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Monitoring of terrestrial gamma radiation exposure in different geological Stress conditions of Uttarakhand Himalayan region, India

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Abstract. Terrestrial gamma radiation dose (TGRD) exposure on the earth's surface establishes the linkages with the distribution of radionuclide elements in that particular environmental condition. The rate of variation of the terrestrial gamma radiation in the environment is directly associated with the regional geology and to the elemental concentration of these elements. In this study, Environmental TGRD rates **(**mSv/h**)** were measured over the three different geological conditions (Kamal valley, Tona valley and Yamuna valley) with the objective of establishing baseline data on the background radiation. An extensive survey of gamma-ray dose rate is conducted focusing the areas highly suitable for fractures and valley zones. The rocks types in the study regions are basically unconsolidated and moderately structured. The Gamma-ray dose rate at one (1) meter above the ground was measured at 46 points, using a pocket survey dosimeter which. The highest TGRD rate (0.27 mSv/h) is observed (with 35% estimation error) at the location of Rama site in the Kamal valley. Similarly, for Buthothra site of Tons valley it is found to be 0.21 mSv/h with estimation error 37% and at Rekhud site of Yamuna valley it is 0.19 mSv/h with estimation error 36%. The ranges of the gamma dose rate in other sites are also found under the recommended value with normal distribution.

1. Introduction

The natural sources beneath the earth surfaces are the preliminary origins of ionizing radiation exposure, and in suitable environmental conditions it may migrate into the dwelling structures and accumulate indoors in sufficient quantities to pose a health hazard [1]. The external irradiation of gamma rays emitted from radionuclides inhaled into lungs causes low-level dose effects in the public living in the exposure to naturally ionizing radiation. Monitoring and measurement of TGRD background levels is vital to assess the dose to the population [2,3]. The understanding of spatial distribution of natural radiation in the water and soil on the basis of local geologic formations is highly valuable because of its radiological effects. In the Himalaya, flow of the seasonal water from different sources is responsible for crust deformation and the seismicity associated with it [4]. This may again be responsible for forming large fractures in crust and providing the path for radioactive progenies in the form of terrestrial gamma radiation (TGR). And hence it is emphasized to monitor the radiation exposures on the Himalayan region. The natural radionuclide has sufficiently longer half-lives that they survived since their creation and decayed to attain the stable state and produce ionizing radiation in various degrees [5]. The Specific levels are related to the types of rocks from which the soils originate[6]. Higher radiation levels are associated with igneous rocks, such as granite and lower levels with sedimentary rocks however in certain conditions the Shales and Phosphate rocks contain the content of radionuclides [6]. People have always been exposed to natural ionizing radiation of both terrestrial and extra-terrestrial origin in indoor and outdoor environments[1,6]. During recent years the studies related to radiation monitoring have globally accepted phenomena due to its hazardous effect on human health (radiation workers and general public). The annual average dose to the human received from natural background radiation is estimated to be 2.4 mSv [7].

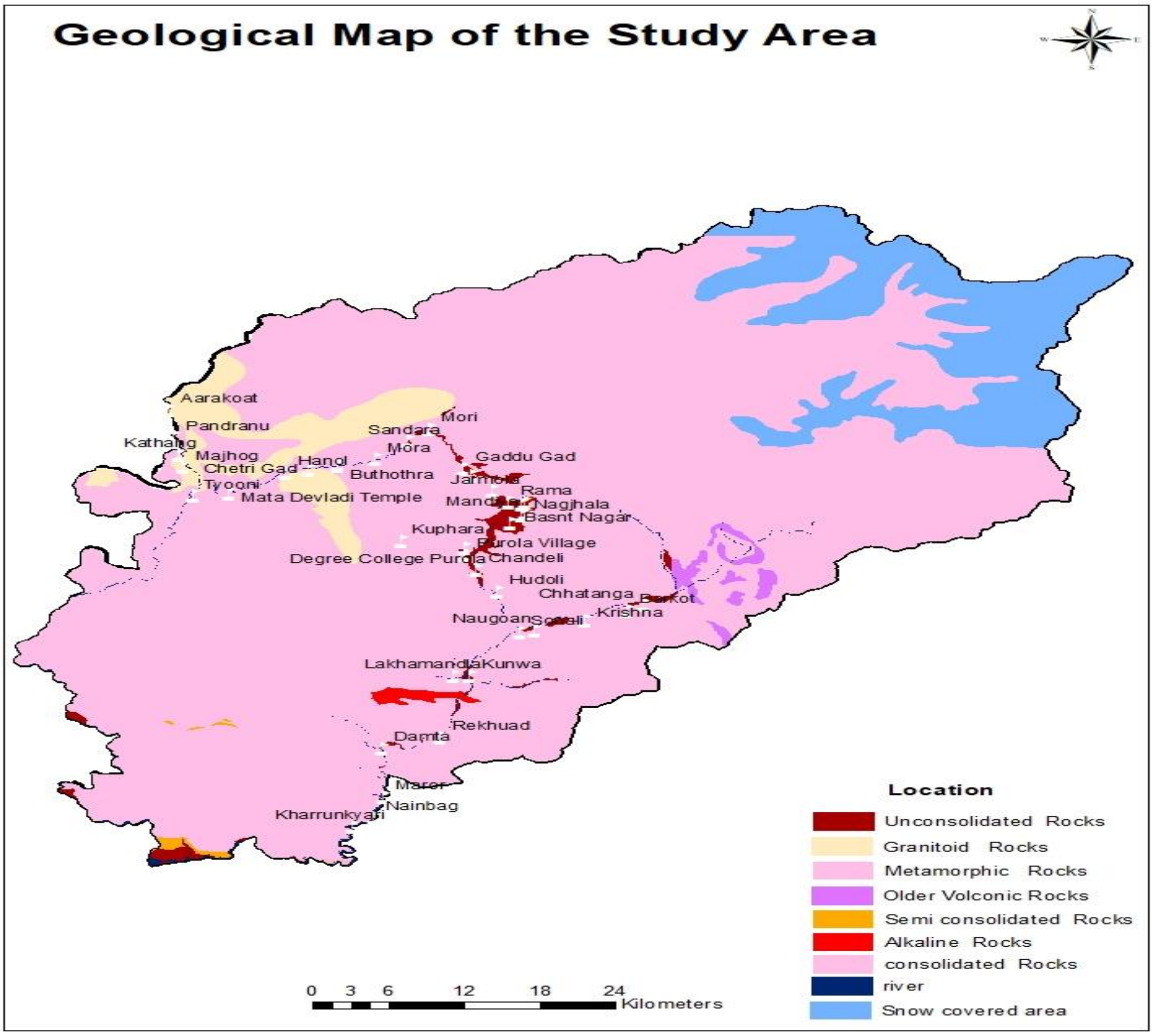

Figure 1: Geology map of the data collection site

The TGRD is region specific and depends on the geological features of the region. The dose level further increases due to anthropogenic activities like mining and processing of different terrestrial rock/ore bodies such as uranium, granites, granulites, coal, iron, cupper, phospogypsum, petroleum products [8]. These materials contain a noticeable amount of radio-elements such as uranium, thorium, potassium and their decay products and hence these materials are commonly termed as Natural Occurring Radioactive Materials (NORM). The facilities which process these materials are called NORM facilities. Radon is a radioactive but chemically inert gas constantly generated and normally emitted in minute amounts from radium containing minerals that are widely distributed in the earth's crust. The emitted concentration level strongly depends on regional geology, geophysical conditions and as well as on atmospheric influences such as barometric pressure and rainfall. ^{222}Rn and/or ^{220}Rn exhaled from the earth's surface into the free atmosphere is rapidly dispersed and diluted by natural convection and turbulence. DTPS and DRPS handy instruments not only measurethe progeny concentration directlybut also one can assess various parameters involved in progeny dynamics. The aim of the present study is to find out the availability or variation of TGRD in different litho-tectonic units of Himalaya of Uttarakhand state (Figure 1). The role of various rock types and associated geological features was also considered in the interpretation of its distribution. The Himalayan foothill region is traversed by the Main Boundary Thrust, the Himalayan Frontal Thrust, the Piedmont Fault and numerous localized thrust and strike-slip fault systems which make the terrain vulnerable to seismo-tectonic activity. Uttarkashi district lies in the northwestern part of Uttarakhand state. It is bounded by North Latitude 30° 27′ 18″ and 31° 27′ 42″ and East Longitude 77° 48′ 26″ and 79°24′ 00″ and falls in Survey of India Degree Sheet Nos. 53E, F, I, J and M.The zone between the Main Boundary Thrust (MBT) and the Himalayan Frontal thrust (HFT) is bearing the maximum impact of the continued movement of the Indian plate.

2. Experimental Technique

Gamma (**γ**) dose rate measured at one (1) meter above the ground at three different geological sites and a total 46 points were collected. The instant values of **γ** dose rate were observed using a Pocket survey dosimeter. It shows gamma-ray dose rate in nGy/h. The geology and point map of data collection site is shown in figure 1. Precision value of the dose is estimated by taking average of 3 stable readings in each location and then the average values converted into dose rate in the air (unit- nGy h^{-1}) by multiplying the measured exposure rate in μR h^{-1} by 8.7 [9].

$$G_{\gamma}\_rad(mSv) = D(nGy\ h^{-1}) * 8760\ h * 0.2 * 0.7\ mSvGy^{-1} * 10^{-6}$$

The γ **-** dose rate measurement was carried out in such a way that each Geological formation was taken into consideration.

Where G_{γ}_rad = effective dose, D = measured gamma dose rate, 0.2 = outdoor occupancy factor and 0.7 = conversion coefficient from absorbed dose in air to human effective dose equivalent[7].

3. Result and Discussion

The rate of variation of the environmental terrestrial gamma radiation **(**TGDR**)** in different geological conditions (locations) is shown in Table 1. Minimum (0.1mSv/h) and maximum (0.27mSv/h) value of TGRD is found in Gundiyad Gaon-II and Rama locations of Kamal valley respectively. The Tons valley consists of the unconsolidated, Metamorphic and Granitoid rocks. The variation of TGRD is found to be minimum (0.08 mSv/h) and maximum (0.21 mSv/h) in Mora and Buthothra locations respectively. The Yamuna valley consists of the basically metamorphic rocks. The variation of TGRD in this valley found minimum (0.1 mSv/h) and maximum (0.2 mSv/h) in Kunwa and Chhatanga locations respectively. In the Kunwa location the geological stress condition the dominating geological feature are alkaline rocks and in Chhatanga it is metamorphic rocks. In all studied geological stress conditions, the variation in the TGRD is found with low deviation range in Kamal valley i.e. 0.032) and followed by 0.026 and 0.023 in Tons and Yamuna valley respectively. The mean value among the measured TGRD is found to be 0.156, 0.153 and 0.136 in Unconsolidated and Metamorphic rocks respectively.

Figure 2 reveals the distribution of TGRD in different three geological stress conditions; it is clearly observed that the high TGRD values (< 0.1mSv/h) are found in regions above the 78.02 deg longitude. The highest gamma dose rate is observed at the location of Rama and Chandeli sites in the Kamal valley. The Rama location consists of unconsolidated rocks and having younger river terraces with suitability of high fracture zones. Similarly, the Chandeli site also has unconsolidated rocks with moderately dissected and runoff zones. The Tons and Yamuna valley consists of Metamorphic rocks and have moderately dissected and runoff zones with high fractures.

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Table 1: Terrestrial Gamma Radiation dose in different geological stress conditions

Site	Point location	Geology	TGRD (mSv/h)
Kamal Valley	Purola Village	Unconsolidated Rocks	0.13
	GundiyadGaon	Unconsolidated Rocks	0.16
	GundiyadGaon-II	Unconsolidated Rocks	0.1
	Rama	Unconsolidated Rocks	0.27
	Mandiya	Unconsolidated Rocks	0.14
	Nagjhala	Unconsolidated Rocks	0.17
	Basnt Nagar	Unconsolidated Rocks	0.12
	Degree College Purola	Metamorphic Rocks	0.15
	Kuphara	Metamorphic Rocks	0.17
	Chandeli	Unconsolidated Rocks	0.21
	Hudoli	Metamorphic Rocks	0.11
	Sonali	Metamorphic Rocks	0.15
Tons Valley	Jarmola	Metamorphic Rocks	0.16
	Danda (Kyari)	Unconsolidated Rocks	0.14
	Gaddu Gad	Unconsolidated Rocks	0.09
	Mori	Metamorphic Rocks	0.2
	Sandara	Alkaline Rocks	0.11
	Mora	Metamorphic Rocks	0.08
	Buthothra	Metamorphic Rocks	0.21
	Khooni Gad	Metamorphic Rocks	0.15
	Chetri Gad	Metamorphic Rocks	0.14
	Hanol	Metamorphic Rocks	0.11
	Mata Devladi Temple	Metamorphic Rocks	0.11
	Tyooni	Metamorphic Rocks	0.15
	Majhog	Granitoid Rocks	0.14
	Kathang	Granitoid Rocks	0.15
	Pandranu	Metamorphic Rocks	0.11
	Aarakoat	Granitoid Rocks	0.14
Yamuna Valley	Naugoan	Metamorphic Rocks	0.11
	Krishna	Metamorphic Rocks	0.13
	Barkot	Metamorphic Rocks	0.15
	Chhatanga	Metamorphic Rocks	0.2
	Kunwa	Alkaline Rocks	0.1
	Lakhamandla	Metamorphic Rocks	0.17
	Rekhuad	Metamorphic Rocks	0.19
	Damta	Metamorphic Rocks	0.15
	Maror	unconsolidated-Gravel dominant	0.15
	Nainbag	Metamorphic Rocks	0.17
	Kharrunkyari	Metamorphic Rocks	0.17

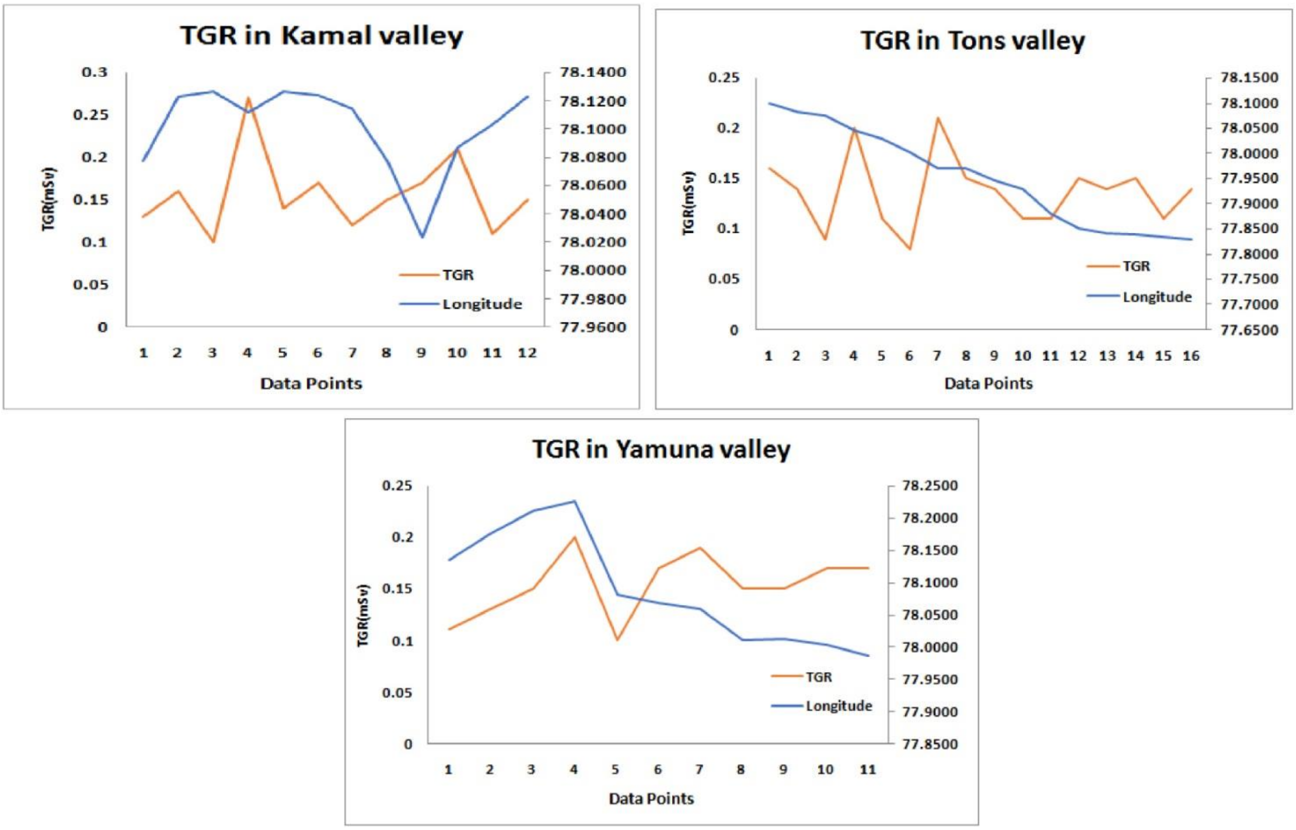

Figure 2: Graphical representation of distribution of TGRD in different geological stress conditions

4. Conclusion

Radioactive progenies such as Radon-222 and thoron-220 exposure may affect the public because of their wide distribution in the environment. Consequently, the annual TGRD may be estimated inside the different geological stress conditions in the higher Himalayan region of Uttarakhand. Instant TGRD variation along the altitudinal variation is measured in the natural environment and analyzed in view of the geological distribution of the study area. The rate of variation of the terrestrial gamma radiation in the environment is directly associated with the regional geology and to the elemental concentration of these elements. In this region the concentration in all locations was found with less deviation i. e. 0.03 and of mean 0.15. Although the TGRD concentrations in all studied locations are found in standard limits under normal distribution, monitoring of TGRD is further extended using different detectors (e.g Nai and CaI) and techniques. In the context of different geological stress conditions especially in the fragile Himalayan regions, an extensive survey of gamma-ray dose rate is highly required to assess the areas with highly fractured and valley zones.

References

[1] Ramola R.C., Choubey V. M., Negi M. S., Prasad Y. and Prasad G. 2008 *Radiat. Measurements* **43**: 98-101.
[2] Chen C. J., Weng P. S. and Chu T. C. 1993 *Health Physics* **64**, 74–78.
[3] Miah F. K., Roy S., Touhiduzzaman M. and Alam B. 1998 *Appl. Radiat. Isot.* **49**, 133–137.

[4] Saji A. P., Sunil P. S., Sreejith K. M., Gautam P. K., Kumar K. V., Ponraj M., Amirtharaj S., Shaju R. M., Begum S. K., Reddy C. D. and Ramesh D. S.J. 2020 *Geophys. Res. Earth surface* **125**: 1-17.
[5] Nursama H. A., Ramli A. T. and Sutisna. 2013 *Earth Science Research*, **2**: 122-127.
[6] UNSCEAR. 2000a. UNSCEAR Report 2000: *Sources and effects of ionizing radiation* (46 (A/55/46).). U. N. Publication.
[7] UNSCEAR. 2006 *Effects of Ionizing Radiation-Volume II: Scientific Annexes* C, D and E.
[8] Lin Y. M., Lip P. H., Chen C. J. and Huang C. C. 1987 *Health Physics* **52**, 805–811.
[9] Martin A., Harbison S., Beach K. and Cole P. (6th edition, 2012) *An introduction to radiation protection*. Hodder Arnold.