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EFFECT OF GEOLOGY AND ALTITUDE ON AMBIENT OUTDOOR GAMMA DOSE RATES IN DISTRICT POONCH, AZAD KASHMIR

Muhammad RAFIQUE[1,*] Muhammad BASHARAT[2], Raja Azhar SAEED[1] & Saeed Ur RAHMAN[3]

[1]*Department of Physics University of Azad Jammu & Kashmir Muzaffarbad, 13100, Azad Kashmir, Pakistan*
mrafique@gmail.com; mrafique@ajku.edu.pk; rafi_722002@yahoo.com
[2]*Institute of Geology, University of Azad Jammu & Kashmir Muzaffarbad, 13100, Azad Kashmir, Pakistan*
[3]*Department of Medical Physics, Nuclear Medicine, Oncology and Radiotherapy Institute, Islamabad, Pakistan*

Abstract: The back ground radiation in the natural environment is the constant companion of human beings since from their creation. Humans are continuously exposed to these radiations coming from outside and inside their bodies. Outside and inside radiations are coming from ground, building materials, food, air, the universe and even elements from human own bodies. According to UNSCEAR 2000 report, background radiations deliver an average effective dose of 2.4 mSv per person worldwide. Sustained exposure from high background radiation levels may pose substantial health threats to general public. In the current study we are presenting the results of ambient outdoor gamma dose rates measured for district Poonch of the state of Azad Kashmir. The study has been carried out by using Ludlum micrometer-19 which is an active and portable detector. Effects of geology and altitude on measured values of gamma dose rates have been investigated. Maximum and minimum values of gamma dose rates were recorded as 156 $nGy.h^{-1}$ and 65.25$nGy.h^{-1}$ respectively. The annual average dose for the whole area was estimated as 102 $nGy.h^{-1}$. Highest gamma dose rate was recorded at two places in Rawalakot and both places are the part of Quaternary Formation which is exposed to the lithology of gravels, sandstones and siltstone. Similarly the lowest individual gamma dose rate value (65.25 $nGy.\ h^{-1}$) was recorded in Androat, which is situated in Siwalik Formation and exposed to the lithology of red clay, brownish gray sandstone. Current study findings shows no appreciable changes in gamma dose rates with altitudes and variations in measured gamma dose rates depends upon lithology of the area under investigation. The average gamma dose rate (102 $nGy.h^{-1}$) measured for the current study is higher than world average gamma dose rate (57 $nGy.h^{-1}$) as reported in UNSCEAR 2000.

KeyWords: back ground radiation, ambient outdoor gamma dose rates, lithology, Azad Kashmir

1. INTRODUCTION

General public is exposed to background radiations at all the times. Once a link was established between detrimental health effects and sustained radiation exposure through the several epidemiological studies conducted on underground working miners, after than this subject has got the sizeable importance. There is no single source of these radiations, many sources exists naturally and are the essential part of environment. However the most significant sources of natural background radiations are 1) Cosmic radiations, 2) Food and drink, 3) Radon, 4) Rocks and buildings. Cosmic radiations come from neutron stars, black holes and supernovae. Food and drink contains small proportions of radioactive isotopes (like ^{40}K) that are also the source of radiations. Radon is also contributor of background radiations. It contributes approximately half of total back ground radiations. It is produced in uranium and radium bearing rocks and seeps out from its point of production to the ground. Radon concentrations in specific areas depend mainly upon different geographical and geological factors. Another important source is terrestrial radiations. Terrestrial radiations deals with the sources present on the earth. Terrestrial radiations exposure of individuals is most significant part of their total exposure to radiation **(**BEIR VI 1999).

Manmade sources also contribute to

background Radiation. Manmade sources results from mining of uranium and the use of naturally radioactive material in power generation, nuclear medicine consumer product, military and industrial applications (UNSCEAR, 1993, 2000)

Levels of these background radiations are different in different parts of the world. These variations are due to many factors like; geology of the area, disposed wastes of artificial radionuclide's, nuclear weapon testing and nuclear reactor accidents**.** Keeping in view the significance of subject, research in this area burgeoned from last several decades. Many scientists at national and international (Chikasawa et al., 2001, Hewamanna & Sumithrarachchi 2001, Sivakumar et al., 2002, Clouvas et al., 2004, Bouzarjomehri & Ehrampousch 2005, Erees et al,. 2006, Rahman et al., 2010a,b, 2011, 2012, 2013; Rafique et al., 2010a,b, 2011a,b,c,d,e, 2012a,b,c,d, 2013; Matiullah et al., 2012) have conducted several studies on this subject.

To conduct the present study we have divided the area in to four Zones. namely, 1) Rawalakot (Zone 1) 2) Thorar (Zone 2) 3) Hajira (Zone 3) and 4) Abbaspur (Zone 4).District Poonch lies at latitude of 33° 20'' 16' and longitude 73° 33' 30''. Rawalakot is, district headquarter of Poonch located at 1615 meters above sea level. Rawalakot is 131 km far from Islamabad (Capital city of Pakistan) and 95 km far from Muzaffarbad (Capital city of State Azad Jammu & Kashmir) (Saeed Asad 2012). Attractive climate of district Poonch and natural beauty of Tooleepeer and Bunjosa attract Pakistani tourist as well as foreigner. Tourist gets their way to toleeper for hiking and trekking especially.

The aim of this study is to provide a baseline data of natural radioactivity levels and will be useful in assessing public doses. And in future in case of any radiation accident, present data can be used as a standard in remedial actions against environmental contamination of the area. Present study results have been compared with the national and world averages data available from the literature.

2. MATERIAL AND METHOD

Current study has been conducted by using a portable radiometric instrument, Ludlum micrometer 19 (manufactured by Ludlum measurements Inc) It consists of $1'' \times 1''$ NaI (TI) scintillator. The Ludlum Model 19 MicroR survey meter is used for low level micro R gamma survey. Sensitivity of the devise is 175 cpm/$\mu R/hr$, based upon Cs-137 gamma. Measurements of gamma dose rates were carried out at the distance of one meter above the ground. Two measurements spanning over the time period of two minutes were taken for each location (at different times Data presented in the paper is mean value of two measurements for each location. The exposure rate measured in $\mu R/h$ was converted into absorbed dose rate nGy/y using the conversion factor:

$$1\,\mu R/h = 8.7\,nGy/h\ .$$

The readings are represented in terms of nGy/h.

3. GEOLOGY OF DISTRICT POONCH

The District Poonch is situated in the western axial zone of Hazara Kashmir Syntaxis in the sub-Himalayas of Pakistan. The Himalayan Frontal Thrust (HFT) is the prominent structural feature of the area. The HFT runs north-northwest to south-southeast in the region. The simplified geological map of Poonch district showed that the geological units are mostly comprises molassic rocks of Miocene Murree Formation, Siwalik Formation and Quaternary sediments (Fig. 1). These rock units includes sandstones, siltstones, shales, claystones and conglomerates. These rocks are well exposed in Rawalakot, Hajira and Abbaspur areas. In the central part of the study area the Quaternary sediments are exposed on the surface. They are mostly comprises gravel, boulders and pebbles of alluvial deposits. The eastern part of the area is underlain by thick sequence of Siwalik Formation (Fig. 1).The stratigraphic sequence of the study area is presented in table 1. The brief description of these rock units are as follows.

Murree Formation

The Murree Formation represents the molasse of the young Himalayas and it covers the most part of the study area (Fig. 1). The Murree Formation comprises sandstones, siltstones, shales and claystones. The weathered color of sandstone is grey to dark grey and reddish brown, whereas, fresh color is grey (Shah, 1977). The color of shale is reddish brown. The calcite and quartz veins are present within the sandstone. The shales of Murree Formation are reddish brown.

Siwalik Formation

The outermost hills of Himalayas are mainly composed of Siwalik Formation. These rock units include alternating bed of sandstone and argillaceous material. The group, as a whole consists of sediments of clastic origin of molasses type (Cheema et al., 1977).

Table 1. The stratigraphic sequence of the study area

Name	Lithology	Age
Quaternary	Stream bed deposits and alluvium.	Holocene
Siawalik Formation	sandstones, clays, shales, mudstones and conglomerates	Pliocene to Pleistocene
Murree Formation	Interbedded sandstones, siltstones with shales and claystones.	Early Miocene

The formation consists of sandstones, clays, shales, mudstones and conglomerates. The color of clay is red with subordinate ash grey or brownish grey sand-stone. The sandstone is fine to medium grained, occasionally gritty, cross-bedded and soft.

Quaternary Sediments

The terraces presents in the area are mainly composed of alluvial deposits. They are well exposed in the central part of the study area (Fig. 1). These quaternary sediments includes the gravels, boulders and pebbles of Miocene Murree and Siwalik Formations. The alluvial fan in these areas includes angular and sub-angular fragment of sandstone and siltstone of Siwalik Formation

4. RESULTS AND DISCUSSIONS

As already have been discussed that area of study was divided in to four Zones, namely, 1) Rawalakot 2) Thorar 3) Hajira and 4) Abbaspur. Results obtained from the current study have been listed in the tables 1 to 4.

Table 1 shows the measured values of outdoor gamma dose rate in Zone 1 i.e., Rawalakot. The results presented in table 1 show that the maximum value of gamma dose rate of 156 $nGy.h^{-1}$ was obtained at two places namely, housing scheme and near united hospital at height of 1615 m and 1629 m respectively while the minimum dose rate of 65.25 $nGy.h^{-1}$ was estimated in Mujahidabad and Pothee Bala lying at the height of 1465 m and 1545 m respectively.

The annual average dose assessed in Rawalakot was 103.21 $nGy.h^{-1}$. For the Zone 2 (Thorar) the measured values of outdoor gamma dose rates are listed in table 2. Result obtained shows that the maximum outdoor gamma dose rate of 130 $nGy.h^{-1}$ is reported for Nehr Bazar lying at the height of 1662m; while the minimum dose rate of 65.25 $nGy.h^{-1}$ is reported for Androat lying at the height of 1545m. The annual average dose value of 95.54 $nGy.h^{-1}$ was estimated for the Zone 2 (Thorar).

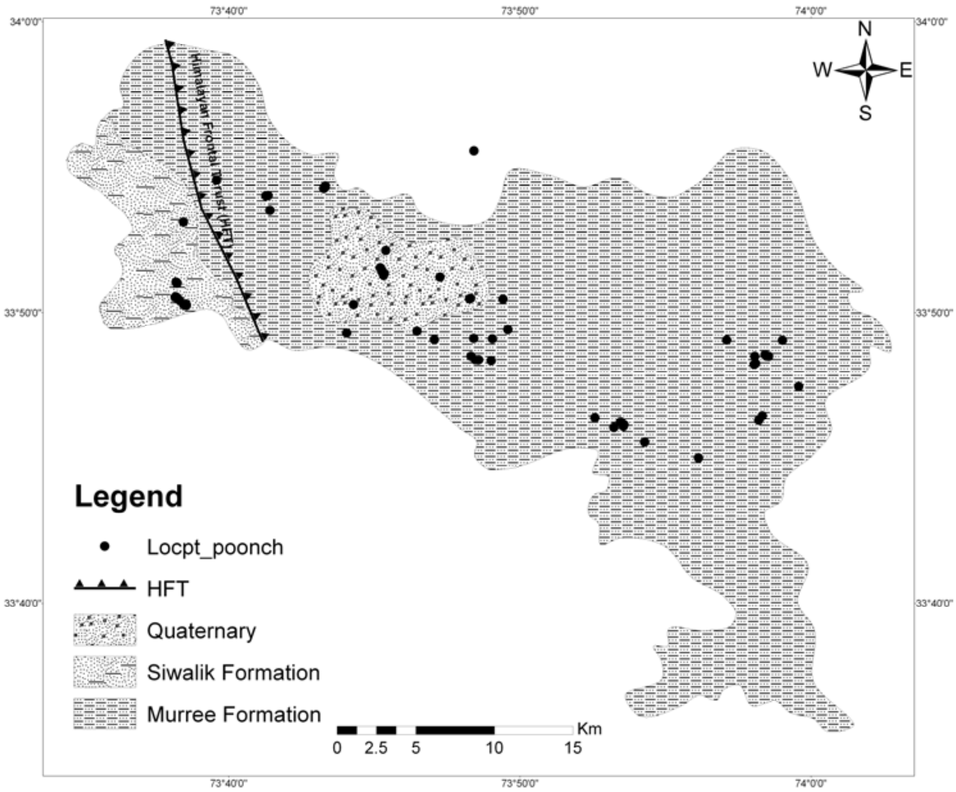

Figure 1. The map shows the geological units of district Poonch (Compiled after Wadia, 1928 and Akhtar et al., 2004).

Table 1. Outdoor gamma dose rates measured for the Zone 1 (Rawalakot)

Name of Place	Latitude (N)	Longitude (E)	Geological Formation	Lithology	Altitude (meter)	Dose Rate nGy.h^{-1}
Mohri Furman Shah	33°54.26	73°43.27	M.F[1]	Sandstone,shale,Claystone	993	104
M.F.Shah merkaz	33°54.31	73°43.32	M.F	Sandstone,shale,Claystone	1058	130
M.F Shah Near HBL	33°54.35	73°43.32	M.F	Sandstone,shale,Claystone	1067	95.59
Rehra	33°53.11	73°38.45	S.F[2]	Red clay,Brownish gray sandstone	1416	69.58
Chahrotee Lower	33°54.02	73°41.36	M.F	Sandstone,shale,Claystone	1447	139
Mujahid abad	33°53.51	73°41.42	M.F	Sandstone,shale,Claystone	1465	65.25
Chahrotee Upper	33°54.01	73°41.28	M.F	Sandstone,shale,Claystone	1514	104
Pothee Bala	33°52.13	73°45.40	Q.F[3]	Gravels,sandstone,siltstone	1545	65.25
Motyal Mehra	33°49.30	73°44.06	M.F	Sandstone,shale,Claystone	1581	86.92
Thundi Kassi	33°50.28	73°44.29	Q.F	Gravels,sandstone,siltstone	1605	86.92
Housing Scheme R.Kot	33°51.54	73°45.21	Q.F	Gravels,sandstone,siltstone	1615	156
Drake Eid gah	33°49.36	73°46.47	M.F	Sandstone,shale,Claystone	1621	95.59
Ali Firdous Hospital(R.Kot)	33°51.39	73°45.28	Q.F	Gravels,sandstone,siltstone	1623	99.93
Near united hospital(R.Kot)	33°51.35	73°45.35	Q.F	Gravels,sandstone,siltstone	1629	156
Rawalakot City	33°51.28	73°45.32	Q.F	Gravels,sandstone,siltstone	1634	122
Kahigellah road R.Kot	33°50.49	73°48.31	Q.F	Gravels,sandstone,siltstone	1651	91.26
Koohyaan	33°50.48	73°48.28	Q.F	Gravels,sandstone,siltstone	1653	86.92
Chehr	33°55.55	73°48.43	M.F	Sandstone,shale,Claystone	1672	104
Dhamni	33°51.22	73°47.26	Q.F	Gravels,sandstone,siltstone	1687	91.26
Kahigellah	33°50.46	73°49.43	M.F	Sandstone,shale,Claystone	1754	73.92
Joholanara	33°54.55	73°39.59	M.F	Sandstone,shale,Claystone	1708	113
Dothaan	33°49.42	73°49.59	M.F	Sandstone,shale,Claystone	1768	86.92
Bunjosa Lake	33°48.36	73°48.58	M.F	Sandstone,shale,Claystone	1791	113
Drake	33°49.07	73°47.07	M.F	Sandstone,shale,Claystone	1778	99.93
Trar Khel Road Bunjosa	33°48.37	73°48.48	M.F	Sandstone,shale,Claystone	1793	130
Bunjosa Park	33°48.34	73°49.02	M.F	Sandstone,shale,Claystone	1805	122
Bunjosa near Rest house	33°48.37	73°48.59	M.F	Sandstone,shale,Claystone	1791	130
Chota Gala Road(Bunjosa)	33°48.49	73°48.33	M.F	Sandstone,shale,Claystone	1862	95.59
Chottagellah Upper	33°49.10	73°49.06	M.F	Sandstone,shale,Claystone	1849	86.92
Chottagellah lower	33°49.11	73°48.42	M.F	Sandstone,shale,Claystone	1752	95.59
Average outdoor dose Rate (nGy.h^{-1})						103.21

M.F[1]=Murree Formation
S.W[2]=Siwalik Formation
Q.F[3]=Quaternary Formation

Table 3 reports outdoor gamma dose rate values reported for the Zone 3 (Hajira). As can be seen from the table 3 that maximum outdoor gamma dose rate of 139 nGy.h^{-1} is reported for upper Hajira city lying at the height of 976 m, while the minimum dose rate of 86.92 nGy.h^{-1} is reported for Muhammadan College lying at the height of 984 m. The annual average dose value of 110.75 nGy.h^{-1} was estimated for the Zone 3 (Hajira). For the Zone 4 (Abbaspur) the measured values of outdoor gamma dose rates are listed in table 4.

Table 2. Outdoor gamma dose rates measured for the Zone 2 (Thorar)

Name of Place	Latitude	Longitude	Geological Formation	Lithology	Altitude	Dose Rate
	N	E			meter	nGy.h^{-1}
Androat	33°50.53	73°38.17	S.F[1]	Red clay,Brownish gray sandstone	1544	65.25
Aziz abad	33°50.55	73°38.18	S.F	Red clay,Brownish gray sandstone	1569	91.26
Police station Thorar	33°51.05	73°38.20	S.F	Red clay,Brownish gray sandstone	1596	104
Pandie	33°51.01	73°38.22	M.F[2]	Sandstone,shale,Claystone	1600	86.92
Thorar City	33°51.01	73°38.24	S.F	Red clay,Brownish gray sandstone	1604	113
R.kot Road Thorar	33°50.25	73°38.55	S.F	Red clay,Brownish gray sandstone	1609	78.25
Mung Road Thorar	33°50.30	73°38.54	S.F	Red clay,Brownish gray sandstone	1612	95.59
Yadgar.a.Shodah	33°50.52	73°38.23	S.F	Red clay,Brownish gray sandstone	1598	91.26
Boys collegeThorar	33°50.43	73°38.32	S.F	Red clay,Brownish gray sandstone	1608	99.93
Nerh Bazar	33°50.27	73°38.46	S.F	Red clay,Brownish gray sandstone	1662	130
Average Outdoor Dose (nGy.h^{-1})						95.54

S.F[1]=Siwalik Formation
M.F[2]=Murree Formation

Table 3: Outdoor gamma dose rates measured for the Zone 3 (Hajira)

Name of Place	Latitude	Longitude	Geological Formation	Lithology	Altitude	Dose Rate
	N	E			meter	nGy.h^{-1}
Boys college Hajira	33°46.09	73°53.56	M.F	Sandstone,shale,Claystone	939	104
Hajira merkaz	33°46.12	73°53.57	M.F	Sandstone,shale,Claystone	959	113
Upper Hajira City	33°46.14	73°53.58	M.F	Sandstone,shale,Claystone	976	139
Muhammadan College	33°46.23	73°53.45	M.F	Sandstone,shale,Claystone	984	86.92
Upper bazar	33°46.23	73°53.48	M.F	Sandstone,shale,Claystone	992	104
Abbaspur Road Hajira	33°45.54	73°54.29	M.F	Sandstone,shale,Claystone	1001	109
Plandri Road Hajira	33°46.04	73°53.23	M.F	Sandstone,shale,Claystone	1012	95.59
Dowarandi	33°46.29	73°58.21	M.F	Sandstone,shale,Claystone	1038	113
Akorebun	33°46.38	73°52.58	M.F	Sandstone,shale,Claystone	1061	130
Ghambeer	33°45.00	73°56.14	M.F	Sandstone,shale,Claystone	1074	113
Average outdoor Dose rate(nGy.h^{-1})						110.75

Result obtained shows that the maximum outdoor gamma dose rate of 113 nGy.h^{-1} is reported for one of the measurement carried out at the Bi Pass road, whilst the minimum dose rate of 73.92 nGy.h^{-1} is reported for Abbaspur College lying at the height of 1545m.The annual average dose value of 96.86nGy.h^{-1} was estimated for the Zone 4 (Abbaspur).

As may be seen from table 1 to 4 that highest mean annual dose rate of 110.75 nGy.h^{-1} was estimated for the Zone 3 (Hajira). On the other hand for individual measurements highest recorded value was 156 nGy.h^{-1} and this value was obtained at two places in Zone 1 (Rawalakot). Both places lie in Quaternary Formation which is exposed to the lithology of gravels, sandstones and siltstone.

Since the presence of environmental radiations depend on geological surfaces, mainly on rocks and soil of the area. Therefore these values of gamma dose rate may be attributed due to ubiquitous presence of uranium in some extent in all type of rocks and soil of area under investigation. Concentrations of ^{238}U in shale and sandstone (sedimentary rocks) are expected to be 3.7 ppm or 40 Bq/kg, whilst in carbonate rocks is 2 ppm or 25 Bq/kg. In soils ^{238}U concentration is found to be 1.8 ppm or 66 Bq/kg, whilst in continental upper crust the average uranium concentration is found to be 2.8 ppm or 36 Bq/kg (NCRP Report No. 94, 1987).

Similarly other contribution of higher gamma dose rate may be attributed due to the presence of thorium. Thorium is considered as second abundant element in the crust with average concentration of 11 ppm. For different rock types ^{232}Th exceeds ^{238}U by a factor of from 3 to 5. Granite rocks exceed basalts in the igneous category and shales are more productive than carbonates (e.g. limestone's) in the sedimentary class (Wilkening, 1990).

Concentrations of ^{232}Th in shale and sandstone (sedimentary rocks) is expected to be 12 ppm or 50 Bq/kg, whilst in carbonate rocks is 2 ppm or 8 Bq/kg. In soils ^{232}Th concentration is found to be 9 ppm or 37 Bq/kg. Where in continental upper crust the average ^{232}Th concentration is found to be 10.7 ppm or 44 Bq/kg (NCRP Report No. 94, 1987).

Similarly minimum annual average dose rate was assessed as 95.54 nGy.h^{-1} in the Zone 2 (Thorar), whilst for individual measurement lowest value was recorded as 65.25 nGy.h^{-1}. Lowest individual value of gamma dose rate was obtained at more than one place in different Zones. Lowest value in Zone 1 were recorded at the places of Mujahid Abad and Pothee Bala. Mujahida Abad lies in Murree Formation and exposed to the lithology of sandstone, shale and claystone. On the other hand Pothee Bala lies in Quaternary Formation and exposed to the lithology of Gravels, sandstone and siltstone. Similarly the same lowest individual value (65.25 nGy. h^{-1}) was recorded in Zone 2 at the place Androat, which lies in Siwalik Formation and exposed to the lithology of Red clay, Brownish gray and sandstone.

We have investigated variations of gamma dose rates with altitudes. For the Zone 1 no specific variation in gamma dose rates has been observed with altitude (as may be seen from Fig. 2). The linear regression mathematical expression (Y = A + B * X) for indoor and outdoor gamma dose rates is given as;

$$\text{Gamma Dose Rates with Altitude} = -0.0004 \times \text{altitude} + 103.83$$

The linear correlation analysis between gamma dose rates with altitude gives slope of -0.0004. The value of linear correlation coefficient (r) between gamma doses rates with altitudes was found as -0.00359. This shows a weak negative correlation of gamma dose rates with altitude. Probability value 'p= 0.93257' shows gamma dose rates are independent from any variation observed in altitudes.

For the Zone 2 slight variation in gamma dose rates have been observed with increasing altitude as shown in figure 3. Linear regression mathematical expression (Y = A + B * X) for indoor and outdoor gamma dose rates is found as,

$$\text{Dose Rates with Altitude} = 0.4706 \times \text{altitude} - 657.57$$

The linear correlation analysis between gamma dose rates with altitude gives slope of 0.4706. The value of linear correlation coefficient (r) between gamma doses rates with altitudes was found as 0.79311.

Table 4. Outdoor gamma dose rates measured for the Zone#4 (Abbaspur)

Name of Place	**Latitude**	**Longitude**	**Geological**	**Lithology**	**Altitude**	**Dose Rate**
	N	**E**	**Formation**		**metre**	**nGy.h^{-1}**
College abaspur	33°46.44	73°58.33	M.F	Sandstone,shale,claystone	1144	73.92
Hajira Road	33°48.49	73°58.07	M.F	Sandstone,shale,claystone	1165	95.59
Kass Bazar	33°48.50	73°58.47	M.F	Sandstone,shale,claystone	1169	82.59
Kahuta road	33°48.49	73°58.55	M.F	Sandstone,shale,claystone	1185	104
Bi Pass Road	33°48.55	73°58.42	M.F	Sandstone,shale,claystone	1191	113
Mahmoodgelli road	33°49.05	73°59.02	M.F	Sandstone,shale,claystone	1213	104
Chattra lower	33°48.24	73°58.10	M.F	Sandstone,shale,claystone	1220	104
Chattra upper	33°48.21	73°58.05	M.F	Sandstone,shale,claystone	1251	109
Kalran	33°49.06	73°57.11	M.F	Sandstone,shale,claystone	1422	86.92
Potha	33°47.45	7359.58	M.F	Sandstone,shale,claystone	1093	95.59
Average outdoor dose Rate(nGy.h^{-1})						**96.86**

M.F=Murree Formation

This shows a significant positive correlation of gamma dose rates with altitude. The p-value, ‘p=0.00619’ confirms positive correlation of gamma dose rates with altitude.

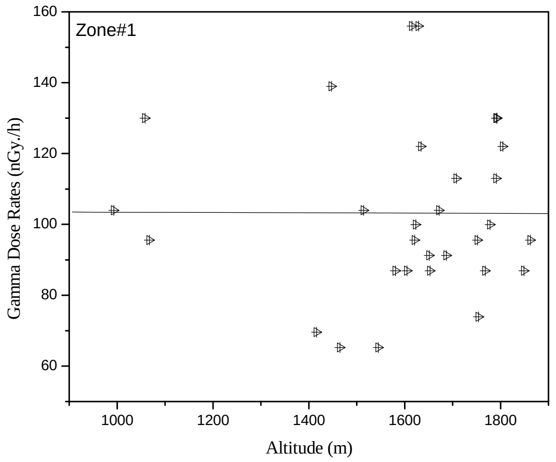

Figure 2. Variation of gamma dose rates with altitude for Zone 1.

For the Zone 3 the linear correlation analysis between gamma dose rates with altitude has been shown in figure 4, with slope of 0.0778. Linear regression mathematical expression (Y = A + B * X) for indoor and outdoor gamma dose rates is given as,

$$\text{Gamma Dose Rates with Altitude} = 0.0778 \times \text{altitude} + 32.655$$

The value of linear correlation coefficient (r) between gamma doses rates with altitudes was found as 0.2224. This shows that gamma dose rates have no correlation with altitude. P-value, ‘p= 0.53686’ shows weak correlation of gamma dose rate with altitude.

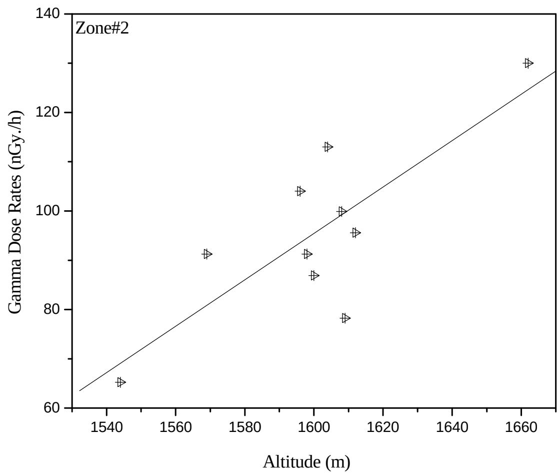

Figure 3. Variation of gamma dose rates with altitude for Zone 2.

For the Zone 4 the linear correlation analysis between gamma dose rates with altitude has been shown in figure 5 with slope of 0.0044. Linear regression mathematical expression (Y = A + B * X) for indoor and outdoor gamma dose rates is given as,

$$\text{Gamma Dose Rates with Altitude} = 0.0044 \times \text{altitude} + 91.587$$

The value of linear correlation coefficient (r) between gamma doses rates with altitudes was found as 0.03085. This shows that gamma dose rates have no correlation with altitude. Computed p-value, p= 0.93257’ confirms that gamma dose rates are not dependent on altitude.

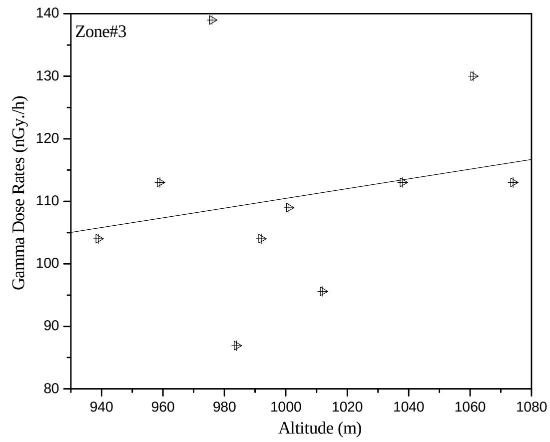

Figure 4. Variation of gamma dose rates with altitude for Zone 3.

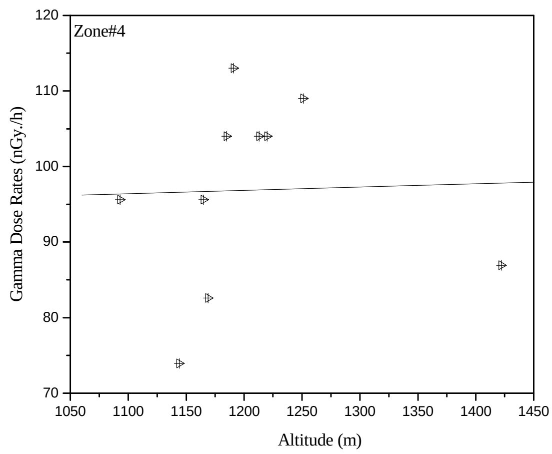

Figure 5. Variation of gamma dose rates with altitude for Zone 4.

Comparison of current gamma dose rates with the data available in literature has been carried out. Annual effective outdoor gamma dose rate of this study (102 nGy h^{-1})) is higher than the values reported for the Greek population, (32 nGy h^{-1}) (Clouvas et al., 2004) and the world population-weighted average (59 nGy h^{-1}) respectively and less than the values, varying from 78.3 to 135.7 nGy h^{-1} as reported by Erees et al. (2006) for Turkey, and Chikasawa et al., (2001), ranging from 13.8 nGy h^{-1} to 187 nGy h^{-1} reported for Japan.

5. CONCLUSIONS

Ambient gamma dose rate monitoring in district Poonch has been carried out. Minimum and maximum outdoor gamma dose rates were found as 65.25nGy.h^{-1} and 156 nGy.h^{-1} respectively. An average value of outdoor gamma dose rate was found as 102 nGy.h^{-1} respectively. Effect of altitude on gamma dose rate has been studied and measured values of gamma dose rates shows positive correlation with the altitude in only Zone 1. No significant correlation of gamma dose rates with altitude has been found in Zone 2, 3 and 4. Variation of gamma dose rates with lithology of the area under investigation has been found. High values of gamma dose rates were found for the areas within Murree Formation, exposed by interbedded sandstones, siltstones with shale's and clay stones lithology. These higher values may be attributed due to greater concentrations of ^{238}U and ^{232}Th (which are one of gamma dose rates contributing radionuclide's) in shale and sandstone. The average gamma dose rate (102 nGy.h^{-1}) measured for the current study is higher than world average gamma dose rate (57 nGy.h^{-1}) as reported in UNSCEAR 2000.

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