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ASSESSMENT OF GROSS BETA RADIOACTIVITY CONCENTRATIONS IN COMMERCIAL PACKAGED DRINKING WATERS IN FEDERAL CAPITAL TERRITORY, ABUJA, NIGERIA.

Samson, D.O.[1*], Ramalan A. M.[1]

[1]Department of Physics, University of Abuja, Abuja, Nigeria

[*] E-mail of the corresponding author: damilola.samson@uniabuja.edu.ng; saamdoftt82@gmail.com[*],

ABSTRACT

The activity concentrations of gross beta in some selected packaged drinking water samples within the six local councils in Federal Capital Territory, Abuja, Nigeria was investigated using the portable single channel gas free proportional counter (MPC2000B-DP) detector. The results obtained in this study indicates that concentrations of gross beta activity in Gwagwalada, Abuja Municipal, Bwari, Abaji, Kuje and Kwali are in the ranges of (2.239 ± 1.970)Bq/L to (0.0494 ± 0.0141)Bq/L; (2.099 ± 1.966)Bq/L to (0.0465 ± 0.0112)Bq/L; (2.161 ± 1.889)Bq/L to (0.0582 ± 0.0241)Bq/L; (5.265 ± 4.983)Bq/L to (0.0224 ± 0.0429)Bq/L; (4.292 ± 3.397)Bq/L to (0.0488 ± 0.0294)Bq/L; and (2.438 ± 1.983)Bq/L to (0.0481 ± 0.0165)Bq/L while their corresponding mean values are (0.5219 ± 0.4195)Bq/L; (0.5053 ± 0.3986)Bq/L; (0.5129 ± 0.4219)Bq/L; (0.9964 ± 0.8543)Bq/L; (0.7784 ± 0.5865)Bq/L and (0.7495 ± 0.6031)Bq/L respectively. Based on this study, the concentrations of gross beta activity are considerably higher in Ero (43%), Omatola Obida (42%), Hajedoc (42%), Abayaro (53%), Gera life (55%), Brudan (32%) and Felvin (27%) packaged drinking waters when compared with both the WHO and ICRP standard limit for gross beta concentrations in packaged drinkable water of 1.0Bq/L. Continuous proliferation of these packaged drinking water and their indiscriminate consumption significantly constitutes a serious public health hazards. It is concluded that the above mentioned brand of packaged drinking waters spread through the six local councils are not safe for human consumption. Kwali local council area is particularly the worst hit as 20% of these dangerous packaged sachet water is localized there.

Keywords: Concentrations, Gross beta, Activity, Assessment, detector, packaged water

1. INTRODUCTION

All known forms of life depend on hygienic water. Portable water is vital both as a solvent in which many of the body's solutes dissolve and as an essential part of many metabolic processes within the body. Radioactivity in packaged drinking water is an easy means for human beings internal contamination with radionuclides. Packaged drinking water factories in the Federal Capital Territory, Abuja, Nigeria and it's environ is increasing rapidly and the production of adequate supply of clean packaged drinking water in this area is a fundamental need for all human beings. For many people packaged sachet water popularly called "pure water" offers a convenient choice to stay hydrated (Oyedeji et al., 2010; Ahmed et al., 2014). This is probably because of its accessibility, portability and affordability. However, the problems of its purity and other health concerns are beginning to manifest (Omalu et al., 2011). The increased demand for these brands of drinking water products is attributed largely to factors such as inadequate or non-availability of reliable, safe municipal water in urban areas; impression that high quality natural spring water and drinking water offer a healthy, refreshing and great tasting alternative to high-calorie soft drinks and ordinary tap water; and convenience which has made the products meet the requirements of any lifestyle when needed (Oyedeji et al., 2010). The integrity of the hygienic environment and conditions where the majority of the packaged drinking water factories are located and produced has been of great concerns. However, there are processes drinking water undergo in its journey from source to consumption which may involve some contaminations often led to diseases such as dysentery, cholera, cancer of bladder, typhoid fever, high prevalence of diarrhoea amongst children and infants, guinea worm etc. (Mead et al., 1999; Omalu et al., 2011). The activity concentrations of natural radionuclides depends on the water source which are typically very low in the surface water (Fasae, 2012). The radionuclides in drinking water are members of three natural radioactive series, which includes: uranium series, thorium series and actinium series. The nuclides of the uranium series which can be dangerous to health because of their presence in packaged drinking water are ^{222}Rn, ^{226}Ra (Uranium series) and their decay products are more concentrated in deep ground water than in surface water (Alam et al., 1999; Urkiye et al., 2009). They contaminate the water body directly with their radionuclide products; and indirectly through the radon gaseous products which can solidify and attach themselves as aerosols to the air particles and are washed down by rain into water bodies. Packaged drinking water sources can be polluted by Naturally Occurring Radioactive Materials (NORMs) of the earth's crust; which emits alpha, beta and gamma radiations. Radiation is part of the natural environment and it is therefore estimated that approximately eighty percent of all human exposure comes from NORMs. Previous studies carried out on packaged drinking water phenomenon in Federal Capital Territory, Nigeria, have indicate that factors responsible for its contamination ranges from sharp practices, poor hygiene of locations, polluted environment and non-adherence to World Health Organization (WHO) regulations. Recently, a great interest arose towards the natural radioactivity concentration in drinking water around the world due to the great danger it presents (Alam et al., 1999; Onoja, et al., 2007; Fatima et al., 2007; Ajayi et al., 2009; Bomben et al., 1996; Isinkaye and Shitta, 2010; Zaini et al., 2011; Urkiye et al. 2009; Garba et al., 2013; Ahmed et al., 2014). Hence, drinking this water samples may pose serious health side effects to the public consumers. Therefore, measuring the radioactivity concentrations in packaged drinking water is of great interest in this study. This work therefore tends to determine the current activity concentrations of gross beta radiation in packaged drinking water marketed in the six local councils of Federal Capital Territory, Abuja, Nigeria.

2. MATERIALS AND METHODS

The Federal Capital Territory, Abuja is a federal territory in central Nigeria. The territory is located just north of the confluence of the Niger River and Benue River. The study area lies with latitude $8^{o}25'\mathrm{N}$ and $9^{o}20'\mathrm{N}$ of the equator and longitude $6^{o}45'\mathrm{E}$ and $7^{o}39'\mathrm{E}$ of Greenwich Meridian. It has a landmass of approximately 7315km^2, and it is situated within the savannah region with moderate climatic conditions. The International Standards Organization procedure (ISO 9696 and ISO 9697; 1992E) for the measurement of gross beta activity in water was employed in this analysis. This method provided a screening technique to measure the beta radioactivity in water samples. The water samples collected were preserved in accordance with the ISO standard (20ml of 50% V of HNO_3 per litre of water). The purpose of this is to minimize the loss of radioactive material from solution due to absorption.

Samples Collection

The technique applied to this samples is the stratified random sampling method. Ten different samples were collected in each locations in different parts of the six local councils of Federal Capital Territory, Abuja, making a total of sixty samples of packaged drinking water collected for effective coverage of the study area as shown in Tables (1, 2, 3, 4, 5 and 6) respectively. At every point of sample collection the container is first rinsed twice before the water is put in the plastic container and concentrated trioxonitrate (v) (HNO_3) acid (nitric acid) is added (10ml per two litres) in order to prevent adherence of the radionuclide on container walls. Then the samples were analysed three days after collection.

Samples Preparation

Two litres of water samples treated with 10ml of concentrated nitric acid were needed for each sample. The addition of concentrated nitric acid is to prevent the absorption of the water sample by the wall of the container, minimizing the precipitation and reducing the pH of the water samples. Evaporation at low temperature of measured volume of each water sample were carried out using beaker (about 600ml) and set on hot plate at a steady temperature to avoid boiling in order to prevent loss of much residue and unnecessary samples thickness which may lead to self-absorption, the volume evaporated was then taken and recorded. The next process is surface drying in which the residual volume was transferred quantitatively into a petri-dish for further drying until the final dry residue is obtained. Then about 77mg of the residue was weighed using digital analytical weighing balance and transferred into an aluminium planchet and dried until precipitation take place in the detector. Each samples precipitation in planchet was directly applied to the counting systems. Few drops of acetone and vinyl-acetate were applied into the residue. The vinyl-acetate helps in removing the moisture content while the acetone serves as a binder to avoid contamination of any kind. This samples were analysed for gross beta activity using the portable single channel gas free proportional counter (MPC2000B-DP) detector at the Centre for Energy Research and Training (CERT), Ahmadu Bello University, Zaria, Nigeria. With particular focus on the concentration gradient of these activities from the water samples, which serves as bio-data of the environment clearly shows the radiological effect of the water on the consumers. Then the samples were counted for gross beta radioactivity using the International Standards Organization (ISO) procedure (ISO 9696; 9697) for the measurement of gross beta activity concentration. The background measurements, plateau test and sample efficiency were done to determine the background beta radioactivity concentrations, optimal operational voltage and frequencies using standard techniques.

Gross Beta Counting

The counting equipment used for this study is the portable single channel gas free proportional counter (MPC2000B-DP) detector. The procedure involves entering the pre-set time, number of cycles and counting mode then the counting is automated. The beta standards are Strontium-90 beta sources of diameter 38mm and active film of $12mg/m^3$ thick with beta detection limit of 1.02cpm. The results were displayed as raw counts and count rate (cpm). The raw counts (cpm) were repeated three times each for all the sixty samples and the mean values were used in calculating the gross beta activity. The high voltage for gross beta counting was set at 1700 volts and sample were counted for three cycles of 3600 sec per cycle in beta only mode. The counting system incorporates interference from high energy cosmic radiation into the measuring environment and was calibrated following the ISO calibration standard procedure (ISO, 1997). The samples efficiency for beta counting and volume for the water samples were determined using equations (1 and 2):

$$\text{Sample efficiency}, S_{\varepsilon(\beta)} = \frac{\mathrm{S_w}}{\mathrm{M_r}} \times 100\% \tag{1}$$

$$\text{Sample volume}, \mathrm{S}_V = \frac{\mathrm{V}}{\mathrm{M}} \times \mathrm{S_w} \tag{2}$$

Where; S_w is the sample weight on the planchet in (mg), M_r is the residual sample weight from evaporated water samples, V is the volume of water sample evaporated in litres and M is the residue mass in milligram (mg) from volume V. We obtained the gross beta sample count rate and activity concentration in Becquerel per litre for each water samples as follows:

$$\text{Beta Count Rate}, \beta_{(CR)} = \frac{R_{(\beta)} \times 60}{t} \tag{3}$$

$$\text{Activity}, A_{(\beta)} = \frac{N_{(\beta)} \times U_{(\beta)}}{S_{\varepsilon(\beta)} \times V_{(S)} \times D_{\varepsilon(\beta)}} \tag{4}$$

$$Net\ counts, N_{(\beta)} = \text{Raw count rate(cpm)} - \text{Background count rate(cpm)} = R_{(\beta)} - B_{(\beta)} \tag{5}$$

$$Activity\ Concentration, C_{(\beta)} = \frac{\{R_{(\beta)} - B_{(\beta)}\}}{\{R_{(S)} - B_{(\beta)}\}} \times \frac{M}{1000} \times \frac{1.02}{V} \tag{6}$$

We then calculate uncertainty associated with the sample activity using equation (7):

$$Uncertainty, \epsilon_A = \pm\sqrt{\frac{N_{(\beta)} \times B_{(\beta)}}{\left[B_{t(\beta)}\right]^2}} \times \frac{U_{(\beta)}}{60 \times D_{\varepsilon(\beta)} \times S_{\varepsilon(\beta)}} \tag{7}$$

Where; $\beta_{(CR)}$ is the count rate (cpm), $R_{(\beta)}$ is raw count rate (cpm), $R_{(S)}$ is the standard count rate (cpm), t is the count time, $A_{(\beta)}$ is the beta activity, $B_{(\beta)}$ is the background count rate (cpm), $U_{(\beta)}$ is the unit coefficient of beta particle, $S_{\varepsilon(\beta)}$ is the sample efficiency for beta counting, $D_{\varepsilon(\beta)}$ is the detector's efficiency of the beta counting, ϵ_A is the uncertainty or error associated with the sample activity and $B_{t(\beta)}$ is the background count time.

3. RESULTS AND DISCUSSION

The results of the gross beta radioactivity values and associated uncertainties in the concentrations of the different ten samples used for beta counting in each water samples according to the six locations are presented in Tables (1) – (6).

Table 1: Gross beta activity concentration for the ten different sachet water samples in Gwagwalada

S/N	Sample ID	Beta Activity (Bq/L)	Error Beta	Estimated Reading
1	E-bright	7.153×10^{-1}	3.140×10^{-1}	$(7.153 \pm 3.140) \times 10^{-1}$
2	Jimroose	2.896×10^{-1}	1.680×10^{-1}	$(2.896 \pm 1.680) \times 10^{-1}$
3	Persido	3.682×10^{-1}	3.730×10^{-1}	$(3.682 \pm 3.730) \times 10^{-1}$
4	Ajason	1.438×10^{-1}	2.980×10^{-1}	$(1.438 \pm 2.980) \times 10^{-1}$
5	Mumal	2.418×10^{-1}	1.940×10^{-1}	$(2.418 \pm 1.940) \times 10^{-1}$
6	Chidera	3.374×10^{-1}	2.200×10^{-1}	$(3.374 \pm 2.200) \times 10^{-1}$
7	Ero	2.239×10^{0}	1.970×10^{0}	$(2.239 \pm 1.970) \times 10^{0}$
8	Zaneta	4.940×10^{-2}	1.410×10^{-2}	$(4.940 \pm 1.410) \times 10^{-2}$
9	Righteous	7.157×10^{-1}	4.620×10^{-1}	$(7.157 \pm 4.620) \times 10^{-1}$
10	Frost	1.183×10^{-1}	1.820×10^{-1}	$(1.183 \pm 1.820) \times 10^{-1}$

Table 2: Gross beta activity concentration for the ten different sachet water samples in Abuja Municipal (AMAC)

S/N	Sample ID	Beta Activity (Bq/L)	Error Beta	Estimated Reading
1	Vabe Glory	1.228×10^{-1}	2.770×10^{-1}	$(1.228 \pm 2.770) \times 10^{-1}$
2	Zinno	3.095×10^{-1}	3.575×10^{-1}	$(3.095 \pm 3.575) \times 10^{-1}$
3	Nibodas	6.014×10^{-1}	2.151×10^{-1}	$(6.014 \pm 2.151) \times 10^{-1}$
4	Manawes	2.573×10^{-1}	1.391×10^{-1}	$(2.573 \pm 1.391) \times 10^{-1}$
5	Zippos	2.836×10^{-1}	1.750×10^{-1}	$(2.836 \pm 1.750) \times 10^{-1}$
6	Koye	4.079×10^{-1}	2.481×10^{-1}	$(4.079 \pm 2.481) \times 10^{-1}$
7	Giovani	7.062×10^{-1}	3.149×10^{-1}	$(7.062 \pm 3.149) \times 10^{-1}$
8	Aristo	2.184×10^{-1}	2.825×10^{-1}	$(2.184 \pm 2.825) \times 10^{-1}$
9	De-Rehoboth	4.647×10^{-2}	1.117×10^{-2}	$(4.647 \pm 1.117) \times 10^{-2}$
10	Omatola Obida	2.099×10^{0}	1.966×10^{0}	$(2.099 \pm 1.966) \times 10^{0}$

Table 3: Gross beta activity concentration for the ten different sachet water samples in Bwari

S/N	Sample ID	Beta Activity (Bq/L)	Error Beta	Estimated Reading
1	Cholas	2.915×10^{-1}	3.133×10^{-1}	$(2.915 \pm 3.133) \times 10^{-1}$
2	Balin Crown	8.044×10^{-1}	5.207×10^{-1}	$(8.044 \pm 5.207) \times 10^{-1}$
3	Hajedoc	2.161×10^{0}	1.889×10^{0}	$(2.161 \pm 1.889) \times 10^{0}$
4	BSK	1.052×10^{-1}	1.636×10^{-1}	$(1.052 \pm 1.636) \times 10^{-1}$
5	Qbase	5.817×10^{-2}	2.411×10^{-2}	$(5.817 \pm 2.411) \times 10^{-2}$
6	Peak Fresh	7.164×10^{-1}	3.097×10^{-1}	$(7.164 \pm 3.097) \times 10^{-1}$
7	Dewluk	3.649×10^{-1}	3.841×10^{-1}	$(3.649 \pm 3.841) \times 10^{-1}$
8	Shybof	1.583×10^{-1}	2.921×10^{-1}	$(1.583 \pm 2.921) \times 10^{-1}$
9	Second Adam	2.227×10^{-1}	1.305×10^{-1}	$(2.227 \pm 1.305) \times 10^{-1}$
10	Rock Pool	2.461×10^{-1}	1.928×10^{-1}	$(2.461 \pm 1.928) \times 10^{-1}$

Table 4: Gross beta activity concentration for the ten different sachet water samples in Abaji

S/N	Sample ID	Beta Activity (Bq/L)	Error Beta	Estimated Reading
1	Angvel	1.833×10^{0}	1.401×10^{0}	$(1.833 \pm 1.401) \times 10^{0}$
2	Abayaro	5.265×10^{0}	4.983×10^{0}	$(5.265 \pm 4.983) \times 10^{0}$
3	Ohirehi	3.647×10^{-1}	2.125×10^{-1}	$(3.647 \pm 2.125) \times 10^{-1}$
4	Angus	7.096×10^{-1}	4.622×10^{-1}	$(7.096 \pm 4.622) \times 10^{-1}$
5	Akala	2.889×10^{-1}	1.938×10^{-1}	$(2.889 \pm 1.938) \times 10^{-1}$
6	Success	2.236×10^{-2}	0.429×10^{-2}	$(2.236 \pm 0.429) \times 10^{-2}$
7	Manko	2.184×10^{-1}	2.980×10^{-1}	$(2.184 \pm 2.980) \times 10^{-1}$
8	Bamu	3.319×10^{-1}	2.107×10^{-1}	$(3.319 \pm 2.107) \times 10^{-1}$
9	Omowumi	1.538×10^{-1}	3.724×10^{-1}	$(1.538 \pm 3.724) \times 10^{-1}$
10	Simac	7.760×10^{-1}	4.047×10^{-1}	$(7.760 \pm 4.047) \times 10^{-1}$

Table 5: Gross beta activity concentration for the ten different sachet water samples in Kuje

S/N	Sample ID	Beta Activity (Bq/L)	Error Beta	Estimated Reading
1	Valento	6.642×10^{-1}	3.081×10^{-1}	$(6.642 \pm 3.081) \times 10^{-1}$
2	Nabila	4.883×10^{-2}	1.935×10^{-2}	$(4.883 \pm 2.935) \times 10^{-2}$
3	Maochem	7.119×10^{-1}	3.635×10^{-1}	$(7.119 \pm 3.635) \times 10^{-1}$
4	Fakubs	1.460×10^{-1}	2.783×10^{-1}	$(1.460 \pm 2.783) \times 10^{-1}$
5	Kalmed	3.254×10^{-1}	3.916×10^{-1}	$(3.254 \pm 3.916) \times 10^{-1}$
6	Jeffco	7.371×10^{-1}	4.824×10^{-1}	$(7.371 \pm 4.824) \times 10^{-1}$
7	Gera Life	4.292×10^{0}	3.397×10^{0}	$(4.292 \pm 3.397) \times 10^{0}$
8	Mojifet	2.469×10^{-1}	1.920×10^{-1}	$(2.469 \pm 1.920) \times 10^{-1}$
9	Fatras	2.753×10^{-1}	1.488×10^{-1}	$(2.753 \pm 1.488) \times 10^{-1}$
10	Victory	3.368×10^{-1}	2.739×10^{-1}	$(3.368 \pm 2.739) \times 10^{-1}$

Table 6: Gross beta activity concentration for the ten different sachet water samples in Kwali

S/N	Sample ID	Beta Activity (Bq/L)	Error Beta	Estimated Reading
1	Chydera	8.183×10^{-1}	6.644×10^{-1}	$(8.183 \pm 6.644) \times 10^{-1}$
2	Maranatha	1.926×10^{-1}	2.251×10^{-1}	$(1.926 \pm 2.251) \times 10^{-1}$
3	Kawo	4.785×10^{-2}	1.849×10^{-2}	$(4.785 \pm 1.849) \times 10^{-2}$
4	Chimex	2.230×10^{-1}	3.066×10^{-1}	$(2.230 \pm 3.066) \times 10^{-1}$
5	Brudan	2.438×10^{0}	1.983×10^{0}	$(2.438 \pm 1.983) \times 10^{0}$
6	Clement	7.595×10^{-1}	3.334×10^{-1}	$(7.595 \pm 3.334) \times 10^{-1}$
7	Danita	4.481×10^{-2}	1.651×10^{-2}	$(4.481 \pm 1.651) \times 10^{-2}$
8	Felvin	2.016×10^{0}	1.896×10^{0}	$(2.016 \pm 1.896) \times 10^{0}$
9	Solap	6.352×10^{-1}	2.071×10^{-1}	$(6.352 \pm 2.071) \times 10^{-1}$
10	Tahur	3.194×10^{-1}	3.804×10^{-1}	$(3.194 \pm 3.804) \times 10^{-1}$

The results presented in the above Tables (1) – (6) shows that the concentrations of gross beta activity in Gwagwalada ranges from (2.239 ± 1.970)Bq/L to (0.0494 ± 0.0141)Bq/L with a mean value of (0.5219 ± 0.4195)Bq/L; Abuja Municipal (AMAC) ranges from (2.099 ± 1.966)Bq/L to (0.0465 ± 0.0112)Bq/L with a mean value of (0.5053 ± 0.3986)Bq/L; Bwari ranges from (2.161 ± 1.889)Bq/L to (0.0582 ± 0.0241)Bq/L with a mean value of (0.5129 ± 0.4219)Bq/L; Abaji ranges from (5.265 ± 4.983)Bq/L to (0.0224 ± 0.0429)Bq/L with a mean value of (0.9964 ± 0.8543)Bq/L; Kuje ranges from (4.292 ± 3.397)Bq/L to (0.0488 ± 0.0294)Bq/L with a mean value of(0.7784 ± 0.5865)Bq/L and Kwali ranges from (2.438 ± 1.983)Bq/L to (0.0481 ± 0.0165)Bq/L with a mean value of (0.7495 ± 0.6031)Bq/L. Comparison of the results of mean gross beta activity concentrations within the reference point of study indicate that the highest beta radioactivity concentrations is obtained in Ero (43%), Omatola Obida (42%), Hajedoc (42%), Abayaro (53%), Gera life (55%), Brudan (32%) and Felvin (27%) packaged drinking waters respectively. The bar charts representation showing gross beta activity concentrations for the ten different packaged/sachet drinking water samples in each of the six local councils are illustrated in figures 1(a) – 6(a).

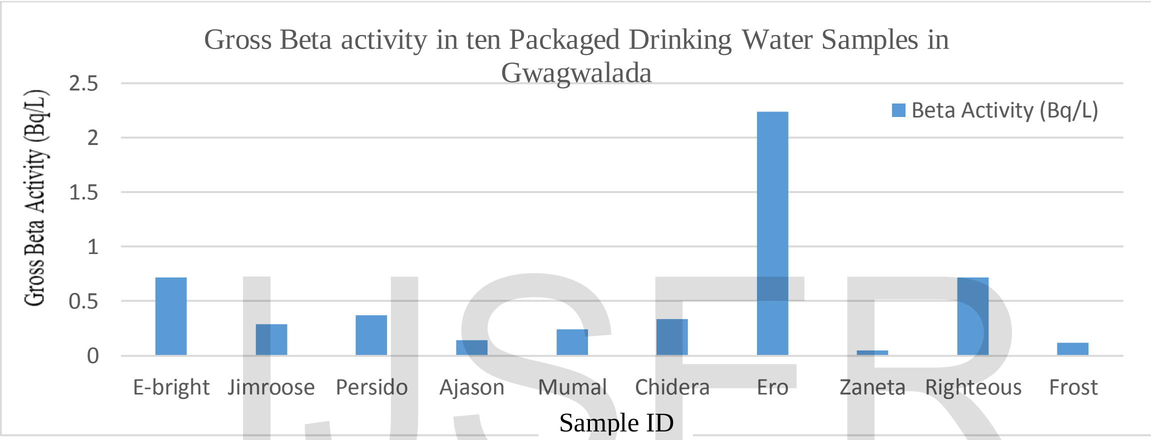

Figure 1(a): Bar charts representation showing gross beta activity concentration for the ten different packaged/sachet drinking water samples in Gwagwalada.

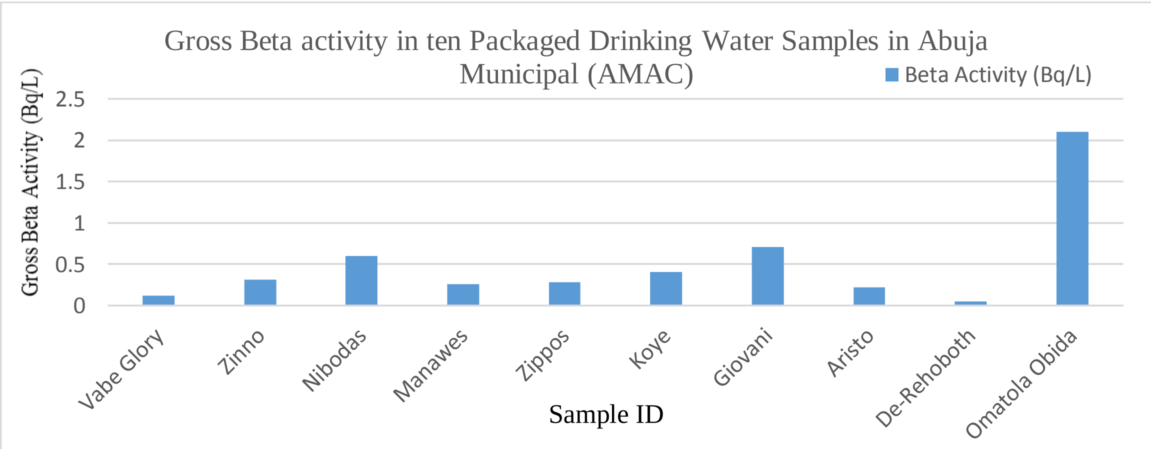

Figure 2(a): Bar charts representation showing gross beta activity concentration for the ten different packaged/sachet drinking water samples in Abuja Municipal (AMAC).

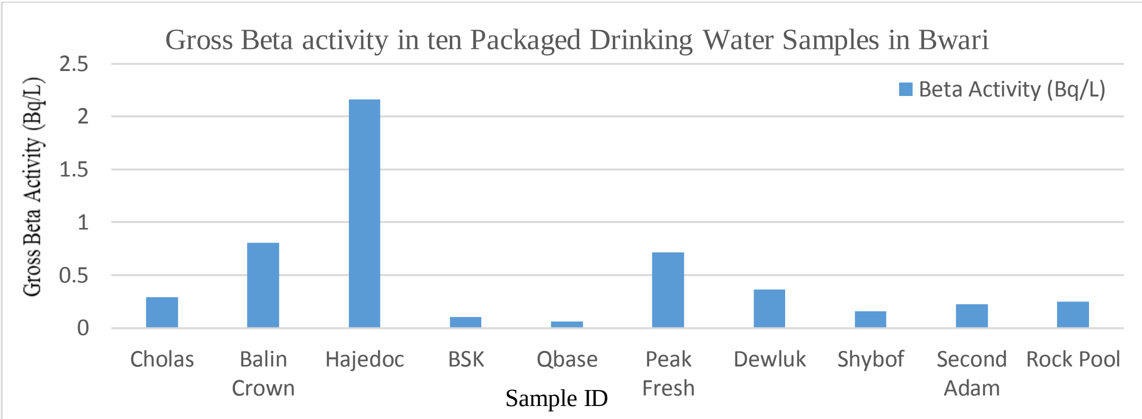

Figure 3(a): Bar charts representation showing gross beta activity concentration for the ten different packaged/sachet drinking water samples in Bwari.

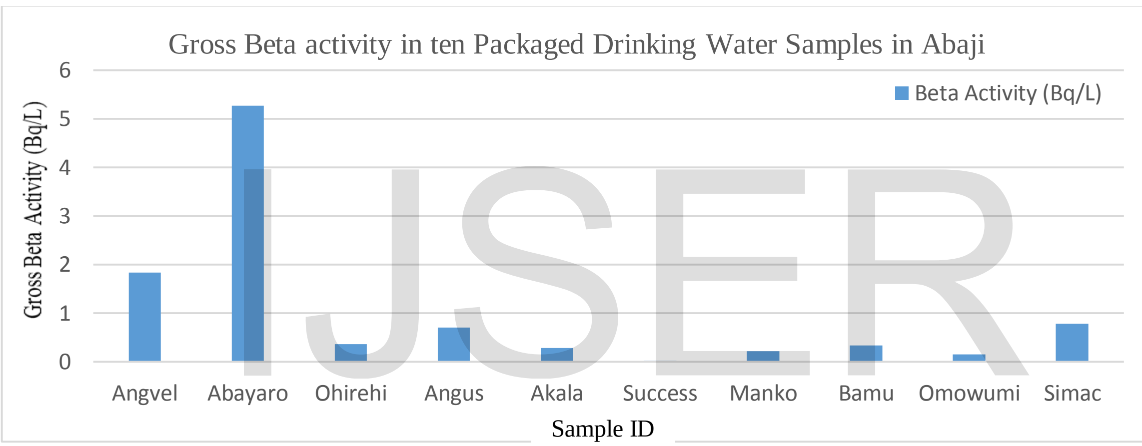

Figure 4(a): Bar charts representation showing gross beta activity concentration for the ten different packaged/sachet drinking water samples in Abaji.

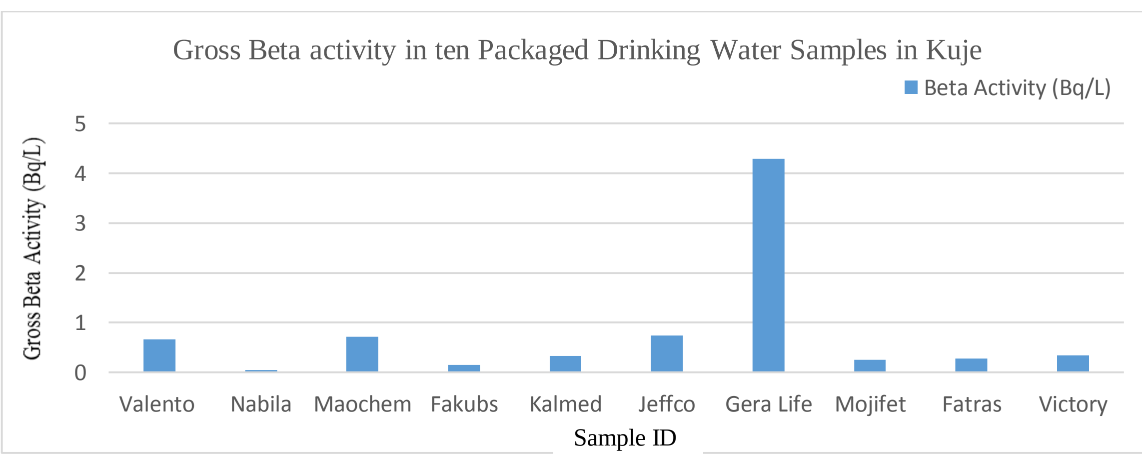

Figure 5(a): Bar charts representation showing gross beta activity concentration for the ten different packaged/sachet drinking water samples in Kuje.

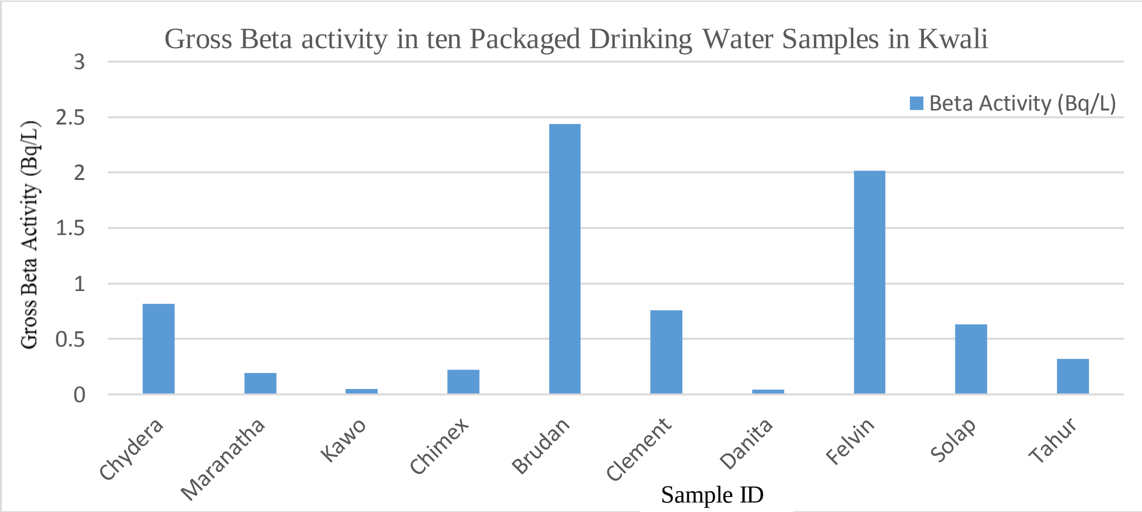

Figure 6(a): Bar charts representation showing gross beta activity concentration for the ten different packaged/sachet drinking water samples in Kwali.

The high level bar charts of Ero (43%), Omatola Obida (42%), Hajedoc (42%), Abayaro (53%), Gera life (55%), Brudan (32%) and Felvin (27%) waters from the above figures is as a result of their high rate of beta activity concentrations in those locations, as such does not satisfy the International Commission on Radiological Protection (ICRP) recommended standard limit for beta concentration in drinkable water of 1.0Bq/L per year (ICRP, 2007) , continue the intake will results in health issues. The low level bar charts indicate the gross beta activity concentrations of water samples with low rate of beta activity obtained from Zaneta (1%), De-Rehoboth (1%), Qbase (1%), Success (0%), Nabila (1%) and Danita (1%) for Gwagwalada, AMAC, Bwari, Abaji, Kuje and Kwali which satisfy the ICRP recommended contaminant limit of 1.0Bq/L. Figures (1b) – (6b) shows the pie chart percentage distribution of gross beta activity concentrations for the ten different packaged/sachet drinking water samples, while figures (1c) – (6c) illustrates the line chart representation showing the variation of beta activity concentration in respect to the International Commission on Radiological Protection (ICRP) recommended standard limit in packaged drinking water samples in each of the six local councils.

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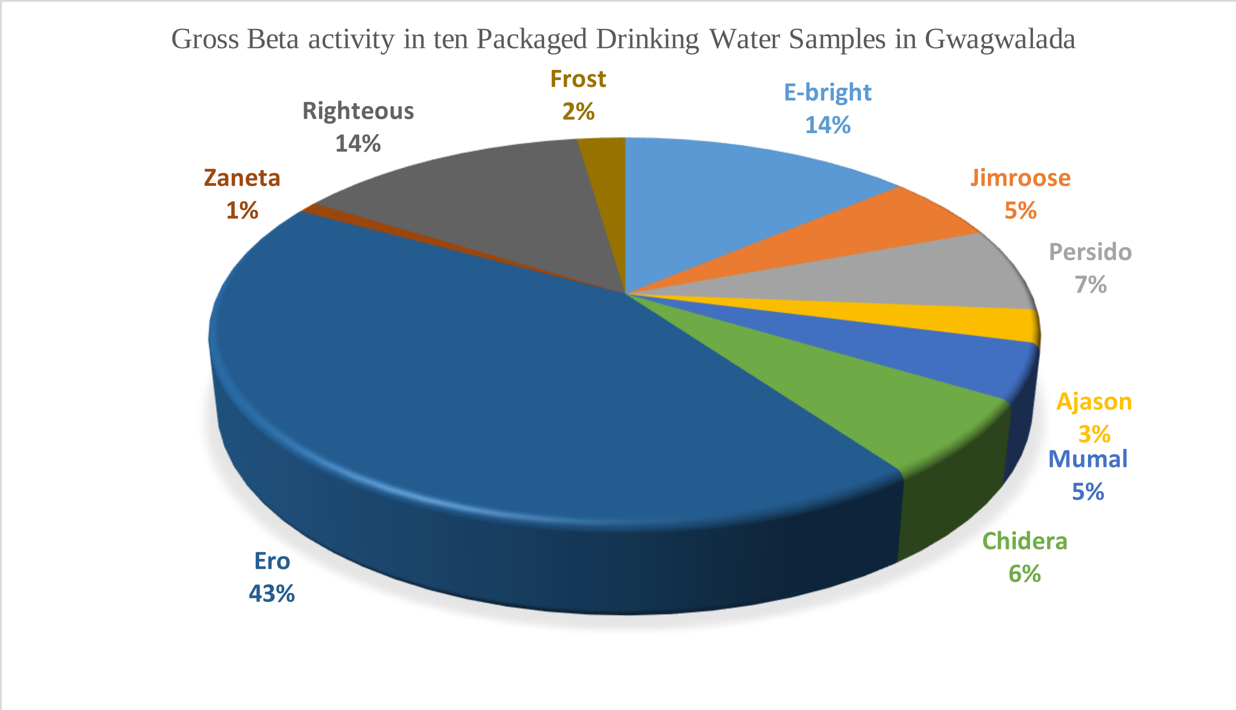

Figure 1(b): Pie chart showing the percentage distribution of gross beta activity concentration in Gwagwalada.

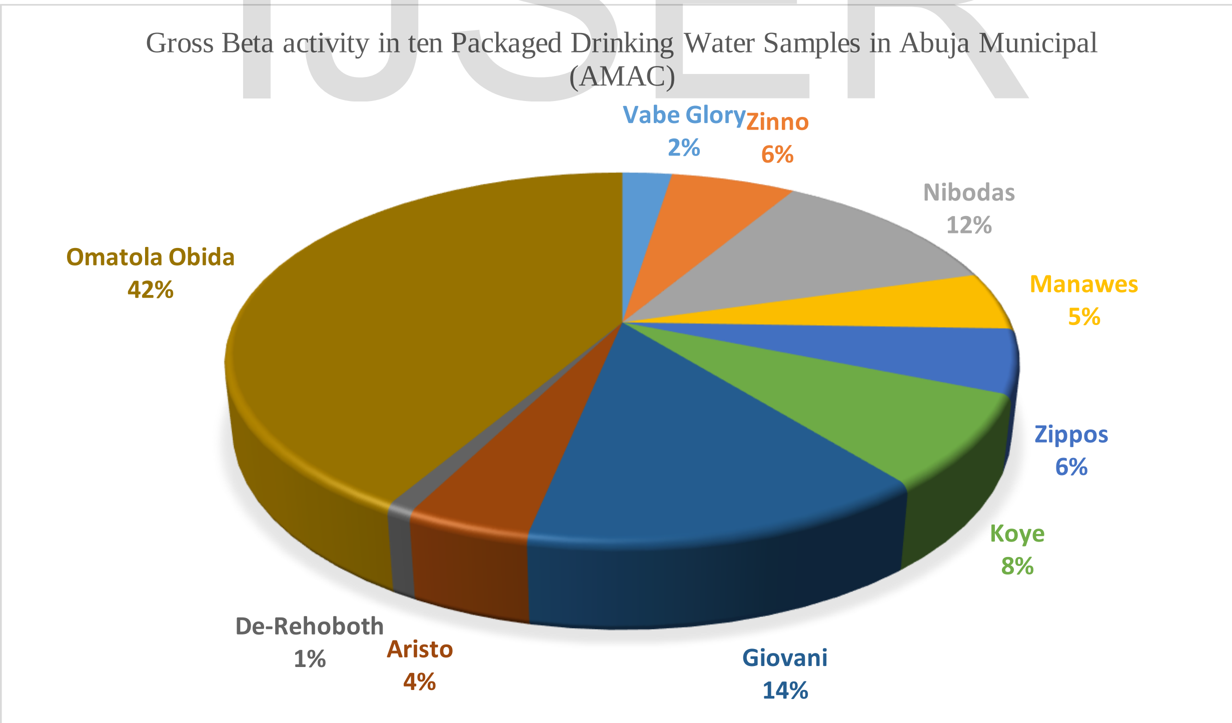

Figure 2(b): Pie chart showing the percentage distribution of gross beta activity concentration in Abuja Municipal (AMAC).

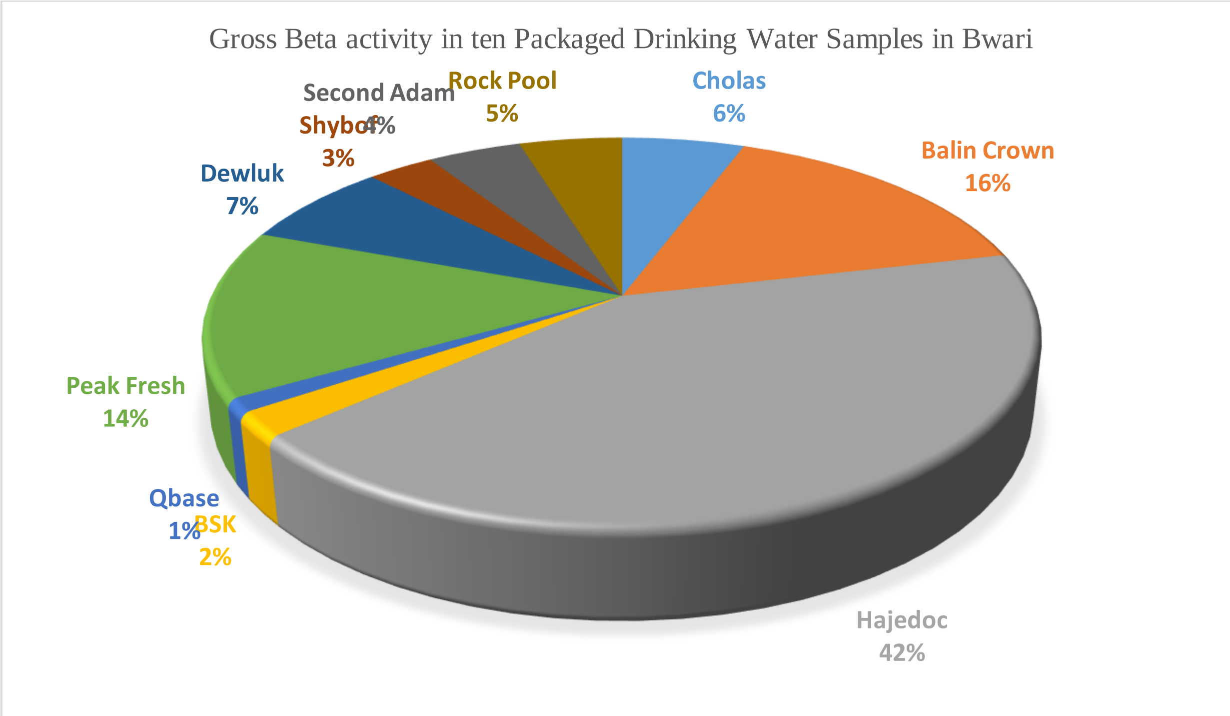

Figure 3(b): Pie chart showing the percentage distribution of gross beta activity concentration in Bwari.

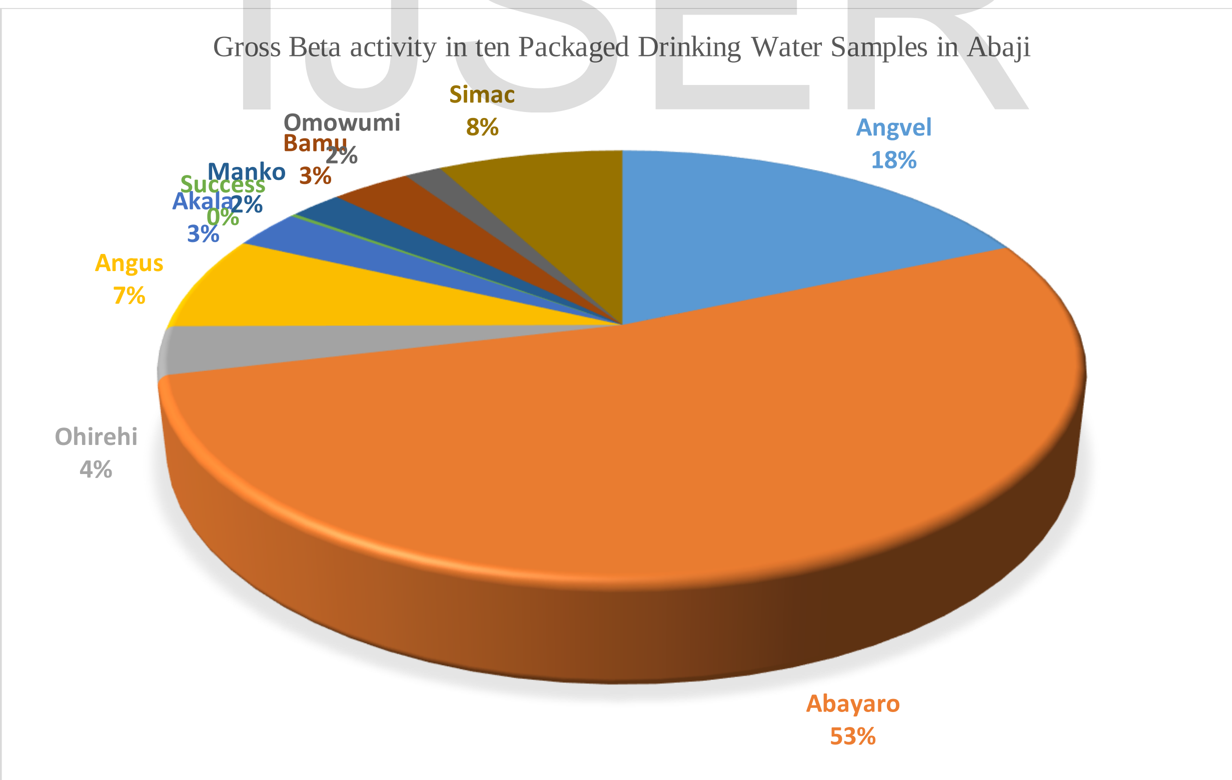

Figure 4(b): Pie chart showing the percentage distribution of gross beta activity concentration in Abaji.

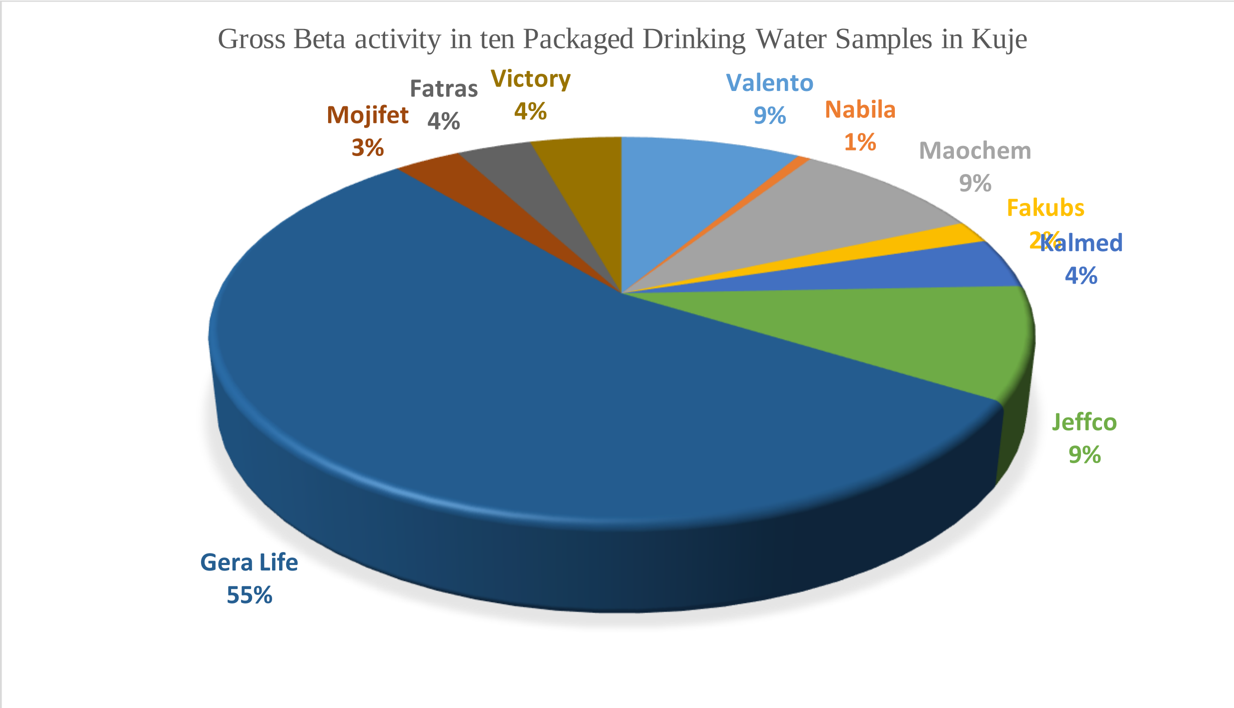

Figure 5(b): Pie chart showing the percentage distribution of gross beta activity concentration in Kuje.

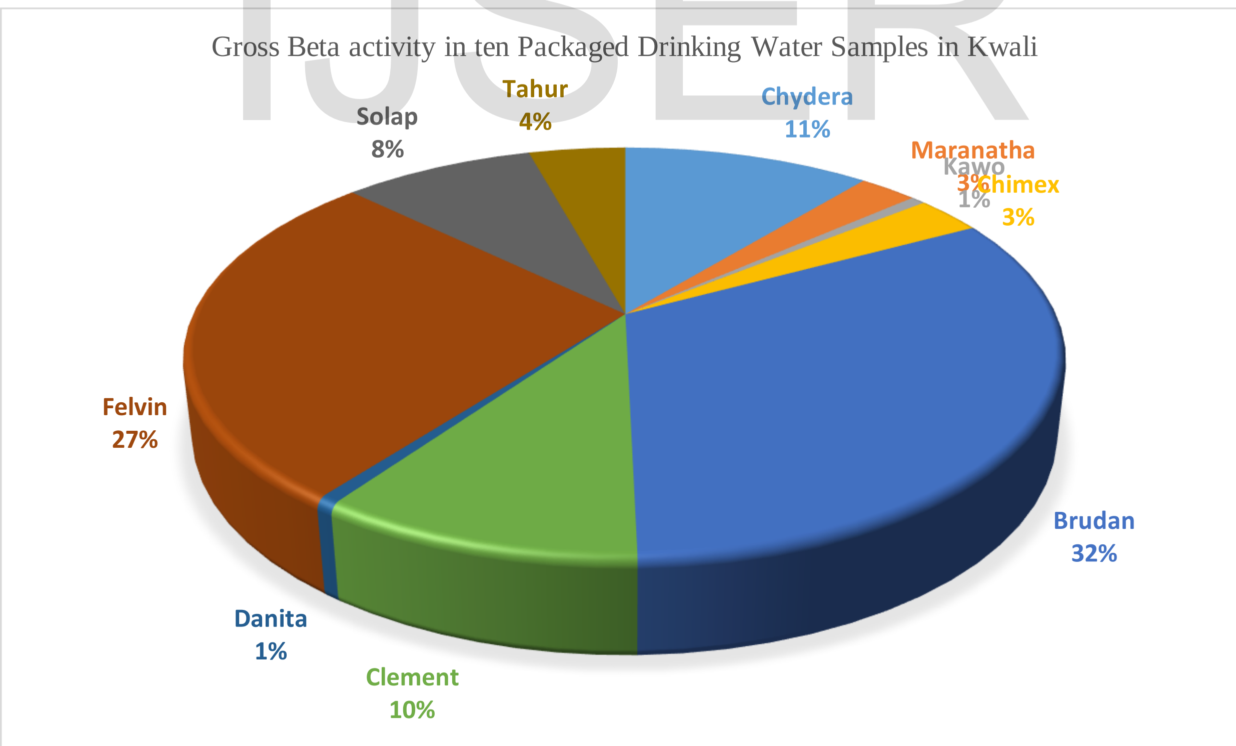

Figure 6(b): Pie chart showing the percentage distribution of gross beta activity concentration in Kwali.

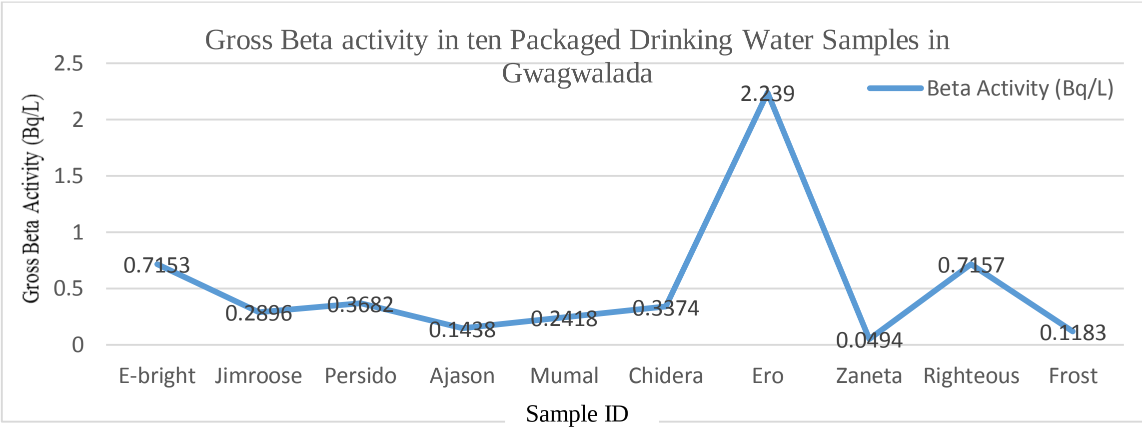

Figure 1(c): Line chart representation showing the variation of beta activity concentration in respect to the ICRP recommended standard limit in packaged water samples for Gwagwalada.

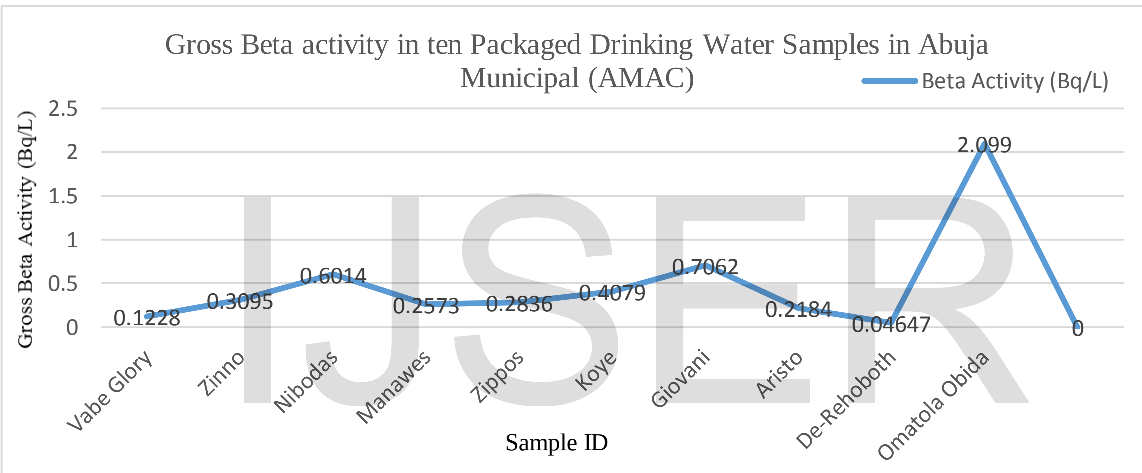

Figure 2(c): Line chart representation showing the variation of beta activity concentration in respect to the ICRP recommended standard limit in packaged water samples for Abuja Municipal.

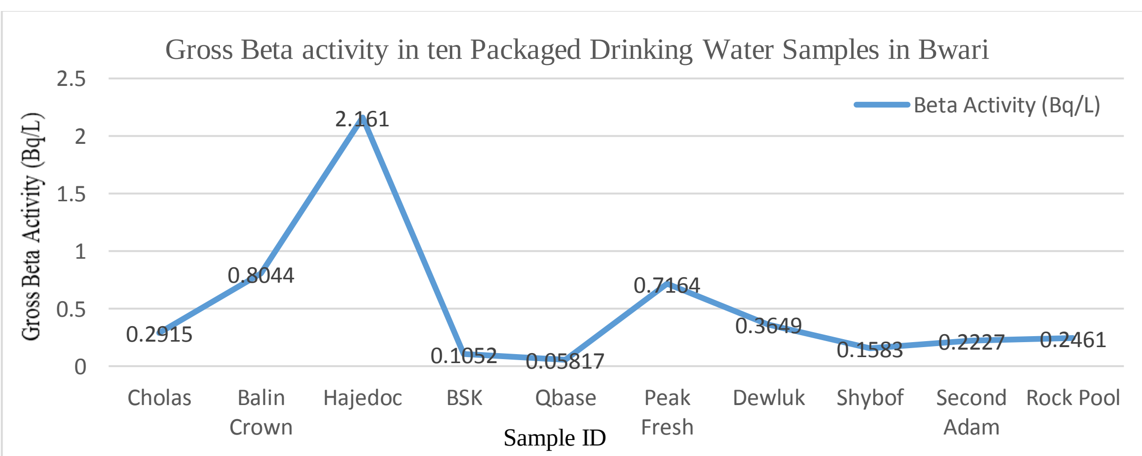

Figure 3(c): Line chart representation showing the variation of beta activity concentration in respect to the ICRP recommended standard limit in packaged drinking water samples for Bwari.

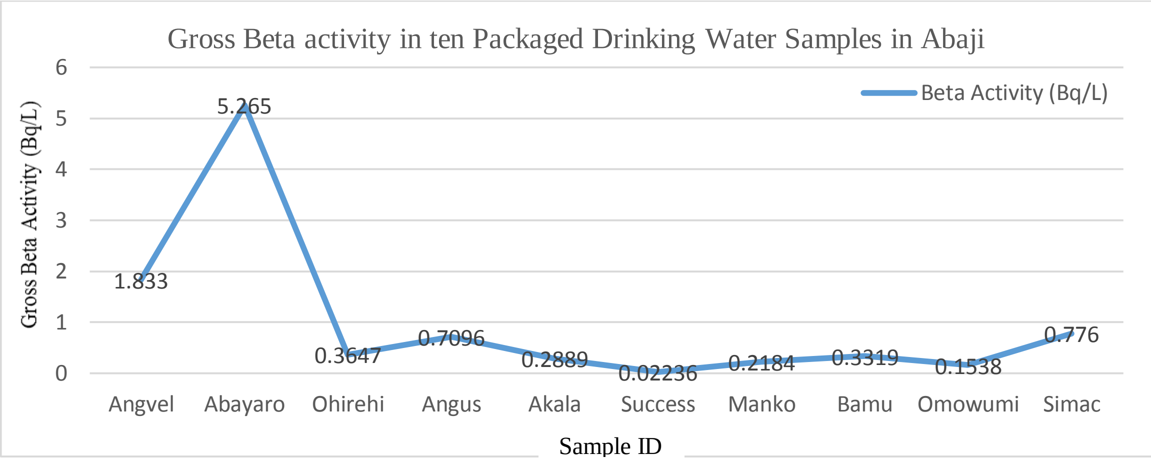

Figure 4(c): Line chart representation showing the variation of beta activity concentration in respect to the ICRP recommended standard limit in packaged drinking water samples for Abaji.

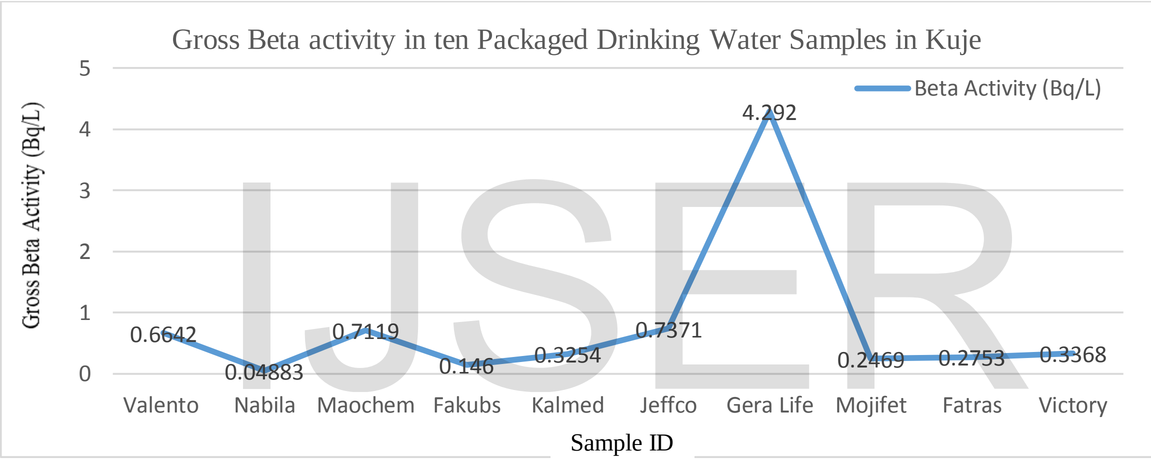

Figure 5(c): Line chart representation showing the variation of beta activity concentration in respect to the ICRP recommended standard limit in packaged drinking water samples for Kuje.

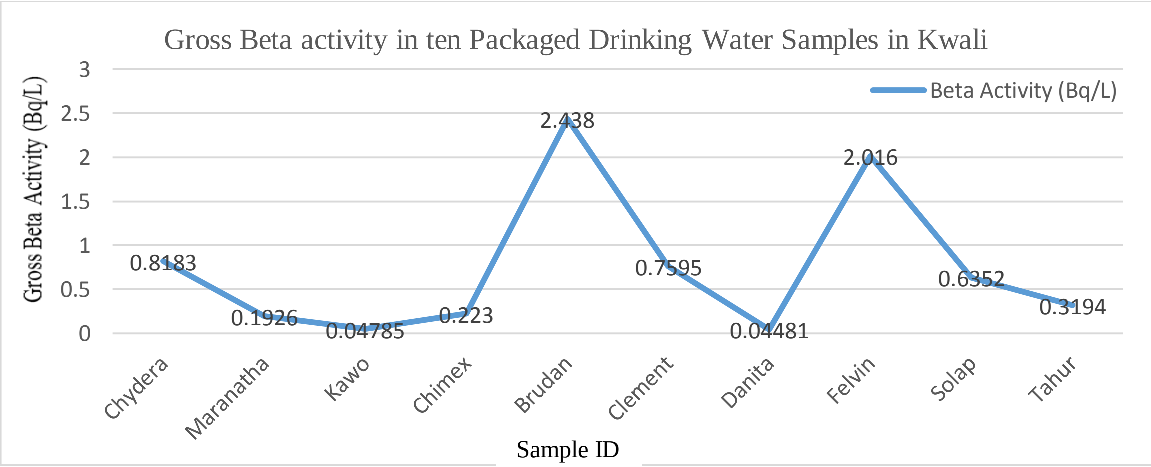

Figure 6(c): Line chart representation showing the variation of beta activity concentration in respect to the ICRP recommended standard limit in packaged drinking water samples for Kwali.

It is clearly shows in the above line charts that forty-five out of the fifty water samples obtained from Gwagwalada, AMAC, Bwari, Kuje, Kwali (see figures 1c, 2c, 3c, 5c, 6c), eight out of the ten samples in Abaji (see figure 4c) satisfy the recommended value which indicated that they are safe for human consumption since it is in accordance with the maximum acceptable beta activity concentrations, while all the remaining seven out of the sixty water samples obtained from the six local councils are slightly higher than the recommended contaminant limit, hence has abnormal gross beta activity concentrations, as such can be dangerous to human health and therefore not safe for human consumption. The major contributors to the risk laden beta concentration from this water samples may trace back to their source, probably from a very deep borehole water source due to the fact that depth of the underground water is directly proportional to activity concentrations. On the other hand, the water source may be originated from mountainous environment or directly from beneath the rock. This is simply due to the primordial source of natural radioactivity in rocks. The remaining water samples are not dangerous due to their beta activity concentrations were below the International Commission on Radiological Protection (ICRP) (ICRP, 2007) standard limit value and does not exceed the World Health Organization (WHO) (WHO, 1993; 2004; 2006) stated above. The atmospheric fall out sometimes contributed immensely to the water concentration measured. This normally occurred as a result of nuclear disaster like disposal of radioactive waste material into the river. Radionuclide particles suspended in air could be deposited on the soil surface which later dissolved and the level of contamination therefore depends on the surface area of the water.

4. CONCLUSION

The comprehensive gross beta concentrations in commercial packaged water samples commonly consumed was presented in this study in the six local councils of Federal Capital Territory, Abuja, Nigeria. The results obtained clearly shows that fifty-three water samples out of the sixty samples selected representing 88.3% for gross beta activity concentrations satisfy the recommended standard contaminant limit and thus does not constitute any radiological threat to the people consuming them, while the remaining (11.7%) water samples fall out of range recommended by ICRP, ISO and WHO acceptable values. The above mentioned brand of packaged drinking water spread through the six local councils areas of Federal Capital Territory, Abuja are not safe for human consumption with Kwali local council area been the worst hit as 20% of these dangerous packaged sachet water is localized there. Therefore, continuous to drink this water samples may pose serious health side effects like cancer, leukemia, erithemia, hematological depression and eye cataracts etc. to the public users and thus it will be highly dangerous to consume due to the high level of the beta radioactivity concentration in them. This study demand extensive investigation to be carried out in other to ascertain the contributing factors to high gross beta activity concentrations in Ero, Omatola Obida, Hajedoc, Abayaro, Gera life, Brudan and Felvin packaged drinking waters.

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