Gross Alpha Activity Concentration in Water Sample of Old Dhaka, Bangladesh by Zinc Sulphide Scintillation Detector

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ABSTRACT

ZnS(Ag) was used to measure the gross alpha activity in drinking water of Old Dhaka, Dhaka District, Bangladesh. Screening was carried out for collected twenty samples; of which ten were tap water, five were ground water and the rest of five were bottled water samples. The gross alpha activity concentration was ranged from 0.84 ± 0.06 to 14.40 ± 0.23 mBq/L with an average activity of 6.52 ± 0.18 mBq/L for tap water samples. For ground water samples, the gross alpha activity concentration was ranged from 0.87 ± 0.18 to 1.46 ± 0.48 mBq/L with an average activity of 1.22± 0.63 mBq/L. The gross alpha activity concentrations were ranged from 5.07 ±0.30 to 24.70 ± 0.69 mBq/L with an average activity of 13.89 ± 0.45 mBq/L for bottled water samples. The gross alpha activities for all cases were found below than the recommended value of 0.5 Bq/L or 500 mBq/L given by World Health Organization (WHO) in 2004. The annual effective doses for all cases were found below than the recommended value of 0.1 mSv/year given by International Commission on Radiological Protection (ICRP).

Keywords: Effective dose, Tap water, Ground water, Bottled water, Guidance level, World Health Organization (WHO), International Commission on Radiological Protection (ICRP).

1. Introduction

Radioactivity in major element like soil, water, air etc. of earth has been a major concern in recent years. Water is an inevitable part of the environment. People are mainly prone to ionizing radiation. Ionizing radiation comes from both natural sources and artificial sources. Natural sources are cosmic rays and natural radio nuclides in air, food and drinking water. Alpha particles, beta particles, and gamma rays are the expected sources of ionizing radiation. It will not be unwise to say that we are living in the sea of Natural radioactivity. The percentage of water in adult men is about 60%. On the other hand, for adult women the percentage fall down to 55% due to increased amount of fat tissues. So, whatever the percentage is, human body possesses a great threat of radiological exposure from water as it is the main constituent [1]. The radiation corresponding to most water supplies is such a small proportion of the normal background to which all human beings are exposed. People exposed to radiation dose from water sources which are very small fraction but measuring any significant health effects with certainty was hard [2]. According to UNSCARE report, it was estimated that people received 0.01mSv/y ingested dose only drinking water purposes from the total ingested dose 0.3 mSv/y [1]. But underlying geology of the ground water source sometimes adds variation of the radioactivity. Radium found in some water supplies can contributes higher concentrations that pose a higher risk of bone cancer and kidney failure due to elevated uranium levels in drinking water [2]. Thus, it is needed to establish a standard for radiation exposure due to ingestion of radio-nuclides through drinking water to protect people. The biological effects of alpha and beta particles within human body either through internal or external exposure is far more detrimental compared to gamma rays. So, it is equally significant to quantify the alpha or beta concentration in water sample [3]. Radionuclide when ingested may be reached into the intestines where it can be absorbed in the body fluids. As a result, it can spread out to all the delicate internal organs through the fluids. Due to the effects of radionuclide to our body, it is necessary to estimate the effective dose equivalent of alpha due to intake of drinkable water to ascertain the contributed doses by the major alpha emitters. The objective of this present study was to measure the gross alpha activity concentration in tap water, tube-well water and bottled water samples and estimate radiological health hazard to public health of the investigated area.

2. Material and methods

2.1. Study area

For the study, water samples were collected from different places of Old Dhaka in the year 2018. Old Dhaka consists of eight metropolitan than as such as Hazaribagh, Lalbagh, Chowkbazar, Bangshal, Kotwali, Wari, Sutrapur and Gandaria under the administration of Dhaka South City Corporation. Table 1 shows the locations of sample collection.

Table 1: Locations of sample collection

Sl no.	Sample ID	Place of collection	Type of sample	Geographical coordinates
1.	F-1	Hatkhola road	Tap water	23° 43’ 08.8” N - 90° 25’06.9”E
2.	F-2	South Muhshendi	Tap water	23° 42’ 45.6” N - 90° 25’03.9”E
3.	F-3	Narinda Road	Tap water	23° 42’ 45.7” N - 90° 25’06.9”E
4.	F-4	Pachbhai Lane	Tap water	23° 42’ 40.0” N - 90° 24’58.9”E
5.	F-5	Shingtola	Tap water	23° 42’ 24.0” N - 90° 24’56.3”E

6.	F-6	Jagannath University	Tap water	23° 42’ 31.7” N - 90° 24’40.9”E
7.	F-7	Collegiate School	Tap water	23° 42’ 28.9” N - 90° 24’38.0”E
8.	F-8	Bahadurshah Park	Tap water	23° 42’34.3” N - 90°24’44.7”E
9.	F-9	LalmohanSaha Street	Tap water	23° 42’ 42.4” N - 90° 24’57.7”E
10.	F-10	Vojohori Street	Tap water	23° 42’ 51.4” N - 90° 25’2.4”E
11.	F(T)-11	Luxmibazar	Ground water	23° 42’ 31.4” N - 90° 54’52.3”E
12.	F(T)-12	K.G Gupta Lane	Ground water	23° 42’ 27.7” N - 90° 24’52.1”E
13.	F(T)-13	Banglabazar	Ground water	23° 42’ 24.6” N - 90° 24’40.5”E
14.	F(T)-14	Sutrapur	Ground water	23° 42’ 09.5” N - 90° 25’05.5”E
15.	F(T)-15	South Muhshendi	Ground water	23° 42’ 45.4” N - 90° 25’03.6”E
16.	F(B)-16	Jibon	Bottled water	Not applicable
17.	F(B)-17	Lilia	Bottled water	Not applicable
18.	F(B)-18	Fresh	Bottled water	Not applicable
19.	F(B)-19	Shyamoli	Bottled water	Not applicable
20.	F(B)-20	Kinley	Bottled water	Not applicable

2.2. Sample collection and preparation

Twenty samples were collected and sampled for experimental use. Of these, ten samples were tap water, five samples were of tube-well water and the rest of the five samples were bottled water found in different mini stores. All samples were collected and prepared according to EPA 900 method [4]. Each of the samples was collected in separate 1L plastic containers. The collected samples were transferred to chemical processing laboratory of Health Physics Division at Atomic Energy Centre Dhaka (AECD). For sample preservation concentrate nitric acid was used. Each of 1L capacity Pyrex beakers was washed with distilled water and dry to avoid contamination. Then the sample was poured into Pyrex beaker and added 1N HNO_3 in order to avoid the intrusion of organic agents. With a view to measuring gross alpha activity the samples were slowly evaporated by water bath at 70^0-80^0C in order to reduce its volume near to 30 mL to 40mL. Then 40 mL water was transferred to a 2-inch stainless steel counting plancheet and dried under IR lamp till the volume was reduced to dryness. The samples were cooled and weighed to determine the activity. Then the prepared samples were kept in desiccators to avoid moisture.

2.3. ZnS (Ag) scintillation detector

Zinc sulphide scintillation detector was used in the present study. The model of this detector is MPC-2000-B-DP which contains a custom designed detector with a ZnS layer bonded to a plastic scintillator. It is a dual scintillation detector coupling two scintillating materials to a photomultiplier tube (PMT). The combination is optically coupled to a PMT. The outermost layer detects alpha particles, and the inner layer detects beta particles. It is Desktop lightweight portable gross alpha/beta counter. The machine has three modes such as alpha plus beta, alpha only and beta only modes respectively The detector was calibrated using standard sources ^{230}Th (1020 dpm) and ^{239}Pu (1397 dpm). The efficiency of the detector is 36.8% [5].

2.4 Gross alpha activity calculation

Calculations was performed on the raw data in order to convert the raw counts from counts per minute (CPM) into disintegrations per minute (DPM) and finally into units of activity per sample such as mBq/L. A blank plancheet was used for background count. Subtraction of the background count from the sample count gives the net count of the environmental sample. The data were acquired for alpha mode. The activity of gross alpha has been calculated using equation (1) and (2) [6-7]:

$$DPM = \frac{Net\ CPM \times 100}{\eta} \quad (1)$$

Where,

DPM is the Net Alpha Disintegrations per

Minute,

Net CPM is the Sample CPM - Background

CPM,

η is the Alpha Efficiency in Percent.

$$A = \frac{DPM}{60 \times V} \times 1000 \quad (2)$$

Where,
A is the gross alpha activity concentration (mBq/L),
V is the volume of water sample

2.5 Annual effective dose calculation

In the present study, the effective dose over one year was calculated using equation (3) [8]:

$$D = \frac{A \times IR_w \times ID_w}{1000} \quad (3)$$

Where,
D is the annual effective dose (mSv/y),
A is the gross alpha activity concentration (mBq/L),

IRw is the intake of water for an adult in a year (730 L/y). According to WHO an adult takes water 2 L/day which results in 730 L/year,
ID_w is the ingestive equivalent dose factor (3.58×10^{-4} mSv/y = 0.000358 mSv/y) [9-10].

3. Results and discussion

Twenty samples were collected from different locations of Old Dhaka, Bangladesh. The gross alpha activity ($mBqL^{-1}$) and annual effective dose (mSv/year) were determined for twenty samples. The gross alpha activity concentration of the ten tap water samples was calculated using equation (1) and (2).

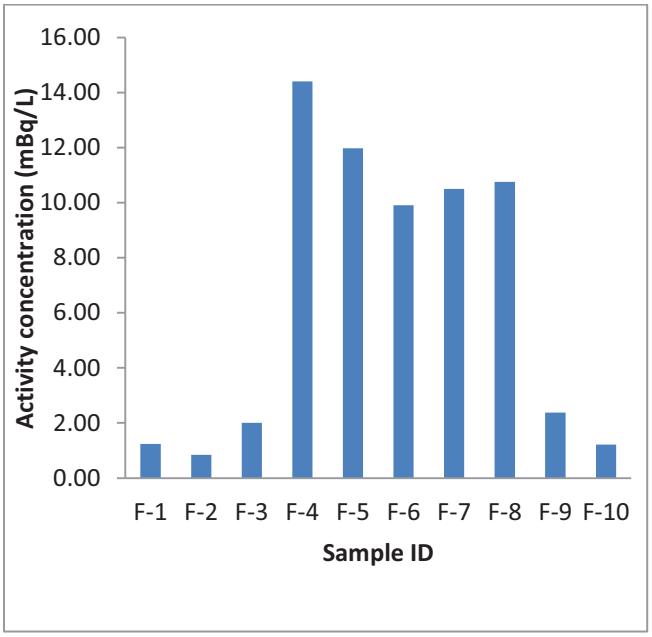

Fig. 1: The variation of gross alpha Activity in tap water sample

Fig. 1 shows the variation of the gross alpha activity concentration of tap water sample. The maximum gross alpha activity concentration was found 14.40 ± 0.23 mBq/L for F-4 sample, collected from Panch Bhai Lane and lowest gross alpha activity concentration was found 0.84 ± 0.069 mBq/L for sample F-2 collected from South Muhshendi. The average gross alpha activity was found 6.52± 0.18 mBq/L. All the values found for gross alpha activity of tap water samples were well below the permissible value of gross alpha activity of 0.5 Bq/L or 500 mBq/L and 0.1 Bq/L given by World Health Organization (WHO) [10-12]. Annual effective dose (mSv/year) for tap water samples were determined using equation (3).

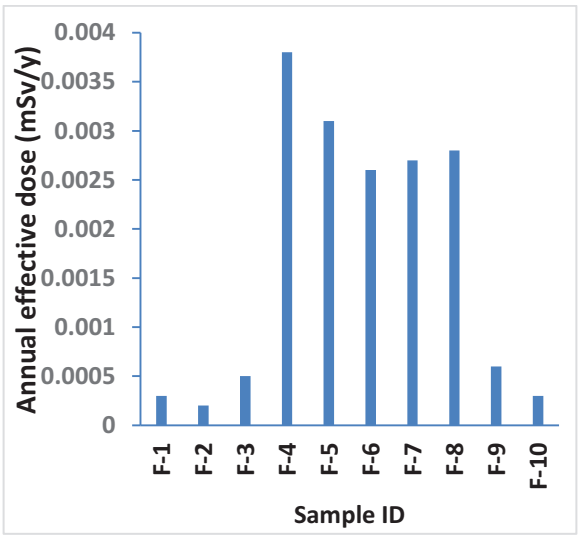

Fig. 2: Annual effective dose for tap water sample

From Fig. 2, it has been seen that the maximum annual effective dose 0.0038 mSv/year is found for sample no. F-4 collected from Panch Bhai Lane and lowest annual effective dose 0.0002 mSv/year for F-2 collected from South Muhshendi. The average annual effective dose was calculated 0.0017 mSv/year. All the values found for annual effective dose of tap water samples were well below the permissible value of annual effective dose of 0.1 mSv/year recommended by ICRP in the year 2000 [13].

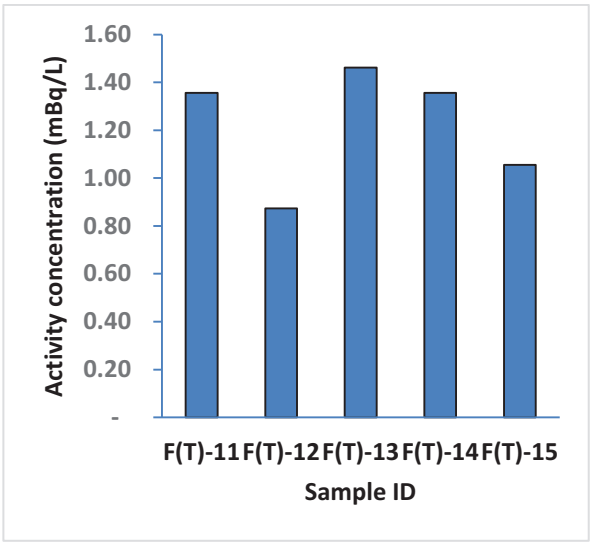

Fig. 3: The variation of gross alpha activity in ground water sample

The variation of gross alpha activity concentration in ground water sample was shown in Fig.3. The maximum gross alpha activity was found 1.46± 0.48 mBq/L for sample F(T)-13 collected from Banglabazar and lowest was found 0.87± 0.18 mBq/L for F(T)-12 sample collected from K.G Gupta Lane. The average gross alpha activity was obtained 1.22± 0.63 mBq/L. All the values found for gross alpha activity concentration in ground water samples were well below the permissible value of gross alpha activity of 0.5 Bq/L or 500 mBq/L given by WHO [10]. Annual effective dose for all the ground water samples were determined by using equation (3).

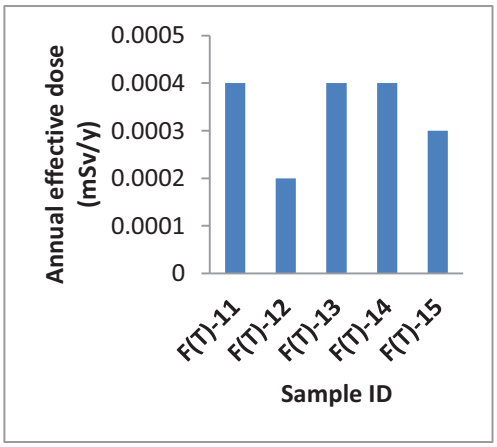

Fig. 4: Annual effective dose for ground water samples

It has been observed from Fig. 4 that the maximum annual effective dose was found 0.0004 mSv/y for sample ID F(T)-13 and lowest annual effective dose was found 0.0002 mSv/y for F(T)-12 sample. The average annual effective

dose was found 0.00034 mSv/y. All the values of annual effective dose of ground water sample were found well below the permissible value of annual effective dose of 0.1 mSv/y recommended by ICRP in the year 2000. Five bottled water samples of different brands were collected from mini stores of Old Dhaka for screening gross alpha activity and determining effective dose equivalent from them. Mean activity of the five bottled water samples were calculated using equation (1) and (2).

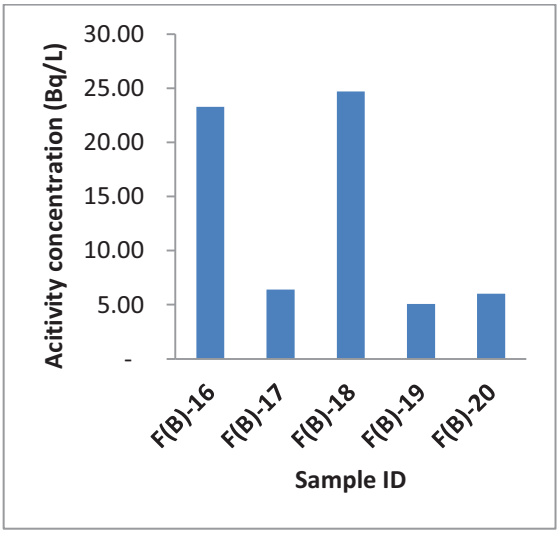

Fig. 5: The variation of gross alpha activity concentration in bottled water

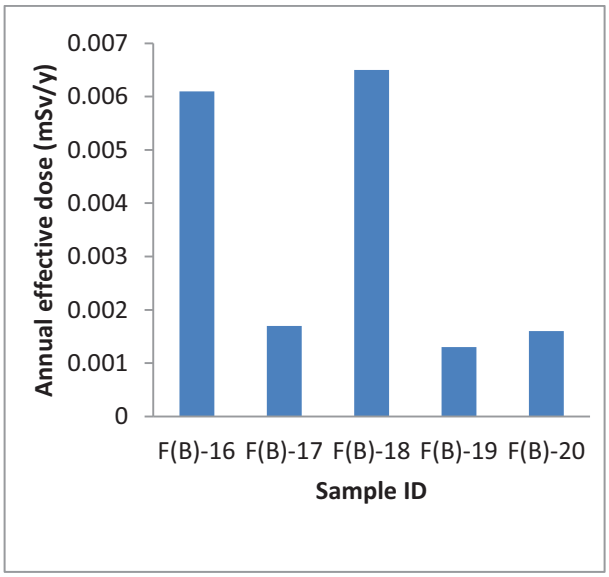

Fig. 6: Annual effective dose for bottled water samples

From the Fig. 5, it has been seen that the maximum gross alpha activity was found 24.70± 0.69 mBq/L for sample F(B)-18 of "Fresh" brand and lowest gross alpha activity was found 5.07± 0.30 mBq/L for F(B)-19 of "Shyamoli" brand. The average gross alpha activity was calculated 13.89± 0.45 mBq/L. All the values of gross alpha activity of bottled water were found well below the permissible value of gross alpha activity of 0.5 Bq/L or 500 mBq/L recommended by WHO in the year 2004. Annual effective dose (mSv/y) for the bottled water samples were presented in Fig. 6.

From Fig. 6, it has been seen that the maximum annual effective dose was found 0.0065 mSv/y for F(B)-18 of "Fresh" brand and the lowest annual effective dose was 0.0013 mSv/y for F(B)-19 sample of "Shyamoli" brand. The obtained average annual effective dose was 0.00344 mSv/y. All the values found for annual effective dose of bottled water samples were well below the permissible value of annual effective dose 0.1 mSv/y recommended by ICRP [13]

Table 2: Comparison between the sample collected and those in literatures

Location	Max. Activity(Bq/L)	Reference
Ekiti state, Nigeria	1.29	[14]
Ankara, Turkey	2.58	[15]
Gboko, Nigeria	14.48	[16]
Bahia state, Brazil	0.80	[17]
Kadunu state, Nigeria	0.04	[18]
Gombe Metropolis, Nigeria	0.05	[19]
Markazi, Iran	7.65	[20]
Kebbi state, Nigeria	0.08	[9]
Dhaka city, Bangladesh	0.96	[21]
Kurigram district, Bangladesh	0.133	[22]
Old Dhaka(tap water)	0.014	Present study
Old Dhaka (ground water)	0.0014	Present study
Dhaka city (bottled water)	0.024	Present study

From Table 2, it has been seen that the maximum gross alpha activity was 14.488 Bq/L in Gboko, Nigeria and minimum gross alpha activity was 0.0014 Bq/L in Old Dhaka of the present study from ground water sample.

4. Conclusions

Gross alpha activity was measured in water samples collected from the old Dhaka area using zinc sulphide scintillation detector. The average gross alpha activity was found 6.52 ± 0.18 mBq/L for tap water samples, 1.22 ± 0.63 mBq/L for ground water samples, and 13.89 ± 0.45 mBq/L for bottled water samples. The gross alpha activity for all cases was found well below than the recommended value of 0.5 Bq/L or 500 mBq/L and 0.1 Bq/L for gross alpha activity in drinking water given by WHO. The effective dose equivalent was found 0.0017 mSv/y for tap water samples, 0.00034 mSv/y for ground water samples and 0.00344 mSv/y for bottled water samples. The annual effective dose for all cases was found very low as compared to the recommended value of 0.1 mSv/year given by ICRP in 2007. The values can also work as baseline data for further study and create public awareness regarding drinkable water.

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