#7654 DIGITAL MAPPING OF EXCHANGEABLE CATIONS IN SOILS OF SOUTHWESTERN NIGERIA

M.K. Idowua*, O.E. Awosiyana and E.A. Adesinab
[a]Department of Soil Science and Land Resources Management, Faculty of Agriculture, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria; [b]Department of Geography, Faculty of Science, Obafemi Awolowo University, Ile-Ife. Osun State, Nigeria
midowu@oauife.edu.ng; +234 803 8272 331

ABSTRACT

The study created Geo-database and developed a digitized map of soil exchangeable cations indicating the spatial distribution in soils of southwestern Nigeria. The existing electronic and hard copy records were used for secondary data and geographical coordinates of locations where the primary data of exchangeable cations were obtained. Geographic information system (GIS) was used to show the regional level perspective of the cations. Topographical maps were used for extraction and update while shape file of administrative map of each state within the region was geo-referenced to World Geodetic System of 1984. The cations were interpolated using kriging technique in ArcGIS® 10.4 environment. The data collected were subjected to geostatistical analysis. Results showed that exchangeable calcium has the highest average concentration and the spread around the mean value was least in exchangeable potassium. Exchangeable calcium and magnesium which have skewness values of 0.34 and 0.92 respectively, were more normally distributed than exchangeable potassium and sodium which has skewness values of 3.07 and 2.79 respectively. Exchangeable calcium contents were dominantly low in major parts of southwestern Nigeria but high at the eastern fringes of Ogun and Lagos States and southern fringe of Oyo State. The low soil exchangeable magnesium and K were low while exchangeable sodium was low to medium. The study concluded that digitized map of exchangeable cations showing their spatial distribution could be used as digital nutrients map and could also form basis for precise fertilizer recommendation.

Keywords: exchangeable cations, digitized map, Geographic Information System, soil fertility

INTRODUCTION

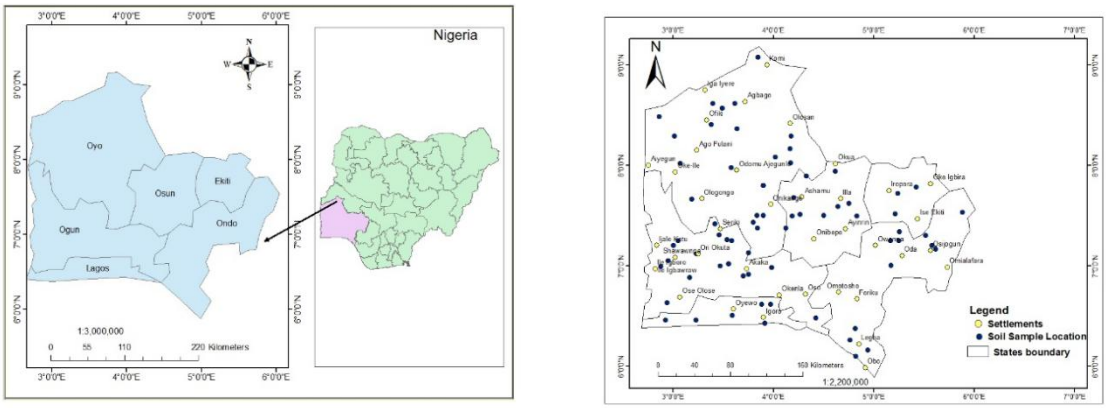
Soil fertility depletion has been established as one of the major factors for decline in crop yield, low quality resulting in poverty among smallholder farmers in Nigeria in particular and sub-Saharan Africa in particular (Aduayi, 1989, Adepetu *et al*., 2014; Idowu *et al.,* 2020; Egbebi *et al.*, 2020). The current blanket method of fertilizer application could be the reason that discourage farmers from using fertilizer. The average fertilizer usage SSA is about 17 kg / ha, which is the lowest in the world. There is the need to used resources including fertilizer in an efficient way which is one of the philosophies of precision agriculture. Information on soils in African continent and their characteristics are scanty, with its constrain in agricultural development (Omran, 2005; Lal, 2020). Soil information maps available have not been used for research because they are not available in digital formats. Soil models essentially do not yield empirical results due to inadequate basic soil data (Stroosnijder, 2005). This makes geospatial data, methods and tools simply defined as information with geographical component to be relevant for Agriculture.

It was evident that most of the locations where good quality and reliable soil data were obtained were not geo-referenced. There is a huge reservoir of soil data on exchangeable cations which are not available to users in southwest Nigeria. Hence, this study were to collated exchangeable cations data to produce digital map and developed a digitized map of soil cations with their spatial distribution in soils of southwestern Nigeria.

MATERIALS AND METHODS

The study was carried out in Southwestern Nigeria located within latitudes 5^0 52′ 52.12″ N and 9^0 12′ 44.60″ N and longitudes 2^0 38′ 42.39″ E and 6^0 0′ 17.66″ E. It comprises of Lagos, Ogun, Oyo, Osun, Ondo and Ekiti states (Figure 1). Mean annual rainfall ranges between 1200 mm and 1900 mm and temperature ranges from 26 ^{0}C to 32 ^{0}C (Akintola, 1986). The secondary data used were obtained from electronic publications and hard copies of data record on exchangeable cations. Topographical maps at the scale of 1:50,000 were used for the extraction of settlement name for each sample point. The settlement names were updated on the topographical map using google earth satellite image. The coordinates of the locations where the exchangeable cations and their respective values were collected from existing electronic and hardcopy records. Some of the exchangeable cation values with only location but without geographic coordinates (latitude and longitude) were carefully located and their geographic coordinates collected with the aids of a hand-held Global Positioning System Receiver. Figure 2 shows the soil sample points map of soil exchangeable cations. The shape file of the administrative map of Southwest Nigeria containing all the states within the region was geo-referenced to World Geodetic System (WGS, 1984).

GIS was used to show regional and state level perspective of exchangeable cations in southwest Nigeria. Geo-database was created and the value fields for exchangeable cations (Ca^{2+}, Mg^{2+}, K^+ and Na^+) were entered into the attribute table in GIS environment. To show spatial variation of the exchangeable cations for southwest region, kriging interpolation was done.



(a) **(b)**

Figure 1. (a) Administrative Map of the Study Area and (b) Map showing soil sample points

RESULTS AND DISCUSSION

Exchangeable calcium content of soils in southwest Nigeria was relatively low due to the climatic conditions and some human factors that contributed to the depletion and loss of the cations (Figure 2). The nature of the parent materials, the soil forming processes and the particle size distribution as well as soil organic matter content might have also affected the

content. High values which ranges between 10.00 and 20.00 cmol/kg at the extremes of Lagos state shows its dominant concentration. The low Ca^{2+} content generally could be related to dominance of 1:1 type of clay minerals in the soils of Lagos state (Akamigbo, 2001), which was associated with the sandy nature of soils and low organic matter which might have evolved from flooding or colluviation (Essoka and Namaku, 2007). Exchangeable calcium of Ogun state soils was dominated by low to moderate values. The weathering of minerals in these soils was strongly influenced by high rainfall and temperature that had a significant impact on the weathering of feldspar and mica that played a significant role in the mineralization of kaolinite which is an important clay mineral of Ogun state soils for food crop production (Fernandes *et al.* 2011). High exchangeable calcium in Oyo state might be due to recycling and fallowing process in soils from accumulation of refuse and waste disposal (Areola, 1982). The exchangeable calcium content of Ondo State soils was related to the medium grained granite and gneiss as parent rock and materials (Periaswamy and Ashaye, 1982) and land use types. Low calcium content in Ekiti State indicates that the soils would have low ability to retain nutrients (Negassa, 2001; Fashina, 2005) due to continuous cultivation, leaching of plant nutrients, weathering, runoff and major crop harvest (Senjobi and Ogunkunle, 2011).

Low exchangeable magnesium (Figure 2) and low to medium for exchangeable potassium and sodium in this region. This could be linked to deforestation in some secondary forest and reduced soil cover in some parts of the states (Wakene and Negassa, 2001).

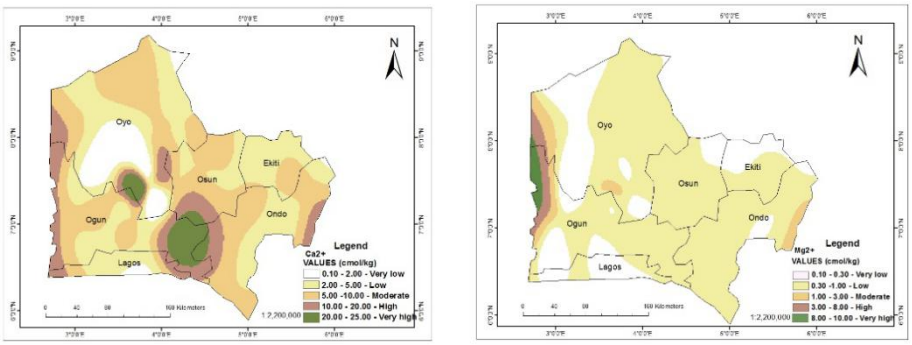


Figure 2. Spatial Distribution of (a) Exchangeable Calcium and (b) Exchangeable magnesium of Southwest Nigeria Soils Analyzed using GIS

The exchangeable potassium of the soils of this region are dominated by low to moderate values but high at the northern and southern fringe of Oyo state and towards the eastern fringe of Ogun state. The low to moderate values might be due to potassium fixation in soils of Southwest region especially when K fertilizers are applied. Also, some pedogenic and anthropogenic conditions as well as high rainfall in most part of the regions would have influenced little variation in the exchangeable K content (Kiflu and Beyene, 2013).

Low to moderate values of exchangeable sodium were also dominant in soils of south-western Nigeria and high towards the Northern to Central part of Oyo state. It was also high at the fringes of Ogun, Lagos, and Ondo states. This could be due to the selective mobilization of cations as well as micronutrient content in the soils of some part of southwest Nigeria influences the availability of exchangeable sodium in different soil types. Restricted leaching of cations in oil palm dominated states also have a positive influence on exchangeable sodium accumulation on the soils of southwestern Nigeria (Odjugo, 2015).

CONCLUSIONS

The study concluded that digitized map of exchangeable cations showing their spatial distribution could serve as a tool for digital nutrients map and also form basis for precise fertilizer recommendation and precision agriculture in Nigeria.

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