GROSS ALPHA AND GROSS BETA RADIOACTIVITY IN COMMERCIAL BOTTLED WATER SOLD IN MINNA, NIGER STATE.

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ABSTRACT
Ten samples of commercial bottled water sold and consumed in Minna town, were selected and assessed for their gross alpha and gross beta radioactivity. The analysis was done using the Eurisis system-eight-channel-gas-filled proportional counter at the Center for Energy Research and Training (CERT), Ahmadu Bello University Zaria, Kaduna State. The results obtained ranged between 0.0031±0.0004 – 0.21±0.0002Bq/l for gross alpha, while the gross beta activity concentration range between 0.0097±0.0003 – 0.2±0.0003Bq/l. The overall result show that the natural radioactivity of the commercial bottled water consumed in Minna town is far below the practical screening levels recommended by the World Health Organization, WHO (2004) for good water quality and therefore fit for human consumption and other domestic activities.

Keywords: gross alpha; gross beta; bottled water; Minna.

INTRODUCTION

A great interest has arisen over the years in many countries towards the occurrence of natural radioactivity in drinking water (Isam, 2003; Hakam, et al., 2001; Alfatih, et al., 2008). EPA (1997), CAC (2001), Health Canada (2007), and several other nations have published their national standards for limiting radiation exposure, by establishing maximum permissible radionuclide concentration in drinking water. According to World Health Organization, WHO (2004), access to safe drinking water is important as a health and development issue at national, regional and local levels, to the extent that it has form a component of effective policy for health protection. Safe drinking water as defined by WHO (2004), does not represent any significant risk to health over a lifetime of consumption including different sensitivities that may occur between life stages.

Primeval radionuclides have survived in detectable amounts since the time of nucleosynthesis and contribute to natural terrestrial radioactivity (Bonotto and Bueno, 2008). The activity concentrations of natural radionuclides in groundwater are connected to the activity concentration of uranium (^{238}U and ^{235}U) and thorium (^{232}Th) and their decay products in the ground and bedrock (Pia, 2007). Natural waters contain several alpha and beta emitting isotopes in a widely varying concentrations, which, when ingested by humans, contribute to the dose due to natural sources (Davila et al., 2002).

Potential health hazards from natural radionuclides in consuming water have been considered worldwide (Bonotto, et al., 2008), with many countries adopting the guideline activity concentration for drinking water quality recommended by WHO (2004). Radiological hazards may derive from ionizing radiation emitted by a number of radioactive substances (chemicals) in drinking water. Since the calculation of the total dose requires the measurement of all these dissolved natural radionuclides, WHO guideline for drinking water suggested performing an indirect evaluation of committed dose by measuring the alpha and beta gross activity and checking compliance to derived limit values (WHO, 1993; WHO, 1996). This screening procedure is an initial practical approach where the total radioactivity present in the form of alpha and beta radiation is first determined without regard to the identity of specific radionuclides. For practical purposes, 0.5Bq/l for gross alpha and 1.0Bq/l for gross beta activity has been set by WHO (2004) as routine operational limits for existing or new water supplies. If the values for gross alpha and gross beta activity determined exceed these recommended values, the contents of specific radionuclides have to be determined by alpha and/or gamma spectrometric measurements (Jasminka, et al., 2007).

There is an increasing demand for potable drinking water to satisfy the need of the uncontrolled increasing population in Minna town. The consumption of commercial bottled water has been increasing in Nigeria for the past years and has become more popular in recent years in Minna due to lack of adequate and sufficient sources of potable water in the town. This rise in the rate of consumption of commercial bottled water (to nearly 85%) may not be unconnected with the nature of the vocation of the inhabitants which make them spend most of their day outdoor. The high standard of living also witnessed in the town of recent has made certain group of the population fulfill the need for drinking water almost exclusively with commercial bottled water. A general random survey indicates that the working class group (25 – 60 years old) form the highest consumer of commercial bottled water, with more than 80% of this group consuming about 3litres per day. Though water is not likely to be a major source of natural radionuclides intake compared to food, yet the increasing contribution of natural radionuclides in bottled water to the total ingestion dose should be assessed for radiation protection reasons (Kralik, et al., 2003). This paper attempts to investigate gross alpha and gross beta radioactivity in commercial bottled water sold in Minna town and to test their radiological quality and confirm the radiological burden on the consumers. Since the baseline radioactivity in potable water in Minna is not known, the result will serve as additional information for the management of drinking water sources.

MATERIALS AND METHOD

Ten brands of commercial bottled water sold in Minna were bought at random from different supermarkets for this study. The selected samples represent about 85% of the commercial bottled water consumed on daily basis in the town. 3litres of each brand was bought and thoroughly mixed together in a polyethylene bottle to give the true representation of the sample. Both the pH and conductivity of the samples were recorded immediately at the site of purchase. The samples were then acidified with 20ml nitric acid (HNO_3) so as to minimize precipitation and adsorption of the radionuclides to the walls of the containing vessels, and to maintain the homogeneity of the samples (Joseline, et al., 2001; Katzlbeger, et al., 2001; Khan, et al., 2002; Onoja, 2004; Gabrielle, et al., 2008). The samples were then tightly sealed and taken to the laboratory for analysis. The sample preparation and analysis was done at the Center for Energy and Research (CERT), Ahmadu Bello University, Zaria, Kaduna State.

Several quantification methods have been developed over trhe years for the detection of gross alpha and gross beta radioactivity in water. The generally accepted method, however, in several countries is based on ISO methods whose efficiency is dependent on the water residue mass (Ross, 2004). This method involves evaporating water to dryness and counting the residue deposited on a planchet/disk through a gas proportional counter (Bonotto, et al., 2008). The ISO method adopted in this study is ISO9697-water quality measurement for gross beta in non-saline water.

At the laboratory, the preserved water samples were evaporated using a Binatone temperature-regulated hotplate until the volume dropped to about 10ml. it was then transferred to a round petri dish and placed under an infra red lamp to evaporate slowly to dryness. The sample residue, now dried to constant weight was transferred to an already weighed 7.1cm^2 planchet and was reweighed to determine the mass of the dry residue. This was then placed in a decicator to prevent moisture absorption before the counting was done. Each of the samples was counted for 1800 seconds using an eight-channel-gas-filled proportional counter. The sample frequency, volume and other counting parameters were obtained following the procedure earlier reported (Onoja, 2004; Juliet, 2006; Avwiri and Agbalagba, 2007).

Table1 Alpha and Beta background values and channel efficiency

Water Brand	Channel No	Alpha background values (cpm)	Beta background values (cpm)	Channel Efficiency	
				Pu-239(α-%)	Sr-90 (β-%)
Nestle	1	0.259	1.47	34.85	46.47
Al-Kawathar	2	0.254	1.27	33.85	35.39
Mowa	4	0.250	1.21	35.65	38.79
Faro	5	0.240	1.25	38.20	40.66
Eva	6	0.207	1.02	31.97	42.94
Heve	8	0.172	0.918	36.17	34.88
Ultra cool	1	0.259	1.47	34.85	46.47
Maizube	2	0.254	1.27	33.85	35.39
Aquadana	5	0.240	1.25	38.20	40.66
La Voltic	6	0.207	1.02	31.97	42.94

Background values and channel efficiency are obtained from calibration of the equipment

Table 2 pH and conductivity of the water samples

Water brand	Conductivity (μs/cm)	PH
Eva	68.9	7.05
Nestle	117.7	6.62
Aquadana	77.1	7.51
Maizube	111.4	6.93
Mowa	35.6	7.31
Ultra cool	49.9	7.24
Faro	5.82	7.02
La Voltic	88.2	7.08
Heve	99.5	7.36
Al-Kawathar	25.6	6.38

Table3 Gross Alpha and Beta radioactivity of the bottled water samples

Sample Water Brand	α – Activity (Bq/L)	β – Activity (Bq/L)
Eva	0.0031±0.0004	0.049±0.0004
Nestle	0.018±0.0004	0.042±0.0004
Aquadana	0.01±0.0003	0.027±0.0003
Maizube	0.0068±0.0003	0.0097±0.0003
Mowa	0.034±0.0004	0.097±0.0005
Ultra cool	0.0081±0.0003	BDL
Faro	0.095±0.0003	0.2±0.0003
La Voltic	0.0083±0.0003	0.013±0.0003
Heve	0.21±0.0002	0.59±0.0003
Al-Kawathar	0.0032±0.0004	0.014±0.0003

BDL: Beyond detection limit.

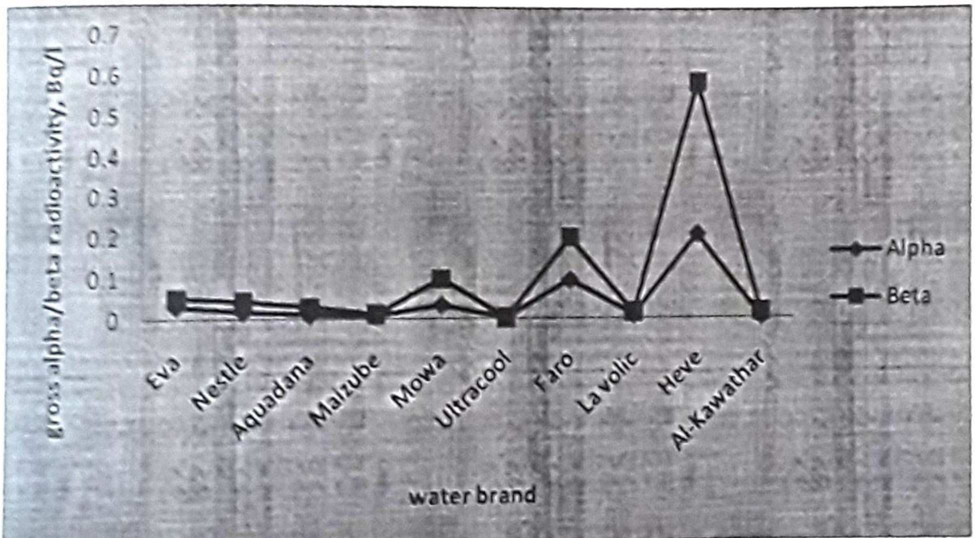

Fig.1 gross alpha/beta activity in the samples

RESULTS AND DISCUSSION

The set of conditions for the counting technique are given in table 1. Table 2 show the pH and conductivity readings of the water brands. The conductivity is the dissolved concentration of the ionic elements in the water. The variations noticed in the conductivity of the samples may not be unconnected with the source of the water supply and the minerals present in each water sample. The conductivity values fall below the stipulated maximum limit of 500µs/cm and therefore considered acceptable. The pH values vary between 6.38 and 7.31. This shows that the samples are neither highly acidic nor alkaline and falls within the range acceptable for potable water.

Table 3 shows the results for gross alpha and gross beta radioactivity concentrations for all the water samples. The gross alpha concentration for all the samples range between 0.0031±0.0004 – 0.21±0.0002Bq/l, with an average value of 0.039±0.003Bq/l, while the values for the gross beta concentration is between 0.0097±0.0003 – 0.2±0.0003Bq/l with an average value of 0.116±0.01Bq/l. the gross beta activity concentration for the Ultra cool bottled water is below the detection limit. The obtained values for the gross alpha and gross beta activity concentrations for all the water samples falls below the guidance values for limiting radiation exposure in drinking water recommended by WHO (2004). It could also be judged that the purification processes has no effect on the radionuclide concentration of the bottled water and so pose no health effect to the users thereof. There may therefore be no need for further radionuclide specific screening for the commercial bottle water consumed in Minna town since they are all safe for drinking.

Figure 1 shows a generally low distribution of alpha activity. The beta activity concentration shows a higher elevation over the alpha activity concentration. Davila, et al (2002) reported that gross alpha activity is composed predominantly by uranium and its daughter radioisotopes. The gross beta radioactivity in the natural waters is due to the natural long-lived isotopes, ^{40}K, ^{210}Pb, and ^{228}Ra (Cothern et al., 1986).

CONCLUSION

Though the activity concentrations of the commercial bottled water sold and consumed in Minna vary from brand to brand, the general results show that the gross alpha and gross beta activity concentrations of all the brands is far below the screening levels recommended by WHO for good water quality. All the commercial bottled water investigated, show good quality and very low levels of radionuclide concentration. They are all therefore fit for human consumption. Though the results show compliance with the internationally recommended limits for potable water, it is advisable that the regulatory bodies standardize the commercial water market generally in the state and constantly undertake regular programmes of environmental audit and monitoring particularly with regard to the quality control of bottled water.

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