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Studies on the Mineral Contents of the Pod of *Abelmoschus Esculentus* Harvested from Some Parts of Rivers State, Nigeria

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Abstract: *Soil and the pods of Abelmoschus esculentus (okra vegetable) samples were collected from selected locations in Oyibo, Etche and Eleme Local Government Areas of Rivers State, and analyzed for their mineral contents using atomic absorption spectrometry, except for chlorine, iodine and phosphorus. Phosphorus was determined by a modified complexometric titration, while the classical Argentometry afforded chlorine and iodine in a potentiometric titration using silver nitrate as titrant. The results of detectable concentrations (mg/kg) in the soil for Oyibo, Etche and Eleme respectively were: 3.7183±0.1172, 2.4269±02431, 3.8727±0.1563 for Ca; 5.1164±1.2134, 3.1672±0.2241, 2.9728±0.0215 for Mg; 39.1032±6.3132, 36.2389±6.2321, 34.8401±5.4123 for P; 14.7284±3.4789,18.5169±3.5124, 21.6942±4.4813 for Zn; 4.8136±1.2234, 3.8143±0.4650, 2.6018±0.2445 for K; 3.1172±0.3541, 6.5132±2.5541, 10.8246±2.4131 for Na; 6.3891±3.0215, 8.6012±3.1200, 12.0147±3.0599 for Mn; 39.7060±3.2341, 73.1561±9.3142, 97.6262±23.2351 for Cl; 0.0072±0.0011, 0.0114±0.0022, 0.0242±0.0012 for I and 118.4849±28.9215, 129.4173±31.3110, 141.6181±32.2441 for Fe, while in the okra vegetable, the values were: 2.8494±0.2012, 1.5328±0.3110,3.0069±0.1120forCa;3.6671±0.3412, 2.1647±0.3412, 2.3780±0.2142 for Mg; 24.7039±9.4341, 20.8456±6.3342, 16.8270±4.4315 for P; 12.8162 ±0.3412, 9.1816±2.2145, 15.7184±3.1554 for Zn; 2.0391±0.2131, 1.8613±0.3412,1.9027±0.5012 for K; 1.7148±0.6541, 2.6932±0.5412, 3.1359±0.6641 for Na; 3.6932±1.3101, 4.9716±0.9541, 6.2046±2.201 for Mn; 32.6104±9.0001, 62.1418±21.0012, 40.1874±9.2110 for Cl; 0.0001±0.0000, 0.0014±0.0000,0.0031±0.0001 for I and 58.7169±10.9102,69.0632±25.7001, 81.7189±19.8641 for Fe. One way Analysis of variance in the concentrations of the elements in both the soil and the vegetable showed no significant variations (p>0.050). There were however, significant pairs of association with Pearson's Correlation matrices suggesting substantial anthropogenic inputs from the soil to the vegetable. Of all the mineral elements determined, only magnesium and zinc call for caution, judging from the permissible limits prescribed by FAO/WHO.*

Keywords: *studies, mineral contents, soil, pod, Abelmoschus esculentus, Rivers State, Nigeria*

1. Introduction

Okra vegetable (*Abelmoschus esculentus*) initially belonged to the genus, *Hibiscus* (Aladele, Ariyo, & Lapena, 2008), but was later labeled *Abelmoschus,* which is distinguished from the genus *Hibiscus* (Aladele et al., 2008). A proposal was subsequently made to raise *Abelmoschus* to the rank of distinct genus by Medikus in 1787 (Benchasri, 2012). Okra is a multi-purpose crop due to its various uses of the fresh leaves, buds, flowers, pods, stems and seeds(Habtamu *et al.*, 2014). It ranks one of the top-most in India in terms of its consumption but its original home is Ethiopia and Sudan, the north-eastern African countries (Kumar *et al*., 2013).

It is a semi-woody, fibrous, herbaceous annual vegetable with an indeterminate growth habit; it grows to a height of 3 to 6 ft (0.9 to 1.8 m). The plant is known to form a deeply penetrating taproot with dense, shallow feeder roots in the upper 18 inches (46 cm) of the soil with large, alternate, palmate leaves with small stipules (Lamont and Wall, 1999).

Okra, also known as "lady's fingers"and is one of the vegetable crops grown in Southwestern Nigeria (Okoh *et al*., 2018). In Nigeria, fresh okra vegetable is preferred to dry Okra by the majority of people and as such, consumption is highest in the raining season when production is highest (Jain *et al*., 2012). In 2016, the world production of okra was estimated at 8.9 million tons, Nigeria producing 1.98 million tons as the largest African producer and second largest producer in the world, next to India which produced 5.51 million tons in 2016 (Okoh *et al*., 2018).

Abelmoschus esculentus is a commercial vegetable crop and economically very important, rich in mineral elements. Habtamu *et al* (2014) in their study reported the presence of elements such as potassium, sodium, magnesium and calcium as principal components of the pod as well as iron, zinc, manganese and nickel in the seed. Minerals are inorganic substances, present in all body tissues and fluids and their presence is necessary for the maintenance of certain physicochemical processes which are essential to life. The importance of mineral elements in human, animal and plant nutrition has been well recognized (Underwood, 1971; Darby, 1976). Deficiencies or disturbances in the nutrition of an animal cause a variety of diseases and can arise in several ways (Gordon, 1977).

The study therefore focused on the analysis of the pod of *Abelmoschus esculentus* (okra vegetable) for mineral elements which included:calcium, magnesium, phosphorus, zinc, potassium, sodium, manganese, chlorine, iodine and iron. More so, because the plant, just like any other, mainly gets its nutrients from the soil on which it is grown, soil samples were also collected from the sample locations and analyzed for the elements in order to correlate the contents of the two matrices.

2. Materials and Methods

2.1. Studied Areas

Three study areas in Rivers State, labeled A, B and C which represented Umuebele in Oyibo Local Government Area, Chokocho in Etche Local Government Area and Alesa in Eleme Local Government Area were respectively chosen for the study. In these areas, there are less or no industrial activities but may be affected by exploration and exploitation activities of companies prospecting for oil. Eleme in particular, however hosts the Indorama Petrochemicals Industry Limited that produces petrochemicals for polymer industries as well as fertilizers for agricultural activities. The Port Harcourt Refinery Company (PHRC), which is also a hub of oil activities, is located in Eleme. It is also pertinent to note that the studied areas are fast developing with increasing population of people moving to settle there, with large expanse of land available for farming. Consequently, the inhabitants are gradually moving from subsistence farming to large scale farming.

2.2. Samples Collection

Soil Samples

Soil samples were collected monthly for four months between March and June, 2019 at four to six (4-6) points, and 15-20 *m* apart (depending on the availability of the plant) by means of a stainless steel hand auger. It has been reported that the degree of mixing in soils is usually very high at a depth of 10 or 15 *cm* in an industrial activity prone area. For this reason, considering increasing activities following increasing population also, soil from a depth of 15 cm often used for assessments of health and ecological risk factors was adopted (Luo *et. al*., 2012).

About 50 g of soil were taken from each particular sub-site where the plants were growing, and then mixed together in a single clean plastic bag to obtain one bulk sample (composite). The samples were placed in clean polyethylene plastic bags and taken to the lab for further pre-treatment. After sun drying, the soil samples were pounded into a fine powder in a porcelain mortar and pestle and then sieved through a 500 µm mesh sieve. The powdered sample was stored in a pre-cleaned screw capped polyethylene container until digestion was carried out for the elemental analysis, except for phosphorus, chlorine and iodine.

2.3. *Abelmoschus esculentus* (okra vegetable) pod Samples

The crops were harvested at the peak of the harvest period between the months of April and June, from farms. The peak of the harvest period was chosen when farm crops were generally in their bloom, with the assumption that metal concentration in plants varies with the age of the plant as well as the season (Mogo, 2002). The crops were randomly harvested from two or three farms within each location by mutual understanding with the farm owners. Samples of each crop were collected and placed in polythene bags for onward transportation to the laboratory for storage and analysis (Marcus and Jack, 2016).

2.4. Sample Preparation and Analysis

Soil samples were oven-dried at 60^{0}C for 3 days, pulverized and sieved through 1 *mm* mesh screen to remove coarse materials. The *Abelmoschus esculentus* (okra vegetable) samples were properly rinsed with tap water and then with distilled water to remove any attached soil particles. They were then cut into smaller portions, the pods isolated and placed in large clean crucibles and air-driedat room temperature in enclosed chamber for about two weeks. They were then pulverized to fine powder using a stainless grinder. The powdered vegetable samples were then labeled in polythene bags and placed in a desiccator awaiting laboratory analysis (Marcus and Jack, 2016). 2 *g* each of soil and okra samples were digested using 50 *ml* 1:3:1 mixture of HCIO4, HNO3 and H2SO4 acids in a water bath. The solutions were filtered using Whatmann No.1 filter paper into other 50 *ml* volumetric flasks and made up to mark with deionized water (Umoren and Onianwa, 2005). The samples were aspirated in AAS (model 6650) to determine the concentrations of Cu, Mg, Zn, K, Na, Mn and Fe.

For Cl and I contents, the method of classical Argentometry was used. The samples were burned in an Erlenmeyer flask saturated with oxygen. The gaseous products of the combustion were in the process absorbed into a working solution of hydrogen peroxide which was subsequently transferred to a titration flask. The chlorine and iodine contents were then determined by potentiometric titration using silver nitrate as titrant. Phosphorus followed a similar procedure, but in its case, the combustion product was mineralized to determine the phosphorus content by a modified complexometric titration.

2.5. Statistical Analysis

Data were statistically analyzed on the platform of *SPSS* v 20.0 (*SPSS* Inc.) for analysis of variance (ANOVA) according to the method of Wahua (1999). Pearson correlation (2-tailed) analysis to test the relationship between the levels of the metals in the soil and okra vegetable was also conducted at □□= *0.01* and *0.05* confidence limits.

3. RESULTS AND DISCUSSION

Results of the analyses of soil and *Abelmoschus esculentus* (okra vegetable) for mineral elements at Oyigbo, Etche and Eleme are discussed as follows;

3.1. Results of the Analysis of Mineral Elements in the Soil

Mineral elements in the soil: calcium, magnesium, phosphorus, zinc, potassium, sodium, manganese, chlorine, iodine and iron were determined in the soils of selected communities in Oyigbo, Etche and Eleme Local Government Areas and the mean concentrations (mg/kg) reported in table 1. Calcium was found to be highest at Eleme town with a mean value of 3.8727±0.1563, while the least 2.4269±0.2431 was obtained at Etche. Magnesium on the other hand, had its highest concentration at Oyigbo as 5.1164±1.2134 and the least, 2.7928±0.0215 at Eleme.

Phosphorus followed the same trend as magnesium by recording the highest concentration, 39.1032±6.3123 at Oyigbo and the least 34.8401±5.4123 at Eleme. Zinc however, recorded 21.6942±4.4813 as the highest concentration at Eleme, and 14.7284±4.4789 at Oyigbo as the least. Potassium on the other hand, gave 4.8136±1.2234 at Oyigbo as the highest, while the least was found at Eleme as 2.608±0.2445. Sodium had it highest concentration, 6.5132±0.5541 at Eleme and least at Oyigbo with 3.1172 ± 0.3451 as its value.

Manganese showed a similar trend as sodium with the highest at Eleme 12.0147±3.0539 as the highest concentration and 6.3891±3.0215 as the least at Oyigbo. Similarly, chlorine was highest at Eleme with a concentration of 91.6261±23.2351 at Eleme and 39.7060±3.2341 at Oyigbo. The trend was replicated with Iodine and Iron. Iron in particular had a concentration of 141.6181±32.2441 at Eleme and 118.4849±28.9215 at Oyigbo. On the whole, Iodine had the least concentration at the three locations with the highest as 0.0242±0.0012 at Eleme.

Table1. *Mean Concentrations (mg/kg) of Mineral Elements in the Soils of Oyigbo, Etche and Eleme*

Mineral Elements	Oyigbo	Etche	Eleme	WHO/FAO Limits
Calcium	3.718±0.1172	2.4269±0.2431	3.8727±0.1563	60.00
Magnesium	5.1164±1.2134	3.1672±0.2241	2.9728±0.0215	-

Phosphorus	39.1032±6.3123	36.2389±6.2321	34.8401±5.4123	-
Zinc	14.7284±3.4789	18.5169±3.5124	21.6942±4.4813	38.60
Potassium	4.8136±1.2234	3.8143±0.5640	2.6018±0.2445	32.50
Sodium	3.1172±0.3451	6.5132±2.5541	10.8246±2.4131	-
Manganese	6.3891±3.0215	8.6012±3.1200	12.0147±3.0559	31.9
Chlorine	39.7060±3.2341	73.156±9.3142	91.6261±23.2351	-
Iodine	0.0072±0.0011	0.114±0.0022	0.0242±0.0012	10.00
Iron	118.4849±28.9215	129.417±31.3110	141.6181±32.2441	148.00

The soil is a major source of nutrients needed by plants for growth. Plants need them in small quantities but the roles they play seem to be complex (Sparks, 2003). Mineral elements in soil have been reported in Nigeria and outside Nigeria (Njinga *et al*., 2013; Mekassa and Chand-ravanish, 2015). The concentrations obtained in the present study are far less than those of Njinga *et al* (2013) who analysed for essential elements in the Guinea savanna region of Niger state, Nigeria, but comparable with those of Mekassa and Chanravamsh (2015) in their study on the levels of selected essential and non-essential metals in seeds of *Korarima* (*aframomumconorima*) cultivated in Ethiopia

Parikh and James (2012) had also posited that the bulk of soil solid fraction is constituted by soil minerals, which exert significant direct and indirect influences on the supply and availability of most nutrient elements following the process of the release and fixation of nutrient elements in the soil. They further contended that the process may include dissolution, precipitation and adsorption-desorption.

It is believed that the physical, chemical and biological weathering of primary mineral releases a number of nutrient elements into the soil solution. The nutrient supply capacity of a soil through weathering of mineral diminishes as the extent of soil weathering increases (Havlin *et al*., 2005). Thus, these conditions may have influenced the availability of Ca, Mg, P, Na, Mn and Iodine at the three studied sites in Rivers State due to seismic operations and other environmental consequences such as ecological disturbances.

Analysis of variance conducted on the concentrations of the soil mineral elements revealed that there were no significant variations ($p>0.05$) at the three sites, and the pattern of their distribution with respect to the sites depicted by their mean plots (Figures 1a-j).

The distribution of the elements in the soils of the three sample locations are however shown by figures 1a-j

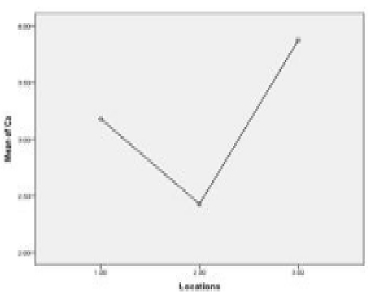

Figure 1a Mean Plot of Calcium in Soils of the three Locations : 1 2 3 represent Oyigbo, Etche and Eleme respectively

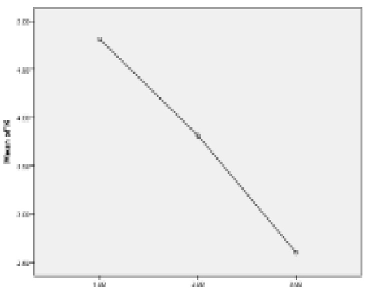

Figure 1e Mean Plot of Potassium in Soils of the three Locations : 1 2 3 represent Oyigbo, Etche and Eleme respectively

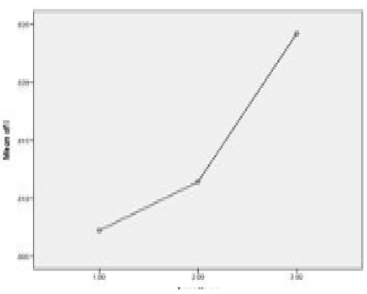

Figure 1e Mean Plot of Potassium in Soils of the three Locations : 1 2 3 represent Oyigbo, Etche and Eleme respectively

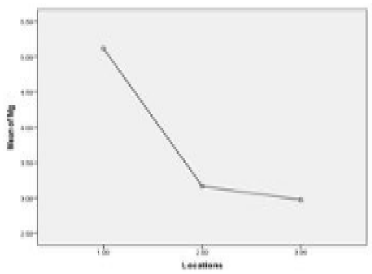

Figure 1b Mean Plot of Magnesium in Soils of the three Locations : 1 2 3 represent Oyigbo, Etche and Eleme respectively

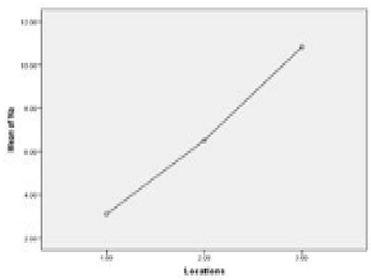

Figure 1f Mean Plot of Sodium in Soils of the three Locations : 1 2 3 represent Oyigbo, Etche and Eleme respectively

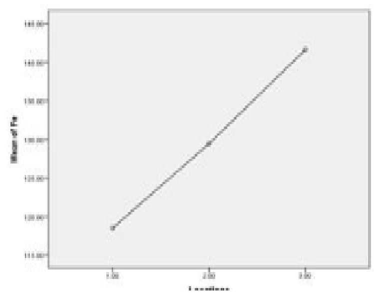

Figure 1j Mean Plot of Iron in Soils of the three Locations : 1 2 3 represent Oyigbo, Etche and Eleme respectively

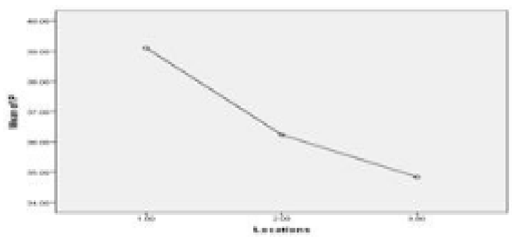

Figure 1c Mean Plot of Phosphorus in Soils of the three Locations : 1 2 3 represent Oyigbo, Etche and Eleme respectively

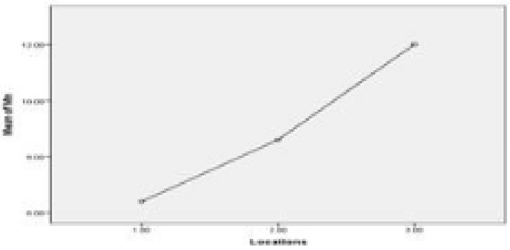

Figure 1g Mean Plot of Manganese in Soils of the three Locations : 1 2 3 represent Oyigbo, Etche and Eleme respectively

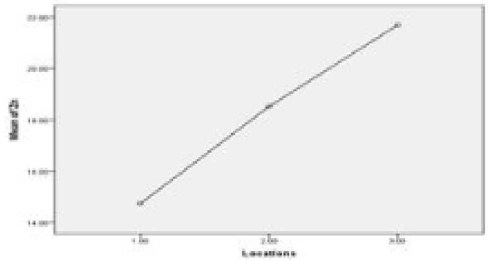

Figure 1d Mean Plot of Zinc in Soils of the three Locations : 1 2 3 represent Oyigbo, Etche and Eleme respectively

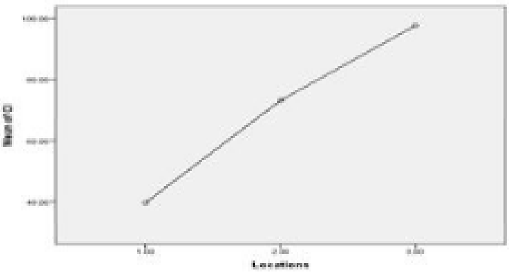

Figure 1h Mean Plot of Chlorine in Soils of the three Locations : 1 2 3 represent Oyigbo, Etche and Eleme respectively

3.2. Results of Analysis of Mineral Elements in *Abelmoschus esculentus* (okra vegetable)

The mean levels (*mg/kg*) of mineral elements in the Okra vegetable of Oyigbo, Etche and Eleme were also determined and are given in table 2.

Table2. Mean Concentrations (mg/kg) of Mineral Element in *Abelmoschus esculentus* (okra vegetable) of Oyigbo, Etche and Eleme

Mineral Elements	Oyigbo	Etche	Eleme	WHO/FAO Limits(1984)
Calcium	2.8494±0.2012	1.5328±0.3110	3.0069±0.1120	-
Magnesium	3.6671±0.3412	2.1647±0.3412	2.3780±0.2142	2.00-3.50
Phosphorus	24.7039±9.4341	20.8456±6.3342	16.8270±4.4315	-
Zinc	12.8162±0.3412	9.1816±2.2145	15.7184±3.1554	24.4-27.4
Potassium	2.0391±0.2131	1.8613±0.3412	1.9027±0.5012	-
Sodium	1.7148±0.6541	2.6932±0.5412	3.1359±0.6641	-
Manganese	3.6932±1.3101	4.9716±0.9541	6.2046±2.2010	1.63-2.30
Chlorine	32.6104±9.0001	62.1418±21.0012	40.1874±9.2110	-
Iodine	0.0001±0.0000	0.0014± 0.0000	0.0031±0.0001	-
Iron	58.7169±10.9102	69.0632±25.7001	81.7189±19.8641	18-20

Calcium recorded highest at Eleme with 3.0069±0.1120 as its concentration, while the least 1.532±0.3110 was found at Etche. The concentration of magnesium, 3.6671±0.3412 was highest at Oyibo and least 2.6647±0.3412 also at Etche. Phosphorus also recorded the highest mean, 24.7039±9.4341 at Oyigbo and 16.8270±4.4315 at Eleme as the least. Zinc on other hand was highest at Eleme with 15.7184±3.1554 as the mean value, while Etche was least with 9.1816±2.2145.

The concentrations potassium followed the pattern of Magnesium with a 2.0391±0.2131 as the highest at Oyigbo, while the least with a concentration of 1.8613±0.3412 was found at Etche. Eleme gave the highest for sodium whose concentration was 3.1359±0.6641 and the least value, 1.7148±0.6541 was recorded at Oyigbo. The trend was replicated with manganese with the highest (6.2046±2.2010) and lowest (3.6932±1.3101) at Eleme and Oyigbo respectively. For chlorine, the highest was 62.1418±21.0012 at Etche and 32.6104±9.0001 at Oyigbo as the least. Iodine was almost not detectable at the three studied sites. Iron was 19.7189±0.8641 as its highest value at Eleme, while the least, 58.7169±10.9102, was obtained at Oyigbo.

Minerals are considered to be essential in human nutrition as noted by Ibanga and Okon (2009) because they are needed for the overall mental and physical wellbeing, being important constituents of bones, teeth, muscles, blood and nerve cells. The mineral composition of Okra vegetable is shown in table 2 is discussed on the basis of their relevance to the consumer, using a separate on okra vegetable by Adetuya *et al* (2011)

Calcium is a major component of bone and can assist in teeth development, blood coagulation and maintenance of intercellular cement substances (Okaka and Okaka, 2001). The concentrations of calcium shown in table 2 varied at the three studied sites. These results are however higher than the calcium content of Okra reported to vary between 5.822mg/kg and 5.831mg/kg by Adetuya *et al* (2011).

Magnesium is required for extracellular fluid to help maintain osmotic balance. It is also a requirement for certain enzymatic reactions with regard to nucleotides (Nkuba and Mohammed, 2017). Its deficiency could result in abnormal irritability of muscle and convulsion, while depression of the central nervous system can also be an inevitable consequence if it is in excess. Phosphorus contents as shown in table 2 differ to large extent from those of Adetuya (2011) which varied between 6.005 and 6.217mg/kg. Phosphorus is essential for acid-base balance in every cell and is required for healthy bone and teeth development.

Zinc is also part of many enzymatic reactions including protein synthesis; it is essential for sperm production, normal growth and sexual maturity as well as healthy immune system (Jabeen, 2010; Mlitan *et al*., 2014). Zinc deficiency can result in hyperthyroidism and gum disease. It has also been reported to be beneficial in the treatment of viral infections, diabetes mellitus as well as those of HIV/AIDs and postrate gland enlargement (Kermnsha *et al*., 2014). The zinc content as observed by this study are far lower than those reported by Adetuya (2011) whose values varied between 0.383 and 0.63mg/kg.

Potassium has a diuretic nature (Arinanthan *et al*., 2003) that helps inproper brain and nerve function thereby preventing stroke. It plays a vital role in acid-base balance and osmotic regulation. Its deficiency diet can lower blood pressure (He and MacGregor, 2008). Conversely, high amount in the body has been reported to increase iron utilization (Elinge *et al*., 2012). The observed concentration of Potassium in the study are for lower than those of Adetuya (2011) whose values ranged from 12.259 to 31.820mg/kg

Sodium is needed for proper fluid balance, nerve transmission and muscle contraction. However, sodium concentrations as observed by this study are comparable with those of Adetuyi *et al* (2011) who reported values that varied between 3.330 and 8.310 mg/kg.The effects of sodium on plants are similar to those of exposure to drought. Increasing concentration of sodium in plants can amount to toxic levels that cause poor growth and arrested cell development. Although not essential for most plants, sodium (Na^+) can be beneficial to plants in many conditions, particularly when potassium (K^+) is deficient. As such, it can be regarded a ‘non-essential’ or ‘functional’ nutrient (Maathuis, 2013).

Manganese is a part of many enzymes and its widespread in foods especially plant foods. Manganese helps with photosynthesis and is also freely available in the North Coast’s acid soil, often in toxic amounts in very acidic soil. However, its toxicity can be remedied with time. The values of manganese are far less than those found in some medicinal plants by Nkuba and Mohammed (2017) who reported concentration in high on 58.81 to 84.08 mg/kg

Chlorine in form of chloride is needed for proper fluid balance and also plays a role in photolysis. Its deficiency can cause wilting, chlorosis and death of some leaves (Soetan *et al*., 2010). The concentrations of chloride ion is subject to variation than that of sodium because other anion especially in bicarbonate form in the system can exchange for chlorine. As a major negative ion in extracellular fluid, it has been found to play important role in the production of acid in the stomach.

Deficiency disease may occur in infants if salt free formula is more often used. In chloride-deficit diet, the excretion of chloride in urine or sweet is remarked reduced (Hays and Swenson, 1985; Murray *et al*., 2000). However, with the observed concentrations in this study, levels may be safe for the Okra crop, provided that proper irrigation management practices are applied.

Iodine was almost below detection limits as the concentration varied between 0.0000 and 0.00031mg/kg. Iodine is important in thyroid hormone that helps regulate growth development and metabolism. It is however not considered essential for land plant like Okra, but in some aquatic plant it plays critical role in antioxidant metabolism. The concentrations of iodine in the present study reveal that Iodine is non-bioavailable due probably to environmental pollution as opined by Muhammad *et al* (2018), which is notoriously consistent with the studied locations.

Iron as is well known, is an essential element for hemoglobin formation and proper functioning of the central nervous system as well as oxidation of carbohydrates, proteins and fats (Kermanshah *et al.*, 2014) ; Mlitan *et al*., 2014). The relatively higher concentrations of iron compared to other elements might be due coparticipation of green vegetable in the synthesis of ferrodoxin, a well-known factor for attributing green vegetables as useful sources of iron (*Hart et al.*, 2005). The values obtained in this study are far higher than those of Adetuyi *et al* (2011) who reported values that varied from 0.081 to 0.096 mg/kg for all the elements discussed.

Analysis of variance conducted on the concentrations of the mineral elements in *Abelmoschus esculentus* (okra vegetable) of the three studied sites revealed that there were also no significant variations ($p>0.05$) and the pattern of distribution of the elements with respect to the three sample locations are shown in figures 2a-j.

The pattern of distribution of the elements at the three sample locations are also shown by figures 2a-j

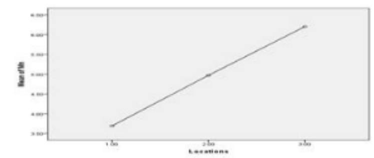

Figure 2a Mean Plot of Calcium in *Abelmoschus esculentus* (okra vegetable) at the three Locations : 1 2 3 represent Oyigbo, Etche and Eleme respectively

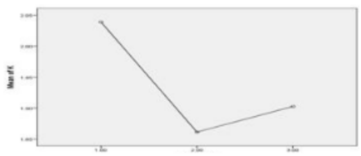

Figure 2e Mean Plot of Potassium in *Abelmoschus esculentus* (okra vegetable) at the three Locations : 1 2 3 represent Oyigbo, Etche and Eleme respectively

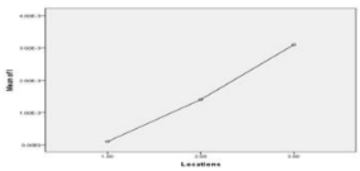

Figure 2i Mean Plot of Iodine in *Abelmoschus esculentus* (okra vegetable) at the three Locations : 1 2 3 represent Oyigbo, Etche and Eleme respectively

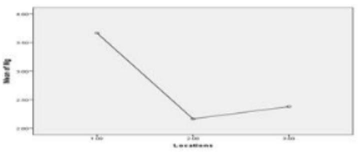

Figure 2b Mean Plot of Magnesium in *Abelmoschus esculentus* (okra vegetable) at the three Locations : 1 2 3 represent Oyigbo, Etche and Eleme respectively

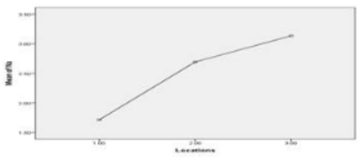

Figure 2f Mean Plot of Sodium in *Abelmoschus esculentus* (okra vegetable) at the three Locations : 1 2 3 represent Oyibo, Etche and Eleme respectively

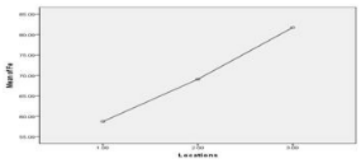

Figure 2j Mean Plot of Iron in *Abelmoschus esculentus* (okra vegetable) at the three Locations : 1 2 3 represent Oyigbo, Etche and Eleme respectively

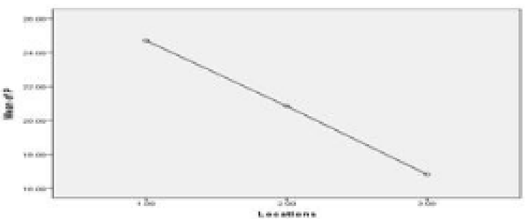

Figure 2c Mean Plot of Phosphorus in *Abelmoschus esculentus* (okra vegetable) at the three Locations : 1 2 3 represent Oyigbo, Etche and Eleme respectively

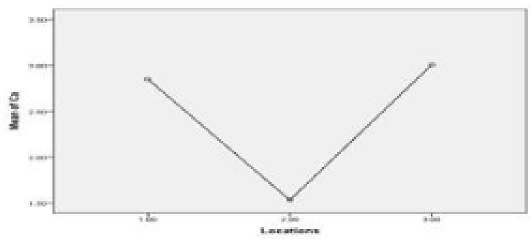

Figure 2g Mean Plot of Manganese in *Abelmoschus esculentus* (okra vegetable) at the three Locations : 1 2 3 represent Oyigbo, Etche and Eleme respectively

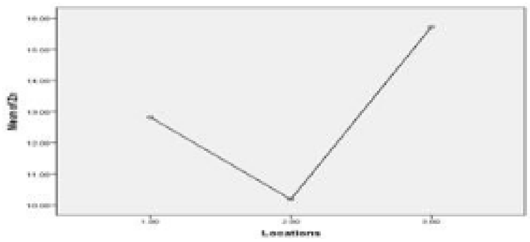

Figure 2d Mean Plot of Zinc in *Abelmoschus esculentus* (okra vegetable) at the three Locations : 1 2 3 represent Oyigbo, Etche and Eleme respectively

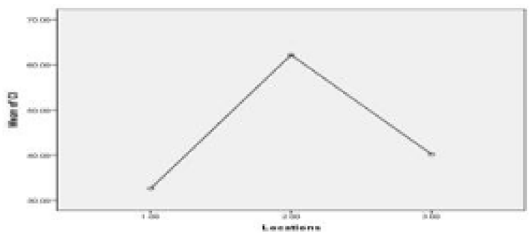

Figure 2h Mean Plot of Chlorine in *Abelmoschus esculentus* (okra vegetable) at the three Locations : 1 2 3 represent Oyigbo, Etche and Eleme respectively

The matrices of correlation coefficients /r/ are also given in table 3.

	V(Ca)	V(Cl)	V(I)	V(Fe)	V(Mg)	V(Mn)	V(P)	V(K)	V(Na)	V(Zn)	S(Ca)	S(Cl)	S(I)	S(Fe)	S(Mg)	S(Mn)	S(P)	S(K)	S(Na)	S(Z)
V(Ca)	1																			

V(Cl)	-.810**	1																		
V(I)	-.055	.272	1																	
V(Fe)	.302	.180	.115	1																
V(Mg)	.390	-.406	-.213	-.045	1															
V(Mn)	.334	-.002	-.011	.766**	-.159	1														
V(P)	-.442	-.040	-.066	-.968**	-.092	-.750**	1													
V(K)	-.134	-.363	-.378	-.587*	.024	-417	.613*	1												
V(Na)	-.216	.580*	.396	.709**	-.223	.533	-.602*	-.488	1											
V(Zn)	.874**	-.760**	-.405	.340	.214	.403	-.428	.099	-.262	1										
S(Ca)	.430	-.420	-.185	.080	.269	-.095	-.014	.294	-.250	567	1									
S(Cl)	.216	.275	.092	.991**	-.073	.742**	-.956**	-.618*	.712**	.272	.024	1								
S(I)	.202	-.018	-.032	.410	-.091	.420	-.404	.122	.200	.325	.024	.402	1							
S(Fe)	.332	.158	.087	.993**	-.074	.753**	-.971**	-.565	.680	.387	.079	.987**	.444	1						
S(Mg)	.267	-.691*	-.280	-.696*	.360	-.278	.575	.522	-.736**	.215	.059	-.736**	-.320	-691*	1					
S(Mn)	.409	.018	-.126	.925**	.078	.663*	-.924**	-.380	.477	.530	.244	.916**	.574	.938**	-.616*	1				
S(P)	-.163	-.024	.668*	-.542	-.025	-.353	.563	.096	-.139	-.477	-.119	-.579*	-.449	--.589*	.382	-.721**	1			
S(K)	-.373	.197	.052	-.698*	-.066	-.771**	.707*	.274	-.270	-.445	-.043	-676*	-.366	-.671*	.121	-.647*	.374	1		
S(Na)	.252	.149	-.039	.936**	-.108	.693	-.907**	-.439	.645*	.373	.030	.937**	.534	.949**	-.661	.905**	-.711**	-.697*	1	
S(Zn)	.158	.376	.274	.946**	-.153	.616*	-.901**	-.693*	.743**	.152	-.024	.963**	.396	.948**	-.827**	.842**	-.486	-.543	.902**	1

****. Correlation is significant at the 0.01 level (2-tailed).** **V. Okra vegetable (pod)**

***. Correlation is significant at the 0.05 level (2-tailed).** **S. Soil**

There were significant associations at *p<0.01* and *p<0.05*. As could be seen in table 3, Some of those that were significant at *p<0.05* were:V(Na)/V(Cl); S(Mg)/V(I); S(P)/V(I); S(K/V(Fe); S(Mn)/V(Mn), etc., while those that were at *p<0.01* were:V(Cl)/V(Ca); V(Zn)/V(Ca); V(Zn)/V(Cl); S(Cl)/V(Fe); S(Mn)/V(P), etc.

The association between pairs in the same matrix such as V(Na)/V(Cl) or S(Zn)/S(Fe) may imply that such elements have common source, while other between unlike matrices such as S(Mg)/V(I) or S(Mn)/V(P) could suggest that the soil as a repository of such nutrient mineral elements for plants grown on it may be their major source. This position is in good agreement with the opinion held by Marcus (2011) in his study on trace metals contents of Bonny River and creeks around Okrika, Rivers State, Nigeria and Marcus and Jack (2016) in a separate study on trace metals levels in *Telfeiria occidentalis* (Pumpkin Leaf) and soil of selected locations in Omoku town, Niger Delta.

All the positive correlation matrices between the soil and the okra vegetable could be ascribed to substantial anthropogenic input of the element from the soil. Negative correlations on the other hand could be due to high flushing and dilution rates in the rainy season during which some the samples were collected (Welcome, 1986; King and Nkanta, 1991).

4. CONCLUSION

The study focused on soil and pod of *Abelmoschus esculentus* (okra vegetable) collected from selected locations in Oyigbo, Etche and Eleme local Government Areas of Rivers state. The values obtained in the vegetable are however appreciable with the location in Eleme carrying higher concentrations than those of the others in most of the elements except for magnesium, phosphorus, potassium which were highest at Oyigbo on one hand, and chlorine at Etche on the other hand. There's however, need for caution with respect to calcium, zinc, potassium and manganese, except iron in the soils; but for the vegetable, only magnesium and zinc appear to portend a near dangerous trend, judging from the set standards compared with their levels.

Analysis of variance conducted on the data obtained from both the soil and the vegetable with respect to the three locations, revealed that there's were no significant variations ($p>0.05$). This may suggest that the activities that could be implicated for the presence of these metals at the three studied sites may be similar, judging from the fact that, Oyigbo, Etche and Eleme are not only all famous for farming, they are also exposed to activities of companies prospecting for oil in the oil-rich Niger Delta.

There were also both positive and negative correlations /r/ with significant associations at $p<0.05$ and $p<0.01$, suggesting substantial anthropogenic inputs of the elements from the soil to the vegetable.

REFERENCES

[1] Adetuyi F. O., Osagie A. U. &Adekunle A. T. (2011). Nutrient, Antinutrient, Mineral and Bioavailability of Okra Abelmoschus esculentus (L) Moench. American Journal of Food and Nutrition, 1, 49–54.

[2] Arinanthan V., Mohan V. R. &Britto A. J. (2003).Chemical Composition of Certain Tribal Pulses in South India.International Journal of Food Science and Nutrition, 3, 103–107.

[3] Elinge C. M., Muhammad A., Atiku F. A., Itodo A. U., Peni, I. J. &Sanni O. M. (2012). Proximate Mineral and Anti-Nutrient Composition of Pumpkin (Cucurbitapepo L) Seeds Extract. International Journal of Plant Resources, 2, 146–150.

[4] FAO/WHO. (1984). Contaminants. In Codex Alimentarius, Vol. XVII, Edition 1. Food and Agricultural Organization/World Health Organization Codex Alimentarius Commission, Rome.

[5] Ibanga, O. I. &Okon, D. E. (2009).Minerals and Antinutrients in Two Varieties of African Pear (Dacryodes edulis).Journal of Food Technology. 7, 106–110.

[6] Kermanshah A., Ziarati P., Asgarpanah J. &Qomi M. (2014).Food Values of Two Endemic Wild Almond Species from Iran.International Journal of Plant, Animal and Environmental Science, 4, 380–388.

[7] Jabeen, S., Shah, M. T., Khan, S. & Hayat, M. Q. (2010).Determination of Major and Trace Elements in Ten Important Folk Therapeutic Plants of Haripur Basin, Pakistan.Journal of Medicinal Plant Research, Lagos, 4 (7), 559-566.

[8] King, R.P & Nkanta, N.A. (1991).The Status and Seasonality in the Physicochemical Hydrology of a Nigerian Rain Forest Pond.The Japanese Journal of Limnology, 52, 1-12.

[9] Luo, X.S., Yu, S. & Li, X.D. (2012). The Mobility, Bioavailability, and Human Bioaccessibility of Trace Metals in Urban Soils of Hong Kong. Applied Geochemistry, 27, 995–1004.

[10] Hart A.D., Oboh, C.A., Barimalaa, I.S. &Sokari, T.G. (2005).Concentrations of Trace Metals (Lead, Iron, Copper and Zinc) in Crops Harvested in Some Oil Prospecting Locations in Rivers State, Nigeria. African Journal of Food, Agriculture, Nutrition and Development, 5(2), 1-22.

[11] Hays, V.W. & Swenson.M.J. (1985).Minerals and Bones. In: Dukes' Physiology of Domestic Animals, Tenth Edition pp. 449-466.

[12] Havlin, J. L. (2005). Soil Fertility and Fertilizers: An Introduction to Nutrient Management, 7th ed. Upper Saddle River, NJ: Prentice Hall.

[13] He, F.J. &MacGregor, G.A. (2008).Beneficial Effects of Potassium on Human Health. Physiologia Plantarum, 133(4), 725-735.

[14] Mekassa, B. &Chandravanhi, B.S. (2015).Levels of Selected Essential and Non-Essential Metals in Seeds of Korarima (Aframomumcorrorima) Cultivated in Ethiopia. Brazillian Journal of Food Technology, 18(2), 102-111.

[15] Mlitan A. M., Sasi M. S. &Alkherraz A. M. (2014).Proximate and Minor Mineral Content in Some Selected Basil Leaves of Ocimumgratissimum L, in Libya. International Journal of Chemical Engineering. Application, 5, 8–17.

[16] Maathuis, F.J.M. (2014). Sodium in Plants: Perception, Signalling, and Regulation of Sodium Fluxes. Journal of Experimental Botany, 65 (3), 849–858.

[17] Marcus, A.C. (2011). Trace Metals Contents of Rivers and Creeks around Okrika, Rivers State, Nigeria. Ph.D Dissertation, University of Nigeria, Nsukka, Nigeria.

[18] Marcus, A.C. & Jack, I.R. (2016).Trace Metals Levels in Telfeiria Occidentalis (Pumpkin Leaf) and Soil of Selected Locations in Omoku Town, Niger Delta. International Journal of Chemistry and Chemical Engineering, 6 (2), 111-124.

[19] Mogo, F.C. (2002).Assessment of Heavy Metals in Soil, Water, Sediments and Certain Plant Taxa in Imo and New Calabar Rivers. Ph.D Thesis 2002, University of Port Harcourt, Port Harcourt, Nigeria.

[20] Murray, R.K., Granner, D.K., Mayes, P.A. & Rodwell, V.W. (2000).Harper's Biochemistry, 25th Edition, McGraw-Hill, Health Profession Division, USA.

[21] Muhammad, M., Muhammad, I., An, P., Zhad, H. & Muhammad, S. (2018). Bioavailability of Iodine to Mint from Soil Applied with Selected Amendments. Environmental Pollution and Bioavailability, 31(1), 138-144.

[22] Nkuba, L.L. & Mohammed, N.K. (2017).Heavy Metals and Essential Elements in Selected

[23] Medicinal Plants Commonly Used for Medicine in Tanzania.Chemical Science International Journal, 19 (2), 1-11.

[24] Njinga, R.L., Moyo, M.N. &Abdulmaliq, Y.S. (2013).Analysis of Essential Elements for Plant Growth Using Neutron Activation Analysis.International Journal of Agronomy (Hindawi Publishing Corporation, 2013, 1-10

[25] Okaka J. C. & Okaka A. N. O. (2001).Food Composition, Spoilage and Shelf Life Extension, Ocjarc. Academic Publishers, Enugu, Nigeria. Pp. 54–56

[26] Parikh, S. J. & James, B. R. Soil: The foundation of agriculture. Nature Education Knowledge, 3(10), 2 (2012).

[27] Soetan K. O., Olaiya C. O., and Oyewole O. E. (2010). The importance of mineral elements for humans, domestic animals and plants: a review. African Journal of Food Science, 4(5), 200-222.

[28] Sparks, D. L. Environmental Soil Chemistry, 2nd ed. San Diego, CA: Academic Press, 2003.Wahua, T.A.T. (1999). Applied Statistics for Scientific Studies. Afrika-Link Press, Nigeria.

[29] 1999.

[30] Umoren, I. U., and Onianwa, P.C. (2005). Concentrations and Distribution of Some Heavy Metals in Urban soil of Ibadan, Nigeria. Park Journal of Industrial Resources, 48, 397 – 401.

[31] Welcome, R.L. (1986) The Niger River system. Longman Group Ltd, London. pp 9-23.

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