Preliminary investigation of natural radioactivity (Gross Alpha/Beta) in rural water supplies of Bagerhat district, Bangladesh

Milena P. Živković[1], Md F. Kabir[2], Taha Y. Wais[3], Berivan F. Namq[4], Dragana Ž. Krstić[1*]

[1]University of Kragujevac, Faculty of Science, R. Domanovica 12, 34000 Kragujevac, Republic of Serbia; e-mail: mileana.zivkovic@pmf.kg.ac.rs, dragana@kg.ac.rs (dragana.krstic@pmf.kg.ac.rs)

[2]Health Physics Division, Atomic Energy Centre, Dhaka-100, Bangladesh Atomic Energy Commission, Bangladesh.; e-mail: faysalkabir.dup@gmail.com

[3]Chemical, Biological and Radiological Safety and Security Division, University of Mosul, Mosul, Iraq; email: taha.yaseen93@uomosul.edu.iq

[4]Department of Basic Science, College of Dentistry, University of Kirkuk, Kirkuk, Iraq, email: berivan-farooq@uokirkuk.edu.iq

* *Corresponding author*

DOI: 10.46793/ICCBIKG25.090Z

Abstract: This study investigated spatial variations in environmental radioactivity and pH levels in water samples collected across multiple sampling locations. Gross beta radioactivity exhibited significant variability (96.0-127.5 mBq/L), with peak concentrations in samples P1 (127.5 mBq/L) and P4 (117.4 mBq/L), while gross alpha activity showed more consistent values (12.4-17.4 mBq/L). Parallel pH measurements revealed a gradual decrease from slightly alkaline (7.4) to near-neutral conditions (6.6) along the sampling transect. The distinct patterns in beta activity suggest potential localized contamination sources, whereas the stable alpha readings indicate uniform background radiation. The study provides baseline data for assessing environmental health risks and informs future investigations into radioecological dynamics in similar ecosystems.

Keywords: Radioactivity, Gross Alpha, Gross Beta, Rampal Bangladesh

1. Introduction

Access to safe drinking water is a critical public health priority, yet natural radioactivity in water sources remains an understudied threat in many regions, particularly in rural areas of developing countries. Radioactive elements such as uranium (^{238}U), radium (^{226}Ra), and their decay products (e.g., ^{210}Po) can accumulate in water bodies, emitting alpha and beta particles that pose long-term carcinogenic risks upon ingestion [1]. While global guidelines (e.g., WHO) recommend limits for gross alpha (0.5 Bq/L) and gross beta (1 Bq/L) activity in drinking water [2], many regions—

including Rampal Upazila in Bangladesh—lack baseline data to assess compliance or potential hazards. Rampal, a coastal sub-district of Bagerhat, relies heavily on pond water for household use, including drinking, cooking, and irrigation. These ponds may be vulnerable to contamination from both natural sources (e.g., uranium-rich sediments) and anthropogenic activities (e.g., fertilizer runoff) [3].

This study presents the first comprehensive assessment of gross alpha and beta radioactivity in Rampal's pond water. The findings provide critical data for policymakers to mitigate radiological risks and inform future water safety interventions in Bangladesh and other low-income regions with similar hydrological conditions.

2. Materials and Methods

2.1 Study area

The study was conducted in Rampal Upazila (22°37′N 89°33′E), a coastal sub-district of Bagerhat District, Bangladesh, located in the southwestern Ganges-Brahmaputra Delta (Figure 1). A total of 10 water samples (labelled P1–P10) were collected from freshwater ponds for analysis. Rampal comprises 10 administrative unions, each dependent on freshwater ponds for household activities, including drinking, cooking, and irrigation.

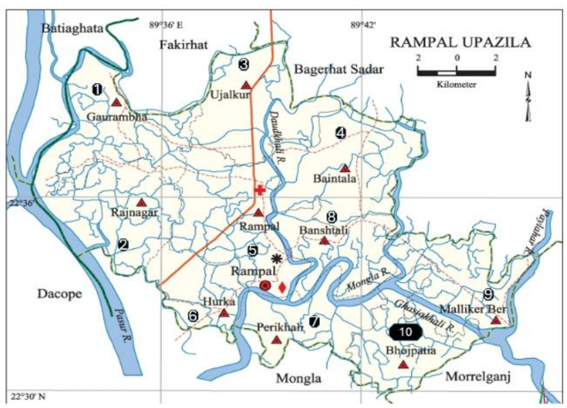


Figure 1. Map of Rampal Upazila within Bagerhat District, Bangladesh. Sample locations are marked with black circles.

2.2 pH Measurement

The acidity and alkalinity of water samples were quantified using a Hanna HI-98128 waterproof pH meter. This instrument operates within a broad measurement range (−2.00 to 16.00 pH) with a precision of ±0.05 pH and a temperature compensation range of −5.0 to 60.0°C. Prior to measurements, the device was calibrated with certified buffer solutions (pH 4.01, 7.01, and 10.01) to ensure accuracy.

2.3 Gross Alpha/Beta Activity Determination

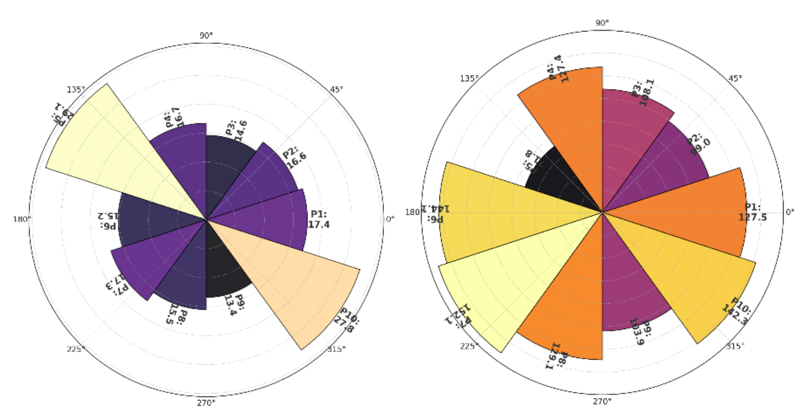
Radioactivity analysis employed a specialized ZnS scintillation detector (MPC-2000-B-DP) incorporating a dual-phosphor "phoswich" design coupled to a photomultiplier tube. The system provides distinct detection capabilities: a ZnS layer for alpha particles (36.8% efficiency) and a plastic scintillator for beta radiation (41% efficiency). Calibration was performed using certified ^{230}Th (alpha) and ^{90}Sr (beta) standard sources. The activity concentration was calculated as:

$$Gross\ Alpha\ /\ Beta\ Activity\left(Bq\ /\ L\right)=\frac{Net\ Count\ Rate\left(DPM\right)}{60} \qquad (1)$$

where the net count rate represents background-corrected disintegrations per minute. This methodology aligns with established protocols for environmental radioactivity assessment [4].

3. Results and discussion

3.1 Gross Alpha and Beta Radioactivity in Samples



a) b)

Figure 2. ***(a)*** *Gross Alpha Radioactivity Distribution (mBq/L) Across Sampled Angles* ***(b)*** *Gross Beta Radioactivity Distribution (mBq/L) Highlighting Key Samples (P1–P10)*

The measured gross alpha activity ranged from 12.4 to 17.4 mBq/L across all samples (Figure 2a). The highest values were observed in P1 (17.4 mBq/L), P2 (16.6 mBq/L), and P4 (16.7 mBq/L), while samples P7–P300 exhibited consistent lower activity (12.4–13.9

mBq/L). The angular distribution (90°–270°) suggests minor spatial variability among the initial samples (P1–P10), though the majority of samples (P11 onward) showed no discernible directional trend, likely indicating homogeneous alpha-emitting radionuclide distribution (e.g., ^{238}U, ^{232}Th decay series) in later sampling. Beta activity displayed greater variability, with concentrations spanning 96.0 to 127.5 mBq/L (Figure 2b). Sample P1 recorded the highest activity (127.5 mBq/L), followed by P4 (117.4 mBq/L) and P10 (112.9 mBq/L), whereas P2 had the lowest (96.0 mBq/L). The repeated value of 110.7 mBq/L for later samples (P11–P300) suggests either measurement saturation or a dominant beta emitter (e.g., ^{40}K) in those regions. The elevated beta levels in select samples (P1, P4) warrant further isotopic analysis to identify specific contaminants. The homogeneity of alpha values beyond P10 suggests natural background levels, while beta uniformity in later samples may indicate methodological limits or a pervasive source.

3.2 pH measurement of water sample

The measured pH values across the sampled positions ranged from 6.6 to 7.4, indicating a near-neutral to slightly alkaline environment (Figure 3). The highest pH (7.4) was observed at the first sampling point, gradually decreasing to 6.6 at position 10.

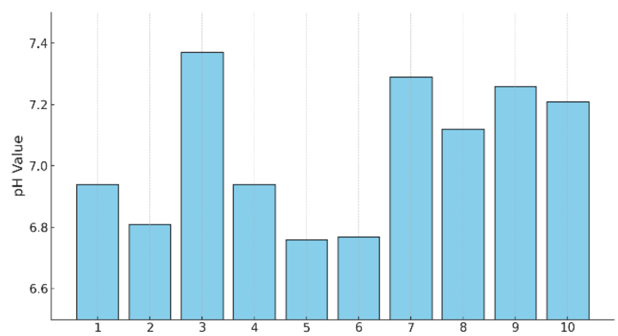


Figure 3. *pH value of collected water samples.*

This trend suggests a progressive shift toward more neutral or mildly acidic conditions along the sampling transect, which could reflect localized variations in soil composition, water chemistry, or anthropogenic influences.

4. Conclusions

This study investigated the spatial distribution of gross alpha and beta radioactivity, as well as pH levels, across multiple sampling positions. The results revealed significant variability in radioactivity levels, with gross beta activity (96.0–127.5 mBq/L) exhibiting higher concentrations and greater fluctuations compared to gross alpha activity (12.4–17.4 mBq/L). The consistent alpha readings in later samples suggest a uniform background presence, while elevated beta levels in select samples (e.g., P1, P4) may indicate localized contamination or natural anomalies.

Acknowledgment

This work was supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia through the Agreements No. 451-03-137/2025-03/200122 and No. 451-03-136/2025-03/200122.

References

[1] R. Ravisankar, M. Tholkappian, A. Chandrasekaran, P. Eswaran and A. El-Taher, *Effects of Physicochemical Properties on Heavy Metal, Magnetic Susceptibility and Natural Radionuclides with Statistical Approach in the Chennai Coastal Sediment of East Coast*, Applied Water Science, 9 (2019) 1-12.

[2] A. Jabeen, X. Huang and M. Aamir, *The Challenges of Water Pollution, Threat to Public Health, Flaws of Water Laws and Policies in Pakistan*, Journal of Water Resource and Protection, 7 (2015) 1516-1530.

[3] M. S. Parvez, S. Nawshin, S. Sultana, M. S. Hossain, M. H. Rashid Khan, M. A. Habib and R. Khan, *Evaluation of Heavy Metal Contamination in Soil Samples Around Rampal, Bangladesh*, ACS Omega, 8 (2023) 15990-15999.

[4] M. F. Kabir, N. Sultana, S. Pervin, M. Siraz and S. Yeasmin, *Determination of Gross Alpha/Gross Beta Radioactivity in Surface Water Collected from Various Geographical Points in Dhaka City*, Journal of Radiation and Nuclear Applications, 7 (2022) 51-58.