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SURVEY OF GROSS ALPHA AND GROSS BETA RADIOACTIVITY IN SACHET WATER HAWKED IN MINNA, NIGER STATE.

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ABSTARCT

20 samples of sachet water produced by different sachet water making factories and hawked in Minna city were selected at random and assessed for their natural radioactivity content. Alpha and beta activities of the samples were determined using the eurysis system-eight-channel-gas-filled proportional counter at the Center for Energy Research and Training (CERT), ABU Zaria. The results show that the alpha activity concentration range between 0.002±0.001-0.024±0.004Bq/L with an average value of 0.0121±0.003Bq/L, while the beta activity concentration vary between 0.072±0.007-0.558±0.19Bq/L with an average value of 0.174±0.01Bq/L. The overall results show that alpha and beta activities in the sampled sachet waters are below the practical screening level of radioactivity in drinking water stipulated by the World Health Organization, WHO (2004) and therefore safe for drinking and other domestic activities.

Key words: Gross alpha and beta, radioactivity, sachet water.

Introduction

Radionuclides have been essential constituents of the earth since its creation (Khan et al, 2003) and up till now, the decay of the long-lived isotopes of U, Th and K is heating the earth's interior. Surface water and especially the groundwater play a role in the migration and redistribution of these radionuclides in the earth crust (Ortega et al. 1996).

Naturally occurring radionuclides are present in the food we eat, the air we breathe, and the water we drink and have resulted in the health hazard among the general public (Avwiri and Agbalagba, 2007). The unavoidable consequence of the presence in the earth crust, air food and water, of these naturally occurring radionuclides, is the exposure of man. Aregunjo et al (2004) reported that some of these exposures are relatively constant and uniform to all individuals throughout the world.

Potential health hazards from natural radionuclides in consuming water has been considered worldwide (Bonotto et al, 2008), with many countries adopting the guideline activity concentration for drinking water quality recommended by the World Health Organization (WHO, 2004). EPA (1997), CAC (2001), Health Canada (2007), WHO (2004), and several other national standards for limiting radiation exposure, establish maximum permissible radionuclide concentration in drinking water. To give an approximate idea of the amount of radionuclide in water, the gross alpha and gross beta activities are measured which gives the degree of contamination (Semkow and Parekh, 2000). Limit values for gross alpha and beta radioactivity concentrations for existing or new water supplies as set by WHO (2004) are 0.5Bq/l and 1.0Bq/l respectively. According to WHO guidelines, gross alpha radioactivity includes all the alpha emitters, excluding radon, and gross beta radioactivity includes all beta emitters excepting ^{3}H. these guidelines, according to

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Rangel et al (2002) and Joksic et al (2007) ensure an exposure lower than 0.1mSv/yr, assuming a water consumption rate of 2l/d. these recommendations apply to routine operational conditions of water supply systems and do not differentiate between natural and man-made radionuclides (de Oliviera et al, 2001).

In general gross alpha is more of concern than gross beta for natural radioactivity in water as it refers to the radioactivity of Th, U, Ra as well as Rn and its decay products (Bonotto et al, 2008). For anthropogenic radioactivity, gross alpha may pertain to screening for transuranics in water, while gross beta pertains to screening for fission products from accidental reactor releases (Anonymous, 1997a; Senkow and Parekh, 2001). Due to the many advantages of the detection of gross alpha and beta in water, several quantification methods have been developed. The generally accepted method in several countries is based on ISO methods whose efficiency is dependent on the water residue mass (Kleinschmidt, 2004). The 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 work is ISO9697, water quality measurement for gross beta activity in non-saline water.

There is an increasing demand for potable drinking water to satisfy the need of the uncontrolled increasing population in Minna city. Lack of adequate and sufficient sources of potable water in the city, coupled with the nature of the vocation of the inhabitants, which make them spend most of their day outdoors, has led to tremendous increase in the daily consumption of sachet drinking water hawked all around the city. The quality of this water therefore must be as important as the quantity, where the chemical physical, bacteriological and indeed radiological characteristics determine, to a great extent, their suitability to municipal, industrial, agricultural and domestic water demands (Karem and Hassan, 2000). With this increase in sachet water consumption, however, the regulations of the quality of this kind of water with regards to the limits of radioactive content is not specific. Due to the importance of drinking water for human life and the increased consumption of the sachet waters, their quality must be carefully and systematically controlled (Joksic et al, 2007) and investigated so as to guarantee a low level of radioactivity.

In Minna, sachet water is supplied to the market by over 100 sachet water production industries, where a variety of methods, from the very rudimentary filling techniques up to modern automated systems are used (Sajo-Bohus et al, 1997). 20 of these sachet water supplies were selected for radiological analysis. Though the selection was done at random, these supply about 55% of the potable drinking water demand in Minna city. Since the base-line radioactivity in potable water in Minna is not known, the gross alpha and beta radioactivity were investigated in this representative sachet water with the aim of testing their radiological quality and to attempt to confirm the radiological burden on the populace. This result will also form a baseline data for radionuclide activity for the sachet water.

Materials and Methods

Five (5) sachets of water were collected from each sample point (sachet water production factory). One of the sachets was used to thoroughly wash the sample container (2l polyethylene bottle) to minimize contamination. The remaining four were mixed together to give a true representation of the water samples from each sample point. The volume of water collected was such that an air space of about 1% of container capacity was created for thermal expansion (Onoja, 2004). Both the pH and the conductivity of the samples were taken in situ. To maintain the homogeneity of the samples, minimize precipitation and adsorption of radionuclides to the walls of the container, all the samples were each immediately acidified with three drops of concentrated HNO_3 (de Oliviera et al, 2001; Katzlberger et al, 2001; Khan et al, 2002; Onoja, 2004; Wallner et al, 2008). The sample containers were then labeled, tightly covered and taken to the laboratory for analysis.

Sample Preparation

Sample preparation and analysis was done at the Center for Energy Research and Training (CERT) Ahmadu Bello University, Zaria, Kaduna State. The preserved water samples were evaporated to a small volume using a Binatone regulated temperature hot plate and then transferred quantitatively to a $7.1cm^2$ counting planchet whose weight has already been determined. Sample residue is dried to constant weight using the infrared radiation lamp and reweighed to determine the dry residue weight. The dry sample was then counted for alpha and beta radioactivity. The sample frequency, volume of sample used, alpha activity and beta activity were all obtained following the procedures earlier reported by Avwiri and Agbalagba (2007). The counting was done with an eight-channel-gas filled proportional counter which was first automated by entering the preset time, counting voltage and number of counting cycles, along with the counter characteristics (efficiency and background), volume of sample used and sampling efficiency. The mode of counting was selected arbitrarily.

Results and Discussion

The set of conditions for the counting technique are given in table 1. Table 2 shows the pH and conductivity values for all the sachet water samples. The results for the gross alpha and beta radioactivity concentrations for the water samples are reported in table 3.

Table 1: Alpha and beta background values and channel efficiency

Channel No	Alpha background Values (cpm)	Beta background Values (cpm)	Channel Efficiency	
			Pu-239 (α-%)	Sr-90 (β-%)
1	0.128	1.070	33.76	28.94
2	0.200	1.310	33.20	31.84
3	0.178	0.969	33.09	32.52
4	0.249	1.360	33.79	30.88
5	0.187	1.060	33.53	26.26
6	0.258	1.570	33.22	35.18
7	0.220	1.240	33.49	25.43
8	0.195	1.125	34.01	29.05

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Table 2: pH and conductivity of the sachet water samples

Sample Code	Brand	pH	Conductivity (µmho/cm)
SW1	Harmed	8.08	$1.4x10^2$
SW2	Mars	8.28	$1.9x10^2$
SW3	Sauki	8.26	$3.5x10^2$
SW4	Sabel	8.44	$1.5x10^2$
SW5	Sabo-Best	8.27	$1.4x10^2$
SW6	Dogara	8.56	$1.3x10^2$
SW7	FUTMin	8.31	$1.1x10^2$
SW8	Probest	8.01	$1.0x10^2$
SW9	Top Al-Ishan	8.31	$1.1x10^2$
SW10	M. D. Wakil	8.69	$2.0x10^2$
SW11	Sunrise	8.15	$0.9x10^2$
SW12	Pace	8.26	$1.0x10^2$
SW13	Yesmi	8.56	$3.5x10^2$
SW14	Super	8.16	$0.9x10^2$
SW15	Bani	8.30	$0.8x10^2$
SW16	Lifefresh	8.27	$1.0x10^2$
SW17	Happydays	8.12	$1.4x10^2$
SW18	Farid	8.12	$1.4x10^2$
SW19	Evershine	8.18	$1.5x10^2$
SW20	Supreme	7.78	$1.4x10^2$

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Table 3: Alpha and beta radioactivity of the sachet water

Sample code	α –Activity (BqL^{-1})	β –Activity (BqL^{-1})
SWS1	0.012±0.003	0.076±0.007
SWS2	0.014±0.003	0.183±0.011
SWS3	0.024±0.004	0.140±0.010
SWS4	0.005±0.002	0.165±0.010
SWS5	0.013±0.003	0.220±0.012
SWS6	0.013±0.003	0.165±0.011
SWS7	0.009±0.002	0.139±0.010
SWS8	0.018±0.004	0.415±0.017
SWS9	0.013±0.003	0.226±0.012
SWS10	0.009±0.002	0.138±0.010
SWS11	0.015±0.003	0.145±0.010
SWS12	0.004±0.002	0.094±0.008
SWS13	0.021±0.004	0.207±0.012
SWS14	0.012±0.003	0.092±0.008
SWS15	0.014±0.003	0.133±0.009
SWS16	0.008±0.002	0.101±0.008
SWS17	0.004±0.002	0.123±0.009
SWS18	0.009±0.002	0.092±0.008
SWS19	0.023±0.004	0.558±0.019
SWS20	0.002±0.001	0.072±0.007

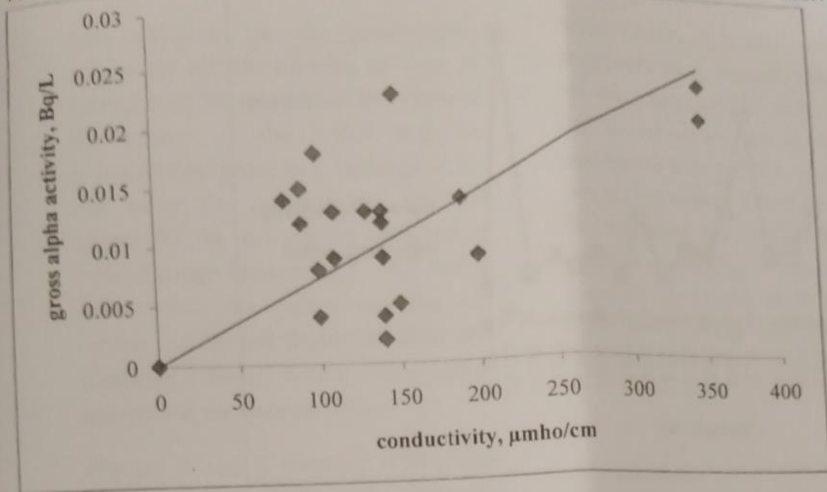

Fig.1. Conductivity vs gross alpha radioactivity (±1 standard deviation)

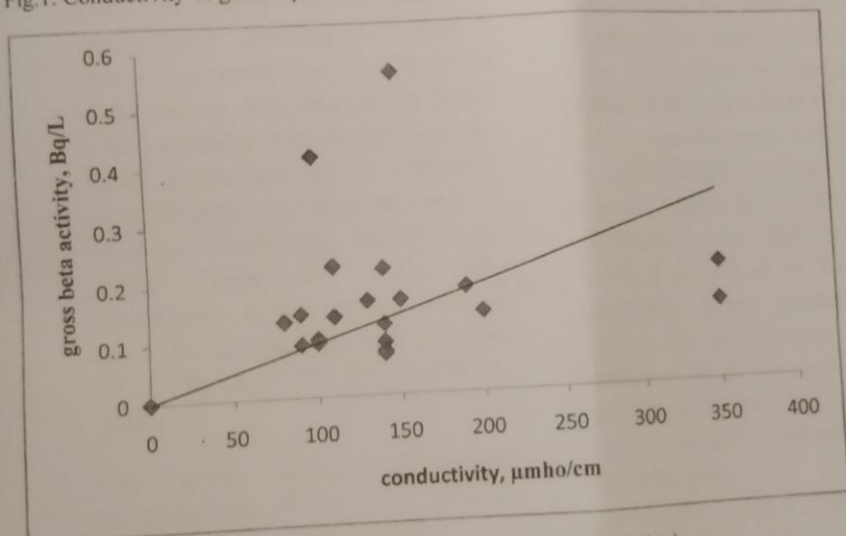

Fig.2. Conductivity vs gross beta radioactivity (±1 standard deviation)

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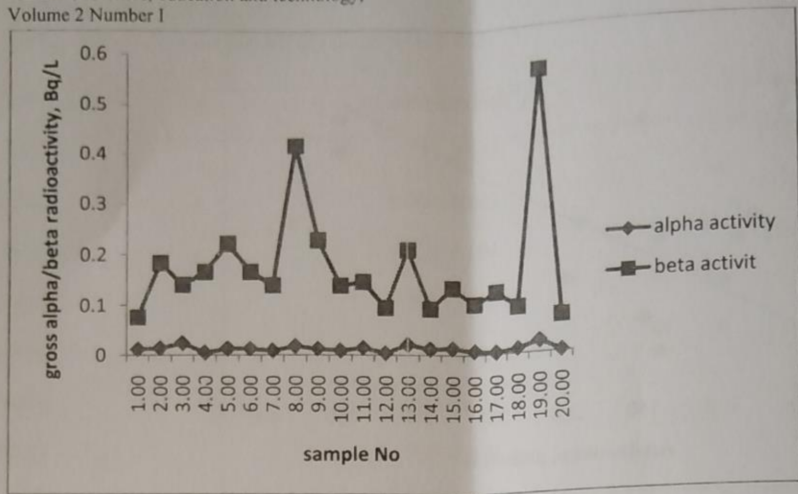

Fig.3. Alpha/Beta activity in the sample

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The variations in the conductivity values for all the samples as seen in table 2 may be related to the origin of the source of the water and the pretreatment processes undergone by the water for purification. The pH values for the samples as observed in table 2 range between 7.7 – 8.7 which shows that the water samples are neither acidic nor highly alkaline and therefore falls within the range acceptable for potable water.

Figures 1 and 2 shows a relationship between conductivity, gross alpha and gross beta activity concentrations in all the samples investigated. Figure 3 shows a generally low distribution of alpha activity. The beta activity shows a little elevation over the beta activity. Gross alpha activity is composed predominantly by uranium and its daughter radioisotopes (Rangel et al., 2002), while 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).

The gross alpha radioactivity concentrations of the water samples range from 0.002±0.001 – 0.024±0.004Bq/L with an average value of 0.0121±0.003Bq/L while the gross beta concentrations range from 0.072±0.007 – 0.558±0.019Bq/L with an average value of 0.174±0.01Bq/L. The values obtained for both the alpha and beta radioactivity in the water samples are far below the guidance values for limiting radiation exposure in drinking water recommended by WHO (2004). It is also indicative that the purification processes has no effect on the radionuclide concentration of the sachet water and so do not pose any health effect to the public users of the sachet water. There may therefore be no need for further radionuclide specific screening in the sachet water hawked in Minna since they are all safe for drinking and other domestic activities.

Conclusions

The gross alpha and gross beta radioactivity of sachet waters hawked in Minna city were carefully measured. The values obtained ranged between 0.002±0.001 to 0.024±0.004Bq/L for alpha activity and 0.072±0.007 to 0.558±0.19Bq/L for beta activity. The overall results shows that the natural radioactivity of the sachet water hawked in Minna is far below the screening levels recommended by WHO for good water quality and therefore fit for human consumption and other domestic activities. Though the results shows compliance with the internationally recommended permissible limits for drinking waters, there is still need for a more stringent standardization of the sachet water market in Niger state in general and a regular programme of environmental audit and monitoring particularly with regard to the labeling and quality control of the sachet water.

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