ISSN: 2695-2556 (Online)
ISSN: 2651-5679 (Print)

AKSU Journal of Agriculture and Food Science 7(2) 40-51, 2023

Profile Distribution of Iron and Zinc in Soils formed from Three Different Parent Materials in Akwa Ibom State, Nigeria

*Christiana J. Ijah, Florence O.Umoh, Otobong A. Essien, Itakufok G. U. and Victor I. Moses

Department of Soil Science, Akwa Ibom University, Obio Akpa Campus

*Corresponding author e-mail: christyjamesijah@yahoo.com, Tel:+2348023854805

Abstract

The distribution of total and available levels of iron (Fe) and zinc (Zn) was studied in three major soil types derived from different parent materials in Akwa Ibom State. The parent materials were: Sandstone (SS), Coastal Plain Sands (CPS) and Beach Ridge Sands (BRS), respectively. Six representative soil profiles, two each for SS, CPS and BRS were dug. The soils from the different parent materials were sampled at different depths of 0 – 20, 20 – 40, 40- 60, 60 – 80, 80 – 100 and 100 – 120 cm. The soil samples were air dried, crushed and sieved using a 2mm sieve and stored in labeled bags for analysis. Laboratory analysis was conducted. The soils were strongly weathered, coarse in texture, acidic and generally low in fertility. Total Fe contents ranged from 365-1576mg/kg with sandstone soils having the highest mean of 1400mg/kg, followed by those of the coastal plain sand with a mean value of 883mg/kg and 485mg/kg for beach ridge sands. The total content of Zn followed the same trend ranging from 43 to 335mg/kg with a mean value of 246, 114 and 79mg/kg for the sandstone soils, coastal plain sands and beach ridge sand soils, respectively. Available Fe contents in the entire profiles ranged from 9.8 to 33.3mg/kg with sandstone having the highest mean value of 28.2mg/kg, followed by those of coastal plain sands with a mean of 14.7mg/kg and beach ridge sands with a mean of 12.2mg/kg. The available Zinc content followed the same trend. Available Zn content ranged from 4.2-20.0mg/kg with a mean value of 12.2, 9.3 and 6.5 mg/kg for the sandstone, coastal plain sands and the beach ridge sands, respectively. The distribution of the micronutrients in the soil profile was generally irregular, but in some profiles, it decreased with depth. The micronutrients were weakly correlated with organic carbon, clay and silt in the three parent materials. The available levels of the micronutrients in the soils were relatively high, having values above the critical levels of 4.5mg/kg for available Fe and 1mg/kg for available Zn. The result showed that the content of the two micronutrients were highest in sandstone soils, followed by that of coastal plain sands and least in the beach ridge sand. The high content of the available iron and zinc indicate possible toxicity effect to plant grown on these soils.

Key words, Iron, Zinc, Parent materials, Profile pit, Soil properties

1.0 Introduction

Iron and zinc are important micronutrients for plant growth. However, their presence in the soil in quantities lower or greater than the optimal amount could adversely affect plant growth. Though they are needed in small quantities, there are soils in which they can be present at toxic levels. Gao *et al*., (2008) and Jurist *et al*., (2018) reported that through their involvement in various enzymes and other physiologically active molecules, these micronutrients are important for gene expression, biosynthesis of proteins, nucleic acids, growth substances, chlorophyll, secondary metabolites, metabolism of carbohydrates, lipids and stress tolerance etc. Tommy *et al.*, (2021a) observed a higher release of micronutrients in wet season than in the dry season and these adversely affected the growth of Fluted pumpkin (*Telferia occidentalis*) which contains higher content of heavy metals which may affect the life of the consumers. According to Tommy *et al.*, 2021b) the transfer factor of heavy metals from the soil to plant, based on the root uptake and absorption of metals were higher in the wet season than in the dry season and the concentration of the elements were above the range limit in plant (WHO, 2011). The authors also observed a decrease in the metal concentration in *Telferia occidentalis* plant with increased in concentration from a distance of 80 to 100m away from the dumpsites.

The status and the distribution of available micronutrients along a soil profile has been considered essential for the understanding of the soil inherent ability to sustain an adequate amount or supply of these elements to crop in order to meet the demand of zero hunger by 2030 through sustainable food production (United Nations, 2012).

Most agricultural soils in Akwa Ibom State are developed from parent materials which are grouped into coastal plain sands, beach ridge sands, sandstone and alluvial deposits. The characteristics of these soils are largely determined by these original materials and influenced by climate, topography and the general agricultural land use pattern and management (Ibia and Udo, 2009). Although a number of studies have been carried out on the micronutrient status in wetland soils (Udo *et al*,2008) not much work has been done on the total contents and the availability levels of these important micronutrients in these soils. The objective of this study, therefore, was to determine the distribution of total and available iron and zinc in the three parent materials which are the major agricultural soils of Akwa Ibom State.

2.0 Materials and Methods

2.1 The Study Area

The study was conducted in Akwa Ibom State in Southeastern Nigeria. The area is situated between latitude 4º 30¹ and 5º30¹N and longitude 7º 30¹ and 8º20¹E in the rainforest zone, with a mean annual rainfall of over 3000 mm. Temperature values are relatively high, with the mean annual temperature varying between 26 and 28^{o}C (SLU-AK, 1989).The geological formation of Akwa Ibom State is made up of the quaternary sediments which give rise to alluvial plains and beach ridge sand. The alluvial plains include the mangrove mudflats and the fresh-water flood plains and swamp. The entire formations are highly weathered unconsolidated sandstones which lie uncomfortably over the Nkporo shales. The tertiary coastal plain sands consist of beds of unconsolidated coarse-textured sandstones interbedded with layers of fine-grained massive clay (Udo, E. J. 2001). Six representative soil profiles, two each for coastal plain sands (CPS), sandstone (SS) and beach ridge sands (BRS) soils were used. Soil sample were collected in triplicate at 0-20, 20-40, 40-60, 60-80, 80-100 and 100-120. The samples were air-dried and sieved using a 2mm sieve and stored in bags for analysis.

The soil samples collected were analyzed in the laboratory using standard procedures as described by Udo *et al.*, (2009). Particle size distribution was determined by the Bouyoucous hydrometer method. Soil pH was determined using a ratio of 1:2.5 in soil-water medium and read with a digital pH meter. Organic carbon content was determined by the Walkley-Black dichromate oxidation method. Organic matter was obtained by multiplying total carbon by a factor of 1.724. Total nitrogen (N) was determined by the micro kjeldahl method. Available phosphorus (P) was extracted by the Bray 1 extraction method, and the content of P was determined colorimetrically using a Technico AAII auto analyser (Technico, Oakland, Calif). Determination of exchangeable bases was by neutral ammonium acetate extraction and read with an atomic absorption spectrophotometer (AAS). Exchangeable acidity was determined by the 1 N potassium chloride (KCl) extraction method and titrated with 1 M sodium hydroxide (NAOH) using phenolphthalein as an indicator. The effective cation exchange capacity (ECEC) was the summation of the total exchangeable bases and exchangeable acidity. Base saturation was calculated by dividing the sum of exchangeable bases by ECEC and multiplying by 100. Available micronutrients (Iron and Zinc) were extracted with 0.1N HCl and determined by the use of Atomic Absorption Spectrophotometer. Total Iron and Zinc were also extracted by Hydrofluoric/perchloric acid digestion method and Iron and Zinc (Fe and Zn) in the extracts were determined using an Atomic Absorption Spectrophotometer.

2.2 Statistical Analysis

Soil data collected were subjected to *statistical* analysis. Mean differences in the physicochemical properties and cationic micronutrient content between the soils of the three parent materials were analyzed using analysis of variance (ANOVA) (SPSS Statistics 17.0). Correlation analysis was used to determine the relationship between the physicochemical properties and the cationic micronutrients (SPSS Statistic 17.0 and StatPoint, 2005).

3.0 Results and Discussion

The physico-chemical properties of the three soils used for the study are shown in Table 3.1. Sand fraction varied from 48.5 to 74.5%, (mean = 59.2), 68.5 to 88.5% (mean=77.2) and 70.5 to 88.5% (mean=79.0%) for sandstone, coastal plain sands and the beach ridge sand, respectively. Silt content ranged from 5.5 to 21.5%, (mean=14.5%)5.5 to 9.5%(mean= 6.7%) and 4.18 to 8.15% (mean= 6.5%) for sandstone, coastal plain sands and beach ridge sands while clay content ranged from18.0 to 34.0 (mean= 25.5%), 6.0 to 24.0 (mean= 16.2%) and 5.32 to 21.32 (mean=14.5%) for sandstone, coastal plain sands and beach ridge sands .The results showed that, the sand fraction in the three parent materials decreased with increase in depth while the clay content significantly increased with soil depth. Silt content was irregularly distributed.

Considering the particle size distribution, the textures of the soils were sandy clay loam for soils developed from sandstone, loamy sand for soils derived from coastal plan sands and the beach ridge sand. The variation in soil texture may be attributed to differences in soil forming factors such as climate and parent materials as well as land use and management practices

(Fasina, 2003).The soil pH ranged from 6.0 to 6.80 (mean= 6.54), 5.40 to 6.50 (mean = 5.68) and 5.20 to 5.80 (mean= 5.99) for sandstone, coastal plain sands and the beach ridge sands, respectively indicating a slight to moderate acidic reaction (Table 3. 1). Though generally acidic, the pH values varied between the locations and depth considered. This could be attributed to the removal of basic cations from the soil by rainfall, leaching and runoff (Umoh *et al.,* 2018 and Ijah, *et al.,* 2021).

The electrical conductivity (EC) values ranged from 0.033 to 0.093ds/m for sandstone soils, 0.024 to 0.088ds/m for coastal plain sand and 0.026 to 0.173ds/m for the beach ridge sand soils. Since these values are less than 1ds/m, the soils are therefore non-saline and cannot pose any threat to crops that will be grown (FAO, 1976). The organic carbon (OC) and total nitrogen were generally low in all the profiles as characteristics of tropical soils. The values of organic carbon ranged from 0.24 to 2.20% (mean = 2.68%), 0.01 to 1.65% (mean= 0.72%) and 0.01 to 1.65% (mean= 0.72%) in sandstone, coastal plain sands and soils derived from beach ridge sands. The low content of organic carbon agrees with what is recorded about the acid sands of South eastern Nigeria by Enwezor *et al.,* (1981).Total nitrogen content ranged from 0.010 to 0.095% (mean=0.031%) 0.012 to 0.061% (mean= 0.033%) and 0.015 to 0.072% (mean= 0.029 %)in the sandstone, coastal plain sands and beach ridge sands, respectively. The values are quite low compared with 0.15% determined as critical level for coastal plain sands.

The soil available phosphorus (P) ranged from 10.33 to 24.66mg/kg (mean =16.30mg/kg), 16.66 to 97.66mg/kg (mean = 53.53mg/kg) and 6.60 to 18.99mg/kg (mean = 12.80mg/kg) for soils of the sandstone, coastal plain sands and beach ridge sand. (Table 3.1) The exchangeable calcium content ranged from 4.08 to 8.40mg/kg (mean= 6.01cmol/kg), 1.02 to 3.12mg/kg (mean =1.86mg/kg) and 0.96 to 3.12mg/kg (mean =2.21mg/kg) for sandstone, coastal plain sands and beach ridge sands. The values of exchangeable Ca were higher in soils derived from sandstone parent material and were low in the coastal plain sands and the beach ridge sands.

Similar trend was also observed in exchangeable magnesium (Mg) content in all the soils studied. Generally, exchangeable Mg was higher than the critical limits of 0.5cmol/kg (FAO, 1976). The soil K content ranged from 0.13 to 0.48cmol/kg (mean= 0.17cmol/kg), 0.10 to 0.19cmol/kg (mean= 0.13cmol/kg) and 0.06 to 0.13cmol/kg (mean =0.09cmol/kg) in sandstone, coastal plain sands and beach ridge sands. Exchangeable acidity was high in all the soils studied. The effective cation exchange capacity (ECEC) and the base saturation were low. The values of ECEC ranged from 11.56 to 25.8 4cmol/kg (mean =17.24cmol/kg) 4.97 to 8.55cmol/kg (mean = 6.57cmol/kg) and 5.39 to 8.32cmol/kg (mean = 6.41cmol/kg)in sandstone soils, coastal plain sands and s beach ridge sands. There is the need for the addition of organic matter to improve on the CEC for better nutrient supply in the soil. (Adeoye, *et al.,* 2005). Base saturation ranged from 40.77 to 56.66cmol/kg (mean = 46.07cmol/kg) for sandstone, 28.46 to 54.99cmol/kg (mean = 42.39cmol/kg) for coastal plain sand soils and 20.00 to 59.62 (mean = 59.62cmol/kg) for beach ridge sand. Considering the critical limits of 50.0% for a fertile soil, these soils are described as being low in percent base saturation.

This result conforms with the work reported by the following authors for the soils of Nigeria (Enwezor *et al*., (1981); Umoh *et* al., (2014); Edem *et al*., (2015); Umoh *et al*., (2017); Ijah *et al*., (2018); Ijah *et al*., (2021) and Umoh *et al*., (2021).

Table 3. 1: Physicochemical Properties of Sandstone, Coastal Plain Sands and Beach ridge Sands

	Depth (cm)	Sand %	Silt %	Clay %	Text Class	pH	EC ds/m	Org.C %	T/N %	Av.P (mg/kg)	Ca Cmo/kg	Mg Cmo/kg	Na Cmo/kg	K Cmo/kg	EA Cmo/kg	ECEC Cmo/kg	BS %
S1	0-20	74.5	5.5	20.0	SCL	6.20	0.093	2.20	0.095	10.3	8.40	2.49	0.08	0.48	8.00	22.49	50.91
	20-40	62.5	15.5	22.0	SCL	6.60	0.063	0.59	0.026	10.9	7.68	2.80	0.07	0.29	8.91	20.76	52.21
	40-60	60.5	15.5	24.0	SCL	6.00	0.059	1.21	0.052	13.3	5.76	2.06	0.06	0.16	7.70	19.72	40.77
	60-80	56.5	17.5	26.0	SCL	6.50	0.056	0.48	0.021	14.0	8.16	2.16	0.07	0.37	6.10	25.84	45.51
	80-100	54.5	13.5	28.0	SCL	6.60	0.048	0.28	0.012	24.7	8.20	2.98	0.06	0.18	6.10	22.14	51.58
	100-120	48.5	21.5	30.0	CL	6.50	0.049	0.26	0.011	24.3	6.10	2.10	0.06	0.16	6.68	16.10	52.29
	Mean	59.5	15.5	25.0		6.40	0.061	0.84	0.036	16.3	7.38	2.60	0.07	0.30	7.25	21.20	48.87
S1	0-20	72.5	9.5	18.0	SL	6.80	0.056	0.98	0.042	18.6	5.20	2.00	0.06	0.25	7.88	15.39	48.79
	20-40	60.5	15.5	24.0	L	6.80	0.038	1.49	0.065	15.3	4.20	1.66	0.06	0.21	7.36	13.49	45.44
	40-60	58.5	15.5	26.0	CL	6.70	0.040	0.26	0.011	18.1	5.60	2.60	0.05	0.12	6.56	14.93	56.66
	60-80	56.5	11.5	32.0	CL	6.60	0.033	0.24	0.010	14.5	4.88	1.67	0.06	0.15	4.80	11.56	58.48
	80-100	54.5	13.5	32.0	CL	6.40	0.057	0.24	0.010	15.6	4.08	1.56	0.06	0.13	6.08	11.91	48.95
	100-120	50.5	15.5	34.0	CL	6.00	0.045	0.24	0.010	15.6	4.40	1.68	0.06	0.14	6.24	12.52	50.16
	Mean	58.8	13.5	27.7		6.55	0.044	0.60	0.025	16.3	4.73	1.86	0.06	0.17	6.50	13.30	51.41
	Grandmean	59.2	14.5	25.5		6.54	0.052	2.68	0.031	16.3	6.01	2.21	0.17	0.06	6.90	17.24	46.07
C1	0-20	88.5	5.5	6.0	L	5.50	0.036	1.41	0.06	51.1	2.88	1.20	0.05	0.18	3.68	7.99	53.94
	20-40	82.5	5.5	12.0	SL	5.60	0.045	0.34	0.15	71.9	1.20	0.60	0.06	0.19	3.84	5.89	34.80
	40-60	78.5	7.5	14.0	SL	5.60	0.088	1.25	0.54	79.3	1.68	0.70	0.06	0.13	2.40	4.97	51.71
	60-80	78.5	5.5	16.0	SL	5.40	0.054	0.64	0.28	85.3	2.64	1.40	0.06	0.14	3.45	7.69	55.14
	80-100	76.5	5.5	18.0	SL	5.60	0.074	0.34	0.15	97.6	1.20	0.70	0.05	0.10	3.04	5.09	40.28
	100-120	74.5	5.5	20.0	SCL	5.60	0.047	0.28	0.12	94.9	2.00	1.10	0.05	0.08	2.72	5.75	52.70
	Mean	79.8	5.8	14.3		5.55	0.057	0.17	0.22	80.0	1.93	0.78	0.06	0.14	3.19	6.23	48.10
C2	0-20	84.5	5.5	10.0	L	6.50	0.024	1.65	0.07	24.9	3.12	1.00	0.05	0.13	3.52	7.82	54.99
	20-40	78.5	5.5	16.0	SL	6.50	0.027	0.62	0.03	16.6	1.20	0.50	0.06	0.15	4.80	6.71	28.46
	40-60	74.5	9.5	16.0	SL	5.40	0.024	1.07	0.05	39.3	2.40	1.00	0.06	0.19	4.90	8.55	42.70
	60-80	70.5	9.5	20.0	SCL	5.50	0.046	0.10	0.03	30.6	1.20	0.50	0,05	0.11	4.16	6.02	30.90
	80-100	70.5	7.5	22.0	SCL	5.60	0.050	0.48	0.02	21.5	1.20	0.40	0.05	0.08	4.32	6.05	28.60
	100-120	68.5	7.5	24.0	SCL	5.40	0.040	0.42	0.02	28.7	1.68	0.40	0.05	0.08	4.20	6.41	34.50
	Mean	74.5	7.5	18.0		5.82	0.035	0.72	0.04	26.9	1.80	0.63	0.05	0.12	4.32	6.93	36.70
	Grand mean	77.2	6.7	16.2		5.68	0.046	0.72	0.033	53.53	1.86	0.70	0.13	0.05	3.75	6.57	42.39
B1	20-40	86.5	8.18	5.32	SL	5.80	0.050	1.68	0.072	6.66	3.12	1.67	0.05	0.12	3.36	3.32	59.62
	40-60	80.5	6.18	13.32	SL	5.50	0.153	0.95	0.042	10.6	2.40	1.00	0.06	0.11	2.88	6.45	55.35
	60-80	76.5	6.18	17.32	SL	5.40	0.173	0.68	0.029	18.9	2.00	0.09	0.07	0.07	4.00	7.04	43.18
	80-100	74.5	6.18	19.32	SL	5.70	0.043	0.48	0.021	10.3	2.40	1.20	0.05	0.08	3.20	6.93	53.82
	100-120	70.5	8.18	21.32	SCL	5.60	0.048	0.36	0.015	21.0	1.92	0.80	0.05	0.06	2.72	5.55	50.99
	Mean	77.8	6.85	15.32		5.60	0.107	0.84	0.036	12.9	2.45	1.13	0.06	0.09	3.12	6.02	47.16
B2	0-20	88.5	6.18	5.32	SL	5.20	0.043	0.74	0.034	11.1	2.88	1.60	0.06	0.13	3.52	7.86	55.39
	20-40	86.5	6.18	7.32	SL	5.60	0.026	0.52	0.022	10.3	1.80	0.70	0.06	0.11	2.72	5.39	49.54
	40-60	82.5	8.18	9.32	SL	5.50	0.029	0.40	0.022	18.6	1.92	0.80	0.06	0.10	2.72	5.60	51.43
	60-80	76.5	6.18	17.32	SL	5.50	0.026	0.40	0.017	14.6	0.96	0.30	0.05	0.11	3.20	4.62	30.74
	80-100	74.5	4.18	21.32	SCL	5.60	0.031	0.39	0.017	10.3	2.16	1.20	0.05	0.10	3.04	6.55	53.59
	100-120	72.5	6.18	21.32	SCL	5.40	0.037	0.35	0.016	13.6	2.11	1.00	0.04	0.08	2.56	5.79	55.79
	Mean	80.2	6.18	13.7		5.47	0.032	0.47	0.021	13.1	1.97	0.93	0.05	0.12	2.96	5.97	49.41
	Grand mean	79.0	6.5	14.5		5.99	0.149	0.66	0.029	3.04	2.21	1.03	0.09	0.06	3.04	6.41	48.28

Key: S1 S2 = Profile pits for sandstone, C1 C2 = Profile pits for coastal plain sands, B1 B2 = Profile pits for beach ridge sands. SCL = sand clay loam, SC = sandy clay, L = Loam.

3.2 Total Fe and Zn Contents in the Three Parent Materials

The total Fe and Zn contents in the three parent materials are showed in Table 3.2. Total Fe contents ranged from 1211 to 1576mg/kg (mean=1400mg/kg), 601 to 1043mg/kg mean = (883mg/kg) and 365 to 608mg/kg (mean =485mg/kg) for sandstone, coastal plain sands and the beach ridge sands, respectively. The highest values of total Fe were observed in sandstone soils, followed by those of coastal plain sands and least in the beach ridge sands. Total Zn content followed the same trend. Total content of Zn ranged from 146 to 335mg/kg (mean= 246mg/kg) 100 to 121 mg/kg (mean = 114mg/kg) and 43 to 98mg/kg (mean=79mg/kg) for sandstone, coastal plain sands and beach ridge sands, respectively. Generally, soil total Fe and Zn were high in all the profiles irrespective of the parent materials. This work is in consonance with that of Shittu *et al*., (2010) who reported higher concentration of total Fe in the Ap horizon.

3.3 Available Fe and Zn in the Three Parent Materials

Table 3.3 shows that available Fe in the soils ranged from 24.8 to 33.3mg/kg (mean= 28.2mg/kg), 13.0 to 16.8mg/kg (mean =14.7mg/kg) and 9.8 to12.6mg/kg (mean =11.2mg/kg) for sandstone, coastal plain sands and the beach ridge sands. Soil available Zn ranged from 6.5 to 20.0mg/kg (mean =12.2mg/kg), 3.3 to 14.0 mg/kg (mean = 9.3mg/kg) and 4.2 to 8.8mg/kg (mean = 6.5mg/kg) for sandstone, coastal plain sands and the beach ridge sands. Available Fe content was rated high having values above the critical level of $4.5mg/kg^{-1}$ (Agbenin (2003) and Ibrahim *et al*., (2011) for all the parent materials. The high level of available Fe in these soils may be attributed to the acid conditions of the soils. Also, the high Fe in the soils connotes that Fe deficiency is not likely for crops grown in these soils. However, the presence of Fe in high concentrations in soils could lead to its precipitation and accumulation and upon complex chemical reactions leading to the formation of Phlintite (laterite). This upon alternate wetting and drying could irreversibly yield hard consolidated material (Petrophlintite or ironstone) which could restrict root penetration and drainage (John *et al.*, 2019). The result obtained from this study is similar to that of Oyinlola and Chude, (2010) and Mustapha *et al.*, (2011). Similarly, the proportion of available Zn obtained in this study was above the critical level of $0.8mg/kg^{-1}$ Lindsay and Norvell, (1978) and $1mg/kg^{-1}$ (Udoh*et al.*, 2008) The high content of available Fe and Zn obtained in these studies may be attributed largely to the parent material in which the soil was formed. According to Irmak *et al.*, (2007), parent material has an influence on chemical compositions of soils.

3.4 Relationship between Total Fe and Zn with Soil Physicochemical Properties

Presented in Table 3.4 is the correlation matrix between total Fe and Zn with soil properties among the three parent materials. Total Fe significantly (P< 0.05) correlated with sand (r =0.826*), K (r =0.884*) and negatively with clay (r = -0.902*) in the sandstone parent material while total Zn had no correlation with the soil properties. In coastal plain sands, total Fe correlated negatively with available phosphorus (r = -0.823*) and EA (r=0.863*) while total Zn significantly correlated (P<0.01) with sand (r =0.976*), EC (r =0.899*), organic carbon (r =0.839*),total nitrogen (r =0.843*) and negatively with silt (r =0.927*) Table 3. 4. Total Fe also correlated significantly (P< 0.05) with sand (r =0.838*) and K (r =0.896*). However, total Zn did not show significant relationship with soil properties in the beach ridge sands. This indicates that as one parameter increases, there is also a corresponding increase with the other.

Table 3.2: Total Fe and Zn contents

	Depth (cm)	Sandstone (SS) Fe(mg/kg)	Zn(mg/kg)	Mg/kg	Costal Plan Sands (CPS) Fe(mg/kg)	Zn(mg/kg)		Beach Ridge Sands (BRS) Fe(mg/kg)	Zn (mg/kg)
S1	0-20	1576	335	C1	1043	119	B1	600	96
	20-40	1574	280		995	118		602	82
	40-60	1380	239		885	121		608	82
	60-80	1366	190		880	116		500	85
	80-100	1220	196		601	114		408	88
	100-120	1360	146		742	110		401	43
	Mean	1413	231		858	116		620	79
S2	0-20	1550	320	C2	1020	120	B2	504	98
	20-40	1460	308		1012	116		504	92
	40-60	1400	291		1010	116		501	80
	60-80	1396	206		800	112		415	80
	80-100	1211	262		800	110		365	65
	100-120	1300	180		803	100		402	60
	Mean	1386	261		908	112		449	79
	Grand mean	1400	246		883	114		485	79

S1 S2 = Profile pits for sandstone, C1 C2 = Profile pits for coastal plain sands, B1 B2 = Profits pits for beach ridge sands.

Table 3.3 Available Fe and Zn contents

	Depth (cm)	Sandstone (SS) Fe (mg/kg)	Zn (mg/kg)		Costal Plan Sands (Cps) Fe (mg/kg)	Zn (mg/kg)		Beach Ridge Sands BRS Fe (mg/kg)	Zn (mg/kg)
S1	0-20	28.8	20.0	C1	16.8	10.6	B1	12.2	8.7
	20-40	27.8	16.0		14.4	8.2		12.1	8.5
	40-60	30.1	13.0		14.2	3.6		10.7	4.8
	60-80	30.2	8.60		14.3	3.3		10.8	4.3
	80-100	32.3	10.2		15.8	11.5		11.2	4.7
	100-120	33.3	12.0		16.0	14.0		11.2	4.2
	Mean	30.4	13.3		15.3	8.53		11.4	5.87
S2	0-20	25.6	17.0	C2	15.6	13.0	B2	12.6	8.8
	20-40	24.8	12.0		15.2	8.6		12.0	6.5
	40-60	24.9	8.5		13.3	5.2		9.8	6.2
	60-80	25.2	6.5		13.0	10.2		10.1	5.8
	80-100	27.2	10.2		13.0	12.0		10.3	6.5
	100-120	28.0	12.0		14.0	10.5		11.9	8.7
	Mean	26.0	11.0		14.0	10.0		11.1	7.1
	Grand mean	28.2	12.2		14.7	9.3		11.2	6.5

S1 S2 = Profile pits for sandstone, C1 C2 = Profile pits for coastal plain sands, B1 B2 = Profile pits for beach ridge sands.

Table 3.4: Correlation matrix between Total Fe and Zn with Soil Properties

Soil Properties	Total Fe (Mg/Kg)	Total Zn (Mg/Kg)
	Sandstone (SS)	
Sand	0.826*	0.644 ns
Clay	-0.845*	-0.492 ns
Av.P	-0.902*	-0.687 ns
K	0.884*	0.726 ns
	Coastal Plain Sands (CPS)	
Sand	0.750 ns	0.976**
Silt	-0.654 ns	-0.927*
Clay	-0.730 ns	-0.981*
Av.P	-0.823*	-0.785 ns
EA	0.863*	0.766 ns
EC	0.784 ns	0.899*
Org.C	0.624 ns	0.839*
T/N	0.630 ns	0.843*
	Beach ridge Sands (BRS)	
Sand	0.838*	0.757 ns
K	0.896*	0.650 ns

*Correlation is significant at 0.05%**Correlation is significant at 0.01%ns = Not significant at 0.05%.

Av.P = Available phosphorus, K= potassium, EA = Exchangeable acidity, EC = Electrical conductivity, Org. C = Organic carbon, T/N = Total nitrogen

3.5 Relationship between Available Fe and Zn with Soil Physicochemical Properties

The correlation analysis between available Fe and Zn with soil properties are shown in Table 3.5. Available Fe significantly ($P < 0.05$) correlated with sand (r = 0.6797*) and negatively with silt (r = - 0.792*). Available Zn gave a negative but significant correlation with total nitrogen (r = -0.774*) and Na (r = – 0.856*) in sandstone. In coastal plain sands available Fe did not show significant relationship with soil properties but available Zn correlated significantly with sand (r = 0.737*), EC (r =0.813*), organic carbon (r = 0.729*) , total nitrogen (r = 0.728*), Na (r = 0.608*), K (r = 0.599*), EA (r = 0.849*) and negatively with clay (r = - 0.701*). In beach ridge sand only, Zn correlated significantly ($P < 0.05$) with K (r = 0.613*) and available Fe.

3.6 Profile distribution of Total Fe and Zn

Figure 3.1 and 3.2 shows the profile distribution of total Fe and Zn in sandstone, coastal plain sands and beach ridge sands, respectively. In sandstone, total Fe was high at the surface soils and was irregularly distributed in the subsoil. Although the distribution of total Fe down the profile did not follow a uniform trend in coastal plain sands, total Fe content decreased from 0-80cm depth and then gradually increased down the profile while in beach ridge sands, total Fe was irregularly distributed Figure 3.1. However, total Zn did not follow definite sequence in its distribution irrespective of the parent materials (Figure 3.2).

Table 3.5: Correlation matrix between Available Fe and Zn with Soil Properties

Soil Properties	Available Fe	Available Zn
Sandstone		
Sand	0.6797*	-0.079 ns
Silt	-0.792*	-0.248 ns
T/N	-0.223 ns	-0.774*
Na	-0.264 ns	-0.856*
Coastal Plain Sands (CPS)		
Sand	-0.369 ns	0.737*
Clay	0.105 ns	-0.701*
EC	0.299 ns	0.813*
Org.C	-0.126 ns	0.729*
T/N	-0.126 ns	0.728*
Na	0.259 ns	0.608*
K	0.209ns	0.599*
EA	-0.010 ns	0.849*
Beach Ridge Sands (BRS)		
K	0.288 ns	0.613*
Av.P	---	0.0642*

*Correlation is significant at the 0.05 level**Correlation is significant at the 0.01ns = Not significant at 0.05 level. Av.P = Available phosphorus, K= potassium, EA = Exchangeable acdity, EC = Electrical conductivity, Org. C = Organic carbon, T/N = Total nitrogen

3.7 Profile distribution of Available Fe and Zn

The distribution of available Fe and Zn in the three parent materials are shown in Figure 3.3 and 3.4. In sandstone available Fe initially decreased from 0-20cm and then gradually increased down the profile to 120cm depth while in both coastal plain sands, it decreased from 0-40cm depth and was constant from 60-80cm and then rose to 120cm depth. In beach ridge sands, available Fe was constant between 0-40cm and decreased from 40-60cm, then increased down the profile to 120cm depth. Available Zn decreased from 0-60cm depth, and then increased down to 120cm depth in soils developed from sandstone parent material. In coastal plain sands, available Zn decreased from 0-40cm depth and then increased up to 80cm depth and remained constant from 100-120cm depth while in beach ridge sands, available Zn decreased from 0-60cm depth and then gradually increase down to 120cm depth. Generally, the two micronutrients were irregularly distributed in all the parent materials studied.

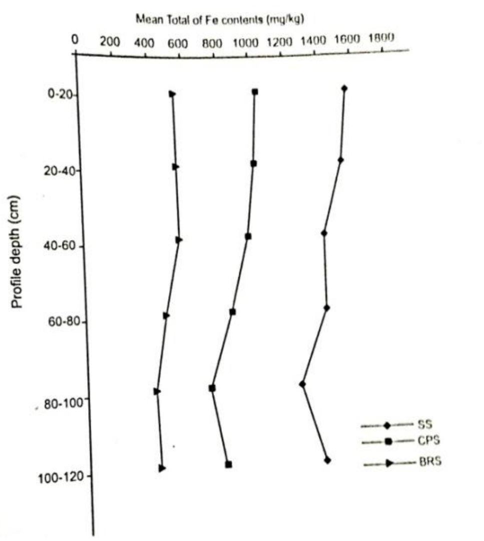

Figure 3.1: Profile distribution of total Fe (mg/kg) with depth among three different materials

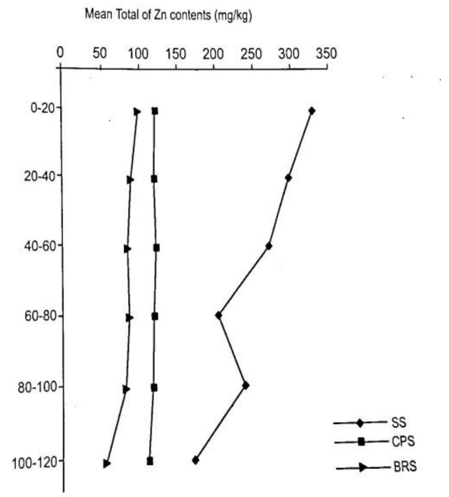

Figure 3.2: Profile distribution of total Fe (mg/kg) with depth among three different materials

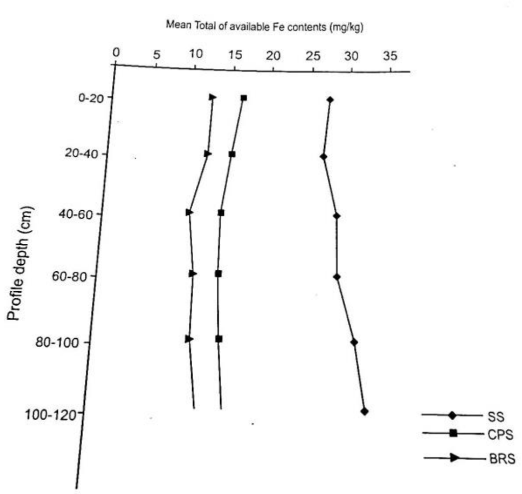

Figure 3.3: Profile distribution of available Fe (mg/kg) with depth among different materials

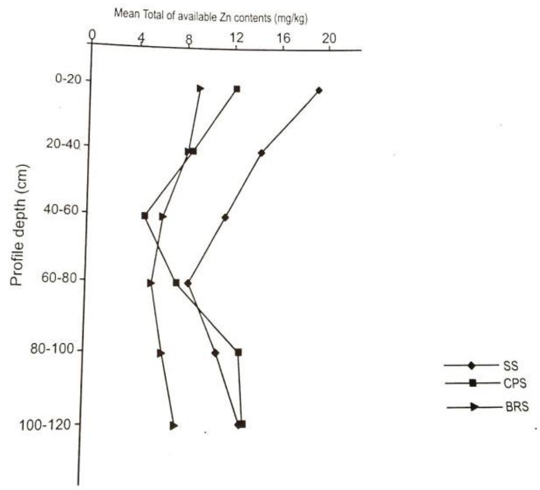

Figure 3.4: Profile distribution of available Zn (mg/kg) with depth among different materials

4.0 Conclusion

In conclusion, this study has shown that the two micronutrients were generally high having values above the critical levels in all the parent material studied. The micronutrients were irregularly distributed and were associated with one or more of the soil properties. Total and available content of Fe and Zn were higher in soils derived from sandstone, followed by those of coastal plain sands and low in beach ridge sands. However, despite the apparent sufficiency of the micronutrients as indicated by soil analysis, it is recommended that regular soil test be carried out to monitor the available levels, for proper fertility management of the soils to increase crop production.

Acknowledgements
We acknowledge the support of the Department of Soil Science, Akwa Ibom State University in giving us access to facilities and the anonymous peer reviewers for their useful contributions.

References

Adeoye, G. O., M.K.C, Sridhar, O. O. Adeoluwa and N. A. Akinsoji, (2005). Evaluation of naturally decomposed solid wastes from municipal dumpsites for their manorial value in southwest Nigeria.*Journal of Sustainable Agriculture*: 26 (4): 143-152.

Agbenin, J. O. (2003). The distribution and transformation of iron and manganese in soil fractions in a savanna Alfisol under continuous cultivation. Nutrient Cycle. Agroecosystems 66: 259-270.

Ijah, C. J., Essien, G. G.,Umoh, F. O and Edem, T. T. (2021). Amelioration of Soil Acidity Using Local Liming Materials for the Production of Chilli Pepper in Acid Ultisol of South-eastern Nigeria. *AKSU Journal of Agriculture and Food Sciences :* 5 (2) 10-19.

Enwezor, W. O. Udoh, E. T. and Sobulo, R. A. (1981). Fertility Status and productivity of Acid sands In: Acid sands of Southern Nigeria. Monograph No *1 Soil Science Society of Nigeria*, pp 56-73.

FAO (1976). A framework for Land Evaluation. FAO Soils Bull. 32. FAO, Rome.87pp.

Fasina, A. S. (2003). Top soil variation of soil properties in some mapping units in a farm in southern Nigeria. *Journal of Sustainable Agriculture and Environment* 5(1): 137-146.

Gao, S., Yan. R., Cao, M., Yang, W., Wang, S., Chen, F. (2008). Effect of copper on growth, antioxidant enzymes and phenylalanine ammonia-Iyase activities in Jatropha curcas L. seedlings. *Plant, Soil andEnvironmental*, 54: 117-122.

Ibia, T, O. and E, J. Udo (2009). Guide to Fertilizer Use for Crops in Akwa Ibom State, Nigeria. Lagos: Sibon Books Limited.

Ibrahim, A. K., Usman, A., Abubakar, B. Aminu, U. H. (2011). Extractable micronutrients status in relation to other soil properties in Billiri Local Government Area. *Journal of Soil Science and Environmental Management* 3 (10): 282-285.

Ijah, C. J., Umoh, F. O., Essien, G. G. and Edem, T. T. (2021) Phosphous status of Coastal Plain Sands of Akwa Ibom State. *AKSU Journal of Agriculture and Food Science 5(2) 36-48*

Irmak, S. Kaoso, Y. Surucu, A. (2007). Effects of town waste on heavy metal contents and nutrient elements contents of soils in Haran Plain, Turkey, Free Turkey Fresenius Environment Bulletin 16 :285-289.

John, k., Ayito, E. O., Akpanidiok, A. U and Effiom, O. D. (2019) Status and Distribution of soil available micronutrients along a hillslope at EkpriIbami in Akamkpa Local Government Area of Cross River State, Nigeria. *African Journal of Agricultural Research14* (1)40-45.

Jurist, A. H., Herojit, S. A., Singh, J. S., Devi, K. N and Singh, N. G. (2018). Profile Distribution of Micronutrient Cations in Soils under Jhum Land in Chandel District of Manipur (India*). International Journal of Current Microbiology and Applied Sciences* 7:(11)332-340.

Lindsay, W.I. and Norvell, W. A. (1978). Development of DTPA Soil test for zinc, iron, manganese and copper. *Soil Science Society of American Journal*, 42: 421-428

Mustapha, S., Voncir, N., Umar, S., Abdulhamid, N. A. (2011). Status and distribution of some available micronutrients in the Haplic Usterts of Akko Local Government Area, Gombe State, Nigeria. *International journal of Soil Science* 6 267-274.

Shittu, O. S., Ogunwale, J. A. and Ayodele, O. J. (2010) Total and Extractable Iron and Manganese in Soils Developed on Charnockite in Ekiti State, Nigeria. *International Journal of Water and Soil Resources Research*1 : 1 – 3.

SLUS-AK (1989). Physical background soil and land use and physical problems. Technical report of the task force on soil and land use survey, Akwa Ibom State. The Government Printer, Uyo.

SPSS. *Statistical package for Social Sciences*. *SPSS Statistics* 17.0 (http:/www.spss.com.)

StatPoint. (2005). The *User's Guide to STAT-GRAPHIC Centurion* XV. (www.statgraphic.com.)

Tommy, I. E., Umoh, F. O and Ijah, C. J. (2021a) Seasonal Variations in Heavy Metals Concentrations in Soils and *Telfairia occidentalis* grown around selected dumpsites in Uyo Metropolis, Akwa Ibom State. *Journal of Agriculture, Forestry and Environment.* 5 (1): 37 – 47.

Tommy, I. E., Umoh, F. O and Ijah, C. J. (2021b) Assessment of Heavy Metals in Soils and Plant Samples around some Dumpsites in Uyo, Akwa Ibom State, Nigeria. *AKSU Journal* of *Agriculture and Food Science*. 5 (3): 126- 140.

United Nation (2012). Zero Hunger Challenge.www.un.org/en/zerohunger

Udo, E. J. (2001). Soil potentials of the coastal zone of Akwa Ibom State. Uniuyo Consult Ltd, Uyo, Nigeria

Udoh, B. T., Ibia, T. O., Udo, B. U and Edem, S. O. (2008). Assessment of Micronutrient status of Inland depression and floodplain (Wet land) soils in Akwa Ibom State, Southeastern Nigeria. *Journal of Tropical Agriculture, Food, Environment and Extension* 7 (2) pp 156-161

Udo, E. J., Ibia, O. T., Ogunwale, A. J., Ano, A. O., and Esu, J. E. (2009). Manual of soil, plant and water analysis. Sibon Books Limited.

Umoh, F. O., Osodeke, V. Edem, I. D. and Effiong, G. S. (2014). Application of langmiuin and freundlich model in Phosphate Sorption Studies in the soil of Contracting Parent Material in South-Eastern Nigeria. *Open assess library journal 1:e989.Htt://dx.Doi.org/10.4236/09hb.*

Umoh, F. O., Osodeke, V. E and Akpan, U. S. (2018). Assessment of potassium Leaching Behaviours in Selected Soils of Southeastern Nigeria. *International Journal of Sustainable Agricultural Research*. 5 (1): 10 – 18.

Oyinlola, E. Y. and Chude, V. O. (2010). Status of Available Micronutrients of the Basement Complex Rock-Derived Alfisols in Northern Nigeria Savanna. Tropical and Subtropical Agroecosystems, 12 (2): 229-237. http://www.veterinaria.uady.mx/ojs/index.php/TSA/article/view/226)

World Health Statistics (WHO) (2011). Available at: https://www.who.int/publications-detail-redirect/9789241564199.