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Radon exhalation in some building construction materials and effect of plastering and paints on the radon exhalation rate using fired bricks

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ABSTRACT

The technological endeavors of human beings have modified the levels of radiation exposure slightly. The emanation of radon is primarily associated with radium and its ultimate precursor uranium. The radiation dose received by human beings from indoor radon and its progeny is the largest of all doses received either by natural or man-made sources. In order to investigate the effect of paints available in the market on the radon exhalation rate from building materials, several bricks were collected. These bricks were plastered with a mixture of cement and sand. Before measurements, bricks were dried for 24 hours. These plastered bricks were then coated with white wash and again dried for 1-2 hours. After drying the bricks were coated with different brands and colors of paints. In the present study radon exhalation rates measurements were carried out for these painted bricks using "Sealed Can Technique". Radon activities were found to vary from 897.4 Bq m^{-3} to 1514.6 Bq m^{-3} with an average value of 1117.5 Bq m^{-3}. Radon exhalation rates were found to varies from 537.1 mBq m^{-2} h^{-1} to 906.5 mBq m^{-2} h^{-1} with an average value of 669.5 mBq m^{-2} h^{-1}, whereas the Indoor inhalation exposure (radon) effective dose were found to varies from 63.3 μSvy^{-1} to 106.8 μSv y^{-1} with an average value of 78.9 μSvy^{-1}.

Key words: LR-115 type II detector; Radon activity; Radon exhalation rate; Building construction materials; Indoor inhalation exposure (radon) effective dose

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INTRODUCTION

Ever since the genesis, biosphere has been exposed to natural environment radiation originating from the atomic species like uranium, thoium, potassium, and traces of very long-lived naturally occurring nuclides. The technological endeavors of human beings have modified the levels of radiation exposure slightly. The emanation of radon is primarily associated with radium and its ultimate precursor uranium. The radiation dose received by human beings from indoor radon and its progeny is the largest of all doses received either by natural or man-made sources **[1].** In rooms kept closed for a long duration and in air- conditioned rooms, high radiaton levels are possible by the accumulation of radn gas **[2].** Radon in indoor space orginates from walls, floors, ceilings, and soil benath the floor. Since the nature of building maerials and their uranium content vary regionally, the contribution of building materials to indoor radon will also vary. Radon appears mainly by diffusion processes from floors, walls and ceilings which are constructed with cement, sand and other buildings materials. Bricks are made from soil and fired in Kilns. These bricks are used in the construction of walls of the house and then the walls are plastered with a mixture of cement and sand. Construction materials are one of the major sources of indoor radon concentration in dwellings and largely contribute to the domestic radiation dose rates received by humans **[3-5]**. Existences of three primordial radio nuclides (^{40}K, ^{238}U and ^{232}Th) in building materials cause internal and external exposures to residents. External exposure is caused by gamma radiation emitted from ^{40}K and daughter products of ^{238}U and ^{232}Th **[6]**. It is well known that as a result of inhalation of ^{222}Rn, a daughter product of decay chain of ^{238}U and its daughter products, equivalent dose to entire lung is higher than the equivalent dose to entire lung is higher than the equivalent dose in other tissues **[7]**.The rate at which radon escapes or emanates from solid into the surrounding air is known as radon emanation rate or radon exhalation rate of the solid. This may be measured by either per unit mass or per unit surface area of the solid **[8].** The fraction of radon formed in the soil grains that escapes into pores is known as the emanation power, coefficient or fraction. Some building materials may be responsible for increased indoor radon levels either due to their higher radon exhalation rates or due to their uranium/ radium enrichment as compared to other materials depending on their micro-structure **[9, 10].** Radon an inert radioactive gas whose predecessor is uranium, is emitted from soil beneath the house and from building materials. Noble radon gas (^{222}Rn) originates from radioactive transformation of ^{226}Ra in the ^{238}U decay chain in the earth's crust **[11].** The assessment of radiological risk related to inhalation of radon and radon progeny is based mainly on the integrated measurement of radon in both indoor and outdoor environments. The exhalation of radon from the earth crust and building materials forms the main source of radon in indoor environment **[12].**The walls and roofs are painted with different kind of paints and may affect the radon exhalation from these construction materials. As different brands of paints are available in the market and widely used as a cover for plastered bricks for increasing the life and for ornamental purpose, the study is important for understanding the effect of the wall coverings on radon exhalation from the building materials.

MATERIALS AND METHODS

2.1. Radon exhalation rate

Cylindrical plastic "Can" of 7.5cm height and 7.0 cm diameter was sealed to the individual samples by plasticin (Fig.1). In each can a LR-115 type II plastic detector (2cm × 2cm) was fixed at the top inside of the Can, such that the sensitive surface of the detector faces the material and is freely exposed to the emergent radon. Radon decays in the volume of the Can record the alpha particles resulting from the Po ^{218} and Po ^{214} deposited on the inner wall of the Can. Radon and its daughters will reach equilibrium in concentration after one week or more. Hence the equilibrium activity of the emergent radon can be obtained from the geometry of the can and the time of exposure. The detectors were exposed to radon for 100 days. After the exposure the detectors were etched in 2.5 N NaOH at 60^{0}C in a constant temperature water bath for revelation of tracks. The resulting alpha tracks on the exposed face of the track detector were counted using an optical microscope at a magnification of 400X. The radon exposure inside the Can was obtained from the track density of the detector by using calibration factor of 0.56 tracks cm^{-2} d^{-1} obtained from an earlier calibration experiment **[13].**

The exhalation rate is found from the expression **[14, 15]**:

$$Ex = \frac{CV\lambda}{A[T + \frac{1}{\lambda}(e^{\lambda t} - 1)]} \quad (1)$$

Where,

E_x = Radon Exhalation rate (Bq m^{-2} h^{-1})
C= Integrated radon exposure as measured by LR-115 type II solid state nuclear track detector (Bq m-^{3} h^{-1}).
V= Volume of Can (m^{3})
λ= Decay constant for radon (h^{-1})
T= Exposure time (h)
A= Area covered by the Can (m^{2})

2.2 Indoor internal exposure due to radon inhalation:

The risk of lung cancer from domestic exposure of radon and its daughters can be estimated directly from the indoor inhalation exposure (radon) effective dose. The contribution of indoor radon concentration from fly ash samples can be calculated from the following expression **[15-19].**

$$C_{Rn} = \frac{E_x \times S}{V \times \lambda_v} \tag{2}$$

where C_{Rn} is the radon concentration (Bq m^{-3}) ; E_x is radon exhalation rate (Bq $m^{-2}h^{-1}$); S is radon exhalation area (m^2) ; V is room volume (m^3) , and λ_v is air exchange rate (h^{-1}) .The maximum radon concentration from the building material was assessed by assuming the room as a cavity with S/V = 2.0 m^{-1} and air exchange rate of 0.5 h^{-1}. The annual exposure to potential alpha energy E_p (effective dose H) is then related to the average radon concentration C_{Rn} by following expression:

$$E_P\left[WLM.y^{-1}\right] = \frac{8760 \times n \times F \times C_{Rn}}{170 \times 3700} \tag{3}$$

where, C_{Rn} is in Bq m^{-3}; n is the fraction of time spent indoors; 8760, the number of hours per year; 170, the number of hours per working month and F is the equilibrium factor for radon and is taken as 0.4 as suggested by UNSCEAR, 2000 **[20]**. Radon progeny equilibrium is most important quantity, where dose calculations are to be made on the basis of the measurement of radon concentration, it may have value 0<F<1. Thus, the values of n=0.8 and F=0.4 were used. From radon exposure the indoor inhalation exposure (radon) effective dose were estimated by using a conversion factor of 3.88 mSv $(WLM)^{-1}$ (ICRP, 1993) **[21].**

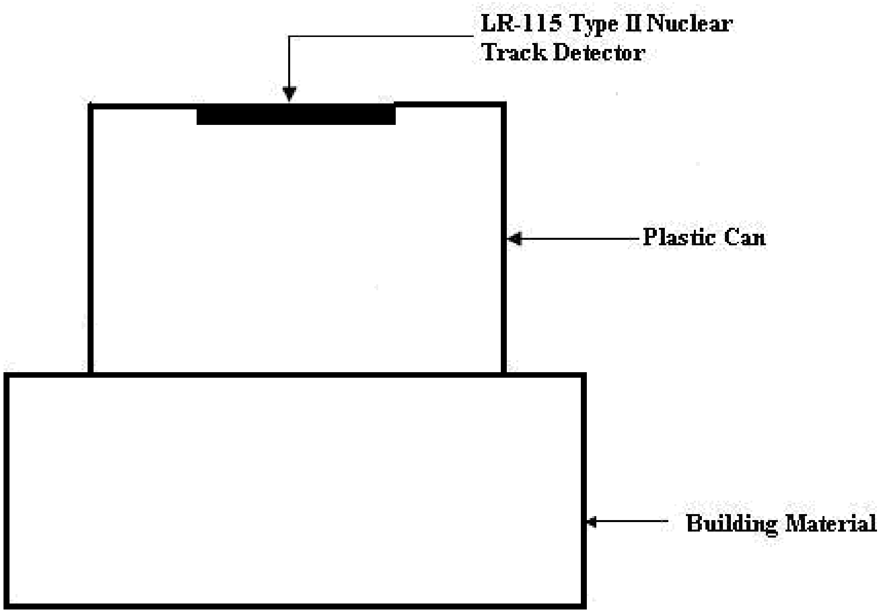

Figure 1: Assembly for the measurement of radon exhalation rate using "Can technique" (7 cm diameter and 7.5 cm height)

RSULTS AND DISCUSSION

Track density, Radon activity, radon exhalation rate and indoor inhalation exposure (radon) effective dose from plastered and painted fired bricks are given in Table -1. Radon activities are found to variy from 897.4 (Red color) Bq m^{-3} to 1514.6 (Yellow color) Bq m^{-3} with an average value of 1117.5 Bq m^{-3}. Radon exhalation rate varies from 537.1 mBq m^{-2} h^{-1} to 906.5 mBq m^{-2} h^{-1} with an average value of 669.5 mBq m^{-2} h^{-1} whereas the Indoor inhalation exposure (radon) effective dose varies from 63.3 (Red color) µSvy^{-1} to 106.8 (Yellow color) µSv y^{-1} with an average value of 78.9 µSvy^{-1}.

The results show highest radon exhalation rate (4162.8 mBq m^{-2} h^{-1}) from unfired bricks. In the case of unfired bricks, there may be many voids and the emanation can escape from inside i.e. from few cm below the surface and thus the amount of radon that can escape should depend on the internal surface area while in plastered brick with different brands colors of paints the number of voids are reduced to a large extent and the radon may be emanated from the surface layer only.

The radon exhalation rate from building materials varies appreciably from one building material to another. This may due to the differences in radium content [**22]** and porosity [**23].**

It is worth mentioning that it is difficult to predict the radon exhalation rate from the concentration of uranium or its decay series products in the sample, since the radon exhalation rate depends also on the texture and grain size composition **[24]**

Table 1 Track density, Radon activity, radon exhalation rate and Indoor inhalation exposure (radon) effective dose from plastered and painted fired bricks

Brands/ Colours of Paints	**Track Density (track/cm^{2}d)**	**Radon activity (Bq m^{-3})**	**Exhalation Rate (mBq m^{-2} h^{-1})**	**Indoor inhalation exposure (radon) effective dose (μSv y^{-1})**
Unfired brick	385.5	6885.7	4162.8	490.8
Fired brick	47.6	850.7	514.3	60.6
Plastered brick	60.1	1073.0	648.7	76.4
Black	62.1	1108.2	663.3	78.2
Yellow	84.8	1514.6	906.5	106.8
Green	65.8	1175.1	703.3	83.0
Red	50.2	897.4	537.1	63.3
Blue	53.6	956.6	572.5	67.5
Orange	72.1	1288.3	771.1	90.9
White	58.5	1044.0	624.8	73.7
Silver	56.0	1000.3	598.7	70.6
Minimum	50.2	897.4	537.1	63.3
Maximum	84.8	1514.6	906.5	106.8
Average value	62.6	1117.5	669.5	78.9

The effect of paints is not significant although different colors of paints affect the values by different amounts. The change may be due to different amounts of uranium concentration in the plastering materials and paints and porosity of the material. Unfired brick shows the higher values of radon activity and radon exhalation rate. In unfired bricks, there may be many voids and the emanation can escape from inside i.e few cms, below the surface and thus the amount of radon that can escape should depend on the internal surface area while in plastered bricks the numbers of voids are reduced to a large extent and the radon is emanated from the surface layer.

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REFERENCES

[1] Khan A J, Prasad R, Tyagi R K, *Tracks Radiat. Meas.* **1992,** 20, 609.
[2] UNSCEAR Report, United Nations Scientific Committee on Effects of Atomic Radiation, UN, New York, **1888,** No. E 88.
[3] Lowder W M, Natural Environmental Radioactivity and Radon Gas, In., Tommasino, L., Furlan, L.G.., Khan, H.A., Mommin, M. (Eds), Radon Monitoring in Radioprotection, Environmental Radioactivity and earth Sciences, World Scientific, Singapore, **1990,** 1-17.
[4] Lowder WM, Natural Environmental Radioactivity and Radon Gas, In., Tommosino, et al. (Eds.), Radon Monitoring in Radio protection., Environmental Radioactivity and Earth Sciences. World Scientific. **1989**
[5] Mclaughlin JP, Proc. Intern. Workshop on Radon Monitoring in Radio Protection, Environmental and Earth sciences. ICTP, Trieste, Italy. **1989**
[6] Nassiri P, Ebrahimi H and Jafari Shalkouhi P, *Journal of Scientific & Industrial Research,* **2011,** 70, 230-231.
[7] Sundar SB, Ajoy KC, Dhanasekaran A, Gajendiran V, & Santhanam R, Measurement of Radon Exhalation Rate from Indian Granite Tiles, in Proc Int Radon Symp, vol II (Amer Assoc of Radon Sci and Technol, USA), **2003**
[8] Singh BP, Pandit B, Bhardwaj V N, Singh,Paramjit, & Kumar, Rajesh,. *Indian Journal of Pure & Applied Physics*, **2010**, 48, 493-495.

[9] Kumar V, Ramachandran TV, & Prasad R, *Applied Radiat Isot*, **1999** 51, 93.
[10]Nageswara MV, Rao, Bhatti SS, Seshu P & Reddy A R,. *Radiation Protection Dosimetry*, **1996,** 63, 207.
[11]Vaupotic J, Gregoric A, Kobal I, Zvab P, Kozak K, Mazur J, Kochowska E, & Grzadziel D,. *Hazards Earth Syst. Sci*, **2010,**10, 895.
[12]Gusain G S, Prasad Ganesh, Prasad Yogesh, Ramola R C, *Radiation Measurements,* 44, **2009,**1032.
[13]Singh AK, Khan AJ, & Prasad R, *Rad, Prot. Dosim*, **1997,** 74, 189.
[14]Fleischer RL, & Margo-compero A, *Geophys. Res*, **1978,** 83, 3539.
[15]Sharma J, Mahur A K, Kumar R, Varshney R, Sonkawade R G, Swarup R, Singh H, Prasad R, *Advances in Applied Science Research*, **2012**, 3 , 1085.
[16] Mahur A K, Kumar R, Mishra M, Ali S A, Sonkawade R G, Singh B P, Bhardwaj V, N, Prasad R, *Ind. J. Pure and Appl. Phys*. 48, **2010**, 486.
[17] Mahur A K, Kumar R, Sengupta D, Prasad R, *J. Environ. Radioact*. 99, **2008a,** 1289.
[18] Mahur A K, Kumar R, Mishra M, Sengupta D, Prasad R, *Appl. Radiat. Isot*. 66, **2008b**, 401.
[19] Nazaroff, W W, Nero Jr. A V, Radon and its Decay Products in Indoor Air. Wiley- Interscience, New York, **1988.**
[20] UNSCEAR. United Nations Scientific Committee on the Effects of Atomic Radiation: Sources and Effects of Ionizing Radiation, Vol.1.United Nations, New York, **2000.**
[21] ICRP, .International Commission for Radiological Protection. New York.**1993.**
[22] Ramchandran TV& SubhaRamu MC, Estimation of Indoor Radiation Exposure from the Natural Radioactivity Content of Building Materials. Oncology 3, **1989,** 20.
[23] Folkerts KH, Keller G and Muth R, *Radiat. Prot. Dosim.* **1984** 9, 27.
[24] Tufail M, Mirza, SM , Chughati M K, Ahmad N, Khan H A, *Nucl. Tracks. Radiat. Meas*., **1991,** 19,427.