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Variation of indoor and outdoor gamma dose rate in the lesser Himalayan region of India

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AbstractThe exposure of natural background radiation imparts a major contribution to inhalation doses received by the general population, and its amount relies upon the lithology, altitude, and building construction materials. The preliminary results of ambient indoor and outdoor gammaray dose rate of Jammu and Kashmir, India are presented. Estimations of indoor/outdoor environmental exposures were carried out utilizing a portable Gamma Survey Meter. For the outdoor environment, the minimum and maximum gamma dose rate were 0.11 and 0.29µSv/h, whereas, for indoor conditions, the minimum and maximum gamma dose rates were 0.1 and 0.22µSv/h, respectively. Impact of elevation on estimated estimations of gamma dose rates has likewise been examined. Measured values of gamma dose rates demonstrate a weak positive relationship with altitude. Effects of lithology on indoor and outdoor gamma dose rates have likewise been investigated. The average estimation of annual effective dose from background gamma radiations were well within the possible range and does not cause a health hazard to the occupants.

Keywords: Gamma dose rate, exposure, Annual Effective dose, indoor/outdoor environment,

1.1 INTRODUCTION

Normally occurring radio-active materials (NORMs) are found in variable amounts in rocks and soils of different locations and in this way the proportion of terrestrial radiation from rocks and soils changes topographically. The proximity of terrestrial radiations due to NORMs noticeable in the air (environment) may result in an external and internal dosage estimations gotten by a populace through the ingestion or inhalation pathways (Sharma et al. 2018). The external dosage is taken by standing in the environment of gamma or high-vitality beta-transmitting source, while internal dosage measurements are gotten by ingesting or inhaling radioactive materials through sustenance (food) and other pathways. The estimation of terrestrial radiations is essential since they may have a significant contribution to the aggregative dosage (1–10 mSv) of the population (BEIR-IV 1999).

The prime contribution of the ionizing radiation (more than50%) received by human population originates from Radon(^{222}Rn), thoron (^{220}Rn), and their naturally occurring radioactive short-lived decay products considering all sources of radiationinto account (Mazur and Kozak 2014). Therefore, this field has picked up a lot of importance for last many years, both as far as of their transport properties and their influence on human health (United Nation Scientific Committee on the Effects of Atomic Radiation,UNSCEAR 2000).

Radioactivity in building materials can possibly be exposed to extensive quantities of individuals. This exposure rate could bring about generally large additional exposures contrasted with that because of the normal background of around 2 mSv/y. The previous shows that the improvement of criteria to point of confinement such potential outcomes ought to be supported (Sharma et al. 2017).

Radioactivity in structure materials can be presented to broad amounts of people. This introduction rate could realize commonly extensive extra exposures appeared differently in relation to that due to the normal foundation of around 2 mSv/y. The past demonstrates that the improvement of criteria to purpose of repression such potential results should be bolstered (Sharma et al. 2017).

This investigation was a part of our effort to set up standard information for natural environmental radiation levels in Reasi district of Jammu & Kashmir state, India and helpful for evaluating the general population dose. In the underlying period of this investigation, radon concentration levels in water (Kumar et al. 2017) and radio-nuclide &exhalation studies in soil samples (Kumar et al. 2018) were also estimated in selected locations of the district.

The present study has been carried out for monitoring of gamma dose rates in indoor and outdoor environments of Jammu& Kashmir, India. This sort of work has not been completed up until this point, in this part of the country and subsequently happens to be the first of its kind. Gamma dose rates were measured from the base of Shiwalik hills, whereas the Resai district is located in the foothills of the Shiwalik. Results obtained from the current study has been compared with the neighboring district data available from the literature. The primary objective of this investigation was to compute the annual effective dose (AED) received by the inhabitants of the study area. This study is expected to provide a baseline data of natural radioactivity level and will be useful in assessing public doses. Additionally, data obtained from the current study can be used as a standard in remedial actions against environmental contamination in the future.

1.2 GEOLOGY OF THE REGION

The district lies between 330 05" N latitude and 740 50" E longitudes. The districtshares its boundaries with Udhampur district in the South, Ramban in the East, Shopian o Kashmir in North and Rajouri in West. The

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district is watershed of the River Chenab and its tributaries (Ans, Rudd, Plassu, Banganga, Pai, Anji).

This study focuses on the area along and across Reasi thrust (RT) zone in the region of Reasi district, India. Geologically, the area represents a part of foreland basin comprising the rocks of Sirban group, Subathu Group, Murree and Siwalik Groups and Quaternary deposits.

There are prominent structural units present in the district which has played a major role in the configuration of the rock formations in the district viz. Reasi Inlier Mandili-Kishanpur thrust, Muree thrust and Panjal thrust.The fault separating the Jammu Limestone and the Murree Formation from the Siwalik group was initially named as the Boundary Fault (Wadia 1928) and the Main Boundary Fault (Wadia 1931), and the Reasi Thrust by later workers (Karunakaran and RangaRao 1979). As a part of the geotechnical study for construction of the Salal hydroelectric project across the Chenab river, Geological Survey of India (GSI) carried neo-active tectonic studies in the Reasi, Katra and adjoining areas. This particular region across Reasi fault line comprises our study area and is shown in fig.1. These authors described reactivation of the Reasi Thrust as late as Pleistocene and Holocene, based on their field observations and mapping. The Mandili-Kishanpur thrust is a northerly dipping reverse fault extending from NowsheraTawi River in the west to Basholi in the east. In the north of Udhampur, the Kishanpur thrust merges into this Main Boundary Fault (MBF). This fault is observed to the south of Rajauri and Kalakot regions of the district (Kumar et al. 2017). Different faults/thrusts in and around the study area are shown in Fig. 1.1.

1.3 MATERIAL AND METHODOLOGY

The ambient outdoor gamma dose rate measurements weretaken in the air at different locations of Jammu & Kashmir state, India, one meter over the ground level utilizing a versatile radiometric instrument, Dosimeter-Radiometer MKS-03D(manufactured by LLC "Vega Kharkiv" measurements Inc.),which utilizes an internally mounted 1" × 1" NaI(TI) scintillator for measuring doses due to gamma radiationexposure (Sharma et al. 2017). The device works well at all altitudes with maximum relative humidity less than 95% and within thetemperature range -20°C to 50°C. The sensitivity of the device is 0.05 to 3.0 MeV, with a precision factor of ±15%. For calibration, a fixed source-to-detector distance variable-dose rate method was used.Calibration of the system was carried out within a temperature range of 25±10 °C for free space geometry. The survey meter is then exposed at computed distances and actual exposure dose rate readings are recorded. From the readings taken, the Calibration Factor (C.F.) is computed. Acceptable limit ranges from 0.8 to 1.2.The exposure rate that can be estimated by this device ranged between 0.01 μSvh^{-1} to 0.1 Svh^{-1}. Because of the random nature of the radioactive decays, the radiation exposure rate varies rapidly with respect to time. For each location, two estimations (at different circumstances) were taken, each spanning over-time period of 2 minutes. The data presented in the paper are the mean value of two measurements for each location. Locations in the present examination are both in urban and rural areas, so mixed (cemented, marble and mud) type of houses have been selected for indoor measurements. The exposure rate estimated in μRh^{-1} was converted into absorbed dosage rate µGy/y using the transformation factors (Rafique 2013):

$$1\mu R/h = 8.7\ nGy/h = \frac{8.7\times10^{-3}}{\left(\frac{1}{8760}\right)}\ \mu Gy/y \qquad (1)$$

$$= 76.212\ \mu Gy/y$$

The results are presented in terms of both µR/h and µGy/y.

1.3.1 Absorbed dose (AD)

The exposure rate measured in µSv/h was converted into absorbed dose (AD) rate by using the following conversions:

1 µSv/h = 1000 nGy/h

1.4 RESULTS AND DISCUSSIONS

Table 1.1 shows measured values of indoor and outdoor gamma dose rates in the different geological formation of Jammu & Kashmir State, India. Minimum outdoor gamma dose rate value (0.11 µSv/h) was recorded at GujarKoti location while maximum value (0.29 µSv/h) was measured at Silla location. On the other hand, minimum and maximum indoor gamma dose rate (0.1 µSv/hand 0.22 µSv/h) were recorded in a house located in Bida and Sarna location of study area, respectively. The average values of indoor and outdoor gamma dose rates were found as 0.14 ± 0.03µSv/h and 0.17 ± 0.05 µSv/h. Minimum indoor and outdoor gamma dose rate is reported for the region with Sirban and Shiwalik Formations which is exposed with sandstone and shale lithology. Sandstone and shale (other than black) contain 2.2 and 3 ppm uranium (Nagda 1994).^{232}Th concentrationin sandstone may be up to 10 mg/kg and in normal shale and mudstone its concentration range 10–13 mg/kg.Black shale may have higher ^{232}Th levels, but never as high as the Uranium contents. Monazite sands, may containlarge fractions of ^{232}Th and constitute one of themajor ores of ^{232}Th. Limestone contains a small proportion of ^{232}Th (Rafique 2013).

Maximum outdoor gamma dose rates are reported atthe 'Sarna region' located at the contact of Shiwalik and SirbanFormation, which is exposed with sandstones, slits, dolomite, limestone and quartzite lithology (Sharma et al. 2018b). Kumar et al. (2018) reported the concentrationof uranium and thorium (sample collected from these geological Formations) found in the area under current study, varying from 2.76to 38.96 Bq/Kg and 12.47 to 65.70 Bq/Kg. the maximum indoor gamma dose rate was found in one of the houses situated in SirbanFormation, which is exposed with slate, white and gray dolomitic limestone lithology (GSI 1977). Such kind of lithology contains uranium and thorium in trace amounts. As in one of the previous study, Kumar et al. (2018) reported uranium and thorium concentrations at 'sarna location' in outdoor soilsamples (collected as per the protocol provided by the BARC) were19.31 ± 0.31 and 38.48 ± 0.16 Bq/Kg. These uranium and thorium concentrations are slightly greater than those found in Sirbanformations ofReasi district. Since uranium and thoriumdeposits are a source of gamma rays this may be one of the reasons for elevated gamma dose rates in this region.

1.4.1Gamma dose rates at high altitudes

We have measured the gamma dose rate with respect to altitude.For this purpose, the measurement of gamma dose rates fromfoothill of PirPanjalat a height of 420 m was started. Variation of gamma dose rates with height can be seen in Fig. 1.4. The maximum value of a gammadose rate of 0.22µSv/hwas obtained at a height of 831 m, while the minimum value of 0.09µSv/h was obtained at a height of 420 m. The linear correlation analysis between gamma dose rates with altitudehas been shown with an intercept of 477. The value linear correlationcoefficient (r) between gamma dose rates with altitudes was found as 0.52. This shows a positive correlation of gamma dose rates with altitude. This strong positive relation may be due to the geology of area under study.

The minimum indoor and outdoor gamma dose rate is accounted for in locations (Bidda and Jadli) which is exposed with sandstone and shale lithology while the maximum indoor and outdoor gamma dose rate was found at Sarna and Silla location. The average annual indoor gamma dose rate was higher than the annual indoor gamma dose rate because of construction materials has less radioactivity content than that of the surrounding environment.

The indoor annual effective dose rate was observed to be higher than the outdoor annual effective dose rate may be expected to the indoor-outdoor pressure difference which is caused by temperature difference, wind, barometric pressure, unbalanced mechanical ventilation, and poor ventilation rate and more accumulation of radioactive gases in the indoor environment. The outdoor radioactive nuclides concentration is far below compared to the indoor radionuclide concentration because the radiation exhaled from the ground is rapidly diffused over vast atmosphere, but buildings and structures may keep this dilution. This result in an accumulation of radionuclides inside the buildings, rising up out of the floor and wall materials, but also relies upon house-to-house variability, even for areas with low exhalation rates from the ground (Gulam et al. 2013).

In this study, we have also obtained the variation of indoor to outdoor gamma dose ratio as given in Table .The arithmetic mean of indoor to outdoor gamma dose rate has found to be 0.87± 0.32 obtained from gamma survey meter. In normal background areas of India, the ratio of indoor to the outdoor gamma dose rate is found tobe approximately 1.2, particularly in tiled/cemented floor and concrete walls and ceilings (Nimbi et al. 1986).Sharma et al. (2017) has reported the mean value of indoor to outdoor ratio forbricks, cemented and tiled houses.The obtained average values of the ratio are almost the same as that of Sharma et al. (2017) because construction materials have less radioactivity content than that of surrounding earth (mean value = 0.8). The higher values of the ratio than 1.2 attributes to mud typesof houses (wall/floor of mud) and has the radioactivity content greater than that of the surrounding soil.

CONCLUSIONS

A primary investigation of ambient indoor/outdoor gamma dosage rates estimations have been undertaken with minimum and maximum outdoor gamma dosage rate was found as 0.11 and 0.29 µSv/h, respectively. Similarly, minimum and maximum indoor gamma dose rates were found as 0.1µSv/hand 0.22 µSv/h, respectively. The variation in measured values from location to location isbecause these locations fall in different geological formations. The maximum average value of annual indoor and outdoor gamma dose was found in Shiwalik Formation.Average values of indoor and outdoor gamma absorbed dose rate was higher than the world average value as reported by the UNSCEAR (2000).The reason for higher dosage rates might be attributed because of the particular geography of the area under study when contrasted with the rest of the world. The indoor annual effective dosage rate was observed to be higher than the outdoor annual equivalent dosage rate which might be because of the indoor-outdoor pressure difference. All the estimations of outdoor and 40% estimations of indoor annual equivalent dosage rate were observed to be below the possible range given by ICRP.

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Table 1.1 Variation of indoor and outdoor gamma dose rate of 10 locations

Sr. No.	Village name	Elevation (in meter)	Indoor Gamma Dose rate (μSv/h)				Outdoor gamma dose (μSv/h)
			LI	L2	Average	SD	
1	Darol	631	0.19	0.11	0.15	0.04	0.13
2	Nomain	682	0.1	0.09	0.10	0.01	0.14
3	Sarna	831	0.26	0.18	0.22	0.04	0.22
4	Silla	768	0.12	0.17	0.14	0.02	0.29
5	Mari	643	0.11	0.1	0.10	0.01	0.14
6	Bidda	745	0.08	0.09	0.09	0.01	0.19
7	GujarKoti	612	0.07	0.12	0.10	0.02	0.11
8	Talwara	512	0.08	0.11	0.10	0.02	0.19
9	Kanskhasan	601	0.16	0.11	0.14	0.02	0.21
10	Dhirti	589	0.27	0.09	0.18	0.09	0.19

***L1 = First location, L2 = 2nd location, SD = Standard deviation**