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MEASUREMENT OF RADON CONCENTRATION LEVELS IN OLD BUILDINGS OF LAHORE, PAKISTAN

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Radon concentration was measured in old buildings of Lahore, Pakistan having ages between 66-321 years by using CN-85, nuclear track detectors. The maximum value of radon concentration is found to be 69.4 Bq m^{-3} in General Gallery of Lahore Museum, while in the Officers' rooms of GPO, Lahore, it is minimum i. e. 20 Bq m^{-3} which may be attributed to the use of paints in these rooms. Other factors which influence radon concentration are the ventilation condition of the old buildings and the radon emanation from the building materials and articles inside the buildings.

The internal doses in terms of effective dose equivalent (mSv y^{-1}) due to potential alpha energy concentration (WLM) from radon progeny has also been estimated. The estimated effective dose equivalent to bronchial tissue has been found very much below to that of ICRP limit of 20 mSv y^{-1} to limit the probability of lung cancer.

Key words: Radon concentration, Old buildings, CN-85 nuclear track detectors.

Introduction

Radon and thoron are the gaseous decay products in uranium and thorium decay series (Hopke 1987; Telford *et al* 1978). Because of short half life the contribution of thoron is insignificant in natural dosimetric pattern as compared with radon (Claus 1985). The contribution of radon to outdoor atmosphere is the result of its diffusion and transportation from the ground (Nazaroff and Nero 1988; Kristiansson 1982). The variation in the outdoor radon is due to the variation in atmospheric pressure, temperature and wind velocity (Israelsons 1968; Kraner 1964; King 1978). Other factors influencing the outdoor radon concentration are the geology of the area, rain fall and snow cover (Gableman 1987; Singh *et al* 1988; Cember 1989). The indoor radon level is found to be related with building materials (Abu-Jarad *et al* 1980; Folkerts 1984) and ventilation rate (Nero 1984; Swedgemark 1979). A considerable spread in the radon level has been observed in buildings which are poorly ventilated and contain excess amount of radium in building materials (Stranden 1979; Abu-Jarad 1993; Mahmood *et al* 1993).

Radon and its short lived decay products are alpha emitters and pose a significant internal hazard if taken into the body via inhalation (ICRP 1981; Fleischer 1988). It has been observed that the membranes lining the bronchi are supposedly sensitive to alpha radiation and are the primary sites of many cases of lung cancer which are attributed to inhaled radon and its decay products (Crameri and Burkat 1989; Donaldson 1969; ICRP 1987). The external hazard due to radon and its daughter products is negligible, as alpha particles from the decay of radon and its decay products can not penetrate living cells externally (Martin and Harbnison 1986) and therefore can not damage the living cell. The aim of this work is to assess the dose to sensitive tissue specially to bronchial tissues due to inhaled radon progeny. It is also aimed to speculate the important factors which may affect the radon concentration in old buildings of Lahore.

Experimental

Sufficient work has been done on radon concentrations in Pakistani houses (Tufail *et al* 1991a; Mahmood *et al* 1994; Tufail 1991b; Tufail and Ahmad 1992a) which are generally made of the conventional construction materials such as cement, bricks and concrete etc. and based upon modern architectural designs. Almost no work has yet been carried out on measurement of radon concentration in old buildings and possible health hazards due to radon and its progeny on the residents/workers of old buildings. Old buildings (60-300 years) were chosen for the measurement of radon concentration. The buildings were inspected and different parts of the buildings were selected for radon concentration measurements. The detector used in the experiment was cellulose nitrate, CN-85, having thickness of 100 μm and capable of detecting the α particles from ~ 0.1 MeV to ~ 6MeV (Durrani 1977). The upper and lower detection limits are intended as

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rough guides only. They depend on etching conditions and many post and pre exposure conditions (Khan *et al* 1993). The CN-85 detector, is therefore capable of recording α emitting Rh^{222} ($T_{1/2}$ = 3.82 d, E = 5.49 MeV), a gaseous member of uranium decay series.

Two pieces of CN-85 having area of 32 mm x 32 mm were used in a geometry which consists of a box type square frame covered with two square lids as shown in Fig. 1. Whole of the assembly was enclosed in a polyethylene envelope of thickness 23 μm which has the maximum permeation for radon (Mahmood *et al* 1994). The radon gas permeates through polyethylene while it acts as a barrier for thoron, water vapours and dust particles (Tommasino 1990). The radon monitors were fixed in different parts of the selected buildings; 5-10 monitors were fixed in each part at the height of 2-4 ft from the ground level. The choice of the height was based upon the assumption that the radon concentration is large at lower indoor atmosphere as it is heavier than air. After an exposure of two months, the radon monitors were brought to the laboratory, where the detectors were detached from the box type monitors and etched in 6N NaOH at 50±1° C for 90 min (Tufail *et al* 1991b; Tufail and Ahmad 1992a). The tracks were counted under an optical microscope and track density was converted to radon concentration (Bq m^{-3}) by using the conversion factor i. e. 0.92 tracks cm^{-2} h^{-1} per 100 Bq m^{-3} (Tufail *et al* 1991a, Tufail *et al* 1991b; Tufail and Ahmad 1992b).

Results and Discussion

The average radon concentrations in different parts of old buildings of Lahore are presented in Table 1. The observed radon concentration in the officers' rooms of General Post Office (GPO) has the minimum value of 20 Bq m^{-3}. The internal painting of the walls and ceilings of these rooms may have acted as sealing agent for radon release. All other parts of GPO have the same radon level due to the same and equally good ventilation rate. Radon level is high in all parts of Museum i. e. 55-69.4 Bq m^{-3}, because of the poor ventilation.

The building of Directorate of Research & Training (DRT) Walton, is well ventilated except for the store and model room, but radon level recorded here have two different levels i.e. extremely high and low 50.2 and 22.5 Bq m^{-3}. In the model room the marble bridges used for training purpose may be the radon source. Ventilation in the store is as bad as in the model room but the recorded radon level is very low, which indicates the absence of uranium contents in building material. It can therefore be concluded that ventilation is only important for the cases in which the building materials exhibit high radon emanation.

Badshahi Mosque shows the radon level ranging between 35.8 and 60.2 Bq m^{-3}, ventilation plays the dominant role there i. e. extremely good in main hall and poor in Tabarrukat section. The Text Book section for girls in Quaid-e-Azam Library has a relatively high level of radon (67.3 Bq m^{-3}) as compared with that of boys (40 Bq m^{-3}). Both sections are poorly ventilated,

Table 1

Radon concentration in different parts of some old buildings of Lahore

General Post Office (1845)		Lahore Museum (1890)		Direct. of Research & Training (1929)		Badshahi Mosque (1674)		Quaid-e-Azam Library (1864)	
Different parts	Radon conc. Bq m^{-3}	Different parts	Radon conc. Bq m^{-3}	Different parts	Radon conc. Bq m^{-3}	Different parts	Radon conc. Bq m^{-3}	Different parts	Radon conc. Bq m^{-3}
Officer's room	20	Swat Gallery	67.9	Exam. Branch	29.9	Open air	14.8	Text Book Sec.(Boys)	40
Main Hall	33.7	General Gallery	69.4	Class room	35.2	Tabarruka Section	60.2	Text Book Sec.(Girls)	67.3
Tower	32.2	Hindu Gallery	55	Stores	22.5	Tower	42.4	Reference Section	41.5
Accounts Branch	26.7	Tasvir Gallery	62.3	Model Room	50.2	Main Hall	35.8	Audio & Video Sec.	35.9
Delivery Section	30.4	--	--	--	--	--	--	Scholar's Room	37.2

however the high radon level in the text book section for girls is not clearly understood.

Radon concentration levels are also measured in the two towers of the old buildings, selected for the monitoring. Radon level recorded here varies significantly i. e. 32.2-42.4 Bq m^{-3} in equally good ventilation rate. The variation can not be explained without considering the different factors which may influence the level in the towers. A study of building's height, effect of wind direction with respect to its architectural design and turbulence of air may be important in this regard.

The average radon concentration in different old buildings does not have any correlation with the age of the buildings (Table 2). The increase in radon concentration is purely dependent upon ventilation and the amount of uranium or radium in the building materials.

For estimation of the risk of lung cancer from the radionuclides to the discrete organs, a special unit known as "Effective Dose Equivalent" has been developed (ICRP 1977). As radon and their progeny are supposedly hazardous to bronchial tissues, the dose in terms of effective dose equivalent to the bronchial tissues of the workers of old buildings of Lahore has been worked out. A wide range of reference conversion factors (5-15 mSvy^{-1}/WLM) between the absorbed dose in the bronchial tissues and exposure to radon progeny has been described both for domestic and mine exposures (ICRP 1981a; ICRP 1981b; UNSCEAR 1982). In view of the uncertainties involved in different measurements, the value of 10 mSv y^{-1} / WLM has been adopted as the best suitable conversion unit to evaluate the effective dose equivalent for the exposure in either environment (Nazaroff and Nero 1988).

The annual exposure to potential alpha energy E_p (WLM) is related to the average radon concentration (Bq m^{-3}) and described by the following relation (Nazaroff and Nero 1988; NEAGE 1985).

$$E_p\ (WLM/y) = \frac{8760\ n\ F\ C_{Rn}}{170 \times 3700}$$

Where n, the fraction of time spent in indoor atmosphere is equal to 0.8 (UNSCEAR 1982; NEAGE 1983); 8760 is the number of the hours per year, and 170 is the number of the hours spent per working month. F is the equilibrium factor and may be taken of any value between 0.4-0.5 (Porstendorfer 1984; Vanmarcke *et al* 1985). Thus on the basis of extensive study, a single value of F equal to 0.5 (ICRP 1981) has been used. Hence the annual exposure to alpha potential energy, E_p in terms of radon concentration is given by 0.0055 C_{Rn} in the conversion unit of 1WLM y^{-1} per Bq m^{-3}.

Using the relationship and conversion unit described above, the absorbed doses in terms of mSv y^{-1} for bronchial tissues of workers are shown in Table 2. The results indicate that the maximum dose of 3.46 mSv y^{-1} has been estimated for the workers of Lahore Museum. This value of effective dose equivalent, however is much below than that of ICRP limit of

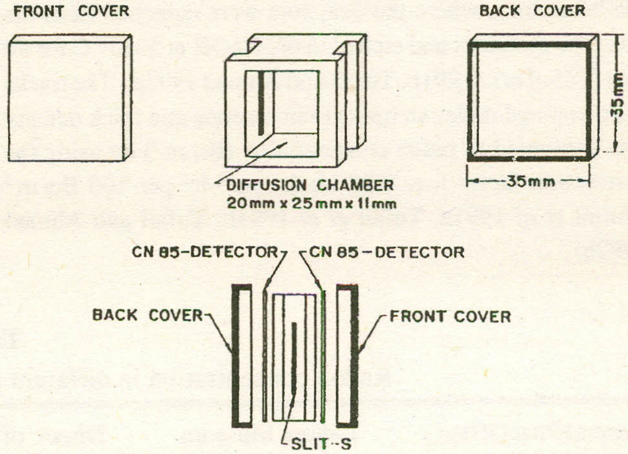

Fig 1. Schematic diagram of box type dosimeter. The position of CN-85 is also given.

Table 2

Average radon concentration in some old buildings of Lahore and estimated doses to bronchial tissues

Name of the Building	Age of the Building (Years)	Ave. Radon Conc. (Bq m^{-3})	Exposure to Pot. α energy (WLM)	Effective Dose equivalent (MSv y^{-1})
General Post Office	150	28	0.154	1.54
Lahore Museum	105	63	0.346	3.46
D.R.T. (Walton)	66	34	0.187	1.87
Badshahi Mosque	321	38	0.209	2.09
Quaid-e-Azam Library	131	44	2.42	2.24

Table 3

Comparison of doses received by the residents of the different areas of Pakistan

Name of the cities	Ave. Radon conc ($Bq\ m^{-3}$)	Exposure to pot. α energy (WLM)	Effective dose equivalent ($mSv\ y^{-1}$)	Reference
Islamabad/Rawalpindi	20	0.271	2.71	Tufail and Ahmad, 1992a
Lahore	26	0.352	3.52	do
Islamabad/Rawalpindi	23-83	--	1.8	Tufai *et al* 1991b, 1992b
Lahore	28-93	--	2.0	do
D.I. Khan	88.3	--	1.73-4.21	Tufail *et al* 1993
Lahore	41.44	0.227	2.27	Present work

20 mSv y^1 to limit the probability of lung cancer (Tufail *et al* 1993). The data regarding doses to lung tissues for the residents of Lahore and some other areas of Pakistan is also listed (Table 3) for comparison. The observed value of effective dose equivalent for Lahore is larger than that of twin cities of Islamabad/Rawalpindi but very small as compared with that of D.I. Khan (Tufail *et al* 1993). The variations among estimated doses linked to the workers of old buildings of Lahore (present work) and previous measurements (Tufail *et al* 1991b; Tufail and Ahmad 1992a, Tufail *et al* 1992b) carried out in the city of Lahore, are due to different conversion factors adopted by the investigators and the nature of the two types of buildings i. e. old and new buildings. In the new houses/ buildings the factors contributing to higher radon concentration are the building materials, utilities and designs which are less ventilated. Whereas old buildings are generally well ventilated and a relatively less amount of radium is probably present in the construction materials. However, for the exact assessment of radioactivity in the construction materials of old buildings, a comprehensive programme would be carried out in near future.

Conclusion

It may be concluded from the foregoing discussion that radon concentration has no relation with the age of the building. The variation of radon in general depends upon the ventilation, uranium rich building materials and the articles present inside the building. However in some cases other factors, such as use of paints in some parts, variation of height of towers, change in the air pressure and wind direction with respect to architectural design have been found to be important for indoor radon study.

The average annual dose to bronchial tissues of the workers belonging to the old buildings of Lahore, from inhaled radon progeny, has been found to be lower than that of D.I. Khan. This decrease in the doses chiefly depends upon the good ventilation of the old buildings. The observed effective dose equivalent for the workers of old buildings of Lahore is large as compared with that of twin cities of Islamabad/Rawalpindi, but it is still very much lower than that of ICRP limit of 20 mSv y^{-1}. The average effective dose equivalent of 2.27 mSv y^{-1} reflects that the probability of hazard attributable to exposure of radon progeny in the old buildings of Lahore is negligible.

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