RESIDENTIAL RADON CONCENTRATIONS IN KATHMANDU VALLEY USING SOLID STATE NUCLEAR TRACK DETECTORS

Dinesh Thapa and Buddha Ram Shah

Physical Science Laboratory, Faculty of Science,
Nepal Academy of Science and Technology (NAST), G.P.O.3323,Khumaltar, Lalitpur, Nepal.
buddharshah25@gmail.com

Abstract

Measurement of radon is very important in dwellings because of its radiological impact on public health. Radon contributes more than half of the total ionizing radiation dose. It is known from the recent surveys in many countries that radon is the second cause of lungs cancer after smoking. In this context, we have measured radon (^{222}Rn) concentration in different dwellings of Kathmandu valley, Nepal. The time integrated method using LR-115, type II plastic track detectors, was employed for the measurement based on Solid State Nuclear Track Detector (SSNTD). In addition, radon concentrations in the bedroom and kitchen were also measured. The overall concentration of radon in Kathmandu valley varied from 8±2 to 787±134 Bq/m^3 with the average value of 80±15and annual effective dose varied from 0.14 to 13.54 mSv per year. The radon concentration was found more in the dwellings of highly urbanized areas and in the poor ventilated dwellings of Kathmandu Valley.

Introduction

Radon and its progeny constitute the most important natural radiation exposure not only in mining but also in many dwellings. After smoking, radon represents the second most important cause of developing lungs cancer (Szacsvai, 2013; UNSCEAR, 1994; IAEA/AQ/33, 2013).The main sources of radon are soil and rocks, however, it is present in trace amounts almost everywhere because of its parent radioactive element uranium which is commonly found in the earth's crust. Radon belongs to the noble gas column in the periodic table with a fairly long half-life of 3.8 days. Three natural isotopes of radon occur; Radon (^{222}Rn), Thoron (^{220}Rn), and Actinon(^{219}Rn) emerging from the radioactive decay of Uranium (^{238}U), Thorium and the Actinium series respectively (Sathish, 2011).

Radon emanates mainly by diffusion processes from the point of origin following alpha decay of ^{226}Ra in underground soil and water, building materials used in the construction of floors, walls, ceilings, natural gas used for cooking, etc. The concentration of radon in the atmosphere varies depending upon the place, time, height above the ground and meteorological conditions (Kant, 2004). Generally, all building materials contain certain amount of uranium and radium. So the exhalation of radon from these materials to the inside of the house can be a source of residential radon. Outdoor air can also play a role for the radon entering inside the dwellings through open doors and windows, cracks and fissures in the buildings, etc. (Ahmed, 1994). Also, the concentration of radon and its decay products show large fluctuations in the indoor atmosphere

due to the variations of temperature, pressure, nature of building materials, wind speed, occupants' behavior, etc. (Al-Khalifa, 2006).

When radon gas is inhaled, densely ionizing alpha particles emitted by deposited short-lived decay products of radon (^{218}Po and ^{214}Po) can interact with biological tissue in the lungs and disrupt the DNA of these lung cells. The damaged DNA is potential enough to lead to cancer. This DNA damage, associated with radon, can occur at any level of exposure because a single α-particle can genetically damage a cell (Mehra, 2006; BEIR VI 1999; WHO 2009). It has been pointed out that indoor radon exposure is also tentatively linked with the risk of leukemia and certain other cancers, such as melanoma and cancers of the kidney and prostate (Henshaw, 1990).

Keeping the radiation hazards of radon in mind, it is quite important to make a systematic study of the indoor radon concentration. For this purpose, radon measurements have been carried out in a number of dwellings of Kathmandu valley. The nuclear track detector technique a fairly reliable method for the integrated and long term measurement of indoor radon activity (Subba Ramu, 1992). In this work, we have used the SSNTD technique for the assessment of indoor radon (^{222}Rn) and its progeny concentration.

Materials and Methods

Study Area: Kathmandu Valley at a Glance

Kathmandu valley is comprised of three different districts; Kathmandu, Bhaktapur and Lalitpur. It lies between the latitudes 27º 32' 13" and 27º 49' 10" north and longitudes 85º 11' 31" and 85º 31' 38" east. It is located around1, 300 meters above sea level. The climate of Kathmandu valley is sub-tropical cool temperate with maximum of 35.6°C in April and minimum of –3°C in January and 75% annual average humidity. The average rainfall is 1,400mm, most of which falls during June to August (Dangol, 2009).

The Kathmandu valley is surrounded by the high rising mountains such as Shivapuri (2,732 m) in the north and Phulchoki (2,762 m) in the south. The rugged topography of the mountains with steep slopes reflects the geological structure of the valley. The basin is in the middle part of the lesser Himalaya, and bounded by the hill ranges Mahabharatlekh to the south and Shivapurilekh to the north (Upreti, 2001).The surface of Kathmandu valley is generally broad and almost flat except towards the boundaries of the valley, where rivers are deeply incised. Well developed terraces, formed by erosion from rivers, are common in the valley. The Kathmandu valley infilling consists of three million year-old fluvial and lacustrine sediments, consisting mainly of gravel, sand, silt, clay, peat, lignite and diatomaceous earth, etc., delivered mainly from the mountains in northern parts of the basin. Mines and minerals found in Kathmandu Valley are quartzite, dolomite, pegmatite, gneiss, schist, slates, limestones and marbles. The soil of the basin of Kathmandu valley is mainly alluvial soil, residual soil, and alluvial fan deposit
(Shrestha, 2004).

Detector

A passive method using LR-115 type-II plastic track detectors (1 cm × 1 cm size) developed by Kodak-pathe, France, based on SSNTD technique, was employed for the assessment of radon concentration. The cellulose nitrate LR-115 (12 μm thickness), is a very useful detector for the direct registration of alpha particles in the energy range of 0.17-4.80 MeV. Such alpha particles penetrate through the thin film of LR-115, forming observable tracks (Abd-Elzaher, 2012; Dwivedi, 1997; Gupta, 2012).

Dwellings

Altogether 41 dwellings around Kathmandu Valley were selected for the radon study. The choice of the houses was random. LR-115 was kept in both the kitchen and bedroom of each house. The majority of the houses were concrete with plastered walls with proper ventilation system. The detectors were fixed on a thick flat card with both sides taped and exposed in an unfiltered mode by hanging them on the wall of the room with the sensitive side facing the environment such that the detector viewed a hemisphere of radius at least 6.9cm, the range of ^{214}Po α-particles in the air. See Figure (1). No surface was closer than this range in order to prevent the surface decay products's alpha particles from reaching the detector. The detectors were exposed for 100 days inside the dwellings. The height of detectors was kept about 2m from the floor. Arrangements were made to avoid settling of dust on the detectors, which could possibly effect the radon concentration (Kant, 2004; Kumar, 2010; Kumar, 2000).

Figure (1): Radon dosimeter hanged on the wall of a dwelling.

Exposure measurement:

The exposed detectors were collected and sent to Dosirad laboratory, France, for track reading. The detectors were etched in a solution of 2.5 mol/l NaOH at 60℃ for one and half hour. The counting of alpha tracks was done using a binocular optical research microscope with a magnification of 400 ×.The calibration factor of the detector was 2.1tracks/cm^2 per kBqh/m^3. For open dosimeter the indoor equilibrium factor for radon (UNSCEAR, 2000) is equal to 0.40.

The average radon concentration (C_{Rn}) in terms of Bq/m^3 was determined using equation 1(Kodalpha, 2014).

$$C_{Rn} = \frac{1000 \times \text{Exposure (kBq.h/m}^3\text{)}}{\text{Exposure time (h)}} \qquad (1)$$

The annual effective dose from radon was calculated using equation 2, given by International Commission on Radiological Protection (ICRP, 1993),

$$D=\frac{C_{Rn}\times K\times 0.4\times H}{3700 Bq m^{-3}\times 170 h} \quad (2)$$

where D is the annual effective dose in mSv/yr; C_{Rn} is the average radon concentration in Bq/m^3; K is the ICRP dose conversion factor 3.88 mSv per Working Level Month (WLM) for general public; H is the annual occupancy at the location (7000 hours for residents), i.e 80% of the total time; 170 is the exposure hours taken for Working Level Month.

Results and Discussion

Radon monitoring was carried out at three different districts of Kathmandu Valley. Table (1) summarizes the average radon concentration and annual effective dose in three different districts of Kathmandu Valley.

S.N.	Name of districts	Total number of Dwellings	Radon Concentration in(Bq/m^3)			Annual Effective dose in(mSv)
			Minimum	Maximum	Average±2σ	
1.	Bhaktapur	12	36±8	415±71	90±17	1.54
2.	Kathmandu	20	8±2	161±29	56±11	0.96
3.	Lalitpur	9	8±2	787±134	93±17	1.59
Average					80±15	1.36

Table (1): Average radon concentration and annual effective dose in Kathmandu Valley

In addition, the variation in radon concentrations both in the bedroom and kitchen of dwellings has been shown in the Figure (2).

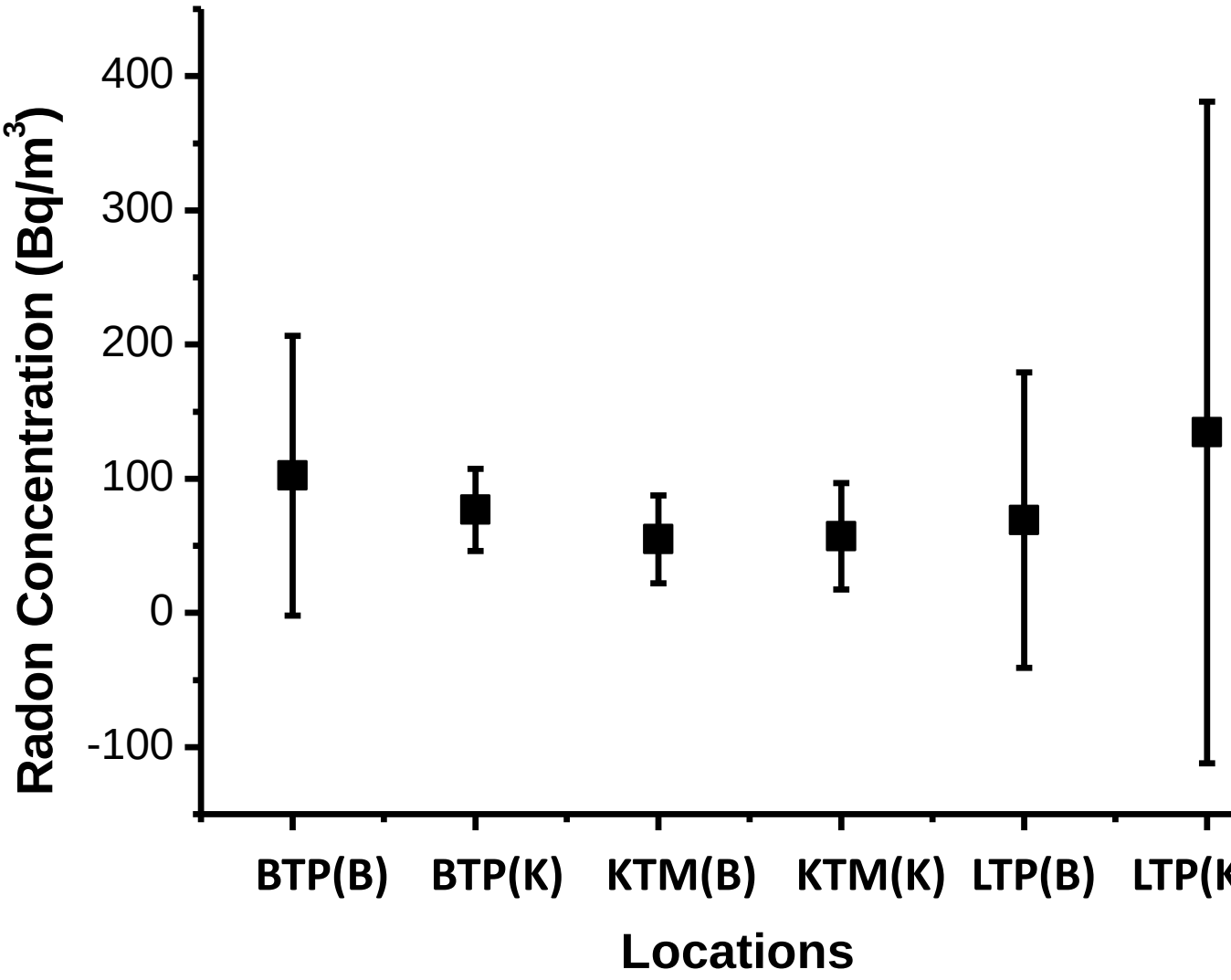

Figure (2): Radon concentrations in dwellings; BTP-Bhaktapur; KTM- Kathmandu; LTP-Lalitpur; B-Bedroom; K- Kitchen

The overall concentration of radon in Kathmandu valley varied from 8±2 to 787±134 Bq/m^3 with the average value of 80±15 Bq/m^3 and annual effective dose varied from 0.14 to 13.54 mSv.

Conclusion

The higher radon concentrations are found in the following locations: Kamalbinayak, Kirtipur, Maharajgunj, Sinamangal and Godamchaur of the Kathmandu valley. These places are densely populated and polluted. Many industries are set up in these areas. A large amount of coal is being used as fuel in the brick factories near the Kamalbinayak area of Bhaktapur district and near the Godamchaur area of Lalitpur district. This could be one reason for the elevated levels of radon. In addition, a large marble factory near the Godamchaur area of Lalitpur district may contribute more radon to that area. However, the possibility of higher radon concentrations in the Bhaktapur and Lalitpur districts could be the presence of minerals which have a high abundances of uranium (Kaphle, 1990; Shah, 1999) like granite, gneiss, shale, schist, limestone, dolomite, sand, etc. This fact was also observed in other, previous, studies (Fairbridge, 1972).

We found the radon concentration is higher in the kitchen than in the bedroom in most of the dwellings. Higher concentration of radon in the kitchen could be the result of contribution from radon sources like water, cooking gas, kerosene etc. In addition, the overall concentration of radon and annual the effective dose of radon in Kathmandu valley are well within the reference levels (200-600 Bq/m^3 and 3-10 $mSvy^{-1}$) of International Commission of Radiological Protection (ICRP-103, 2007), except Godam Chaur of Lalitpur district (which needs further investigation).

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