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# Radiological Impact Assessments on Some Selected Brands of Sachet Drinking Water Produced in the Accra Metropolis of Ghana

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**ABSTRACT**

The activity concentrations of gross alpha, gross beta, $^{228}$Ra and $^{226}$Ra in fifteen brands of sachet water produced in Accra Metropolis of Ghana were measured. The analysis was carried out in the Alpha Spectrometry Laboratory at Radiation Protection Center of Ghana Atomic Energy Commission by using gross alpha/beta counter system to quantify the radionuclides of interest in the water samples. The investigation revealed a recorded measured activity concentration for alpha ranged from 1.28±0.04 to 8.3±0.02 mBq/L with an average concentration of 3.36±2.05 mBq/L. Beta activity concentration also ranged from 21.34±0.03 to 64.38±0.04 mBq/L with average activity of 33.69±12.23 mBq/L. The concentration values of gross - alpha and gross -beta for all the sachet water samples were below the Ghana Standard Authority and World Health Organization recommended guideline levels set for drinking water quality which is 0.1Bq/L and 1.0Bq/L, and 0.5Bq/L and 1.0Bq/L respectively. The results obtained indicated that, the inhabitants in the Accra municipality are not exposed to any significant radiological health hazard associated in drinking sachet water produced in Accra. This research would provide some useful monitoring data for establishing a regulatory limit (base –line radiometric radioactivity) on radiation in public drinking water as well as sachet water produced in Ghana, which could be used as baseline data for future studies in the study area and provide some useful data (base –line radiometric values) to be used by the regulatory authority to evaluate possible changes in the future.



## 1.0 Introduction

Water is essential for the survival of all organisms, including humans; hence the need for adequate safe water cannot be overemphasized. The rise of human internal exposure through inhalation and ingestion are link to the existence of radionuclides in the water bodies[1,2] Gross alpha activity concentration in water describes the total activity of alpha emitters including $^{226}$Ra once the radon $^{222}$Rn gases has been eliminated, while gross beta activity concentration is the total activity of the entire beta emitters including $^{3}$H, $^{14}$C. Among $^{238}$U and $^{210}$Po alpha emitters and $^{40}$K and $^{210}$Po beta emitters, 226Ra with half – life of 1600 years and 228Ra with half-life of 5.8 years are the predominant alpha and beta emitting radioactive element in water resources. As alpha and beta particles interact with living cells primarily by ionization or excitation processes, they lose their energies to the cells on impact which could lead to formation of chemical species that could alter the chromosomes since the particles carry energies. Exposure to ionizing radiation/particles at low doses for a long time may result to delayed deterministic effects, stochastic effects and genetic effects. Concern for gross alpha and beta status of water resources in different countries of the world has led to increased investigations so as to have and compare data and also create awareness for members of the public and radiation protection and measurements agencies/organization.

A lot of research has been conducted to determine the activity concentrations of alpha and beta as well as some radionuclides in drinking water in many parts of the world used two analytical techniques namely; gas proportional counter and liquid scintillation counter to determined gross alpha, gross beta and tritium concentration in water in Portugal[3]. The gas proportional counter was calibrated with Americium-241 and Strontium-90 standard sources. Samples were obtained from wells, artesian boreholes and springs. They obtained gross alpha and beta activities ranging from 0.0015 to 0.330Bq/L and 0.018 to 0.457Bq/L respectively which are below the Portuguese recommended level of 0.1 and 1.0Bq/L respectively. Saudi Arabia, established that gross alpha activity concentrations of samples of drinking water were below the World Health Organization (WHO) reference limit 0.5 whereas gross beta values of two water samples exceeded the WHO reference limit of 1.0.In central Italy, gross alpha and beta activities in drinking water, respectively, ranged in <18.8 to 128.18 and <41.57 to 258.59 mBq/L. In Greece, alpha and beta concentrations ranged in 8-94 and 71-350mBq/L[4,5].But concentrations up to 1400 and 1150mBq/L were respectively found for gross alpha and beta in Australia[6].According to[7] from 2009 to 2010 the consumption of sachet water had increase to 50% in Accra and it has been growing ever since.

However, studies on radiological contamination due to alpha and beta activity concentrations of sachet drinking

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**Figure 1. Map of study area.**

water in the study locations is important because there is limited information on the radioactivity of sachet drinking water and the associated radiation dose to consumers in Ghana hence, the need for this study; to evaluate the potential gross alpha and beta activity concentrations, annual and radiological effects on sachet drinking water could serve as preliminary and baseline report, for ensuring publicprotection from radiation exposure .subject to further investigations.

**2.0 Materials and Method**

**2.1 The study Area**

The location is Accra; it is located on the East coast of Ghana, at latitude 5°33' N and longitude 0°11' W° of the equator. The city of Accra is the biggest city in Ghana, with a total area of 173km$^2$ and a population of about 1.6 million people. It is one of the five districts that serve as the administrative hub of the nation's economy. Below is the geology and geophysical study of the study locations.

**2.2 Sample Collection and Preparation**

Fifteen brands of sachet drinking water sold and drank in the capital city Accra were collected for the gross alpha and beta analyses. One lit

er (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 concentrated nitric acid was added to each of the filtered samples to maintain and to liberate dissolved metals and dissolved organic particles. It was left to stay overnight. For each sample, 300ml of the residue was measured into Pyrex glassware. It was evaporated to near dryness using an electrical hot plate in a fume chamber between 80ºC-90ºC until a volume of 20-30ml was obtained and thereafter transferred to an evaporating dish and few drops of vinyl acetate were added to the samples to act as a binder to prevent the residue formed from scattering during counting. The remaining residues were transferred using a spatula to 47mm stainless-steel sterilized planchets at a temperature between 10ºC-20ºC on an electric hot plate. The samples were evaporated to dryness and placed in a desiccator to prevent them from absorbing moisture and allow them to 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. The planchets containing the residue was placed in a sample carrier which was thereafter placed in a sample drawer of the counting instrument and then slide into the counter detector for gross alpha and gross beta counting.

**2.3. Description of Gross Alpha/Beta Counter System.**

A low background counting system of Imatic Gross Alpha/Beta counter system available in Ghana Atomic Energy Commission was used for gross alpha and beta counting. The gasless imatic gross alpha/beta counter system provides a screening technique to investigate the quantities of alpha / beta emitting radionuclides in sampled water. In principle it is to determine alpha particles separately from beta particle in the same water sample. The entire program is stored on a flash memory. The chamber has a lead shied and guard detector with stainless steel linings to prevent part of ambient gamma rays from entering the measuring environment. The set up for the counter includes passivated implanted planar silicon detector, guard detector, auto-sensing power supply, automatic system calibration for background, automatic sample changer, high voltage supply for the detector; signal processing modules; preamplifier and amplifier; counter; displayer module; operation and display control board equipped with LCD display. The system was connected to a microprocessor (PC) connected with I Link Communication Software to process downloaded data.

**2.4 Calibration of the Alpha/Beta Counter System**

The alpha/beta concentration measurement was performed using a low background automatic gross alpha/beta counter (Canberra Imatic). Americium-241 and strontium-90 standard sources were used to calibrate the system; it was counted for 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. 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.

**2.5. Determination of Gross Alpha and Beta Activity Concentrations**

The residues were counted for 3 cycle of 200 mins per cycle and the results display and recorded as raw count rate (in Becquel per Liter) 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[8]. Data were acquired for alpha and beta mode and alpha and beta count rate.

**3.0 Results**

The results in Table 1 shows the radiological indices of gross alpha and gross beta activity Concentrations in the sachet drinking water from the studied area.

**4.0 Discussion**

**4.1. Mean Gross alpha and beta activity concentrations and associated radiological indices**

Table 1 shows gross alpha/beta activities in fifteen sachet drinking water brands in Accra.The gross alpha and beta activities ranged from 1.28±0.04 to 8.31±0.02mBq/L and 21.34±0.03 - 64.38±0.04mBq/L respectively. The mean gross alpha activity was 3.36±2.05mBq/L and the mean gross beta activity was 33.69±12.23mBq/L. The results show that gross beta activities were generally higher than the corresponding gross alpha activities. This can be attributed to the fact that beta particles are more soluble in water than alpha particles and also to the fact that radionuclides that decay by emitting beta particles have shorter half-lives than those that decay by emitting alpha particles. This finding is supported by a study conducted by [9] in Amman, Jordan. However, the gross alpha/beta activities in this study did not exceed WHO and GSA limits which are 0.5 and 1.0Bq/L,

**Table1. Gross alpha and gross beta activity concentrations of the selected sachet drinking water brands.**

| Sample ID(Sachet Drinking Water-SDW) | Gross alpha activity concentration (mBq/L) | Gross beta activity concentration (mBq/L) |
|---|---|---|
| SDW1 | 2.75±0.01 | 22.59±0.28 |
| SDW2 | 1.75±0.01 | 40.12±0.01 |
| SDW3 | 2.48±0.01 | 22.36±0.02 |
| SDW4 | 2.36±0.01 | 35.70±0.02 |
| SDW5 | 4.78±0.04 | 45.96±0.03 |
| SDW6 | 1.88±0.06 | 30.98±0.01 |
| SDW7 | 1.63±0.03 | 24.12±0.02 |
| SDW8 | 1.32±0.03 | 37.27±0.03 |
| SDW9 | 2.25±0.02 | 26.57±0.01 |
| SDW10 | 5.90±0.01 | 36.15±0.02 |
| SDW11 | 3.51±0.02 | 21.34±0.03 |
| SDW12 | 8.31±0.02 | 50.62±0.01 |
| SDW13 | 1.28±0.04 | 23.90±0.05 |
| SDW14 | 5.62±0.04 | 64.38±0.04 |
| SDW15 | 4.51±0.02 | 23.65±0.05 |
| Average | 3.36±2.05 | 33.69±12.23 |
| GSA Recommended Limit | 100 | 1000 |
| WHO Recommended Limit | 500 | 1000 |

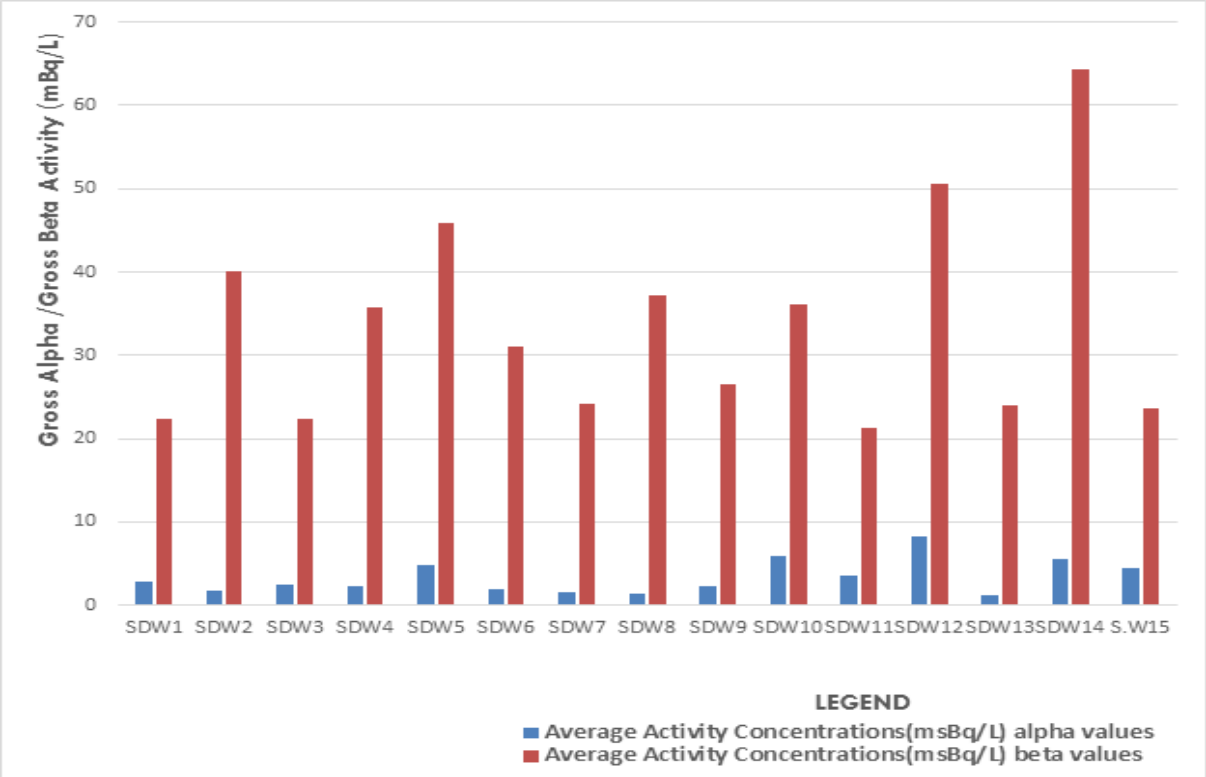


**Fig 2. Shows a bar graph of activity concentrations of the selected brands of the sachet waters.**

0.1Bq/L and 1.0Bq/L for alpha and beta respectively. The results from this study are lower than the values from different countries[5]. Measured gross alpha and beta activities in drinking water in Greece and obtained results ranging from 8-94 and 71-350mBq/L respectively[6].Also obtained concentrations up to 1400 and 1150mBq/L for alpha and beta. In Central Italy, (4) obtained concentrations up to 128.18 and 258.59 mBq/L for alpha and beta activity respectively. The gross alpha and beta concentrations of all the fifteen brands were within acceptable limits of both GSA and WHO[8-10].

**5.0 Conclusion**

Activity concentrations measurements by gross alpha/beta analysis were investigated in fifteen different brands of sachet water samples produced in Accra using an automatic Alpha/Beta counter (Canberra, iMatic TM) system. The investigated recorded value for activities for gross alpha and gross beta ranges from 1.28±0.04mBq/L to 8.31±0.02mBq/L and 21.34±0.03mBq/L to 64.38±0.04mBq/L with an average value of 3.36±2.05mBq/L to 33.69±12.23mBq/L.Gross beta activities were higher in all the sachet samples than the corresponding gross alpha activities .Gross alpha and gross beta activities were below the permissible guidelines limits set by Ghana Standard Authority and World Health Organization which is 0.5Bq/L, 1.0Bq/L, 0.1Bq/L and 1.0Bq/L respectively. It was concluded that the selected sachet drinking water produced in Accra is radiologically safe and pose no significant hazard to the public.

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