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Effect of Plastering and Paints on the Radon Exhalation Rate and Radiation Doses from Fired Bricks.

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Abstract: 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. Radon exhalation rates measurements were carried out for these painted bricks through sealed can technique II using LR-115 type II detectors.

Radon activity varies from 845.71 Bq m^{-3} to 1682.86 Bq m^{-3}.. Radon exhalation rate varies from 506.17 mBq m^{-2} h^{-1} to 1007.22 mBq m^{-2} h^{-1} whereas the effective dose equivalent for radon decay products vary from 59.69 **μ**Sv y^{-1} to 118.77 **μ**Sv y^{-1} .

Radon exhalation is found to increase slightly with golden (yellow), Asian (orange) and Berger (yellow) while it decreases with others.

Key words: LR-115 type II dector, Effective Dose, Radon exhalation rate.

1. Introduction

Ever since the genesis, biosphere has been exposed to natural environment radiation originating from the atomic species like uranium, thorium, 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 radon gas [2]. Raon 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 [3,4,5]. 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)

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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.

2.Expermental Technique

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 an 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 60^0C 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].

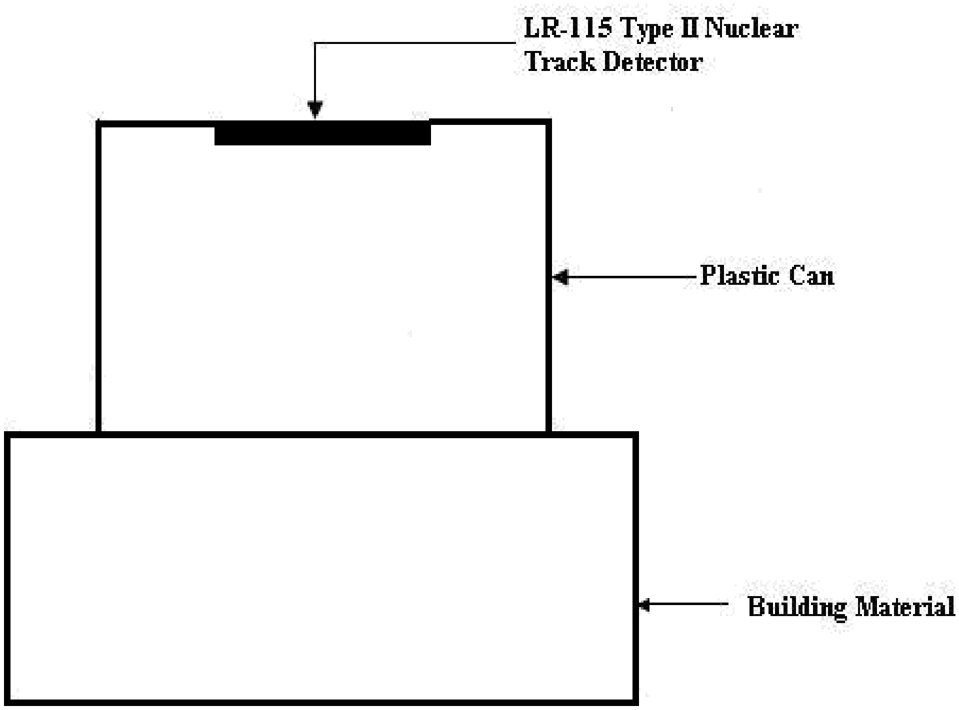

Figure 1: Assembly for the measurement of radon exhalation rate using "Can technique II"

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

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

Where,

Ex	=	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)

Risk Estimates

The risk of lung cancer from domestic exposure of ^{222}Rn and its daughters can be estimated directly from the indoor inhalation exposure (radon) effective dose. The contribution of indoor radon concentration from the samples can be calculated from the expression [15]:

$$C_{Rn} = \frac{E_X \times S}{V \times \lambda_V}$$

Where C_{Rn}, E_x, S, V, and λ_V are radon concentration (Bq m^{-3}), radon exhalation rate(Bq $m^{-2} h^{-1}$), radon exhalation area (m^2), room volume (m^3) and air exchange rate (h^{-1}) respectively. In these calculation, 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 equivalent) is then related to the average radon concentration C_{Rn} by the following expression:

E_p (WLM yr^{-1}) = $8760 \times n \times f \times C_{Rn} / 170 \times 3700$

Where C_{Rn} is in Bq m^{-3}; n, 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. Radon progeny equilibrium factor is the most important quantity when dose calculations are to be made on the basis of the measurement of radon concentration. Equilibrium factor F quantifies the state of equilibrium between radon and its daughters and may have values $0 < F < 1$. The value of F is taken as 0.4 as suggested by UNSCEAR (1988). Thus the values of n = 0.8 and F= 0.4 were used to calculate E_P. From radon exposure, effective dose equivalents were estimated by using a conversion factor of 6.3 mSv WLM^{-1} [16].

2. Results and Discussion

Radon activity and radon exhalation rate are measured from unplastered brick, plastered brick and plastered bricks painted with different brands and colors of paints. Computed values of radon activity, radon exhalation rate and effective dose equivalents are presented in Table 1.

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Table 1
Radon activity concentration, radon exhalation rate and effective dose equivalent from plastered and painted fired bricks.

Brands/ Colours of Paints	Track Density ($track/cm^2d$)	Radon activity ($Bq\ m^{-3}$)	Exhalation Rate ($mBq\ m^{-2}\ h^{-1}$)	Effective Dose equivalent ($\mu Sv\ y^{-1}$)
Plastered Brick	65.44	1168.57	699.41	82.48
Unplastered Brick	80.00	1428.57	855.02	100.82
Gold				
Oxford Blue	79.84	1425.71	853.31	100.62
P.O. Red	70.08	1251.43	748.99	88.32
Black	68.96	1231.43	737.03	86.91
Yellow	94.24	1682.86	1007.22	118.77
Bus Green	62.88	1122.86	672.05	79.25
King Lac				
Black	62.24	1111.43	665.21	78.44
Crimson	69.28	1237.14	740.45	87.31
Bus Green	70.56	1260.00	754.13	88.93
P.O. Red	68.64	1225.71	733.60	86.51
Gold yellow	69.28	1237.14	740.45	87.31
O.X. Blue	64.00	1142.86	684.02	80.66
Phirozi	52.00	928.57	555.76	65.54
White	74.24	1325.71	793.46	93.54
Ganga				
Silver	62.24	1111.43	665.21	78.44
Asian paints				
Golden Yellow	64.8	1157.14	692.56	81.67
Phirozi	51.04	911.43	545.50	64.33
Orange	80.16	1431.43	856.73	101.03
Red	55.84	997.14	596.80	70.38
Blue	59.52	1062.86	636.14	75.01
Bus Green	73.12	1305.71	781.49	92.15
Ampro				
Bus Green	61.76	1102.86	660.08	77.84
White	64.96	1160.00	694.28	81.87
Phirozi	60.48	1080.00	646.39	76.22
Golden Yellow	53.28	951.43	569.44	67.15
Red	51.36	917.14	548.92	64.73
Berger				
Black	47.36	845.71	506.17	59.69
Bus green	57.44	1025.71	613.90	72.39
Phirozi Blue	61.28	1094.29	654.95	77.23
Golden yellow	85.76	1531.43	916.58	108.08
Snow white	70.56	1260.00	754.13	88.93
Touch				
Silver	53.76	960.00	574.57	67.75

It can be seen from the Table 1 that radon emanation is reduced by plastering. The effect of paints is not significant although different brands and colors of paints affect the values by different amounts. The change may be due to different amounts of U concentration in the plastering materials and paints and porosity of the material . Radon activity varies from 845.71 Bq m^{-3} to 1682.86 Bq m^{-3}.. Radon exhalation rate varies from 506.17 mBq m^{-2} h^{-1} to 1007.22 mBq m^{-2} h^{-1} whereas the effective dose equivalent for radon decay products vary from 59.69 **µ**Sv y^{-1} to 118.77 **µ**Sv y^{-1} . Radon exhalation is found to increase slightly

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with golden (yellow), Asian (orange) and Berger (yellow) while it decreases with others. UNSCEAR 2000 has reported the exhalation rates from walls and floor of half slab thickness 0.1 m and 0.05 m as 5760 mBq m^{-2} h^{-1} and 2860 mBq m^{-2} h^{-1} respectively. The values reported in the present study are less than these values.

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