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Background Radiation Observation and Measurement: A Case Study Around HSTU Campus, Dinajpur, By Using a Geiger-Muller (GM) Counter

M. J. Hossen, M. F. Kabir, A. Amin, M. A. Khatun & M. A. Sattar

Abstract

Radiation is the name for energy that travels as electromagnetic waves or particles. According to energy or ionizing power, ionizing radiations might be harmful to people's health. We were interested in radiations with high energy to ionize materials for our work. Overexposure to ionizing radiations like Alpha (α), Beta (β), and Gamma (ϒ) radiations can result in a variety of malignancies. Different types of radiation sources could be present. The main contributors of radionuclides are ^{40}K, ^{226}Ra, ^{238}U, and ^{232}Th. Man-made sources and naturally occurring radioactive materials found in the earth's crust are the principal sources of ionizing radiation to which humans are exposed. The background radiation level of a region on the earth's surface is defined as the total radiation from all sources that fall inside that region. A GM counter was utilized in our research project to measure the total radiation level at several locations within the university region and its environs. For every location in the sample, there are no aberrant radiation count values. Therefore, despite the presence of natural radioactivity in the study region, there is typically no risk to workers and the general public's immediate health, particularly our students.

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Introduction

Energy is typically transferred by radioactive materials using various radiations. Radiation exists in various forms everywhere around us. Ionizing and non-ionizing radiation are two different types of radiation that can be categorized based on energy. Non-ionizing radiation is considered non-destructive because the damage caused by this radiation is much less than that of ionizing radiation. Hence, we were concerned about ionizing radiation in this study. Accordingly, radiation is referred to here as ionizing radiation (Balmori, 2005). Numerous investigations on the biological impacts of radiation emissions from various sources have been carried out. A study conducted at the time of an international event on "Effects of Electromagnetic Fields on the Living Environment" take place in Imaging, Germany in 1999 under the World Health Organization's International EMF Project, found out the effects of EMFs on the environments are modest and restricted (ICNIRP, 1998) recommended EMF exposure limits will also be environmentally friendly (Foster et al., 2000). The primary external radiation source in the human body is gamma rays produced by naturally occurring radioisotopes such as the 40K, ^{232}Th, and ^{238}U series radionuclides and decay products, those found in trace amounts in terrestrial region. About 82 percent of the radiation doses that are uncontrollably absorbed by the human body come from background radiation sources. High-level background radiation zones have more background radiation because there are some quarries and mines there. The rate of background radiation dosage can be impacted by the kind of construction material used in homes. Monitoring the amounts of radiation that are expressed in humans directly or indirectly requires an understanding of radioactivity in the environment (Al-Khawlany et al., 2018). Ionizing radiation affects human life as well. Extreme exposure to alpha particles, gamma rays, beta particles, and X-ray beams can induce pathogenesis. Radiation wells can be of different types such as astronomical beams (radiation from space), and radiation. The radiation comes from various sources like the outer layer of the earth where the radioactive molecules prepare sent, and radiation from our bodies and so the radiation will include radio waves, microwaves, infrared, visible light, X-ray beams, and atomic particles. Here, we are concerned with radiation with high energy to ionize matter. (Rajan Paudel Chhetri, 2018). Numerous advantageous uses of radiation exist, including cancer cell treatment, radiation therapy, agriculture, industry quality enhancement, and medical imaging. The background radiation layer of a certain area on the earth's surface is the sum of all the radiation coming from various sources there. Background radiation exposure is an unavoidable aspect of the environment. The overall radiation levels were measured at several places using a portable GM counter. Variations in radiation levels are evident in its detection. (Billaudel et al., 2009). Additionally, there are two types of radiation: natural and artificial. Natural radiation is emitted from the sun or cosmic stars or radioactive material present on the surface of the earth. Where radiation from artificial sources is used for various purposes is known as artificial or man-made radiation which is used for the treatment of X-rays, radiotherapy, etc. There are many types of human activities, and the non-nuclear industries naturally contribute to the concentration of some of the radioactive substances located in the crust of the earth that affect humans and the environment. The major contributors to radionuclides are potassium (40K), uranium (^{238}U), and thorium (^{232}Th) (Abu-Haija, 2012). Humans are primarily exposed to ionizing radiation from the Earth's crust, as well as from naturally occurring radioactive material from man-made sources (Nasir et al., 2012). The Hajee Mohammad Danesh Science & Technology University (HSTU) is situated in Dinajpur Sadar, a region of Bangladesh's northwest known for its straightforward citizens. At present several multi-storied buildings are under construction at HSTU, Dinajpur. Different types of stones, cement, rods, and materials are being used as construction materials in the buildings under construction. All these materials used in construction work have the potential to contain different types of radiation. Since there are many halls and buildings to live in, the number of settlements is much higher. On this campus, there are about 11,000 students and 309 teachers among them 195 foreign students. (International Affairs Section, HSTU, n.d.) Since radiation is harmful to our body, it is important for people, especially the students and employees, living here to know how safe it is.

Figure 1. Satellite view of HSTU (study site)

The purpose of our research project is,

i. Measuring different types of radiation from rocks, cement, rods, and materials used in the buildings inside the HSTU campus, Dinajpur.

ii. Analyze large doses of ionizing radiation with the standard values of radiation absorbed doses, which are responsible for human health risks, such as cancer and leukemia (blood cancer).

To protect the population from ionizing radiation, it is essential to know the baseline data on environmental radiation and radioactivity. Therefore, a continuous environmental monitoring program is required to detect any changes due to natural radiation emitted from exposed rocks, cement, rods, and water in the area under construction in HSTU, Dinajpur.

Materials and Methods

Geographical Location of the Study Area

HSTU is located at Dinajpur Sadar, the people of Bangladesh's Dinajpur area in the northwest are renowned for their simplicity.

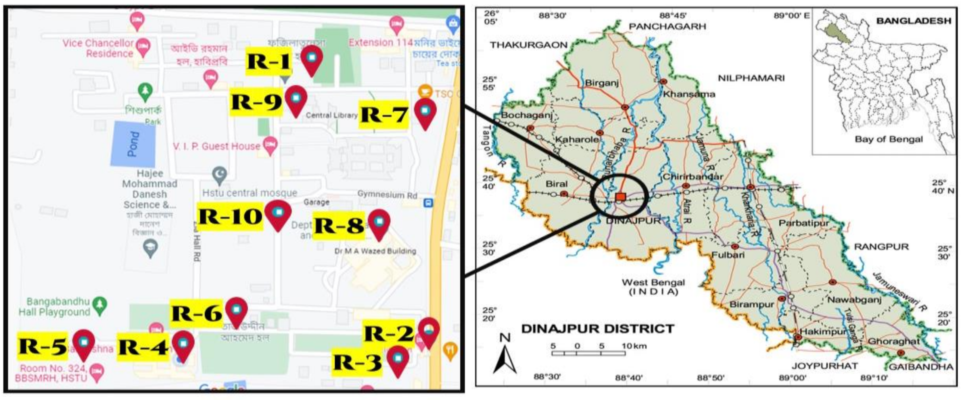


Figure 2. Site Map of HSTU

Its high-quality educational system and greenish campus attracted students all over the country and also foreign students. Dinajpur is situated at an altitude of 34.5 m above mean sea level and is located at 25.13°N latitude and 88.23°E longitude. (International Affairs Section, HSTU, n.d.) The sample size was selected randomly inside different places.

Measurement Set-Up:

Various tools can be used to find ionizing background radiation. Using GM counter equipment, radiation from several areas around the HSTU campus area was precisely studied. A Geiger counter consists of a Geiger-Müller tube, a radiation-sensing substance, and processing circuits that show the data. It was given that name in honor of Hans Geiger, who developed the notion behind it in 1908, and Walter Muller, who investigate with Geiger in 1928 to improve the method for creating a real tube that could detect various types of radiation. The Geiger Muller tube is a portable radiation measuring and detection device used to find radiation in the area. Alpha particles, gamma rays, beta particles, or X-rays can all be the source of this radiation. Additionally, it provides a measurement of radiation intensity. (N.N. Ghuge, 2015). The Geiger counter model is identified by the ST-160 nuclear lab station S / N-248. This device can calculate high-energy β-particles, γ-particles, and X-rays entering the tube. It shows the count and count rate on the display screen. This counter has a timer and a self-contained unit. So, we can set the time for 60 seconds. It makes a less audible noise when detecting each radiation and gives a higher audible sound after the time set is over (Rajan Paudel Chhetri, 2018).

Data Analysis and Graphical Presentation

Today, new methods for teaching nuclear science can be developed utilizing a variety of widely used spreadsheet tools. The ST160 nuclear lab station offers self-contained equipment with an 11-piece suction set, a GM tube, and a flexible timer/counter. The package includes a personal computer that is Macintosh or IBM compatible as well as a serial interface with a USB interface. Fully changeable between 0 and +800 volts and manually controlled by a high voltage keypad or pushbutton on the front panel. The processor has complete control over and regulation over the supply of digital precision and readout on the display of computer displays.

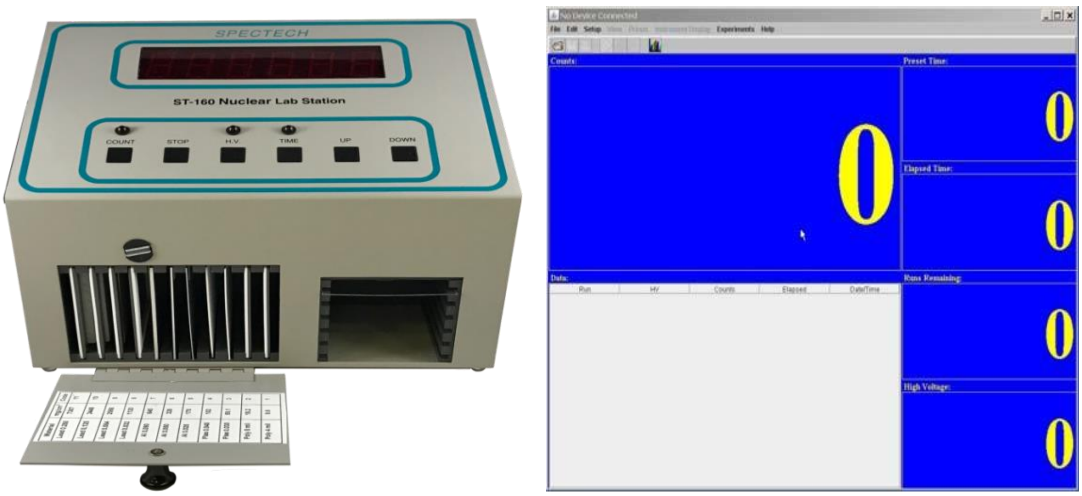


Figure 3. A conventional GM counter & Computer screen capture of ST160

Digital readouts on the front panel are displayed using extra-large, 1 "LEDs for a variety of clear visual readouts under various ambient light levels, with zero suppression. Using the integrated USB or serial RS-232 interface and STX emulation software, Windows PCs can now execute nuclear tests and demonstrations in the classroom. Starting the calculating function on a computer or the ST160 is an option. The supplied software enables all functions, including analog and digital emulation of rate meters, to be shown on a computer screen. Automatic real-time data transfer to the computer and spreadsheet-compatible file storage.

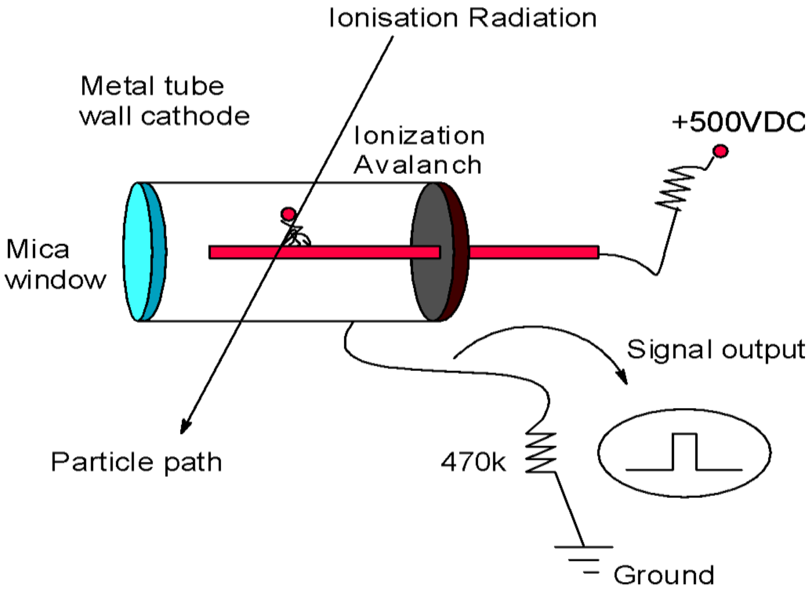


Figure 4. A thin-end window tube and a high voltage source applied through a resistor are used in a traditional Geiger Muller counter.

Working on Gm Tube

At low pressure and high voltage, inert gases like helium, neon, or argon are placed within Geiger-Müller tubes. When the incident conducts gas by the ionization of a particle or photon of radiation, the tube briefly conducts an electrical charge. When passing through the gas tube at the GM counter, ionizing particles ionize the gas and electrons, which then move in the direction of the anode that is created. The velocity is pretty great, and after numerous collisions with gas particles, secondary electrons are eventually produced. The Townsend discharge effect amplifies the ionization in the tube to provide an easy-to-measure detection pulse that is supplied to the processing and display circuits. Due to the succeeding circuits being substantially simplified, it is quite cheap to construct a gigabyte counter thanks to this significant tube vibration. (1981; Kraner) High voltages, typically between 0 and 800 volts, are also generated by electronics and must be delivered to the Giger-Muller tube for it to function. To the discharge in the Geiger-Müller tube, a tiny amount of halogen gas or alcohol is introduced to the gas combination.

Detector Circuit

The detector circuit consists of a pulse counting circuit, a boost converter, and a GM tube radiation detector (to provide the GM tube with the necessary voltage) (to count and transmit the pulses generated by the GM tube). (N.N. Ghuge, 2015)

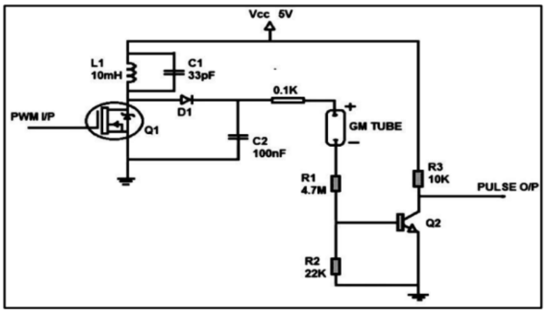


Figure 5. Detector circuit diagram

When ionizing radiation occurs, Geiger-Muller tubes produce electrical vibrations in their sensitive volumes. These detectors must be used at a specific operating voltage established experimentally or by the manufacturer for proper operation. Many GM tubes feature incredibly narrow entrance windows that need to be handled with utmost caution to enhance the radiation sensitivity to beta and alpha particles. Keep all objects away from the GM tube that is sitting on the sample's crest container. The ST160 has a compatible high-voltage power source with a variety of applications. Extreme voltage levels can be exhibited in digital readouts by pushing the H.V. key once. Extreme voltage adjustment can then be created using the UP / DOWN button to increase the 20-volt. Press H.V for going back to the computer display mode buttons again. (*SPECTECH-ST160: Service Manual Spectrum Techniques*, 2009)

Gm Plateau

The specific working voltage of a Geiger-Mueller cylinder can be temporarily resolved to make use of a tiny radioactive source, for example, 1 micro-currency Cs-137 or Co-60. A properly operated cylinder will show a "level" effect, where the set rate is virtually the same at the applied voltage. Put the radioactive source near the GM test window and increase the high voltage bit by bit until the radiation event is recognized. Increase the voltage to the current 20-volt step; record the starting rate at each connection. This rate should be truly consistent at different voltages and then increase rapidly with high voltage surges, showing that the cylinder is approaching the break zone. Try not to continue the cylinder in this state of dissolution, but still cut back on the high voltage and create a space at a fixed rate as opposed to the voltage used. The proposed working voltage cannot be set on the rock as the level district trot. Note in the model below that the level has risen from about 350V to 600V. An intelligent working voltage for this situation would be 500V.

Results and Discussion

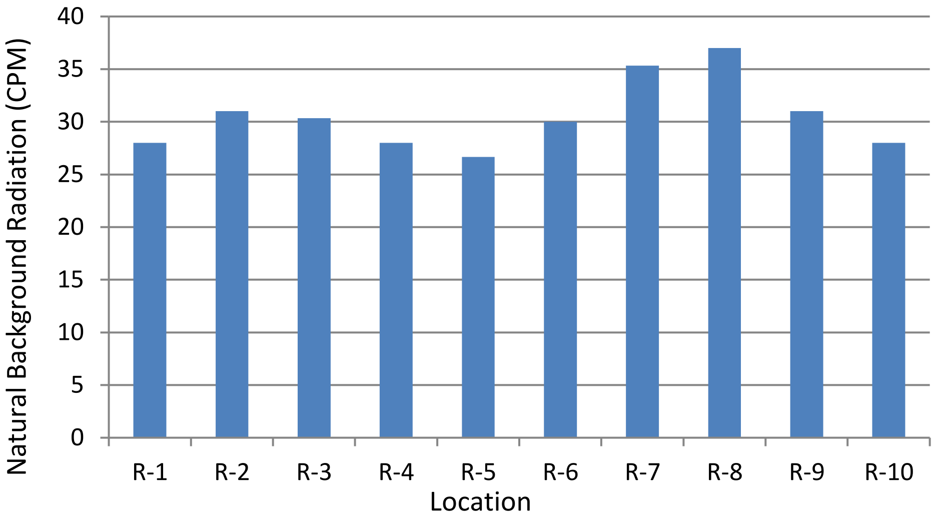
The location's latitude and longitude of the locations where readings of radiation were taken there on the field discovered using a Global Positioning System (Plate XXXI). The following table shows the data for naturally occurring background radiation by using a GM counter (model no: ST-160, Nuclear lab station).

Table 1. Background radiation data at the HSTU campus area.

NO.	Location		Reading (Counts per min.)			
	Longitude (N)	**Latitude (E)**	**Reading-1**	**Reading-2**	**Reading-3**	**Average**
R-1	25°41’57.9”	88°39’15.6”	26	28	30	28
R-2	25°41’43.9”	88°39’21.7”	30	28	35	31
R-3	25°41’42.9”	88°39’20.1”	31	27	33	30.333
R-4	25°41’43.6”	88°39’08.8”	28	25	31	28
R-5	25°41’43.7”	88°39’03.6”	26	24	30	26.666
R-6	25°41’45.3”	88°39’11.6”	24	30	32	30
R-7	25°41’49.7”	88°39’19.2”	40	35	31	35.333
R-8	25°41’55.2”	88°39’21.5”	38	32	41	37
R-9	25°41’55.9”	88°39’14.7”	29	31	33	31
R-10	25°41’50.2”	88°39’13.9”	30	26	28	28

Observation time: 1 Min (60 Sec.), Operating Voltage: 600V

There were ten different places around our study area which was selected randomly. These are populated areas both at HSTU that’s why the chance of absorbing nuclear radiation by a person is very high. The average value of radiation found from the range of 28 to 35.333 counts per minute (CPM) is the minimum and maximum value respectively. In the case of the HSTU Campus area, the lowest value of 28 CPM was found at the locations 25°41’57.9” N, 88°39’15.6” E, and 25°41’43.6” N, 88°39’08.8” E. On the other hand, the highest value 35.333 CPM was found at the location 25°41’49.7” N, 88°39’19.2” E.



Graph-1. Location Vs Natural Background Radiation (CPM) graph for at HSTU campus area.

Standard Value of Background Radiation

For the majority of people, background radiation that occurs naturally is the predominant source of exposure. Usually, levels vary from about 30 CPM or 0.171 μSv/h to 70 CPM or 0.399 μSv/h (1.5 mSv/yr. to 3.5 mSv/yr.). Data from initial field gamma radiation observations translated to different units of dosage like dose equivalents (mSv/yr) as follows to create maps of the distribution of radiation dose rates. The dose equivalent was found below one (01) mSv/yr. (≤ 1mSv/yr.). These values are not health hazards for the dwellers of that area.

Conclusion

The following are the main conclusions of a study that was recently completed on the distribution of dose rates and natural radiation levels in various areas of the HSTU campus area: The values of external hazard dose rate compared with the global average values (1.5 mSv/yr. to 3.5 mSv/yr). By this comparison, we found that the radiations in this area, below 1 mSv/yr, are not hazardous to human health for the people living here. The highest value 35.333 CPM was found at the location 25°41'49.7" N, 88°39'19.2" E. The minimum value was 28 CPM which was found in three different places inside the campus area. Geologically, basaltic regions are the safest for ionizing radiation exposure from terrestrial natural sources since dose rates there are typically around 50% less than the most allowable dose limit. As a result, it may be argued that using rocks in structures is radiologically safe. For the protection of the population from ionizing radiation, it is essential to know the baseline data on environmental radiation and radioactivity. So, there is a need for continuous environmental monitoring programs to determine any change due to natural radioactivity released from the material used in the buildings. Since radioactive elements are taken into the body through food and drinking water, it is crucial to routinely check for radioactivity in these substances. The investigation has produced scientific information on local natural radiation levels that medical experts might utilize to verify and make their choices concerning potential radiation concerns. Last but not least, establishing a hygienic atmosphere for people depends greatly on this study.

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