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Determination of Gross Alpha/Gross Beta Radioactivity in Surface Water Collected from Various Geographical Points in Dhaka City

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Abstract: Radioactivity in surface water has become a severe matter of health concern worldwide. Gross Alpha and Beta calculation is a test performed to determine the overall radioactivity in water. Gross Alpha/Beta testing detects these alpha and Beta particles in the water and indicates the presence of radioactive substances. These studies have been measured in 23 surface water samples collected from different areas of Shahbag and Ramana thana, situated at the central point of Dhaka city. The measured dose rates due to natural radionuclides ranged from 0.09 μSvh^{-1} to 0.227 μSvh^{-1}, and the average dose rate was calculated to likely 0.130435±0.019183 μSvh^{-1}. pH is an essential parameter of water because there is a strong correlation between several water properties and this value. The pH value of collected surface water was found from 6.7 to 7.5 on the standard pH scale, and the average pH value was around 7.1±0.287623. The ZnS scintillation detector was used to determine the amount of gross alpha and gross beta activity in the dry residue of surface water samples. The gross alpha activity of our collected surface water sample ranged from 7.987 mBq/L to 28.179 mBq/L, and the mean Alpha activity of samples was calculated at about 18.19661±5.357773 mBq/L. The highest beta activity was observed at 120.864 mBq/L, and the lowest activity was 57.329 mBq/L. The average Beta activity of samples was calculated at 93.90048±17.54712 mBq/L .Moreover; there was no registered exceeding of the maximum allowed limits for gross alpha activity stipulated in the national and international legislation. The values obtained in this study were compared with those presented in similar studies from Bangladesh and other world regions. The purpose of this study was to provide a more straightforward approach for quantifying the radioactive contamination in surface water and to offer a scientific basis for making decisions regarding the management of radioactive pollution. In addition, the results of this study will contribute to the preparation of data for the national Survey on the gross alpha radioactivity in surface water samples. These data will serve as a reference for comparing the various levels of radioactivity.

Keywords: Radioactivity, Gross Alpha, Gross Beta, Background radiation and scintillation.

1 Introduction

Ionizing radiation can come from various sources, including cosmic rays and natural radionuclides in air, food, and water [1]. Humans are naturally subjected to this type of radiation. Radionuclides are the elements that give rise to radioactivity and give off nuclear radiation, both of which are now commonplace in our everyday lives. Ionizing radiation comes in various forms, the most common of which are alpha particles, beta particles, and gamma rays [2]. Because water is required for all life forms on Earth, it is undoubtedly one of our most essential resources. The problem consists of mitigating the continued negative effect of the contemporary world and securing water supplies in an environment where the climate is changing and the population is growing [3]. Rainfall and other groundwater sources are the two most crucial surface water sources. Rivers, wells, dams, lakes, and streams are all excellent places to look for it [4]. Both human actions and natural occurrences contribute to the steady pollution of water sources and an overall decline in water quality [5]. The discharge of trash and sewage into the environment and rivers by industries and hospitals, as well as the use of products such as fertilizers, are the primary contributors to the problem of water pollution. The water found in rivers, lakes, and ponds should also be considered a potential contamination source [7].
Radiation of the alpha, beta, and gamma types is also given off by naturally occurring radioactive elements [8]. These often include elements from the uranium and thorium series, namely radon and thoron, whose radioactive gaseous daughters create significant airborne particle activity and contribute to the radioactivity of rain and ground fluids [9]. Both directly (via their radioactive products) and indirectly

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(by means of the gaseous byproducts of radon and thorium, which can condense and attach themselves as aerosols to the particles in the air; these particles are then transported into bodies of water through precipitation) do they poison the water body [10]. The location of water sources affects the concentration of natural radionuclides' activity [11]. While drinking water obtained from deep wells and boreholes is often anticipated to contain a greater concentration of radioactive nuclides, activity concentration in the surface water is typically modest [12]. This type of water enters the streams via fissures in bedrock or soil, including mineral deposits containing radioactive components [13]. Additionally, the concentration rises in the summer because of the high rates of evaporation and the rise in salt solubility brought on by the warmer water [14].

Water pollution by biological organisms is a significant concern for the approximately 1.1 billion people who do not have access to safe drinking water, as reported by the World Health Organization (WHO) [15]. The levels of biological, chemical, and radioactive pollution in the drinking water must be at or below those suggested by international health organizations like the World Health Organization or national legislation [16]. For alpha activity, the World Health Organization (WHO) mentions a boundary of 0.1 Bq/L in drinking water and 1 Bq/L for gross beta activity [17]. Therefore, natural radioactivity in the ground, surface, and residential water have been measured in many places around the globe, often to assess the dosages and dangers associated with drinking water.

Water radioactivity studies have been conducted in the past. However, they were limited to specific regions. Okpare–creeks, Delta State, has been surveyed for radioactivity in their water [18]. According to their calculations, the alpha and beta activities in the Okpare stream are much below the WHO-recommended practical screening levels of radioactivity in drinking water. Habila participated in the Jos municipal study of gross beta radiation in wells and boreholes [19]. 0.25 to 9.64 Bq/L range was observed, with a geometric mean of 1.56 Bq/L. Radiation in the surface water is only one of several environmental phenomena observed in the South Asian area. No significant projects using surface water have been undertaken in Bangladesh; nevertheless, several projects involving piped and bottled water have been completed using the same methods and tools. In essence, numerous nations have already established a baseline for radionuclide detection and radiation measurement in their local region, which data are instrumental in concluding a specific place.

Because of this, it is necessary to ascertain the concentration of gross alpha and gross beta particles in the surface water of these local areas in order to evaluate the radiological health risks because communities from all over the country and even further afield are involved in this capital area. This research will help in the knowledge of a quantitative detection of gross alpha and beta radioactivity, which is essential for a fast survey of both natural and manmade radioactivity in surface water in the study region. The primary purpose of this investigation is to ascertain the levels of gross alpha and gross beta radiation that are present in the environmental surface water sample. pH is an essential parameter of water because there is a strong correlation between several water properties and this value. The pH value of collected surface water was measured. In the meantime, background radiation data were collected using the Gama Scout survey meter because this experiment is convenient for gathering preliminary information on radiation in selected sampling aria.

2 Study Area and Sample Collection

2.1. Study Area

Our main study area was the centre point of Dhaka city. Dhaka is located in the central part of the Bengal delta, where Latitude bounds: 23° 42' 37.44" N and Longitude: 90° 24' 26.78" E. Ramna and Shahbag are Two major historical parts of Dhaka city [20]. We can define Shahbag as Latitude: N 23° 44.3836' and Longitude: E 90° 23.6557' [21]. Ramna area is also located at Latitude: N 23° 43.9813'. Longitude: E 90° 23.903' [22]. Both of them are the nearest neighbours in Thana of Dhaka metropolitan. In Fig.1, the location of Dhaka city and the broad diagram of Shahbag and Ramna was shown very effectively. Many people live in this area. The oldest University of Bangladesh and a famous park are situated in this part of Dhaka city [23]. Our targeted pond and lake water are usually used for bathing, gardening, and daily activities of students and general people. Moreover, Dhaka city corporation uses these water sources to control dust on roads and highways. For the aforementioned causes, it is crucial to conduct a baseline study to provide reference data for future research in the form of baseline radiation levels.

2.2. Sample Collection points

Twenty-three water samples were collected from several ponds and lakes within the areas, namely: Dr Muhammad Shahidullah Hal, Jagannath hall, Shahid Sergeant Zahrul Haq Hall, Bangladesh national museum, Bangla Academy, Institute of fine arts, and Ramna park area. The area of ponds and lakes was extensive. For this reason, several samples were taken from different parts of the Ponds and Lakes. Moreover, in the Ramna area, the lake is divided into Lakes 1 and 2. Four samples were taken from different areas of each lake for more accuracy. In Fig 1 (right side), the location of sampling points was shown, and the details of sample collection location and sample names were shown in table 1. The samples were collected in 2-litre plastic bottles and taken to the Health physics division, Atomic Energy Centre, Dhaka, for analyses. During sample collection time, the Gamma Scout radiation detector measured every sample point's background radiation. The P^H level of collected water samples was measured in the Environmental Monitoring Laboratory using a portable P^H meter.

Gross alpha and gross beta radioactivity on the ambient samples that had been gathered.

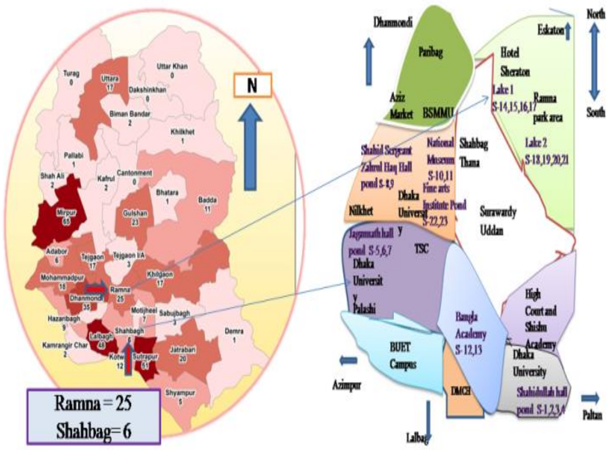

Fig.1: Important regional area of Dhaka city (left side) and broad diagram of Shahbag and Ramna area with sampling points (right side).

Samples name and locations

Table 1: Samples name and locations.

Sample location	Sample name
Dr MuhammadShahidullah Hall pond (North side)	S-1
Dr Muhammad Shahidullah Hall Pond (South side)	S-2
Dr Muhammad Shahidullah Hall Pond (middle-East side)	S-3
Dr Muhammad Shahidullah Hall Pond (middle-West side)	S-4
Jagannath hall pond (East side)	S-5
Jagannath hall pond (West side)	S-6
Jagannath hall pond (North)	S-7
Shahid Sergeant ZahrulHaq Hall pond (North side)	S-8
Shahid Sergeant ZahrulHaq Hall pond (Southside)	S-9
Bangladesh national museum pond (East side)	S-10
Bangladesh national museum pond (West side)	S-11
Bangla Academy Pond (South side)	S-12
Bangla Academy Pond (North side)	S-13
Ramana Park Lake 1 (North side)	S-14
Ramna Park Lake 1 (South side)	S-15
Ramna Park Lake 1 (middle East side)	S-16
Ramna Park Lake 1 (middle West side)	S-17
Ramna Park Lake 2 (North side)	S-18
Ramna Park Lake 2 (South side)	S-19
Ramna Park Lake 2 (east side)	S-20
Ramna Park Lake 2 (west side)	S-21
Institute of fine arts pond (North side)	S-22
Institute of fine arts pond (North side)	S-23

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3 Experimental

3.1. pH meter: A hydrogen ion activity meter, or pH meter, assesses the acidity or alkalinity of a solution by monitoring the concentration of hydrogen ions in the sample being tested. pH is a scale from 1 to 14 that quantifies the concentration of hydrogen ions in a solution. We used a Hanna HI-98128 Waterproof pH meter, which measures in the range of -2.00 to 16.00. Precision in pH measurement is.05, the temperature range is from -5.0 to 60.0 degrees C (23.0 to 140.0 degrees F), and the resolution in both temperature and pH measurement is 0.1 degrees C (0.1 degrees F). Working relative humidity is at 100%.

3.2 GAMMA-SCOUT Radiation Detector: The GAMMASCOUT was developed to identify potentially dangerous forms of ionizing radiation, such as gamma, alpha, beta, and x-radiation. The radiation level may be measured around the clock with the press of a single button, and it has an extremely long-lasting V-MAX battery that lasts for ten years.

3.3 Zinc sulphide scintillation detector: A dual scintillation detector is a dual phosphor detector or a dual scintillation detector that couples two scintillating materials to a photomultiplier tube. A ZnS scintillation counter is an example of this kind of detector (PMT). The term "phoswitch" is used to refer to these detectors in various contexts (for phosphor sandwich). A ZnS layer that is attached to a plastic scintillator can be found within the MPC-2000-B-detector. DP's This detector was specially constructed. A photomultiplier tube (PMT) is optically connected to the combination. The deepest layer is responsible for detecting alpha particles, whereas the outermost layer is responsible for detecting beta particles. The DP (phoswich) detector gives an efficiency that is comparable to the alpha detector but somewhat lower than the beta detector. The environment has a significant impact on the overall functioning of the background [24]. The raw counts were converted from counts per minute (CPM) to disintegration per minute (DPM) and finally into units of activity per sample, such as Bq kg^{-1} and Bq L^{-1}, using equations based on the original data. The ZnS scintillation detector and the gas proportional counter were used, one at a time, to determine the total amount of gross alpha and gross beta activity in the dry residue of the tap water samples. In order to calibrate the detectors, known activity standard sources such as Th-230 and Sr-90 were used. The effectiveness of the detector in terms of gross beta is 41 percent, while its efficiency in terms of gross alpha is 36.8 percent. For each counting period, the total amount of time allotted for counting gross alpha and gross beta activities was 120 minutes. When it came time to do the backdrop count, a blank planchette was employed. The net count of the environmental sample may be calculated by taking the sample count and subtracting the background count from that number.

The Bangladesh Atomic Energy Commission's Secondary Standards Dosimetry Laboratories (SSDLs) laboratory was responsible for the calibration of the aforementioned equipment.

3.4 Preparation of water sample: Each sample was given around 1 L and put into a 1 L beaker. Each water sample received 1 mL of concentrated HNO3. The water samples were then gradually evaporated during a water birth close to dryness (20 mL approximately). The beaker was covered with a watch glass as the liquid evaporated. After drying under an IR light and cooling, it was placed to a 2-inch stainless steel counting planchet. Weighing and storing the dry residue in desiccators. In Fig.2, the process of water sample preparation was described schematically, and every step was followed for each sample.

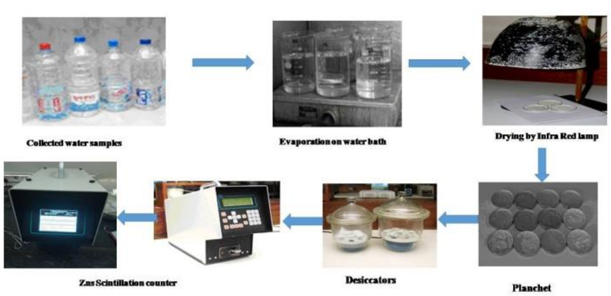

Fig.2: schematic diagram of water sample preparation and gross Alpha/Beta measurement.

3.5 Calculation of gross alpha/beta activity: The following equation was used to compute the gross alpha/beta activity:

"DPM=NET_CPM×100/EFF……………………………(1)

Where, DPM = alpha/beta disintegration per min,

NET_CPM = Net alpha/beta countper min, and

EFF = alpha/beta efficiency percentage.

Gross Alpha/Beta Activity (Bq/L) = DPM/(60 xW_t)………………..(2)

Weight of water W_t= 1 litter" [18,19].

The difference between the background count rate and the sample count rate is what is meant when people talk about the net count rate in relation to activity measurement. This is because the gross count rate of the sample is equal to the sum of the background count rate and the sample count rate.

4 Results and Discussion

4.1 Dose rate measurement: The measured dose rates in Fig.3, due to natural radionuclides were ranged from 0.10 μSvh^{-1} to 0.16 μSvh^{-1}. All the measured values of our study have existed within the normal range of background radiation [25]. The average dose rate was calculated, likely 0.130435±0.019183 μSvh^{-1}. Usually, the annual outdoor dose can be calculated using this data, but all the data were in the normal range. For this reason, annual dose measurement was not compelling work.

In addition, monitoring ambient radioactivity and radiation is essential for developing a baseline database using information derived from natural sources [26]. The national baseline database is significant for comparison to any study report. This study is beneficial to knowing our selected sampling area's current background radiation dose rate.

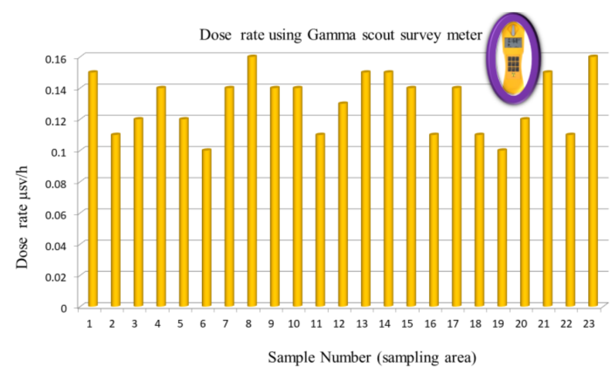

Fig.3: Dose rate of the sample location using portable Gamma Scout radiation detector.

4.2. pH measurement of water sample: The pH values for all the collected samples for the research are presented in Fig.4, the pH values of the samples analyzed show that the samples have pH values within the typical values accepted for water use [27]. The pH variation observed in our founded value range was between 6.7 and 7.5. A maximum pH value was observed for four samples, and a minimum range was observed for three. The average pH value was around 7.1±0.287623, nearly the expected pH value of water. There are many reasons for the pH variation of our collected sample. We measured all the Ph values at the sample collection spot. So mainly, these values were related to the source area of water—the primary sources of our collected water sample water rainwater and natural borehole water of selected areas. Nevertheless, many local people use this water for bathing, washing clothes, dishes, and daily uses. Moreover, several types of chemicals like soaps, detergents and powder were used for bathing and washing purposes, and it is mainly responsible for changing the average pH value of our collected water sample.

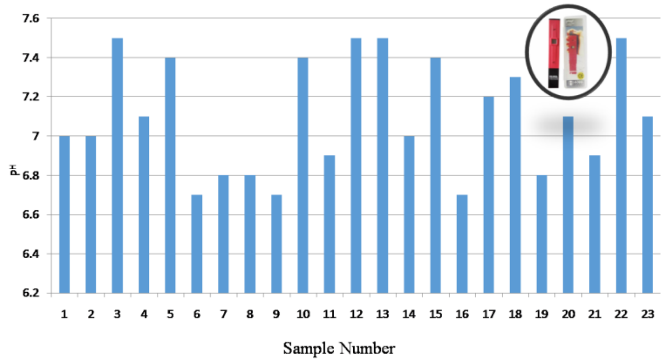

Fig.4: pH value of collected water samples.

4.3. Alpha count of Background: Fig.5, presents the alpha background count rate obtained in the alpha-only mode. The range of the background count rate was observed from0.03 to 0.10 CPM. Samples9, 16, and 20showa higher alpha background count rate of 0.10, although it is within the acceptable limit for drinking water set by the World Health Organization (WHO) of 0.5CMP. The low alpha background count rate recorded at the study site of samples1 and 3 is .02 CMP. The average calculated Alpha background counts per minute were 0.071304±0.021171 CPM. All experimental values were in a suitable range, but it is slightly higher than several previous research but within the acceptance limit. Several planchets were used for this experiment, but it was ensured that the same planchet was used for the corresponding sample measurement. So, this type of change can be a reason for different count rates.

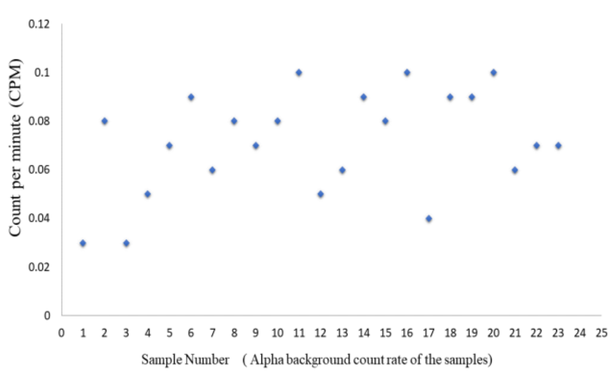

Fig.5: Background Alpha count for all samples.

4.5. The Beta count rate of Background: At the time of beta count rate, the background count rates in the dual-mode of Alpha and Beta count mode because in our instrument, the only beta mode was unavailable. The obtained value was nicely decorated in Fig. 6, and all values were found in a suitable range. In the Dual mode, the Beta background count rate range was observed from 96.123 to 103.211 CPM. The value of obtained count per minute was matched withina slight variation. The lowest value was found at 96.123 CPM in four samples, and the highest was obtained at 103.211 CPM. So, the difference in this range was only about 7 CPM. The average values were also calculated below the WHO limit, 99.6483±2.35377 CPM. So, this was a slight variation, and all of the data were in the acceptance range according to the international guideline.

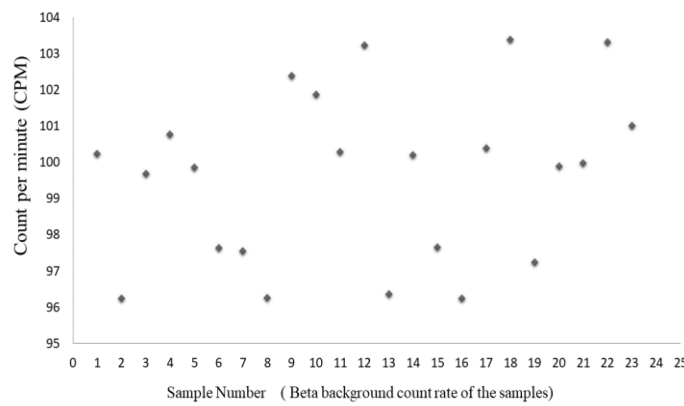

Fig.6: Background Beta count rate for all samples.

4.6. Gross Alpha and Beta Radioactivity in Samples: The alpha and beta activity concentration results on the analyzed samples were presented in Fig.7 and Fig.8, respectively. The activity was measured in mBq/L unit and was represented in the graph. The results of the activity concentration confirm that most of the samples had low alpha activity. Higher alpha activity concentration was observed in sample 12, and sample 6 had the lowest alpha activity compared to all the samples analyzed. The samples' mean Alpha and Beta activity were calculated at about 18.19661±5.357773 mBq/L and 93.90048±17.54712 mBq/L, respectively. However, in terms of the Beta activity of the analyzed samples, higher beta activity was observed in most of the samples. The results of beta activity in the samples show that most of the analyzed samples had an immediate difference in beta activity concentration beyond the accepted level for drinking water set by the United States Environmental protection agency (USEPA) and World Health Organization (WHO). The highest beta activity concentration was observed in descending order on samples 5, 23, 19, 13, and 6; the lowest beta activity was recorded in sample 1 and the second-lowest in sample 4. In Fig.7, the gross Alpha radioactivity was indicated by mBq/L, and the gross Alpha activity concentration range was from 7.987mBq/L to 28.179mBq/L. The highest value, 28.179mBq/L, was found in sample number 12, collected from Bangla Academy Pond and the Second highest, 26.394mBq/L, was collected from Ramna Park Lake 2 (south side).

Similarly, the highest beta activity was observed at 120.864mBq/L, and the Lowest activity was57.329 mBq/L which was collected from Dhaka University residential area. In the case of both gross Alpha and Gross Beta radioactivity, the lowest and the highest value difference was not too large. Moreover, the values were significantly lower than the recommended range of the World Health Organization (WHO). So, there was no significant alarming radiation activity in gross Alpha and gross Beta measurements. There was no Industrial zone in our study area, and there was no artificial toxic radioactivity creation system around this area. It was apparent that natural radionuclide was the primary source of our recorded gross Alpha and Beta radioactivity.

As per our knowledge, this study can be considered the first research work on determining the gross Alpha and beta activity in drinking water at the study site. However, validation and comparison are required with the studies conducted across the country and with the standards. For the studies reported in this section, all the analyses of the samples were carried out with the same sampling technique. As per our knowledge, some research groups also worked with tap water in Dhaka city, and they found the highest gross Alpha activity at 8.16 mBq/L, and the lowest value was 1.88mBq/L which water directly used for drinking purposes of city people [29]. Similarly, the highest and the lowest gross beta activity were 115.74mBq/L and 29.30mBq/L. Another report was found where research groups worked on bottled water, which was commercially manufactured water. In that research, the highest value was 0.96 mBq/L, and the lowest was 0.73 mBq/L for gross Alpha activity [29]. Moreover, in that paper, 77.29mBq/L and 65.54mBq/L was the highest and lowest Beta activity, respectively.

Moreover, the scientist group working with an environmental sample of Dhaka city investigated the drinking water of several areas of the city. They found the average gross Alpha activity of 0.91 mBq/L and gross beta activity of 175 mBq/L [30]. All previous works were on drinking water, but our research was on surface water in this area. There isa slight variation in gross Alpha activity result compared to drinking water. On the other hand, gross Beta activity is almost similar to their work.

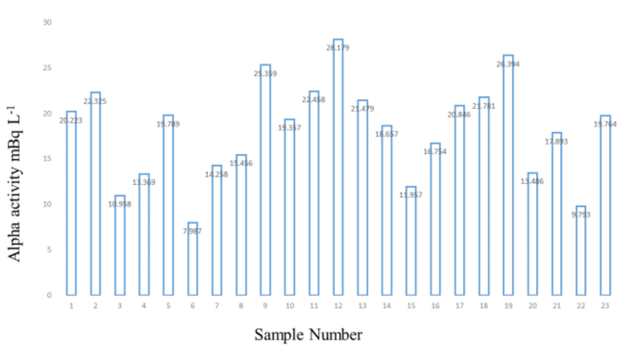

Fig.7: Gross Alpha Radioactivity in samples.

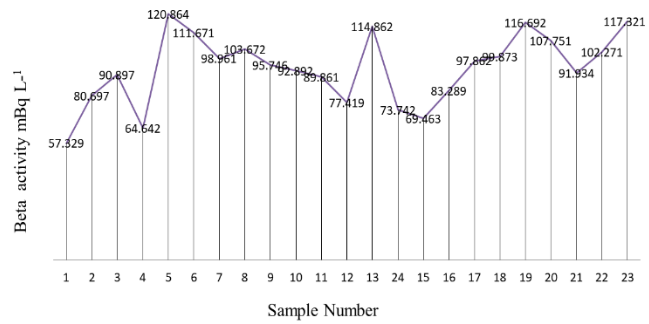

Fig.8: Gross Beta Radioactivity in samples.

5 Conclusions

Our survey and study of gross Alpha and beta radioactivity indicate that the water samples under investigation have a low concentration of alpha and Beta emitters; the activity was less than 0.5Bq/L for Alpha and 1 Bq/L for Beta activity. Moreover, the background radiation in the sampling area was below critical ranges. Another part of our research was the pH investigation of our collected water sample. No significant finding of pH value exceeded the standard range of measurement. It is possible to draw the conclusion that the radioactivity of water samples taken from any of the chosen places falls much below the threshold that has been established by the WHO. This seems to be the first comprehensive research of the gross Alpha and Beta activity concentration in surface water samples from this region, at least to the best of our knowledge. Nevertheless, further study has to be done in order to determine the specific radionuclides that are contributing to the overall gross radioactivity.

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Health Physics Division, Atomic Energy Centre Dhaka, Bangladesh Atomic Energy Commission**.**

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