

Original Research Article

EFFECTS OF SEASONAL VARIATION ON SOME SOIL CHEMICAL PROPERTIES UNDER DIFFERENT LAND USE IN SANTA BARBARA, BAYELSA STATE-NIGERIA

ABSTRACT

A study was carried out to examine the effect of seasonal variation on some soil chemical properties under different land use in Nembe, Bayelsa State-Nigeria. The objective was to evaluate changes in soil nutrient contents in both wet and dry seasons. A total of seven soil samples were collected at 0-30 cm depths in August, 2017 (Wet Season) and March, 2018 (dry season) and analyzed for pH, soil organic carbon (SOC), total nitrogen (N), available phosphorus (P), exchangeable cations (Ca, Na, K and Mg), and cation exchange capacity (CEC) using standard analytical methods. Results showed that soil pH was highest (4.2) under Oil palm plantation in the wet season, while high content of Nitrogen 0.52 mg/kg was recorded during the wet season in all the ~~three-land~~ use. Organic carbon was highest 1.69 mg/kg in Natural forest, followed by 1.39 and 1.04 mg/kg for oil palm plantation and Arable land use. Maximum value of Phosphorus-P 0.0022 mg/kg was observed under natural forest during the dry season, and the minimum was recorded under Arable land use during the wet season. The concentration of exchangeable Ca was highest 0.3 mg/kg in the oil palm plantation, while Na was highest 2.19 mg/kg for Natural forest, 1.26 mg/kg and 1.06 mg/kg for oil palm plantation and arable land use. The CEC values of the soils in the Natural Forest were moderately high, followed by Oil palm plantation and Arable land use in the wet season; whereas low CEC values were observed across the ~~three-land~~ use in the dry season. The study concluded that soil nutrients were more available during the wet season than in the dry season in the various land use, probably due to adequate soil moisture availability in the wet season that facilitates soil nutrient release, this implies that chemical properties of soils were influenced by seasonal changes which could in turn affect agricultural production. It is recommended that crop production is encouraged in the dry season than in the wet season so as to utilize more availability of soil nutrients.

Keywords: Seasonal changes, Chemical properties, Land use, Santa Barbara

INTRODUCTION

Soil is a major source of nutrients needed by plants for growth; it also provides a dwelling place for plants, animals and microorganisms (Deyn and Van der Putten,

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2005). Soil is an essential component of the ecosystem, which has the potential to threaten food security through its effects on soil properties and processes (Brevik, 2013). In order to prevent extreme losses in agricultural productivity due to seasonal climatic changes such as heavy rainfall and drought, there is a need to monitor physical and chemical properties of the soil as it has a direct impact on soil health and crop yields (Meghana *et al.*, 2015). Poor management practices, climate change and land degradation have caused tremendous changes in the physical and chemical properties of agricultural soils resulting in low productivity (Brevik, 2013). This has adverse effects on food insecurity in many developing countries like Nigeria (Birara *et al.*, 2015). One of the approaches to mitigating the challenge of climate change on soil is to examine the relationship between soil physical and chemical properties. Changes in the soil chemical properties are strongly influenced by seasonal variations in temperature, moisture, plant growth and root activity, and by organic matter accumulation from litter fall (Perrot *et al.*, 1990; Mc Grath *et al.*, 2000). Land cover changes also affect the soil properties and biogeochemical process (Ross *et al.*, 1999; Zeng *et al.*, 2000). Bodner *et al.* (2008) discussed the impact of the rainfall intensity, soil drying on the seasonal changes of the soil hydraulic properties in the texture related range. There is dearth of information on

seasonal changes on soil characteristics in the study area. Thus, this study focuses on evaluation of soil chemical parameters such as pH, total nitrogen, available phosphorous, organic carbon and exchangeable cations (sodium, potassium, calcium and magnesium) and seasonal variability under different land use in Santa Barbara area of Bayelsa state-Nigeria. Thus, this paper is aimed at determining the effect of seasonal changes on soil chemical properties under different land use in the study area.

MATERIALS AND METHODS

Location of the study area

Santa Barbara is located in Nembe Local Government Areas of Bayelsa State in Niger Delta region. It lies between latitudes $04^{\circ}32'22''$ N and $06^{\circ}24'59''$ N.

The study area covers some selected sites in Nembe and its environment. The study area was chosen for the study due to the proposed agricultural intensification by local farmers within the community. The annual rainfall ranged between 2000-4500mm per annum spread over 8 to 10 months of the year and bimodal, peaking in June and September. The relative humidity average is 80% all over the state and temperature is fairly constant with a maximum of 30°C . The natural vegetation is

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tropical rainforest. Food crops are cultivated on the levee crest, levee crest soils are no longer flooded while most flood plain soils and alluvial soils in the channels of active rivers are flooded yearly by the Niger River floods according to Dickson *et al.* (2021), but most levee crest soils are also flooded in recent years due to climate change.

Vegetation and land use

The study area is dominated by agricultural farmlands which made up of 85% of the vegetation cover. Land use in the entire area comprises farm lands used for the cultivation of food crops mainly cassava which is often cultivated along with maize in a mixed cropping system, banana and oil palm plantation. These are mainly subsistence agriculture. There were a few infrastructures for residential and commercial use outside of the farming occupation of the people in the study area.

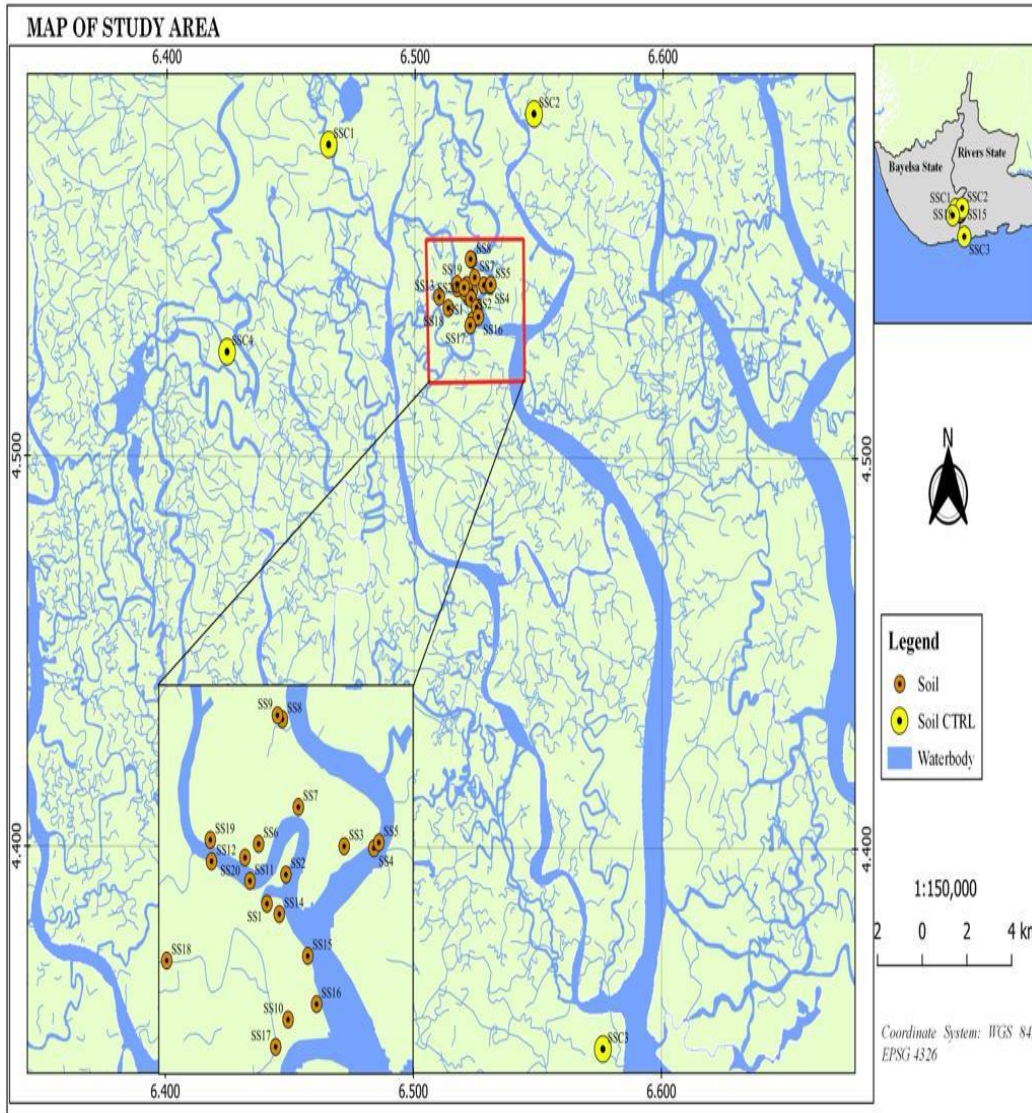


Figure 1: Map of the study area

Table1: Soil sampling location, depth and geographical points

Land use types	Sampling I.D/ code	Soil depth (cm)	GPS coordinates	
			Northing	Easting
Natural forest	SS1	0-30	451099.921	60041.100
	SS2	0-30	451269.974	60206.566
	SS3	0-30	451791.607	60367.116
	SS4	0-30	452058.004	60355.329
	SS5	0-30	452102.499	60388.391
	SS6	0-30	451025.655	60380.269
Oil palm plantation	SS7	0-30	451381.468	60589.455
	SS8	0-30	451238.515	61087.589
	SS9	0-30	451194.171	61109.833
	SS10	0-30	451289.366	59384.060
	SS11	0-30	450947.372	60170.324
	SS12	0-30	450603.536	60281.876
	SS13	0-30	449792.475	60040.760
Arable land	SS14	0-30	451210.772	59982.414
	SS15	0-30	451466.068	59745.113
	SS16	0-30	451544.937	59471.851
	SS17	0-30	451177.930	59229.511
	SS18	0-30	450202.343	59718.864
	SS19	0-30	450592.769	60403.577
	SS20	0-30	450903.330	60303.177

Sample collection and analysis

Representative soil samples were collected randomly at 0-30 cm depths with auger sampler and bulked to form a composite sample. A total of 7 composite samples were generated from each location namely, Natural forest, Oil palm plantation, and Arable land. Soil sampling was carried out between 21st and 30th August, 2017 (Wet Season) and from 26th February 8th March, 2018 (Dry Season). Samples coordinate points were read using Geographical Position System (GPS). All soil samples collected into well labeled polythene bags were transported to Dukoria Laboratories for further processing and analysis. The samples were air-dried at room temperature and crushed to pass through a 2mm mesh sieve for determination of selected soil physical and chemical properties. Soil samples were subjected to soil chemical properties analysis such as soil pH, total nitrogen, available phosphorus, soil organic carbon, sodium, potassium, calcium and magnesium, CEC, Soil total nitrogen was determined using the micro kjeldahl distillation and titration method described by Bremner, and Mulvaney, (1982). Soil organic carbon (SOC) was determined by a modified Walkley-Black procedure as described by

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Nelson and Sommers (1982). Exchangeable K of the soil samples was extracted with neutral normal ammonium acetate buffered at pH 7 after shaking for 2 hours. Exchangeable Na, K, Ca and Mg were extracted with BaCl₂ 0.1 M (Hendershort, 1993) and analysed by atomic absorption. Exchangeable acidity was determined from 0.1 N NaCl extracts and titrated with 1.0 N HCl. Cation exchangeable capacity (CEC) was determined by summing up total exchangeable bases (TEBS).

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RESULTS AND DISCUSSIONS

Soil physical and chemical properties

The pH of the soils in the different land use is presented in Figure 1. The study revealed that the pH of soils in the ~~three-land~~ three-land use evaluated were acidic in nature (pH < 5.5) irrespective of the season. The pH of the soils ranged between 1.3 to 4.2 across the two seasons in all the three land use types (Fig. 1). However, the natural forest had low pH (1.3) in the dry season compared to 1.6 and 3.4 for aArable land and oil palm plantation respectively in dry seasons. The low pH observed in the nNatural forest may be due to the present of organic matter in form of plant litters, compost and manure which decrease the pH. Adams and Sidle

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(1987) also reported a low pH levels in undisturbed forest compare to disturbed forest. This finding is consistent with Leskiw, (1998) who noted that for a balanced nutrient supply, forest soils should be slightly acidic innature. Dimiri *et al.*, (1987) also confirmed that, an elevated level of humus in forest soils is attributed for the low pH levels. Generally, the low pH observed in both wet and dry seasons is an indication that all the ~~three land~~ three-land use could probably be of the same soil types. The pH range of 5.5 to 6.5 has been reported to be optimum for best plant growth (Jone, 2012) because most nutrient elements are usually available (Motsara and Roy, 2008). Bessah *et al.* (2016) reported that crop yields are normally high in soils with pH values between 6.0 and 7.5. Ronen, (2007) stated that most soil nutrients are available for plant uptake in the pH range of 5.5 - 6.5.

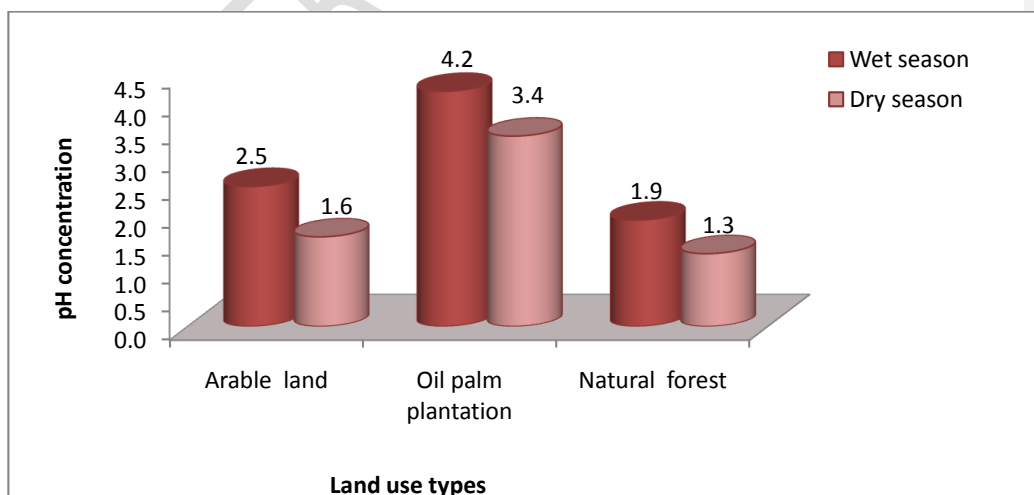


Figure 2: Soil pH content in wet and dry season under different land use in the study area

Soil total nitrogen for arable land, oil palm plantation, and natural forest for both wet and dry seasons is shown in **Figure 2**. The nitrogen content in both seasons within the ~~three land~~ three-land use was less than 1%. However, it was observed that nitrogen content was highest (0.52 mg/kg) in natural forest, 0.42 ~~mg/kg~~ and 0.34 mg/kg for oil palm plantation and aArable land during the wet season across the three lands use **(Fig 2)**. This may be due to the rapid mineralization of nitrogen in the wet season as a result of adequate soil moisture availability. This observation corroborates the works of Bergeron *et al.*, (2002) ~~who~~ who stated that ~~rapid mineralization~~ rapid mineralization of nitrogen ~~occurs~~ occurs during the rainy season, which results in increased levels of nitrogen during this season. Choudhri and Sharma, (1975) ~~also~~ also reported that elevated levels of total nitrogen in the soil during rainy season indicates blue green algae fixation, input from rain water and higher release rate of mineral nitrogen by means of microbial decomposition. On the other hand, it was observed that, nitrogen content was low (0.12 mg/kg) in the dry season under aArable land compared to 0.31 ~~mg/kg~~ and 0.41 mg/kg for oil palm plantation and Natural forest land use. This observation may be due to

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inadequate soil moisture that will enhance nitrogen mineralization. Singh and Singh (2006) also reported that plant uptake of nutrients during dry periods is significantly reduced and the process of N-mineralization and nitrification are either immobilized in the microbial biomass or are accumulated in the soil in the form of inorganic nitrogen.

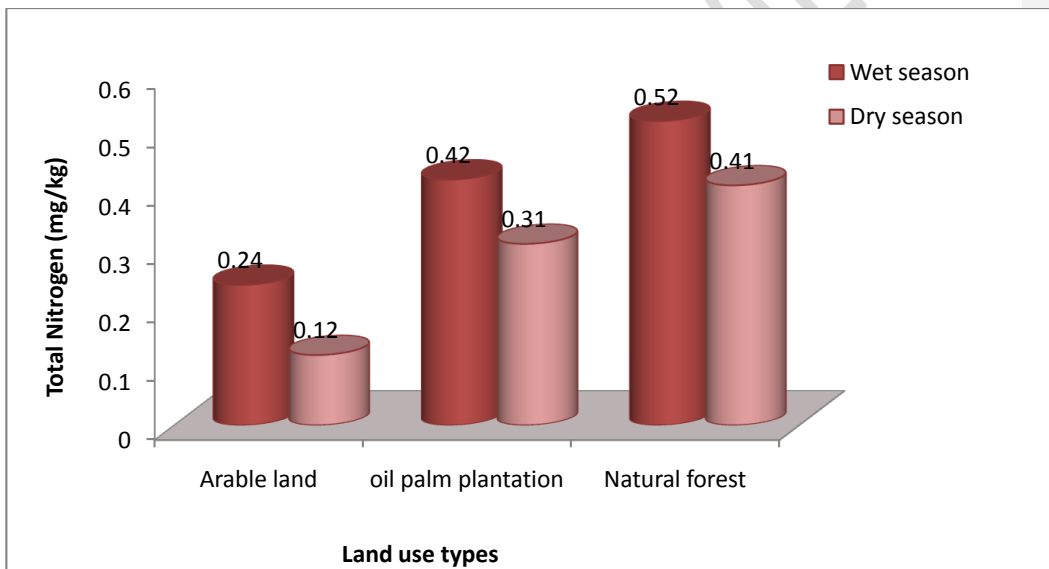


Figure 3: Total ~~n~~Nitrogen content in wet and dry season under different land use in the study area.

Soil organic carbon content among the ~~three-land~~~~three-land~~ use in wet and dry season is presented in Figure 3. The result showed that organic carbon content was highest (1.69 mg/kg) in ~~Natural~~~~natural~~ forest followed by 1.39 ~~mg/kg~~ and 1.04

mg/kg in oil palm plantation and aArable land use, respectively, during the dry season. This may be due to the fact that, forests have greater canopies, and they provide litter in high quantity (Yingaet *al.*, 2020), hence, accumulating higher carbon content compared to the aArable land and oil palm plantation. This corroborates the findings of Sevgi and Tecimen (2008) who reported that due to the production and return of high amount of litter in natural forest organic carbon content is usually high.

However, there was a decline in organic carbon content of 0.73 mg/kg in aArable land compared to 0.88 mg/kg and 1.16 mg/kg for oil palm plantation and nNatural forest in the dry season (Fig. 3). This might be due to low rains and burning that usually occurs in the area. Soil organic matter tends to decrease as a result of low decomposition due to little or absence of soil microorganisms that are responsible for the decomposition.

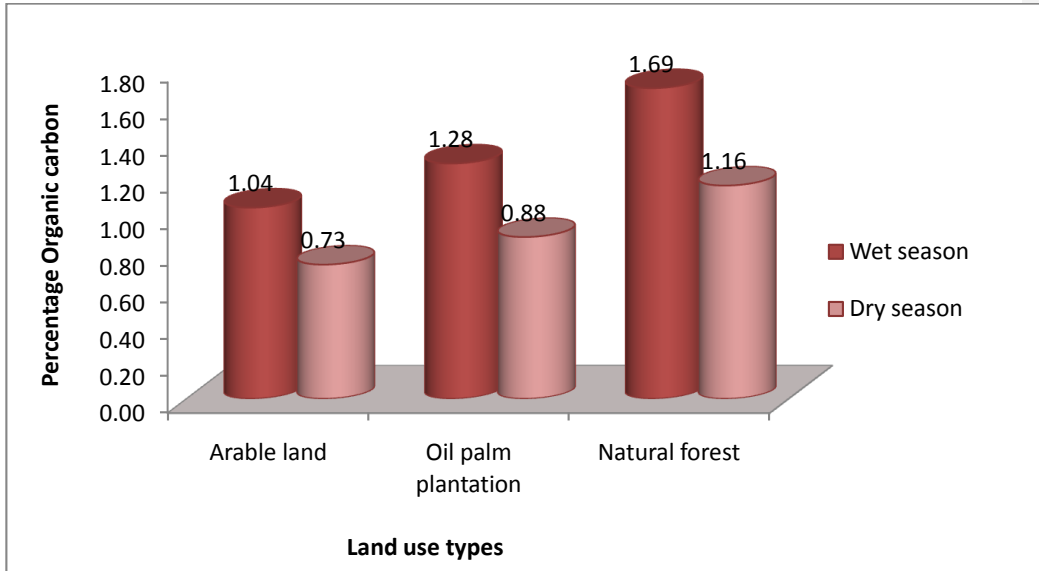


Figure 4: Soil organic carbon content during wet and dry seasons in three land uses

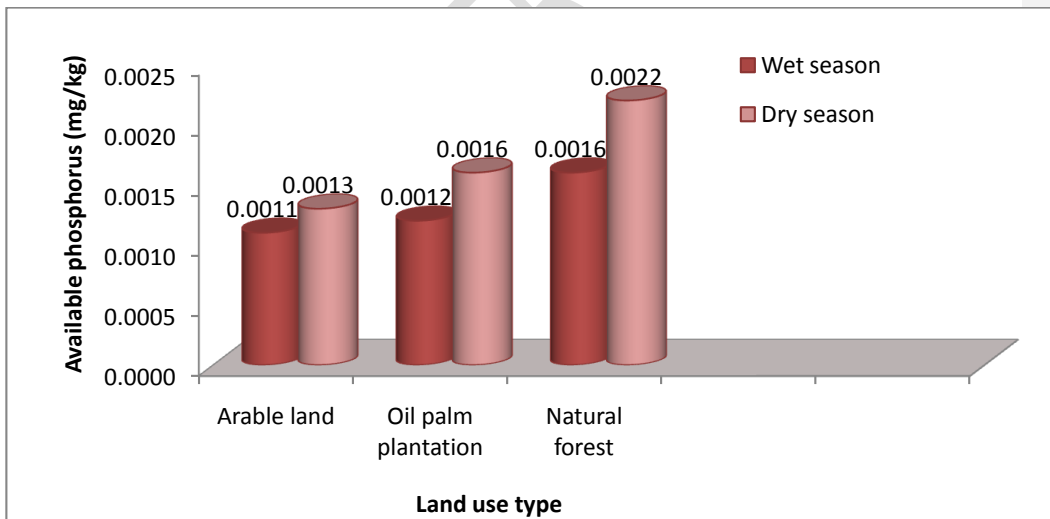


Figure 5: Available pPhosphorus content during wet and dry seasons in three land uses.

The phosphorus content during the wet and dry seasons is presented in [Figure 5](#). The results showed that the maximum value of phosphorous content was observed in natural forest during dry season and the minimum was recorded under arable land use during the wet season ([Fig. 5](#)).

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The high content of available phosphorus observed in the dry season under natural forest may be adduce to the fact that during the dry season there is less or no rain, no leaching of nutrients and high deposition of litter falls which results in the accumulation of high nutrients during this period. This observation is in line with Miller and Donahuer(2001) who reported that soils with high organic matter content have better supplies of organic phosphate for plant uptake. Gupta and Sharma (2008) also reported that carbon and phosphorus were positively correlated because all these attributes were intimately linked with soil humus. Less amount of available Phosphorus occurs in the wet season because of leaching due to excessive rainfall and soil erosion. Ashraf *et al.*(2012) also reported that soils with maximum leaching are known to contain low amount of phosphorus as compared to the soil with minimum leaching.

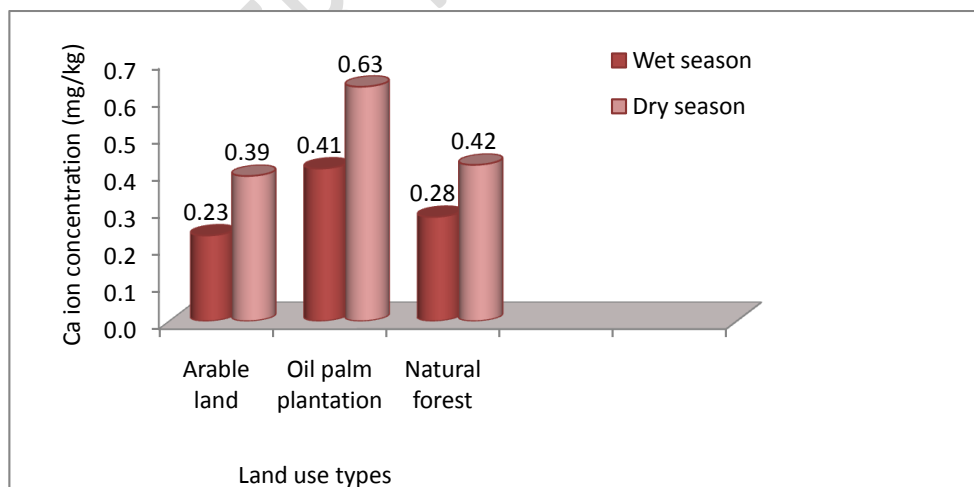


Figure 6: Calcium concentration in wet and dry season in three land use types.

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The concentration of exchangeable cations (Na, K, Ca, and Mg) in the ~~three land~~ ~~three-land~~ use evaluated in wet and dry ~~seasons are~~ ~~seasons are~~ presented in ~~Figure~~ ~~in Figures~~ 6, 7, 8 and 9). Oil palm plantation had the highest (0.63 mg/kg) Ca content compared to ~~Natural~~ ~~natural~~ forest (0.42 mg/kg), ~~a~~ ~~Arable~~ land (0.39mg/kg) in the dry season **Fig. 6**. Similar trend was observed on K content of the soils. It was noted that, highest amount of K (1.68 mg/kg) was observed in oil palm plantation, followed by natural forest (1.42mg/kg) and Arable land (1.25mg/kg), respectively. Similarly, low values of Ca and K were recorded in the wet season in all the ~~three land~~ ~~three-land~~ use **Fig. 7**. This may be as a result of the low ~~Organic~~ ~~c~~ ~~Carbon~~ content of the soils in the dry season occasioned by inadequate moisture which affect decomposition of organic matter to releases these nutrients. This shows that there was a decline in the soil nutrients (Chen *et al.*, 2006). This could be due to the leaching of cations down the soil depth by rainfall (Wong *et al.*, 2005).

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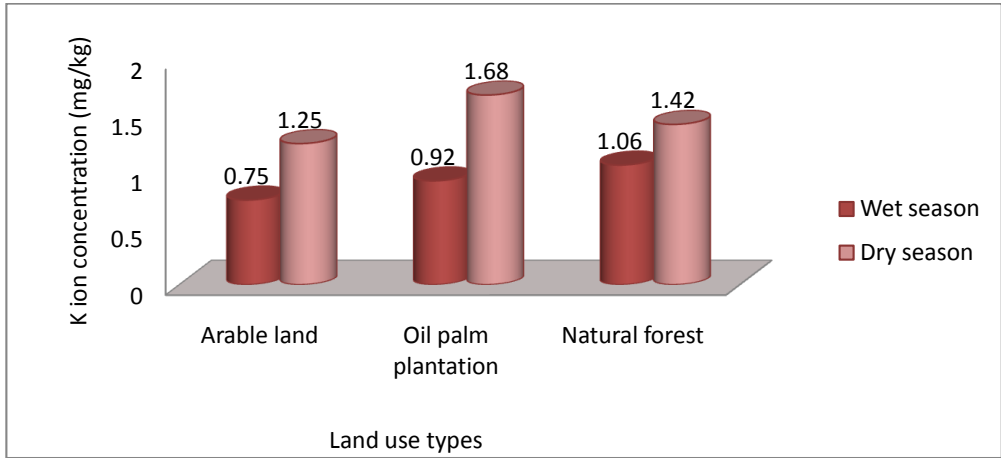


Figure 7: Potassium concentration in wet and dry season in three land use types.

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The Na content of the soil was highest (2.19mg/kg) in the natural forest in comparison to oil palm plantation (1.26mg/kg) and Arable land (1.06mg/kg) respectively in the wet season. Also, low values of Na were observed in all the three land use during the dry season (Fig.

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8). Likewise, Mg values was highest (0.68 mg/kg) followed by oil palm plantation (0.51 mg/kg) and Arable land (0.42 mg/kg) in the three land use during the dry season (Fig. 9). This

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study revealed that rainfall reduced the concentration of Na and Mg in the soils. There is a possibility that these basic cations were being eroded and leached faster by high rainfall which occurred during the wet season. This is in alignment with the findings of Olujugba and Fatubarin (2015), who postulated that high precipitation might lead to decrease in exchangeable bases. This implies that seasonal variation has affected the content of exchangeable bases in the three land use types.

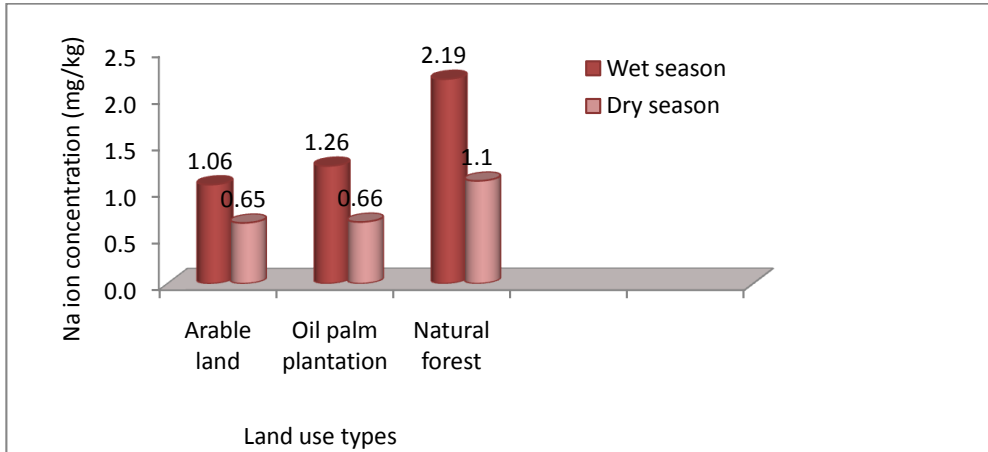


Figure 8: Sodium concentration in wet and dry season in three land use types.

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The CEC values of the soils in the nNatural forest was moderately high (4.71 mg/kg) followed by oOil palm plantation (3.75 mg/kg) and 2.12 mg/kg for Arable land use during the wet season. However, low CEC values were observed across the three-landthree-land use in the dry season (Fig. 10). The low values of CEC recorded may be attributed to the low values of the exchangeable

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bases. This is expected because soils with low exchangeable bases are expected to have low CEC.

This observation agrees with the findings of Rayment and Higginson (1992) who reported that the main ions associated with CEC in soils are the exchangeable bases. Protection of the litter layer is strongly recommended to ameliorate soil degradation and nutrient limitation in the study area, since litter layer was not only the main source of soil organic matter and available nutrients, but also the regulator of soil microbial activity (Chen *et al.*, 2003). Generally speaking, the seasonal variations of the physicochemical parameters in the three-landthree-land use could probably be due to the inherent properties of the soils such as the physical nature and chemical activities

which in turn influenced by changes in season in the study area. This study noted that different seasons affected the concentrations of exchangeable bases differently in the ~~three land~~ three-land use.

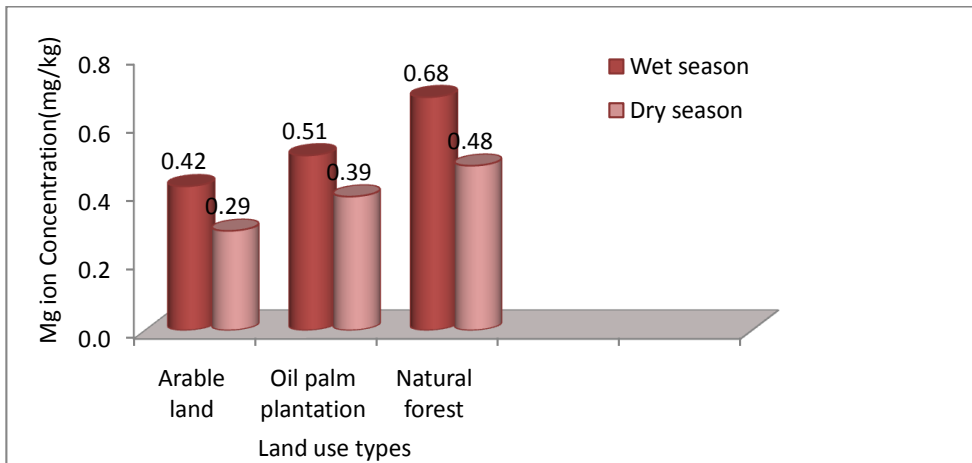


Figure 9: Magnesium concentration in wet and dry season in three land use types.

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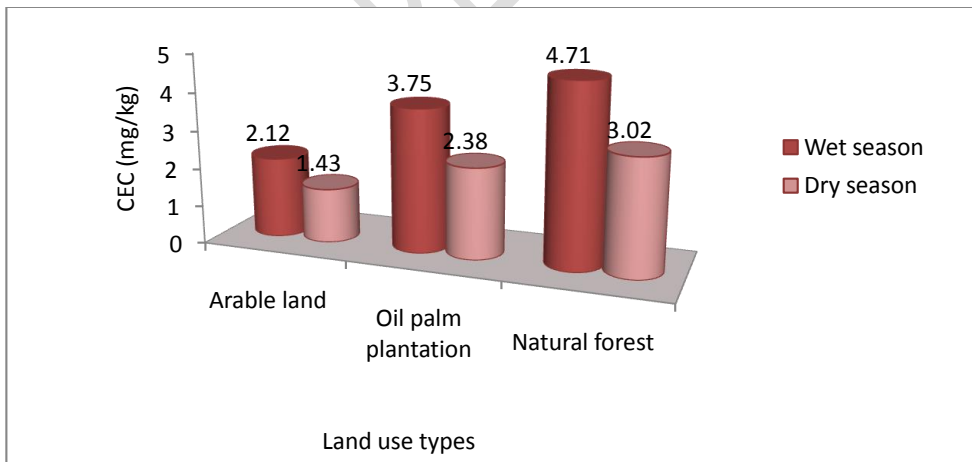


Figure 10: Cation exchange capacity in wet and dry season in three land use types.

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Conclusion and recommendation

Results obtained during this study revealed that the chemical properties of the soil under different land use showed significant variations among the seasons, thus, crop production is encouraged in the dry season than in the wet season so as to utilize the more available soil nutrients. However, bush burning must be avoided to minimize the loss of nitrogen through volatilization. Application of organic materials such as crop residues, compost, and farmyard manure are recommended to improve the organic matter level of the soils for sustainable crop production for the arable land in the study area to increase soil fertility.

Limitation of the study

The limitation of this study was due to lack of needed finance which limited elaborate experimental set ups; the research was funded solely by the researchers. No grant was obtained due to difficulty in the process of assessing grants.

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