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RESEARCH ARTICLE **OJAS0601001-724**

SPATIAL DISTRIBUTIONS OF SOIL CHEMICAL PROPERTIES IN WETLAND SOIL HORIZONS OF EKITI STATE, SOUTHWEST NIGERIA.

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ABSTRACT

Wetlands play a pivotal role in maintaining ecological balance through nutrient cycling, carbon sequestration, and biodiversity conservation. This study explores the spatial distribution of soil chemical properties in wetland soils of Ekiti State, Nigeria, to guide sustainable management practices. Soil samples were collected from designated horizons across thirteen locations (13 pedons) in Ekiti State. Laboratory analysis included particle size distribution, organic carbon, nitrogen, phosphorus, exchangeable bases, and electrical conductivity (EC). ArcGIS interpolation techniques were employed to visualize spatial patterns. Results revealed pH values ranging from acidic to neutral across horizons, with Ayede exhibiting neutrality in the surface layers. EC varied, peaking at Ilawe (0.87 dS/m) and Igbara-Odo (0.73 dS/m). Organic carbon was highest at surface horizons, with Igbara-Odo recording 96.62%, while nitrogen levels were significant at surface layers, reaching 4.76% in Ilawe. Phosphorus displayed similar trends, ranging from 3.47–41.53 mg/kg, attributed to surface organic matter accumulation. Exchangeable bases—potassium, sodium, calcium, and magnesium, had low to moderate distribution levels, influenced by leaching and hydrological dynamics. The findings emphasize the heterogeneity of soil properties, underscoring the need for tailored soil management. Regular monitoring, conservation of organic-rich areas, and the application of organic amendments are recommended to enhance soil fertility and ecological function. GIS mapping is invaluable for targeting interventions and ensuring sustainable wetland use amidst climate challenges and anthropogenic pressures.

Keywords: *Management, Spatial distribution, Soil properties, Sustainable, Wetlands.*

INTRODUCTION

Wetlands, often referred to as the "kidneys of the landscape," are critical ecosystems that provide numerous ecological services, including water purification, flood regulation, and biodiversity support (Gearey *et al*., 2020). Their unique hydrology and biological activity lead to distinctive soil chemical properties, which play a fundamental role in maintaining their ecological functions (Megonigal and Neubauer, 2019). In wetland soils, effective management and conservation methods require an understanding of the spatial distribution of soil properties, especially in light of growing anthropogenic pressures and climate change. The spatial variability of soil chemical properties in wetlands is governed by a complex interplay of factors such as hydrological dynamics, vegetation type, parent material, and human interventions (Wang *et al*., 2020). Chemical properties like pH, organic carbon, total nitrogen, phosphorus, and micronutrients often exhibit significant heterogeneity across wetland landscapes (Rasekoele, 2016). This variability is critical to the functionality of wetlands, influencing nutrient cycling, carbon sequestration, and the support of plant and microbial communities (DeLaune *et al*., 2018). However, improper land use practices and drainage activities often disrupt these delicate balances, underscoring the need for detailed spatial assessments. Spatial patterns of soil properties are often studied using geostatistical tools, which enable researchers to map and analyze the distribution of soil nutrients and other properties. For instance, studies by Zhang *et al*. (2021) demonstrated that soil organic carbon in wetland soils varies significantly at micro and macro scales due to differences in hydrological regimes and vegetation coverage. Similarly, Lin *et al*. (2018) reported that phosphorus and nitrogen distributions are highly influenced by water flow patterns, deposition processes, and anthropogenic activities. These findings highlight the necessity of spatially explicit data to support sustainable wetland management practices. Another critical aspect of wetland soil properties is its role in carbon storage and greenhouse gas emissions. Wetland soils are major reservoirs of organic carbon, accounting for approximately 30% of global terrestrial carbon stocks despite occupying only 1.3% of the Earth's land surface (Poulter *et al*., 2021). The spatial variability of soil organic carbon in wetlands has been linked to factors such as elevation gradients, water table depth, and vegetation types, which collectively affect carbon sequestration potential (Lewis and Feit, 2015). Understanding these spatial distributions is pivotal in mitigating climate change impacts. Moreover, wetland soils are hotspots for nutrient transformation processes, including nitrification, denitrification, and phosphorus cycling, which are tightly regulated by their chemical properties. For instance, studies by Salimi *et al*. (2021) showed that variations in redox potential and pH significantly influence nutrient availability and microbial activity. Zhang *et al*. (2016) declared that these processes exhibit spatial heterogeneity due to differences in hydrological connectivity and soil texture, further emphasizing the need for targeted soil management approaches. The objective of the study is to investigate the spatial distribution of soil properties in wetland soils of Ekiti State, Southwest Nigeria.

MATERIALS AND METHODS

Description of Study Site

The study location is situated in Ekiti State, southwestern Nigeria. It lies between longitudes 40°51′ and 50°451′ east and latitudes 70°151′ and 80°51′ north of the Equator. The state experiences a tropical climate characterized by distinct wet and dry seasons. The rainfall distribution is bimodal, with peaks in June and September, and a brief dry spell between late July to mid-August (August break). The mean annual total rainfall is approximately 1387 mm occurring over an average of 112 rainy days per year. Temperatures remain relatively uniform throughout the year with a mean of 27° c, though February and March are the hottest averaging around 28° c. Ekiti state is part of Nigeria's Precambrian Basement Complex geology, The vegetation is a mix of tropical forest, prevalent in the southern parts, and savannah, which is found in the northern peripheries. The land is characterized by various forms of bush growth, creepers, and grasses.

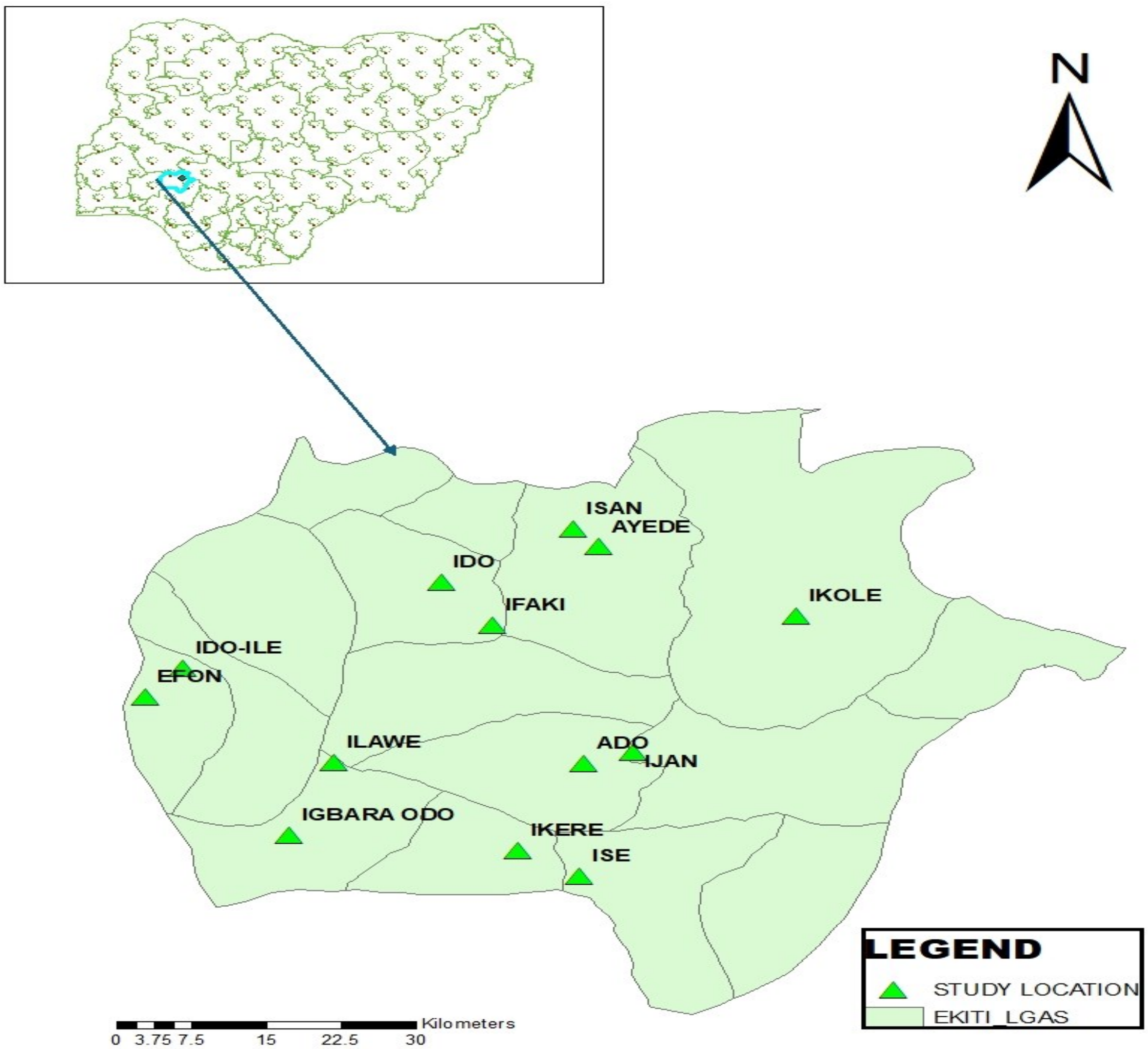


Figure 1.1: The Map of Ekiti-State showing the study locations.

Fieldwork and Soil sampling

A pedon (1.5 m wide x 1.0 m long x 1.5 m deep) was established at each study site. The pedon locations were Geo-referenced using the Global Positioning System (GPS). Each pedon was described following the procedure described in the USDA Soil Survey Manual (Soil Science Division Staff, 2017). The soil morphological properties were observed and described for each horizon in the pedons. 500 g soil sample was collected from each designated horizon. The samples were neatly packed inside labelled polythene bags and taken to the laboratory for analysis.

Laboratory analysis

The soil samples were gently crushed to break up the peds and subsequently sieved with a 2 mm sieve. Materials that passed through the sieve were labeled 'fine earth' (< 2 mm) fractions, the fine earth (material < 2 mm) was weighed and separated for further analysis. The following parameters on soil physical and chemical properties were determined: Particle size distribution was determined by Gee and Bauder (1986) method. The Bulk density was determined by Grossman and Reinsch's (2002) method, organic carbon was determined using the Walkley and Black method as described by Nelson and Sommers (1982), and was converted to organic matter using a coefficient of 1.724. Total Nitrogen (N) was determined using the kjeldahl method of nitrogen determination Bremmer (1966). Available Phosphorus (P) was determined by Bray's method (Kuo, 1996). Exchangeable bases (calcium, magnesium, potassium, and sodium) in the soil were determined using the ammonium acetate extract from the CEC determination (Thomas, 1982). Soil electrical conductivity (EC) is measured by a conductivity meter.

Spatial Data analysis

The spatial distribution pattern was done using ARC GIS Version 10.8 software developed by the Environmental System Research Institute (Esri). The images were geo-referenced, classified, and digitized. The resulting data from the samples collected were used to generate the spatial distribution maps for the study area using the inverse distance weighted (IDW) interpolation technique.

RESULTS AND DISCUSSIONS

Spatial Distribution of Soil Chemical Properties

The spatial distribution of soil chemical properties in Ekiti State (Ado, Ayede, Ido, Ido-ile, Efon, Igbara-Odo, Ilawe, Ifaki, Ikere, Ikole, Ijan, Isan, Ise) is presented in Figure 1- 14.

Figures 1-4 revealed the soil pH properties at horizons A_1, A_2, Btg_1, and Btg_2 in all the locations. The pH value ranges from 4.34 -7.67 in all the horizons. The pH in all the locations is acidic, except For Ayede which is neutral in A_1 horizon, A_2 horizon revealed that the pH values at Ayede and Isan are also neutral, at horizon Btg_1 the pH value in the pedon at Ayede is also neutral while Ado is moderately alkaline. The acidic level decreases in the profile, possibly due to leaching processes, these conditions can hinder plant growth by limiting nutrient availability and microbial activity, necessitating soil amendment strategies like liming (Tang *et al*., 2013). The results are also in agreement with Fasina *et al*. (2007) because the pH values obtainable at the different locations fall within the optimal range for some soils on the basement complex geology.

Figure 5-8 revealed the Electrical conductivity (EC) properties at horizons A1, A2, Btg1, and Btg2 in all the pedons. The figures indicate that EC is higher in Igbara-Odo (0.73) and Ilawe (0.86) compared to other locations for A_1 horizons. The A_2 horizons indicated that higher values were recorded at the pedon in Ikole (0.62) compared to other locations. At horizon, Btg_1 and Btg_2, the highest value for EC were recorded at the Ilawe pedon (0.87 and 0.64). The soils are non-saline because the values were below the critical level of 4.00 dsm m-1 as suggested by Brady and Weil (2005).

Figure 9-12 revealed the soil Nitrogen properties at horizons A_1, A_2, $Btg_{1,}$ and Btg_2 in the study locations. The percentage Nitrogen value ranges from 0.42-4.76 in all the pedons. The figures indicate that the percentage of Nitrogen in all the locations was very high at the surface horizons (A_1) with the highest value recorded at Ilawe (4.76) while the lowest value was in horizon Btg_2 at Igbara-Odo (0.42). This also corresponded with research by Babalola *et al*. (2021) and Adegbite *et al*. (2019), who reported that the distribution of TN was usually observed to be highest at the surface horizon.

Figure 13-16 revealed the soil Phosphorus properties at horizons A_1, A_2, $Btg_{1,}$ and Btg_2 in all the study locations. The Phosphorus value ranges from 3.47-41.53 in all the locations. Similar to OC and TN, higher values were recorded at the surfaces. Eriksson *et al*. (2016) and Yuan *et al*. (2021), reported that the highest value of phosphorus in the surface horizon is likely from organic matter and fertilizers. Eriksson *et al*. (2016) also noted that the decrease in the subsoils is possibly due to leaching, then rises again with depth, possibly due to phosphorus accumulation.

Figure 17-36 revealed the soil exchangeable K, Na, Ca, and Mg properties at horizons A_1, A_2, $Btg_{1,}$ and Btg_2 in the study locations ranged from 0.05-1.96, 0.11-1.07, 0.2-6.2, and 0.1-5.6, respectively. The values suggest a low to moderate distribution level. Potassium and sodium decrease throughout the soil profile, likely leaching downward. Calcium and magnesium consistently decrease as well, possibly due to leaching or uptake by plants (Osman and Osman **2018)**. Ayodele and Babalola (2021) illustrated that lower levels of exchangeable bases suggest leaching and low nutrient retention capacity, while Shaheen *et al*. (2019) assert that frequent leaching from flooding, high organic matter leading to acidity, and redox conditions can limit the availability and retention of exchangeable bases.

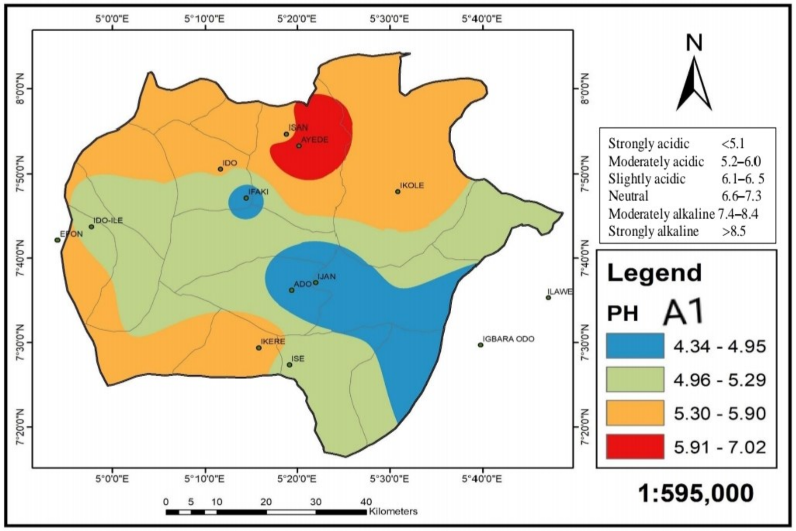


Figure 1: A map showing the soil pH properties at horizon A1

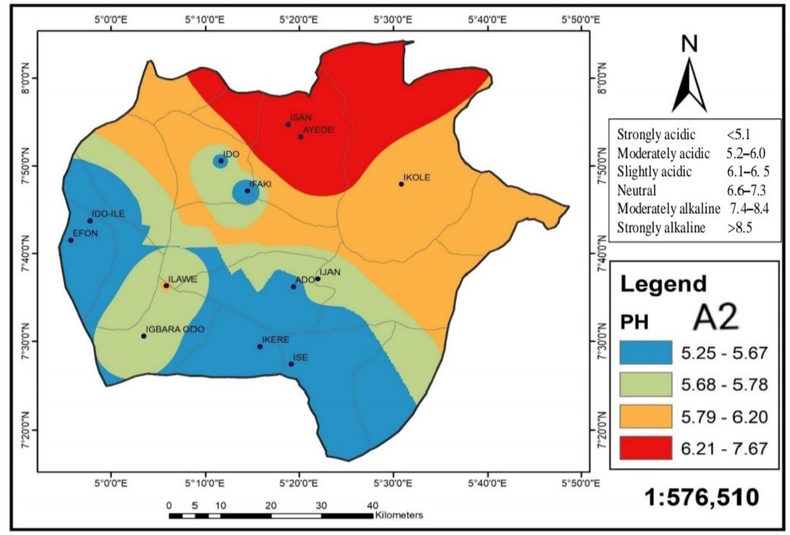


Figure 2: A map showing the soil pH properties at horizon A2

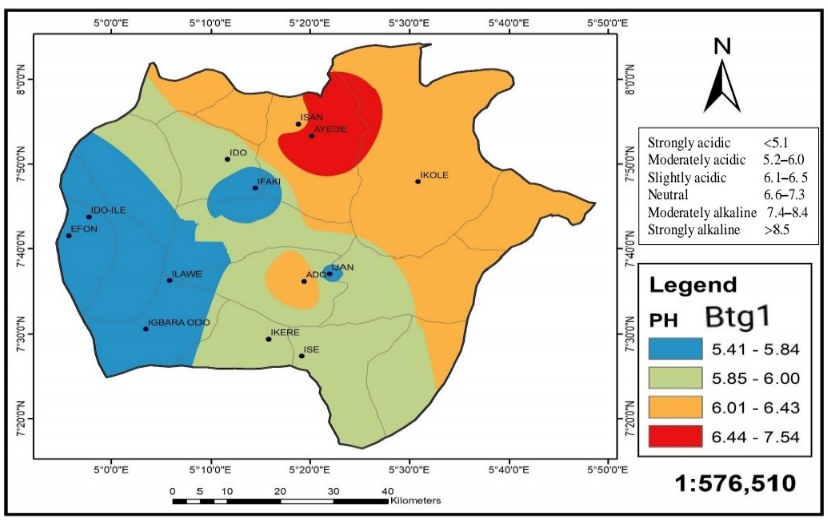


Figure 3: A map showing the soil pH properties at horizon Btg1

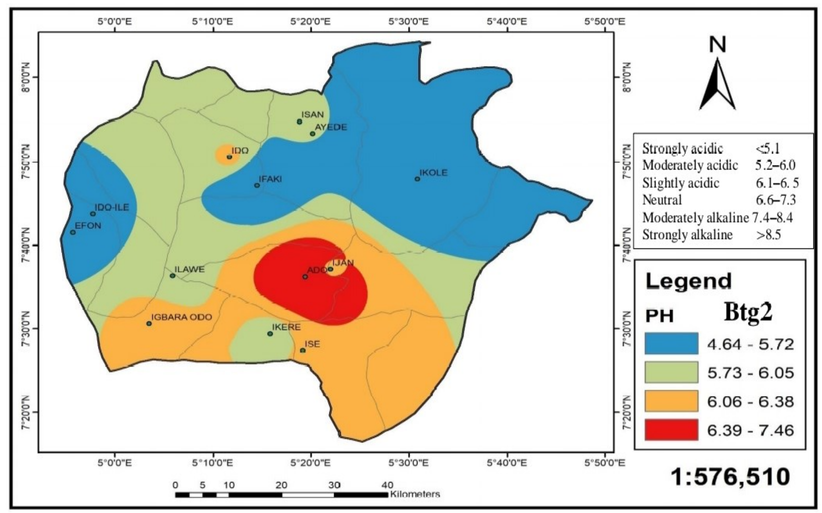


Figure 4: A map showing the soil pH properties at horizon Btg2

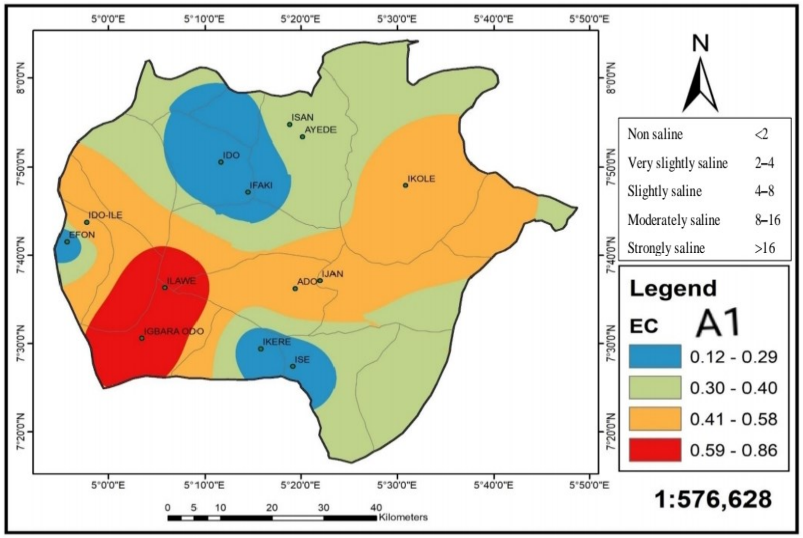


Figure 5: A map showing the soil EC properties at horizon A1

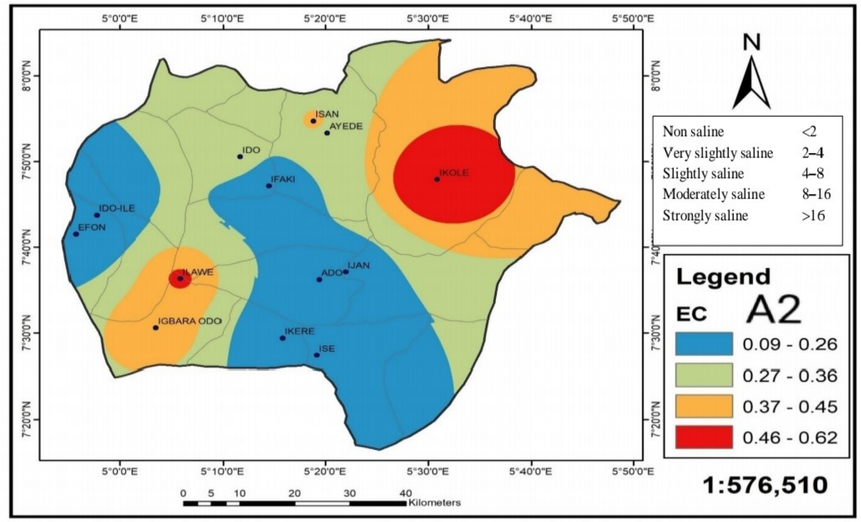


Figure 6: A map showing the soil EC properties at horizon A2

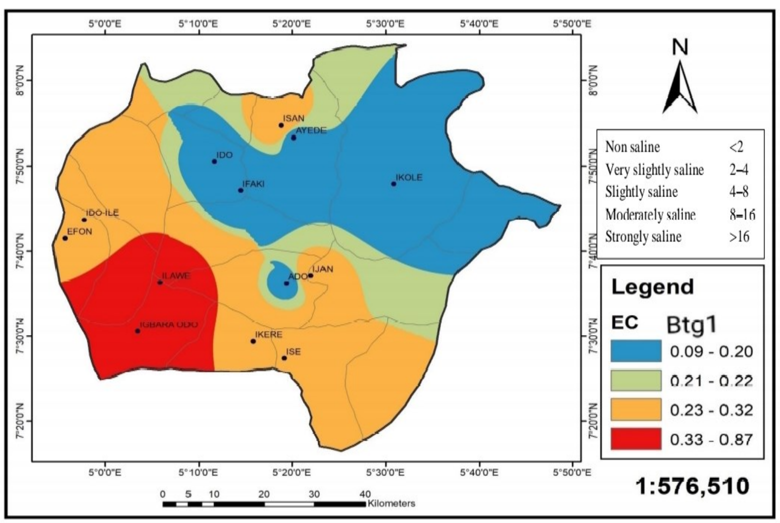


Figure 7: A map showing the soil EC properties at horizon Btg1

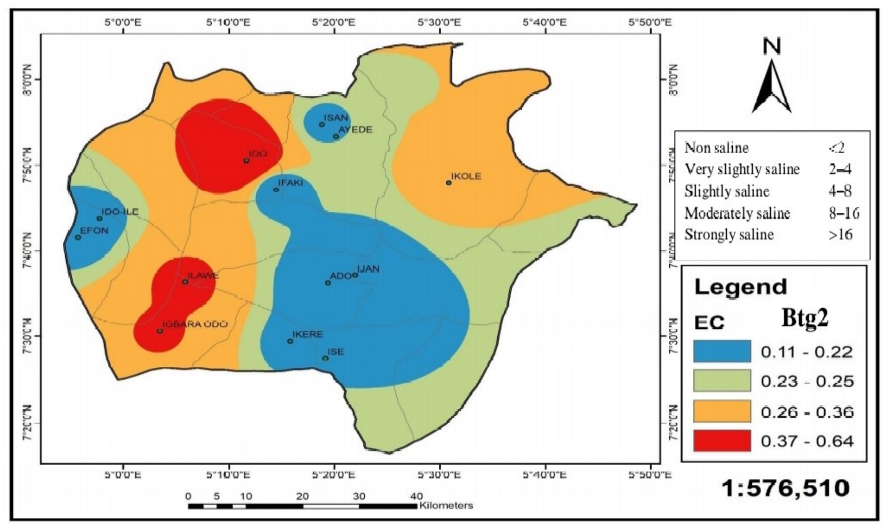


Figure 8: A map showing the soil EC properties at horizon Btg2

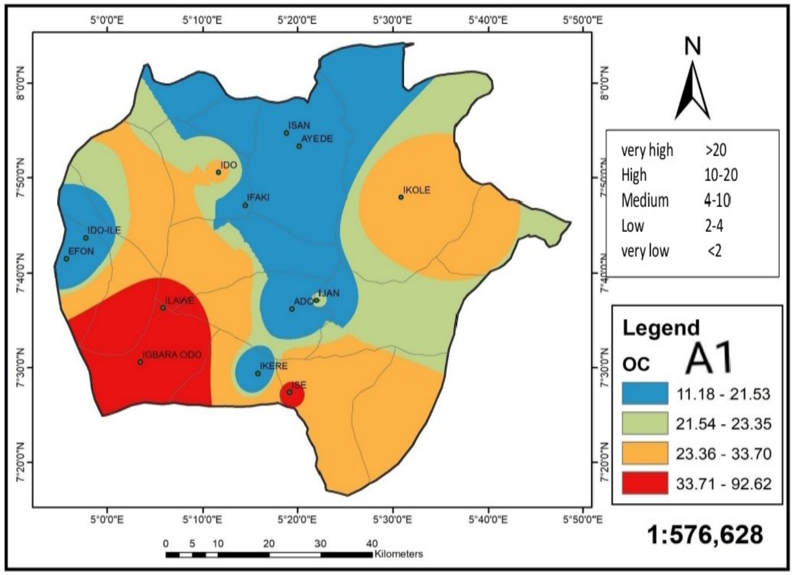


Figure 9: A map showing the soil OC properties at horizon A1

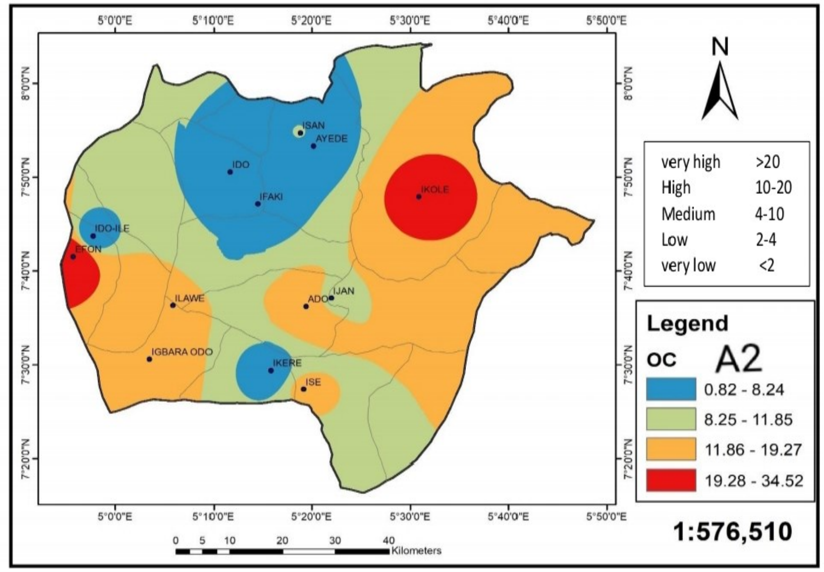


Figure 10: A map showing the soil OC properties at horizon A2

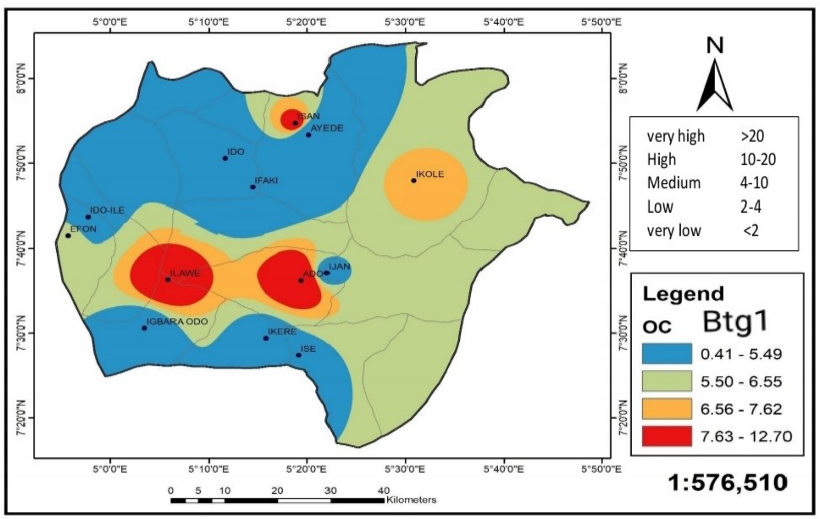


Figure 11: A map showing the soil OC properties at horizon Btg1

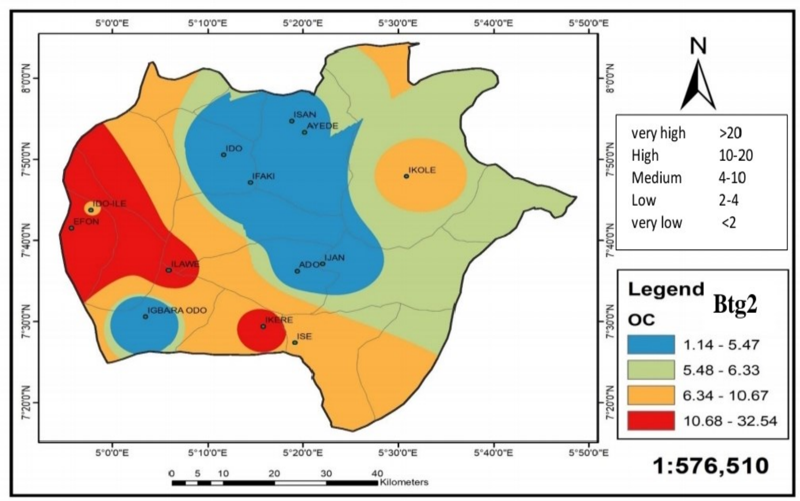


Figure 12: A map showing the soil OC properties at horizon Btg2

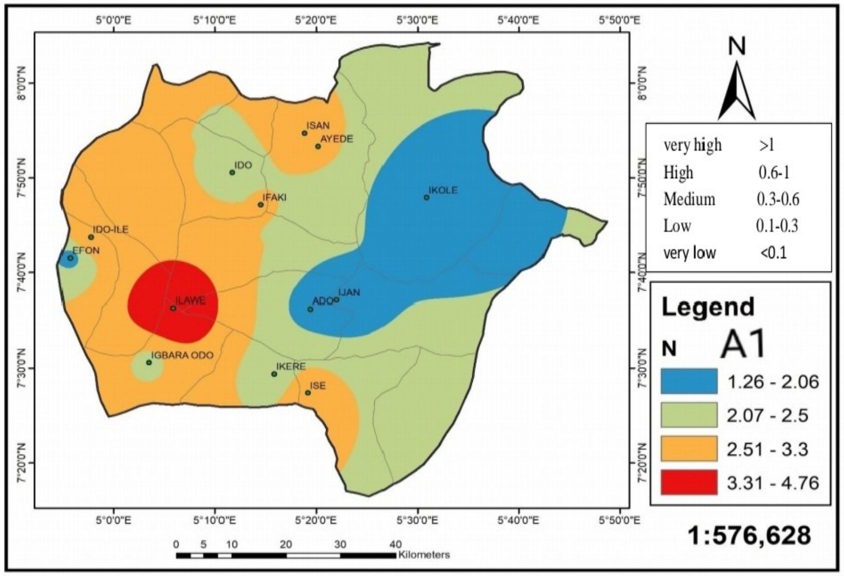


Figure 13: A map showing the soil N properties at horizon A1

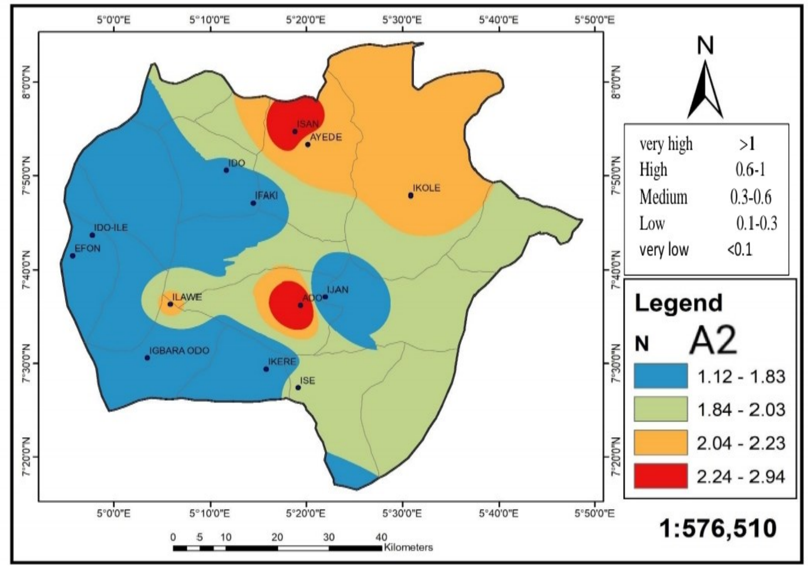


Figure 14: A map showing the soil N properties at horizon A2

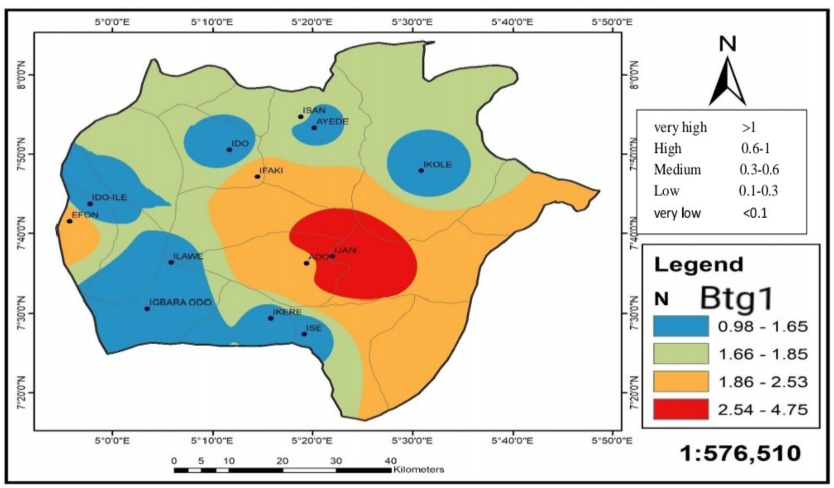


Figure 15: A map showing the soil N properties at horizon Btg1

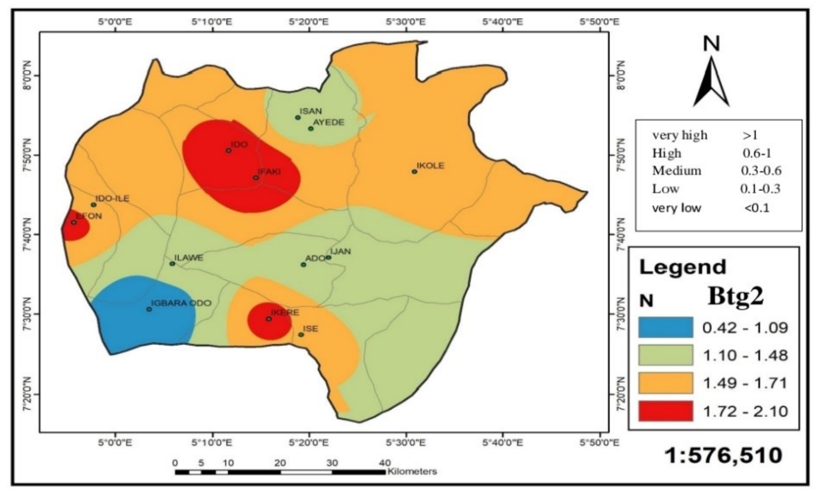


Figure 16: A map showing the soil N properties at horizon Btg2

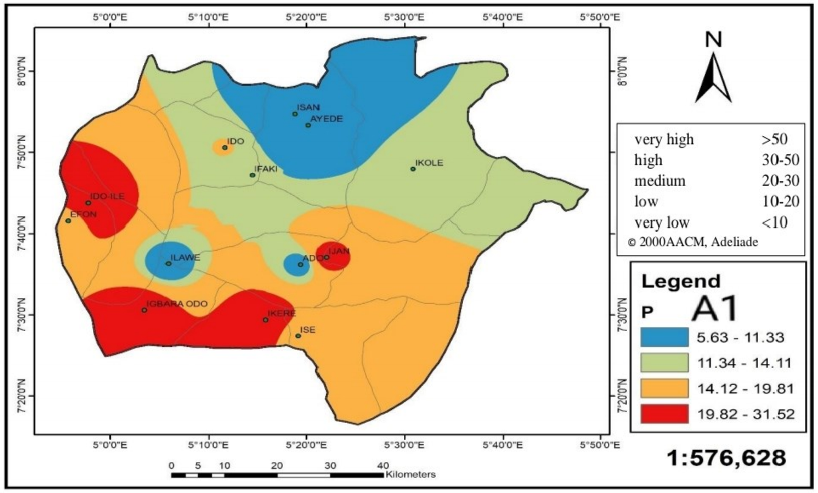


Figure 17: A map showing the soil P properties at horizon A1

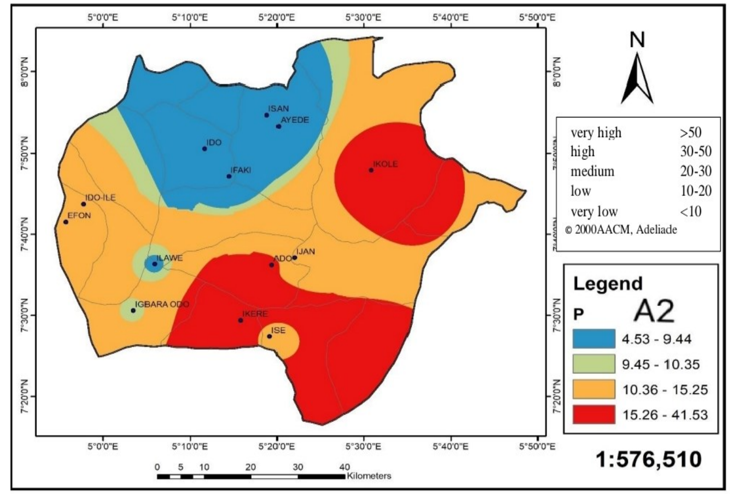


Figure 18: A map showing the soil P properties at horizon A2

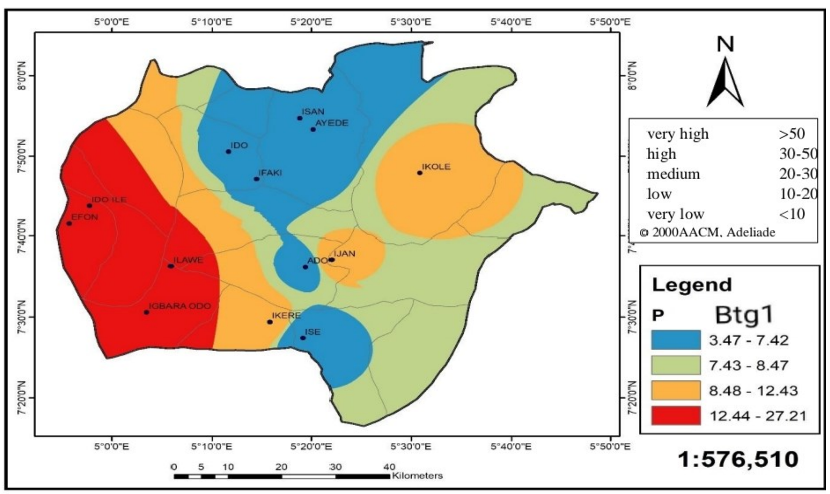


Figure 19: A map showing the soil P properties at horizon Btg1

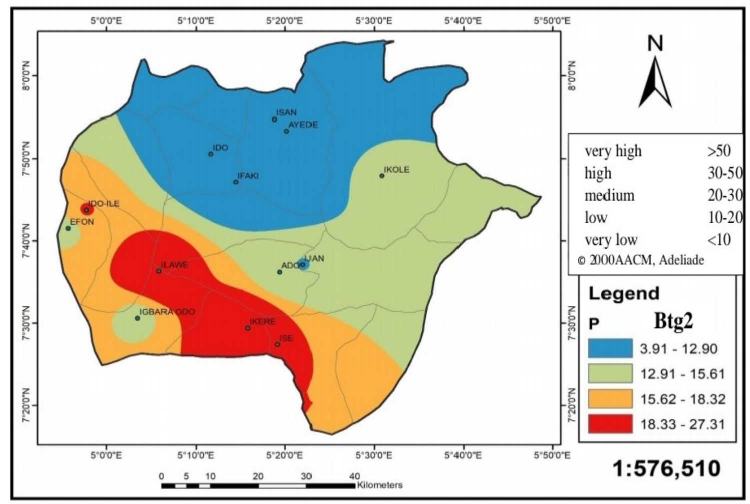


Figure 20: A map showing the soil P properties at horizon Btg2

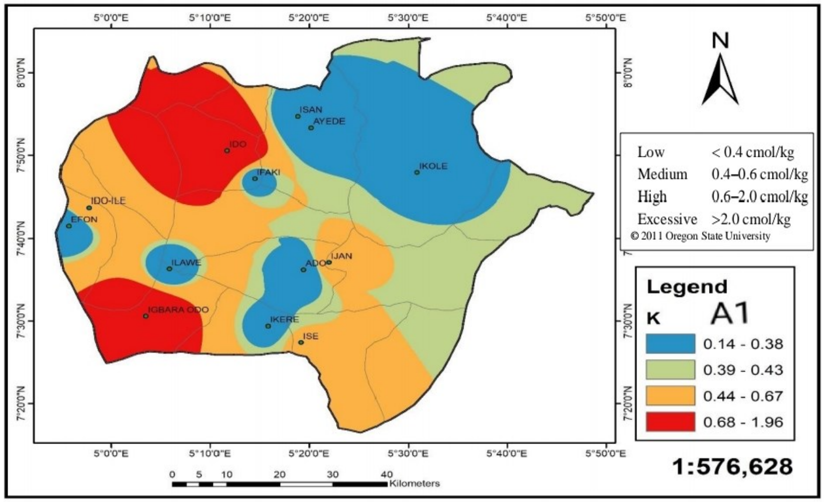


Figure 21: A map showing the soil N properties at horizon Btg2

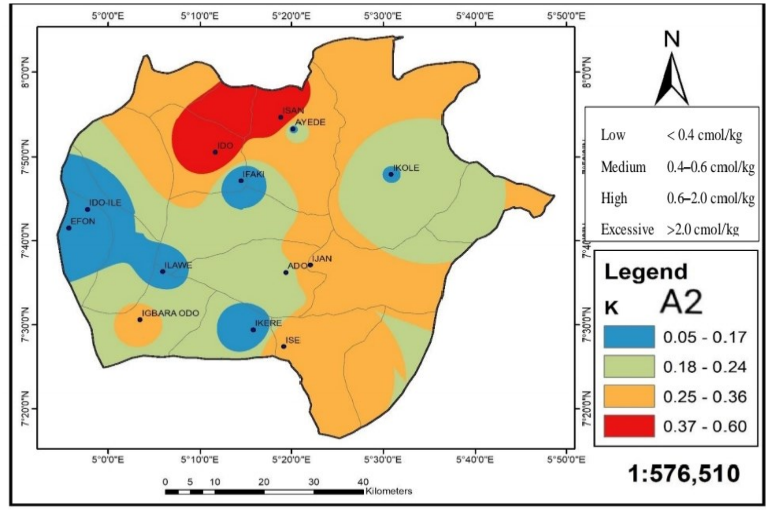
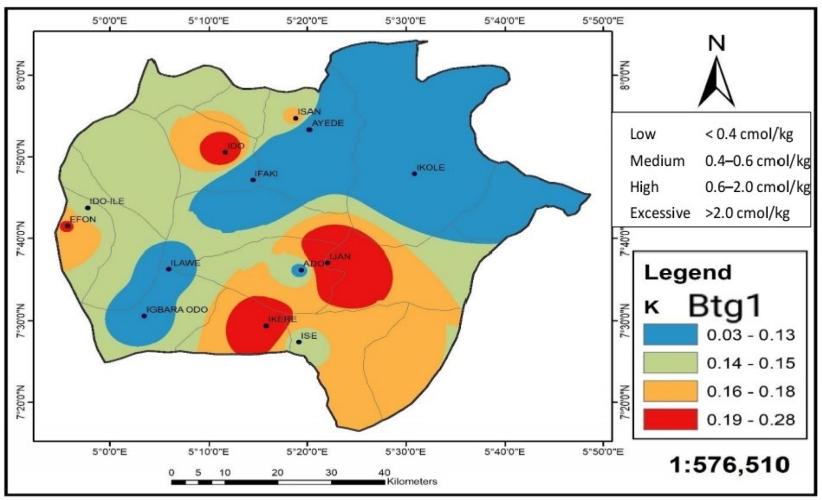


Figure 22: A map showing the soil N properties at horizon Btg2



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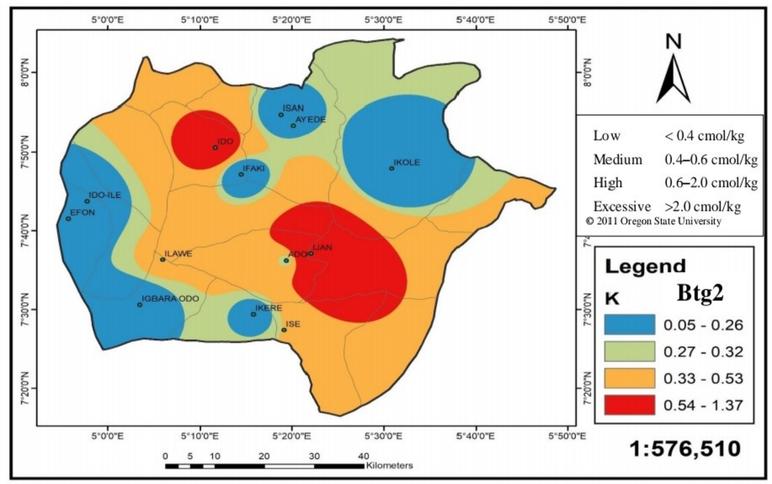

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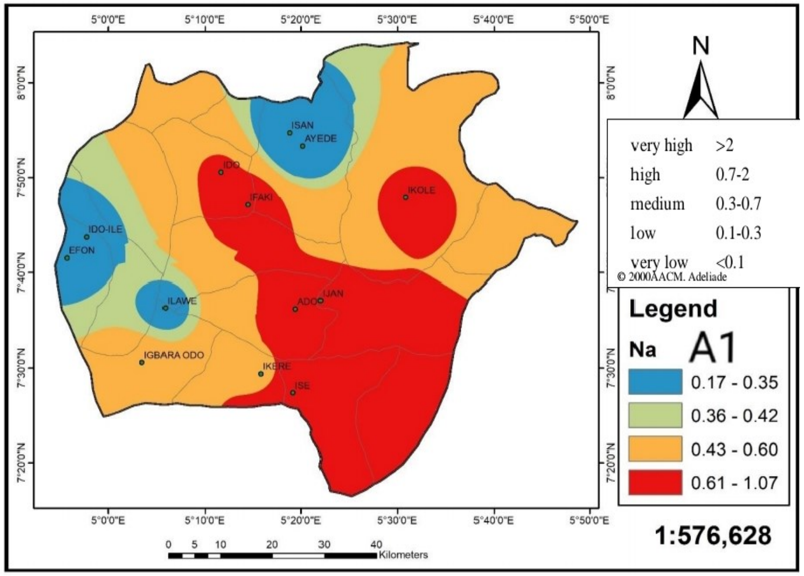

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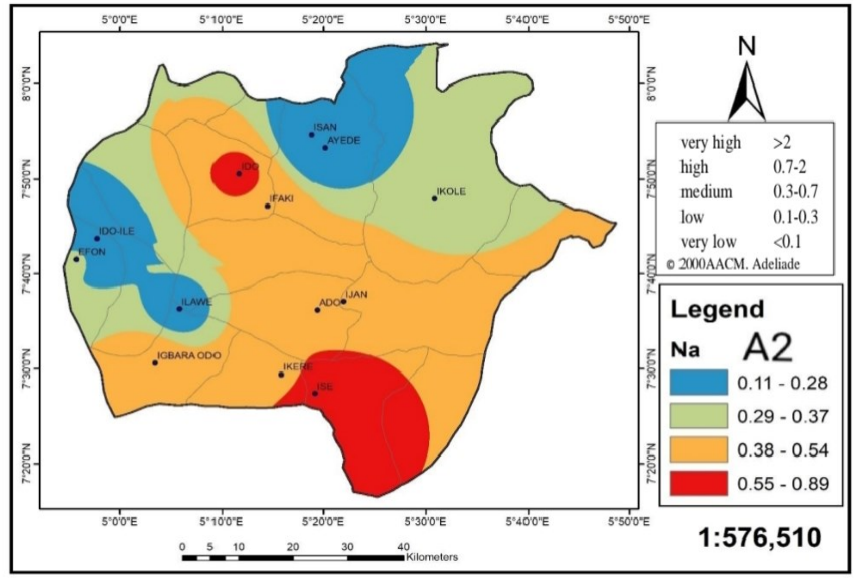

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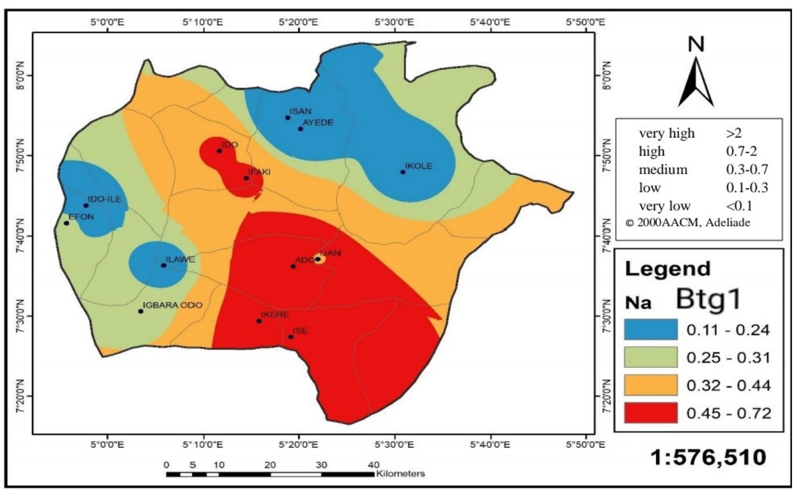

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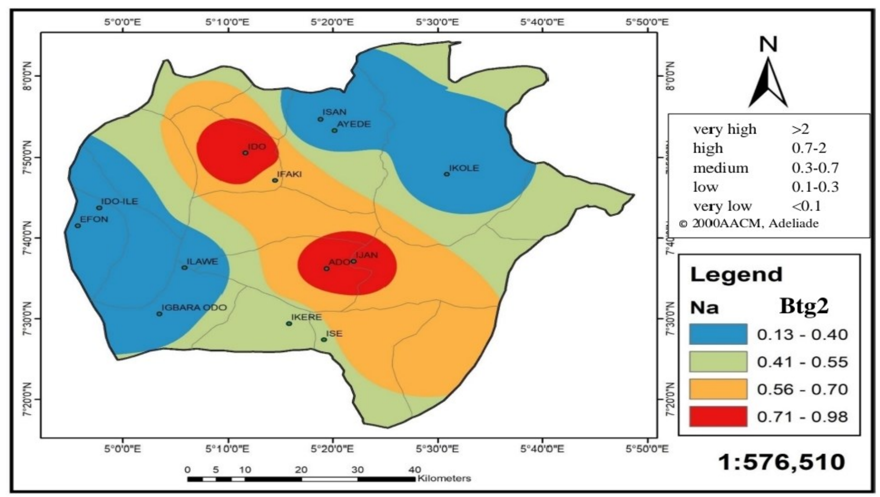

Figure 28: A map showing the soil N properties at horizon Btg2

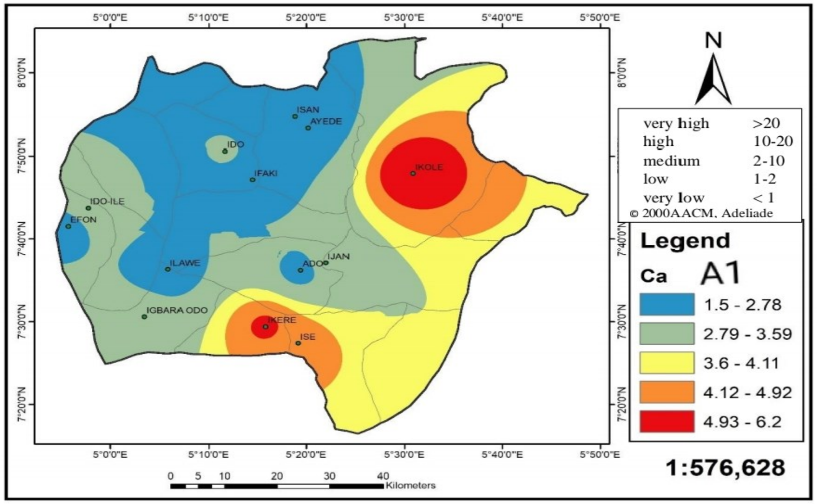

Figure 29: A map showing the soil N properties at horizon Btg2

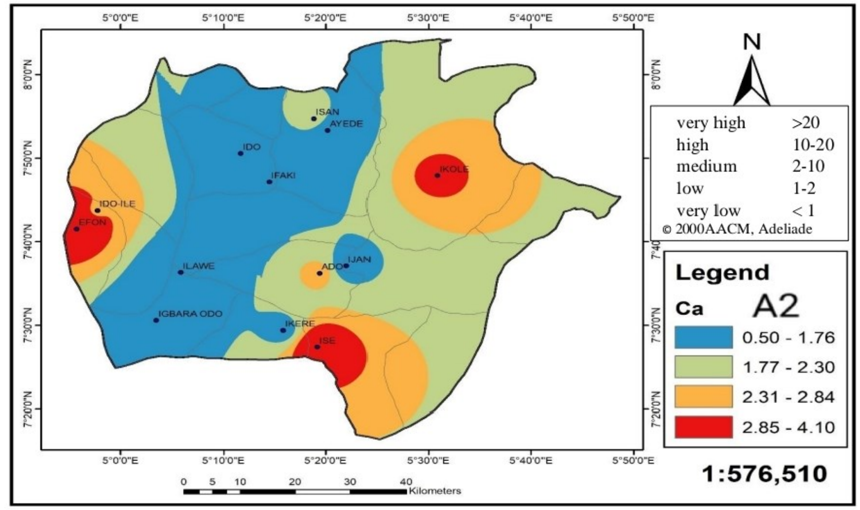

Figure 30: A map showing the soil N properties at horizon Btg2

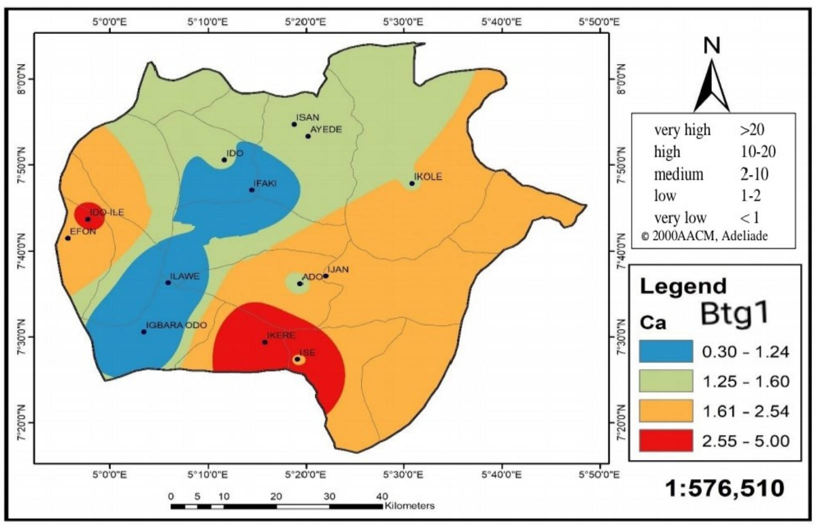

Figure 31: A map showing the soil N properties at horizon Btg2

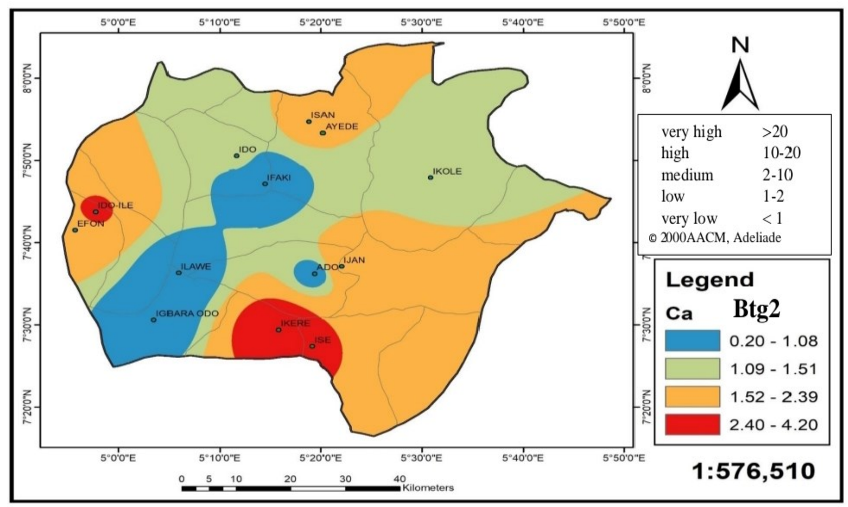

Figure 32: A map showing the soil N properties at horizon Btg2

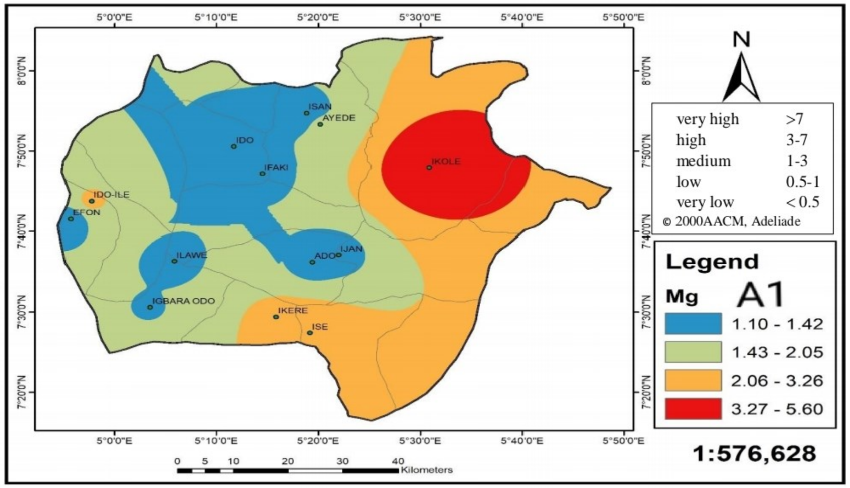

Figure 33: A map showing the soil N properties at horizon Btg2

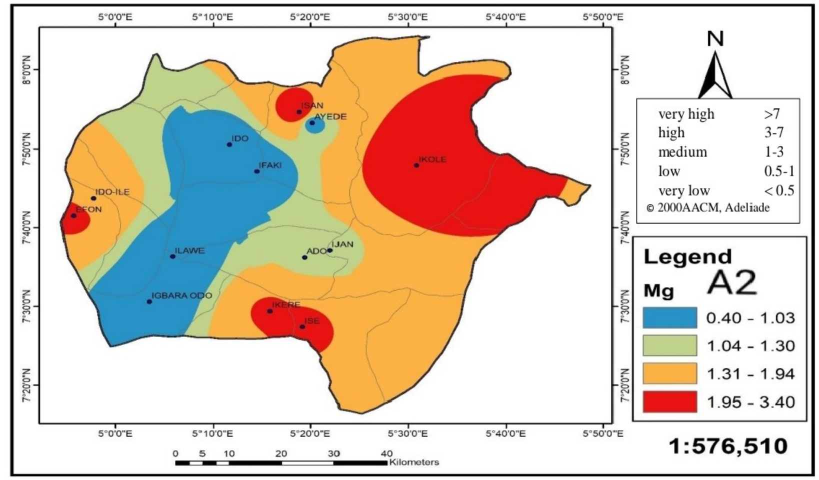

Figure 34: A map showing the soil N properties at horizon Btg2

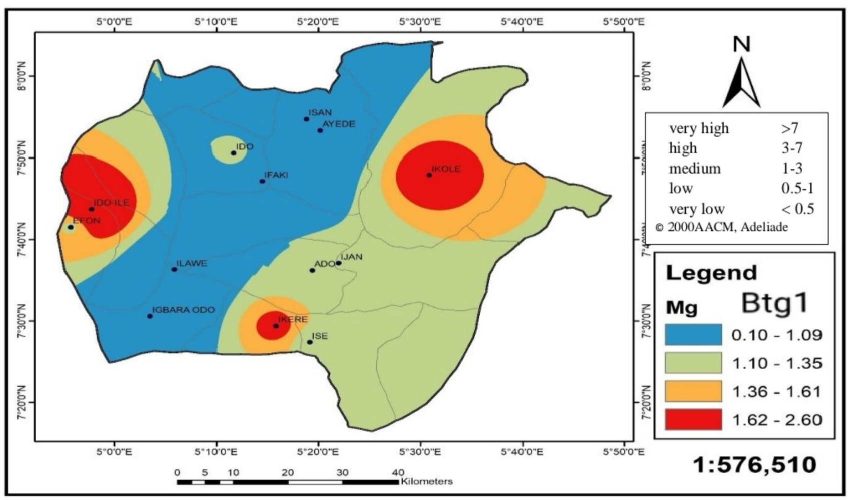

Figure 35: A map showing the soil N properties at horizon Btg2

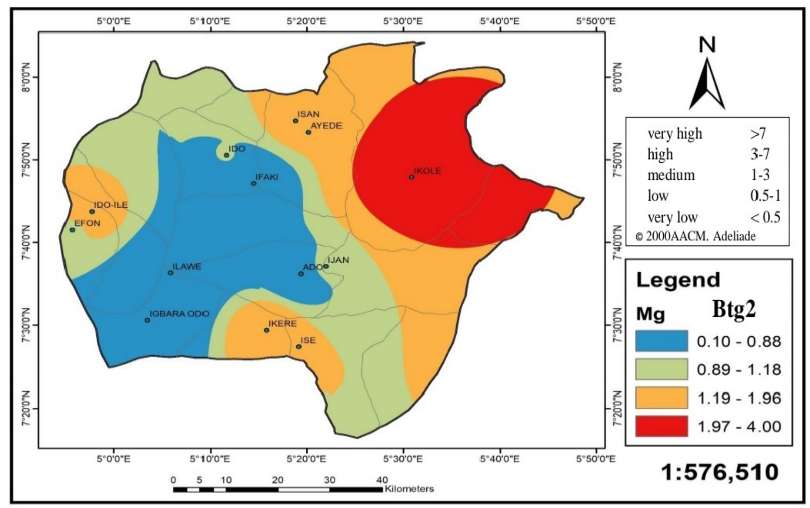

Figure 36: A map showing the soil N properties at horizon Btg2

CONCLUSION

This study underscores the spatial variability of soil chemical properties in wetland soils of Ekiti State, Southwest Nigeria, highlighting its implications for sustainable land use and conservation. The findings reveal moderate to high distribution levels for most soil properties, while exchangeable bases such as potassium, sodium, calcium, and magnesium exhibit low to moderate variability. The soil pH ranged from acidic to neutral, reflecting the influence of wetland hydrology and organic matter on soil chemistry. These results emphasize the importance of understanding spatial patterns for effective nutrient cycling, wetland productivity, and ecological balance.

RECOMMENDATIONS

To optimize wetland management, site-specific soil management strategies should be developed using GIS mapping to address variability. Regular monitoring of soil pH and nutrient levels is essential to sustain conditions conducive to plant growth. Areas rich in organic matter should be prioritized for conservation to enhance carbon sequestration and support nutrient dynamics. Additionally, measures to replenish exchangeable bases, such as the application of fertilizers or organic amendments, should be implemented to improve soil fertility.

CONFLICT-OF-INTEREST

Authors hereby declare that no conflicts of interest exist.

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