***Original Research Article***

# Gross Alpha and Beta Activity Concentrations in Locally Processed Salt from Ebonyi State, Nigeria


## ABSTRACT

Salt lakes and small – scaled salt production in Ebonyi State, Nigeria have long interesting history and the need to be informed of the radiological quality of the salt is essential to radiation measurement and protection agencies. Gross alpha and beta activity concentrations have been determined in locally processed salt samples and iodized sachet salt samples consumed in Ohaozara Local Government Area and neighboring towns in Ebonyi State using Protean Instrument Corporation (PIC) MPC 2000DP proportional counter. The gross alpha and beta activity concentrations in Okposi Okwu salt were found to vary from 0.0057 to 0.0082 $Bq\,g^{-1}$ with a mean of 0.0063$\pm$0.0002 Bq/g and from 0.2393 to 12.12 $Bq\,g^{-1}$ with a mean of 1.763$\pm$1.160 Bq/g respectively; for Uburu salt between 0.0058 to 0.0068 $Bq\,g^{-1}$ with a mean of 0.0061$\pm$0.0001 Bq/g and from 0.2204 to 63.46 $Bq\,g^{-1}$ with a mean of 20.0150$\pm$8.1065 Bq/g for gross alpha and beta activity respectively; while the gross alpha and beta activity concentrations of the iodized sachet salt ranged from 0.0055 to 0.0067 $Bq\,g^{-1}$ with a mean of 0.0059$\pm$0.0001 Bq/g and 2.136 to 25.92 $Bq\,g^{-1}$ with a mean of 7.217$\pm$0.0001 Bq/g respectively. Findings showed that the mean gross alpha activity results for the three brands were in good agreement whereas, gross beta activity concentrations for Uburu salt and iodized sachet salt were respectively about 13.37 and 4.09 times higher than that of Okposi Okwu salt. The trend of the mean of gross alpha activity concentration of the three brands of salt in this study shows that Okposi Okwu salt > Uburu salt > industrial sachet salt while that of gross beta activity shows that Uburu salt > industrial sachet salt > Okposi Okwu salt. The results of the gross beta and, sum of gross alpha and beta activity concentrations are greater than the standard activity limit for general consumed foods which is given as 0.1 Bq/g. High consumption of Okposi Okwu salt brand by the populace may have radiological impact on them as a result of the relatively high level of beta radiation. It is suggested that as a means of radiological protection, These salt brands should be screened for radioactivity concentration before consumption.



*Keywords:* Gross alpha and beta, activity concentration, salt lakes, Ebonyi State


## 1. INTRODUCTION

In Nigeria, we can find deposits of spring salt in Okposi and Uburu salt lakes, Ebonyi State and salt springs in Awe, Plateau State [1, 2]. Generally, a number of salt types are used in the manufacture of many industrial, agricultural, and consumer substances like chlorine gas, fertilizers and laxatives. The focus of this study is sodium chloride salt commonly known as table salt and one of the examples of normal salt. It is used for cooking of food, as food preservatives and as a drying agent. Most table salts used in Nigeria may not have been screened to ascertain the concentrations of natural radionuclides as a result of primary interactions with radiation prone minerals due to geophysical and geochemical characteristics of the sources (as is the case in the surveyed area where lead- zinc mineralization is predominant and also serves as channels/conduit for salt ground water) [3]. The knowledge of radionuclide activity concentrations in table salts is desirable and very important so as to be informed of the potential radiological status and associated risk or otherwise when such salts are ingested via food intake over a long period of time.

Since naturally occurring radionuclides of uranium series, thorium series and radioisotopes of potassium are found in environmental media including rock, soil, seas and oceans; the salt lakes may contain both alpha emitters (such as; $^{238}U$, $^{226}Ra$ and $^{210}Po$) and beta emitters (such as; $^{40}K$, $^{228}Ra$ and $^{210}Pb$) which could contribute significantly to ingested dose of radiation [4].

Several researches on gross alpha and beta activity concentrations on materials have been conducted and reported, however data and information on gross alpha and beta activity

concentrations in salt samples are relatively scarce. Previous researchers have reported the ranges of values of 0.5 to 1.3 Bq/kg, 0.4 to 0.9 Bq/kg and 15.0 to 34.0 Bq/kg for activity concentrations of $^{226}$Ra, $^{232}$Th and $^{40}$K respectively in rock salt samples collected from Pakistan which resulted to the value of 0.0638±0.015 mSv/y as the mean annual effective dose due to the intake of the radionuclides [5]. Salt samples collected from Khewra Salt Mine located about 160km South of Islamabad, Pakistan had been investigated for the activity concentration of radionuclides $^{40}$K, $^{226}$Ra and $^{232}$Th using high purity germanium (HPGe) detector. Their results showed that mean activity concentrations of 36±20 Bq/kg were recorded in $^{40}$K radionuclides while below detection limits (BDL) were reported for $^{226}$Ra and $^{232}$Th respectively [6]. Furthermore, the computed annual effective dose due to intake of $^{40}$K contained in the salt was found to be 20±11 µSv/year which is below 290 µSv/year recommended in [7]. It was reported that the annual effective dose to an adult individual in Accra Metropolis, Ghana due to intake of natural radionuclide in salt is insignificant to cause radiological health hazards [8]. It was established that gross alpha activities were higher in the Single Super Phosphate (SSP) fertilizers than the Nitrogen Phosphorus and Potassium (NPK) fertilizers while there were more beta activities in NPK fertilizers than in SSP fertilizers used in Nigeria [9]. Studies on gross alpha and beta activity concentrations in surface water from mining areas of Plateau State, Nigeria reported high annual committed effective dose for all age groups above the International Commission on Radiological Protection (ICRP) acceptable standard [10]. Previous researches had reported the presences of metallic and non – metallic ions in Uburu salt lake of Ebonyi State [11]. Also, hepatotoxicity of the Okposi and Uburu salt lakes has been demonstrated in [12]. The Japanese Department of Food safety has placed a new standard limit for activity concentration of radionuclides in general food to be 0.1 Bq/g [13].

Despite the high consumption of salt from the surveyed salt lakes, studies on the gross alpha and beta activity concentrations of these commonly consumed salts have not been carried out to allay the fears of possible intrusion of alpha and beta emitting radionuclides from natural sources into the salt deposits, and to ascertain if the table salts consumed from the surveyed sources do not have activity concentrations exceeding the permissible limits. This work was therefore considered relevant in order to address the aforementioned issues.

## 2. MATERIAL AND METHODS

### 2.1. Study Area

Okposi and Uburu (the study areas) are neighboring towns situated in Ohaozara Local Government Area of Ebonyi State, Nigeria and lie between 06$^0$ 02′ 20″N; 007$^0$ 48′ 37″E and 06$^0$ 02′ 60″N; 007$^0$ 44′ 52″E respectively. The salt lakes found in the two towns gave Ebonyi State its slogan as the “Salt of the Nation” in Nigeria. The study areas are made up of sedimentary rock of Asu River Group of the Albian age. The hydrogeology of the area is controlled by the bedrock lithology and structural trend of the study area [14]. It had been reported that the occurrence of the saline brines in this area is associated with the fracture system within the bedrock; in addition, the well- developed folds and fractures of the lower Benue trough form host to lead- zinc mineralization predominant in the area and also serve as channels/conduit for salt ground water [3]. The Map showing Okposi Okwu and Uburu salt lakes are presented in Figures 1 and 2 respectively. Small – scale salt production among elderly women and large scale farming activities have been identified as the major occupations of people living within the salt lakes. The saline water from the salt lakes is used in the production of salt and the processes include collection of saline water with a special pot, transferring into a container (usually a basin), heating to evaporate water, and living behind crystals of salt in the container.
Okposi Okwu and Uburu salt brands have been superstitiously reported by the consumers to relief feverish condition and detoxicate toxins in the body system which could be the reason it is relatively expensive and highly consumed in the locality compared with the commonly sold iodized sachet salt registered with National Agency for Food and Drug Administration and Control (NAFDAC). However, these claims have not been evaluated by NAFDAC and Standard Organisation of Nigeria (SON).

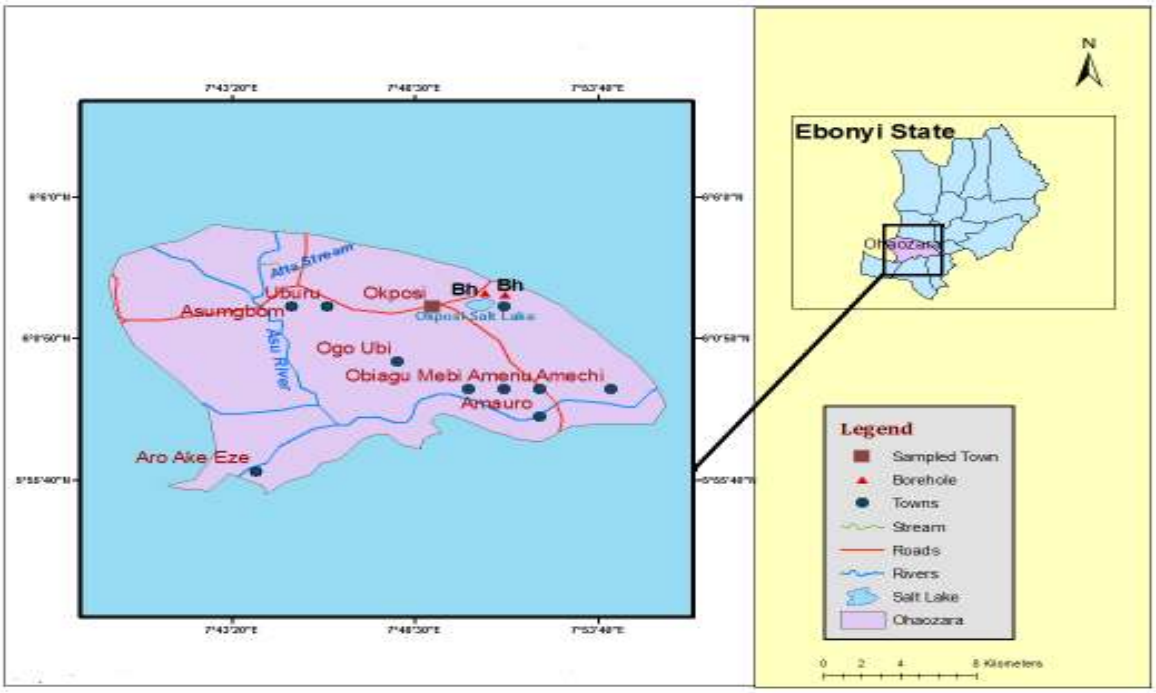


**Figure 1. Map showing Okposi Okwu salt lake in Ohaozara LGA, Ebonyi State Nigeria**

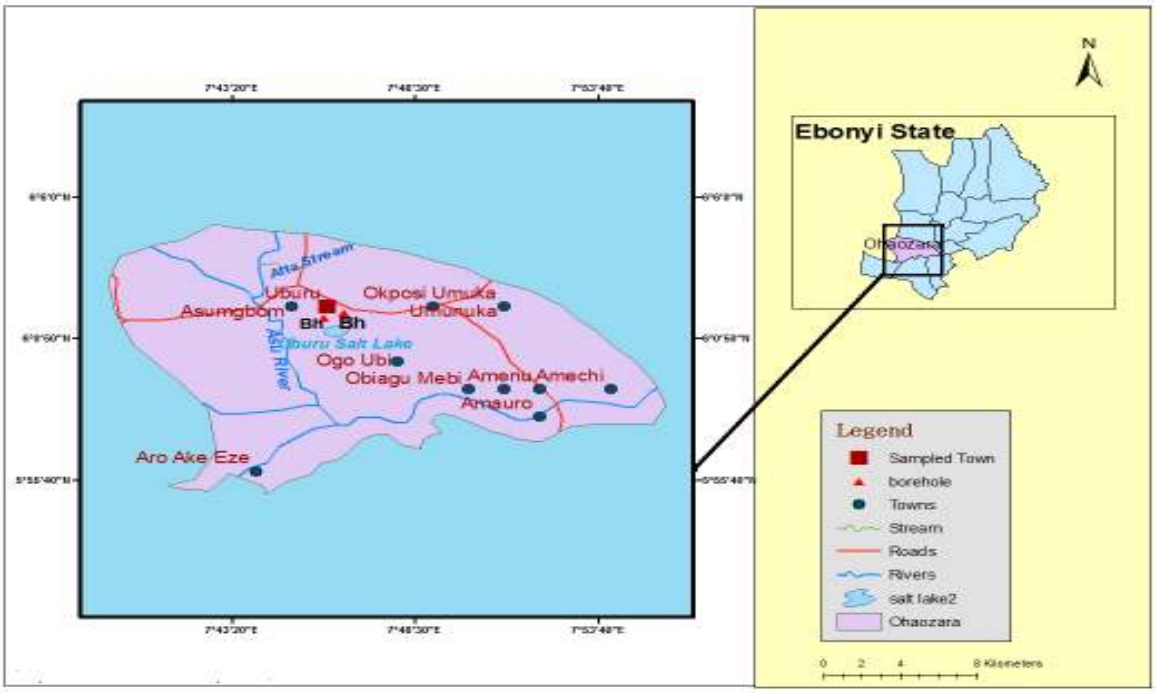


**Figure. 2 Map showing Uburu salt lake in Ohaozara LGA, Ebonyi State, Nigeria**

## 2.2. Sample Collection and Pelletisation

Three brands of salt were considered; the Okposi Okwu brand, Uburu brand and the sachet iodized salt commonly sold by the local marketers. Ten samples each of the three brands were collected with plastic containers sealed, labeled and transported to the laboratory for preparation and analyses.

Each labeled sample was ground into a fine particle using electric grinding machine and small portion of the samples transferred into agate mortar and ground further to a grain size of about 125 µm and about 0.5 g weighed using analytical weighing balance. Three drops of liquid binder were added and ground until the liquid binder evaporates into the atmosphere. Thereafter, it was put into a set of dyne of about 19mm in diameter to give it the pellet shape. Each sample was placed in a hydraulic press gauge and about 10 tons of pressure was exerted on it to produce a pellet. Finally all the thirty (30) prepared pellets were subjected to gross alpha and beta radioactivity count at a preset time of 45minutes each.

### 2.3. Counting Equipment and Calibration of the Detector

Protean Instrument Corporation (PIC) MPC 2000DP proportional counter(a low background alpha and beta detector: 0.05 CPM Alpha; 50 CPM Beta) available in Centre for Energy Research and Training (CERT), Ahmadu Bello University (ABU) Zaria, Nigeria was used for the gross alpha and beta measurements. This equipment is a non-gas proportional counter with an ultra thin window. For the gross alpha activity measurements, the standard used was $^{239}$Pu alpha source with half life of 24,110 years while for the beta activity measurements, the standard used was $^{90}$Sr beta source with half life of 28 years [15]. The detector efficiencies of the equipment are 87.95% and 42.06% for gross alpha and beta counts respectively. The sample efficiency ($S_E$) and, the alpha and beta activity concentrations ($A_{\alpha/\beta}$) in Bq g$^{-1}$ for all the samples were determined using equations (1) and (2).

$$S_E = \frac{W_{B+S} - W_B}{0.077} \times 100 \quad (1)$$

Where $W_{B+S}$ is the weight of the planchet plus sample after evaporation, $W_B$ is the weight of the empty planchet and 0.077g is the mass of the residue transferred to the planchet before evaporation.

$$A_{\alpha/\beta} = \frac{count\ rate\ (alpha\ or\ beta) - background\ count\ rate\ (alpha\ or\ beta)}{S_E \times detector\ efficiency \times V \times 60} \quad (2)$$

(The measured background count rates with empty planchets were 0.13cpm and 78.49 cpm for gross alpha and beta respectively). Also, according to Protean Instrument's specification, MPC 2000DP has nearly 0.0% spill-over. Therefore, the gross beta count rate was not affected by spill-over effect.

### 2.4 Data Analyses

All the data analyses were performed using MINITAB (Release 14) Statistical Software. This software aided us in computing the sample mean (Sm), standard error of the mean (SEM), standard deviation ($\sigma$) and t-test based on equations (3), (4), (5) and (6) respectively. We plotted frequency distribution histograms to account for the specific activity distribution of the samples and regression curves to ascertain the nature of correlation between the trends of gross alpha and gross beta radiations.

$$S_m = \frac{\sum_1^n s}{n} \quad (3)$$

$$SEM = \frac{\sigma}{\sqrt{n}} \quad (4)$$

$$\sigma = \sum \sqrt{\frac{(s - s_m)^2}{n}} \quad (5)$$

We went further to perform a t-test at 95 % Confidence Interval (CI) so as to obtain the Interval Estimates for the Sample Mean (IESM) because, for each location, our sample size is n< 30. This test was carried out to reduce the level of uncertainty of the calculated mean which was based on a relatively small sample size. The Interval Estimates for the Sample Mean (IESM) was calculated as;

IESM = $S_m \pm t(SEM)$ (6),
Where t is the t-table value for 'n-1' degrees of freedom.

## 3. RESULTS AND DISCUSSIONS

### 3.1 Results

The results of the gross alpha and beta activity concentrations (Bq/g) in Okposi Okwu salt, Uburu salt and the sachet iodized salt brands are presented in Tables 1, 2 and 3 respectively. Summary of the Statistical Analyses of the Results of Surveyed Sample and Comparison of the Results with Standard Activity Limit for General Foods Consumed are presented in Tables 4 and 5 respectively. The frequency distribution histogram of the total gross alpha and beta activity concentrations in Okposi Okwu salt brand, Uburu salt brand and common iodized salt brand consumed in the surveyed area are presented in Figures 3, 4, 5 respectively. Figures 6, 7 and 8 show the regression plots to determine the correlation coefficients between gross alpha and beta activity concentrations in Okposi Okwu, Uburu and iodized sachet salts respectively.

**Table 1: Gross alpha and beta activity concentrations (measured in Bq/g) in locally processed salt brand from Okposi Okwu Salt Deposit**

| SAMPLES | ALPHA ACTIVITY | BETA ACTIVITY | TOTAL ACTIVITY (ALPHA + BETA) |
|---|---|---|---|
| OKP SALT 01 | 0.0062 | 0.4032 | 0.409 |
| OKP SALT 02 | 0.0082 | 12.1200 | 12.128 |
| OKP SALT 03 | 0.0059 | 0.6922 | 0.698 |
| OKP SALT 04 | 0.0059 | 0.2393 | 0.245 |
| OKP SALT 05 | 0.0060 | 0.6273 | 0.633 |
| OKP SALT 06 | 0.0063 | 1.4130 | 1.419 |
| OKP SALT 07 | 0.0058 | 0.4298 | 0.436 |
| OKP SALT 08 | 0.0059 | 0.4936 | 0.499 |
| OKP SALT 09 | 0.0066 | 0.5056 | 0.512 |
| OKP SALT 10 | 0.0057 | 0.7025 | 0.708 |
| MEAN | 0.0063 | 1.763 | 1.769 |
| STANDARD DEVIATION ($\sigma$) | 0.000735 | 3.653 | 3.654 |
| STANDARD ERROR (SEM) | 0.000232 | 1.160 | 1.160 |

**Table 2: Gross alpha and beta activity concentrations (measured in Bq/g) in locally processed salt brand from Uburu Salt Deposit**

| UBURU SAMPLES | ALPHA ACTIVITY | BETA ACTIVITY | TOTAL ACTIVITY (ALPHA + BETA) |
|---|---|---|---|
| UBU SALT 01 | 0.0058 | 5.8490 | 5.8550 |
| UBU SALT 02 | 0.0060 | 0.4098 | 0.4160 |
| UBU SALT 03 | 0.0059 | 0.3586 | 0.3650 |
| UBU SALT 04 | 0.0058 | 0.4504 | 0.4560 |
| UBU SALT 05 | 0.0059 | 0.2451 | 0.2510 |
| UBU SALT 06 | 0.0059 | 44.4200 | 44.4800 |
| UBU SALT 07 | 0.0068 | 0.2204 | 0.2270 |
| UBU SALT 08 | 0.0068 | 54.5200 | 54.5900 |
| UBU SALT 09 | 0.0059 | 30.2200 | 30.2800 |
| UBU SALT 10 | 0.0060 | 63.4600 | 63.5200 |
| MEAN | 0.0061 | 20.0150 | 22.0440 |
| STANDARD DEVIATION ($\sigma$) | 0.000385 | 25.6350 | 27.2780 |
| STANDARD ERROR (SEM) | 0.0001 | 8.1065 | 8.6261 |

**Table 3: Gross alpha and beta activity concentrations (measured in Bq/g) in iodized sachet salt brand consumed in the surveyed area**

| IODISED SACHET SALT SAMPLES | ALPHA ACTIVITY | BETA ACTIVITY | TOTAL ACTIVITY (ALPHA + BETA) |
|---|---|---|---|
| SACH SALT 01 | 0.0057 | 2.136 | 2.142 |
| SACH SALT 02 | 0.0067 | 6.083 | 6.089 |
| SACH SALT 03 | 0.0064 | 5.655 | 5.661 |
| SACH SALT 04 | 0.0060 | 3.499 | 3.505 |
| SACH SALT 05 | 0.0061 | 25.920 | 25.926 |
| SACH SALT 06 | 0.0055 | 2.383 | 2.389 |
| SACH SALT 07 | 0.0055 | 2.161 | 2.167 |
| SACH SALT 08 | 0.0056 | 4.087 | 4.092 |
| SACH SALT 09 | 0.0058 | 17.230 | 17.236 |
| SACH SALT 10 | 0.0058 | 3.018 | 3.024 |
| MEAN | 0.0059 | 7.217 | 7.223 |
| STANDARD DEVIATION ($\sigma$) | 0.000395 | 7.957 | 7.957 |
| STANDARD ERROR (SEM) | 0.0001 | 0.0001 | 2.5162 |

Table 4: Summary of the Statistical Analyses of the Results of Surveyed Samples

| Samples | Gross Radiation | Mean Results | Standard Error of Mean | Standard Deviation | Interval Estimates for Sample Mean at 95% Confidence Interval (CI) |
|---|---|---|---|---|---|
| Okposi Okwu Salt Deposit | Alpha | 0.0063 | ±0.0002 | 0.0007 | 0.0058 - 0.0068 |
| | Beta | 1.7630 | ±1.1552 | 3.6530 | -0.8502 - 4.3762 |
| | Total | 1.7690 | ±1.1555 | 3.6540 | -0.8449 - 4.3829 |
| Uburu Salt Deposit | Alpha | 0.0061 | ±0.0001 | 0.0004 | 0.0058 - 0.0063 |
| | Beta | 20.0150 | ±8.1065 | 25.6350 | 1.6768 - 38.3532 |
| | Total | 22.0440 | ±8.6261 | 27.2780 | 2.5305 - 41.5575 |
| Iodized sachet Salt | Alpha | 0.0059 | ±0.0001 | 0.0004 | 0.0056- 0.0062 |
| | Beta | 7.2170 | ±0.0001 | 0.0004 | 1.5249 - 12.9091 |

| | | | | | |
|---|---|---|---|---|---|
| | **Total** | **7.2230** | ±2.5162 | 7.9570 | **1.53091 - 12.9151** |

Table 5: Comparison of Interval Estimates (Range) for Sample Mean with Standard Activity Limit for General Foods Consumed

| Samples | Range of Gross Alpha Mean (Bq/g) | Range of Gross Beta Mean (Bq/g) | Range of Total Mean (Gross Alpha + Gross Beta) (Bq/g) | Standard Activity Limit for General Consumed Foods (Bq/g) [13] |
|---|---|---|---|---|
| **Okposi Okwu Salt** | **0.0058 - 0.0068** | **-0.85020 - 4.3762** | **-0.8449 - 4.3829** | **0.1** |
| **Uburu Salt** | **0.0058 - 0.0064** | **1.6768 - 38.3532** | **2.5305 - 41.5575** | **0.1** |
| **Iodized sachet Salt** | **2.5305 - 41.5575** | **1.5249 - 12.9091** | **1.5309 - 12.9151** | **0.1** |

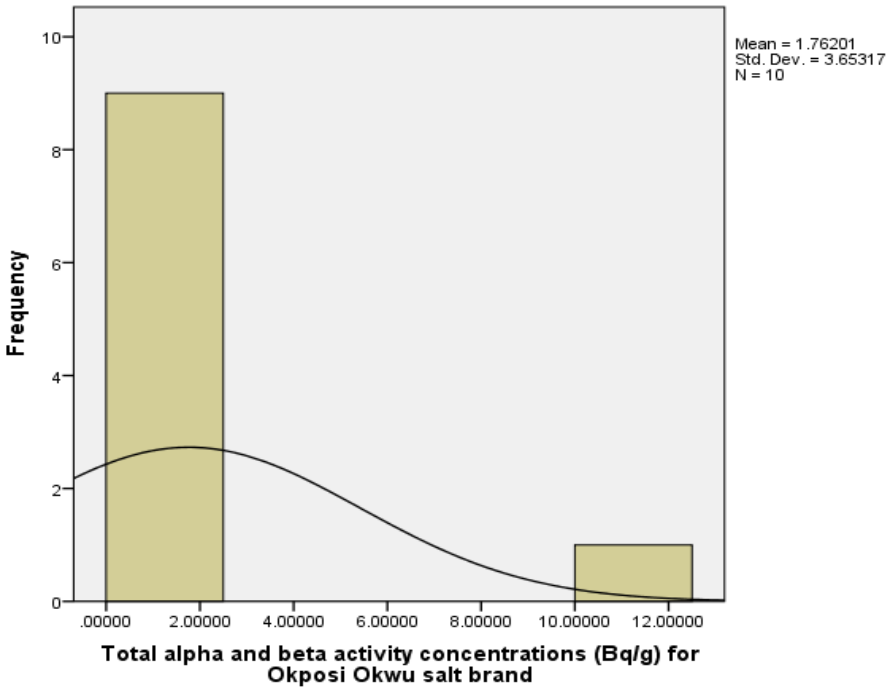


**Figure 3: Frequency distribution histogram for total alpha and beta activity concentrations in Okposi Okwu salt brand**

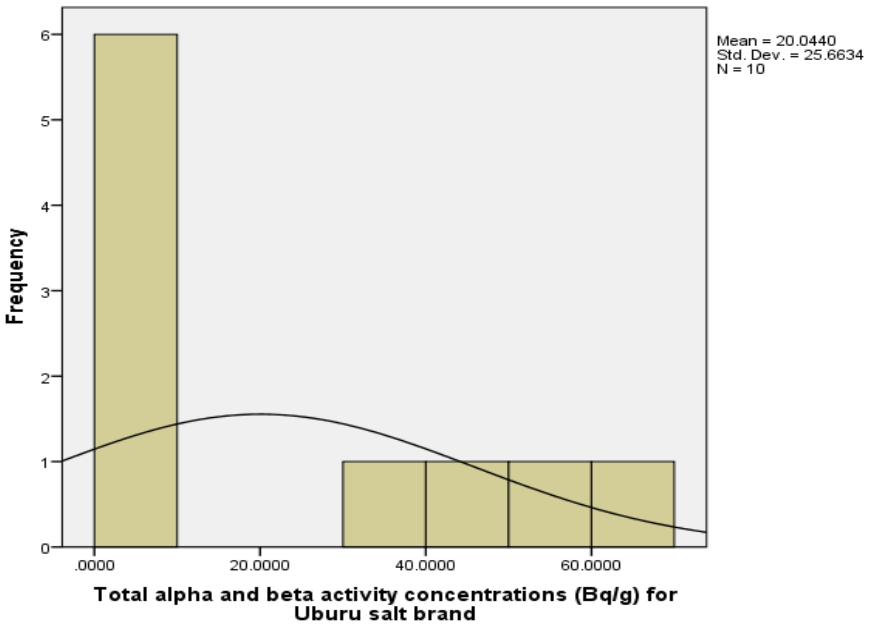


**Figure 4: Frequency distribution histogram for total alpha and beta activity concentrations in Uburu salt brand**

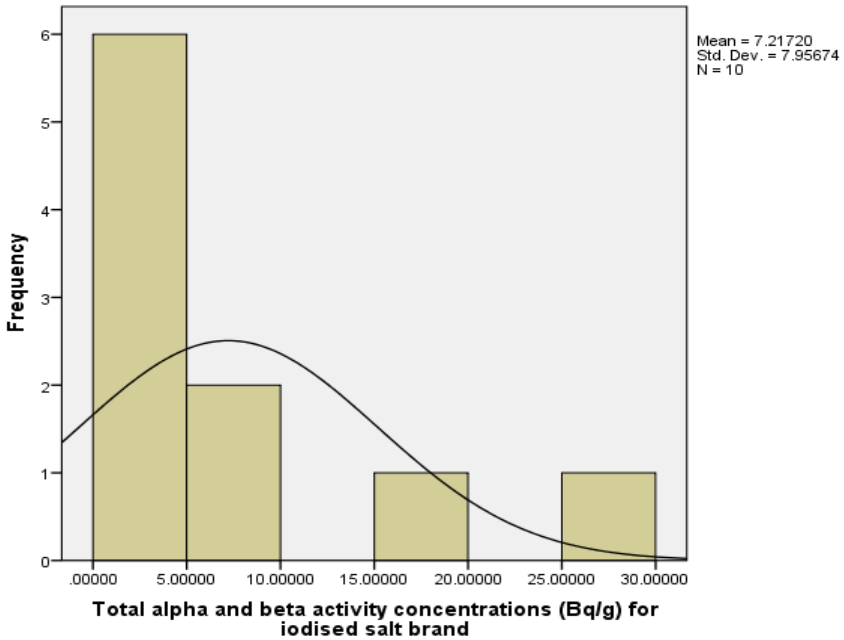


**Figure 5: Frequency distribution histogram for total alpha and beta activity concentrations in iodized edible salt brand**

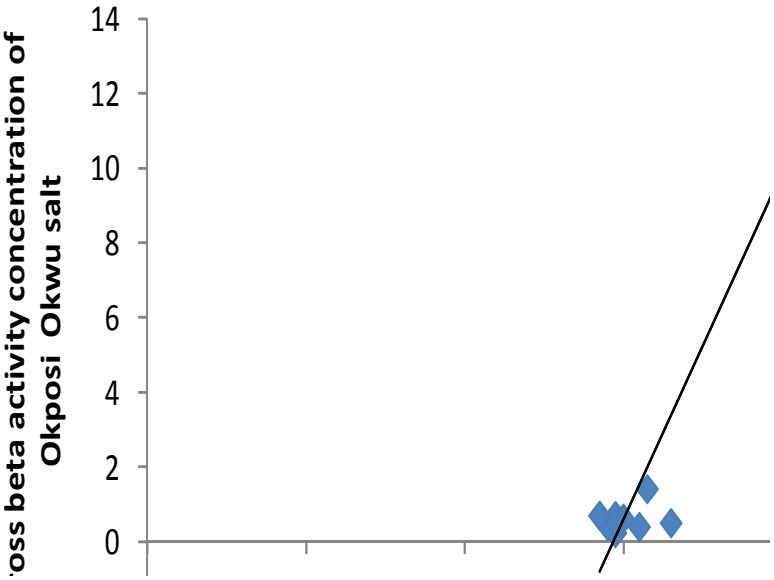


**Figure 6: Correlation of gross alpha and beta activity concentration in Okposi Okwu salt brand**

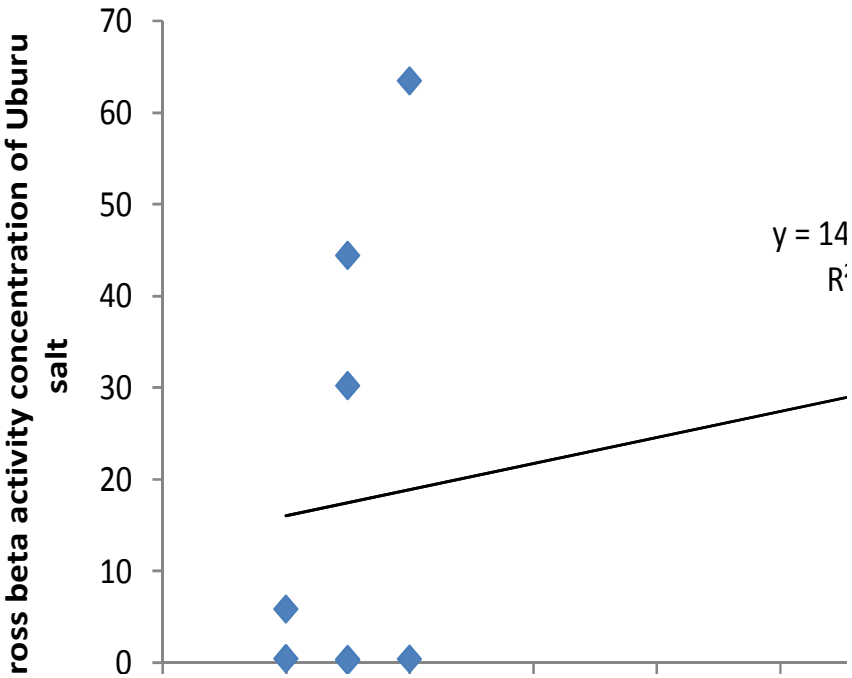


**Figure 7: Correlation of gross alpha and beta activity concentration in Uburu salt brand**

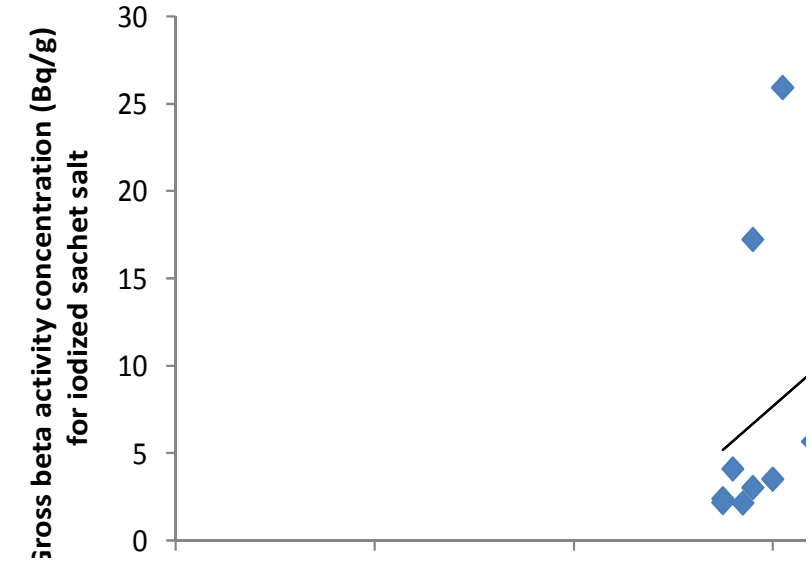


**Figure 8: Correlation of gross alpha and beta activity concentration in iodized sachet salt brand**

### 3.2 Discussions

**Okposi Okwu salt**

Table 1 shows that the gross alpha activity of locally made salt from Okposi Okwu ranged from 0.0057 to 0.0082 $Bq\,g^{-1}$ with a mean of 0.0063±0.0002 Bq/g (and with a range of Sample Mean of 0.0058 - 0.0068 Bq/g computed at 95 % CI). The gross beta activity concentrations ranged from 0.2393 to

12.12 $Bq\ g^{-1}$ with a mean of 1.763±1.160 Bq/g (and with a range of Sample Mean of -0.85020 to 4.3762 Bq/g computed at 95 % CI). The results of the sum of gross alpha and beta activity concentration ranged from 0.245 to 12.128 Bq/g with a mean of 1.769 ±1.160 Bq/g (and with a range of Sample Mean of -0.8449 to 4.3829 Bq/g computed at 95 % CI). The results of the gross beta and, sum of gross alpha and beta activity concentrations are greater than the the standard activity limit for general consumed foods which is given as 0.1 Bq/g in Table 5. This implies that high consumption of Okposi Okwu salt brand by the populace may have radiological impact on them as a result of the relatively high level of beta radiation.

Figure 3 shows that the frequency distribution histogram for total alpha and beta activity concentrations from Okposi Okwu salt brand is positively skewed with the hump on the left side indicating that few of the samples had high activity concentrations and majority of the samples had low activity concentrations.

From Figure 6, the linear regression plot of gross beta versus alpha activity concentrations of Okposi Okwu salt brand gave a high R-square value of 0.876. High $R^2$ value is an indication that the concentrations of gross alpha and gross beta are linearly related. The strong positive correlation between alpha and beta activity in Okposi salt could be an indication that the source of gross alpha and beta activities may be from the same natural radionuclides. This relationship between alpha and beta activities was similarly reported in [16], with $R^2$ = 0.84.

**Uburu salt**

Table 2 shows that the gross alpha activity of locally made salt from **Uburu** ranged from 0.0058 to 0.0068 $Bq\ g^{-1}$ with a mean of 0.0061±0.0001 Bq/g (and with a range of Sample Mean of 0.0058 - 0.0063 Bq/g computed at 95 % CI). The gross beta activity concentrations ranged from from 0.2204 to 63.46 $Bq\ g^{-1}$ with a mean of **20.0150±8.1065** Bq/g (and with a range of Sample Mean of - 1.6768 - 38.3532 Bq/g computed at 95 % CI). The results of the sum of gross alpha and beta concentration ranged from **0.227** to 63.52 Bq/g with a mean of **22.044±**8.6261 Bq/g (and with a range of Sample Mean of 2.5305 - 41.5575 Bq/g computed at 95 % CI). The results of the gross beta and, sum of gross alpha and beta activity concentrations are greater than the standard activity limit for general consumed foods which is given as 0.1 Bq/g in Table 5. This implies that high consumption of Uburu salt brand by the populace may have radiological impact on them as a result of the relatively high level of beta radiation.

Figure 4 shows that the frequency distribution histogram for total alpha and beta activity concentrations from Uburu salt brand is positively skewed with the hump on the left side indicating that few of the samples had high activity concentrations and majority of the samples had low activity concentrations.

From Figure 7, the linear regression plot of gross beta versus alpha activity concentrations of Okposi Okwu salt brand gave a low R-square value of 0.045. This $R^2$ value implies a weak positive correlation between alpha and beta activities and is an indication that the concentrations of gross alpha and gross beta activities are not linearly related, rather the distribution is scattered.

**Iodized Sachet Salt**

From Table 3, it is observed that the gross alpha activity of iodized sachet salt sold at both Okposi Okwu and Uburu area ranged from 0.0055 to 0.0067 $Bq\ g^{-1}$ with a mean of 0.0059±**0.0001 Bq/g** (and with a range of Sample Mean of 0.0056 to 0.0062 Bq/g computed at 95 % CI). The gross beta activity concentration ranged from 2.136 to 25.92$Bq\ g^{-1}$ with a mean of 7.217±0.0001 **Bq/g** (and with a range of Sample Mean of 1.5249 to 12.9091Bq/g computed at 95 % CI). The results of the sum of gross alpha and beta concentration ranged from **2.142** to **25.926** Bq/g with a mean of

**7.223±2.5162** Bq/g (and with a range of Sample Mean of 1.53091 to 12.9151Bq/g computed at 95 % CI). The results of the gross beta and, sum of gross alpha and beta activity concentrations are greater than the standard activity limit for general consumed foods which is given as 0.1 Bq/g in Table 5. This implies that high consumption of iodized salt brand by the populace may have radiological impact on them as a result of the relatively high level of beta radiation.

Figure 5 shows that the frequency distribution histogram for total alpha and beta activity concentrations from iodized salt brand is positively skewed with the hump on the left side indicating that few of the samples had high activity concentrations and majority of the samples had low activity concentrations.

From Figure 8, the linear regression plot of gross beta versus alpha activity concentrations of Okposi Okwu salt brand gave a low R-square value of 0.061. This $R^2$ value implies a weak positive correlation between alpha and beta activities and is an indication that the concentrations of gross alpha and gross beta activities are not linearly related, rather the distribution is scattered.

## General Discussion

It was observed from Tables 4 that the mean values of gross alpha activity concentrations for the three brands were very close which indicates that the sources may possibly contain homogeneous alpha emitting natural radionuclides. For all the three brands of salt, the mean gross beta activity concentrations were higher than the gross alpha activity concentrations which suggest that there are more beta emitting radionuclides than alpha emitters. This could be as a result of the presence of lead- zinc minerals in the surveyed areas [3]. Recall that $^{210}$Pb a beta radiation emitter is a radioisotope of lead and its presence may have contributed immensely to the relatively high concentration of gross beta activity. The sedimentary rocks, aquifer parameters, lithology and associated complex tectonic features are likely the significant contributors to radioactivity in the environment. During salt water and bedrock interaction at the fracture system, some beta emitting radionuclides may become more soluble at certain pH conditions thus enhancing beta activity concentration. Some other geophysical and geochemical characteristics controlled by the bedrock geology may be responsible for higher beta activity concentration relative to alpha activity in the locally processed salts. Correspondingly, higher mean gross beta activity relative to alpha activity was recorded in NPK fertilizers used in Nigeria [9]; and in soil samples from different locations of Beamer and Shard, Bangladesh [4]. The trend of the mean of gross alpha activity concentration of the three brands in this study shows that Okposi Okwu salt > Uburu salt > industrial sachet salt while that of gross beta activity showes that Uburu salt > industrial sachet salt **>** Okposi Okwu salt. The sum of gross alpha and beta activity for the three brands also follows the trend for gross beta activity concentration of the present study.

## 4. CONCLUSION

Gross alpha and beta activity concentrations have been determined in three brands of salt consumed in Ohaozara LGA and neighboring LGAs within Ebonyi State, Nigeria in order to assess the potential ingestion risk to the population. The results showed that the mean alpha activities were exceptionally lower than the beta activity results for the three salt brands. Beta activity concentrations for Uburu salt and iodized sachet salt were respectively about 13.37 and 4.09 times higher than that of Okposi Okwu salt which reveals that there were more beta emitting radionuclides in Uburu salt and iodized sachet salt than Okposi salt. The results of the gross beta and, sum of gross alpha and beta activity concentrations are greater than the standard activity limit set for general consumed foods which is given as 0.1 Bq/g [13]. High consumption of Okposi Okwu salt brand by the populace may have radiological impact on them as a result of the relatively high level of beta radiation. It is suggested that as a means of radiological protection. These salt brands should be screened for radioactivity concentration before consumption. There is presently no safe regulatory limits for gross alpha and beta activity concentration of salt in Nigeria; therefore the data and information from this work could be used as a baseline for future references and also serve as useful information for NAFDAC and radiation measurement and protection agencies. There is need to investigate the surface and ground water sources within the vicinity of the salt lakes for radionuclide contamination.

## REFERENCES


[1] Okaji, O.O. (2009). Salt production in Uburu and Okposi Okwu autonomous community, Ebonyi State. *Ebonyi State Business Directory,* 11: 1 – 3

[2] Anyim, C. Aneke, C.J., Orji, J.O., Nworie, O., Egbule, U.C.C. (2012). Microbiological examination and antimicrobial susceptibility of microorganisms isolated from salt mining site Ebonyi State. *Journal of Natural Sciences Research,* 2 (7): 95 – 102

[3] Tijani, M.N. and Uma, K.O. (1998). Geological, geophysical and hydrochemical studies of the Okpoma brine field, Lower Benue Trough, south – eastern Nigeria. *Journal of min. and Geol.,* 34 (1): 55 – 68

[4] Biswas, S., Ferdous, J., Begum, A., and Ferdous, N. (2015). Study of gross alpha and beta radioactivity in environmental samples. *Journal of Scientific research,* 7 (1 – 2): 35 – 44

[5] Tahire, S.N.A., Alaa,er, A.S. (2008). Determination of natural radioactivity in rock salt and radiation doses due to its ingestion. *Journal of Radiological Protection,* 28: 233 – 236

[6] Baloch, M.A., Quereshi, A.A., Waheed, A. Ali, M., Ali, N., Tufail, M. *et al.,* (2004). A study of natural radioactivity in Khewra Salt Mine Pakistan. *Journal of Radia Res.,* 53(3): 411 – 421

[7] UNSCEAR, (2000). United Nations Scientific Committee on Effects of Ataomic Radiation. Souces Effects and Risks of Ionising Radiation. *UNSCEAR Report to the general Assembly with Scientific Annexes,* United Nations New York

[8] Kansaana, C., Darko, E.O., Schandorf, C., Adukpo, O.K., Faanu, A., Lawluvi, H., Kpeglo, D.O. (2012). Determination of natural radioactivity in saline water and salt from Panbros Salt Industry Limited in the Accra Metropolis Ghana. *International Journal of Science and Technology,* 2 (3): 107 – 111

[9] Jibiri, N.N. and Fasae, K.P. (2013). Gross alpha and beta activities and trace heavy elemental concentration levels in chemical fertilizers and agricultural farm soils in Nigeria. *Natural Science,* 5 (1): 71 – 76

[10] Mangset, W.E., Solomon, A.O., Christopher, D.L., Ike, E.E. Onoja, R.A. and Mallam, S.P. (2015). Gross alpha and beta activity concentrations in surface water supplies from mining areas of Plateau State, Nigeria and estimation of infants and adults annual committed effective dose. *Physical Science international Journal,* 5(4): 241 – 254

[11] Akubugwo, I.E., Ofoegbu, C.J., Ukwuoma, C.U. (2007). Physicochemical studies on Uburu salt lake, Ebonyi State, Nigeria. *Pakistan Journal of Biological Sciences,* 10 (18): 3170 – 3174

[12] Akubugwo, I.E. and Agbafor, K.N. (2007). Hepatotoxic evaluation of water and salt from Okposi and Uburu salt lakes, Nigeria. *Estud.Biol.,* 29: 99 – 104

[13] Department of Food Safety Pharmaceutical & Food Safety Bureau, Ministry of Health, Labour and Welfare (2011). New Standard limits for Radionuclides in Foods. Retrived on 17/08/2016 from www.mhlw.go.jp/english/topics/2011

[14] Okoyeh, E.I., Akpan, A.E., Egboka, B.C.E., Okolo, M.C. and Okeke, H.C. (2015). Geophysical delineation of subsurface fracture associated with Okposi – Uburu salt lake Southeastern Nigeria. *International Research Journal of Environmental Sciences,* 4 (2): 1 – 6

[15] ORTEC MPC 2000 Gross Alpha/Beta Counter. Retived from www.ortec-online.com on 02/08/2016.

[16] Siak K. L, Husin W, and Ahmed T .R. (2014). A survey of gross alpha and gross beta activity in soil samples in Kinta District Perak, Malaysia. *Radiation Protection Dosimetry,* 162 (3): 345 – 350