Nuclear Data for Science and Technology (1988 MITO), 1091-1094, Copyright © 1988 JAERI.

RADON MEASUREMENT IN HUMAN ENVIRONMENT USING NUCLEAR TRACK ETCH TECHNIQUE

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Abstract: Radon is important as a possible hazard to health as an indicator of subsurface uranium and potentially as an aid to earthquake prediction. Radon and their daughter products present in man's natural radiation environment pose a significant hazard only when concentrated in some enclosures such as underground mines, caves, cellers or poorly ventillated houses. In order to study the health hazard effects of radon a detailed study is carried out in the indoor and outdoor atmosphere of Guru Nanak Dev University Campus area using LR-115 plastic track detector. The radon values are found to vary with the environmental parameters. The observed radon values are compared with the standard recommended value and the maximum recorded value is found within the safe limit.

(Radon, Plastic Track Detector, Health Hazard)

Introduction

Radon and their daughter products present in human environment can result a significant risk to general public. Due to its alpha emitting short lived daughters Po-218 and Po-214, it has long been known to be a causative agent for lung cancer where present in high concentration in mines/1,2/. These daughter products can attach to the surface of airborne particles and remain airbone for a long time. These radioactive particles in the enhaled air deposit in the lung and irradiate the tissue. The effect of much lower values usually found in homes and other buildings is unknown, but a linear extrapolation of the results given by Sevc et al./2/ to the levels found in home suggests that thousands of people per year could be affected in U.S. by increases in radon levels that are caused by protecting structures against heat loses/3,4/ and public concern over radon in homes is increasing /5,6/. It is therefore desirable, and possible necessary, to have suitable methods for monitoring average concentrations over time in places where people will be exposed to radon.

Since the majority of people's time is spent in homes, there has been a growing concern in recent years about potential health effects due to indoor radon. The source of radon inside the houses is mainly the building material and the soil beneath the house. The concentration of radon and its decay products show large temporal and local fluctuations in the indoor and outdoor atmosphere due to the temperature, pressure, building materials, ventilation conditions, wind speed etc./7-10/. Many techniques were used for radon measurement inside the houses. The solid state nuclear track detector technique is the most reliable technique for integrated and long time measurement of radon activity inside the houses/11-13/.

In industrial countries man is assumed to spend about 20 % of his life in open air. Therefore, exposure of radon dose not only take place in dwelling and the concentration of radon and its daughters in the open air will have an influence on the total exposure /14/. Therefore reliable lung-dose estimation requires knowledge of the levels of radon and its daughters in dwelling as well as in the open air. For this reason, the present investigation were complimated by measurements of radon in the open air.

Experimental Procedure

The measurements of radon in indoor and outdoor atmosphere was carried out by using the LR-115, plastic track detector. The detector films were mounted on the walls at different positions and left exposed for one month. All the detectors were then removed and etched in 2.5N NaOH solution at 60°C in a constant temperature bath for two hours. The detector films were scanned under an optical microscope at a magnification of 600X for the measurement of track density. The calibration constant (33.6 tracks/cm^2 = 1 pCi/l for 30 days exposure) determined by Singh et al./15/, in this laboratory was used to express the radon activity in terms of pCi/l.

Results and Discussion

The results of radon measurements inside the houses are given in Table 1. The radon values in the houses of Rawatgaon, Tehri Garhwal (U.P.) are found to be higher than those recorded in the houses of Guru Nanak Dev University Campus, Amritsar. The high value

Table 1. Radon Concentration in different living rooms

Room No.	Track density (Tracks/cm^2)	Radon Concentration(pCi/l)
AMRITSAR		
1	95	2.83 ± 0.21
2	101	3.01 ± 0.27
3	106	3.15 ± 0.25
4	115	3.42 ± 0.26
5	118	3.51 ± 0.31
6	122	3.63 ± 0.34
7	128	3.81 ± 0.41
8	129	3.84 ± 0.36
9	132	3.93 ± 0.48
10	135	4.02 ± 0.45
RAWATGAON		
11	335	9.97 ± 0.91
12	380	11.31 ± 0.98
13	546	16.25 ± 1.23
14	591	17.59 ± 1.51
15	681	20.27 ± 1.82
16	1163	34.61 ± 2.51

of radon may be due to the high emanation of radon from building materials and the type of construction of houses. The houses in Rawatgaon are constructed with rocks and mild soils and thus allow more radon to diffuse inside the house from earth's surface. The high emanation of radon from rocks may also contribute the additional radon inside the houses. In Amritsar, the houses are constructed with cement and bricks. The ground surface of the room is coated with the layer of cement which resists the flow of radon from the ground surface inside the house. The radon emanation from cement and bricks is low compared to rocks.

The maximum recorded value is found nearly equal to 0.35 WLM. The working level (WL) is defined as any combination of radon daughters in one liter of air and will result in the ultimate emission of 1.3 x 10^5 MeV of potential alpha energy. This value is derived from alpha energies released by a total decay of all short-lived radon daughters at radioactive equilibrium with 100 pCi/l of radon-222. The current standard for cumulative exposure of radon daughters was recommended at 2 WLM in any three month period/16/. Hence the maximum recorded value is found quite low compared with the standard recommended value.

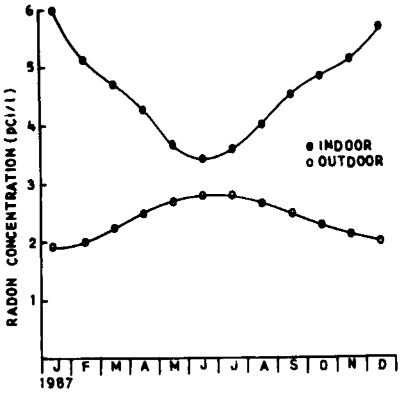

Fig.1 Seasonal variation of indoor and outdoor radon concentration.

Radon measurements were carried out for one year (Jan-Dec, 1987) in a perticular dwelling of Guru Nanak Dev University Campus, Amritsar, to study the effect of environmental parameters on indoor and outdoor radon concentration. In this part of experiment, the measurements were taken each month inside and outside the room. The results of these measurements are shown in Fig.1. The radon concentration inside the room is found to be higher during the winter season than that in the summer. However, the results are just opposite for outdoor radon measurements.

The high values of indoor radon concentration in winter are due to the lack of ventilation, as most of the windows remain closed during this season. The radon emanated from floor and walls accumulates inside the room and thus causes a high value of radon. However, in summer (April-August), the windows mostly remain opened which allows the fresh air to enter the room and causes the fall in indoor radon concentration. The low values of outdoor radon concentration in winter are due to the slow emanation of radon from the ground surface. However, it is high in summer because of high emanation. Overall, the indoor radon concentration is found higher than the outdoor radon concentration. This is because of the radon emitting nature of building materials which contribute the additional radon and thus cause the high concentration of radon inside the house. In outdoor atmosphere, radon is mainly contributed due to its emanation from earth's surface. The contribution of radon due to building materials is negligibly small.

Correlation between Indoor and Outdoor Radon Concentration

In order to establish a correlation between indoor and outdoor radon concentrations, the measurements were carried out in well ventilated rooms with identical shapes. The results are plotted in Fig.2. The best fit linear relation between inddor and outdoor radon concentration is given by solid line.

A possible relation between the indoor and outdoor concentration of radon, C_{in} and C_{out}, is usually based on a simple ventilation model/8/. In this model, one considers a room with volume, V_o, and radon concentration, C_{in}.

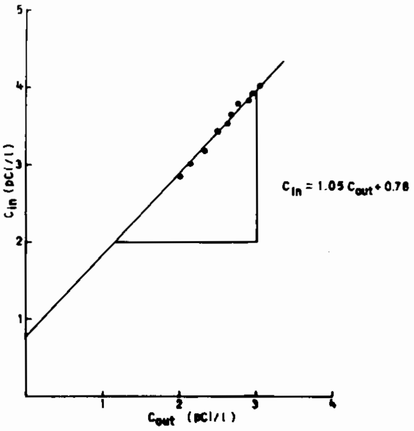

Fig.2 Correlation between indoor, C_{in}, and outdoor, C_{out}, radon concentration.

Due to ventilation in the time interval, Δt, a volume, ΔV, is replaced by outside air with concentration, Cout. In addition the walls exhale radon at a total rate, E, such that the change in concentration is given by

$$C_{in} = -(\Delta V/V_o)C_{in} - \lambda\Delta t[1-(\Delta V/V_o)]C_{in} + [1-(\lambda\Delta t)/2](\Delta V/V_o)C_{out} + (E/V_o)\Delta t[1-(\lambda\Delta t)/2] \quad (1)$$

The terms with Δt represent the decrease in radioactivity due to the decay of radon characterized by the decay constant $\lambda = 2.1 \times 10^{-6}\ S^{-1}$. The decrease of the concentration in the period t of the incoming outside air and the exhaled radon is approximated by a factor $\Delta t/2$. The ventilation rate, K, defined as a number of air changes per unit of time follows from

$$\Delta V/\Delta t = KV_o \quad (2)$$

The change in the concentration per unit of time is then given by

$$\Delta C_{in}/\Delta t = -KC_{in} - \lambda[1-K\Delta t]C_{in} + [1-(\lambda\Delta t)/2]KC_{out} + (E/V_o)\,[1-(\lambda\Delta t)/2 \quad (3)$$

In the limit for $\Delta t \to 0$, this equation yields the differential equation

$$dC_{in}/dt = -(K+\lambda)C_{in} + KC_{out} + E/V_o \quad (4)$$

For stationary state, the solution of this equation will be

$$C_{in} = [K/(K+\lambda)]C_{out} + E/[V_o(K+\lambda)] = \alpha_K\, C_{out} + \beta_K \quad (5)$$

Equation (5) are similar to the one used by Porstendorfer et al./17/ but deviates from the one used by Stranden et al./18/, in which the term depending on the outside concentration is absent.

From equation (5) it follows that there is a linear relationship between the stationary concentrations, Cin and Cout. The value of coefficient α_K usually ranges between 0.8 and 1.0. Assuming that for both inside and outside air there is equilibrium between radon and radon daughters, from the observed value of $\alpha_K = 1.05$ it follows that this simple model holds good for well ventilated living rooms studied.

Conclusions

1. Radon concentration in indoor atmosphere depends on the building materials and type of construction of the houses.
2. Radon concentration in indoor and outdoor atmosphere is found to vary with the environmental conditions.
3. Radon concentration in indoor atmosphere is higher than that in outdoor atmosphere.
4. The observed radon values are found within the safe limit.
5. For a well ventilated room, the indoor radon concentration is found directly correlated with the outdoor radon concentration.

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ACKNOWLEDGEMENTS

The authors acknowledge the financial assistance by Council of Scientific and Industrial Research, New Delhi. They are thankful to Mr. V.P. Gupta, Mr. Narinder Singh and Mr. Santokh Singh for technical assistance. Thanks are also due to Mr. Hazara Singh for typing the manuscript.