Chemical Science International Journal

Volume 32, Issue 4, Page 39-49, 2023; Article no.CSIJ.102462
ISSN: 2456-706X
(Past name: American Chemical Science Journal, Past ISSN: 2249-0205)

Effects of Seasonal Variation on some Soil Chemical Properties under Different Land Use in Santa Barbara, Bayelsa State-Nigeria

Duke Okoro [a*] and Ikyaahemba Philip Tordue [b]

[a] Department of Chemistry, Federal University of Petroleum Resources, Effurun, Delta State, Nigeria.
[b] Soils and Land Management Division, Nigerian Institute for Oil Palm Research, Benin City, Edo State, Nigeria.

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CSJI/2023/v32i4853

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/102462

Original Research Article

Received: 02/05/2023
Accepted: 08/07/2023
Published: 22/07/2023

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 eighteen soil samples were collected at 0-30 cm depths in August, 2017 (Wet Season) and March, 2018 (dry season) in natural forest, oil palm plantation and arable land-use 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 N 0**.**52 mg**/**kg was recorded during the wet season in all the thee-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**.**

**Corresponding author: E-mail: okoro.duke@fupre.edu.ng;*

Maximum value of P 0.22 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 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 wet season than in the dry season so as to utilize more availability of soil nutrients.

Keywords: Seasonal changes; soil chemical properties; land-use; soil nutrients; Santa Barbara.

1. INTRODUCTION

Soil is a major source of nutrients needed by plants for growth; it also provides a dwelling place for plants, animals and microorganisms [1]. Soil is an essential component of the ecosystem, which has the potential to threaten food security through its effects on soil properties and processes [2]. In order to prevent extreme losses in agricultural productivity due to seasonal climatic changes such as heavy rainfall and drought; there is need to monitor physical and chemical properties of the soil as it has a direct impact on soil health and crop yields [3]. 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 [2]. This has adverse effects on food insecurity in many developing countries like Nigeria [4]. 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 [5,6]. Land cover changes also affect the soil properties and biogeochemical process [7,8]. Bodner et al. [9] discussed the impact of rainfall intensity, soil drying on 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.

2. MATERIALS AND METHODS

2.1 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 0 4°32' 22" N and 06° 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 2000-4500 mm per anon 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 $30^{\circ}C$. The natural vegetation is a tropical rainforest. Food crops are usually cultivated on levee crest soils that are not flooded while most flood plain soils and alluvial soils of active rivers are flooded yearly by the Niger River floods according to Dickson et al. [10], but most levee crest soils are also flooded in recent years due to climate change.

2.2 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 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.

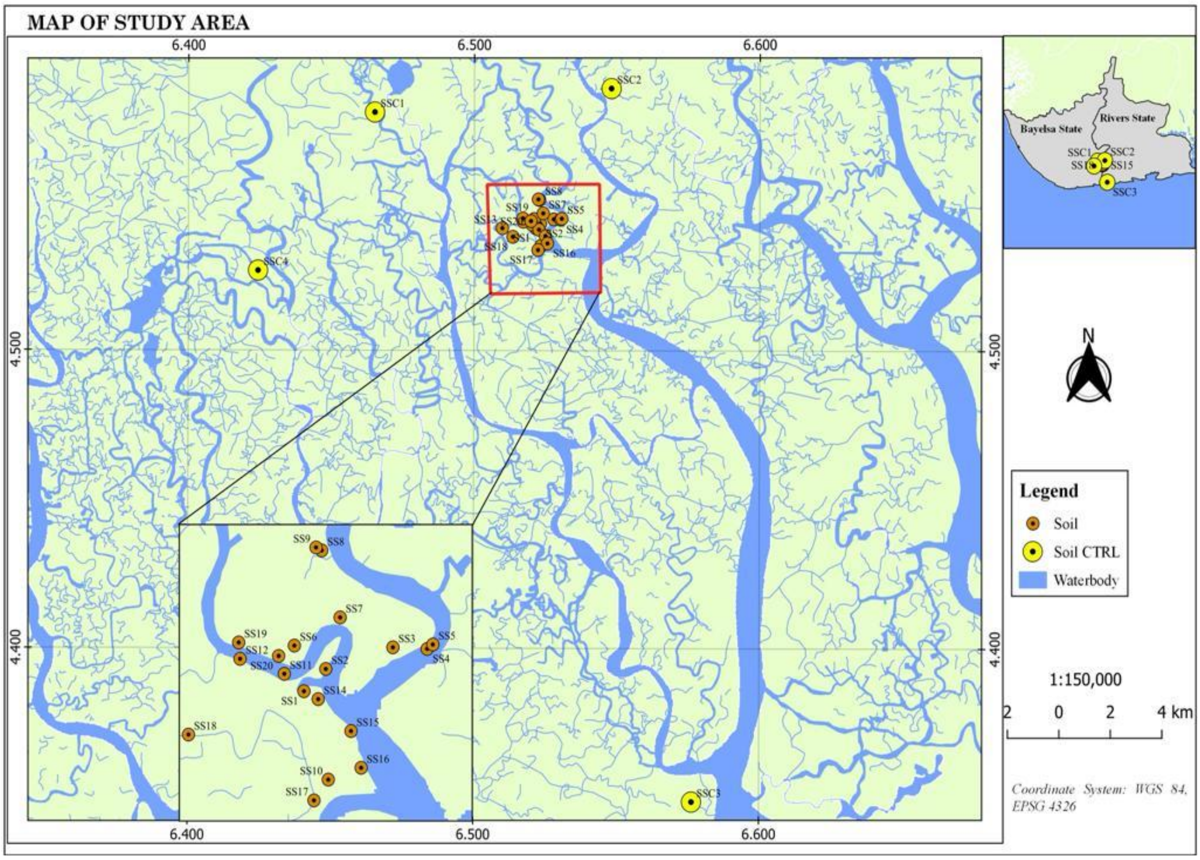

Fig. 1. Map of the study area

Table 1. 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

2.3 Soil Sample Collection and Analysis

The sampling area comprises of three-land uses; natural forest, oil palm plantation and arable land-use. Sampling was conducted between 21st and 30th August, 2017 (Wet Season) and from 26th February 8th March, 2018 (Dry Season). Each sampling site (natural forest, oil palm plantation and arable land-use) were stratified into three segments and plot of 100m × 100m approximately was randomly selected from each segment to make six sampling point per land-use. Soil samples were collected at 0-30 cm depths with auger sampler and bulked to form a composite sample. A total of 18 composite samples were collected from each land-use in wet and dry season. Samples co-ordinate points were read using Geographical Position System (GPS). 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, crushed and allowed to pass through a 2mm mesh sieve for determination of selected soil 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, [11]. Soil organic carbon (SOC) was determined by a modified Walkley-Black procedure as described by Nelson and Sommers [12]. Exchangeable bases (Ca, Mg, K, and Na) were extracted with IN NH_4OAc buffered at pH 7.0 (Thomas, 1982). Exchangeable K and Na were determined by a flame photometer while Ca and Mg were determined by atomic absorption spectrophotometer as described by [13]. The cation exchangeable capacity (CEC) was determined by the summation of the total exchangeable bases (TEBS).

2.4 Statistical Analysis

Results obtained from the analysis were subjected to descriptive and inferential statistical techniques. Mean values of the soil chemical properties in the various land-uses in wet and dry seasons were determined. The statistical analyses were carried out using the Excel statistical tool.

3. RESULTS AND DISCUSSIONS

3.1 Soil Chemical Properties

The pH of the soils in the different land-use is presented in Fig. 1. The study revealed that the pH of soils in the 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 Fig. 1. However, the natural forest had low pH (1.3) in the dry season compared to 1.6 and 3.4 for arable land and oil palm plantation

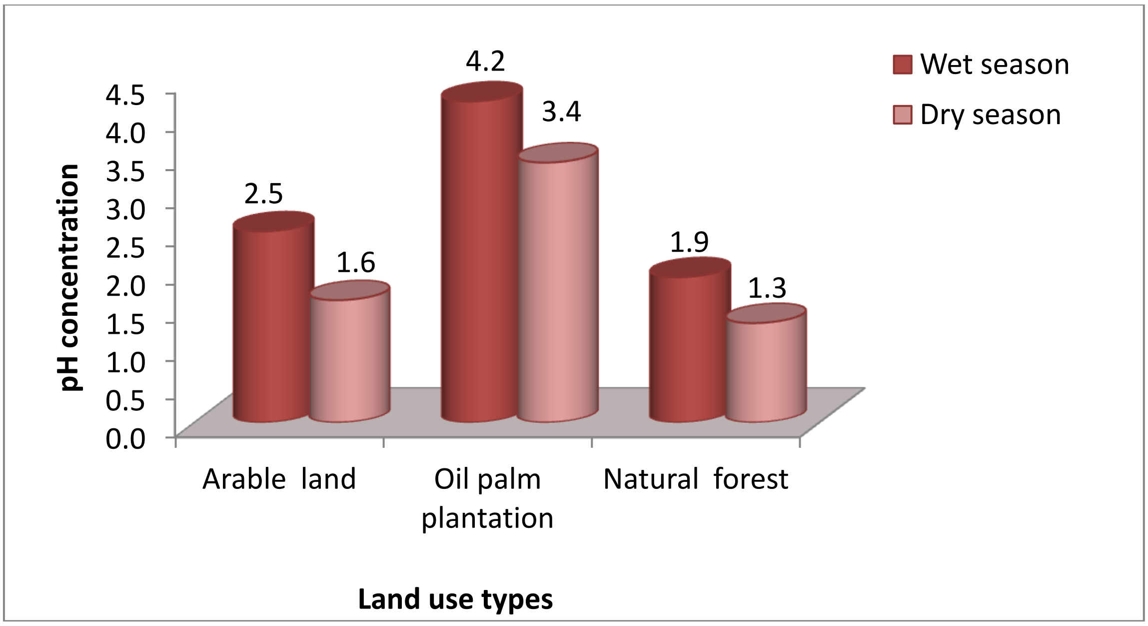

Fig. 2. Soil pH content in wet and dry season under different land use in the study area

respectively in dry seasons. The low pH observed in the natural 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 (1987) also reported a low pH levels in undisturbed forest compare to disturbed forest. This finding is consistent with Leskiw, [14] who noted that for a balanced nutrient supply, forest soils should be slightly acidic in nature. Dimiri et al., [15] 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 use could probably be of the same parent material. The pH range of 5.5 to 6.5 has been reported to be optimum for best plant growth [16].

Total nitrogen for arable land, oil palm plantation, and natural forest for both wet and dry seasons is shown in Fig. 2. The nitrogen content in both seasons within the 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 and 0.34 mg/kg for oil palm plantation and arable land during the wet season across the three-land 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., [17] who stated that rapid mineralization of nitrogen occurs during the rainy season, which results in increased levels of nitrogen during this season. Choudhri and Sharma, [18] also reported that elevated levels of total nitrogen in the soil during rainy season indicates blue green algae fixation, input from rain water and high rate of mineral nitrogen by microbial decomposition. Similarly, nitrogen content was low (0.12 mg/kg) in the dry season under arable land compared to 0.31 and 0.41 mg/kg for oil palm plantation and natural forest land-use. This observation may be due to inadequate soil moisture that enhances nitrogen mineralization. Singh and Singh [19] 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.

Soil organic carbon content among the three-land use in wet and dry season is presented in Fig. 3. The result showed that organic carbon content was highest (1.69 mg/kg) in natural forest followed by 1.39 and 1.04 mg/kg in oil palm plantation and arable land-use respectively, during the dry season. This may be due to the fact that, forests have greater canopies and provide litter in high quantity [20], hence accumulating higher carbon content compared to the arable land and oil palm plantation. This corroborates the findings of Sevgi and Tecimen [21] 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 arable land compared to 0.88 and 1.16 mg/kg for oil palm plantation and natural 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 decomposition.

The phosphorus content during the wet and dry seasons is presented in Fig. 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). 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 [22] who reported that soils with high organic matter content have better supplies of organic phosphate for plant uptake. Gupta and Sharma [23] 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*.,* [24] also reported that soils with maximum leaching are known to contain low amount of phosphorus as compared to soil with minimum leaching.

The concentrations of exchangeable cations (Na, K, Ca, and Mg) in the three-land use evaluated in wet and dry season are presented in Figs. 6, 9). Oil palm plantation had the highest (0.63 mg/kg) Ca content compared to natural forest (0.42 mg/kg), arable land (0.39 mg/kg) in the dry season (Fig. 6), similar trend was observed on K content of the soils. The highest amount of K (1.68 mg/kg) was observed in oil palm plantation, followed by natural forest (1.42 mg/kg) and arable land (1.25 mg/kg), respectively. Similarly, low values of Ca and K were recorded in the wet season in all the three-land use (Fig. 7). This may be as a result of the low organic carbon content of the soils in the dry season occasioned by inadequate moisture which affect decomposition of organic matter to releases these nutrients.

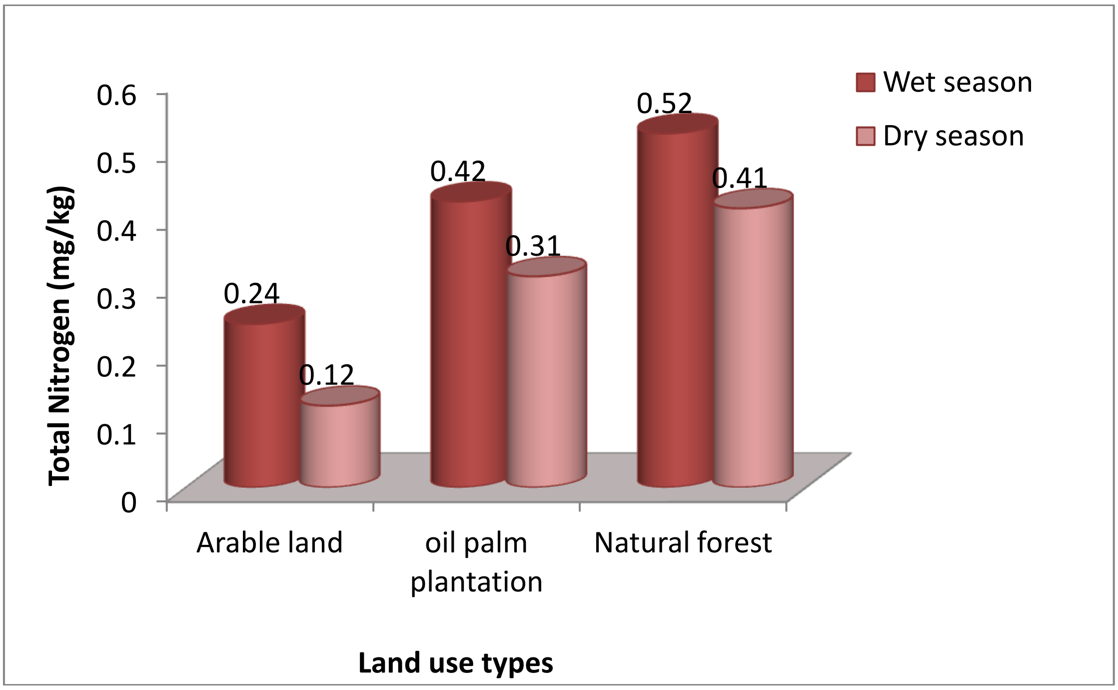

Fig. 3. Total nitrogen content in wet and dry season under different land use in the study area

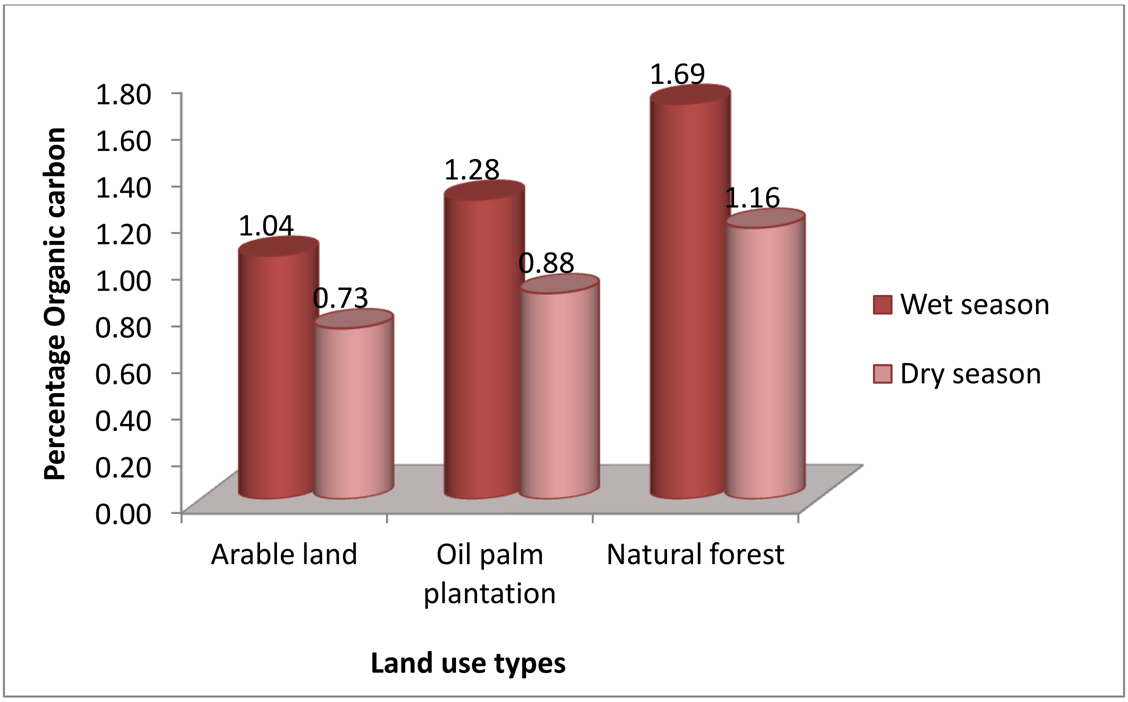

Fig. 4. Soil organic carbon content during wet and dry seasons in three land-uses

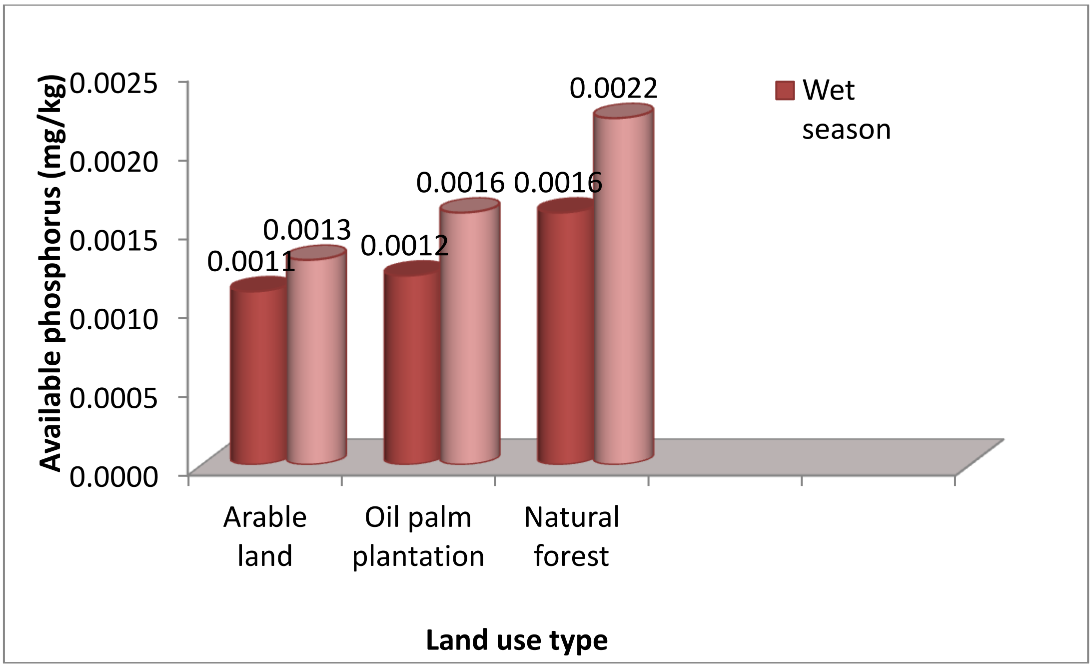

Fig. 5. Available phosphorus content during wet and dry seasons in three land uses

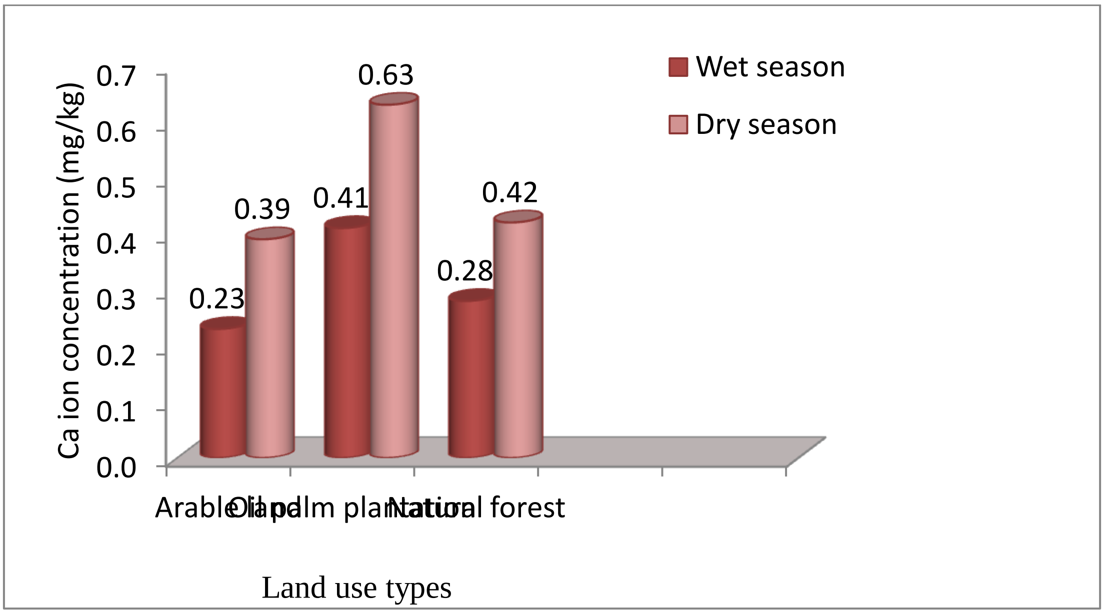

Fig. 6. Calcium concentration in wet and dry season in three-land use types

The Na content of the soil was highest (2.19 mg/kg) in the natural forest in comparison to oil palm plantation (1.26 mg/kg) and arable land (1.06 mg/kg) respectively in the wet season. Also, low values of Na were observed in all the three-land use during the dry season (Fig. 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 study revealed that rainfall reduced the concentration of Na and Mg in the soils. This observation is in alignment with the findings of Olujugba and Fatubarin, [25], 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.

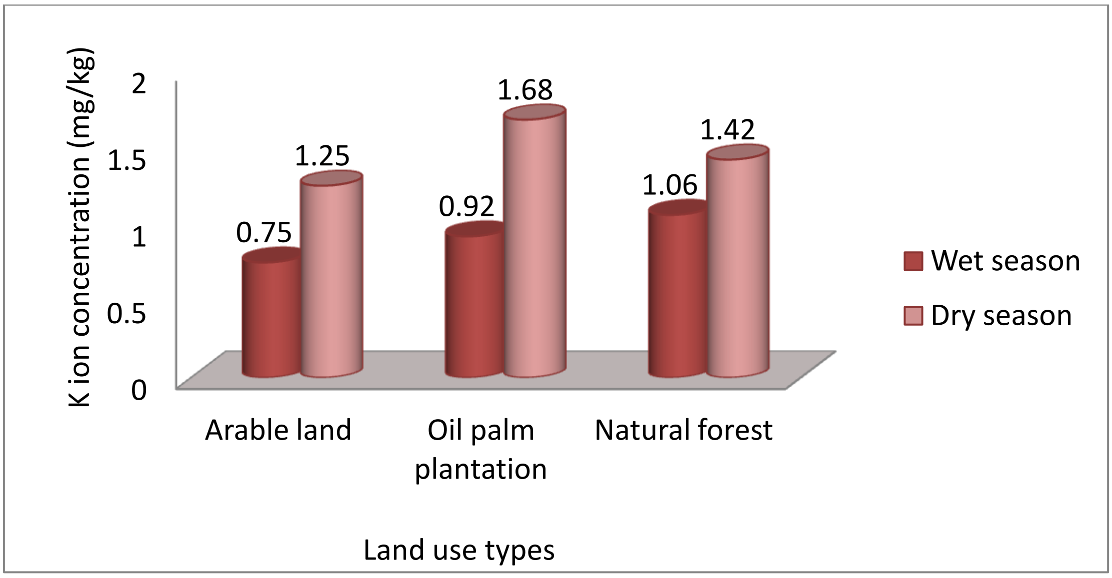

Fig. 7. Potassium concentration in wet and dry season in three land use types

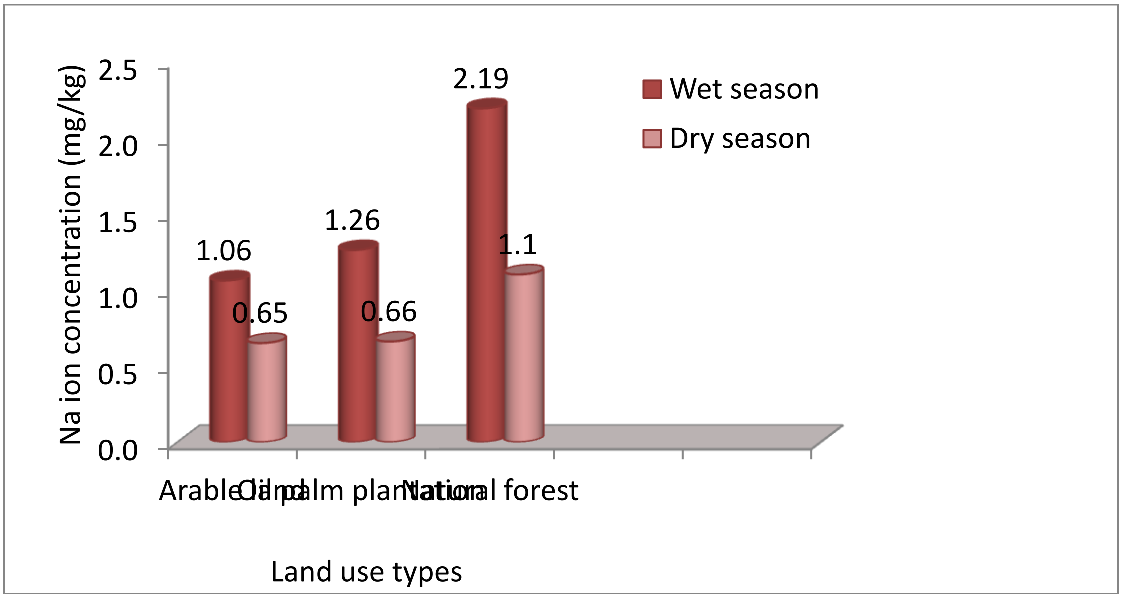

Fig. 8. Sodium concentration in wet and dry season in three land use types

The CEC values of the soils in the natural forest was moderately high (4.71 mg/kg) followed by oil 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-land use in the dry season (Fig. 10). The low values of CEC recorded may be attributed to the low values of the exchangeable 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 [26] 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 [27]. Generally speaking, the seasonal variations of the chemical parameters evaluated in the various land-uses could probably be due to the inherent properties of the soils. This study noted that different seasons affected the concentrations of exchangeable bases differently in the three-land use.

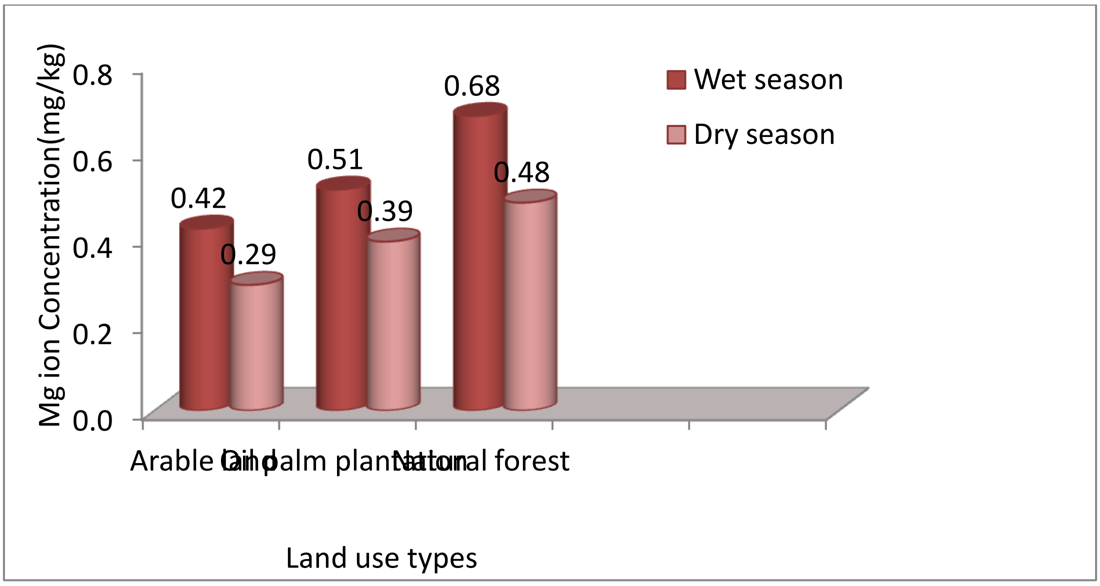

Fig. 9. Magnesium concentration in wet and dry season in three land use types

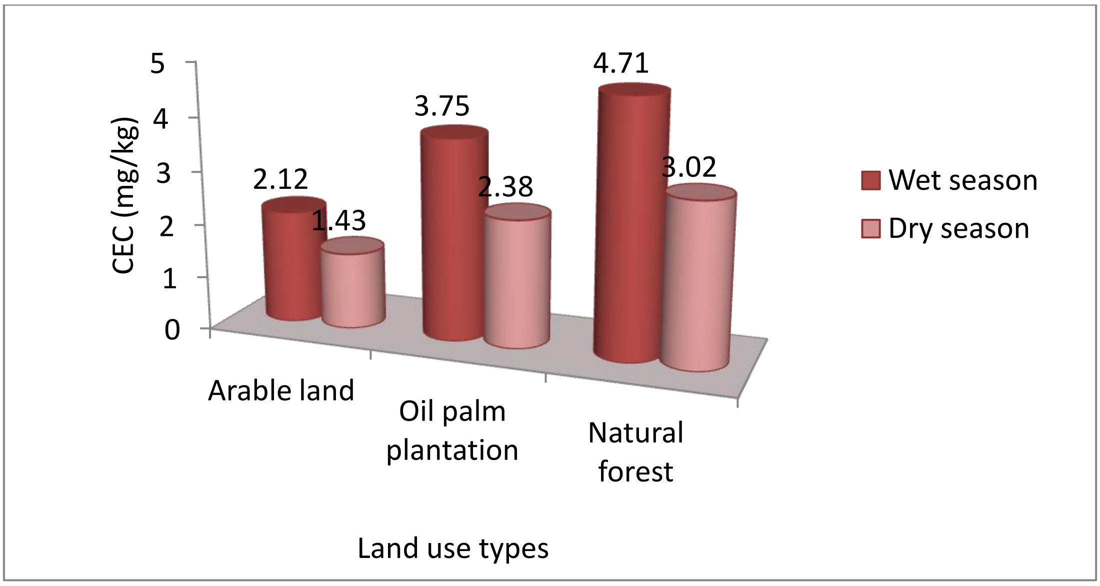

Fig. 10. Cation exchange capacity in wet and dry season in three land use types

4. CONCLUSION AND RECOMMENDATION

The results of this study revealed that the chemical properties of the soil under different land use showed significantly variations among the seasons, thus, crop production is encouraged in the wet season than in the dry season so as to utilize the availability of soil nutrients. However, bush burning must be discouraged to minimize the loss of nitrogen through volatilization. Application of organic materials such as crop residues, compost, and farmyard manure is recommended to improve the organic matter content of soils for sustainable crop production for the arable land in the study area to enhanced soil fertility.

5. 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.

ACKNOWLEDGEMENT

The authors appreciate the benevolence of Dukoria International Limited for their logistics support and laboratory analysis.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Deyn GBD, Van der Putten WH. Linking above ground and below ground diversity.Trends in Ecology & Evolution. 2005;20(11):6633.
   Available:https://doi.org/10.1016/j.tree.2005.08.009
2. Brevik EC. Climate Change, Soils and Human Health, RC Press: Boca Raton, FL, USA. 2013;345-383.
3. Meghana P, Bharat G, Beena P. Seasonal impact on physical-chemical properties of soil in North and South Gujarat. Journal of Agriculture and Veterinary Sciences. 2015;8(6):26-36.
4. Birara E, Mequanent M, Samuel T. Assessment of Food Security Situation in Ethiopia: A Review. Asian Journal of Agricultural Research. 2015;9:55-68.
5. Perrot KW, Sarathchandra SU, Waller JE. Seasonal storage and release of phosphorous and potassium by organic matter and microbial biomass in a high-producing pastoral soil, Australian Journal of Soil Resources. 1990;28:593-608.
6. McGrath DA, Comerford NB, Duryea ML. Litter dynamics and monthly fluctuations in soil phosphorus availability in an Amazonian Agroforestry. 2000;131:167-181.
7. Ross DJ, Tate KR, Scott NA, Felthman CW. Land-use change: effects on soil carbon, nitrogen and phosphorus pools and fluxes in three adjacent ecosystems. Soil Biology and Biochemistry. 1999;31:803-813.
8. Zeng DH, Hu YL, Chang SX, Fan ZP. Land cover change effects on soil chemical and biological properties after planting Mongolian pine (*Pinus svlvestris* var. mongolica) in sandy lands in Keerqin, north eastern China.Journal of Plant and soil Science. 2009;317:121-133.
9. Bodner G, Loiskandl W, Buchan G, Kaul HP. Natural and management- induced dynamics of hydraulic conductivity along a cover-cropped field slope. Geoderma. 2008;146:317-325.
10. Dickson AA, Tate OJ, Kamalu OJ, Ogboin TP. Characterization and Classification of some lower Niger Alluvial Soils in Bayelsa State, Nigeria. Bulgarian Journal of Soil Science, Biochemistry and Ecology. 2021;55:3-5.
11. Bremner JM, Mulvaney CS. Nitrogen-Total. In: Page, A.L., et al., Eds., Methods of Soil Analysis, 2nd Edition, Agronomy Monograph 9. ASA and SSSA, Madisons. 1982;595-624.
12. Nelson DW, Sommer LE. Total carbon, organic carbon and organic matter. Methods of Soil Analysis, Part 2. Chemical and Microbiological properties, 2nd Edition. ASA-SSSA, Madison. 1982;595-579.
13. Hendershort WH, Lalande H, Duquette M. Soil reaction and exchangeable acidity. In; Soil Sampling and Methods Analysis (ed. M.R. Carter). Lewis publishers, USA. 1993;141-149.
14. Leskiw LA. Land capability classification for forest ecosystem in the oil stands region. Alberia Environmental Protection; 1998.
15. Dimri BM, Singh SB, Banerjee SK, Singh B. Relation of age and dominance of tree species with soil chemical attributes in Kalimpong and Kurseong District of West Bengal. Indian Forestry. 1987;113:(4):307–311.
16. Ronen E. Micro Elements in Agriculture. Practical Hydroponic and Greenhouses. 2007;39-48.
17. Bergeron Y, Leduc A, Harvey B, Gauthier S. Natural fire regime: A guide for sustainable management of the Canadian boreal forest. Silva Fennica. 2002;36(1): 81-95.
    Available:https://doi.org/10.14214/sf.553
18. Choudhri GN, Sharma BA. Study of nitrogen dynamics in salt affected (Usar) habitat near Varanasi. Tropical Ecology. 1975;16:133–139.
19. Singh AN, Singh JS. Experiments on ecological restoration coalmine spoil using native trees in a dry tropical environment, India: A synthesis. New Forest. 2006;25-39.
20. Yinga OE, Kumar KS, Chowlani M, Tripathi SK, Khanduri VP, Singh SK. Influence of land-use pattern on soil quality in a steeply sloped tropical mountainous region, India.

Journal of Agronomy and soil science. 2020;1-21.
Available:https://doi.org/10.1080/03650340. 2020.1858478
21. Sevgi O, Tecimen HB. Changes in Austrian pine forest floor properties in relation with altitude in mountainous areas. Journal of Forest Sciences. 2008;54(7): 306–313.
Available:https://doi.org/10.17221/819-JFS
22. Miller RW, Donahuer RL. Soils in our Environment. Seventh edition. Prentice Hall, Inc. Upper Saddle River, New Jersy; 2001.
23. Gupta MK, Sharma SD. Effect of tree plantation on soil properties, profile morphology and productivity index I. Poplar in Uttrakhand. Ann. For. 2008; 16(2):209-224.
24. Ashraf M, Bhatt GA, Dar ID, Ali M. Physicochemical characteristics of grassland soils of Yusmarg Hill Resort (Kashmir, India), Eco. Balkanica. 2014; 4(1):31-38.
25. Olujugba MR, Fatubarin AR. Effect of seasonal dynamics on the physical properties of the soil of a Northern Guinea Savanna Ecosystem in Nigeria Journal of Soil Science and Environmental Management. 2015;6(5):100-107.
26. Rayment GE, Higginson FR. Electrical Conductivity. In 'Australian Laboratory Handbook of Soil and Water Chemical Methods' Inkata Press: Melbourne; 1992.
Available:http://www.soilquality.org.au
27. Chen LD, Messing I, Zhang SR, Fu BJ, Ledin S. Land use evaluation and scenario analysis towards sustainable planning on the Loess Plateau in China-case study in a small catchment. Catena. 2003;54:303-316.
DOI: 10.1016/S0341- 8162(03)00071-7

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/102462