneath structures, but building materials and water used in the homes and in a few cases natural gas may also contribute. The concentrations of radium in soil and in rocks vary several orders of magnitude. This variation in source strength results in the variation of radon concentrations among dwellings. Keeping the radiation hazards of radon for general population in mind, it is quite important to make a systematic study of the indoor radon concentration in Indian dwellings. For this purpose, radon measurements have been carried out in a number of dwellings in the cities of different states of India.

Natural radioactivity is wide spread in the earth's environment coming from Uranium (^{238}U) and Thorium (^{232}Th) series and Potassium (^{40}K), existing in various geological formations like soils, rocks, plants, water and air. Radiological implication of these radionuclides is due to the gamma ray exposure of the body and α-irradiation of lung tissues from inhalation of radon and its daughters. The assessment of gamma radiation dose and radon exhalation rate from natural sources is of particular interest as natural radiation is the largest contributor to external dose of the world population.

In the present study, low level gamma ray spectrometric set up at H N B University Garhwal, Uttrakhand, India using a NaI (Tl) detector was used for measurement of activity concentration of the natural radionuclides (^{226}Ra, ^{232}Th and ^{40}K) in coal, fly ash, soil and cement samples. Radiation dose and health risk have been estimated from the activity concentration of natural radionuclides.

This thesis elaborates the brief description of radon/thoron measurement and natural radioactivity for assessing the total health hazards in the environment.

The present work is organized into following six chapters:

Chapter-I: This chapter describes a brief review of literature and gives an account of the history of radon and thoron and its health hazard effects, the indoor radon sources, factors affecting indoor radon concentration levels and the applications of radon measurements. A brief description of meteorological parameters, radon induced health effects, risk of radon exposure at work places. Introduction of natural radioactivity and health effects due to radioactivity is given. This chapter also contains definitions and discussion of radiation levels and their effects and definitions action level, dose limit, effective dose, Equilibrium Equivalent Concentration of radon (EEC radon), Potential Alpha Energy Concentration (PAEC), Working Level (WL), Working Level Month (WLM), Indoor internal exposure due to radon inhalation, Radium equivalent activity (Raeq), Absorbed gamma dose rate (D) and External (H_{ex}) and Internal (H_{in}) hazard index.

Chapter – II: A brief description of the historical development of Solid State Nuclear Track Detectors (SSNTDs), criteria for track formation in polymeric film (LR-115 type II Solid state nuclear track detector) and revelation of tracks is given in this chapter. This chapter gives an account of various instantaneous and time integrated radon measurement techniques. Tracks etch technique using Solid State Nuclear Track Detectors is one of the most widely used technique for radon measurement. The principle of detection consists of the damage imparted in the detector material by alpha particles from radon and its decay products which can be observed under optical microscope and spark counting system.

In the present study, twin chamber dosimeter cup was used for the measurement of indoor and outdoor radon concentrations. Alpha sensitive plastic track detector (Pelliculable LR-115 Type II Manufactured by Kodak Pathe, France) is used. It is a 12 μm thick film red dyed cellulose nitrate emulsion coated on inert polyester base of 100 μm thickness and has maximum sensitivity for alpha particles, fission fragments and ionizing particles with high enough LET.

Radon exhalation rate is of prime importance for the estimation of radiation risk from various materials. Sealed Can Technique and Smart radon monitor were used for radon exhalation measurements in solid samples.

A low level gamma ray spectrometric set up at H N B University Garhwal, Uttrakhand, India using a NaI (Tl) detector was used for measurement of activity concentration of the natural radionuclides, (^{226}Ra, ^{232}Th and ^{40}K) in coal, fly ash, soil and cement samples.

Chapter-III: In this chapter, the results of measurements of radon and its concentration in a large number of dwellings carried out in following:

(i) In about 60 dwellings of Dwarka, Delhi state of India, to assess the variability of expected exposure of the population to radon and its progeny.

(ii) In some dwellings of Jaipur, Rajasthan, state of India.

(iii) In Aligarh, Uttar Pradesh state of India, near Kasimpur thermal power plant were selected for measurements of indoor radon levels.

Solid State Nuclear Track Detectors (SSNTD's) based twin chamber dosimeters were also used for measuring radon (^{222}Rn) and Thoron (^{220}Rn) gases and their progeny concentration in the dwellings of three cities. The dosimeters employ two LR-115 type-II peliculable, cellulose nitrate detector films inside each of the two chambers fitted with filter and polymeric membrane for the discrimination of radon and thoron gas and a third detector is placed externally for progeny measurements.

Chapter-IV: Measurements of natural radioactivity and radiation doses were carried out on the following material samples having wide applications, collected from different places and parts of the country:

(i) Coal and fly ash samples, collected from different thermal power stations at Kolaghat, and Kasimpur situated in West Bengal and Uttar Pradesh states of India. Measurements have been made to estimate the enhancement of natural radioactivity in fly ash due to coal combustion.

The thermal power plants all over the country produce a large quantity of fly ash which if not utilized or properly disposed off, may become one of the greatest radiation menaces to the nation and its inhabitants.

(ii) Soil samples, collected from Kasimpur thermal power plant situated in Uttar Pradesh state of India.

(iii) Cement samples collected from different benders of Aligarh region of Uttar Pradesh of India.

An attempt has been also made to determine the radium equivalent activity and external hazard index in various commodities. The presence of natural radioactivity level in all the samples have been found to be well below the permissible limits.

Chapter-V: Sealed can technique and Smart radon monitor were used for the measurement of radon exhalation rate from: Coal, fly ash, soil, cement and sand samples collected from different parts of India.

In the present study, we have also made measurements for radon exhalation rate in different building materials like Paints, Plastered, Fired and Unfired Brick etc., commonly used for building construction in this region of the state of Uttar Pradesh of India. Present investigation concludes that the radon effective dose is quit lower than the action level of 1 mSv for all the reported samples.

Chapter-VI: This chapter concludes the outcomes of this research work and presents a discussion of the prevention of health hazards in the study area.

The future scope of the present work has also been presented.