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Study of correlation between indoor radon, thoron and their progeny levels in Srinivasanagar, Bangalore city, India

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ABSTRACT

Exposure of persons to high concentrations of radon and its progeny levels for a long period leads to pathological effects like the respiratory functional changes and the occurrence of lung cancer. It is indicated that the inhalation of short-lived ^{222}Rn daughters seems to be the most important component of the radiation exposure of the population from natural sources. According to an estimate, ^{222}Rn gas may be the major source of public radiation exposure, perhaps accounting for between 5 and 20% of all lung cancer deaths. In view of this an attempt has been made for the measurements of radon and thoron by using solid state nuclear track detector based dosimeters. The average annual dose to the population of Bangalore city due to radon and thoron daughter activity works out to be 1.98m Sv y^{-1}. All India mean effective dose equivalent is 2.49m Sv y^{-1} and the global effective dose equivalent is 2.4m Sv y^{-1}. Seasonal variations in the concentration of indoor radon/thoron and their progeny concentrations are observed with higher values in winter and lower in summer. A strong correlation coefficient was observed between ^{222}Rn, ^{220}Rn and their progenies.

KEYWORDS

Radon;
Thoron;
Progenies;
Correlation;
Concentration.

INTRODUCTION

The main sources for the presence of ^{238}U and its daughter products in surface air are re suspension of soil dust from the earth's crust, release of fly-ash from the coal-fired power plants, mining, milling and processing of Uranium ore, disposal of nuclear wastes from the nuclear power plants, oil refineries, fallout re-suspension from past atmospheric nuclear weapon detonations, satellite and other nuclear-related accidents and industrial activities like phosphate fertilizers[1]. When ^{226}Ra enters into the body, its metabolic behavior is similar to that of calcium and appreciable fraction of this is deposited in bone. More than 70% of ^{226}Ra in the body is concentrated in bone, the remaining fraction being distributed rather uniformly in soft tissues[2]. In order to assess the dose due to indoor ^{222}Rn, ^{220}Rn and its daughters, investigations have been carried out by several researchers by way of measuring the concentrations of ^{222}Rn and ^{220}Rn in the environment[3]. House construction materials can be significant sources of indoor ^{222}Rn in addition to soil and water[4]. Most materials contain ^{238}U and are consequently potential ^{222}Rn emitters, since ^{222}Rn is a daughter product of ^{226}Ra, which in turn is derived from the longer lived antecedent ^{238}U. However, some materials have higher concentrations of ^{238}U and ^{226}Ra such as alum shale and black shale[5] certain granites are typical of ^{238}U bearing natural materials, but it is always possible to find ^{238}U rich bedrock of different types as building materials[6]. Construction materials are sources of indoor airborne radioactivity and external radiation from the decay series of ^{238}U in building. Exhalation of ^{222}Rn from these materials are of interest since the short-lived decay products of ^{222}Rn as the greatest contribution to the lung dose of inhaled radio nuclides[4] . Radon-prone areas can be identified directly by using indoor measurements or indirectly using radon concentration in the soil, provided there is an established correlation with the radon concentrations in the homes. In view of this an attempt has been made study the correlations between ^{222}Rn, ^{220}Rn and their progenies in dwellings of Bangalore city, India.

MATERIALS AND METHODS

The concentrations of ^{222}Rn, ^{220}Rn and their progenies are measured in Bangalore city using Solid State Nuclear Track Detectors, which are thin sheets of dielectric materials such as cellulose nitrate and polycarbonates. They are sensitive to alpha but not to beta and gamma radiations. They are unaffected by moderate humidity, heat and light. For indoor measurements normally LR-115 type II plastic track detector is preferred. The detailed description of methodology and calibration procedures has been given by Sathish et al.[7].

RESULTS AND DISCUSSION

Different rooms

The concentrations of ^{222}Rn, ^{220}Rn and their progenies are measured in different rooms of the same house. Bathrooms were found to have higher concentration. Bed rooms ranked second, next kitchen and living room last. Bed rooms might be expected to be least ventilated, on the average based upon limited use patterns and bath rooms may receive some additional ^{222}Rn due to ^{222}Rn dissolved in water[8]. ^{222}Rn is shown to be released in spray from faucets or shower fixture[8]. Air in living rooms on the other hand is most readily diluted due to outdoor air blow. Similar results all have been reported by other studies[9]. They have also reported the activity of radium from different zones Bed rooms recorded relatively higher concentrations of ^{222}Rn, ^{220}Rn followed by kitchen, front room and hall. This may be due to less atmospheric pressure and less ventilation in the bed room[9]. The correlation between ^{222}Rn, ^{220}Rn and their progenies are shown in figure 1, they show linear variations with the regression coefficient 0.74 and 0.94 respectively. The frequency distribution of ^{222}Rn and ^{220}Rn are plotted in Fig. 2, higher concentrations are observed in least ventilated rooms and lower in well ventilated rooms.

Different floorings

The correlation between ^{222}Rn, ^{220}Rn and their progeny levels and the frequency distributions are shown in figure 3 and 4. The measurements were made covering all the four seasons in a calendar year and the integrated data are discussed. The materials used for construction of buildings are sufficiently porous and allow ^{222}Rn to enter into the indoor atmosphere[10]. The data shows that in the houses with stone and marble-flooring, concentrations of ^{222}Rn is less but in the house with granite flooring it is slightly higher because granite contains high concentrations of ^{226}Ra[11].

Granite samples show higher ^{222}Rn exhalation rate than marble, and the correlation of the ^{226}Ra content of granite with ^{222}Rn exhalation and ^{222}Rn concentration is observed by several researchers[12]. Mosaic flooring houses show slightly less ^{222}Rn exhalation rate than cement flooring houses. The huts have mud walls, bare flooring and poor ventilation. The ^{222}Rn concentration in huts is lower than in concrete and mosaic flooring houses even though ^{222}Rn exhalation from bare flooring is higher than other types of flooring. High ^{222}Rn exhalation from concrete walls may be responsible for increasing the concentration in cement and mosaic flooring houses. This may be due to the high ^{222}Rn concentration in the concrete floorings and also because of the porous floor concrete slab through which ^{222}Rn could

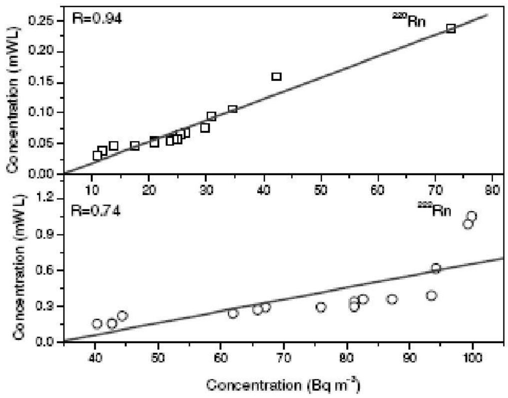

Figure 1 : Correlation between radon and progenies

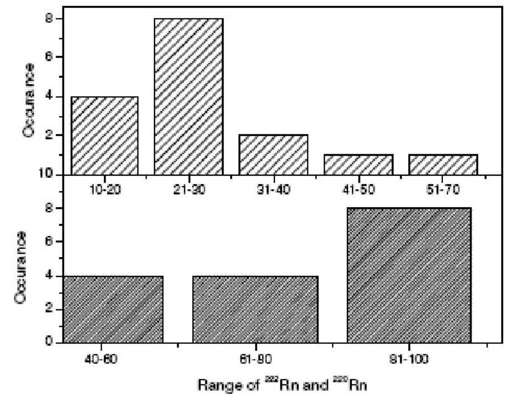

Figure 2 : Frequency distribution of ^{222}Rn and ^{220}Rn

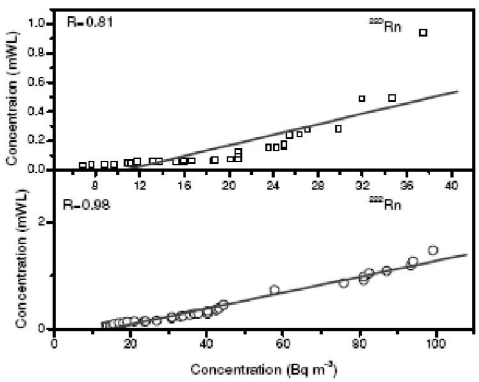

Figure 3 : Correlation between radon and progenies

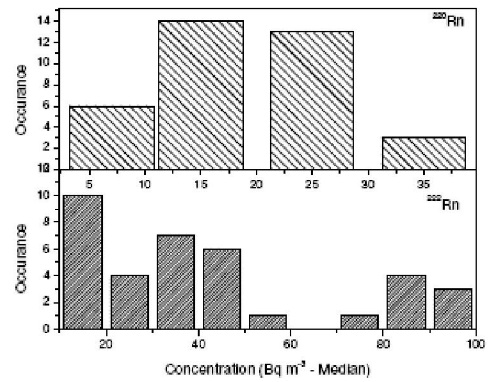

Figure 4 : Frequency distribution of ^{222}Rn and ^{220}Rn

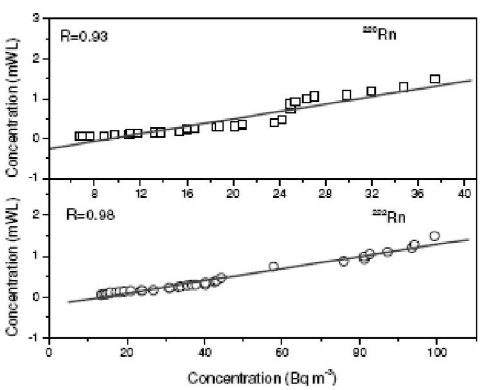

Figure 5 : Correlation between radon and progenies

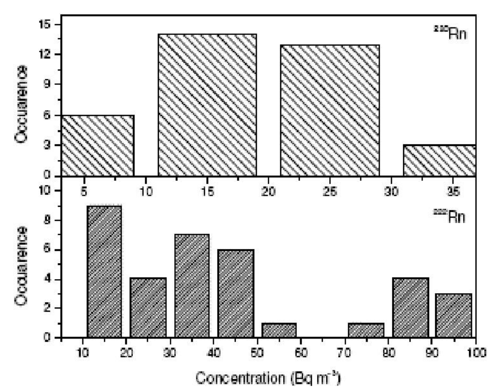

Figure 6 : Frequency distribution of ^{222}Rn and ^{220}Rn

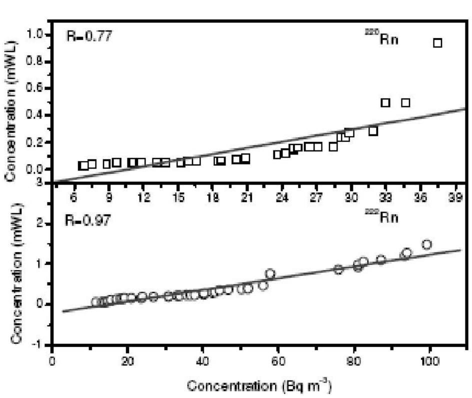

Figure 7 : Correlation between radon and progenies

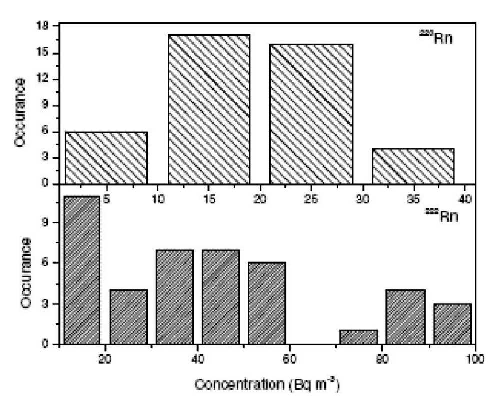

Figure 8 : Frequency distribution of ^{222}Rn and ^{220}Rn

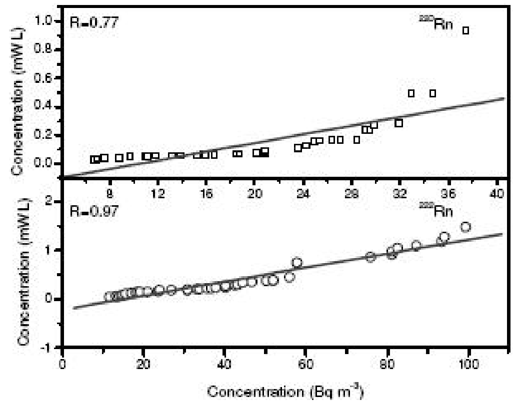

Figure 9 : Correlation between radon and progenies

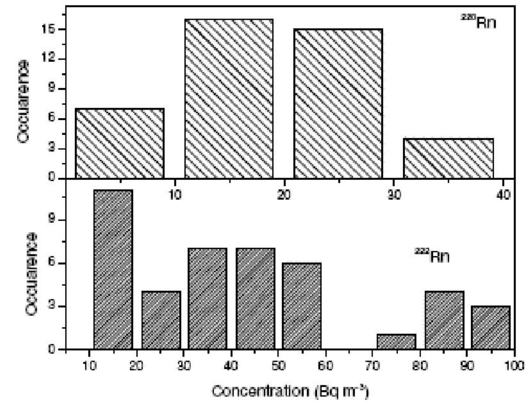

Figure 10 : Frequency distribution of ^{222}Rn and ^{220}Rn

easily enter the houses. The exhalation from brick wall with cement plastering is also high. In addition to this the high indoor ^{222}Rn concentration could be attributed to cracks in the floor as a consequence of poor quality of materials used for construction[13]. High positive correlations between average ^{222}Rn concentrations and the build-up of ^{222}Rn ($r = 0.98$); and between indoor exposure and average ^{222}Rn concentrations ($r = 0.98$) were observed by Sahota et al.[14]. The low correlation might be due to the fact that many physical and meteorological factors affect the variation of the ^{222}Rn progeny in indoor as well as outdoor. Indoor and outdoor pressure difference, wind speed, wind direction and aerosol concentration in the air are main factors in this respect[14].

Different wall

The concentration of ^{222}Rn, ^{220}Rn and their progeny levels for different types of wall materials are measured. The result shows that the concentrations are found to vary from wall to wall. The variation may be due to random distribution of radioactive rock species used ignorantly in the construction of the houses[15]. The reported average values of porosity of the soil and building materials are 0.25 and 0.15[16] respectively. The ^{222}Rn exhalation rate is higher in soil than in concrete, whereas building may contain several tons of concrete. The contribution of this to indoor ^{222}Rn is relatively low because of low escape rate of ^{226}Ra. ^{222}Rn exhalation rate also depends on the thickness of wall[17]. Correlations between ^{222}Rn, ^{220}Rn and their progeny levels and the frequency distributions in different types of wall materials covering all the four seasons in a calendar year during 2007-2009 of Bangalore city are shown in the figure 5 and 6.

Sreenath Reddy et al.[18] have studied inhalation dose due to indoor ^{222}Rn and ^{220}Rn concentrations in the surrounding villages of Hyderabad, Andra Pradesh, India and reported that the indoor ^{222}Rn and ^{220}Rn concentrations in the surrounding villages of Hyderabad ranged from 3 to 47.7 Bq m^{-3} with an average of 9.9 ± 0.8 Bq m^{-3} and from 2.2 to 90 Bq m^{-3} with an average of 15 ± 16.2 Bq m^{-3} respectively. The corresponding progeny concentrations are ranges from 0.04 to 4.0 mWL with an average of 0.82 ± 0.8 for ^{222}Rn progeny and 0.04 to 8 mWL with an average of 3.1 ± 2.0 mWL for ^{220}Rn progeny. The measured annual dose due to inhalation of ^{222}Rn and its progeny varies from 0.08 to 1.26 mSv with an average of 0.26 ± 0.21 mSv and for ^{220}Rn and its progeny varies from 0.05 to 2.12 mSv with a n average of 0.35 ± 0.38 mSv. Further states that the dwellings with mud floor are exhibited relatively higher dose. This establishes that the sub surface soil is predominating source of indoor ^{222}Rn and ^{220}Rn. The dose in the dwellings with mud walls recorded higher dose than other type of walls. Since the mud walls are constructed using local soil and it may contain higher radium and thorium content. A strong correlation coefficient was observed between radon activity and mass exhalation rate (correlation coefficient 0.99), which may be due to the radium content[19] and porosity[20] in the samples.

Different seasons

The correlations between ^{222}Rn, ^{220}Rn and their progenies and the frequency distributions in different seasons are shown in figure 7 and 8. It can be seen that the maximum concentrations of ^{222}Rn and its progenies occurred during winter and minimum during summer in all years and in all locations. This could be due to temperature inversion which can generally be expected to be in winter[21] and also houses are closed during this season most of the time to conserve heat energy. This leads to poor ventilation. The concentration gradually decreases and is lowest in summer. Turbulent transfer during summer causes low concentration of ^{222}Rn and its progenies at lower atmosphere[21]. The decrease of ^{222}Rn concentration and also an exhalation from soil in rainy season has been observed. During rainy season soil becomes saturated with water and hence less concentration is exhaled[22].

The seasonal variation of ^{222}Rn and ^{220}Rn in indoor atmosphere in different buildings reveals the maximum concentrations during the winter periods as observed elsewhere[23]. It is essentially influenced by the temperature inversion and also because almost all windows are closed during winter season. But in summer low concentrations of ^{222}Rn, ^{220}Rn and their progeny were observed because of the vertical mixing and dispersion. Further during summer fans are used and all windows are kept open. During the rainy season and autumn the ^{222}Rn, ^{220}Rn progeny concentrations do not show much variation. Looking at the seasonal correlation coefficients, wind speed is important for radon variations in all seasons, with the highest correlation during spring (0.61 ± 0.03). Horizontal advection is, in principle, as important as vertical mixing for the dilution of surface atmospheric radon[24].

Different volumes

To give new light on radon level inside closed space. We have carried out a large number of measurements of ^{222}Rn and ^{220}Rn concentrations using nuclear track detector based discriminating dosimeters. The obtained values were plotted against room volume and are shown to decrease monotonically as the room volume increases. The data shows an inverse relationship between ^{222}Rn, ^{220}Rn concentrations and volume of rooms. The correlation between ^{222}Rn, ^{220}Rn and their progenies and the frequency distributions are shown in figure 9 and 10.

No significant correlation was found between ^{220}Rn and its progenies. On the other hand, even though the direct correlation between the concentrations of indoor ^{220}Rn and its progeny was weak, a better correlation (R = 0.77) was found by modified ^{220}Rn concentrations with the ratios of source areas to volumes of rooms. It suggests that indoor concentrations of ^{220}Rn progeny may be roughly estimated from the measurements of indoor ^{220}Rn[25].

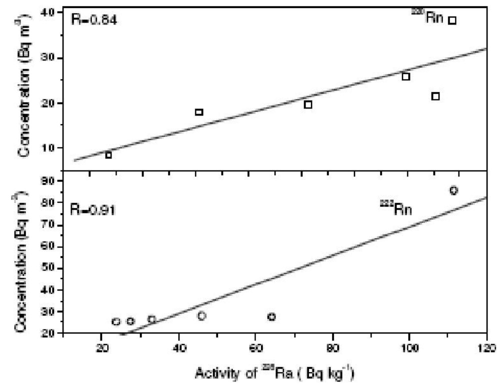

Figure 11 : Correlation between activity concentrations

Radium and radon

Correlation between ^{226}Ra and ^{222}Rn and ^{232}Th and ^{220}Rn are plotted in figure 11. The correlation coefficients are 0.91 and 0.84 respectively for ^{226}Ra and ^{222}Rn and ^{232}Th and ^{220}Rn respectively and indicate that the higher concentrations are mainly due the presence of the activity concentrations of primordial radionuclides.

CONCLUSIONS

^{222}Rn, ^{220}Rn and their progeny levels vary with ventilation conditions, types of the flooring, and types of the materials used for construction of houses. High concentration is observed in very poorly ventilated and granite flooring houses. The positive correlation coefficient between radon and their progenies are more than 0.77 in all the cases and the frequency distribution envisages that the higher concentrations in bed room, poor ventilated houses and the lower in well ventilated houses.

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