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 familiar iodized sachet salt samples commonly consumed at Ohaozara Local Government Area and possibly 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 $Bq\ g^{-1}$ and 0.2393 to 12.12 $Bq\ g^{-1}$ with mean values of 0.0063 $\pm$ 0.150 $Bq\ g^{-1}$ and 1.763 $\pm$ 0.150 $Bq\ g^{-1}$ respectively; for Uburu salt between 0.0058 to 0.0068 $Bq\ g^{-1}$ and 0.2204 to 63.46 $Bq\ g^{-1}$ with mean values of 0.0061 $\pm$ 0.24 $Bq\ g^{-1}$ and 23.564 $\pm$ 0.24 $Bq\ g^{-1}$ respectively; while the iodized sachet salt ranged from 0.0055 to 0.0067 $Bq\ g^{-1}$ and 2.136 to 25.92 $Bq\ g^{-1}$ with mean values of 0.0059 $\pm$ 0.170 $Bq\ g^{-1}$ and 7.217 $\pm$ 0.170 $Bq\ g^{-1}$ 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 total gross alpha and beta activity concentration for the three brands showed the trend that Uburu salt > iodized sachet salt **>** Okposi Okwu salt. These are indications that there are more beta emitting radionuclides in Uburu salt than Okposi salt. Generally, it is suggested that as a means of radiological protection, normal salt 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 rock 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. Table salts used in Nigeria may contain high concentrations of natural radionuclides as a result of contamination due to geophysical and geochemical characteristics of the sources. The knowledge of radionuclide activity concentrations in table salt is desirable and very important so as to be informed of the potential radiological risk associated with the ingestion 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 [3]

Several researches on gross alpha and beta activity concentrations have been conducted and reported. Kansaana *et al.,* 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 [4]. Jibiri and Fasae 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 [5]. Significant alpha and beta activity concentrations were established in the kidney and lung of experimental goat purchased from Turaku area in Minna Niger State [6]. Mangset *et al.* in their study

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 [7]. The presence of metallic and non – metallic ions have been reported in Uburu salt lake of Ebonyi State [8]. Also, hepatotoxicity of the Okposi and Uburu salt lakes has been demonstrated in [9].
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 investigated to allay the fears of possible intrusion of radionuclides from natural sources into the salt deposits. This work was therefore considered relevant in order to address the aforementioned problem.

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 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 led to Ebonyi State is been referred to as the Salt of the Nigerian Nation. 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 [10]. 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 [11]. Small – scaled salt production among elderly women and large scaled farming activities have been identified as the major occupation 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 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). Pictures of Okposi Okwu and Uburu salt lakes are presented in Figures 1 and 2 respectively.

Figure1: Okposi Okwu salt lake in Ohaozara LGA

Figure 2: Uburu salt lake in Ohaozara LGA

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 were about 10 tons of pressure was exerted on it to produce a pellet. The weight of the pellet taken was not less than 0.4 g and finally all the thirty (30) prepared pellets were taken for 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 available in Centre for Energy Research and Training (CERT), Ahmadu Bello University (ABU) Zaria, Nigeria was used for the gross alpha and beta measurements. 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. The detector efficiencies of 87.95% and 42.06% were employed for alpha and beta efficiencies respectively. The detector backgrounds, prior to gross alpha and beta counting were 0.13cpm for alpha and 78.49 cpm for beta while the detection limits were 0.156 cpm and 1.473cpm for gross alpha and beta respectively. The sample efficiency and, the alpha and beta activity concentrations in Bqg^{-1} in all the samples were determined using equations (1) and (2).

$$\text{Sample efficiency } (S_E) = \frac{W_{B+S} - W_E}{0.077} \times 100 \quad (1)$$

Where W_{B+S} is the weight of the planchet plus sample after evaporation, W_B is the weight of the empty planchet and 0.077 is the expected mass of the residue in the planchet.

$$\text{The alpha/beta activity} = \frac{count\ rate(alpha/beta) - background\ count(alpha/beta)}{S_E \times detector\ efficiency \times volume \times 60} \quad (2)$$

3. RESULTS AND DISCUSSION

Results

The results of the gross alpha and beta activity concentrations (Bqg^{-1}) in Okposi Okwu salt, Uburu salt and the sachet iodized salt were presented in Tables 1, 2 and 3 respectively. Figure 3 presented the distribution of the mean gross alpha and beta activity concentrations in the three brands of salt. While Figures 4, 5 and 6 showed the correlation of gross alpha and beta activity concentration in Okposi Okwu, Uburu and iodized sachet salt respectively.

Table 1: Gross alpha and beta activity concentration in Okposi Okwu locally processed salt

OKPOSI OKWU SAMPLES	ALPHA ACTIVITY (BQG^{-1})	BETA ACTIVITY (BQG^{-1})	ERROR±	TOTAL ALPHA AND BETA ACTIVITY (BQG^{-1})
OKP SALT 01	0.0062	4.032 E-01	1.58 E-01	0.409
OKP SALT 02	0.0082	1.212 E+01	2.57 E-01	12.128
OKP SALT 03	0.0059	6.922 E-01	1.26 E-01	0.698
OKP SALT 04	0.0059	2.393 E-01	1.23 E-01	0.245
OKP SALT 05	0.0060	6.273 E-01	1.29 E-01	0.633
OKP SALT 06	0.0063	1.413 E+00	1.37 E-01	1.419
OKP SALT 07	0.0058	4.298 E-01	1.23 E-01	0.436
OKP SALT 08	0.0059	4.936 E-01	1.24 E-01	0.499
OKP SALT 09	0.0066	5.056 E-01	1.39 E-01	0.512
OKP SALT 10	0.0057	7.025 E-01	1.83 E-01	0.708
MEAN	0.0063	1.763	1.50 E-01	1.769

Table 2: Gross alpha and beta activity concentration in Uburu locally processed salt

UBURU SAMPLES	ALPHA ACTIVITY (BQG^{-1})	BETA ACTIVITY (BQG^{-1})	ERROR±	TOTAL ALPHA AND BETA ACTIVITY (BQG^{-1})
UBU SALT 01	0.0058	5.849 E+00	1.69 E-01	5.855
UBU SALT 02	0.0060	4.098 E-01	1.53 E-01	0.416
UBU SALT 03	0.0059	3.586 E-01	2.85 E-01	0.365
UBU SALT 04	0.0058	4.504 E-01	1.36 E-01	0.456
UBU SALT 05	0.0059	2.451 E-01	1.49 E-01	0.251
UBU SALT 06	0.0059	4.442 E+01	3.11 E-01	44.48
UBU SALT 07	0.0068	2.204 E-01	1.59 E-01	0.227
UBU SALT 08	0.0068	5.452 E+01	3.66 E-01	54.59
UBU SALT 09	0.0059	3.022 E+01	2.67 E-01	30.28
UBU SALT 10	0.0060	6.346 E+01	3.66 E-01	63.52
MEAN	0.0061	23.564	0.24 E-01	23.570

Table 3: The gross alpha and beta activity concentration in iodized sachet salt

OKPOSI OKWU SAMPLES	ALPHA ACTIVITY (BQG^{-1})	BETA ACTIVITY (BQG^{-1})	ERROR±	TOTAL ALPHA AND BETA ACTIVITY (BQG^{-1})
SACH SALT 01	0.0057	2.136 E+00	1.38 E-01	2.142
SACH SALT 02	0.0067	6.083 E+00	1.78 E-01	6.089
SACH SALT 03	0.0064	5.655 E+00	1.69 E-01	5.661
SACH SALT 04	0.0060	3.499 E+00	1.52 E-01	3.505
SACH SALT 05	0.0061	2.592 E+01	2.61 E-01	25.926
SACH SALT 06	0.0055	2.383 E+00	1.37 E-01	2.389
SACH SALT 07	0.0055	2.161 E+00	1.41 E-01	2.167
SACH SALT 08	0.0056	4.087 E+00	1.54 E-01	4.092
SACH SALT 09	0.0058	1.723 E+01	2.19 E-01	17.236
SACH SALT 10	0.0058	3.018 E+00	1.46 E-01	3.024
MEAN	0.0059	7.217	0.170	7.223

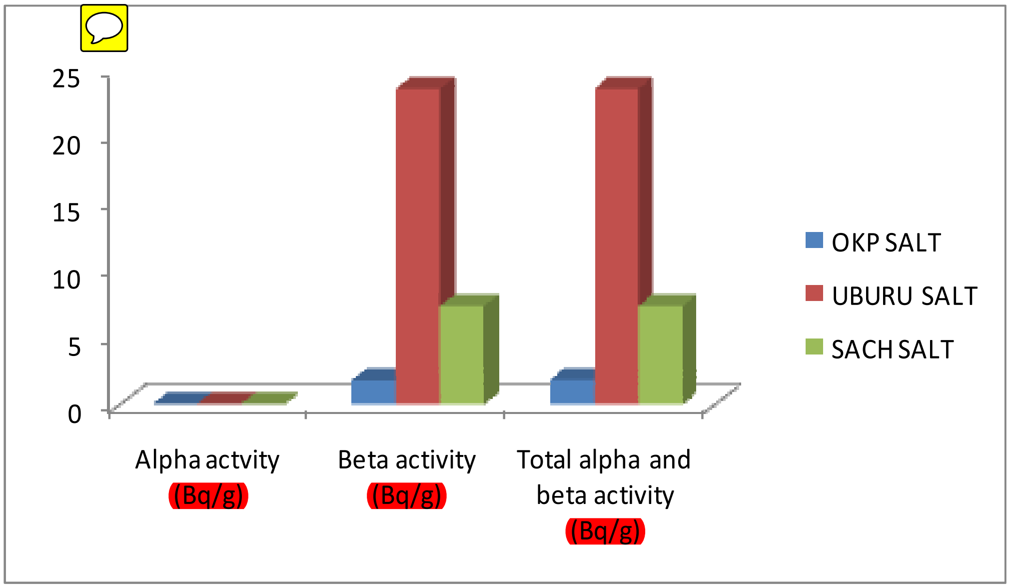

Figure 3: Distribution of the mean gross alpha and beta activity concentrations in the three brands of salt

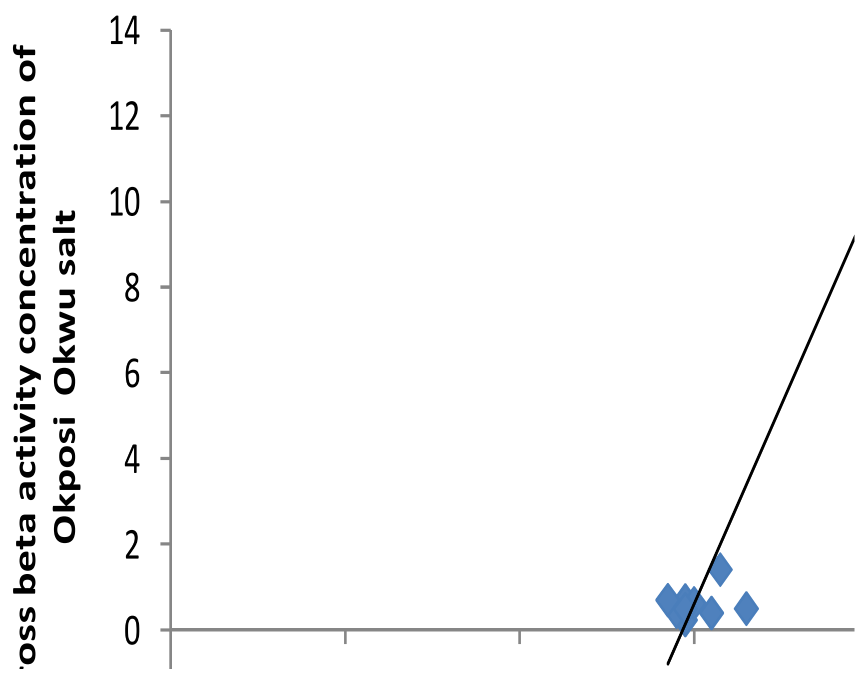

Figure 4: Correlation of gross alpha and beta activity concentration in Okposi Okwu salt

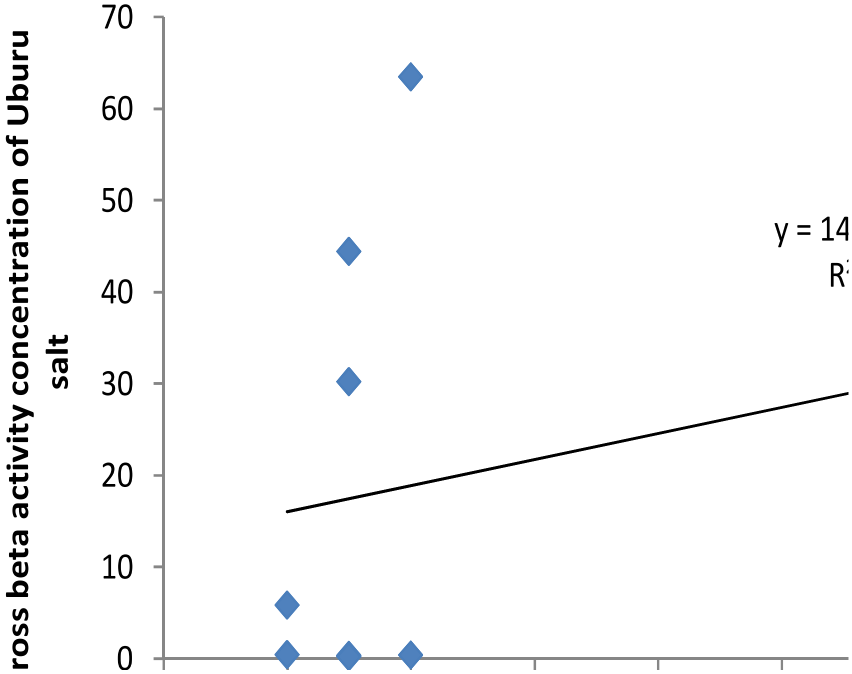

Figure 5: Correlation of gross alpha and beta activity concentration in Uburu salt

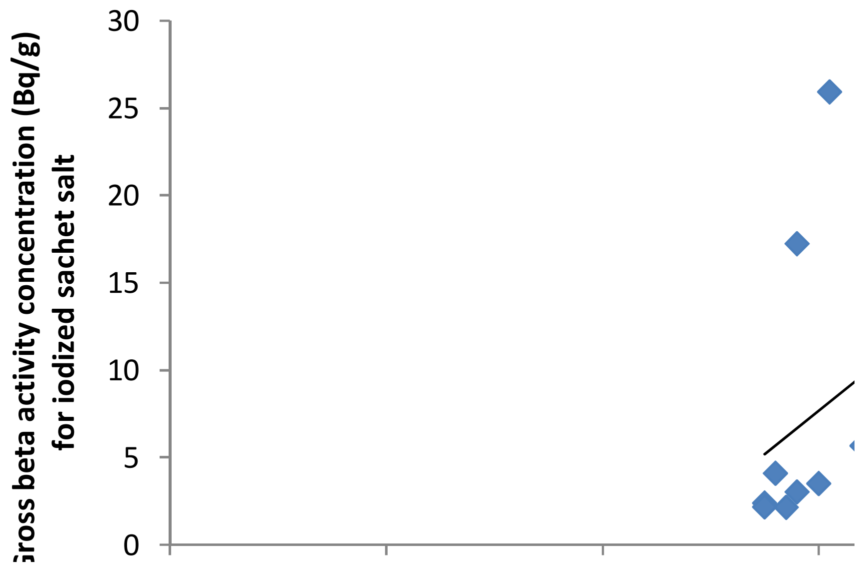

Figure 6: Correlation of gross alpha and beta activity concentration in iodized sachet salt

Okposi Okwu salt

Table 1 shows that the gross alpha activity of locally made salt in Okposi Okwu ranged from 0.0057 to 0.0082 $Bq\ g^{-1}$ with a mean of 0.0063$\pm$0.150$Bq\ g^{-1}$ which indicated that 30% of the results were higher than the mean value while 70% were lower. While for gross beta activity concentrations, it ranged from 0.2393 to 12.12 $Bq\ g^{-1}$ with a mean of 1.763$\pm$0.150$Bq\ g^{-1}$ showing that 10% of the results were higher than the mean value while 90% were found to be lower than the mean value. Gross beta activity concentration was about 282 times higher than the gross alpha activity concentrations.

Uburu salt

Table 2 showed that the gross alpha activity concentration of Uburu locally made salt ranged from 0.0058 to 0.0068 $Bq\ g^{-1}$ with a mean of 0.0061$\pm$0.24$Bq\ g^{-1}$ which revealed that 20% of the gross alpha activity were higher than the mean value of 0.0061$Bq\ g^{-1}$ while 80% were lower. Furthermore, gross beta activity concentration of Uburu salt ranged from 0.2204 to 63.46$Bq\ g^{-1}$ with a mean of 23.564$\pm$0.24$Bq\ g^{-1}$ showing that 50% of the results were higher than the mean value while 50% are lower than the mean value. It was established that gross beta activity of the Uburu locally made salt was about 3876 times higher than the gross alpha activity.

Iodized Sachet Salt

It is observed from Table 3 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$\pm$0.170$Bq\ g^{-1}$. It reveals that 40% of the gross alpha activity concentration results are higher than the mean value of 0.0059$Bq\ g^{-1}$ while 60% are lower. The gross beta activity concentration ranged from 2.136 to 25.92$Bq\ g^{-1}$ with a mean of 7.217$\pm$0.170 $Bq\ g^{-1}$ with 20% of the results higher than the mean value and 80% lower than the mean value. The gross beta activity in the locally made salt is about 1223 times higher than the gross alpha activity concentration.

Correlation of Gross Alpha and Beta Activity Concentration in the three Brands of Salt

Correlation studies were carried out between alpha and beta activity concentration in the three brands of salt in order to find out if the same radionuclides were responsible for alpha and beta activity concentrations in the salt samples. Observation from Figures 4, 5 and 6 respectively displayed the regression and the scatter plots for alpha and beta activities in Okposi salt, alpha and beta activities in Uburu salt and alpha and beta activities in iodized sachet salt respectively.

Discussion

It was observed from Tables 1, 2, 3 and Figure 3 that the mean values of gross alpha activity concentration for the three brands were very close which confirm that the sources may possibly contain homogeneous alpha emitting natural radionuclides. Error due to measuring instrument and manufacturing processes of the salts may also be contributing factors. For all the three brands of salt, the mean gross beta activity concentrations were exceptionally higher than the gross alpha activity concentrations which suggest that there are more beta emitting radionuclides than alpha emitters. 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. The pH conditions are strongly related to surface and ground water chemistry, bedrock geochemistry and in particular availability of chlorine and carboxyl ion. Some other geophysical and geochemical characteristics controlled by the bedrock geology may be responsible for higher beta activity concentration than the alpha activity in the locally processed salt. Correspondingly, higher mean gross beta activity than alpha activity was recorded in Bq kg^{-1} in NPK fertilizers used in Nigeria [5]; and in soil samples from different locations of Beamer and Shard, Bangladesh [3]. However, the trend was a direct opposite of soil samples in Kinta district, Perak, Malaysia where the gross alpha activity were found to be higher than the gross beta activity concentrations [12]. According to decreasing order from left to right, The trend of gross alpha activity concentration of the three brands in this study records that Okposi Okwu salt > Uburu salt > industrial sachet salt while that of gross beta activity records showed that Uburu salt > industrial sachet salt **>** Okposi Okwu salt. The sum of gross alpha and beta activity for the three brands follows the trend for gross beta activity concentration of the present study.
There was very strong positive correlation between alpha and beta activities in Okposi salt as shown in Figure 4 with R^2 value of 0.876 which is an indication that both gross alpha and beta activities are from the natural radionuclides of decay chain of ^{238}U and ^{232}Th. This trend between alpha and beta activities was similarly reported in [12], with R^2 = 0.84. While in Uburu salt and iodized sachet salt

respectively, it was evident from Figures 5 and 6 that weak positive correlation (R^2 = 0.045) and (R^2= 0.061) existed between alpha and beta activities. Most research studies on gross alpha and beta activity concentrations have been on surface and ground water from different environments, fertilizer, farm soils, and food substances. Therefore, the present research on rock salt appears novel. It is suggested that normal salt for cooking should be screened for radionuclide before consumption. There is also need to review the labeling policy in Nigeria by including the radionuclide concentrations of salt consumed in sachet and bags.

4. CONCLUSION

Gross alpha and beta activity concentrations were determined in three brands of salt consumed in Ohaozara LGA and possibly 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 in good agreement which were exceptionally lower than the beta activity results for the three 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 are more beta emitting radionuclides in Uburu salt and iodized sachet salt than Okposi salt. The trend of total gross alpha and beta activity concentration for the three brands revealed that Uburu salt > iodized sachet salt **>** Okposi Okwu salt. Weak positive correlation existed between alpha and beta activity in Uburu salt (R^2 = 0.044) and iodized sachet salt (R^2 = 0.061) while very strong positive correlation (R^2 = 0.876) between alpha and beta activity concentration in Okposi Okwu salt was observed. Likely alpha emitters such as ^{238}U, ^{226}Ra and ^{210}Po and beta emitters such as ^{40}K, ^{228}Ra and ^{210}Pb may be responsible for the gross alpha and beta activities in the locally processed salt samples. There is no regulation for safety limit values 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 database for future references and 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. Generally, it is suggested that normal salt should be screened for radionuclide before consumption.

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