Sri Lankan Journal of Physics, Vol. 13(1) (2012) 01-08

INSTITUTE OF PHYSICS - SRI LANKA

Short Communication

Gross Alpha and Gross Beta Activities of Tap Water Samples from Different Locations of Dhaka City

Mst. Jannatul Ferdous*, Md.Mustafizur Rahman and Aleya Begum

Health Physics Division, Atomic Energy Centre, 4 Kazi Nazrul Islam Avenue, P.O. Box 164, Shahbag, Dhaka 1000, Bangladesh.

Abstract

Gross alpha and gross beta activities were determined for twenty tap water samples collected from different locations in Dhaka city. The instrumentations used to count the gross alpha and gross beta activities were ZnS scintillation detector and gas proportional counter, respectively. Concentrations ranging from 1.88 ± 0.03 *mBq*/*l* to 8.16 ± 0.03 *mBq*/*l* with an average 3.76 ± 1.50 *mBq*/*l* and from 29.305 ± 0.06 *mBq/l* to 115.74 ± 0.16 *mBq*/*l* with an average 60.41 ± 23.57 *mBq*/l were observed for the gross alpha and gross beta activities, respectively. The results showed that the natural activities of alpha and beta emitting radionuclides in tap 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 tap water for the people residing in Dhaka city is not yet a problem. To ensure the safe level of radioactivity in drinking water, however, periodic monitoring of water quality for compliance is necessary.

Keywords: Gross Alpha; Gross beta; Tap water; ZnS Scintillation Counter and Gas Proportional Counter

1. INTRODUCTION

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]. Water is essential to life as the air breath by humans. 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 ^{40}K.

* *Corresponding Author E mail*: ferdous28@yahoo.com

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. Efforts to determine levels of such radioactivity will help in the development of guidelines for the protection of the human beings[2].

Waters contain a number of both alpha such as ^{238}U, ^{226}Ra and ^{210}Po and beta emitters such as ^{40}K, ^{228}Ra and ^{210}Pb in widely varying concentrations which may be responsible for a fraction, generally small, of the internal exposure by ingestion of natural radionuclides. These daily samples may be counted for alpha-beta radioactivity. The radiological examination of tap water requires a rapid screening technique that permits the determination of the gross alpha and gross beta activities of each sample in order to decide if further radiological analyses are necessary. The maximum contamination level (MCL) for total radium (^{226}Ra and ^{228}Ra) in drinking water is specified by the US Environmental Protection Agency as 5 pCi/l [3]. 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[4]. Gross alpha activity is defined as the total activity of all alpha emitters once radon has been eliminated. Gross beta activity is defined as the total activity of all beta emitters excluding tritium, though ^{14}C and other soft-beta emitters are also excluded by most of the commonly used screening techniques. In order to guarantee an exposure lower than 0.1 $mSv\ y^{-1}$ WHO recommends the guideline values for drinking water 0.1 Bq/l for alpha activity and 1 Bq/l for gross beta activity[5].

The aim of this work is to determine the gross alpha and gross beta radioactivity in tap water samples from different locations of Dhaka city and provide a base line data which can be used to evaluate possible future changes.

2. MATERIALS AND METHODS

2.1. Study area

Dhaka is the capital of Bangladesh. A population of over 12 million inhabitants makes Dhaka the largest city in Bangladesh. Dhaka is located at latitude 23.42^o N and longitude 90.375^o E and situated on the eastern bank of the Buriganga River. The city lies on the lower Basins of the Ganges Delta and covers a total area of 153.84 square kilometers (59.40 sq mi). Dhaka district has an area of 1463.60 square kilometers (565 sq mi) and is bounded by the districts of Gazipur, Tangail, Munshigonj, Rajbari, Narayanganj, and Manikgonj. Increasing polluted air and water emanating from traffic congestion and industrial wastes are serious problems affecting public health and the quality of life in the city[6].

2.2. Sample collection

In order to measure the natural and artificial radioactivity in tap waters, twenty tap water samples were collected randomly from different locations. The choice of sampling locations was based on population density and accessibility. The locations are shown in the Figure 1. The samples were kept into previously cleaned 2 *l* capacity plastic bottle using manual procedure. The samples were appropriately coded from 1 to 20, from which the samples were collected and transferred to laboratory for analysis.

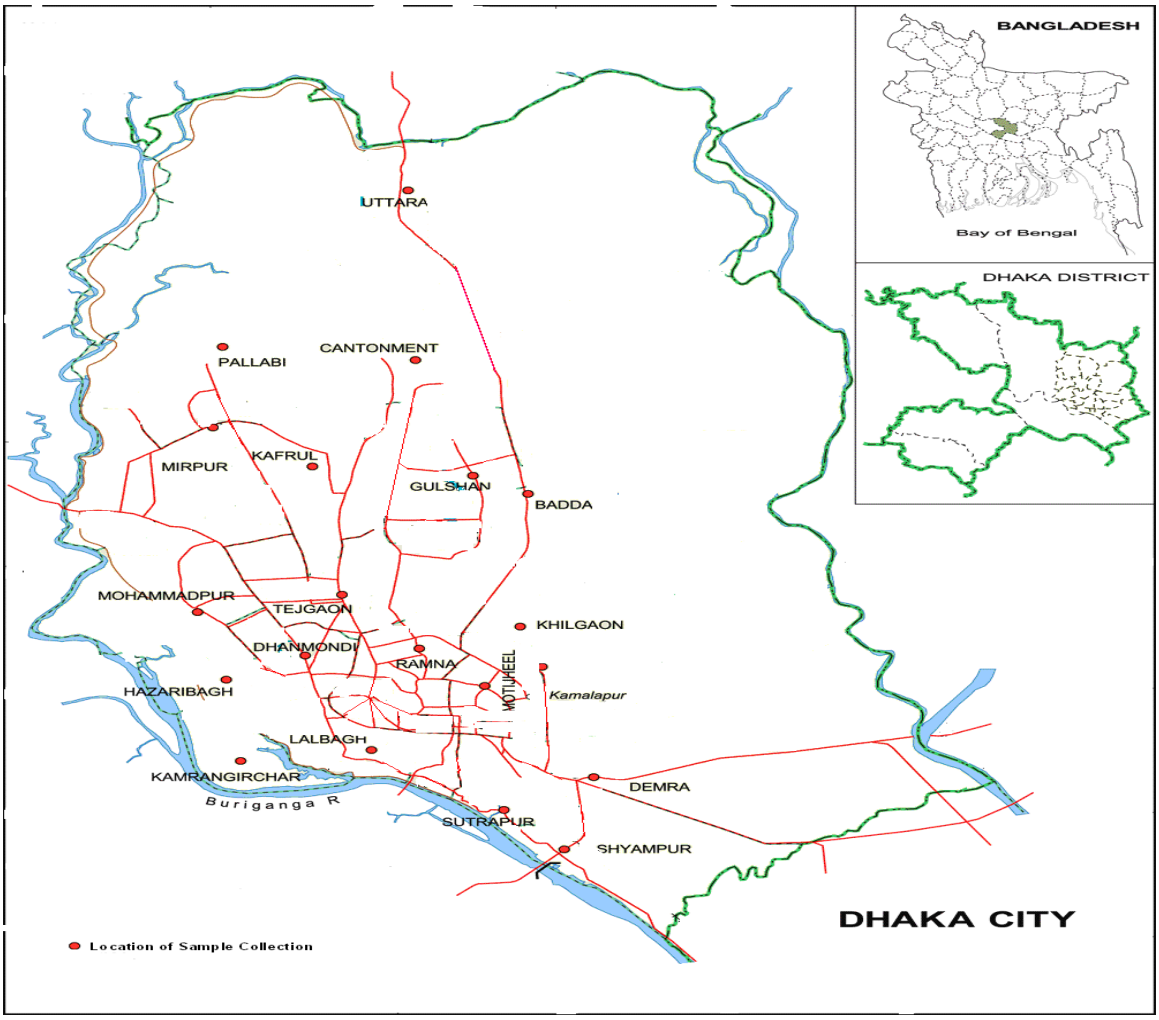

Figure1: Map of Dhaka City

2.3. Sample preparation

Twenty 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 millilitre 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 tap water samples were slowly evaporated by water bath

treatment at 105°*C* in order to reduce its volume near to dryness (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 dry residue. The sampe residue was kept in desiccator to avoid moisture[7].

2.4. Measurement Procedure

The dry residue of tap water samples were counted for gross alpha and gross beta activities using ZnS scintillation detector and gas proportional counter respectively. ZnS Scintillation counter is a dual phosphor detector coupling two scintillating materials to a photomultiplier tube. The detector was calibrated using electrodeposited standard sources of Th-230 (1020 dpm) and Pu-239 (1397 dpm).The efficiency of the detector is 30%.

Gas flow proportional counter is used for the gross beta activity of tap water. The Gas proportional counter was calibrated by planchette deposited standard source Sr-90. The efficiency of the detector is 36%. The counting time was 100 minutes for gross alpha and gross beta activities for each counting period. A blank planchette was used for background count. Subtraction of the background count from the sample count gives the net count of the water sample. When measuring alpha and beta particle activity using a gas-flow proportional system, counting at the alpha voltage plateau discriminates against beta particle activity, whereas counting at the beta voltage plateau is somewhat sensitive to the alpha particle activity present in the sample. This phenomenon is termed "cross talk" and is compensated for during instrument calibrations. Known activity standard source 230-Th and 90-Sr were used for detector calibrations. The gas proportional detector can operate in two modes to detect gross alpha and beta radioactivities: alpha-then-beta or alpha-and-beta. The latter mode is more useful, as it allows for a simultaneous detection. In this case, alpha and beta particles can be distinguished by either the pulse height or shape. The interfering processes are crosstalk or spillover in the case of pulse height or pulse shape, respectively. While the method of simultaneous alpha-and-beta counting can precisely determine the alpha radioactivity in the presence of beta radioactivity, the converse is not possible in general.

2.5. Calculation of Gross Alpha/Beta Activity

The activity of gross alpha/beta was calculated using the following equation:

$$DPM = NET\_CPM \times 100 / EFF \quad (1)$$

where, DPM = Alpha/Beta disintegration per minute, NET_CPM = Net alpha/beta count per minute, and EFF = Alpha/Beta efficiency percent.

3. RESULTS AND DISCUSSION

3.1. Concentration of Gross Alpha Activity

The measured activity concentrations of gross alpha in tap water samples of different locations in Dhaka city are gathered in Table 1. The observed gross alpha activity found in tap water samples vary from 1.88 ± 0.03 to 8.16 ± 0.03 *mBq/l* with average 3.76 ± 1.50 *mBq/l*. The highest gross alpha activity in the water was found in Dhanmondi and the lowest gross beta activity in tap water samples was found in Uttara.

The gross alpha activity in water sample is primarily comprised uranium decay products such as ^{226}Ra and ^{40}K. WHO recommends the parameter of gross alpha activity concentration to be 0.1 *Bq/l*. If the gross alpha activity 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 tap water samples are less than 0.1 *Bq/l* which is the limit recommended by WHO.

Table 1: Gross Alpha and Gross Beta Activity in Tap Water Samples.

Sl. No.	**Name of Location**	**Gross Alpha activity in *mBq/l***	**Gross beta activity in *mBq/l***
1	Uttara	1.88 ± 0.03	60.18 ± 0.07
2	Pallabi	5.02 ± 0.03	63.28 ± 0.17
3	Cantonment	1.91 ± 0.02	74.34 ± 0.17
4	Mirpur	4.39 ± 0.03	33.98 ± 0.06
5	Kafrul	3.77 ± 0.03	77.22 ± 0.06
6	Gulshan	5.65 ± 0.02	43.19 ± 0.17
7	Badda	3.14 ± 0.02	115.74 ± 0.16
8	Tejgaon	4.32 ± 0.03	35.50 ± 0.06
9	Mohammdpur	2.51 ± 0.02	95.69 ± 0.07
10	Dhanmondi	8.16 ± 0.03	106.48 ± 0.07
11	Ramna	4.42 ± 0.02	52.45 ± 0.16
12	Khilgaon	1.88 ± 0.02	75.60 ± 0.17
13	Motijheel	3.14 ± 0.03	52.22 ± 0.17
14	Kamlapur	3.14 ± 0.02	43.24 ± 0.17
15	Hazaribagh	5.02 ± 0.03	60.18 ± 0.06
16	Lalbagh	3.77 ± 0.03	55.55 ± 0.16
17	Kamrangirchar	3.13 ± 0.03	55.56 ± 0.16
18	Demra	3.09 ± 0.02	29.30 ± 0.06
19	Sutrapur	2.51 ± 0.02	37.03 ± 0.06
20	Shympur	4.39 ± 0.03	41.37 ± 0.07
	Mean	3.76 ±1.50	60.40 ± 23.57

3.2. Concentration of Gross Beta Activity

The measured activity concentrations of gross beta in tap water samples of different locations in Dhaka city are shown in Table 1. The observed gross beta activity found in tap water samples vary from 29.30 ± 0.06 to 115.74 ± 0.16 *mBq/l* with average 60.40 ± 23.57 *mBq/l*. The highest gross beta activity in the water was found in Badda and the lowest gross beta activity in tap water samples was found in Demra.

The gross beta activity in water sample is primarily comprised uranium decay products such as ^{228}Ra and ^{40}K. WHO recommends the levels of gross beta activity concentration to be 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 tap water samples are less than 1.0 *Bq/l* which is the limit recommended by WHO.

Figure 2 shows that the gross beta activities are higher than the corresponding gross alpha activities for all tap water samples.

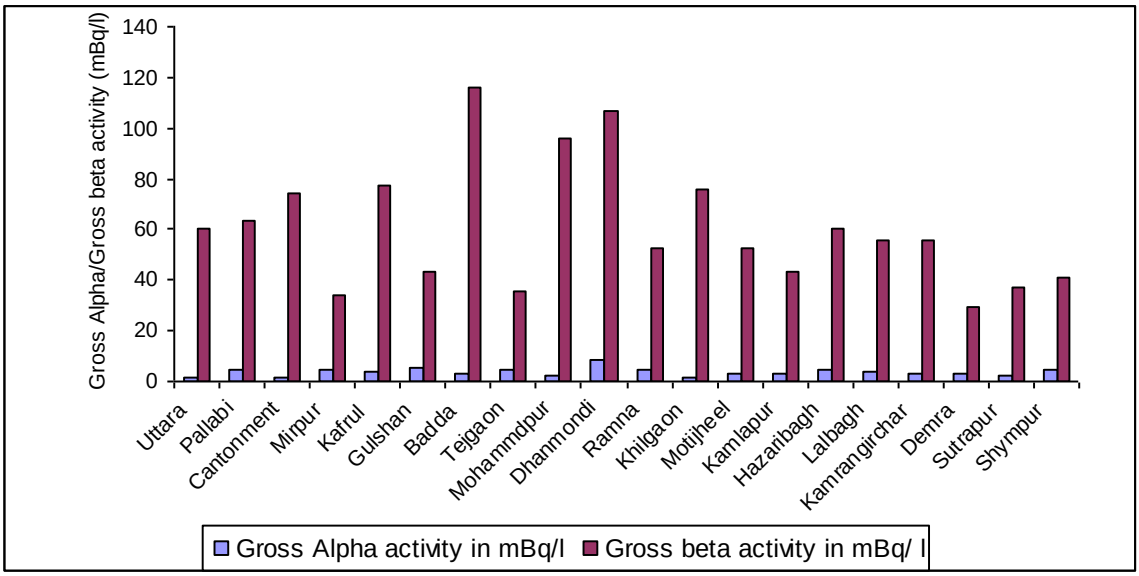

Figure 2: A bar diagram of gross alpha/gross beta activities in tap water samples.

In Table 2, the observed concentrations of gross alpha and gross beta in tap water of Dhaka city of Bangladesh were compared with others countries of the world.

Table 2: Comparison with other Countries[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 Tap water Tap water	<0.0077-0.349 <0.008-0.186 <0.01812-0.1282	<0.025-0.273 <0.048-0.150 <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

4. CONCLUSIONS

Concentrations ranging from 1.88 ± 0.03 to 8.16 ± 0.03 *mBq/l* with an average 3.76 ± 1.50 *mBq /l* and from 29.30 ± 0.06 to 115.74 ± 0.16 *mBq/l* with an average 60.40 ± 23.57 *mBq/l* were observed for the gross alpha and gross beta activities, respectively. For all tap water samples the gross beta activities are higher than the corresponding gross alpha activities. Both gross alpha and gross beta activities are respectively lower than 0.1 *Bq/l* and 1.0 *Bq/l* recommended by WHO. Since the gross alpha activity in drinking water is lower than 0.1 *Bq/l* and the gross beta activity does not exceed 1.0 *Bq/l*, it can be assumed that the annual effective dose is less than 0.1 *mSv* per year. Bangladesh has no public drinking water standards for radioactivity yet. So, the above results are comparable with the guideline values of WHO for drinking water. It is found that the radionuclides concentration in tap water samples of Dhaka city is still below the maximum suggested values.

From the present work, it seems that the dwellers are not supposed to acquire any serious radiological complication from tap water system at least in the Dhaka city. The data gathered in this study will provide base–line radiometric values of tap water as well as drinking water in this region that can be used to evaluate the possible changes in future. This work could help to create a public awareness about the total or gross alpha and beta activities in drinking water and the radiological impact on the dweller's health.

Finally, this work will help in establishing a regulatory limit on radiation in public drinking water as well as in tap water in Bangladesh.

REFERENCES

1. United Nations Scientific Committee on the Effects of Atomic Radiation. Sources, effects and risks of ionizing radiation, *Report to the General Assembly (NY:UN)*, 1988.
2. M.H. Al-Jaser, S.U. El-Kameesy, M.M. Ghannam, F.Al-saleh, I. Zagloul, M.Radwan, N.Al-Essa, M.Al-Garawi and M.Al-Ayed, *Radioactivities of ^{226}Ra, ^{228}Ra and ^{40}K in the groundwater around Buraydah treatment plant in the northwest of Riyadh, Saudi Arabia* Egyptian Journal of Bioaphysics, January, 11, No.1 (2005).
3. K.S.Sidhu, and M.S. Breithart, *Naturally occurring radium-226 and radium-228 in water supplies of Michigan*, Bulletin of Environmental Contamination Toxicology, 61, (1998), 722-729.
4. J.I. Davila Rangel, H. Lopez del Rio, B.L. Rodriguez, M.Solache-Rios, *Gross alpha and beta radioactivity in drinking water from Zacatecas and Guadaluoe cities, Mexico.* Journal of Radioanalytical and Nuclear chemistry, February, 247, No.2. (2001) 425-428.
5. World Health Organization, *Radiological Examination of Drinking Water*, (Copenhagen: WHO), 1978.
6. http://en.wikipedia.org/wiki/Dhaka_District
7. U.S. EPA National Exposure Research Laboratory, EPA 900, *Gross alpha and gross beta radioactivity in drinking water*, 1980.
8. N. Damla, U.Cevik, G. Karahan, and A.I. Kobya, *Gross alpha and gross beta activities in tap waters in Eastern Black Sea region of Turkey*, Chemosphere, 62(6), (2006), 957-960.
9. J.I. Davila Rangel, H. Lopezdel Rio, F.Mireles Garcia, and L.L.Quirino Torres, *Radioactivity in Bottled Waters sold in Mexico*, Applied Radiation and Isotopes, 56(6), (2002), 931-936.
10. D. M. Bonotto, T.O. Bueno, B.W. Tersari and A.Silva, *The Natural Radioactivity in water by gross alpha and beta measurements*, 44(1) (2009), 92-101.
11. D.Karamanis, K. Stamoulis, K.G Loannides, *Natural Radionuclides and heavy metals in Bottled water in Greece*, Desalination, 213 (1-3), (2007), 90-97.
12. R. Rusconi, M. Forte, P.Badalamenti, and S. Bellinzona, *The Monitoring of tap waters in Milanno, Planning, Methods and Results*, Radiation Protection Dosimetry, 111(4); (2004), 373-376.
13. M.Sajedah Al-Amir, F.Ibrahim Al-Hamarneh and Tahseen Al-Abed, *A Study of Natural Radioactivity in Drinking Water in Amman, Jordan.* The Second International Symposium on Nuclear Energy. Al-Balqa' Applied University, JORDAN. 26-28 Oct. 2009.