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A Study of Radon Concentration in Tap Water of Dhaka City, Bangladesh

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Abstract

In this study, radon concentrations were measured in tap water samples collected from Dhaka city, Bangladesh by using a technique called Durridge RAD7 with RAD H_2O accessories in 2017. It was found that, the range of radon concentrations varied from 0.07± 0.014 Bq/L to 4.80± 0.548 Bq/L with the average value 2.67± 0.66 Bq/L. The results were below the radon concentrations of the internationally recommended reference levels of World health Organization limit (500 Bq/m^3) and the maximum contaminant level (11.1 Bq/L) recommended by US Environmental Protection Agency. The calculated average annual effective dose was found 0.0097 mSv/y which was also below the WHO recommended reference levels of annual effective dose due to radon in drinking water of 0.1 mSv/y. So the tap water of this study area is safe from the standpoint of radon concentration or not radioactively contaminated.

Keywords: Tap water; Radon; Rad7; Dhaka city; Annual effective dose

Introduction

Radon is a tasteless, odorless, colorless and radioactive noble gas whose density is 7.5times higher than that of air [1,2]. It has a half-life of 3.8 days.It belongs to the ^{238}U decay series. Radon is present in soil, rocks, building materials and waters [3,4]. It can dissolve and accumulate in water.When water containing radon is used in the home for showering, washing dishes, and cooking, radon gas escapes from the water into the air. Some radon stays in the water. Radon is the major source of naturally occurring radiation exposure for humans. According to the United States Environmental Protection Agency, radon is the second most frequent cause of lung cancer, after cigarette smoking, causing 21,000 lung cancer deaths per year in the United States. About 2,900 of these deaths occur among people who have never smoked [5]. While radon is the second most frequent cause of lung cancer, it is the number one cause among non-smokers, according to EPA estimates [6]. Exposure occurs via the ingestion of radon dissolved in water and the inhalation of airborne radon.Inhalation of radon gas that has been released from tap water which will contribute to the radon content of indoor air and, if inhaled, will result in a radiation dose to the lung. Long-term exposure to high concentrations of radon in indoor air increases the risk of lung cancer [7,8]. Sources of drinking water might be tap water, ground water, spring water, river water, well water, etc. In Bangladesh, most of the people of Dhaka city depend on tap water for drinking and also other everyday purposes. The aim of the present work was to measure the concentration of radon in residential tap water in Dhaka city using RAD7 detector with RAD H20 accessories. The radon concentrations reported in this study were considered as a baseline data for radon concentration in the Dhaka city as no such radon study in tap water had been carried out in this area before.

Materials and Methods

Sampling Area

Dhaka is the capital and largest city of Bangladesh, in southern Asia. It is located in central Bangladesh at 23°42'N 90°22'E, on the eastern banks 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 city has an area of 306.48 square kilometers (118.29 sq mi) and under Dhaka city has two city corporations. It is the most densely populated city in the world with a population of 18.89million people. 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.

Sample collection & preparation

Tap water were taken into account because in Dhaka city most of the people used tap water for drinking and also other everyday household purposes. For collecting tap water, water was allowed to flow about 10 minutes to ensure an accurate radon content of water can be collected from water supplies. Then, the vials were closed rapidly and tight to avoid radon leakage. The samples that had taken were analyzed in the Health Physics Division, Atomic Energy Centre, and Dhaka, Bangladesh. Decay correction was applied to give a more accurate calculation of radon if the sample was analyzed more than three hours after sampling. This is due to the fact that sampling and measurement of radon present complications due to its volatility and relatively short half-life. Due to these phenomena long distance areas from the laboratory were avoiding for sampling. Total eighteen tap water samples were collected from different residential areas of Dhaka city. In this study 250ml of water sample was used for each measurement instead of 40 ml of water sample. A larger sample size was chosen because it will improve sensitivity and precision at low radon concentrations.

Sampling Point.	Location Name	Latitude/ Altitude
TW1	Airport	23.7939, 90.6447
TW2	Agargaow	23.7792, 90.3713
TW3	TSC	23.7242, 90.4003
TW4	Azimpur	23.7286, 90.3854
TW5	Baily Road	23.7409,90.4024
TW6	Zigatula	23.7392,90.3756
TW7	Mohammadpur	23.7673, 90.3572
TW8	Bonany	23.794, 90.4043
TW9	Tongi	23.89, 90.4058
TW10	Dhanmondi	23.7464, 90.376
TW11	Uttara	23.8728, 90.396
TW12	Mirpur	23.8045, 90.3607
TW13	AECD	23.7309, 90.39653
TW14	Jattrabari1	23.7113, 90.4308
TW15	Tajgaow	23.9033, 90.4071
TW16	Jattrabari2	23.7113, 90.4308
TW17	Khilkhet	23.819, 90.4178
TW18	Dohar	23.5847, 90.1401

Table 1: Tap water samples collected from different residence of Dhaka City

Experimental technique

Radon concentrations in these samples were measured with RAD7 an electric radon detector connected to RAD H_2O accessory (DurridgeCo,USA, 2010) [9]. The RAD H_2O is an accessory to the RAD7 that enables to measure radon in water over a concentration range of from less than 10 pCi/L to greater than 400,000 pCi/L. The lower limit of detection is less than 10 pCi/L. The Rad7 H20 requires the desiccant be used at all times to dry the air stream before it enters the RAD7. The good desiccant is in blue colour. If the desiccant was changed to pink colour, it needs to heat in the oven for 2 hours with 200 °C – 225 °C before proceeding to the next measurement. For water sample analysis, the small drying tubes is necessary to avoid using the large drying tube as its much larger volume would cause improper dilution of the radon. Humidity reading for RAD7 has to remain below 10% and must be free of radon and dry before start the measurement. It is convenient to use the larger laboratory drying unit during the initial purging process to save the small drying tubes for the actual measurement in water. They are a source of radon-free (or relatively radon free) air or inert gas to purge the system. RAD7 calculates the sample water concentration by multiplying the air loop concentration by a fixed conversion coefficient that depends on the sample size. This conversion coefficient was derived from the volume of the air loop, the volume of the sample and the equilibrium radon distribution coefficient at room temperature. Conversion coefficient is 25 for 40ml sample volume and 4 for 250mL sample volume. There is no correction for the temperature of the water sample. Theoretically, the correction would slightly improve the analytical accuracy for the larger sample volume (25mL), but it would make little or no difference in the smaller sample volume. The results of the sample were corrected from the time of the sample was drawn to the time it was counted. Decay correction can be used for samples counted up to 10 days after sampling, though analytical precision will decline as the sample gets weaker and weaker. The decay correction factor (DCF) is given by the formula

$$DCF = \exp(T/132.4) \qquad (1)$$

Where T is the decay time in hours

Based on decay correction factor's table (RAD7 H20 manual), decay time of less than 3 hours require very small correction. The decay factor may be neglected for the samples counted quickly. Thus, the actual radon concentration for each sample was calculated as below [10]:

Corrected Radon Concentration = Radon Concentration ∗ DCF…………………….(2)

The background of RAD7 is low enough and can be ignored it. So, there is no need to have this background measured. Numerous experiments were available to measure the background. The results were negligible, especially, after the device has been purged from radon for 15 minutes. The intrinsic background of RAD7 is less than 1 count per hour. Corresponding to 40ml water sample concentration of less than 740Bq/m^3 (even lower for the 250ml sample), the background was less than 1Bq/m^3 after the air has been subtracted by loop and desiccant. The background was ignored during the measurement of radon in water. The RADH_2O gives results after 30 minutes analysis with a sensitivity that matches or exceeds that of liquid scintillation methods. The RADH_2O method employs a closed loop aeration scheme whereby the air volume and water volume are constant and independent of the flow rate. The air recirculates through the water and continuously extracts the radon until a state of equilibrium develops. Then the RAD H_2O system reaches the state of equilibrium within about 5 minutes, after which no more radon can be extracted from the water. Air was then circulated in a close circuit for a period of 5-10 min until the radon was uniformly mixed with the air and the resulting alpha activity was recorded and it directly gives the radon concentration [10,11].

Annual Effective Dose

The annual effective dose to an individual for ^{222}Rn due to intake drinking water is evaluated using the following equation [12,13]:

$D_W = C_w Cr_w Dc_w$ …………………(3)

Where, Dwis the annual effective dose (sv/y) due to ingestion of radionuclides from the consumption of water,
Cw is the concentration of ^{222}Rn in the ingested drinking water (Bq /L),

Cr_w is the annual intake of drinking water (L/y),

Dc_w is the ingested dose conversion factor for 222Rn (Sv/Bq).

According to United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR, 1993), a dose conversion factor of 5 * 10^{-9}Sv/Bq has been used and considering that an adult (age>18 year), on average, takes 730 L water annually [14,15].

Result and Discussion

Figure 1: Radon concentration in tap water using RAD H_2O accessories

Figure 2: Aeration stage during radon measurement in tap water

Radon Activity Concentration

In this study radon concentration in total eighteen tap water samples collected from different residential areas of Dhaka city were measured using radon detector RAD7 with RAD H_2O accessories.

Sampling Point	Location Name	Temp (°C)	Humidity (%)	Mean Activity Concentration (Bq/L)	High~Low
TW1	Airport	13	16	3.70± 0.115	4.34~2.76
TW2	Agargaow	16	14	2.66± 0.882	3.66~1.67
TW3	TSC	22.2	33	4.80± 0.548	5.35~1.67
TW4	Azimpur	24.3	12	0.07± 0.014	0.028~0.00
TW5	Baily Road	22.5	20	4.320± 0.78	5.190~3.800
TW6	Zigatula	22.5	20	1.890± 0.352	2.240~1.400
TW7	Mohammad pur	23.7	28	4.780± 0.845	5.770~3.780
TW8	Bonany	22.7	17	1.500± 0.523	1.520~1.020
TW9	Tongi	21.3	15	1.480± 0.339	1.830~1.320
TW10	Dhanmondi	20.9	18	1.660± 0.800	3.000~1.170
TW11	Uttara	23.4	20	3.320± 0.313	3.640~2.940
TW12	Mirpur	20.7	14	1.000± 2.010	1.400~1.0K0
TW13	AECD	22.5	15	1.380± 0.231	2.523~1.520
TW14	Jattrabari1	24	16	3.760± 0.752	4.370~2.660
TW15	Tajgaow	24	18	2.000± 0.978	3.930~1.630
TW16	Jattrabari2	24	20	3.760± 0.752	4.370~2.660
TW17	Khilkhet	22	16	1.500± 0.179	1.680~1.250
TW18	Duhar	21	24	3.950± 1.570	3.200~2.740

Radon concentration in tap water in Bq/L in Dhaka city

Table 2: shown the radon concentration with temperature and relative humidity details

The radon concentration in tap water samples were ranged from 0.07± 0.014 Bq/L to 4.80± 0.548 Bq/L with the average value 2.67± 0.66 Bq/L. One of our findings was that the concentration levels varies with humidity if humidity increased activity and error also increased. Relative humidity should be below 10% for the entire 30 minutes of measurements. However, during the measurements, the humidity exceeds more than 10% in most of cases. High humidity reduces the efficiency of collection of 218Po atoms. Under these circumstances, a low level of radioactivity can be detected. RAD7 detector has unusual ability to inform about the difference between new radon daughter nuclei and old radon daughter nuclei left from the previous test. The higher radon concentration and the longer previous samples were held in the cell, the more daughter nuclei activity was left behind. In order to remove the background, the detector is purged and the background activity that was left in the detector is flushed from the chamber [16]. According to Environment Protection Agency the allowed maximum contamination level for radon concentration in drinking water up to 11.1 Bq/L [17]. The World Health Organization (WHO) guidelines for drinking water quality suggest that repeated measurements should be implemented if radon activity concentration in public drinking water supplies exceeds 100 Bq/L [18].

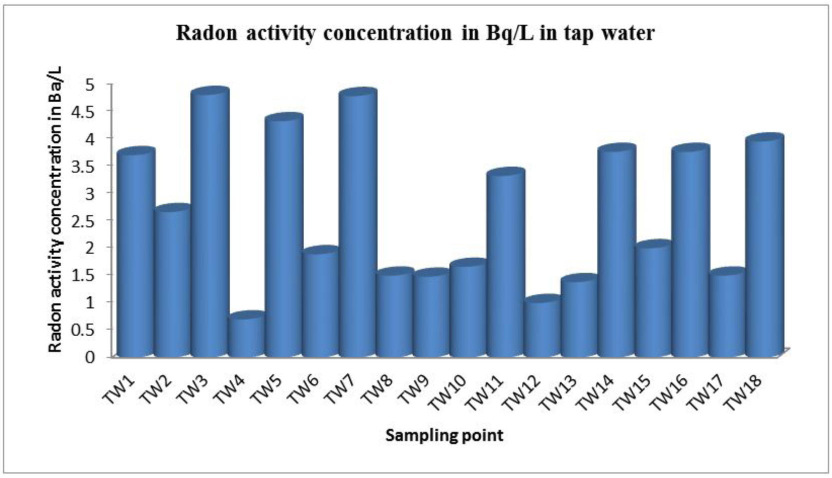


Figure 3 presented the variation of radon concentration in tap water samples of Dhaka city. The highest radon concentration was found in sample ID TW3 and lowest was found in sample ID TW4 as shown in the figure

Figure 3: Radon concentration in Bq/L in tap water collected from different residential in Dhaka city

According to European Union (EU) commission recommendations no remedial action should be required if the concentration of radon in drinking water is <100 Bq/L [19]. It was clear from, that all the value of radon concentration in residential tap water samples were lower than the international recommended value (Table 2).

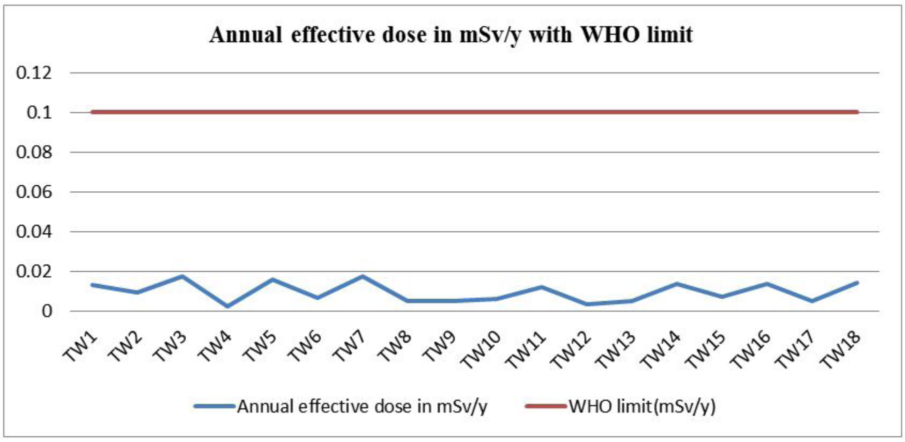
Annual Effective Dose

Sampling Point	Annual effective dose (mSv/y)
TW1	0.0135
TW2	0.0097
TW3	0.0175
TW4	0.0025
TW5	0.0157
TW6	0.0068
TW7	0.0174
TW8	0.0054
TW9	0.0054
TW10	0.006
TW11	0.0121
TW12	0.0036
TW13	0.005
TW14	0.0137
TW15	0.0073
TW16	0.0137
TW17	0.0054
TW18	0.0144

The annual effective doses of all the samples were calculated. The annual effective dose was found ranged from 0.002555 mSv/y to 0.01752 mSv/y with an average value of 0.009765 mSv/y as shown in Table 3.

Table 3: Annual effective dose in tap water collected from different residential in Dhaka city

WHO recommended reference level of annual effective dose due to radon is 0.1 mSv/y for drinking water [18]. The obtained annual effective dose was for tap water of Dhaka city were below the WHO limit. Thus, the tap water can be used as not only everyday household purposes but also for drinking.



The comparison of annual effective dose due to radon between present studies with WHO recommended reference levels were shown in figure 4

Figure 4: Annual effective dose in mSv/y in tap water collected from different residential in Dhaka city with WHO normal limit.

Country Name	Water source	Radon concentration in Bq/L	Reference
Penang, Malaysia	Tap water	23.10± 9.361 pCi/L	[20]
Kirkuk governorate	Tap water	2.740 Bq/L	[21]
United Kingdom	Tap Water	1-2 Bq/L (range)	[22]
Karnataka, India	Tap Water	(0.27–5.4) Bq/L	[23]
Palestine	Tap water	1.0 (0.9-1.3) Bq/L	[16]

Country Name	Water source	Radon concentration in Bq/L	Reference
Jordan	Tap Water	(2.5-4.7) Bq/L	[16,24]
Saudi Arabia	Tap water	37.8± 2.13 pCi/L	[16]
Kufa city, Iraq	Drinking water	(3.9± 0.0432-226± 8.876) Bq/m3	[25]
Kastamonu, Turkey	Tap water	(0.31± 0.03to 13.14± 0.38) Bq/L	[26]
EPA	Drinking water	300 pCi/L (11 Bq/L)	[17]
Present Study, Dhaka City		(0.70-4.80)Bq/L	

A comparison of the concentrations obtained in this research with other parts of worldindicates that ^{222}Rn activity concentration of thetap water samples is bellow compared toJordan, India, Malaysia, Turkey, Iraq, Saudi Arabia as well as EPA limit but slightly high compared toUnited KingdomandPalestine as presented in Table 4

Table 4: A comparison with the radonactivity concentrations of tap waters from different studies of the world

Conclusion

To inspect the radon concentrationin tap water samples, around Dhaka city, eighteen tap water samples were collected from different residence. The radon concentrations of all collected samples were found lower than the action levels recommended by different agencies e.g. US EPA, UNSCEAR, and EU. Also the annual effective dose was found to below the recommended level by WHO. These results indicate that there is no probability of health hazards for public due to presences of radon in tap water and it is safe to use as well as drinking for the standpoint of radon concentration. As far as is known, this is the first study to measure radon concentration in tap water of Dhaka City. Therefore this result will be a baseline data for radon measurement in water and also will be used to evaluate any possible changes in future.

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