# Outdoor Radon Exposure and Doses in Pune, India

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## Abstract

Outdoor measurement of radon at a field site near Pune, India yielded an average value of 17.50 (1.08 – 69.73) Bq m$^{-3}$ at a height of 1 m from the earth's surface. The effective dose equivalent from the radon and its progeny was estimated to be 0.55 m Svy$^{-1}$. These data for the west of India provide reference information useful for the long term India's national goal of monitoring the indoor radon exposure to levels comparable to outdoor exposure.

**Keywords:** Radon, progeny, dose, distribution

## Introduction

Estimates of population dose from natural radioactivity are of ongoing interest to the health physics community. Present estimates suggest that about 45% of total population doses from natural sources are due to indoor radon [1]. Outdoor levels are usually assumed to be small in comparison with indoor levels. Results of survey in India yield a mean value 57 Bq m$^{-3}$ for indoor radon and about 8 Bq m$^{-3}$ for outdoor radon [2]. However, both indoor and outdoor levels vary significantly. Indoor concentrations typically follow log-normal distributions with the tail reaching over 100 KBq m$^{-3}$ for some US houses [3]. Outdoor concentrations of radon found during the surveys in France were as high as 400 Bq m$^{-3}$, being equal to the action level recommended by the ICRP [4]. The variation in outdoor concentrations is due to the fact that the outdoor patterns of radon vary with local geophysical and climate features [5]. Continuous measurements of outdoor radon concentrations are reported for the Pune environment [6, 7]. Although there have been previous measurements near this site, this is the first time careful simultaneous measurements have been made of radon and its progeny, important for dosimetriac calculations. The total number of radon measurements was 504, and the total number of radon progeny measurements

was 486, with sampling varied over different times of the day or night. Previous measurements of radon concentrations and radon exhalation rate at the same site have shown little seasonal variation [7], therefore radon levels particularly during winter months could approximate a true yearly average.

## Experiment

The measurement of radon and its progeny were performed at a site which is plane with no buildings near by. The location is at the bottom of mountain at an altitude of 760m from the mean sea level. During winter months night-time inversions along the valley are common but daytime conditions usually lead to good mixing due to the preponderance of clear days. Winds are generally light with a daytime average less than 3 ms$^{-1}$. Relative humidity is low with an annual average of about 30%.

Estimation of radon concentration in air at a height of 1 m above the surface is made using the Low Level Radon Detection System. The procedure consists of sampling the air in a collection chamber and exposing a circular metallic disc to the radon inside the collection chamber. A delay of at least 10 minutes is normally allowed for any thoron, which may be present in the chamber, to decay completely. The positively charged $^{218}$Po atoms created in the chamber get collected on the metallic plate maintained at an optimum negative potential that should be sufficient to force all the polonium atoms onto the plate. The collection is carried out for an optimized period and thereafter the charged plate is removed from the chamber and alpha-counted. The concentration of radon in Bqm$^{-3}$ is calculated by the well known expressions.

Similarly radon progeny concentration in air at the same height is measured by making use of an air flow meter by drawing atmospheric air through a glass fiber filter paper by means of a suction pump at a known flow rate. The radon progeny in air sample are retained on the filter paper. The filter paper is then alpha-counted at any specific delay time. Total activity on the filter paper is measured at three different counting intervals of 2–5, 6–20 and 21–30 minutes. Activities of polonium, bismuth and lead are calculated using the standard equations.

## Results and Discussions

The result of the semi-continuous radon concentration is presented in Fig.1. A total of 504 samples were taken, each measurement representing a 2 h average. The arithmetic mean of all samples was 17.50 Bqm$^{-3}$, with the maximum values reaching 100 Bqm$^{-3}$. The observed maximum value is close to the mean value estimated for India. The outdoor radon and its progeny concentrations fall in the range indicated by other surveys and are a little higher than the average values reported for Indian environment. However, the log-normal distribution of the measured values suggests that there could be some much higher concentrations of outdoor radon, comparable with the average indoor levels, especially if exposure is weighted to night-time conditions.
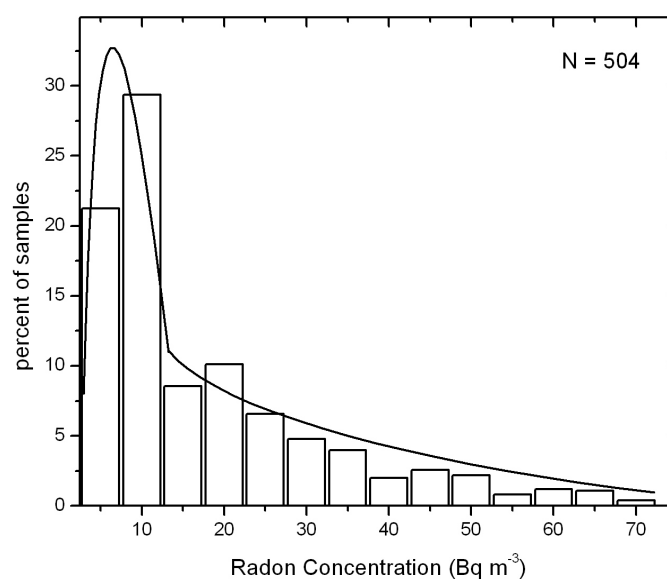
**Fig. 1:** The distribution of radon concentration in Pune

The seasonal variation of concentrations of radon and its progeny shows perfect trend. The maxima attained in the variations are the highest in winter months followed by summer and rainy season. And the minimum levels are almost the same in all the seasons, which are generally attained during 1200 to 1600 hours. The concentration of radon gives a median value of 6.94 Bqm$^{-3}$ for summer, 8.52 Bqm$^{-3}$ for rainy and 16.57 Bqm$^{-3}$ for winter season, respectively. Similarly the progeny concentration also gives a median of 1.22 Bqm$^{-3}$ for summer, 3.72 Bqm$^{-3}$ for rainy and 4.41 Bqm$^{-3}$ for winter season, respectively. The activity is higher in winter than in summer/rainy season since during winter season the radioactive gases are trapped near the surface because of temperature inversions.

The outdoor radon concentration near Pune, India is an average value of 17.50 Bqm$^{-3}$ at a height of one meter from the earth's surface. Inhalation of radon daughters is known to pose a health risk, particularly at higher levels. Estimates of dose were made for the above measurements. The effective dose equivalent from the radon and its progeny was estimated to be 0.55 m Svy$^{-1}$. This is well within the limit of ICRP.

## Conclusions

Outdoor radon and its progeny concentrations as measured in Pune fall in the range indicated by other surveys and are a little higher than the average values reported for Indian environment. However, the log-normal distribution of the measured values suggests that there could be some much higher concentrations of outdoor radon, comparable with the average indoor levels, especially if exposure is weighted to night-time conditions.

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