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Assessment of Radioactivity Concentration of Some Bottled Drinking Water Produced In Delta State

[1]K. Emumejaye and [2]D. Osiga - Aibangbee

[1,2]Science Laboratory Technology Department, Delta State Polytechnic,P.M.B 5 Ozoro,Nigeria

Abstract

The consumption of bottled drinking water in the area of study has widely increased of recent. Over 80% of people living in Delta State make use of bottled drinking water this is partly due to growing awareness that the consumption of unsafe or untreated drinking water is the cause of man diseases especially water borne diseases. Although, the geology of the area does not reveal exposed rocks that could be a source of harmful radionucles, the exploration and exploitation of petroleum in the area could be a potential source of contaminants and so it is important to check the radioactivity concentration present in bottled drinking water, whether it is below WHO permissible values. The activity concentration of ^{40}K, ^{226}Ra and its progenies ^{232}U and physiochemical parameters: pH, Na, Mg, Ca, Cl^{-1}, SO_4^{-2}, NO_3 and CO_2^{-2} were determined. The results obtained indicate that radioactivity concentration is actually present in bottled drinking water but of little value and it shows no significant concentration range compared to WHO maximum permissible values.

Keywords: Radioactivity, Radionuclides,Water,Concentration,Niger-Delta

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1. Introduction

Radioactivity, the term used to describe the decay of atomic nucleus, has existed since time began on earth [1]. One was exposed to natural sources until recent times, when the growth of nuclear energy was created. Its origin has been traced to a number of naturally occurring radioactive material (NORM), which are present in soils, rocks, the floors and walls dwellings, offices in schools, in the food humans eat and drink, in the air humans breathe and in human bodies and man-made or artificial sources. Humans have always been exposed to natural radiation arising from the earth as well as from outer space. Naturally occurring radioactive material enter the human body through two main pathways by inhalation of radioactive gases like radon and dust, and ingestion of primordial radionuclides ^{40}K, ^{232}Th an ^{238}U as well as their radioactive progenies. The decay of inhaled or ingested radionuclides give rise to internal exposure of the tissues and organs in the human body [1-4].In Delta State, consumption of some bottled drinking water has widely increased in recent years. This is partly due to growing awareness that the consumption of unsafe or untreated drinking water is the cause of man diseases especially water borne diseases. Therefore it is important to set an enhanced trend of bottle water consumption in both rural and urban areas of the state [1].

The World Health Organization (WHO) has recommended safe values for various drinking water quality parameters in its general guide lines. These different guidelines have been used by different countries, e.g the USA and EU to formulate this own national water quality guidelines. The increasing consumption of bottled drinking water by people of all ages – infants, children and adult alike – calls for evaluation of its suitability for consumption since its quality varies from source to source.Water is an essential commodity without which there is no life. Considering the high radiotoxicity of ^{226}Ra and ^{228}Ra, their presence in water and the associated health risks require particular attention [5-10].Such evaluation will assist in assessing potential radiation doses so that remedial action or steps can be taken if necessary to avoid undue exposure of consumers. UNSCEAR report provides information on natural radionuclide in North America, Asia and Europe but no such information exists for African States [11].In Nigeria, the National Agency for Food and Drug Administration and Control (NAFDAC) has formulated bottle drinking water quality standards and has been enforcing the standards. The standard emphasizes the physico-chemical parameters (non-radioactive contaminants) at the expense of natural activity concentration limits [1]. Many of the producers of bottle drinking water in Delta State have not been processing and sealing the water as recommended by WHO [12].

Radioactivity contents have been measure in drinking water in different countries by using various analytical methods [1, 3]. In this study, the method for rapid determination of pH, Na, Mg, Ca, Cl^{-1}, SO_4^{-2} , NO_3 and CO_2^{-2} , also for activity concentration of ^{40}K, ^{226}Ra, ^{233}U, and ^{228}Ra in bottled drinking water samples using Unicom 929 AA spectrometer(AAS) and fluorimeter were employed respectively. This method is suitable for both dissolved and total metals in water and waste water samples.

1.2. Materials and Methods

Study Area

The study area lies within the Niger Delta sedimentary basin which is characterized by both Marine and mixed continental quaternary sediments that are composed of abandoned beach ridges and mangrove swamps [13]. The area is bounded by latitude 50 31' and 60 00' North, and longitude 50 00' and 70 00 East. The area experience wet and dry season which are typical seasons in Nigeria [14]. Twelve samples of different brand of bottled water in plastic containers were collected from the producers of drinking water that spread across Delta State (one of the oil producing states in the Niger Delta of Nigeria) and were analyzed using Unicom 929 AA spectrometer(AAS) and Laboratory Fluorimeter, Model CBS-380.

1.3. Principle

The sample is first aspirated into the flame or electro-thermal device where it is vaporized and atomized, radiation of the proper wavelength is then passed through the vapour containing the ground state atoms of the metal where absorption occurs. The magnitude of their AAS absorption signal is directly proportional to the concentration of the analyte metal in the sample solution.

1.4. Apparatus and Reagents

Unicom 929 AA spectrometer (AAS) 1000mg/l stock standard of pH, Na, Mg, Ca, Cl^{-1} , SO_4^{2-}, NO_3 and CO_2^{-2} ,Concentrated HNO_3

1.5. Procedure

Sample Preparation for Turbid and Waste Water Samples

A representative portion of the well mixed samples (100ml) is transferred into a beaker ad 5ml of conc. HNO_3 added.

The solution is evaporated to near dryness on a hot plate, making sure that the sample does not boil. The beaker is allowed to cool and another 5ml of Conc. HNO_3 added. The beaker is covered with a watch glass and returned to the hot plate.

A gentle refluxing action of the solution was set by increasing the temperature of the hot plate. Heating was continued with addition of acid as necessary until digestion was completed (light coloured residue obtained).
1.2ml Conc. HNO_3 was added to dissolve the residue. The residue was washed with distilled water and filtered to remove silicate and other insoluble material. The volume of the solution was adjusted to 100ml in a volumetric flask. A reagent blank determination was carried out, samples and reagent blank was analyzed for total heavy metals with the flames. AAS.

1.6. Sample Preparation for Surface and Bottled Water Samples

Samples are not pretreated in any way; they are analyzed directly using the AAS.

2. Sample Preparation for ^{226}Ra ^{228}Ra (^{233}U) and ^{40}K

A method of fluorescence of radioactive element in a pad prepared by fusion of the dried solids from the water sample with a flux of 10% NaF, 45.5% Na_2CO_3, and 45.5% K_2CO_3. This flux permits use of a low fusion temperature and yields pads which are easily removed from the platinum fusion dishes for fluorescence measurements. Uranium concentration of less than 1 microgram per liter can be determined on a sample of 10millilitres, or less. The sensitivity and accuracy of the method are dependent primarily on the purity of reagents used, the stability and linearity of the fluorimeter and the concentration of quenching element in the water residue. A purification step is recommended when the fluorescence is quenching element in the water residue. A purification step is recommended when the fluorescence is quenched by more than 30%.

3. Calibration and Analysis

Single elemental working standard solutions were prepared by dilution of 1000mg /l stock solution of the individual elements (pH, Na, Mg, Ca, Cl^{-1}, SO_4^{-2}, NO_3 and CO_3). A minimum of five standard working solution were prepared daily from the stock solution, the solutions ranged between 0.1mg/l to 10.0mg/l. external calibration was used by running deionised water and a suite of calibration standards for each element. The calibration curve was then generated for each metal. The extracted solutions and blanks were then run on the AAS to obtain the absorbance value. Concentrations of the metal in water samples were then calculated from the equation of the calibration curve.

Calculation

Conc. Of Element X (mg/l) = A – B

Where A = Conc. Of Element X (mg/l)

B = Conc. Of Blank (mg/l)

Quality Assurance

Blanks, duplicates and laboratory control samples were run as QC samples

Results and Discussion

The result of the measurement of the non-radioactive contaminant in the bottled drinking water samples are presented in table 1. The pH of the samples varied from 5.40 to 6.68. Preswin with pH of 5.40 is nearly pure water. Other samples are alkaline with Esquire being the most alkaline sample. The most variable of the non-radioactive contaminants was chloride that ranged from 0.60 to 15.50mg/l. the least variable was ND to 0.38mg/l.Measured activity concentration of ^{226}Ra and ^{228}Ra which are the decay product of ^{233}U, respectively as well as that of ^{40}K in the bottled drinking water samples are presented in table 2. The activity concentration of ^{40}K, ^{233}U, ^{226}Ra and ^{228}Ra ranged from ND to 0.03 Bqkg^{-1} and ND respectively. Esquire sample has the highest concentration of ^{40}K while others is ND except P.A sample which is 0.02. The concentration of ^{226}Ra, ^{228}Ra and ^{233}U are also ND respectively. The table shows that the activity concentrations of ^{226}Ra in all the samples did not exceed the limit of 1.00Bq1^{-1} recommended by [15]. This is found to be less than the values reported for the USA and Poland as shown in table 3. The mean activity concentration of NDBqkg^{-1} obtained for ^{228}Ra in the water samples were below the value of $1.06 \neq 0.31$ Bql^{-1} reported for commercialized drinking water from Tunisia [16].

	Us	Yoma	Ashton	Mito	Efac	P.A	Preswin	Cy	Esquire	Kool	Gwake	Faith
pH	5.43	5.44	5.53	6.26	5.81	6.06	5.40	5.44	6.68	6.00	5.46	5.50
Cl^{-1}	7.12	2.41	0.60	8.10	2.40	9.60	1.80	3.90	15.50	9.60	2.41	3.70
Alkalinity	1.40	0.50	1.87	0.74	1.42	0.72	1.92	1.94	0.51	1.50	0.75	1.92
Na^{+}	0.30	0.27	0.21	1.78	2.75	4.63	2.01	2.63	3.33	2.70	2.60	3.01
Ca^{2+}	2.00	1.22	0.15	4.29	1.21	2.07	0.87	1.64	9.28	2.06	0.78	0.17
Mg^{2+}	0.84	0.40	0.11	2.07	0.83	1.45	0.42	0.52	1.57	0.11	0.43	0.51
Hardness	0.26	0.27	0.25	7.03	1.36	3.11	1.34	1.78	6.42	1.35	0.25	1.37
SO_4^{2-}	0.23	0.22	ND	0.16	0.07	0.22	ND	0.04	3.83	0.17	0.06	0.21
NO^{3-}	0.10	0.16	ND	0.05	ND	0.17	ND	ND	0.38	0.15	0.12	0.23

ND = Not Detected

Table 1: Concentration of chemical parameter (mg^{-1}) of bottled drinking water samples

Table 2: Activity concentration of different radionuclides present in the bottled water samples

Sample name	^{233}U (Bq/100g)	^{226}Ra(Bq/100g)	^{228}Ra(Bq/100g)	^{40}K(Bq/100g)
Us	ND	ND	ND	ND
Yoma	ND	ND	0.01	ND
Ashton	ND	ND	ND	ND
Mito	ND	ND	ND	ND
Efac	ND	ND	ND	ND
P.A	ND	ND	ND	0.02
Preswin	ND	ND	ND	ND
Cy	ND	ND	ND	ND
Esquire	ND	ND	ND	0.03
Kool	ND	ND	ND	ND
Gwake	ND	ND	ND	ND
Faith	ND	ND	ND	ND

ND = Not Detected

Table 3: Comparison of ^{226}Ra activity concentration range in bottled drinking water from different countries

Country	Concentration range ($mBql^{-1}$)
U.S	0.4 – 1.8[17]
France	7.0 – 700[17]
Finland	10.0 – 49000[17]
Germany	1.0 – 1800[17]
Italy	0.2 – 1200[17]
Poland	1.7 – 4.5[17]
Spain	<20 – 4000[17]
Turkey (Istanbul)	11 – 36[18]
Turkey (Eastern black sea	3 – 45[19]
Nigeria	2220 – 15500[1] , 0 - 0.03 $Bq100g^{-1*}$ *present work

4. Conclusion

This study shows that it is radiologically safe to consume any of the bottled drinking water samples that have been investigated since they are within the World Health Organization limit value. However, bottled drinking water samples should be tested periodically for radioactivity concentration levels to ensure safety of bottled drinking water.

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