

Determination of the Natural Radiation Level: An example from Campus Area of Gumushane University (Between October and November, 2011)

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Abstract
The basic aim of environmental radiation measurements is to evaluate the assignment of radiation dose which the people take from the environmental resources, and the risk of health likely to be originated from it. In order to achieve this, it is necessary to determine separately the condensation of radionuclides in the environmental media forming the natural radiation resources and the contribution of that to the total radiation dose being exposed by the people. In this study, 45 measurements in total were taken each day between the dates 17th October - 30th November in front of Gümüşhane University Faculty of Engineering. These measurements were made by the students of Geophysics Department using 512-channal Gamma Ray Spectrometer device and Total Dose rate and Effective Dose rate values were identified. As a result of the calculations made by using effective dose rate values, annual equivalent dose rate values were found as average of 0.94 mSv/year betwen October and November. World average of annual effective dose value obtained from the natural resources was reported as 2.42 mSv/year. When the measured effective dose rate values were considered, it was seen that the results were under the world average level and that they did not have any disease-making effect on human health.

Keywords: Gümüşhane, Gamma-Ray Spectrometer, Natural Radiation, Annual Equivalent Dose Rate, Effective Dose Rate.

1. Introduction

We live in a world in which radiation exists in every part naturally. For instance, the elements existing in the earth crust naturally such as Uranium, Thorium and Potassium are all radioactive. Thus, the minerals and rocks containing these elements have radioactive characteristics. Radioactivity was found by Wilhelm Conrad Röntgen in 1895 and then by Antoine Henri Becquerel in 1986 not knowing Röntgen's finding. Radiation is the emission or transfer of energy in the form of electromagnetic waves or particles. If the number of the neutrons in the atomic nucleus are much more than that of the protons; then these substances show an unstable structure and the neutrons in the nucleus are fragmentized by emitting various rays such as alpha, beta and gamma. The substances fragmentized by expanding rays to its periphery are called radioactive substances.

Helium cores formed by the fragmentation of an atomic core (2 protons and 2 neutrons) are called alpha particles. It is very easy to stop these radiations. Even a leaf can be sufficient. Beta rays are formed like alpha rays through the fragmentation of an atomic core. Not two protons but an electron and a positron are separated in this fragmentation. Beta radiation is faster when compared to alpha particles. It is harder to stop them. They show deviation in the magnetic area as they are loaded. Gamma rays is the electromagnetic energy separated from the core and expanded in the speed of light. After an alpha or a beta particle is separated from the atomic core, high rate of energy emerges in the core and the structure of the atomic core becomes unstable. Gamma rays are formed as a result of the atom's removing its extra energy from the core so as to have a stable structure. As it is loaded, no deviation is observed in the magnetic area. It is hard to be stopped. It can even pass through a lead plate having a few cm of thickness.

The earth has radioactive characteristics since its formation. Thus, it is natural that there is certain amount of radiation in the environment. High level of radiation threatens human health and can cause death in the next phase. Natural radiation is generated by the radioactive elements and the stars and some objects in the space. Radioactive elements are naturally found in the soil, air, water and even our body. In addition, we take the radioactive elements in our body through water, air and the food we consume every day. There is nowhere on earth in which radioactive elements are found naturally.

The principle aim of environmental radiation measurements is to evaluate the assignment of radiation dose which the people take from the environmental resources, and the risk of health likely to be originated from it. In order to achieve this, it is necessary to determine separately the condensation of radionuclides in the environmental media forming the natural radiation resources and the contribution of that to the total radiation dose being exposed by the people. In addition, the relationship between the radionuclides in the environmental media and the radiation dose the people take from these resources should be determined. As a result of these systematic studies, it is possible to decide whether a region is available for a healthy life in terms of natural radiation. In order to estimate the health risks, there are many study in the literature. (Beretka and Matthew 1985; Malanca et al. 1993; Hayumbu et al.,1995; Llope 2011; Flores et al. 2008; Sari and Maden 2013; Abdel-Rezak et al. 2016; Kalyoncuoğlu 2015), and/or the dose rates at a distance above a large area of the material using the UNSCEAR scale factors (Beck 1972; Kohshi et al. 2001; UNSCEAR, 1993; UNSCEAR, 2000).

The radiation units are activity, irradiation, absorbed dose, equivalent dose and effective dose. Annual effective dose taken for the Natural Radiation Sources Around the World is 2.42 mSv. Annual average dose taken by the workers on radiation in medicine is around 1-5 mSv. Average dose per person taken by the workers in 1986 Chernobyl accident is 150 mSv. Radiation units and conversion factors are summarized in Table 1.

Table 1. Radiation Units and Conversion Factors

Radiation Units	Private Unit	SI Unit	Conversion
Activity	Ci	Bq/s	1Bq = 2.703 x 10^{-11} Ci 1 Ci = 3.7 x 10^{10} Bq
Absorption	Rad	Gy (J / kg)	1 Gy = 100 rad 1 rad = 10^{-2} Gy
Radiation	R	C / kg	1 C / kg = 3.876 x 10^{3} R 1 R = 2.58 x 10^{-4} C / kg
Equivalent Dose	Rem	Sv (J / kg)	1 Sv = 100 rem 1 rem = 10^{-2} Sv

2. Natural and Artificial Radiation Sources

The natural environment contains the greatest radiation sources which people are exposed to. Very long-lived (billions of years) radioactive elements appeared in nature with the formation of the earth have formed a natural radiation level considered normally and inevitably. Human beings are radiated by the natural resources such as the rays of the outer space and sun, the radioisotopes in the earth crust, soil and construction materials, water and foods, etc. In addition, they take dose from the artificial sources used inevitably in energy production, medicine, industry, research, agriculture, livestock, etc. All the living and non-living things in nature are exposed to radiation constantly through internal and external radiation by natural and artificial radiation resources. Gamma and beta rays harm more in external radiation, and alpha rays harm more in internal radiation. The great amount of radiation exposed is originally natural. Radiation originating from natural radiation emerges from two main elements which are the particles of the high-level energy cosmic rays coming from the space to the earth's atmosphere and the natural radioactive isotopes located in the earth crust. External radiation dose taken by the human being is not the same level in every part of the earth.

Table 2. World annual average radiation dose rates caused by the natural resources (UNSCEAR, 2008; URL-1)

Resource	Annual average dose (mSv)	Range of Change (mSv)	Percentage (%)
Radon respiration	1.26	0.2-10	52.07
Natural radiation	0.48	0.3-1.0	19.83
Cosmic radiation	0.39	0.3-1.0	16.12
Internal radiation	0.29	0.2-1.0	11.98
Total	**2.42**	**1-13**	**100.00**

Table 3. World annual average radiation dose rates caused by the artificial resources (UNSCEAR, 2008).

Resource	Annual average dose (mSv)	Range of Change (mSv)
Medical radiation	0.6	It changes between 0.03-2.0 mSv depending upon low and high-level of health services.
Nuclear tests	0.005	It has reached the top rate (0.15 mSv) in 1963. It has been decreasing as of that year.
Professional radiation	0.005	Annual dose being exposed by all workers is 0.7 mSv and it can change between 0-20 mSv. Most of this dose is originated from the natural radiation. For instance, especially radon gas in the mines.
Chernobyl accident	0.002	It has reached the top rate (0.04 mSv) in 1986. It has been decreasing as of that year. It is high near accident sites.
Nuclear power plants	0.0002	It increases by the reproduction of power plants and it can be decreased by refining studies. The dose in the 1 km distance from the power plants can be as much as 0.02 mSv.
Total	**0.61**	

UNSCEAR periodically publishes the data regarding the doses obtained from all resources today. Annual average dose levels obtained by the world population from the natural radiation resources according to the report published in 2008 are seen in Table 2. According to the table, total annual average radiation rate is 2.42 mSv changing between 1-13 mSv. %52.07 of this rate is originated from the respiration of Radon gas, and %19.83 of it is originated from the radioactive elements such as U, Th and K included in the rocks. In Table 3, world annual average dose rates originating from the artificial resources compiled from the UNSCEAR report published in 2008 are seen. According to the table, world annual dose rate taken from the artificial resources is 0.61 mSv. According to Table 2 and Table 3, total annual radiation of the world is 3.03 mSv. %79.8 of this rate is from the natural radiation resources and %20.2 is from the artificial resources. %41,6 of the total radiation source is from the decay products of radon gas and %19.8 from the medical radiation. Artificial radiation sources (radioactive accidents, consumer goods, professional radiation and emissions from the nuclear industry) forms only %0.4 of the total radiation.

3. Geology of Measurement Area and its Circle

Gümüşhane granite is seen in Yenimahalle, İnönü, Karaer and Karşıyaka districts located in the center of Gümüşhane province. Differing easily from other units with its pink color and plenty of cracks, Gümüşhane granite has argillization, hematitation and chloritization as a result of surface separation as well as arenation in the areas where separation is common. As for Çamlıca, Hasanbey, Özcan, Canca and Hacıemin districts in the center of Gümüşhane province, gray and yellowish-gray Alibaba formation is observed composed of andesite and basalt. Basically dark-yellow chloritization is observed in these rocks as well as calcite veins lying through the cracks. In Hasanbey, Özcan and Kayalık districts, agglomerate blocks and exfoliation structures are observed with the diameters ranging between 5-25 cm. Argillization and silification is commonly observed in Canca and Hacıemin districts depending on the surface separation of andesite.

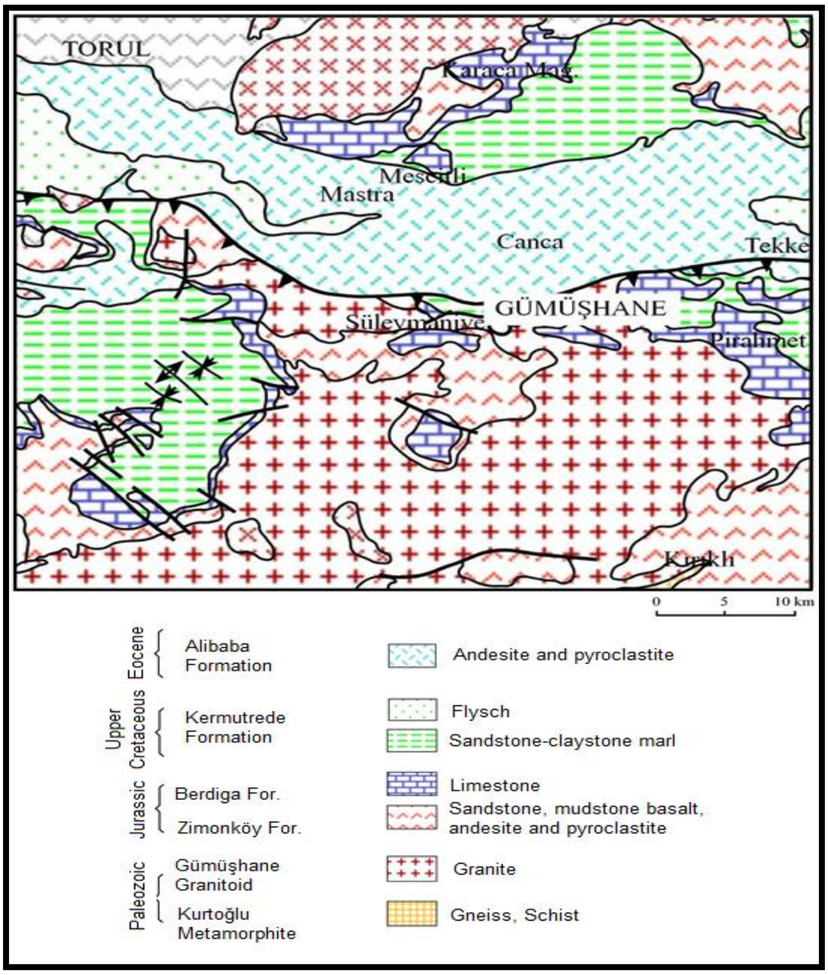

Figure 1. Geographical Map of Gümüşhane Province and its Circle (Turkish-Japanese Team, 1985).

Gümüşhane granite observed in Bağlarbaşı District and the campus area is easily separated from other rocks around in terms of the color tone and the lithologic difference. It is usually in pink having plenty of cracks. Clear surface separations through the cracks are observed. Argillization and chloritization are the most frequently observed separation products. In addition, the granites are arenation with the effect of extreme surface separations. Because the fresh surface of the limestone in Bağlarbaşı district Science High School area is gray and the separation surface is mostly reddish, and the area has a more slope topography when compared to other units, the limestone can easily be recognized on the land and contain settled calcite veins through the cracks with 2-5 cm width. The general geological map of Gümüşhane province and its circle is given in Figure 1.

4. Natural-source Radiation Values and its Effects on Human Health (17th October - 30th November 2011)

In order to identify the daily external gamma dose rate values originated from the radionuclides in Campus area of Gümüşhane University, 45 Total Dose Rate (TDR) and Active Dose Rate (ADR) measurements were made, 15 of which were made between 17-31st October 2011 and 30 of which were made between 01-30th November at the point where the coordinate values are 40°26.266'K and 39°30.968'E (Figure 2) using Gamma Ray Spectrometer device located in the inventory of Gümüşhane University Department of Geophysics Engineering. The measurement values taken can be followed from "Studies" title on http://jeofizik.gumushane.edu.tr - the website address of Gümüşhane University Department of Geophysics Engineering.

Figure 2. Location of the daily measurements made in order to identify the natural radiation level in Campus area of Gümüşhane University.

The measurements made in October were initiated by Pınar Ay on 17th October, 2011. The values of the first measurements are as follow: 1127.7 nGy/hour for TDR, 789.7 nSv/hour for ADR. The last measurement was made by Mustafa Tatlı on 30th November, 2011. TDR value was identified as 1111.7 nGy/hour and ADR value was identified as 778.5 nSV/hour in this measurement. The measurements made in between October and November are shown in Figures 3 and 4.

When the measurements taken are analyzed, it is seen that TDR values range between 1074.5 nGY/hour and 1131.4 nGy/hour (Figure 3), and ADR values range between 749.8 nSv/hour and 789.7 nSv/hour (Figure 4). The average of the measurements made in October and November were calculated as 1107.7 nGy/hour for TDR and 769.8 nSv/hour for ADR.

Annual Equivalent Dose Rate (AEDR) values, being one of the Active Dose Rate (ADR) values were calculated as given in the 5th column in Table 4. These values calculated are shown in Figure 5 ranging between 0.92 mSv/year and 0.97 mSv/year. Annual Equivalent Dose Rate average of the measurements between October and November is 0.94 mSv/year.

As a result of the calculations made, it was identified that the annual equivalent dose rate values obtained was 0.94 mSv/year between October and November (Table 5). When these values are compared with the annual equivalent dose rate average of the world (2.42 mSv/year) it is realized that the rate is too low. Thus, it is not correct to say that these values obtained have a negative effect on human health.

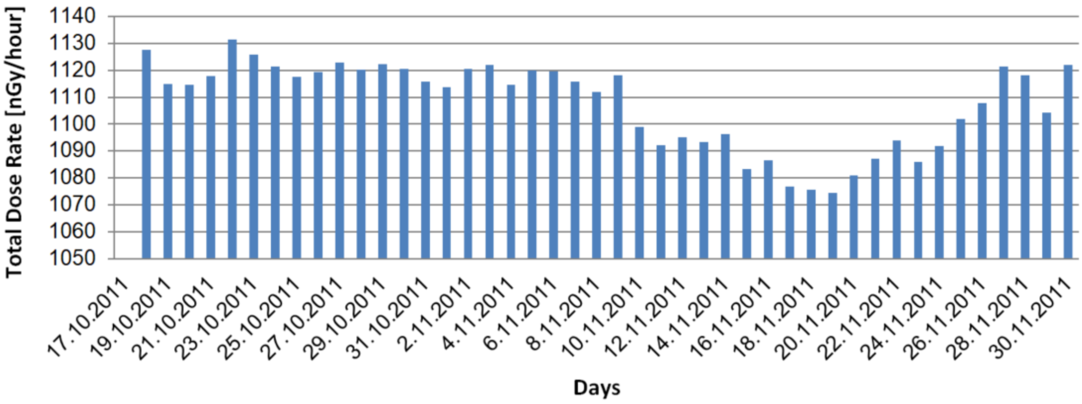

Figure 3. Total dose rate values measured between October and November 2011.

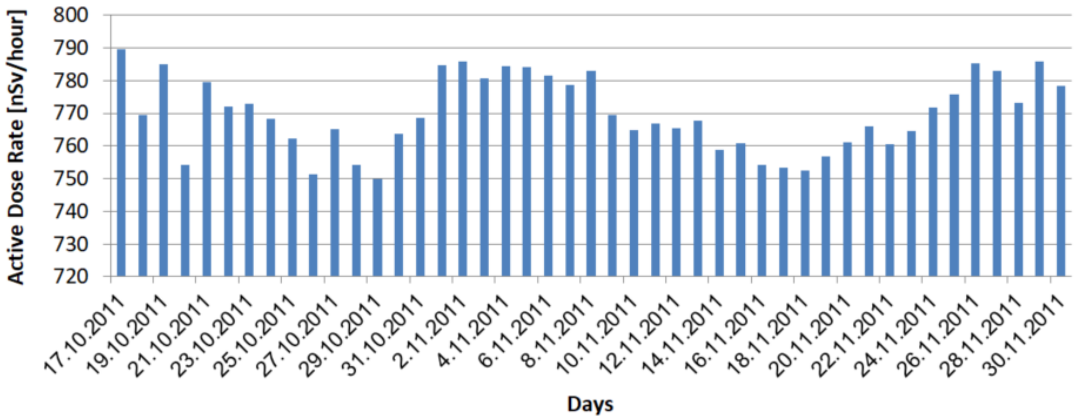

Figure 4. Active Dose Rate Values measured between October and November 2011.

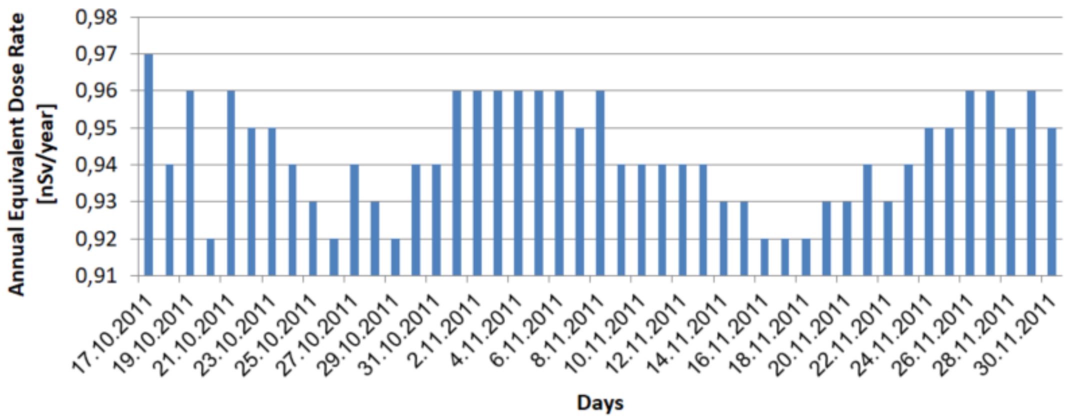

Figure 5. Annual Equivalent Dose Rate Values taken from Active Dose Rate Values measured between October and November 2011.

5. Conclusion

In order to follow the natural radiation level of Campus area of Gümüşhane University, daily measurements were made in October and November (Table 4) 2011 in front of the building of Gümüşhane University Faculty of Engineering. These measurements were made by the students of

Geophysics Department who used 512-channal Gamma Ray Spectrometer device and Annual Equivalent Dose Rates (Table 5) were calculated. The measurement values identified can be followed on the website of Gümüşhane University Faculty of Engineering Department of Geophysics Engineering: http://jeofizik.gumushane.edu.tr

Table 4. Total and active dose rate values and the equivalent dose rate values measured between 17-31st October 2011

Rank	**Date**	**TDR [nGy/hour]**	**ADR [nSv/hour]**	AEDR **[mSv/year]**
1	17.10.2011	1127.7	789.7	0.97
2	18.10.2011	1115.0	769.3	0.94
3	19.10.2011	1114.5	785.1	0.96
4	20.10.2011	1117.8	754.2	0.92
5	21.10.2011	1131.4	779.4	0.96
6	22.10.2011	1125.9	772.0	0.95
7	23.10.2011	1121.4	772.9	0.95
8	24.10.2011	1117.5	768.4	0.94
9	25.10.2011	1119.4	762.2	0.93
10	26.10.2011	1122.8	751.3	0.92
11	27.10.2011	1120.1	765.2	0.94
12	28.10.2011	1122.4	754.3	0.93
13	29.10.2011	1120.4	749.8	0.92
14	30.10.2011	1115.8	763.7	0.94
15	31.10.2011	1113.8	768.5	0.94
16	01.11.2011	1120.4	784.6	0.96
17	02.11.2011	1122.1	785.8	0.96
18	03.11.2011	1114.7	780.6	0.96
19	04.11.2011	1120.0	784.3	0.96
20	05.11.2011	1119.7	784.1	0.96
21	06.11.2011	1115.8	781.4	0.96
22	07.11.2011	1111.9	778.6	0.95
23	08.11.2011	1118.0	782.9	0.96
24	09.11.2011	1098.8	769.5	0.94
25	10.11.2011	1092.2	764.8	0.94
26	11.11.2011	1095.1	766.9	0.94
27	12.11.2011	1093.2	765.5	0.94
28	13.11.2011	1096.2	767.6	0.94
29	14.11.2011	1083.4	758.7	0.93
30	15.11.2011	1086.6	760.9	0.93
31	16.11.2011	1076.8	754.1	0.92
32	17.11.2011	1075.7	753.3	0.92
33	18.11.2011	1074.5	752.5	0.92
34	19.11.2011	1080.9	756.9	0.93
35	20.11.2011	1087.0	761.2	0.93
36	21.11.2011	1094.0	766.1	0.94
37	22.11.2011	1086.0	760.5	0.93
38	23.11.2011	1091.8	764.6	0.94
39	24.11.2011	1102.0	771.7	0.95
40	25.11.2011	1107.7	775.7	0.95
41	26.11.2011	1121.5	785.4	0.96
42	27.11.2011	1118.0	782.9	0.96
43	28.11.2011	1104.3	773.3	0.95
44	29.11.2011	1122.0	785.7	0.96
45	30.11.2011	1111.7	778.5	0.95
	Minimum:	**1074.5**	**749.8**	**0.92**
	Maximum:	**1131.4**	**789.7**	**0.97**
	Average:	**1107.7**	**769.8**	**0.94**

As a result of the calculations made, the average of the annual equivalent dose rate values was identified as 0.94 mSv/year betwen October and November (Table5). It is seen that these values are much lower than that of the world average of annual equivalent dose rate (2.42 mSv/year) included in UNSCEAR reports in 2008.
It is understood that the values calculated in October and November, 2011 are also too low when compared with some dose rate values calculated in various parts of the world (Table 6).
When the annual equivalent dose rate values calculated are analyzed, we conclude that the natural radiation level in Campus area of Gümüşhane University does not have a disease-making effect on human health.

Table 5. Annual equivalent dose rate values calculated with the active dose rate values in October and November in Campus area of Gümüşhane University.

Month	Annual Equivalent Dose Rate [mSv/year]	Range of Change [mSv/year]	World Average [mSv/year]	Range of Change [mSv/year]
Oktober and November	0.94	0.92 - 0.97	2.42	1-13

Table 6. Annual equivalent dose rate values calculated in various parts of the world (UNSCEAR, 2000; URL-1)

Name of Country	Region	Equivalent Dose Rate (mSv/year)
Brazil	Volcanic Regions	3.43
France	Uranium Mine Regions	12.26
India	Monazite Sand, Beach	2.21
Italy	Volcanic Lands	0.69

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