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ASSESSMENT OF GROSS ALPHA AND GROSS BETA ACTIVITY CONCENTRATIONS IN SOME SELECT BRANDED OF NATURAL MINERAL WATER PRODUCED IN THE GREATER ACCRA REGION OF GHANA.

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ABSTRACT

KeyWords: Mineral Water, Gross Alpha Activity Concentration, Gross Beta Activity Concentration, Food and Drugs Authority and Ghana Standard Authority

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INTRODUCTION

The occurrence of radionuclides in drinking-water gives rise to human internal exposure, directly upon the decay of radionuclides taken into the body through ingestion and inhalation and indirectly when they are incorporated as part of the human food-chain. Since the doses from these pathways are strongly related to the amount of radionuclide present, an important objective from the point of view of the radiological protection of the population is the accurate evaluation of the amounts received in the dietary intake. The measurement of radioactivity in drinking water allows the determination of the exposure of the population to radiation of the habitual consumption of water. All organisms including humans needs water for their survival, hence the need for adequate safe water cannot be overemphasized [1].

For practical purposes, the recommended guideline activity concentrations are 0.5 Bq/L and 1.0 Bq/L,0.1Bq/L and 1.0 Bq/L, set by [2, 3]. Radioactive materials are introduced into the environment from a number of sources, naturally occurring and man –made. He natural occurring sources include those substances produced by cosmic rays, which may find their way to the water courses with runoff and rainfall and those present in rocks and soil such as U- 238 and its daughters Ra – 226 and Rn – 222.

The radionuclides of interest were identified on the basis of those present in the natural environment as well as those resulting from man's activities. They are identified basically as the alpha and beta emitters, some of which have radioactive daughters, Ra -226 is typical of the naturally occurring alpha emitting radionuclides of interest and Sr – 90 is among the man-made beta emitters [4].

Radionuclides from the nuclear fuel cycle, medical and other uses of radioactive materials may enter drinking – water supplies, the contributions from these sources are normally limited by regulatory control of the source or practice and it is through this regulatory mechanism that remedial action should be taken in the event that such sources cause concern by contaminating drinking water [5].

However, with the growing global cancer burden, it has become more imperative to investigate all probable sources of radionuclide exposure to humans, one of which is drinking water [6, 7].

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This is because, apart from natural radiation, human activities such as the wrongful disposal of radioactive material from economic, medical and technological processes result in the contamination of water bodies and underground deposits of water and consequently. ^{228}Ra is a beta emitting radionuclide and ^{226}Ra is an alpha emitting radionuclide. ^{226}Ra and ^{228}Ra have been classified by US EPA [8] as human carcinogens.

Hence the importance of assessing gross alpha and gross beta activity concentrations in natural mineral water produced in Accra is necessary to prevent consumers from over exposure to radionuclides and create public awareness on radiological effects due to radiation exposure, because during the last few years there has been an increased in the consumption of mineral water, even though the use of mineral water for therapeutic purposes has been known for a long time.

Materials and Methods

Study Area

Accra is the biggest city in Ghana, with a total area of 173 km^2 and a population of about 2.27 million people [9]. It is one of the five districts that serve as the administrative hub of the nation's economy. The lack of quality potable water has been implicated in the transmission of water-related diseases such as cholera, typhoid and dysentery in Accra. The factors considered in the selection of the study area were the time frame of the research, proximity of the sampling sites to the Alpha spectrometry laboratory of the Ghana Atomic Energy Commission (GAEC), Accra and equipment and resources availability. The map of the study area is shown below in figure 3.

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Fig1: Map of study area **Fig 2: map of Ghana**

Collection of Bottling Drinking Water Samples

A questionnaire survey was conducted to identify the different brands of commercially sold bottle drinking water in Accra from which ten water brands were selected for the radiological assessment. For each brand, 1.5 L of the water sample was collected from the company production line between 8:00 am and 9:00 am into a clean two-liter (2 L) polyethylene gallon. To prevent the radionuclides from adhering to the gallon, 1M of 60% nitric acid was added to each sample. The gallon was then tightly sealed, labeled and transported to the Alpha spectrometry laboratory of GAEC for analysis.

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Physical Parameters Analysis

Temperature, pH, total dissolved solids and conductivity, of each sample were measured using the HI98129 potable Water Quality Test Kit from Hanna Instruments. The pH was probe was calibrated with pH 7 buffer, pH 10 buffer and pH 4buffer solution to check for the neutral, basicity and acidity of the water contents. Distilled water was used to rinse the probe before recording the reading.

Samples Preparation for Gross Alpha and Beta Activity Concentrations

One liter (1L) of each sample was filtered on a filtration system set up and transferred into a one liter (1L) beaker. Two millimeter (2 ml) of HNO_3 was added to all the samples to maintain and to liberate dissolved metals and dissolved organic particles. It was left to stay overnight. For each sample, 300 ml of the filtrate was measured into Pyrex glassware, evaporated to near dryness using an electrical hot plate in a fume chamber at 60ºC-70ºC for three hours until a volume of 20-30 ml was obtained. The remaining filtrate was transferred unto 47 mm stainless-steel planchets at 10ºC-20ºC. The samples were evaporated to dryness and placed in desiccator to prevent them from absorbing moisture and allow them cool down to room temperature before counting. Sample residues were dried to constant weight, re-weighed to investigate the residue weight using a weighing balance [10].

Calibration of the Alpha/Beta Counter System

The alpha/beta concentration measurement was performed using a low background automatic gross alpha/beta counter system (Canberra Imatic). Americium-241 and strontium -90 standard

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sources were used to calibrate the system for counting efficiencies. The background was determined using a clean empty planchets, this was to serve as a check on the operation of the system. It was counted 10mins to investigate the efficiency for alpha and beta. The counting efficiencies of beta and alpha were 31.01 %± 2.18% and 69.01% ± 4.39%, respectively. The average recorded values for background counting rate was 0.023± 0.05 and 0.40 ± 0.03 respectively. Americium – 241 has higher alpha particle energy (5.49MeV) than those emitted by naturally-occurring Uranium. It is therefore the prescribed radionuclide for gross alpha calibration. Strontium – 90 in equilibrium with its daughter Yttrium – 90 is the correct radionuclide for gross beta calibration. The operating voltage of the system was set at 1500 V.

Alpha/Beta Concentration Measurement

The residues were counted for 200 minutes with regards to the procedure selected during the calibration of the instrument to investigate alpha/ beta concentrations within the permissible limits as recommended by WHO [11]. All the samples were counted thrice and the results were recorded. All calculations have been made using appropriate corrections for efficiencies to convert the gross alpha and gross beta measurements to specific activities in m Bq/L.

Data Analyses

Data were entered in Microsoft Excel and screened for errors. The data was expressed as mean ± S.D. Differences between the gross mean of the alpha and beta concentrations of the ten brands of mineral drinking water and the GSA and WHO recommended limits were analyzed using one-sample t-test, $P \leq 0.05$ was use to investigate statistical significance was been tested at $P \leq 0.05$. All analyses were investigated using R [12].

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RESULTS

Table 1: Activity Concentrations Measurements For Gross Alpha and Gross Beta in all the selected Mineral Water Produced in Greater Accra Region of Ghana.

Sample ID	Gross alpha concentrations (mBq/L)	Gross beta concentrations (mBq/L)
NMW1	3.51±0.02	21.34±0.02
NMW2	2.75±0.01	22.36±0.02
NMW3	1.75±0.01	26.57±0.01
NMW4	2.36±0.01	35.70±0.02
NMW5	5.62±0.04	45.96±0.03
NMW6	1.88±0.06	30.98±0.01
NMW7	1.63±0.03	24.12±0.02
NMW8	1.32±0.03	37.27±0.03
NMW9	4.51±0.02	23.65±0.05
NMW10	2.25±0.02	26.57±0.01
Average	2.76±0.03	29.45±0.02
GSA Recommended Limit	100	1000
WHO Recommended Limit	500	1000

Table 2: Physical properties of selected sachet drinking water brands

Sample ID	pH	Temperature	Conductivity(μs/cm)	TDS (ppm)

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		(°C)		
NW1	6.60	27.4	18	23
NMW2	7.13	28.1	5	2
NMW3	6.9	27.3	25	55
NMW4	8.35	28.3	8	4
NMW5	7.07	28.3	50	25
NMW6	7.32	28.3	42	21
NMW7	7.80	28.7	2	1
NMW8	8.63	29.3	48	27
NMW9	7.45	28.6	3	2
NMW10	7.46	28.1	5	2

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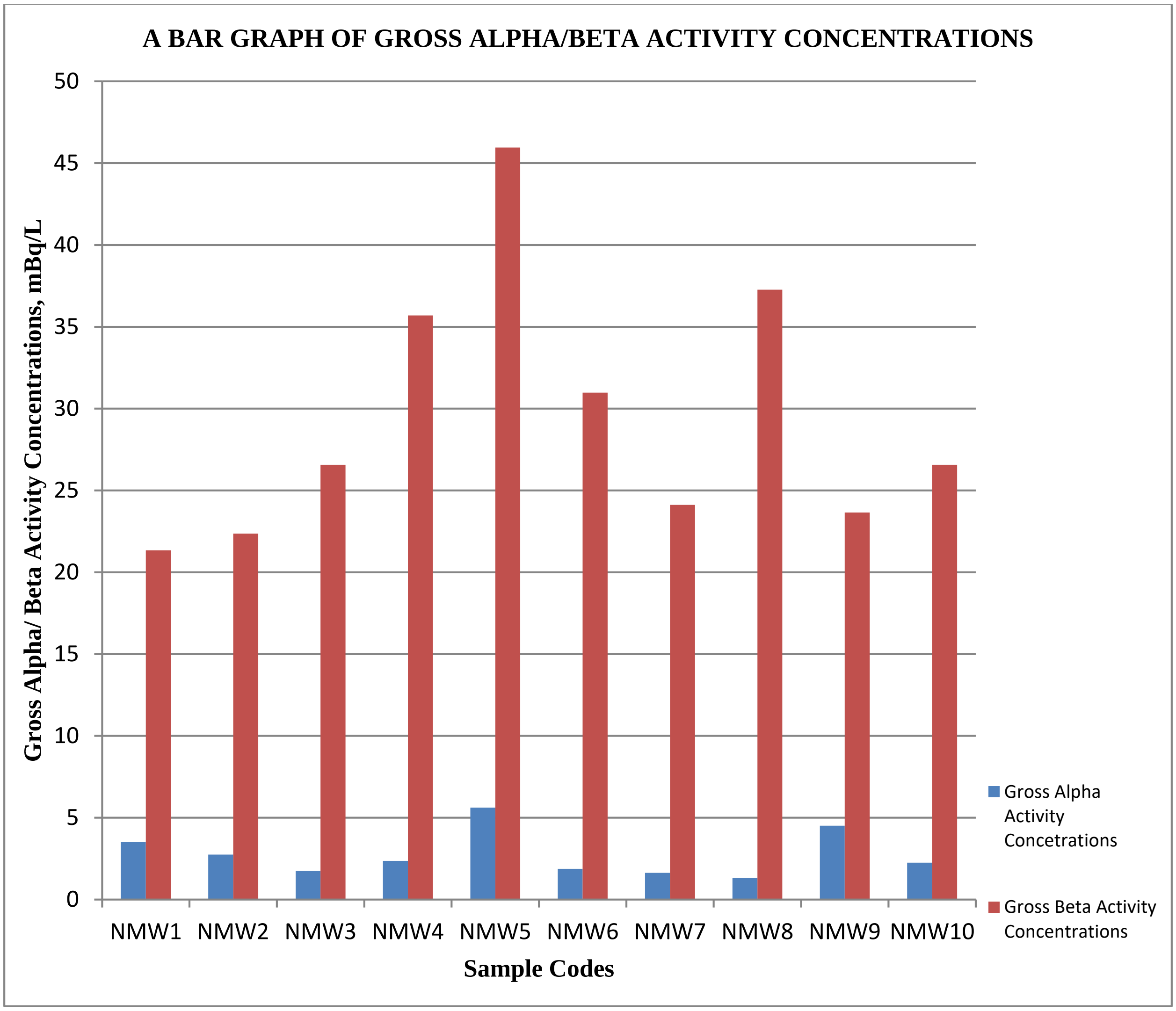

Fig 3: A bar graph of Gross Alpha/Beta Activity Concentrations.

DISCUSSIONS

Gross Alpha and Beta Activity Concentrations

Table 3.1 represents gross alpha/beta activity concentrations in ten selected brands of natural mineral water produced in Accra. The concentration of gross alpha activity concentrations ranged from 1.32/±0.03 mBq/L to 5.62±0.04 mBq/L with an average activity concentration of 36.03±0.33 mBq/L. NMW8 recorded the lowest alpha activity concentration and NMW5 recorded the highest alpha activity concentration value. Beta activity concentrations ranged from

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23.65±0.01 mBq/L to 45.96±0.03 mBq/L with NMW5 recording the highest beta activity concentration value and NMW9 recorded the lowest beta activity concentration value with an average beta activity concentration value of 33.69±12.23 mBq/L. The results investigated that gross beta activity concentrations were higher than the gross alpha activity concentrations. This can be attributed to the fact that radionuclides that decay by emitting beta particles have shorter half-lives than those that decay by emitting alpha particles and also beta particles are more soluble in water than alpha particles. This finding is supported by a study conducted in [13] in Amman, Jordan. However, gross alpha/beta activity concentrations in this study of all the ten selected brands of natural mineral water were within the acceptable limits of both GSA and WHO recommended guideline levels which are 0.1Bq/L, 1.0Bq/L. and 0.5 Bq/L and 1.0 Bq/L respectively. The results from this study are lower than the values from different countries. In Central Italy, [14] obtained concentrations up to 128.18 and 258.59 mBq/L for alpha and beta activity concentrations. [15] also obtained concentrations up to 1400 and 1150 mBq/L for alpha and beta activity concentrations. [16] measured gross alpha / beta concentrations in water in Greece and obtained results ranging from 8-94 and 71-350 mBq/L respectively.

Physical Properties of the Selected Brands

The pH of the samples ranged from 6.60 – 8.63 with NMW8 recording the highest pH value and SWD8 and NMW1 recorded the lowest pH value. The pH of the remaining eight selected brands ranged from 7.07 to 8.35 with NMW4 recording the highest pH (8.35) and NMW5 recording the lowest pH (7.07).

The temperature of the samples ranged from 27.4°C – 29.3°C with NMW3 recording the lowest temperature (27.4°C) and NMW8 recording the highest temperature (29.3°C).There was a strong negative relationship between pH and temperature ($t=-36.42$; $df = 13$; $p<0.001$; $r = -0.995$). High temperature enhances the growth of some bacteria such as *E. coli and Legionella* sp. (WHO, 2008). For conductivity, NMW7 recorded the lowest (1 μs/cm) and NMW5 which recorded the highest conductivity of 50 μs/cm [Table 3.2]. NMW7 also recorded the lowest TDS of 1 ppm and NMW3 recorded the highest TDS value (55ppm). There was a strong positive correlation

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between conductivity and TDS value (t = 3.23; df = 13; p<0.01; r = 0.667). The Physical property of selected sachet drinking water brands is shown in table 3.2.

CONCLUSION

Activity concentrations measurements for gross alpha/beta analysis were conducted in ten selected brands of natural mineral water samples content produced in Accra using an automatic Alpha/Beta counter (Canberra, iMatic $_{TM}$) system. The investigation revealed a recorded value of activity concentrations for gross alpha / gross beta. It ranged from 1.32±0.03 mBq/L – 5.62±0.04 mBq/L and 23.65±0.01 mBq/L – 45.96±0.03 mBq/L with an average values of 3.36±2.05 mBq/L and 33.69±12.23 mBq/L. Gross beta concentrations were higher in all the natural mineral water samples .Gross alpha and gross beta activity concentrations for the samples investigated were below the permissible guideline limits set by Ghana Standard Authority and World Health Organization which are 0.1 Bq/L, 1.0 Bq/L, 0.5 Bq/L and 1.0 Bq/L respectively. It was concluded natural mineral water produced in Greater Accra region of Ghana is radiologically safe and have no significant hazard to the public.

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