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Distribution of Environmental Radioactivity in Drinking Water Samples of the Surrounding Area of Proposed Rooppur Nuclear Plant in Bangladesh

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Abstract
This study was undertaken to measure the radioactivity in drinking water samples, as part of an environmental radioactivity-monitoring program for the proper assessment of radiation exposure to the population of Bangladesh. Natural and artificial radioactivities in Drinking water have been determined from different Upazila of Kushtia district of Bangladesh by using gamma – ray spectrometry system consisting of a HPGe coaxial detector (EG & G ORTEC) coupled with a silena Emcaplus multichannel analyzer (MCA) and associate microprocessors. The average natural radio activities were 0.40±0.3Bq/L, 0.96±0.6Bq/L and 31.913±17.01Bq/L for Ra^{226}, ^{228}Ra and ^{40}K respectively in water samples of Kushtia District. In this study there is no artificial radioactivity. The results are also compared with the literature values reported for other regions of the world.

Key Words: Natural and Artificial Radioactivity, Drinking Water, Gamma Spectrometry, Efficiency and P-gamma.

Introduction

Electric power generation in Bangladesh is very much insufficient to meet the country's demand. In order to improve the power generation capacity, Bangladesh Government is contemplating to install a power reactor of 2000 MW (1000x2 MW) at the Rooppur, Pabna on the north bank of river Padma. To ensure the safety of the occupational worker, public at large and the environment from the harmful effects of radiation, pre installation background radiation survey is mandatory to study the radioactivity level in and around the proposed reactor site before installation of the reactor, in order to assess the base line data which would be needed to compare the same with the post commissioning data of the reactor and any fallout originated from the nuclear accident worldwide. Bangladesh Atomic Energy Commission has decided to assess the pre-commissioning data, viz. geological survey, climatologically survey, flood data survey and background radiation and radioactivity in and around the reactor site.

Radioactivity in soil and water system may ultimately find its way to human through food chain and by direct contact with the ecosystem. So, the knowledge of the distribution pattern of both anthropogenic and natural radionuclides is essential in maintaining some sense of control of prevailing radiation levels. Soil and water are contaminated fast after the nuclear explosion or

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other events such as atmospheric pollution and radioactive fallout. Measurement of natural and fall out radionuclides in soil and water gives information on natural sources, cumulative deposition of fission products from nuclear device testing and/or nuclear accidents.

The United Nations Scientific Committee on Effects of Atomic Radiation (UNSCEAR, 2000) has repoted that the average worldwide exposure to natural sources in foods and drinking water (ingestion exposure) is 0.29 mSv/y (about 0.17 mSv/y from 40K and about 0.12 mSv/y from Uranium and Thorium). In this study, Natural radioactivities of ^{238}U, ^{232}Th, ^{40}K and artificial radioactivity of ^{137}Cs in 18 drinking water samples from different Upazila of Kushtia district of Bangladesh have been determined by using gamma spectrometry.

The main objective of the present work is to provide data on natural and artificial radioactive isotopes and environmental pollution associated with the drinking water of Kushtia district of Bangladesh. The data would be useful for assessment of human radiation exposure from natural environment and radiation monitoring programme aimed at minimizing radiation exposure to population during the post installation area of Rooppur.

Materials and Methods

***Sample Collection & Preparations*:** Eighteen water samples of one litter were collected from different Upazila of Kushtia district of Bangladesh. These samples were evaporated at water bath to reduce its volume to 263 ml, respectively. All samples were transferred to plastic container (dia. 7.0 cm X height 6.5 cm) for gamma counting. These samples were counted by using HPGe system for 5000 s each. Blank plastic container of same geometry was used for background counts.

Radioactivity Measurement: The activity concentrations of 18 drinking water samples were measured using a low level gamma counting system, a high-resolution HPGe eoaxial detector (EG&ORTREC) coupled with a Silena Emcaplus multichannel analyzer (MCA) and associate microprocessors. The effective volume of the detector was 83.469 cm^3 and energy resolution of the 1.33 MeV energy peak for ^{60}Co was found as 1.69 keV at full width half maximum (FWHM) with a relative efficiency of 19.6%. All samples and corresponding background counts for each sample have been taken for 5000s. The prominent gamma photopeaks of the samples and background spectrums at 1460 keV for ^{40}K; 609.3, 1764.50,1120 keV of ^{214}Bi and 295, 352 keV of ^{214}Pb for ^{238}U; 911,969.11keV of ^{228}Ac, 238keV of 212Pb and 583.14, 510.84, 860.37keV of ^{208}Tl for ^{232}Th were clearly identified and used for estimation of respective radionuclides. The radioactivities of ^{238}U and ^{232}Th were estimated on the assumption that they are in secular equilibrium with their respective daughter products within four weeks (Alam et al, 1997; Mollah et al, 1986). ^{226}Ra activity concentations was estimated from its gamma ray peak of 609.3 keV from ^{214}Bi. The 583.14 keV gamma ray of ^{208}Tl was used to estimate the activity concentration of ^{228}Ra. The activity concentration of ^{40}K was estimated by using its own gamma ray photopeak at 1460.2 keV. The calculations of the concentration of different radionuclides were based on the measured detector efficiency as a function of energy curve as in Fig. 1. for the same counting geometry and time. The efficiency of the detector was determined by standard Eu-152 source with 1N HCl.

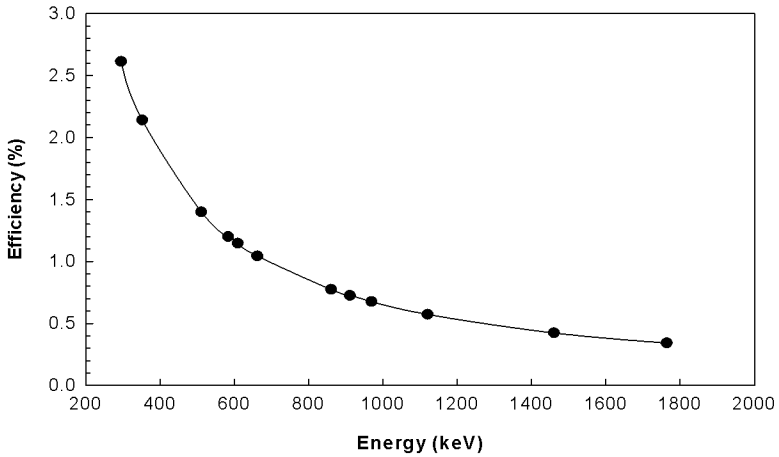

Figure1: Efficiency graph of HPGe detector (EG & G ORTEC).

Results and Discussion

Measured activity concentrations of ^{226}Ra and ^{228}Ra which are the decay product of ^{238}U and ^{232}Th, respectively as well as that of ^{40}K in the water samples are presented in table 1. The activity of Ra^{226} ranged from 0.03±0.02Bq/L to 0.98±0.08Bq/L with an average of 0.40±0.3Bq/L. The activity of ^{228}Range from 0.04±0.02Bq/L to 2.26±0.09Bq/L with an average of 0.96±0.6Bq/L while the activity of ^{40}K ranged from 5.342±1.32Bq/L to 59.903±14.67Bq/L with an average of 31.913±17.01Bq/L. The mean activity concentration values were 0.40±0.3Bq/L, 0.96±0.6Bq/L and 31.913±17.01Bq/L for ^{226}Ra, ^{228}Ra and ^{40}K respectively. Thus ^{40}K contributed the largest activity concentration while ^{226}Ra contributed last activity in the water samples. The ± values associated with the mean values represent the variability (Standard deviation) in the activity concentration values of the radionuclide. The table 1 shows that the activity concentrations of ^{226}Ra in all the samples dose not exceeded the limit of 1.00 Bq/L recommended By IAEA (IAEA 1989). This is found to be greater than values reported for the U.S.A and Poland as shown in table 2.The mean activity concentration of 0.96±0.6Bq/L obtained for ^{228}Ra in the water samples was above the value of 1.06±0.31 Bq/L reported for commercialized drinking water from Tunisia (Tunisia 2005).

In Table 2, effort has also been made to compare the results of the present study with those reported for other regions. It is evident that the range and mean values of concentrations of ^{226}Ra in the present study is higher when compared to the U.S.A., France and Poland ([a]UNSCEAR, 2000). The concentration range of ^{226}Ra in the present study is lower when compared to that of

Nigeria. The concentration range of Turkey (Istanbul), Turkey (Eastern Black Sea) ([b]Karahan et al, 2000) of ^{226}Ra is lower when compare to Kushtia region in water samples. However the concentration of Finland of ^{226}Ra is higher when compare to all reported data as shown as table 2. It is clear that the concentration range of ^{226}Ra is very much comparable.

Table1: Concentrations of Ra^{226}, Ra^{228} and ^{40}K in drinking water samples of Kushtia District of Bangladesh

Concentration of Radioactivity in Bq/L				
No. of samples	Sample sites	^{226}Ra	^{228}Ra	^{40}K
1.	Bheramara Sadar	0.09±0.03	0.15±0.08	33.29±13.08
2.	Bheramara Bazar	0.79±0.07	1.15±0.07	53.67±16.05
3.	Bheramara South	0.22±0.30	0.97±0.50	6.56±1.69
4.	Kushtia Sadar	0.81±0.50	1.27±0.08	6.89±1.97
5.	Kushtia North	0.13±0.07	1.32±0.09	5.34±1.32
6.	Kushtia South	0.47±0.05	1.02±0.03	10.38±3.24
7.	Mirpur Sadar	0.03±0.02	1.06±0.04	39.57±13.23
8.	Mirpur Bazar	0.03±0.02	0.07±0.02	42.92±6.76
9.	Mirpur North	0.65±0.05	1.52±0.03	51.92±14.34
10.	Kumarkhali Sadar	0.42±0.03	2.26±0.09	24.49±4.34
11.	Kumarkhali Bazar	0.07±0.02	0.52±0.03	45.99±12.41
12.	Kumarkhali South	0.08±0.02	0.04±0.02	27.55±12.45
13.	Doulatpur Sadar	0.10±0.03	1.28±0.07	29.613±6.35
14.	Doulatpur North	0.98±0.08	1.25±0.06	39.48±12.23
15.	Doulathpur South	0.09±0.06	1.09±0.05	35.33±5.74
16.	Khuksha Sadar	0.61±0.04	1.75±1.00	59.90±14.67
17.	Khuksha North	0.85±0.07	0.35±0.02	29.61±6.14
18.	Khuksha South	0.76±0.06	0.21±0.01	6.54±1.54
Range		0.03-0.98	0.04-2.26	5.34-59.90
Mean		0.40	0.96	31.91
Standard deviation		0.3	0.6	17.01

(±) values represent counting error.

Table 2: Comparison of ^{226} Ra activity concentration range in drinking water from different countries

Country	Concentration range of ^{226}Ra (mBq/L)
U.S	0.4-1.8[a]
France	7.0-700[a]
Finland	10.0-49000[a]
Germany	1.0-1800[a]
Italy	0.2-1200[a]
Poland	1.7-4.5[a]
Spain	20-40000[a]
Turkey(Istanbul)	11-36[b]
Turkey(Eastern Black Sea)	3-45[c]
Nigeria	2220-15500[d]
Present study (Kushtia)	30-980[e]

[a]UNSCEAR, 2000[1]; [b]Karahan et al, 2000[7]; [c]Cevik et al, 2006[6]; [d]Nigeria ; [e]this study

Conclusions

The study showed that the mean activity concentration values were 0.40±0.3Bq/L, 0.96±0.6Bq/L and 31.913±17.01Bq/L for ^{226}Ra, ^{228}Ra and ^{40}K respectively in water samples of Kushtia District and were comparable with the [a]UNSCEAR, 2000, [b]Karahan et al, 2000 , [b]Karahan et al, 2000, [c]Cevik et al, 2006 and [d]Nigeria . No artificial radioactivity has been detected by means of gamma spectrometry. This paper will provide data base for anticipated radiation protection measures when need arises.

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