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Assessment of residential radon concentration in the dwellings near Sisdol Landfill Site using solid state nuclear track detector (SSNTD)

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Abstract
Radon contributes more than half of the global effective dose. There has been reported some health problems in people near the dwellings of the Sisdol Landfill Site (SLS). In this study, Radon concentration in the dwellings near SLS has been measured by using LR-115 type II plastic track detector based on SSNTD Technique. In addition, radon concentration in these dwellings and Kathmandu city has been compared. Radon concentration varied from 71±14 Bq/m3 to 2026±344 Bq/m3 and annual effective dose varied from 1.3 to 34.99 mSv/yr. Since Radon concentration in some of the dwellings is extremely higher than the ICRP maximum exposure limit, further study and implementation of safety guidelines in these area is necessary.

Keywords: Radon, Landfill Site, annual effective dose, LR-115, Dwellings

1. Introduction

People are continuously exposed to the radiation originating from various sources. Sometimes people themselves produce radiation like in Radiofrequency signals, nuclear power plant, medical diagnosis and treatment etc. but in many cases Radiation is omnipresent so that its exposure to humankind either in less or more quantity is inevitable [1, 2]. Among them radon stands one of the most important natural radiation exposure. Radon is a colorless, odorless and tasteless gas existing in three natural isotopes viz. radon (^{222}Rn), thoron (^{220}Rn) and actinium (^{219}Rn) with its half-life-3.8 days. [2-4]. It has been reported that the short-lived decay products of radon (^{218}P0 and ^{214}Po) reacts with the biological tissue resulting in the damage of the cells and even DNA and chromosomes leading to the different health problems ranging from simple respiratory problems like pneumonia, inflammation in the respiratory tract etc. to the different types of cancers like leukemia, melanoma, lung, kidney and prostate cancers [5-8]. Many epidemiological studies have proved that radon is the primary cause of developing lung cancer among non-smokers. It has been pointed out that genetically disorder can occur at any level of exposure of radon since a single alpha particle can damage DNA and chromosome [9, 10].

Residential indoor radon concentration in the dwellings depends upon the meteorological and geophysical conditions, building materials, outdoor radon concentration and the radon present in the underlying soil [11-13]. Different studies conducted in Europe and America have reported several health problems like eye irritation, respiratory tract inflammation, digginess, sleepiness, fatigue, lack of concentration and interest on any activities, genetic disorder in the children in addition to the low birth weight, high infant mortality rate and birth defects, cancers: Lung, prostate, kidney, leukemia and melanoma [14]. It has been found that most of these problems are caused by the radon exposure also. Many media and local people of the SLS of Nepal have reported these problems in different interactive programs conducted by different NGO's and INGO's. All these points inspire us to conduct a systematic assessment of Radon level in the dwellings near the Landfill site of Nepal.

The radon emanation from the landfill site is significant if it is contaminated with radiological wastes consisting of radionuclides like Uranium and Radium and their associated decay series [15].

In this study, radon level near the dwellings of Landfill sites has been measured after a brief questionnaire survey within the local people using LR-115 detector based on Solid State Nuclear Track Detector (SSNTD) technique. The results thus obtained are compared with that of Kathmandu City, the most residential area of the country.

2. Materials and Methods

2.1 Study Area: Sisdol Landfill Site (SLS), Nepal

The Sisdol Landfill Site, only one waste management site of Capital City: Kathmandu and its surroundings is located at Ward No. 4, Sisdol of Okharpauwa Village Development Committee (VDC) in the Nuwakot District approximately at the latitude of N27º46', Longitude of E85º14' with elevation of about 1140m from sea level. This is about 29 km far from the Kathmandu.

2.2 Experimental Details

This study was conducted in two parts: Questionnaire survey and Radon assessment. During the Questionnaire survey around 50 local people were interviewed asking health problems in the local people of that area. For Radon assessment, Total 17 dwellings near landfill sites (including buildings with different building materials (mud, stone, brick, cement)) which are assumed to be landfill site vulnerable dwellings and 3 dwellings from Kathmandu valley (far from the landfill site) were selected randomly for this study. The later were selected for the purpose of comparison. LR-115 type-II plastic track detectors developed by Kodak-pathe, France was employed for the measurement of radon concentration. This is an alpha track detector which works on the basis of passive method using Solid State Nuclear Track Detector (SSNTD) Technique. The cellulose nitrate (12 µm thickness) film, present on the detector detects alpha particles on the basis of tracks formed by the penetration of these particles through the film [2-4, 19]. The detectors were fixed on a thick flat surface on the wall of the room by facing the sensitive side (containing film) towards the environment keeping in mind that the the detector should avoid the surface decay products' alpha particles from reaching it. Also the detectors were tried to keep safe from the dust, smoke etc. and also the physical contact of the people and any other things during the exposure duration which may affect the radon concentration [5, 18]. After 118 days, the exposed detectors were collected and sent to Dosirad laboratory, France, for track reading. According to the report from Dosirad Laboratory, the detectors were etched in a solution of 2.5 mol/l NaOH at 60 °C for one and half hour and the alpha tracks were counted. Using the calibration factor for the detector (2.1tracks/cm^2 – kBq.h/m^3) and indoor equilibrium factor (0.40) for open dosimeter, alpha tracks counting were converted into radon exposure (kBq.h/m^3) [21]. This is followed by the calculation of the average radon concentration (CRn) and annual effective dose (D) using equation 1 [19] and equation 2 [20] respectively.

$$C_{Rn} = \frac{1000 \times \text{Exposure (kBq.h/m3)}}{Exposure\ time\ (h)} \ldots. (1)$$

$$D = \frac{C_{Rn} \times K \times 0.4 \times H}{3700 \times 170} \ldots.. (2)$$

where D is the annual effective dose in mSv/yr; CRn 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.

3. Results

Most of the respondents of the questionnaire survey has reported different health problems in the local people. According to the survey, in addition to the common respiratory diseases like pneumonia, asthma etc., there exists some cases of lung cancers and blood cancers. Sleepiness, digginess, weariness, depression are the common symptoms on almost all the peoples. Also they have reported the problems in newly born child including neurological birth defects along with low birth weight.

Detailed result of the radon exposure, average radon concentration and annual effective dose with the geographical information of the sampled dwellings (dwellings near Landfill site and Kathmandu city) is listed in the appendix section. According to the result, it is found that the highest value of the average radon concentration is 2206 ±344 Bq/m^3 in the Dwelling No.4 and lowest value of the radon concentration is 71±14 Bq/m^3 in Dwelling No. 6 with annual effective dose: 1.3 to 34.99 mSv/yr respectively. Average radon concentration corresponding to the different dwellings with ICRP recommendation limit is presented in the histogram in figure 1.

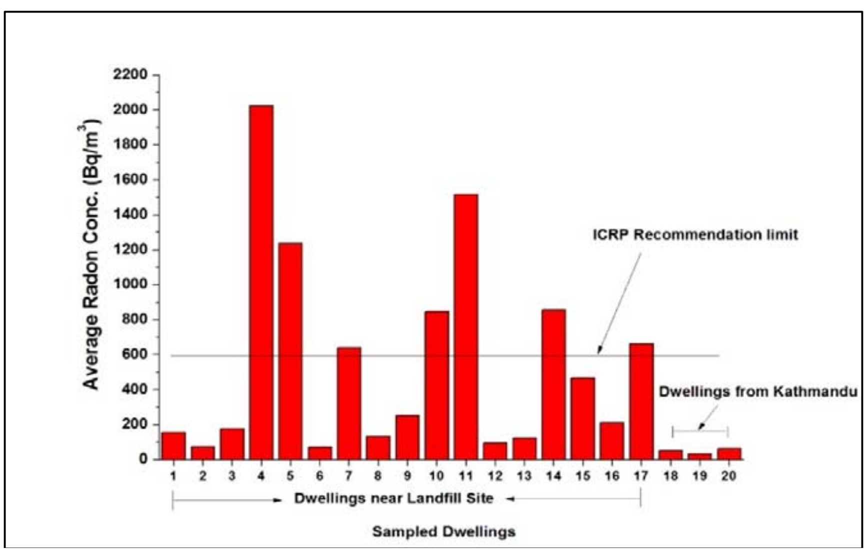

Fig 1: Graph of Average Radon Conc. Vs. Sampled dwellings

4. Discussion and Conclusions

Based on the result of the study, it has been found that the radon concentration in some of the dwellings is extremely greater (approx. 3.4 times) than the higher limit of ICRP Recommendation level (200-600 Bq/m^3). Radon concentration in all the dwellings near Landfill site is far greater than the world average of radon concentration (40 Bq/m3) [21] and USEPA recommendation level (148 Bq/m3) set for USA [22]. Also Radon concentration in all of the dwellings near Landfill site is higher than that of the dwellings of Kathmandu area (samples 18-20). There is a significant variation in the radon concentration in the selected dwellings. This difference in different dwellings is due to the difference in the nature of the building materials, ventilation system in the buildings also the uranium content of the soil including different minerals like granite, gneiss, shale, schist, limestone (marble), dolomite, sand, etc. [23] beneath the building and in the surroundings. According to the local people they are experiencing directional wind from the landfill site, so, the facing of the building to the Landfill site also accounts this difference. Radon concentration in the dwellings of the Kathmandu city agrees with the previous study [4]. Although there can be other known and unknown sources of the radon gas apart from the landfill site effect in that area, this study provides strong evidence for the high concentration of the radon gas in that area. In accordance to the complaints of the local people regarding the health problems, this radon concentration also stands as one of the major cause. Hence, this study opens door for the deep and thorough assessment of the radon gas and its impacts on the general public of that area and implementation of health safety measures in this area to prevent further deterioration of the life of the people.

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