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ASSESSMENT OF GROSS ALPHA AND BETA RADIOACTIVITY IN SURFACE WATER FROM RAMPAL UPAZILA, BANGLADESH: A BASELINE STUDY

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ABSTRACT. This study presents the first radiological survey of surface water in Rampal Upazila, located in Bangladesh's Bagerhat District, where no prior radiation monitoring data have been reported. Water samples were collected from 10 administrative unions, each representing local ponds used for household activities such as washing and bathing. Gross alpha and beta radioactivity measurements were conducted using a ZnS scintillation detector, while Gamma Scout dosimeter was used for background dose rate monitoring. The pH levels of the water were measured on-site to evaluate their possible influence on radioactivity behavior. The dose rates across the sampling sites were within the typical background range. The gross alpha activity in the samples remained below the WHO recommended limit of 0.1 Bq/L, with values varying moderately among locations. Similarly, the gross beta activity was found to be below the 1 Bq/L WHO threshold for drinking water. The findings indicate that the natural radioactivity levels in the surface water of Rampal are within safe limits and primarily of natural origin, with no indications of anthropogenic contamination. This study provides baseline data for future radiological assessments and public health monitoring in the region.

Keywords: Gross alpha, Gross beta, Natural radioactivity, Background radiation, drinking water, Rampal Upazila, Bangladesh.

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INTRODUCTION

Naturally occurring radioactive materials (NORM) are ubiquitous in the environment, present in soil, air, water, and biological systems as a result of the decay of uranium (^{238}U), thorium (^{232}Th), potassium (^{40}K), and their progeny, as well as from primordial radionuclides that are not part of these decay series. In addition, naturally occurring isotopes such as ^{40}K, ^{87}Rb, ^{3}H, and ^{14}C are also present in the environment and contribute to the overall background radiation levels (LEONARDI *et al.*, 2024; AWAN and BRADLEY, 2025). Surface waters, particularly in geologically active or densely populated regions, are especially susceptible to contamination from both natural and anthropogenic sources (ALOTAIBI *et al.*, 2024; YADAV *et al.*, 2024). Activities such as industrial discharge, agricultural runoff, and improper waste disposal can elevate the levels of radioactive isotopes in water bodies, posing potential health risks through ingestion or dermal exposure (KUNARBEKOVA *et al.*, 2024). Monitoring gross alpha and gross beta activity in surface water is an established approach for assessing environmental radioactivity and serves as a screening tool before proceeding to more detailed radionuclide-specific analysis. While alpha particles originate primarily from the decay of heavy radionuclides like uranium and radium, beta emissions are often associated with isotopes such as ^{40}K, ^{228}Ra, and ^{90}Sr. Gross alpha and beta measurements provide valuable initial information on radiological water quality and are routinely used in environmental radiation protection programs worldwide (ONG *et al.*, 2024; LAASSIRI *et al.*, 2025).

Bangladesh, with its dense population and extensive surface water networks, has been facing increasing concern regarding water quality, particularly in areas undergoing rapid urbanization and industrial development. Rampal Upazila, the focus of this study, is a region of increasing environmental interest due to recent land-use changes and proximity to energy-related infrastructure (KABIR *et al.*, 2022). Despite this, data on radioactive contamination in surface water in this area remain limited. Similar studies conducted in other regions have reported comparable findings, confirming that natural radioactivity in surface or drinking water often remains within safe limits. For instance, in Ogwashi-Uku, Nigeria, gross alpha and beta activities in hand-dug reservoirs were found to be below WHO thresholds, indicating minimal health risk to the local population (IJABOR *et al.*, 2024). Likewise, LI *et al.* (2022) demonstrated the effectiveness of liquid scintillation counting for routine monitoring of water samples, reporting alpha and beta concentrations well within safety margins across various water types.

The present study aims to evaluate the gross alpha and gross beta radioactivity levels in surface water samples collected from various ponds and water bodies in Rampal Upazila. The study uses field-deployable radiation monitoring equipment, including a ZnS scintillation detector and Gamma Scout dosimeter, to quantify ambient dose rates and radioactivity levels. The results are analyzed to determine compliance with international safety standards and to identify potential hotspots of radiological concern.

MATERIALS AND METHODS

Study area and sampling

Rampal Upazila is located in the southwestern part of Bangladesh, within the Bagerhat district. It comprises 10 administrative unions, each of which contains numerous ponds that serve as essential water sources for the local population.

These surface waters are commonly used for domestic activities, including bathing, washing clothes and utensils, and occasionally for cooking. Despite the widespread use of these water bodies, no previous radiation monitoring or radiological assessment has been conducted in this area.

In this study, 10 water samples were collected, one from each union (Fig. 1). The sampling points were selected from ponds that are frequently used by residents. Water samples were collected using 2-liter high-density polyethylene (HDPE) plastic bottles. Before collection, each bottle was thoroughly rinsed with water from the corresponding pond to minimize external contamination.

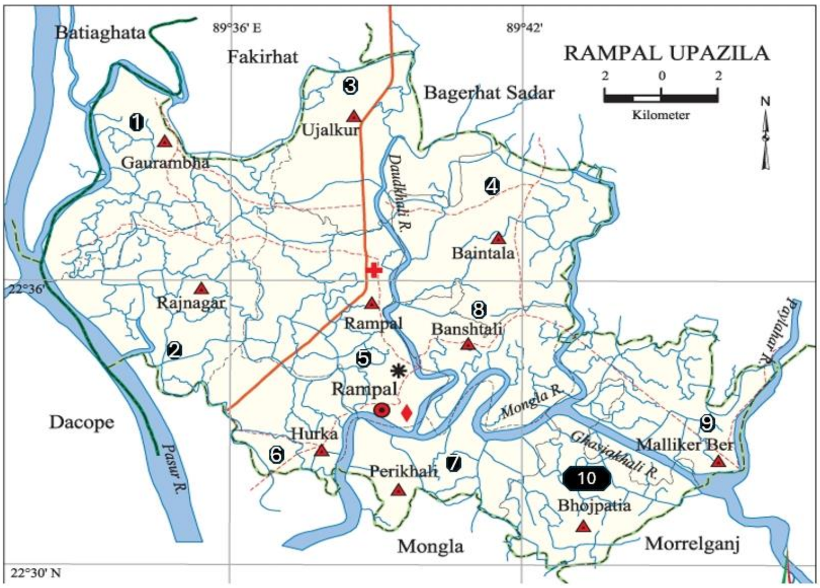


Figure 1. Map of Rampal Upazila within Bagerhat District, Bangladesh. Sample locations (1–10) are marked with black circles.

Measurement of background radiation

The ambient background dose equivalent rate at each sampling site was measured in situ using a portable Gamma Scout radiation detector (Gamma Scout GmbH, Germany). The instrument records the *ambient dose equivalent rate, H**(10), expressed in microsieverts per hour (μSv/h), which represents the dose equivalent at a depth of 10 mm in soft tissue due to external gamma radiation. Although the device is sensitive to alpha, beta, and gamma radiation, in this study it was used solely for quantifying external gamma dose rates in air. Measurements were taken approximately 1 m above ground level at each sampling location under stable meteorological conditions to minimize variations due to temperature, humidity, or precipitation. The collected surface water samples were subsequently analyzed in the laboratory for gross alpha and gross beta activity using a ZnS(Ag) scintillation detector.

pH measurement

pH value of each water sample was measured in the field immediately after collection using a portable digital pH meter (Hanna HI-98128). On-site pH measurement was performed to avoid any alteration in water chemistry that might occur during storage or transport. The pH scale, ranging from 0 to 14, reflects the acidity or alkalinity of water, with values around 7.0 considered neutral. Since pH can influence the mobility and solubility of radionuclides in water, it is a relevant parameter in the context of environmental radioactivity assessments.

Sample preparation for gross alpha and beta activity analysis

In the laboratory, each 1-liter water sample was acidified with 1 mL of concentrated nitric acid (HNO_3) to prevent adsorption of radionuclides onto the walls of the container and to stabilize the sample. The acidified samples were then transferred into beakers and evaporated slowly on a water bath to near dryness (approximately 20 mL remaining). During evaporation, a watch glass was used to cover the beaker to avoid external contamination. Once partially evaporated, the samples were dried completely under an infrared (IR) lamp, cooled, and the dry residues were transferred to 2-inch diameter stainless steel planchets. The planchets were weighed and stored in desiccators until the radioactivity measurement was performed. This method ensures consistent and reproducible sample preparation for gross alpha and beta analysis.

Radioactivity measurement and calculation

Gross alpha and beta activities were measured using a ZnS (Ag) scintillation detector, coupled with a photomultiplier tube (PMT) in a low-background counting system. The system was calibrated using standard reference sources: Thorium-230 (Th-230) for alpha particles and Strontium-90 (Sr-90) for beta particles. The detection efficiency was approximately 36.3% for alpha and 40.8% for beta radiation. Each sample was counted for 120 minutes to ensure reliable statistics. Background radiation was subtracted from the total count using a blank planchet. The following equations were used to calculate the activity concentrations:

$$\text{DPM}\ (\text{disintegrations per minute}) = \frac{(\text{Net CPM} \times 100)}{\text{Efficiency}\ (\%)} \tag{1}$$

$$\text{Activity}\ (\text{Bq/L}) = \frac{\text{DPM}}{60 \times \text{Volume in liters}} \tag{2}$$

Where:

CPM: The number of pulses (or counts) recorded by the detector per minute, representing the raw radioactive events detected.
Net CPM: The CPM value after subtracting background counts obtained from a blank planchet.
Efficiency (%): The percentage efficiency of the detector for the specific type of radiation (alpha or beta), determined using calibration standards (36.3% for alpha, 40.8% for beta in this study).
DPM (Disintegrations Per Minute): The true rate of radioactive disintegrations occurring in the sample, corrected for detector efficiency.

RESULTS AND DISCUSSION METHODS

This section presents the results of the radiological and physicochemical analysis of surface water samples collected from ten different unions of Rampal Upazila. The measurements included background radiation dose rates, pH levels, and gross alpha and beta radioactivity. All values were evaluated against international guidelines, particularly those set by the World Health Organization (WHO), to assess the potential radiological risks to public health (WORLD HEALTH ORGANIZATION, 2018).

Radiation dose rate assessment at sampling locations

The radiation dose rate was measured directly from the collected surface water samples using a Gamma Scout portable radiation detector. This measurement reflects the level of ionizing radiation associated with the water itself, not the ambient environment.

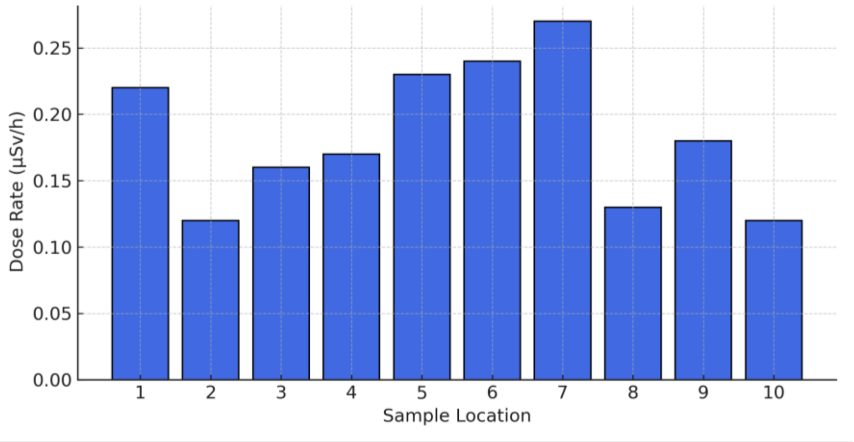


Figure 2. Radiation dose rate of the sample location using portable gamma scout radiation detector.

The results are presented in Fig. 2, which shows dose rates ranging from 0.124 µSv/h to 0.266 µSv/h. The maximum dose rate was recorded at Sample 7, while the lowest values were observed at Samples 2 and 10. The average dose rate across all samples was approximately 0.189 µSv/h, which does not indicate any elevated or abnormal radiation exposure in the studied area. The variation in dose rate among different sample points may be influenced by local geological features, soil composition, or the presence of naturally occurring radionuclides in the area. Importantly, no industrial or artificial sources of radiation are present near the sampling sites, confirming that the observed values likely originate from natural sources only.

pH analysis of water samples

The pH of each water sample was measured directly on-site to assess the chemical characteristics of the surface water. As shown in Table 1., the pH values ranged from 6.75 to 7.37, with an average of 7.05.

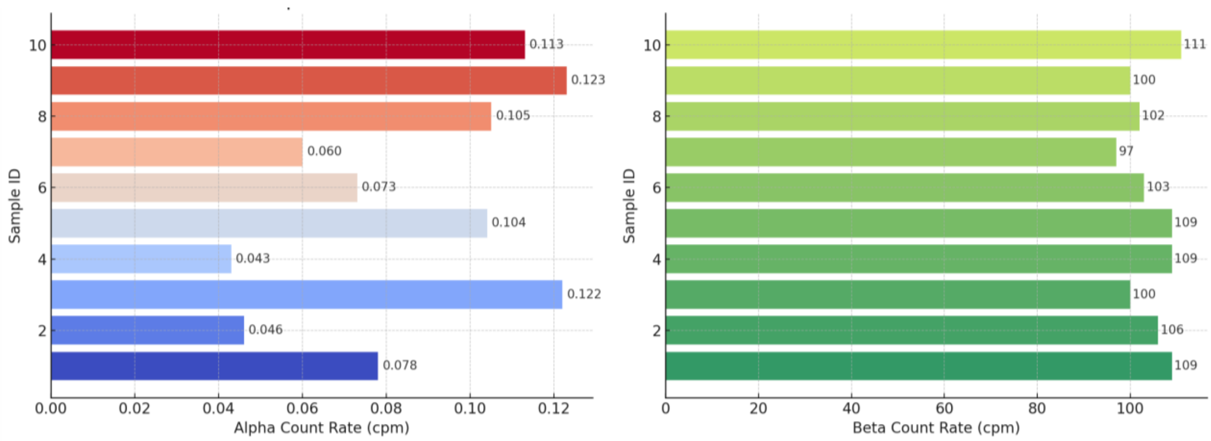
Table 1. pH values at sampling sites.

Sample ID	pH Value
P1	6.94
P2	6.81
P3	7.37
P4	6.94
P5	6.75
P6	6.76
P7	7.34
P8	7.1
P9	7.27
P10	7.23

Most samples exhibited pH levels close to neutral, indicating a chemically stable aquatic environment. The slightly lower pH values observed in Samples 5 and 6 may result from organic content or biological activity in those specific ponds. Conversely, higher pH values in Samples 3 and 7 suggest potential mineral input or detergent use from human activity. All measured values fall within the acceptable range for surface water (typically 6.5–8.5), as recommended by environmental and health standards. Therefore, the water sources are considered safe from a pH perspective for household use such as bathing and washing.

Background count rate measurements for alpha and beta radiation

Prior to measuring gross alpha and beta activity in the water samples, background radiation levels were recorded using the ZnS (Ag) scintillation detector. These measurements, shown in Fig. 3, reflect the baseline count rates in the absence of any samples.



a) b)

Figure 3. Background count rates measured for (a) alpha and (b) beta channels prior to sample analysis.

As shown in Fig. 3(a), the gross alpha background count rates ranged from 0.043 to 0.123 counts per minute (cpm). The highest rate was recorded during the calibration period preceding Sample 9, followed by Sample 3 (0.122 cpm) and Sample 10 (0.113 cpm). The lowest background alpha activity was observed prior to Sample 4 (0.043 cpm). These low values are typical of alpha background in well-shielded systems and confirm stable detector performance. The beta background count rates, presented in Fig. 3(b), ranged from 97 to 111 cpm. The highest was recorded before Sample 10 (111 cpm), and the lowest before Sample 7 (97 cpm). As beta-emitting isotopes are more prevalent in the environment, background beta rates are inherently higher. The variation remained within acceptable margins, validating the system's consistency and low noise level. These background measurements were used to correct the raw sample counts and calculate net activity levels. Their stability across all measurement sessions supports the reliability of subsequent alpha and beta activity data reported in this study.

Gross alpha and gross beta radioactivity

The measured gross alpha and beta activities in surface water samples from Rampal Upazila reveal notable variation, as depicted in Fig. 4. While all values remain within internationally recommended safety limits (World Health Organization, 2018), the relative differences between samples merit further consideration, particularly in the context of environmental and anthropogenic factors.

Gross alpha activity ranged from 13.4 to 27.8 mBq/L, with elevated levels in Samples P5 and P10. These values may be attributed to the natural dissolution of uranium- and thorium-bearing minerals in sediment, as well as the possible accumulation of organic matter. The detection of such peaks in otherwise stable background levels could suggest localized geological inputs or organic decomposition in stagnant water bodies, which can mobilize naturally occurring alpha emitters. Minor fluctuations observed in the dose rate and activity levels among sampling locations may reflect natural heterogeneity in the sediment composition of the Rampal area, which forms part of the lower Ganges deltaic plain. The region is primarily composed of recent alluvial and tidal deposits, including sandy silt, clayey silt, and fine-grained sediments derived from upstream erosion products of the Himalayan foothills and transported through the river network (AHSAN *et al.*, 2022; BANGLAPEDIA, 2023). These geological formations may contain trace concentrations of naturally occurring radionuclides such as ^{238}U, ^{232}Th, and ^{40}K, contributing to spatial variations in background radiation. In addition, organic-rich or stagnant water bodies can influence the mobility and chemical behavior of these radionuclides rather than their production. Organic matter decomposition alters redox potential and pH conditions, promoting complexation or desorption of uranium and radium species from sediments into the water phase (YANG *et al.*, 2012; SIRAZ *et al.*, 2025). Such geochemical and environmental factors together provide a plausible explanation for the minor dose rate variations detected in Rampal's surface water samples.

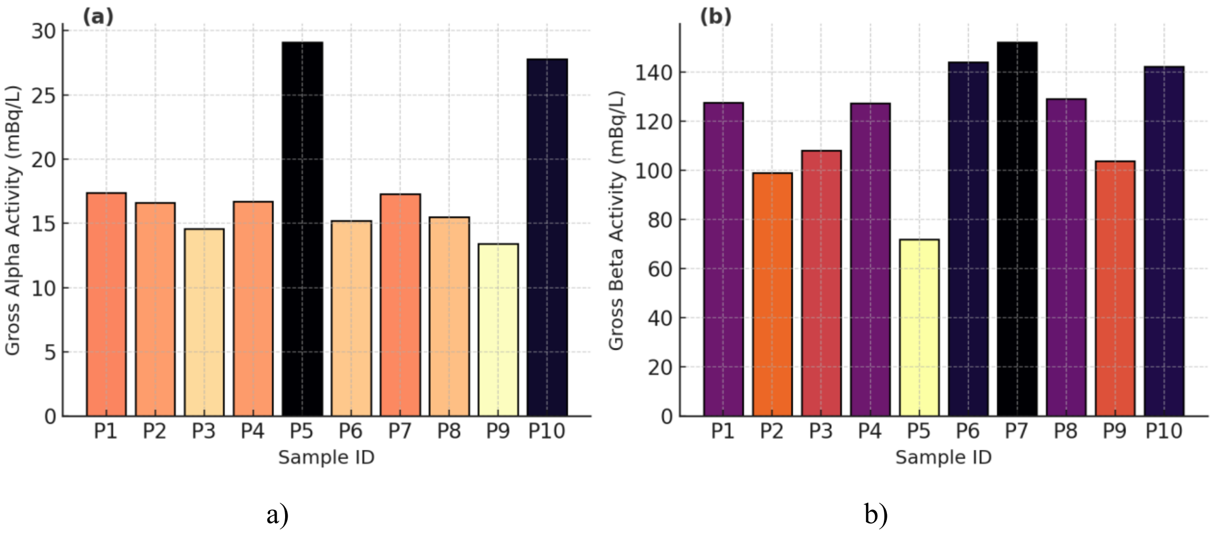


Figure 4. (a) Gross Alpha Radioactivity Distribution (mBq/L) Across Sampled Angles
(b) Gross Beta Radioactivity Distribution (mBq/L) Highlighting Key Samples (P1–P10).

In contrast, gross beta activity exhibited a broader range (97.4 to 152.1 mBq/L) and consistently higher values across all samples. The highest beta activity observed in Sample P10 may reflect diffuse anthropogenic inputs, such as agricultural runoff, domestic wastewater, or residual fertilizer use, all of which are known to introduce beta-emitting isotopes into surface waters. Despite the relative increases in some samples, all measured values are significantly below the WHO recommended screening levels for drinking water quality (gross alpha: 0.5 Bq/L, gross beta: 1.0 Bq/L), implying no immediate radiological risk to the population using these water sources for non-potable purposes. Moreover, the consistency between the spatial patterns of alpha and beta activity in some samples (notably

P10) suggests possible co-migration of radionuclides, which warrants further isotopic analysis to identify specific contributors (e.g., ^{226}Ra, ^{228}Ra). The observed variation underscores the importance of regular monitoring in areas with dynamic land use and hydrological conditions, especially in deltaic regions susceptible to sediment transport and contaminant accumulation.

To contextualize the radiological results obtained in Rampal Upazila, a comparative analysis was conducted with previously published studies from other geographical regions (Table 2). The gross alpha and beta activity concentrations in surface water from Rampal ranged between 0.013–0.028 Bq/L and 0.097–0.144 Bq/L, respectively. These values are significantly lower than those reported in environmentally stressed regions such as the Niger Delta, Nigeria, where crude oil contamination has resulted in gross alpha activity of 1.00 ± 0.09 Bq/L and beta activity of 20.3 ± 1.7 Bq/L (AGBALAGBA *et al*., 2021).

Table 2. Comparative table of gross alpha and gross beta activity across several countries.

Study location	**Matrix**	**Gross Alpha**	**Gross Beta (Bq/L)**	**Notes**
Rampal, Bangladesh (this study)	Surface water	0.013 - 0.028	0.097 - 0.144	All values below WHO limits
Niger Delta, Nigeria (AGBALAGBA *et al*., 2021)	Water	1.00 - 0.09	20.3 ± 1.7	High due to crude oil contamination
China (SANG *et al*., 2020)	Drinkin g water	0.0005 - 0.49 (mean: 0.029)	0.005 - 1.26 (mean: 0.091)	Cancer risk estimated; values within safe limits
Alba County, Romania (TĂBAN *et al*., 2024)	Drinkin g Water	up to 0.14	up to 0.30	Correlations with other quality parameters
Calabria, Italy (CARIDI and BELMUSTO, 2021)	Drinkin g Water	<0.04 - 0.16 ± 0.03	<0.20 - 0.34 ± 0.07	Compared to Italian legal limits

Similarly, studies from China have documented broader ranges of gross alpha (up to 0.49 Bq/L) and beta (up to 1.26 Bq/L) in drinking water, with average values still within WHO-recommended limits (SANG *et al*., 2020). The radiological quality of drinking water in Alba County, Romania and Calabria, Italy also showed elevated but compliant levels, particularly in regions with high natural background or specific hydrogeological conditions (CARIDI and BELMUSTO, 2021; TĂBAN *et al*., 2024).

The comparatively low values measured in Rampal suggest the absence of significant anthropogenic inputs and support the conclusion that natural radioactivity in the region is minimal. Moreover, the consistency of results across different sampling sites further indicates stable hydrogeological conditions with low geogenic radionuclide mobility.

CONCLUSION

This study assessed the gross alpha and gross beta radioactivity in surface water samples collected from Rampal Upazila, Bangladesh, using a ZnS(Ag) scintillation detector and a portable Gamma Scout device. The results indicated that both alpha and beta activity levels were within the permissible limits recommended by the WHO (0.5 Bq/L for gross alpha and 1.0 Bq/L for gross beta in drinking water). Gross alpha activity ranged from 13.4 to 27.8 mBq/L, while gross beta activity varied between 97.4 and 144.1 mBq/L. Samples P5 and P10 showed comparatively higher alpha levels, while Sample P10 also exhibited the highest beta activity. Despite this variation, no sample approached critical thresholds, suggesting the absence of significant radiological contamination in the studied water bodies. However, this study is limited by the relatively small number of sampling points, which may not fully capture spatial heterogeneity across the broader region. Expanding the number of monitoring locations and sampling during different seasons would provide a more comprehensive assessment of radiological variability. Future work should also include isotopic speciation to identify dominant contributors and assess potential seasonal or anthropogenic influences on radionuclide distribution.

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