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Gross Alpha and Gross Beta Activity in the Water Sample from Northern Region of Bangladesh

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Abstract: Natural water is not completely free of radioactive isotopes due to the presence of beta and alpha emitters. Thus, measurements of natural radioactivity in ground, surface and domestic water have been performed in many parts of the world, mostly for assessment of the doses and risk resulting from consuming water. Gross alpha and gross beta particle activity is selected for the screening of radioactive species. The purpose of this study is to determine gross alpha and gross beta activities in water samples and asses the dose from the collected water samples. The radioactivity levels in 45 water samples were collected from tube-wells, shallow pumps, ponds and the river from different places of Kurigram district in the northern region of Bangladesh. The gross alpha and gross beta activities were measured using ZnS(Ag) scintillation counter. The average gross alpha activity concentrations were found to be 9.3±3.5 mBq/l for tube-wells, 12±4.2 mBq/l for shallow pumps, 16±3.8 mBq/l for ponds and 22±4.5 mBq/l for the river. The average beta activity concentrations were found to be 83±24 mBq/l for tube-wells, 80±24 mBq/l for shallow pumps, 252±26 mBq/l for ponds and 248±35 mBq/l for the river. The results show that the natural activities of alpha and beta emitting radionuclides in water samples did not exceed WHO recommended levels and were comparable with the data available in other parts of the world. It suggests that the radioactivity in drinking water for the people residing Kurigram is not yet a problem. This study has been undertaken to measure the radioactivity levels in water samples, as a part of environmental radioactivity-monitoring program for the assessment of radiation exposure to the population of Bangladesh.

Keywords: Gross Alpha and Gross Beta, ZnS(Ag) scintillation counter, Water sample, Annual total indicative dose .

1 Introduction

Man is always exposed externally and internally from natural background radiation as well as artificial radiation sources. Internal exposure comes from ingestion and inhalation. Humans are exposed naturally to ionizing radiation from a number of sources which include cosmic rays and natural radionuclides in air, food and drinking water [1]. The most common forms of ionizing radiation are alpha particles, beta particles and gamma rays [2]. Water is essential to life as air. Natural water is not completely free of radioactive isotopes due to the presence of beta and alpha emitters from the natural decay series of uranium, thorium and actinium and other isotopes such as 40K. Rain water and snow are also early indicators of radioactive contamination. In some places drinking water and rain water can be significant pathways of short lived radionuclides, e.g. radioiodine, to man or animals. Drinking water and household water are potentially important pathways, directly or through their use in food preparation and processing, although dilution, time delays and water treatment can reduce the contamination levels markedly. Water consumed by livestock and used for irrigation purposes can also be a source of radionuclides in foods. Sea water can be a contamination source for seafoods (e.g. mussels, shellfish, fish, algae). Water from streams, lakes and ponds should also be considered as a source of contamination [3]. Exposure of man to ionizing radiation can cause harmful effects. Thus, measurements of natural radioactivity in ground, surface and domestic water have been performed in many parts of the world, mostly for assessment of the doses and risk resulting from consuming water. But in Bangladesh only a limited number of studies on internal dose assessment have been performed. The

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main purpose of this present study is to calculate gross alpha and gross beta activity of water from different upazilas of kurigram, the northern region of Bangladesh and provides a base line data which can be used in future to evaluate any changes. The concentration of the radioactive isotopes in water depends on its geo-chemical history. According to the world health organization (WHO), about 1.1 billion of people do not have potable water and the biological contamination is a serious problem for that population. It is important that the biological chemical and radiological contamination of the potable water be equal or less than the levels recommended by international health organization like that recommended by the WHO or by national regulation. In order to guarantee an exposure lower than 0.1 mSv/y WHO recommends the guideline values for drinking water 0.1 Bq/l for alpha activity and 1 Bq/l for gross beta activity [4].The analysis has been carried out by using a Zinc Sulphide Scintillation Detector ZnS(Ag) in Health Physics Division, Atomic Energy Centre, Dhaka , Bangladesh.

2 Materials and Method

2.1 Location Description

Bangladesh is a reverine country. About 700 rivers including tributaries flow through the country constituting a waterway of total length around 24,140 kilometres (15,000 miles). Its geographical situation is downward to India. Most of the rivers of Bangladesh have been originated from the hill tracts of India, Nepal and Bhutan; and flown through the land of India. Therefore its land (and consequently the ground water) might be contaminated by radioactive sources from upstream [5]. The water samples are collected from different upazila of a northern district (Kurigram) in Bangladesh. The geographical map of Kurigram District is shown in Figure -1. Kurigram District is located in the northern region of Bangladesh along the border of India. The area of Kurigram is 2245.04 Sq Km. It is under Rangpur Division. The number of upazila (sub district) in Kurigram district is 09, named- Kurigram Sadar, Ulipur, Chilmary, Nageshwary, Vurungamari, Char-Rajibpur, Roumari, Rajarhat and Fulbari. Its coordinates are 25°45'0" N and 89°40'0" E in DMS (Degrees Minutes Seconds) or 25.75 and 89.6667 (in decimal degrees). The population is 2,069,273 (2011 national population census).

2.2 Sample Collection and preparation

In order to measure the natural and artificial radioactivity in under-ground [Tube well water (TW), Shallow water (SW)] and surface water [Pond water (PW), River water (RW)], forty-five water samples were collected randomly from different locations of different upazila of kurigram district in winter season. Pond and river water samples were collected from surface region (PWS, RWS), 0-2cm approximately and deep region (PWD, RWD), 15-25cm

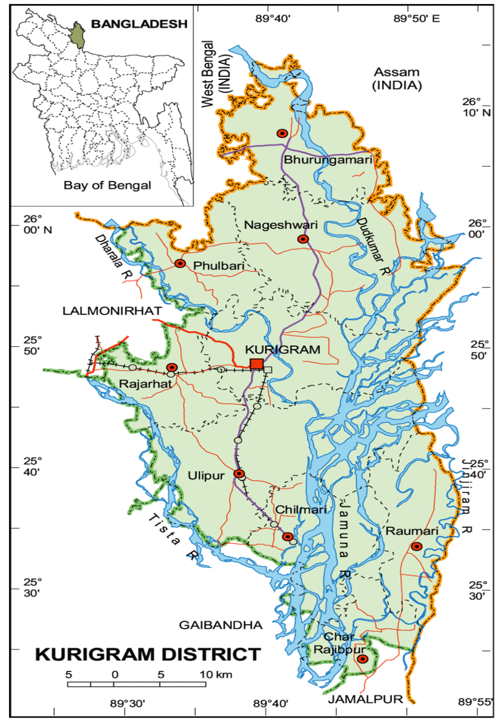

Fig.1: Map of Kurigram District, Bangladesh.

approximately. The depths of the tube wells were greater than 40 feet approximately where the depth of the shallow pumps were greater than 80 feet approximately. The choice of sampling locations was based on elevated radiation background in the northern region in Bangladesh. The samples were kept into previously cleaned 1 L capacity plastic bottle using manual procedure. The samples were appropriately coded from 1 to 45 and transferred to Environmental Radioactivity Monitoring Laboratory of Health Physics Division at Atomic Energy Centre, Dhaka, Bangladesh. Forty five 1 L capacity Pyrex beakers were washed with distilled water and left to dry to avoid sample contamination. About 1 L of each sample was poured into a Pyrex beaker. One milliliter concentrated HNO_3 was added to each water sample to avoid the collection of organic materials and changes in the oxidation state of the ions present in the samples. Subsequently, the water samples were slowly evaporated by water bath treatment at 105^0C and reduced upto 5 mL approximately. During evaporation of water sample, the pyrex beaker was covered with watch glass. Then it was transferred to a 2 inch stainless steel counting planchet and dried under IR lamp, cooled and weighed to determine the activity. Then the sample residue was kept in desiccator to avoid moisture [6].

2.3 Zinc Sulphide Scintillation Detector

ZnS(Ag) Scintillation counter is a dual phosphor detector or dual scintillator detectors coupling two scintillating materials to a photomultiplier tube. These detectors are sometimes referred to as a “phoswich” (for phosphor sandwich). This type of detector is used primarily because it does not need a supply of counting gas. Without a high pressure gas supply the detector and counting system can be moved and located more easily. There is also no safety hazard from the P-10 gas bottle. The combination was optically coupled to a photo-multiplier tube (PMT). The MPC-2000-B-DP contains a custom designed detector with a zinc sulfide layer bonded to a plastic scintillator. The combination is optically coupled to a PMT. The outermost layer detects alpha particles, and the inner layer detects beta particles. In general, and compared to a gas flow detector, the DP (phoswich) detector offers equivalent alpha efficiency, and slightly lower beta efficiency. Background performance is somewhat similar, but is very much dependant on the environment [6]. A sample was inserted underneath a detector, a timer was started and the accumulated counts were recorded at the termination of the preset period. Reporting a result in counts per minute, however, is of little benefit. Calculations must be performed on the raw data in order to produce a meaningful report. These calculations convert the raw counts from counts per minute (CPM) into disintegration's per minute (DPM) and finally into units of activity per sample such as BqL^{-1}. As is the practice in all analytical measurements, propagated uncertainties should also be calculated and reported [6].

2.3.1 Calibrated Factors

In order to accumulate counts in terms of activity, several conversion factors constitute the instrument calibration. Once determined, conversion factors must be revalidated on a routine basis to insure instrument stability. This is accomplished (usually daily) by collecting counts from a standard and comparing the results to those obtained during the calibration. If these results repeat within statistical expectations, the instrument is stable and the calibration conversion factors are valid [6]. To report results in terms of disintegration's per minute (DPM) or other units of activity, the appropriate Conversion factors must be entered. Before counting "real" samples efficiency factors will be determined by counting standards with known levels of activity. Backgrounds will be determined by counting blank samples. For this exercise we will use some typical values. These values are entered into the appropriate Calibration files for our "Gross Alpha" and "Gross Beta" counting routine before counting our sample again [6].

Assume the following calibration factors:
Alpha Efficiency: 36.8%
Alpha Background: 0.05 CPM (determined in a single 120 minute count)
Beta Efficiency: 41.2%
Beta Background: 63 CPM (determined in a single 120 minute count)

2.3.2 Gross Alpha and Gross Beta Activities Calculation

For gross alpha and beta activity each samples was counted for 120 minutes. The results were displayed as count per minute, activity and standard deviation. The data were acquired for alpha and beta mode. The alpha and beta count rate as well as alpha activity and beta activity were calculated using the following formula [6]:

$$DPM = \frac{Net\ \ CPM}{60 \times \varepsilon \times V} \qquad (1)$$

Where, *DPM*= Net Alpha or Beta Disintegrations per Minute

Net CPM= Net Alpha or Beta Counts per Minute

ε = Alpha *or Beta Efficiency* in Percent.

V = Volume

2.3.3 Method for LLD Calculation

The Lower Limit of Detection is defined as the smallest amount of activity that can be detected for comparison with regulatory limits. LLD values also provide a basis for predicting the least amount of radiation which can be detected by the instrument in the given counting time with the given set of calibration factors and sample variables [7]. The method we used for the LLD calculation is derived from the definition of counting sensitivity as given in the National Interim Primary Drinking Water Regulation. These equations were developed by applying probability theory to the counting statistics with pre selected levels of reporting confidence. The equation is shown below:

$$LLD = \{1.92 + \sqrt{(3.69 + 7.68 R_b T)}\} / TE \qquad (2)$$

Where, R_b is Background Count Rate; T is Background count time and E is counting efficiency.

3 Results and Discussion

The measured activity concentrations of gross alpha and gross beta in surface and tube-well water samples from different upazilas in Kurigram are presented in Tables 1- 5. The activity concentration less than the below detection limit which is expressed as BDL in the tables.

Table 1: Gross Alpha and Gross Beta Activity in Water Samples of Ulipur, Kurigram.

Location Name	Sample No.	Sample Type	Activity concentration in mBq/L	
			Gross Alpha	Gross Beta
Atharo Paika	1	TW	BDL	59±33
	2	TW	7.2±2.7	102±36

Borodighi, Atharo Paika	3	PWS	11±3	585±40
	4	PWD	8.6±2.9	1830±49
Janotar Hat, Buraburi	5	TW	19 ± 10	BDL
	6	TW	BDL	BDL
	7	PWS	BDL	87±34
	8	PWD	BDL	127±35
Notun Anontopur	9	SW	15±4	135±29
	10	SW	23±10	BDL
Atharo Paika	11	SW	11±3	135±35
	12	SW	BDL	50±31
Pataripukur, Baparipara	44	PWS	73±19	229±37
	45	PWD	BDL	BDL

Table 2: Gross Alpha and Gross Beta Activity in Water Samples of Rajarhat, Kurigram.

Location Name	Sample No.	Sample Type	Activity concentration in mBq/L	
			Gross Alpha	Gross Beta
Sobuj Para, Forker Hat	13	TW	BDL	BDL
	14	TW	24±10	43±28
	15	PWS	BDL	981±36
	16	PWD	60±18	157±30
Dhopa Para, Forker Hat	17	TW	BDL	246 ±31
	18	TW	5.9±2.7	BDL
	19	PWS	26±10	BDL
	20	PWD	BDL	190±30

The value of Lower Limit of Detection (LLD) is 5.8 mBq/l for alpha and 15.4 mBq/l for beta. The observed gross alpha activity concentration found in all water samples vary from BDL to 133±19 mBq/l with the mean 9.3±3.5 mBq/l for tube-wells, 12±4.2 mBq/l for shallow pumps, 16±3.8 mBq/l for ponds and 22±4.5 mBq/l for the river as presented in Table 6. In most upazilas the alpha activity concentrations of pond water were higher than the tube-well water as shown in figure 2. The highest mean gross alpha activity concentration was found in river water and the lowest mean gross alpha activity concentration was found in Tube-well water as shown in figure 3.The gross alpha activity concentration for underground water was found to be lower than that of surface water as shown in figure 3.

Table 3: Gross Alpha and Gross Beta Activity in Water Samples of Kurigram Sadar.

Location Name	Sample No.	Sample Type	Activity concentration in mBq/L	
			Gross Alpha	Gross Beta
Sara, Jotiner Hat Sadar	21	TW	BDL	122±29
	22	TW	BDL	75±36
	23	PWS	BDL	BDL
	24	PWD	BDL	92±34
Jotiner Hat	25	TW	BDL	91±28
	26	TW	35±10	71±29
	27	PWS	30±5	BDL
	28	PWD	BDL	202±30
Kurigram	43	TW	BDL	66±34

Table 4: Gross Alpha and Gross Beta Activity in Water Samples of Chilmari, Kurigram.

Location Name	Sample No.	Sample Type	Activity concentration in mBq/L	
			Gross Alpha	Gross Beta
Ranigong Bazar	29	PWS	BDL	76±34
	30	PWD	BDL	70±29
RDRS Office, Ranigong	31	TW	BDL	94±29
	32	TW	45±11	153±30
	33	PWS	BDL	48±28
	34	PWD	BDL	137±29
Sonapara	35	TW	BDL	123±29
	36	TW	18±12	105±34
Brahmaputra River River	37	RWS	42±9	207±34
	38	RWD	BDL	288±35

Table 5: Gross Alpha and Gross Beta Activity in Water Samples of Nageshwari, Kurigram

Location Name	Sample No.	Sample Type	Activity concentration in mBq/L	
			Gross Alpha	Gross Beta
Vangamor, Vitorbond	39	TW	BDL	143±33
	40	TW	23±8	86±29
	41	PWS	48±17	BDL
	42	PWD	BDL	246±31

Table 6: Average Gross Alpha and Gross Beta Activity in Different Types of Water Sample

Types of Water Sample		Mean activity concentration in mBq/L	
		Gross Alpha(mBq/l)	Gross Beta(mBq/l)
Under Ground	TW	9.3±3.5	83±24
	SW	12±4	80±24
Surface	PW	16±4	252±26
	RW	22±5	248±35

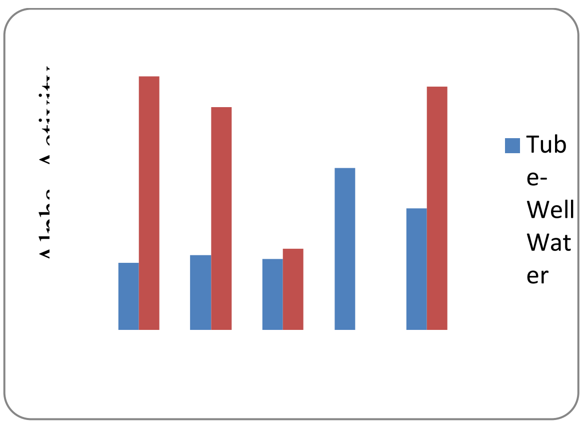

Fig. 2: Comparison of mean gross alpha activity concentration between tube-well and pond water in different upazila of Kurigram.

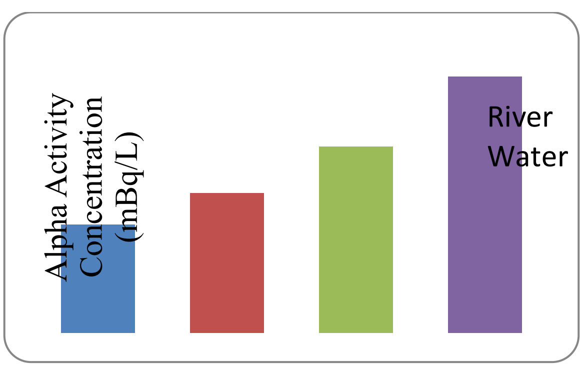

Fig. 3: Comparison of mean gross alpha activity concentration among different types of water in Kurigram

The gross alpha activity concentration in water sample is primarily due to uranium and thorium decay products and ^{40}K. WHO recommends that the gross alpha activity concentration to be less than 0.1 Bq/l. If the gross alpha activity concentration doses not exceed 0.1 Bq/l, it can be assumed that the annual total indicative dose is less than 0.1 mSv per year. The results obtained show that the measured activity concentrations of gross alpha in all tube-well (drinking) water samples are less than the limit recommended by WHO. The experimental gross beta activity concentration found in all water samples vary from BDL to 1830±49 mBq/l with mean 83±24 mBq/l for tube-wells, 80±24 mBq/l for shallow pumps, 252±26 mBq/l for ponds and 248±35 mBq/l for the river as presented in Table 7.

Table 7: Gross alpha and gross beta activity in different types of water in different region in the world [6,8-13]

Country	Type of Water	Gross Alpha *(Bq/L)*	Gross Beta *(Bq/L)*
Greece	Bottle water	0.008-0.094	0.071-0.350
Australia	Drinking water	0.7-1.40	0.98-1.15
Mexico	Mineral water	<0.011-0.415	<0.026-0.695
Turkey	Tap water	0.0002-0.015	0.0252-0.2644
Brazil	Ground water	0.001-0.4	0.12-0.86
Italy	Tap water	<0.0077-0.349	<0.025-0.273
	Tap water	<0.008-0.186	<0.048-0.150

	Tap water	<0.01812-0.1282	<0.04157-0.25859
Jordan Amman	Tap water	<0.05-0.2495±0.0232	<0.1879-0.3270±0.0286
Jordan Aqaba	Tap water	0.04±0.02	0.71±0.03
Bangladesh Dhaka	Tap water	0.0037±0.0015	0.0604 ±0.023
Bangladesh Kurigram (Present study)	Tube-well water	0.0093±0.0035	0.083±0.024
	Shallow water	0.012±0.004	0.080±0.024
	Pond water	0.016±0.004	0.252±0.026
	River water	0.022±0.005	0.248±0.035

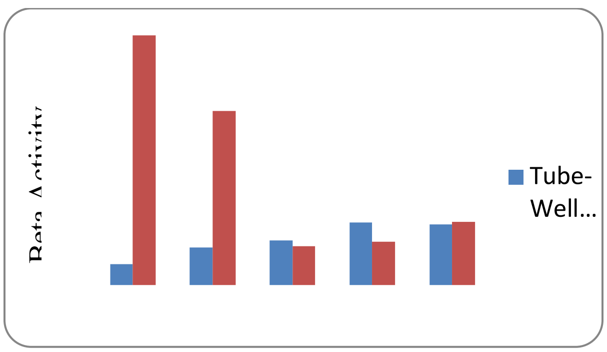

Fig. 4: Comparison of mean gross beta activity concentration between tube-well and pond water in different upazila of Kurigram

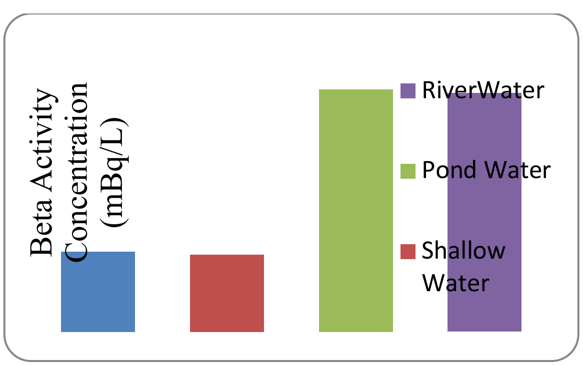

Fig. 5: Comparison of mean gross beta activity concentration among different types of water in Kurigram

In most upazilas the beta activity concentrations of ponds water were higher than the tube-wells water as shown in figure 4. The highest mean gross beta activity concentration was found in pond water and the lowest mean gross beta activity was found in shallow water as displayed in figure 5. The gross beta activity for underground water was lower than surface water as shown in figure 5.The gross beta activity concentration in water sample is primarily due to uranium and thorium decay products and ^{40}K. WHO recommends the levels of gross beta activity concentration to be less than 1.0 Bq/l. If the gross beta activity doses not exceed 1.0 Bq/l, it can be assumed that the annual total indicative dose of adults is less than 0.1 mSv per year. The results obtained show that the measured activity concentrations of gross beta in all tube-well (drinking) water samples are less than 1.0 Bq/l which is the limit recommended by WHO. From Table 7 it is observed that the gross alpha and gross beta activity concentrations in different regions of the world have different values. The activity concentrations of gross alpha and gross beta in the present study are comparable with the data available in other parts of the world. The gross alpha and gross beta activity concentrations in the present study are higher than that of the tap water samples in Dhaka. The observed activity concentrations of gross alpha and gross beta in the drinking water samples did not exceed WHO recommended level. So it can be assumed that the drinking water samples available in Kurigram are safe for public health.

4 Conclusions

The gross alpha and gross beta activity concentrations in 45 water samples of different locations in Kurigram, the northern district of Bangladesh, have been studied for the first time. For all types of water samples the gross beta activities are higher than the corresponding gross alpha activities. For all underground water samples both gross alpha and gross beta activities are respectively lower than 0.1 Bq/l and 1.0 Bq/l recommended upper limits suggests by WHO. The gross alpha and gross beta activity for underground water was lower than surface water. The natural radioactivity in Kurigram poses no health hazards to the population living there. This paper will provide database for anticipated radiation protection measures when need arises. Finally, this work will help in establishing a regulatory limit on radiation in public drinking water as well as in all types of water in the northern region in Bangladesh.

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