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# Variability of micronutrient status and hazard potential in soils of six mapping units within Eastern part of Kogi state, Nigeria

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**ABSTRACT**

Micronutrient imbalance in some soils is a major challenge for cultivation of crops. Hence the need to assess their status and variability in agricultural soils. The aim of this research was to assess the micro-nutrient status, variability and hazard potential in some soils within eastern part of kogi state of Nigeria. Six mapping units, 2a, 17a, 19a, 19c, 21b and 22b from soil map of Nigeria, which dominated this region were chosen for the experiment. These represent wetland and savannah areas, with well drained and poorly drained loamy sand, sandy loam or sandy loam surfaces over sandy clay loam subsurface. Surface samples were collected in each mapping unit using soil auger. Samples were well-labelled in sampling bags and used for laboratory analyses of micronutrients. The results showed that the available zinc in the surface soils was moderate with exception of high values recorded at two points within the 2a mapping unit. The boron levels were low to moderate while moderate to high contents of iron were observed. The findings also showed that harmful effects of zinc were not likely in pedons $17a_4$, $19a_1$, $19a_3$, $19c_2$, $21b_1$, $21b_3$, $21b_4$ and $22a_4$ where the Hazard Quotient (HQ) values obtained were less than 1. Other pedons in Kogi East have likely harmful effects of iron as their calculated HQ values were greater than 1.

## 1.0 Introduction

Micronutrients are metallic chemical elements necessary for plant growth in only extremely small amounts (Brady and Weil, 2002). Although required in minute quantities however, micronutrients have the same agronomic importance as macronutrients and also play vital roles in the growth of plants (Nazif *et al*., 2006). These metallic chemical elements include Zinc (Zn), Iron (Fe), Copper (Cu) and Manganese (Mn), Molybdenum (Mo), Boron (B) amongst others. Most micronutrients are associated with the enzymatic systems of plants. For instance, Zn is known to promote the formation of growth hormones, starch and seed development, Fe is important in chlorophyll formation, Cu in photosynthesis and Mn activates a number of important enzymes in photosynthesis and metabolism (FFTC, 2001). Krauskopf (1972) stated that the main source of micronutrient elements in most soils is the parent material, from which the soil is formed.

The solubility and availability of micronutrients is largely influenced by clay content, pH, organic matter, Cation exchange capacity and phosphorus level in the soil and tillage practices (Fisseha, 1992). Brady and Weil (2002) indicated that the solubility, availability and plant uptake of micronutrient cations (Cu, Fe, Mn and Zn) are more under acidic conditions (pH of 5.0 to 6.5). The availability of these micronutrients determines the quantity and quality of crop produce. As stipulated in Kefas *et* al. (2016), plants grown in soils with deficiency or excess micronutrients exhibit similar reductions in productivity as those grown in soils of the counterpart macronutrients. Hence, Understanding the dynamics among these elements in soils is essential for optimizing plant productivity in Kogi State. At present, there is dearth of information on the micronutrient status and dynamics in soils of this important agricultural region of Nigeria. Therefore, there is need to assess the status, variability and hazard potentials of selected micronutrient elements in soils of six mapping units formed in various lithology and different landscapes within Kogi State. Thus, the objectives of this research were to assess the micro-nutrient status and variability, their fertility classes and determine their hazard potential in major soils within eastern part of Kogi State, Nigeria.

## 2.0 Materials and Methods

### *2.1 Location of the Study Area*

The study area is situated within the eastern zone of Kogi State. Kogi State in turn is situated within the middle belt of Nigeria. Kogi State lies within latitudes 6°51'N to 7°54'N and longitudes 6°45'E to 7°38'E with altitude ranging from 38 to 426 m above sea level. The study area occupies part (parcels) of nine local government areas (LGAs) including Ankpa, Bassa, Dekina, Ibaji, Idah, Igalamela-Odolu, Ofu, Olamaboro and Omala. It covers an area of approximately 13,653 km$^2$ (Wikipedia, 2015). Kogi east is bounded on the west by the Niger river, north by the river Benue, east by Benue state and south by Enugu state (Figure 1).

### *2.2 Climate of the Study Area*

There are two distinct seasons in the study area which are rainy season that lasts from April to October and the dry season observed between November and March (Weatherbase, 2011). A part of the dry season is very dusty and cold as a result of the north-easterly winds which bring about the harmattan. This zone has an annual rainfall ranging from 1100 to 1300 mm with a mean of 1200 mm per annum. The average monthly temperature varies between 17 and 36°C (Amhakhian and Osemwota, 2012). The highest temperature (36°C) has been recorded during the dry season (Amhakhian and Osemwota, 2012). The mean relative humidity is lowest during the dry season and highest during the rainy season of the years, giving 15 and 67% respectively (Gideon and Fatoye, 2012).

### *Geomorphology and Physiography of the Study Area*

The area is naturally drained to the Niger and Benue rivers through their tributaries, rivers and streams forming various lowlands and floodplains. One of these rivers is Okura river which stretches over about 33.6 km within the study area (Gideon and Fatoye, 2012). Other lowland areas are found at Ibaji, Idah and Bassa Local Government Area (Olufemi, 2014). The agroecology of the selected mapping units range from wetland (2a) to savannah areas for the rest of the mapping units. The geology ranges from recent Alluvium (2a) to shales, sandstones, sandy material and undifferentiated basement complex. The relief comprises of nearly level to gently undulating and undulating plains, undulating dissected plains and undulating plains with rock outcrops and hills.

### *2.3 Mapping units and their associated ecological zone, geology, relief and soil descriptions according soil map of Nigeria*

The mapping units and their designations in terms of agroecology, geology, relief and soil descriptions as shown in soil map of Nigeria is summarized in Table 1. Among all the mapping units, only 2a is a wetland and formed from recent alluvium. It has also relatively flat to slightly undulating terrain. All other mapping units are under savannah agroecology. Their geology differed; 22a had undifferentiated basement complex, 19c from sandy materials while the rest are either shales, sandstone or both. Their relief were mostly undulating or gently undulating plains or dissected plains or with scattered rock out crops.

*Table 1: Studied Soil mapping units of Kogi East, their geology, relief and soil descriptions*

| Soil mapping units | Agroecology | Geology | Relief | Soil descriptions |
|---|---|---|---|---|
| 2a | Wetland | Recent alluvium | Nearly level to gently undulating plains | Deep well and deep poorly drained soils, sand, sandy loam, loamy sand or sandy clay loam surfaces |
| 17a | Savannah | Shales | Gently undulating plains | Loamy sand to sandy loam surfaces with underlying sandy clay loam to clay subsoils |
| 19a | Savannah | Sandstone and Shales | Gently undulating to undulating plains | Well drained with few poorly drained sandy loam, few gravelly surfaces and sandy clay loam or clay and few gravelly subsoils. |
| 19c | Savannah | Sandy materials | Gently undulating to undulating plains | Deep well drained soils, loamy sand to sandy loam surfaces over sandy clay loam to sandy clay subsoil |
| 21b | Savannah | Sandstone and shales | Undulating dissected plains | Deep well, poorly drained soils, loamy sandy to sandy loam surfaces over sandy loam to sandy clay loam subsoils |
| 22a | Savannah | Undifferentiated basement complex | Undulating plains with scattered rock out crops and hills | Generally deep with shallow well drained soils; loamy sand to sandy loam and sometimes gravelly surfaces over sandy clay loam to sandy clay and sometimes gravelly subsoil |

Adapted from soil map of Nigeria (FDLAR, 1990)

*2.4 Soil study and sampling*

A soil map of Kogi East (Figure 2) derived from the Soil Map of Nigeria (FDALR, 1990) and a topographical map of Kogi east (Figure 3) were used as base maps for the study using free survey sampling technique. Six mapping units, 2a, 17a, 19a, 19c, 21b and 22b which dominated the study area were delineated and investigated. The soils of the mapping units range from deep well drained to few poorly drained loamy sand, sandy loam to sandy surfaces underlie sandy clay loam to clay loam subsurface. Following the various physiographic positions, four soil samples from A horizons of existing soil profiles were collected with a trowel and bowl in each of the mapping units except in 19c where only two soil samples were collected due to the smaller size of the unit. Altogether, twenty-two (22) soil samples were collected from the entire study area (Figure 4). The specific international coordinates of the sample points were geo-referenced using a hand-held Etrex High Sensitivity Global Positioning System (GPS) as follows 2a1 (06$^o$59'45.8" N, 006$^o$43'38.8" E), 2a2 (07$^o$43'91.4" N, 007$^o$45'64.2" E), 2a3 (08$^o$01'51.5" N, 007$^o$35'07.2" E), 2a4 (07$^o$44'09.7"N, 006$^o$46'67.8"E), $17a_1$(07$^o$26'11.1"N, 007$^o$24'25.0"E), $17a_2$ (07$^o$27' 16.0"N, 007$^o$16'47.7"E), $17a_3$ (07$^o$29'59.9"N, 007$^o$17'04.1"E).$17a_4$ (07$^o$25'41.5"N, 007$^o$34'41.3"E), $19a_1$ (07$^o$24'29.7"N, 006$^o$49'00.3"E), $19a_2$ (07$^o$13' 26.2"N, 006$^o$54'39.3"E), $19a_3$ (07$^o$23'51.2"N, 006$^o$47'11.0"E), $19a_4$ (07$^o$55'35.7"N, 007$^o$30'59.4"E), $19c_1$ (07$^o$34'35.8"N, 006$^o$03'30.1"E), $19c_2$ (07$^o$34' 13.7"N, 006$^o$59'47.0"E), $21b_1$ (07$^o$23'28.5"N, 007$^o$02'10.9"E), $21b_2$ (07$^o$22' 09.8"N, 007$^o$01'41.2"E), $21b_3$ (07$^o$19'43.3"N, 007$^o$13'27.0"E), $21b_4$ (07$^o$10'04.8"N, 007$^o$29'11.9"E), $22a_1$ (07$^o$28'17.4"N, 007$^o$09'55.8"E), $22a_2$ (07$^o$33' 17.0"N, 007$^o$12'06.9"E), $22a_3$ (07$^o$37'25.2"N, 007$^o$13'15.0"E), $22a_4$ (07$^o$26'05.1"N, 007$^o$12'00.1"E). The soil samples collected were preserved in well-labelled polyethylene bags and transported to the University of Nigeria Nsukka Soil Science Laboratory for soil micronutrients chemical analysis.

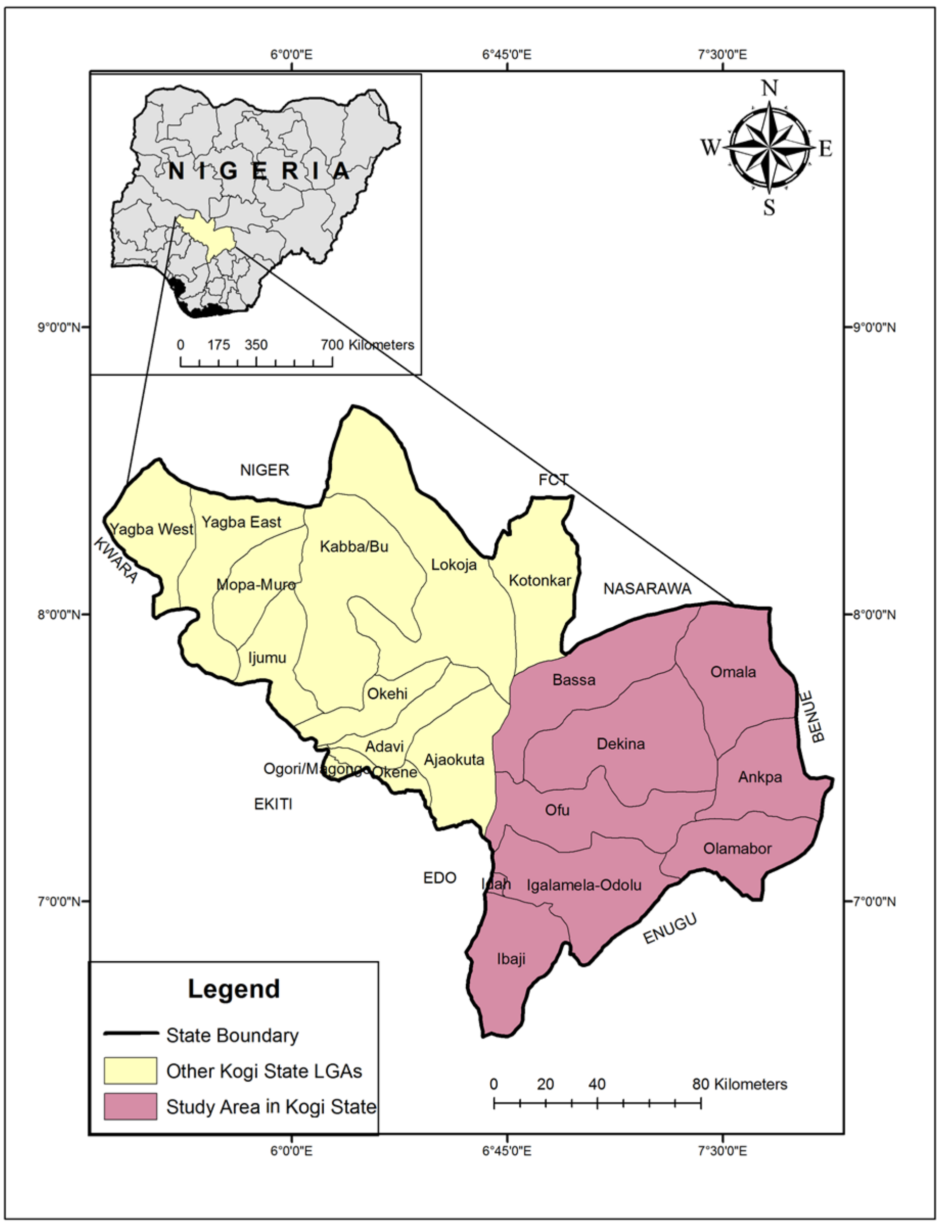


Figure 1: Map of Kogi State showing Kogi East

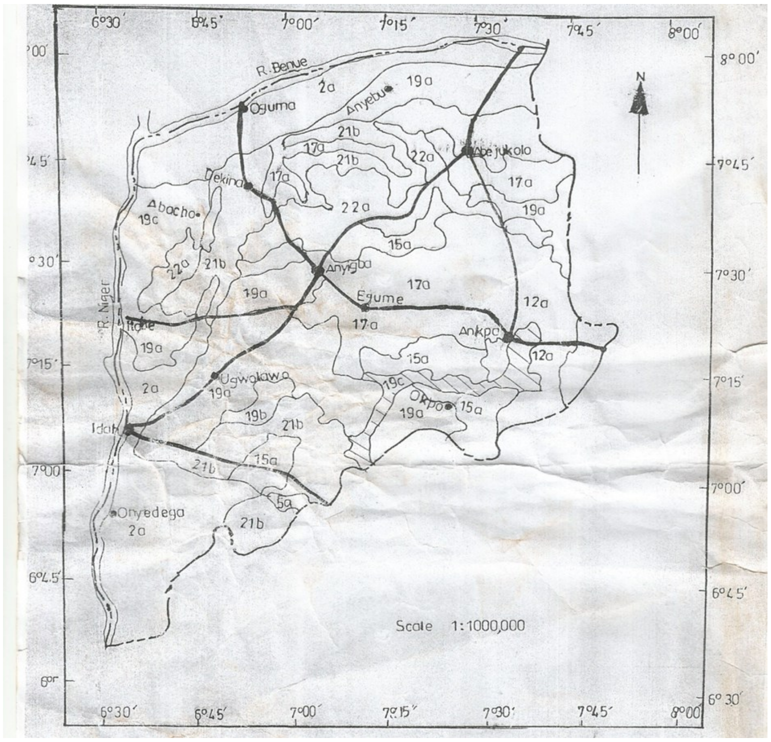


**Figure 2: Soil map of Kogi East**
Reproduced from Soil map of Nigeria (FDALR, 1990)

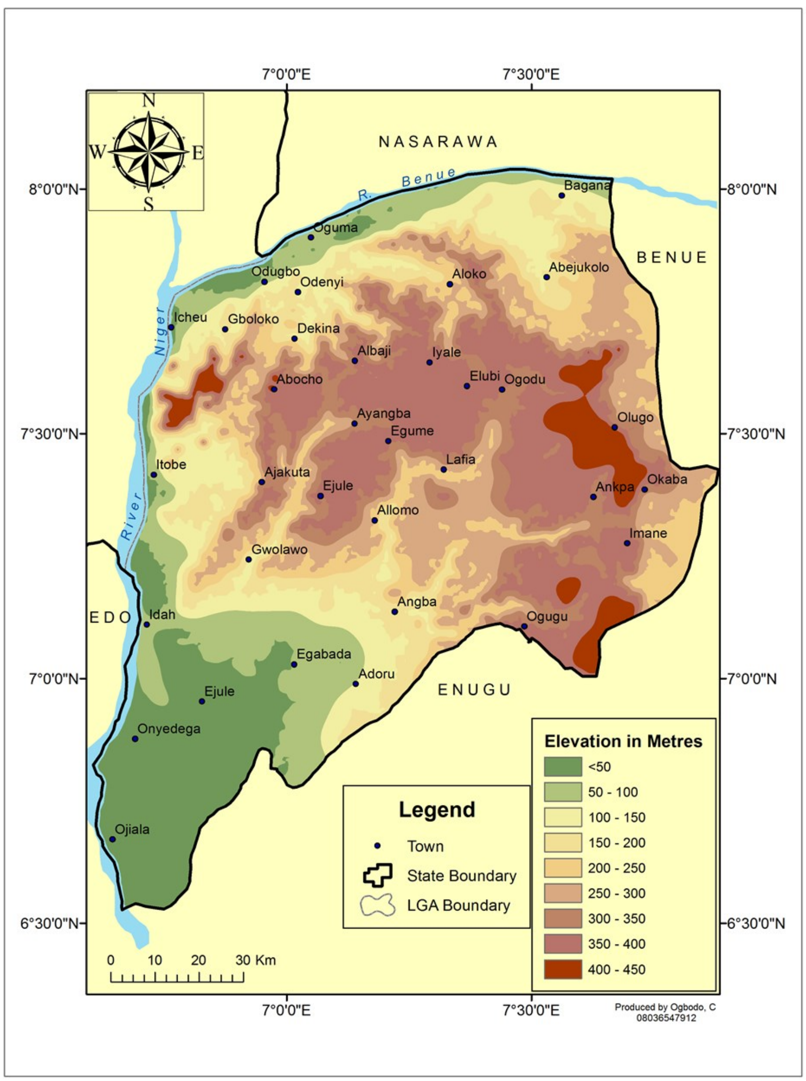


**Figure 3: A topographical map of Kogi East**

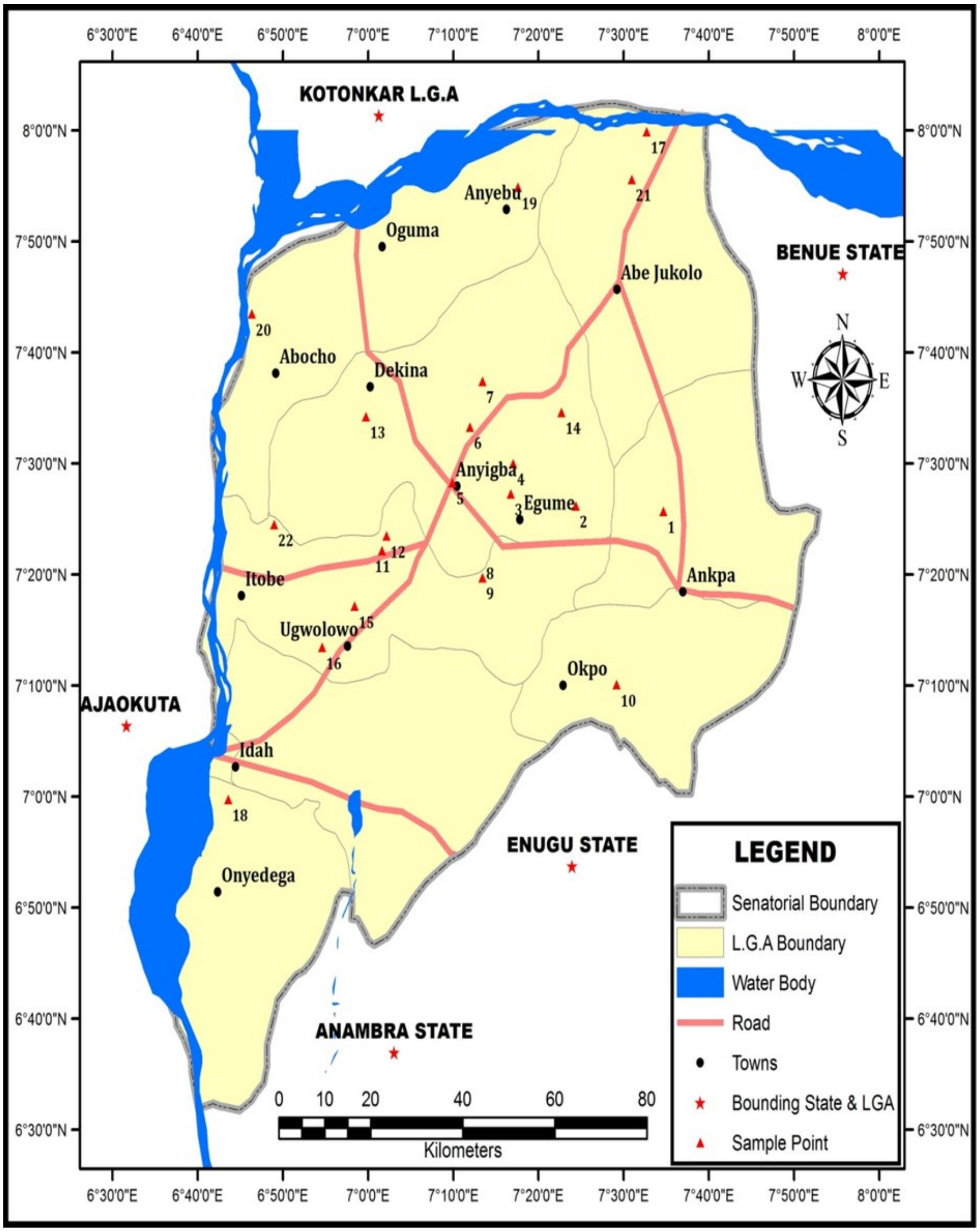


**Figure 4: A map of Kogi East showing sample points**

*2.5 Laboratory Analysis of the Soil Micro-Nutrients*

The micro-nutrients were extracted with 1N HCl solution. Iron, Boron, Manganese and Zinc in the extract were determined by Atomic Absorption Spectrometry (Carter, 1993). The extractable contents of these elements were determined. The results of the chemical analysis were compared with the critical limit classifications postulated by Lindsay and Norvell (1978).

*2.5.1 Classifications for Micro-Nutrients in Soils*

According to Lindsay and Norvell (1978), manganese, zinc and iron in the soils are classified as low when values are < 1.00, < 0.80, < 4.50 mg $Kg^{-1}$; medium when values are 1.00 – 5.00, 0.80 – 2.00, 4.50 – 10.00 mg $Kg^{-1}$; and high when values are > 5.00, > 2.00, > 10.00 mg $Kg^{-1}$, respectively. And according to Dupré et al (2019), Boron extracted with Mehlich-3 is classified as low, medium or high if value ranges < 0.65, 0.65 to 1.03 and 1.03 to 12.70 mg B $Kg^{-1}$ soil respectively. The toxicity reference values are 12.7, 5.00, 2.00 and 10.00 mg $Kg^{-1}$ for boron, manganese, zinc and iron respectively.

*2.5.2 Hazard Quotient of the Soil Micro-nutrients*

Hazard quotient (HQ) which expressed the possibility of the micronutrients in the soils to be of ecological risk or to be a contaminant of potential ecological concern was calculated as follows;

HQ = Measured concentration/Toxicity reference value (Lindsay and Novell, 1978)

HQ > 1; Harmful effects of the element is likely

HQ = 1; Element alone is not likely to cause ecological risk

HQ < 1; Harmful effects of the elements is not likely

## 3.0 Results

### *3.1 Status and Distribution of Micronutrients in surface soils of the Mapping Units of the Study Area*

The result of the extractable micronutrients from soil surfaces of the mapping units are shown in Table 2. Extractable Fe had the highest value compared to other micronutrients in all the mapping units, followed by B and Zn. The least extractable micronutrient was Mn. Manganese concentrations in the soils of the study area ranged from 0.13 to 4.07 mg $kg^{-1}$ with a mean value of 1.96 mg $kg^{-1.}$ The concentrations of Zn in the soils of the study area ranged from 0.94 to 5.44 mg $kg^{-1}$ with a mean value of 2.67 and CV of 52%. The boron concentrations ranged from 1.19 to 5.94 with highest values of 5.94, 5.64 and 5.94 mg $kg^{-1}$ obtained in $2a_1$ (Ejule-Ojebe), $2a_3$ (Bagana) and $19c_2$ (Abocho), respectively. The mean value and CV of boron were 3.52 and 42%, respectively. The values of iron ranged from 3.36 to 15.13 with highest values of 13.44, 15.12, 13.94 and 15.13 mg $kg^{-1}$ obtained in the pedons $2a_1$, $2a_2$, $2a_3$ and $2a_4$ of the 2a mapping unit. The range of values of iron gave rise to the mean value of 6.83 mg $kg^{-1}$ and CV of 55%.

### *3.2 Fertility classes of the micronutrients of soils of the mapping units in Kogi east*

Table 3 shows the fertility classes of the micronutrients of soils of the mapping units in Kogi east. Extractable B was high in all the mapping units. Extractable Mn were moderate or low in all the mapping units, while 2a, 19a, 19c and 21b were all moderate, 17a were all low, 22a1 was low and the rest of 22a were of moderate class. Extractable Zn, B and Fe were high in all 2a, but varied in other mapping units. Extractable Zn was high in all 22a mapping unit, moderate or high in all other mapping units, while Fe was completely moderate in 19a, 19c and 21b mapping units while 17a and 22a were either low or moderate classes.

*Table 2: Micronutrient status and variability of the mapping units in Kogi east*

| Pedon | Location | Extractable Manganese | Extractable Zinc | Extractable Boron | Extractable Iron |
|---|---|---|---|---|---|
| | | mg $kg^{-1}$ | | | |
| $2a_1$ | Ejule-Ojebe | 1.07 | 5.24 | 5.94 | 13.44 |
| $2a_2$ | Shintaku | 1.47 | 4.82 | 4.75 | 15.12 |
| $2a_3$ | Bagana | 1.06 | 5.44 | 5.64 | 13.94 |
| $2a_4$ | Kpata | 1.57 | 4.87 | 4.65 | 15.13 |
| $17a_1$ | Okura | 2.67 | 4.40 | 1.19 | 3.36 |
| $17a_2$ | Egume | 0.40 | 2.93 | 2.38 | 4.48 |
| $17a_3$ | Acharu | 0.27 | 2.41 | 3.36 | 3.92 |
| $17a_4$ | Ankpa | 0.13 | 1.47 | 2.38 | 5.60 |
| $19a_1$ | Itobe | 2.00 | 1.86 | 4.75 | 6.16 |
| $19a_2$ | Ugwolawo | 2.53 | 2.33 | 3.86 | 5.60 |
| $19a_3$ | Ajegwu | 2.93 | 1.94 | 1.19 | 5.60 |
| $19a_4$ | Obakwume | 2.13 | 2.13 | 2.38 | 5.60 |
| $19c_1$ | Okowowolo | 3.47 | 2.53 | 3.36 | 6.16 |
| $19c_2$ | Abocho | 3.07 | 1.73 | 5.94 | 5.60 |
| $21b_1$ | Ochadamu | 2.13 | 1.47 | 3.36 | 5.04 |
| $21b_2$ | Umomi | 3.73 | 2.13 | 4.75 | 5.16 |
| $21b_3$ | Aloma | 2.00 | 1.07 | 3.36 | 6.16 |
| $21b_4$ | Ogugu | 4.07 | 0.94 | 4.75 | 6.16 |
| $22a_1$ | Anyigba | 0.13 | 2.40 | 3.66 | 3.36 |
| $22a_2$ | Okabo | 2.40 | 2.27 | 1.19 | 4.48 |
| $22a_3$ | Ologba | 1.60 | 2.93 | 2.38 | 5.04 |
| $22a_4$ | Abejukolo- Egume | 2.27 | 1.33 | 2.38 | 5.04 |
| Range | | 0.13-4.07 | 0.94-5.44 | 1.19-5.94 | 3.36-15.13 |
| Mean | | 1.96 | 2.67 | 3.52 | 6.83 |
| CV (%) | | 58 | 52 | 42 | 55 |

CV= Coefficient of variation

*Table 3: Fertility classes of the micronutrients from soils of the mapping units in the study area*

| Mapping units | Location | Mn | Zn | B | Fe |
|---|---|---|---|---|---|
| $2a_1$ | Ejule-Ojebe | Moderate | High | High | High |
| $2a_2$ | Shintaku | Moderate | High | High | High |
| $2a_3$ | Bagana | Moderate | High | High | High |
| $2a_4$ | Kpata | Moderate | high | high | high |
| $17a_1$ | Okura | Moderate | High | High | Low |
| $17a_2$ | Egume | Low | High | High | Low |
| $17a_3$ | Acharu | Low | High | High | Low |
| $17a_4$ | Ankpa | Low | Moderate | High | Moderate |
| $19a_1$ | Itobe | Moderate | Moderate | High | Moderate |
| $19a_2$ | Ugwolawo | Moderate | High | High | Moderate |
| $19a_3$ | Ajegwu | Moderate | Moderate | High | Moderate |
| $19a_4$ | Obakwume | Moderate | High | High | Moderate |
| $19c_1$ | Okowowolo | Moderate | High | High | Moderate |
| $19c_2$ | Abocho | Moderate | Moderate | High | Moderate |
| $21b_1$ | Ochadamu | Moderate | Moderate | High | Moderate |
| $21b_2$ | Umomi | Moderate | High | High | Moderate |
| $21b_3$ | Aloma | Moderate | Moderate | High | Moderate |
| $21b_4$ | Ogugu | Moderate | Moderate | High | Moderate |
| $22a_1$ | Anyigba | Low | High | High | Low |
| $22a_2$ | Okabo | Moderate | High | High | Low |
| $22a_3$ | Ologba | Moderate | High | High | Moderate |
| $22a_4$ | Abejukolo- Egume | Moderate | High | High | Moderate |

*3.3 Hazard Quotient Values of Each Micronutrient in the Studied Area*

Hazard quotient (HQ) values of the micro-nutrient elements in the surface soils of Kogi East are shown in figure 5, thereby revealing their ecological risk status. The HQ values obtained for manganese were less than 1 in all the pedons showing that its harmful effects are not likely. Harmful effects of zinc was likely in pedons $2a_1$, $2a_2$, $2a_3$, $2a_4$, $17a_1$, $17a_2$, $17a_3$,$19a_2$, $19a_4$, $19c_1$, $21b_2$, $22a_1$, $22a_2$ and $22a_3$ where HQ values exceeded 1. On the contrary, harmful effects of zinc was not likely in pedons $17a_4$, $19a_1$, $19a_3$, $19c_2$, $21b_1$, $21b_3$, $21b_4$ and $22a_4$ where the HQ values obtained were less than 1. The HQ values of boron were less than 1 in all the pedons in Kogi. The HQ values of iron less than 1 were observed in all mapping units except in 2a's. Only 2a pedons in Kogi East have likely harmful effects of iron as their calculated HQ values were greater than 1.

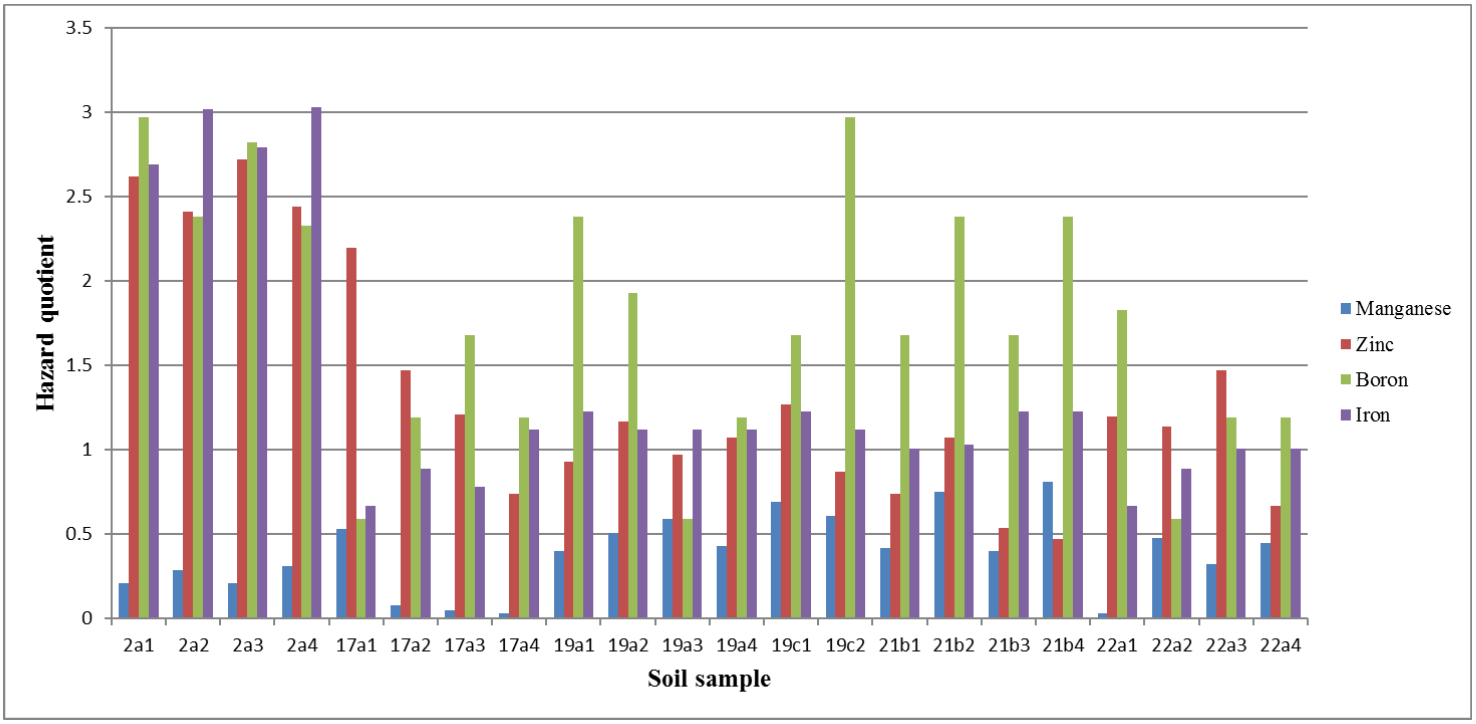


**Figure 5: Ecological risk index of the micronutrient elements in soils of Kogi East**

HQ > 1; Harmful effects of the element is likely

HQ = 1; Element alone is not likely to cause ecological risk

HQ < 1; Harmful effects of the elements is not likely

**4.0 Discussion**

The studied area consisted of wetland and savannah agroecology and this affected the micronutrient status and variability in the area. The wetland exhibited highest values in most of the micronutrient content. Davranche et al (2011) observed that significant amount of trace metals occurs in wetlands with build-up of high concentrations of iron II. Studies by Okon, and Antia-Obong (2003) in wetland soil in Akwa-Ibom south-eastern Nigeria, shows that total Fe ranged between 3.25 to 4.15 ppm. The total value of Zn also ranged from 2.4 to 4.9 ppm. In the wetland soils, the values for zinc (4.82 to 5.44) are similar but extractable Fe in the studied area were higher than in Okon, and Antia-Obong (2003). Other mapping units varied in their content on micronutrients which could have resulted from their geology, which differed among the mapping units.

Low pH has been identified to cause micronutrient toxicity in soils (Enwenzor *et al*., 1989). Reports of Brady and Weil (2002) and (Marx *et al*., 1999) showed that the availability of most of the micronutrients in the soils depends on soil pH as well as organic carbon contents. Lombin (1983) also reported that organic carbon and clay fractions of soils are the mainstay of extractable micronutrients in the soil. According to Sillanpaa (1982), intensive plant production practices have increased crop yields, resulting in greater removal of micronutrients from soils. The available manganese content of the soils of the study area ranged from low to moderate. However, high values were obtained in $19c_1$, $21b_2$, $21b_4$ and $19a_4$ as shown in Table 1. The values obtained in these pedons were well above the critical limit (1.0 mg $kg^{-1}$) of Lindsay and Norvell (1978). This may have resulted from the pH conditions of these soils. Ukabiala (2019) reported low pH conditions of soils in Kogi East. Manganese is very soluble at pH values lower than 5.5.

The available zinc in the surface soils of Kogi East was moderate to high. However, highest values were obtained in $2a_1$ and $2a_3$ which occurred on floodplain (Table 1). This result is in contrast to the finding of Raju *et al*. (2005) who reported deficient levels of available zinc in Chandragiri Mandal of Chittoor District and Nellore District, all in Andhra Pradesh. This variation is supported by the fact that zinc deficiency is associated with calcareous soils and is accentuated by prolonged flooding (IRRI, 1973). Thus, the Andhra Pradesh soils are calcareous while the soils of Kogi East are lower in pH. Boron levels in the soils of Kogi East were observed to be high in availability in all the mapping units. The higher concentration in 2a may have resulted from alluvial deposits in 2a mapping unit, and in-situ parent materials in which the soils (19c) formed. The availability of boron is related to the soil pH and it is being most available in soils of low pH. While boron is most available at low pH, it is also rather easily leached from acid soils. Thus, deficiency of boron in acid soils occurs because of the low supply of total boron rather than because of low availability of the boron present (Brady and Weil, 2002). Brady and Weil continued to postulate that boron so adsorbed is quite tightly bound especially between pH 7 and 9, the range at lowest availability of this element. Hence, boron deficiencies are common in calcareous *Aridisols* and in neutral to alkaline soils with high pH. These reasons may have contributed to the moderate to high levels of boron obtained in most pedons in Kogi East studied.

Low, moderate to high contents of iron were observed in the pedons of Kogi East. All the surface soils of 2a soils had extractable iron content higher than 13.90 mg $kg^{-1}$ (Table 1). Donahue and Miller (1995) opined that the major problem with soil iron is that it has very low solubility in soil solutions and its availability is dependent on how to keep iron sufficiently soluble for plants to absorb enough of it. Thus, in strongly acidic solutions, below pH 5, iron becomes increasingly soluble and is rarely deficient. The high availability of iron in the 2a pedons may have resulted from reduced ferrous iron ($Fe^{2+}$), formed in anaerobic condition. The reason for the moderate levels of iron in the other pedons is the favourable soil pH. Soil pH has dominant influence on iron solubility. Donahue and Miller (1995) reported that at about pH 3, iron is soluble enough to supply plant needs, but plants are usually poisoned by toxic levels of aluminium. However, iron deficiencies are also most common in calcareous soils, arid soils and soils cropped to high iron demand plants (Donahue and Miller, 1995).

**5.0 Conclusion**

The outcome of the research indicated that iron contents recorded the highest values, followed by boron as measured in mg $kg^{-1}$. The values of HQ showed that zinc in this region, had the highest values, thus an indication that this element could pose high ecological risk in the area due to level of availability. Iron in 2a had HQ > 1, showing ecological risk in the area of the mapping unit. The physiographic and parent material variations of the landscape may have led to the moderate and high variations of iron content across the mapping units within the region since the soils occurred on varied toposequences as seen in Figure 3 and Table 1.

**References**


Amhkhian, S.O. and Osemwota, I.O. (2012). Characterization of phosphorus status in soils of the guinea savannah zone of Nigeria. *Nigerian Journal of Soil Science*, 22 (1):37-43.

Brady, N.C. and Weil, R.R. 2002. *The Nature and Properties of Soils*. Pearson Education, Inc. New Jessy, USA.

Carter, M.R. (Ed.) (1993). *Soil Sampling and Methods of Analysis*. Lewis Publishers, Boca Raton, Florida. pp 368.

Davranche, M., Grybos, M., Gruau, G., Pédrot, M., Dia, A. and Marsac, R., 2011. Rare earth element patterns: A tool for identifying trace metal sources during wetland soil reduction. *Chemical Geology*, *284*(1-2), pp.127-137.

Donahue, R.L. and Herren, R.V. (1991). *The Agriculture Dictionary*, Deliner Publishers Inc. New York, pp326.

Dupré, R.L.C.; Khiari, L.; Gallichand, J.; Joseph, C.A. (2019) Multi-Factor Diagnostic and Recommendation System for Boron in Neutral and Acidic Soils. *Agronomy*, *9*, 410. https://doi.org/10.3390/agronomy9080410

Enwezor, W.O., Udo, E.J., Usoro, N.J., Ayotade, K.A., Adepetu, J.A., Chude, V.O. and Udegbe, C.I. (1989) Fertizer use and management practices for crops in Nigeria. *Series 2. Federal Procurement and Distribution Division, Federal Ministry of Agriculture, Water Resources and Rural Development, Lagos.* pp163.

FFTC, (2001). The functions and critical concentrations of micronutrients in crop production. Food and Fertilizer Technology Center. http://www.agnet.org/library/bc/51001/.

Fisseha Itana, (1992). Macro and micronutrients distributions in Ethiopian Vertisols landscapes. PhD Dissertation, University of Hohenheim, Germany. pp201.

Gideon, Y.B. and Fatoye, F.B. (2012). Sediment Geochemistry of river Okura: Implication to Weathering and Transport (EJES). 7:103-111.

IRRI, (1973). Annual Report. International Rice Research Institute, Los Banos, Philippines.

Kefas, P.K., Ukabiala, M.E. and Azuka, C.U. (2016). The physical properties and micronutrients status of Mayo-gwoi floodplain in Taraba state, Nigeria. *International Journal of Plant and Soil ScienceI.* 10(6):1-8.

Krauskopf, K.B., (1972). Geochemistry of micronutrients. *In*: J.J. Mortvedt, P.M. Giordano and W.L. Lindsay (eds.). Micronutrients in Agriculture. Soil Science Society of America, 13(9):7-35.

Lindsay, W.L. and Norvell, W.A. (1978). Development of DTPA soil test for zinc, iron, manganese and copper. *Soil Science Society of America Journal,* 43:421-428.

Lombin, G. (1983). Evaluating the micronutrient fertility of Nigeria's semiarid savannah soils. *Soil Science*, 136: 42-47.

Marx, E. S., Hart, J. and Stevens, R. G. (1999). Soil Test Interpretation Guide, Oregun State University Extension Service.

Nazif, W., Perveen, S. and Saleem, I. (2006). Status of Micronutrients in soils of District Bhimber (Azad Jammu and Kashmir).*Journal of Agriculture and Biological Science*, 1: 34-40.

Okon, A.O. and Antia-Obong, E., 2003. Micronutrient dynamics in some wetland soils of south-eastern Nigeria. *Journal of Environmental Sciences*, *15*(1), pp.38-42.

Raju, D.B., Naidu, M.V.S., Ramavatharam, N., Venkaiah, K., Rama, G.R. and Reedy, k.S. (2005). Characterization, classification and evaluation of soils in Chandragiri Mandal of Chittor District, Andhra Pradesh. *Agropedology*, 15(1):55-62.

Sillanpaa, M. (1982). Micronutrients and the nutrient status of soils: A Global Study. (Rome: U.N. Food and Agricultural Organization).

Ukabiala, M.E. (2019). *Characterization, Classification and Suitability Evaluation of Soils of Eastern Kogi State of Nigeria for Rice, Maize, Cassva and Oil palm Production.* Thesis submitted to the Department of Soil Science, University of Nigeria, Nsukka. Unpublished.

Weatherbase (2011). Historical Weather for Lokoja, Nigeria. http://www.weatherbase.com/weather/weather.php 3?s=3425&refer=wikipedia. Retrieved on November 24th, 2011.

Wikipedia (2015).Weather.