Quest Journals
Journal of Research in Environmental and Earth Sciences
Volume 7 ~ Issue 8 (2021) pp: 17-25
ISSN(Online) :2348-2532
www.questjournals.org

Research Paper

Seasonal Effect on Some Chemical Properties of Mangrove Swamp and Lowland Rainforest Soils in South-South Nigeria

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ABSTRACT
Soils are intricately linked to the atmospheric and climatic system, and soil chemical properties are strongly influenced by seasonal variations which in turn affect agricultural productivity and food security. The aim of this study therefore was to investigate the effect of season on the chemical properties of two vegetation soil types. Samples of surface (0-15cm) and subsurface (15-30cm) soils were collected from June 2018 to May 2019 at Mangrove and Rainforest vegetation types in Port Harcourt during dry and wet seasons. Sampling months were categorized into Peak of Rainy season, Rainy season, Peak of Dry season and Dry season according to rainfall data, relative humidity, atmospheric temperature and soil temperature recorded throughout the sampling period. Soil chemical properties were analyzed using standard analytical methods and the data obtained were subjected to statistical analysis using analysis of variance (ANOVA). Results showed that soil chemical properties were generally higher in topsoil than in subsoil except for available phosphorus which recorded higher concentrations in subsoil than at topsoil. Soils in the mangrove vegetation were strongly acidic (pH-3.1), while soils in the rainforest vegetation were slightly acidic (pH 5.0). Values of available phosphorus followed the trend DS>PDS>PRS>RS, while magnesium and percentage base saturation had similar trend of DS>RS>PDS>PRS. Values of sodium and potassium were similar in all seasons, while effective cation exchange capacity and exchangeable acidity followed the trend PDS>PRS>RS>DS and PRS>PDS>RS>DS respectively. Generally, concentrations of soil chemical properties tend to be higher in the drier seasons than during the wet seasons. This investigation showed that the chemical properties of the soils were influenced by seasonal changes in the region which could in turn influence agricultural production.

KEY WORDS: *Seasonal; Effect; Soil; Chemical Properties; Mangrove Swamp; Rainforest*

Received 24 July, 2021; Revised: 07 August, 2021; Accepted 09 August, 2021 © The author(s) 2021. Published with open access at www.questjournals.org

I. INTRODUCTION

Soils are intricately linked to the atmospheric and climatic systems, and altered climate influences soil properties and processes [1]. Climate change will also influence the global precipitation patterns, altering both the amount of precipitation received and the distribution of precipitation over the course of an average year in many locations [2]. Soils are essential for food security and climate change has the potential to threaten food security through its effects on soil properties and processes [3]. 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 subsequent crop yields [4]. According to [5] climate and geological history are important factors affecting soil properties on regional and continental scales. Change in the soil chemical properties in the form of phosphorus mineralization, and immobilization of organic phosphorus are strongly influenced by seasonal variations in temperature, moisture, plant growth and root activity, and by organic matter accumulation from litter fall [6]. Increase in soil temperature decreases organic matter through combustion [7]. This decrease in organic matter and reduction in clay size, clay fraction as a result of high temperature leads to decrease in the cation exchange capacity of the soil [8]. [9] observed that water-soluble phosphorus increased with soil temperature from 50^0 – 250^0C due to the increase in the movement of phosphorus in the soil controlled by diffusion. Soils with low temperature have low availability of phosphorus, because the release of phosphorus from organic materials is hindered by low temperature [10].

. Each of the wet and dry seasons of the seasonal climate of the tropical ecosystem is characterized by a number of ecological phenomena which set up series of processes that influence the biotic and edaphic components of the ecosystem. Rainfall and temperature regimes are key factors responsible for microbial and physicochemical properties of soil [11]. According to [12], several studies abound in other parts of the world on seasonal factors, but they primarily focus on prediction, verification and statistics in a few study areas. It is therefore the aim of this study to analyze the chemical properties of soils of mangrove swamp and tropical rainforest, and the effect of season on the concentrations of chemical parameters the soils.

II. MATERIALS AND METHODS

2.1. Study Area

The study area was Port Harcourt metropolis in Rivers State. Port Harcourt is situated in the humid rainforest region of Southern Nigeria. It lies between latitude 4.5^0N and longitude 7.0^0E on an elevation of 18m above sea level. The climate of the area is tropical with two prominent seasons, the wet (rainy) and dry seasons. The dry season is short, usually lasting for 4 months, from November to March, with little rains during this period; while the longer wet season prevails during the remaining months. The mean annual rainfall in Port Harcourt ranges from about 3,000mm to 4,500mm [13]. Annual maximum temperature ranges from 22^0C to 29^0C while relative humidity varies between 75% and 95%. The vegetation consists of two well defined and easily recognizable belts namely tropical rainforest and mangrove swamps [14].

2.2. Sampling Stations

The two study stations were a lowland rainforest located in Rivers State university teaching and research farm and mangrove swamp vegetation located in Eagle island environment all in Port Harcourt.

2.3. Collection of Soil Samples

Soil samples were collected during four seasons: wet season, peak of wet season, dry season and peak of dry season. The samples were collected at two depths: 0-15cm and 15-30cm using a soil auger at three randomly selected sampling points, each within an area of 1mxm, and at a distance of 30m apart in each station. The samples were placed into well labeled polythene bags and transferred to the laboratory for analysis. Sampling was done monthly, for a period of 12 months: June 2018 - May 2019. Six representative composite soil samples were collected monthly for analysis from each study station in the four seasons based on monthly rainfall data obtained during the study period as Peak of Dry Season, Dry Season, Rainy Season and Peak of Rainy Season.

2.4. Analysis of Physicochemical Properties of Soils

Soil samples were air-dried at room temperature for a few days, sieved through a 2mm sieve and analyzed for chemical properties using standard analytical procedures. The pH of the soil samples was determined with a standard glass electrode in a ratio of 1:2.5 soils: distilled water suspension [15]. Organic carbon content was determined by the Walkley and Black Wet oxidation method as modified by [16]. Available phosphorus was extracted by the Bray No. 1 method as modified by [17], and determined using a spectrophotometer. Exchangeable K of the soil samples was extracted with neutral normal ammonium acetate buffered at pH 7 after shaking for 2 hours [18]. Exchangeable Ca and Mg was determined by EDTA complexometric titration [19] while Na was determined by flame photometry [20]. Exchangeable acidity was determined from 0.1NaCl extracts and titrated with 1.0N hydrochloric acid. Cation exchange capacity (CEC) was determined by summing up total exchangeable bases and total exchangeable acidity. Base saturation was determined using the equation: Base saturation = TEB/CEC X 100.
Where TEB= Total exchangeable bases; CEC = Cations exchange capacity.

2.5. Statistical Analysis

Data collected from the various parameters was subjected to analysis of variance (ANOVA) at $P< 0.05$. Means were separated using Tukey's Pair Wise Comparison at 95% confidence intervals.

III. RESULTS

The monthly and seasonal classification of climate parameters recorded during the months of sampling are presented in Table 1. Data obtained from the Nigerian Meteorological Agency (NIMET) throughout the study period, June 2018 – May 2019, were used to classify the period into four seasons: Peak of Rainy season (PRS), Rainy season (RS), Peak of Dry season (PDS) and Dry season (DS). Ranges of rainfall data during each season were: Peak of Dry Season (0.00-63.75mm), Dry Season (41.15-288.80mm), Rainy Season (94.23-364.24mm) and Peak of Rainy Season (202.69-401.83mm).

Results of pH, available phosphorus, exchangeable bases, effective cation exchange capacity, exchangeable acidity, and base saturation in the rainforest and mangrove vegetation at 0-15cm and 15-30cm soil depths, during the four seasons are presented in Table 2. The mean pH values at the two depths and during the four seasons are presented in Figures 1 and 2. Soil pH values ranged from 4.5-5.4 in the rainforest vegetation and 2.5-3.9 in the mangrove vegetation at both depths. Mean pH values of 4.1 at 0-15cm depth was slightly higher than 4.0 recorded at 15-30cm depth (Fig 1). Mean seasonal variations showed that soil pH value was highest during the dry season with a value of 4.6, followed by the peak of dry season (4.1), then the rainy season (3.9) and the peak of rainy season (3.6). Values of exchangeable bases (Ca^+, Mg^+, K^+, and Na^+) ranged from 2.4-3.4cmol/kg, 1.0-2.0cmol/kg, 0.3-0.5cmol/kg, and 0.2-0.3cmol/kg for calcium, magnesium, potassium and sodium respectively at the two depths in the rainforest vegetation; while values in the mangrove vegetation ranged from 11.3-21.1cmol/kg, 4.0-8.6cmol/kg, 0.2-0.3cmol/kg and 0-0.3cmol/kg at both depths for calcium, magnesium, potassium, and sodium respectively (Table 2). Mean values of Ca^+, Mg^+, K^+ and Na^+ at the two depths and during the seasons are presented in Figs 3 and 4. Mean Ca^+ and Mg^+ values were slightly higher at 15-30cm with values of 9.6cmol/kg and 3.8cmol/kg than the values of 9.5cmol/kg and 3.6cmol/kg at 0-15cm depth; while K^+ and Na^+ values were 0.3cmol/kg at both depths (Fig 3). Mean seasonal variation of exchangeable bases revealed that Ca^+ values were highest in the peak of dry season (11.6cmol/kg), followed by rainy season (10.2cmol/kg), then dry season (8.9cmol/kg) and peak of rainy season (7.4cmol/kg). Mg^+ values were highest in dry season (4.3cmol/kg), followed by rainy season (4.0cmol/kg), then the peak of dry season ((3.4cmol/kg), and peak of rainy season (3.0cmol/kg). Values for K^+ and Na^+ were similar (0.3cmol/kg) for all seasons, except during the rainy season, where Na^+ was 0.2cmol/kg (Fig 4).

Table 1: Seasonal Classification of Monthly Climate Parameters (2018-2019)

Seasons	Months	Maximum Temperature (^{0}C)	Minimum Temperature (^{0}C)	Rainfall (Inches)	Rainfall (mm)	Soil Temperature (^{0}C)	Relative Humidity (%)
PEAK OF RAINY SEASON	JUNE	31.17	22.95	15.82	401.83	28.87	87.77
	JULY	29.29	22.83	8.61	218.69	28.94	87.74
	AUGUST	29.48	23.50	7.98	202.69	26.90	86.39
	MEAN	29.98	23.09	11.80	299.72	28.24	87.30
RAINY SEASON	SEPTEMBER	30.32	22.46	14.34	364.24	27.17	86.23
	OCTOBER	31.15	22.98	6.04	153.42	28.25	85.52
	NOVEMBER	31.29	23.34	3.71	94.23	27.90	86.07
	MEAN	30.92	22.93	8.03	203.96	27.77	85.94
PEAK OF DRY SEASON	DECEMBER	33.48	21.32	0.00	0.00	29.69	73.29
	JANUARY	33.95	21.86	2.26	57.40	29.90	77.35
	FEBRUARY	33.35	22.60	2.51	63.75	29.44	79.86
	MEAN	33.40	21.93	1.59	40.39	29.68	76.83
DRY SEASON	MARCH	32.88	23.92	3.64	92.46	29.46	82.74
	APRIL	32.78	24.11	1.62	41.15	29.83	83.30
	MAY	31.93	23.86	11.37	288.80	29.64	83.65
	MEAN	32.53	23.96	5.54	140.72	29.64	83.23

Source: Nigerian Meteorological Society (NIMET) (June 2018 - May 2019)

Values of Available phosphorus ranged from 15.5-51.6mg/kg at both depths in the rainforest vegetation, while values in the mangrove vegetation ranged from 47.1-80.2mg/kg (Table 2). Mean values for available phosphorus at the two depths and during the seasons are presented in Figs 5 and 6. Available Phosphorus levels were significantly higher ($P<0.05$) at 15-30cm depth with a mean value of 46.1mg/kg than the value of 38.9mg/kg at 0-15cm depth (Fig 5). Results of the mean seasonal variations on available phosphorus revealed that phosphorus levels were significantly highest ($P<0.05$) in dry season (55.8mg/kg), followed by the peak of dry season (44.9mg/kg), then the peak of rainy season (36.1mg/kg) and rainy season (33.2mg/kg) Fig 6.

Table 2: Mean Seasonal Values of Chemical Properties of Rainforest and Mangrove Vegetation Soils at Two Depths

Vegetation	Season	Depth (cm)	pH	Av. P (mg/kg)	Ca	Mg	K	Na	EA	ECEC	BS
					----------------------cmol/kg					-------------------------	%
Rainforest	Rainy season	0-15	4.7^{cde}	18.7^{fg}	3.4^{f}	1.7^{ef}	0.4^{bc}	0.2^{cde}	1.4^{ef}	10.6^{f}	**61.9^{fg}**
		15-30	4.9^{bcd}	15.5^{g}	3.1^{f}	1.3^{ef}	0.3^{efg}	0.2^{de}	5.5^{de}	5.9^{f}	**77.4^{cd}**
	Peak of rainy season	0-15	4.5^{e}	18.9^{fg}	3.1^{f}	1.4^{ef}	0.5^{a}	0.3^{a}	1.9^{ef}	7.1^{f}	**73.6^{de}**
		15-30	4.7^{de}	31.8^{def}	2.4^{f}	1.0^{f}	0.3^{cd}	0.3^{ab}	2.1^{ef}	5.8^{f}	**66.5^{ef}**
	Dry season	0-15	5.4^{a}	36.5^{cde}	3.4^{f}	2.0^{e}	0.5^{a}	0.3^{a}	0.6^{f}	6.4^{f}	**89.7^{a}**
		15-30	5.4^{a}	51.6^{b}	3.3^{f}	1.4^{ef}	0.3^{cd}	0.3^{ab}	0.9^{f}	5.8^{f}	**86.6^{abc}**
	Peak of dry season	0-15	5.2^{ab}	28.3^{efg}	4.2^{f}	1.9^{ef}	0.4^{b}	0.3^{ab}	1.9^{ef}	7.9^{f}	**81.1^{abcd}**
		15-30	5.1^{abc}	17.5^{fg}	3.5^{f}	1.2^{ef}	0.3^{def}	0.2^{bcde}	2.1^{ef}	6.9^{f}	**77.5^{cd}**
Mangrove	Rainy season	0-15	3.1^{gh}	47.1^{bc}	13.8^{cd}	4.4^{d}	0.3^{def}	0.2^{de}	5.7^{de}	23.9^{e}	**82.1^{abcd}**
		15-30	2.9^{ghi}	51.5^{b}	20.3^{a}	8.6^{a}	0.2^{def}	0.3^{ab}	28.1^{ab}	56.8^{a}	**53.7^{gh}**
	Peak of rainy season	0-15	2.7^{hi}	47.7^{bc}	11.3^{e}	5.7^{bc}	0.3^{fgh}	0.2^{cde}	24.3^{b}	41.3^{c}	**42.1^{i}**
		15-30	2.5^{i}	46.0^{bcd}	13.0^{de}	4.0^{d}	0.2^{gh}	0.2^{cde}	29.8^{a}	46.8^{bc}	**37.3^{i}**
	Dry season	0-15	3.9^{f}	54.9^{b}	15.9^{bc}	6.2^{b}	0.2^{fgh}	0.2^{e}	3.8^{ef}	24.9^{de}	**78.2^{bcd}**
		15-30	3.8^{f}	80.2^{a}	13.2^{de}	7.7^{a}	0.2^{h}	0.2^{bcd}	8.2^{d}	30.0^{d}	**88.8^{ab}**
	Peak of dry season	0-15	3.3^{g}	58.8^{b}	21.1^{a}	5.7^{bc}	0.3^{cde}	0.3^{bc}	18.2^{c}	44.8^{c}	**61.7^{fg}**
		15-30	2.8^{hi}	75.1^{a}	17.6^{b}	4.9^{cd}	0.3^{cd}	0.3^{ab}	28.5^{ab}	50.9^{b}	**46.2^{hi}**

Values of effective cation exchange capacity of soils ranged from 5.8-10.6cmol/kg in the rainforest vegetation, while values in the mangrove vegetation ranged from 23.9-56.8cmol/kg (Table 2). Mean values for ECEC at the two depths and during the seasons are presented in Figs 7 and 8. Effective cation exchange capacity was significantly higher ($P<0.05$) at 15-30cm depth, with a value of 25.5cmol/kg than at 0-15cm depth with a value of 21.5cmol/kg (Fig 7). Mean seasonal variation of ECEC showed that ECEC value was significantly highest ($P>0.05$) in the peak of dry season (27.7cmol/kg), followed by the peak of rainy season (25.2cmol/kg), then rainy season (24.3cmol/kg) and dry season (16.7cmol/kg) Fig 8. Values for exchangeable acidity ranged from 0.6-5.5cmol/kg at both depths in the rainforest vegetation, while values in the mangrove vegetation ranged from 3.8-29.8cmol/kg (Table 2). Results of the mean values for exchangeable acidity at the two depths and during the seasons are presented in Figs 7 and 8. Exchangeable acidity values were significantly higher ($P<0.05$) at 15-30cm depth with a value of 12.1cmol/kg than the value of 8.3cmol/kg at the 0-15cm depth (Fig 7). Results of mean seasonal variation of exchangeable acidity revealed that EA values were highest during the peak of rainy season (14.5cmol/kg), followed by the peak of dry season (12.7cmol/kg), then rainy season (10.2cmol/kg) and dry season (3.4 cmol/kg) Fig 8.

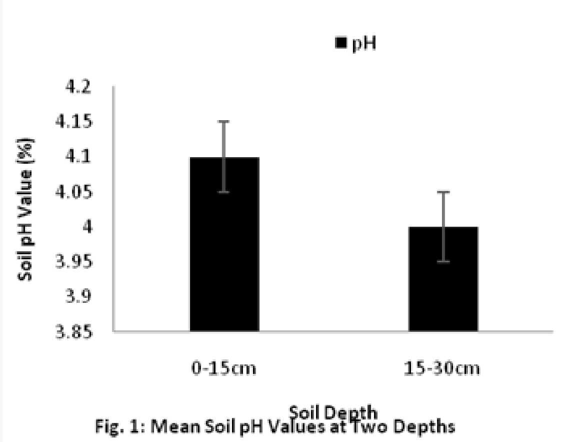

Fig. 1: Mean Soil pH Values at Two Depths

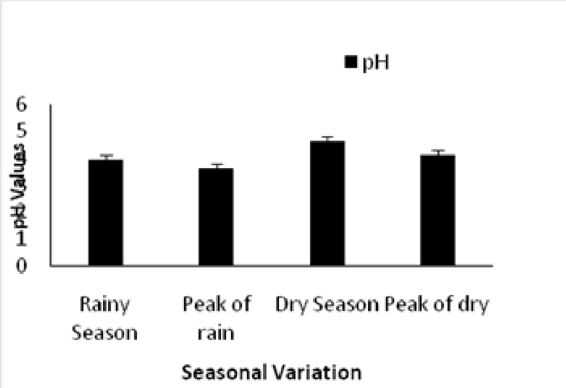

Fig. 2: Mean Seasonal Values of Soil pH

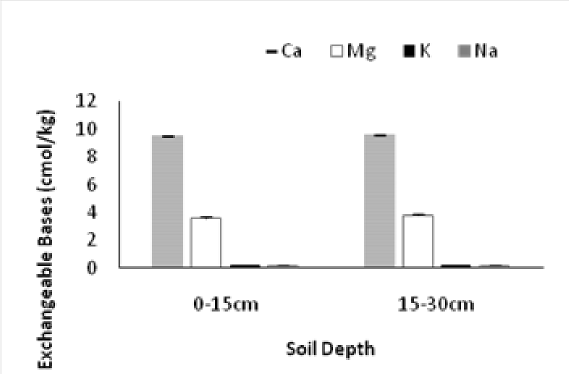

Fig.3: Mean Values of Exchangeable Bases at Two Depths

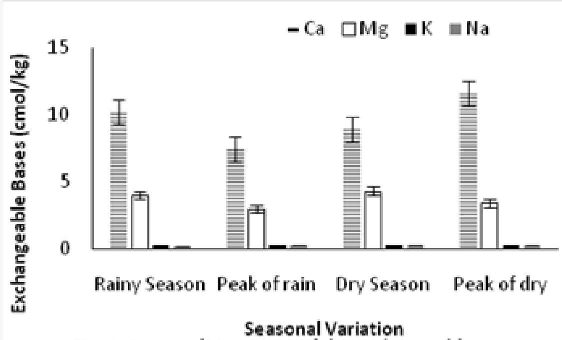

Fig. 4: Seasonal Variations of the Exchangeable Bases of the Study Soils

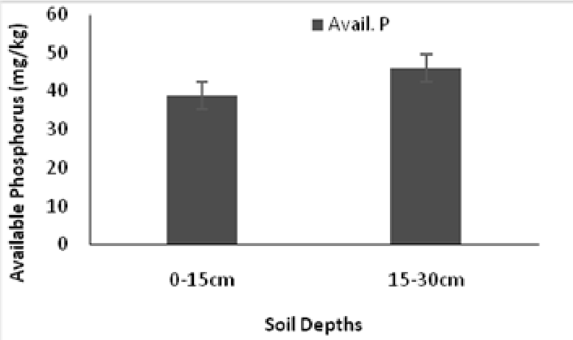

Fig. 5: Mean Values of Available Phosphorus at Two Depths

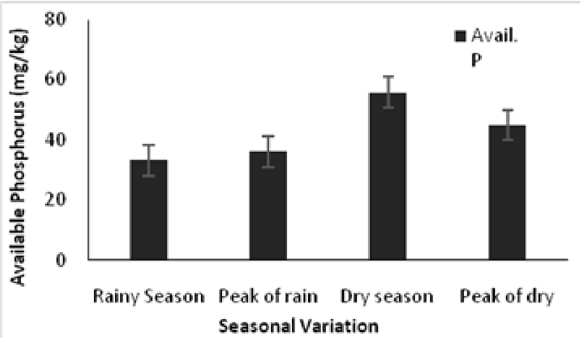

Fig. 6: Mean Seasonal Variations of Avail.able Phosphorus of the study soils

Base saturation values ranged from 61.9%- 89.7% at both depths in the rainforest vegetation, while values at the mangrove vegetation ranged from 37.3%- 88.8% (Table 2). Results of the mean base saturation values at the two depths and during the seasons are presented in Figs 9 and 10. Percentage base saturation was significantly higher ($P<0.05$) at 0-15cm depth with a mean value of 71.3% than the value of 66.7% at the 15-30cm depth (Fig 9). Mean seasonal variations revealed that base saturation was significantly highest ($P<0.05$) in dry season (85.8%), followed by rainy season (68.7%), then peak of dry season (66.6%), and peak of rainy season (54.9%).

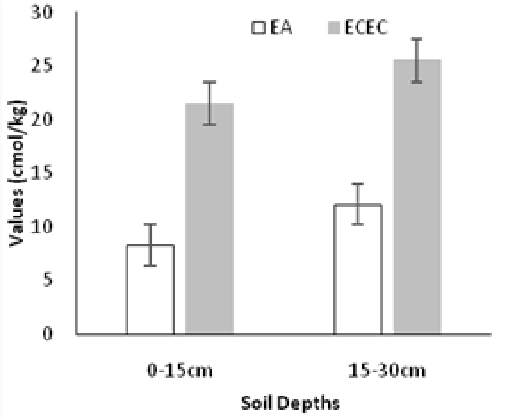

Fig. 7: Mean Values of Exchangeable Acidity and Effective Cation Exchange Capacity at Two Depths

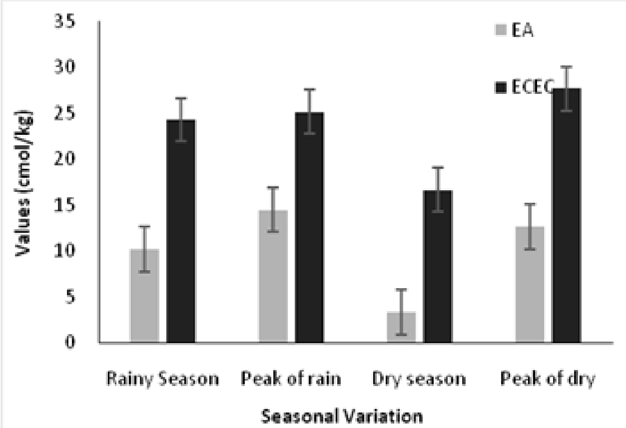

Fig.8: Mean Seasonal Variations of Exchangeable Acidity and Effective cation exchange capacity of the study soils

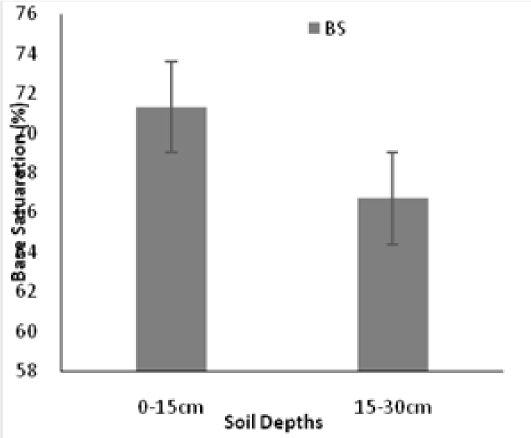

Fig. 9: Mean Values of Base Saturation at Two Depths

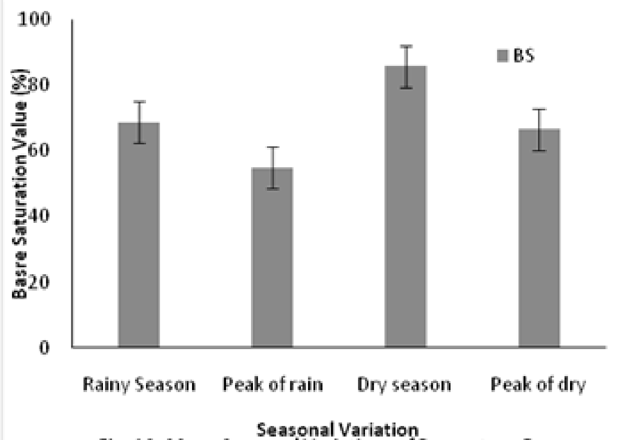

Fig. 10: Mean Seasonal Variations of Percentage Base Saturation of the study soils

IV. DISCUSSION

Soil pH was generally acidic with values being higher at topsoil than at subsoil in both seasons and in the two vegetation soil types. Similar findings were reported by [21, 22], who attributed the higher values in top soils due to the buffering effect of soil organic matter against pH change in addition to the release of basic cations during organic matter decomposition which occurs more in surface soil than the subsurface soil. Seasonal variations in pH values followed the order DS>PDS>RS>PRS, implying that pH in soils were generally higher and less acidic in dry season and peak of dry season than during the rainy season and peak of rainy season in the two vegetation types. Lower soil pH values recorded during rainy months could be probably due to the decrease in the degree of ionization releasing less hydrogen ion (H^+) in the soil due to water-logged condition caused by heavy rainfall during the wet season than the dry season. Similar results were reported in a finding by [23] who evaluated the effects of selected land use types on soil properties in Nando, Anambra State. High rainfall is related to acid dilution, thus lowering the soil acidity down the soil profile during the beginning and at the peak of the rains [24].

Values of exchangeable bases, Ca, Mg, K, and Na varied differently in the soil depths and in the four seasons but their concentrations were not significantly different between topsoil and subsoil, and in the four seasons. Values of Ca and Mg were far higher than the values of K and Na in the two soil depths and the seasons (Table 2). Seasonal influence on the concentration of calcium in the soil followed the descending order of PDS>RS>DS>PRS while Mg concentrations were highest in DS followed by RS and PDS but was lowest during peak of rainy season. This study revealed that heavy rainfall reduced the concentration of Ca and Mg in the soils. There is the possibility that these basic cations were being eroded and leached faster by high rainfall which occurred during the peak of rainy season. These findings were consistent with [25], who postulated that high precipitation might lead to decrease in exchangeable bases. Concentration of potassium and sodium were very low compared to the values of calcium and magnesium. This study noted that different seasons affected the concentrations of exchangeable bases differently in the soil of the two vegetation types. The seasons increased

Ca and Mg concentrations in mangrove soil and decreased the values in rainforest soil but the reverse was the case in K and Na concentrations which were higher in rainforest vegetation soil and lower in mangrove vegetation soil type. Generally, there was a decline in the soil minerals during the peak of rainy season, which could possibly be as a result of the active growth and usage of mineral nutrients by forest trees [26].

Values of available phosphorus varied differently in the two depths and during the seasons, and did not follow any particular trend. The values were significantly higher at topsoil in RS and PDS in rainforest soil, PRS and PDS in mangrove soil; PRS and DS in Rainforest soil, RS, DS and PDS in Mangrove soil for subsoil. The reverse was the case in the other seasons, where phosphorus values were lower in PRS and DS for topsoil, RS and PDS for subsoil in rainforest vegetation; RS, DS and PDS for topsoil, PRS for subsoil in mangrove vegetation. This study showed that values of available phosphorus from the two vegetation types were generally high in the two vegetation soil types and in all the seasons but did not follow any particular trend in their fluctuation. High phosphorus levels in the soil is an indication of the increased decomposition of organic matter, occurring under regenerating canopies, which was suggested by previous researchers [27, 21]. But higher concentrations of available phosphorus in subsoil were reported by [28] in mangrove swamp zones of Delta state, which was in close agreement with results of available phosphorus in mangrove soil obtained in this study but different from the values observed in rainforest soil. The reduced concentrations of phosphorus in the topsoil could be due to complexation with organic matter (H^+ and Al^+ exchange sites on surface area of organic matter) because of high concentration of organic matter in the topsoil [29, 21]. Generally, the study soils contain high concentration of available phosphorus in all the seasons. Soils with maximum leaching were reported to contain low amounts of phosphorus while soils with minimum leaching had higher amounts of phosphorus [30].

Exchangeable acidity values were higher in subsoil than in topsoil in the two vegetation soils in all the seasons. This could be due to aluminum saturation, which increases with soil depth. In rainforest soil, exchangeable acidity was highest during the rainy season, followed by the peak of rainy season and peak of dry season (which had same values) with lowest value in dry season. In the case of mangrove soil, exchangeable acidity was highest during the peak of rainy season, followed by the peak of dry season and then rainy season while least value was observed in dry season. Effective cation exchange capacity values were higher in topsoil than in subsoil in rainforest vegetation in all the seasons but reversed in mangrove vegetation where the subsoil had higher values than in topsoil in all the seasons. This could be attributed to the leaching of the cations down the soil depth by rainfall [31], which probably could be faster in rainforest soil than in mangrove soil due to differences in water holding capacity of the two soils. Mean seasonal ECEC values of the two depths in rainforest soil followed the order of RS>PDS>PRS>DS while the mangrove soil had the order of PDS>PRS>RS>DS. The reason for the seasonal variations of ECEC in this study could probably be due to changes in the inherent properties of the soils influenced by the climatic conditions particularly rainfall.

Base saturation values were generally higher in the topsoil than in the subsoil. This could be due to the leaching of cations down the soil depth by rainfall [31]. It was observed that the soil content of most of the exchangeable bases reduced down the profile. This is apparent because the cations are concentrated in the organic matter rich topsoil at different stages of decomposition which continually releases the cations [22]. Also higher values for base saturation were recorded in the soil of rainforest vegetation than in the soil of mangrove swamp vegetation. In rainforest vegetation, mean base saturation values of the two depths followed the order of DS>PDS>RS>PRS while the values in mangrove vegetation followed the sequence DS<RS<PDS<PRS in this study. Generally speaking, the seasonal variations of the physicochemical parameters in the two vegetation types could probably be due to the inherent properties of the soils such as the physical nature and chemical activities which in turn are influenced by changes in season in the study area.

V. CONCLUSION

Results obtained during this study revealed that the chemical properties of the soil under mangrove swamp and lowland rainforest vegetation types in Port Harcourt significantly varied among the variables. Changes in precipitation and temperature regime influenced soil chemistry significantly. The study revealed that rainy/peak of rainfall resulted in increased concentrations of macro-nutrients such as Ca, Mg, EA, ECEC and BS in the mangrove vegetation when compared with the dry/peak of dry season while in the rainfall vegetation, rainy/peak of rainy seasons showed no significant effect on the concentration of most macro-nutrients particularly Av. P, Na, Ca, Mg, EA, and ECEC) but significant effect was observed in dry/peak of dry seasons. However, in dry and peak of dry seasons, phosphorus and potassium were available in the soil. There was however significant difference in the pH values of the mangrove and rainforest vegetation. This condition could be attributed to the poor differences in the drainage pattern of the two soil types. This study showed that the soils of the two vegetation types across the profile and seasons contain somewhat high concentration of chemical nutrients, which could be useful in sustainable crop production.

ACKNOWLEDGEMENT

We acknowledge the contributions of Dr. B. Udom and Dr. A. O. Ano of Research Institute, Umudike and Mr. F. O. C. Harry for their technical assistance during this study.

Limitation of the study

The limitation of this study was 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.

Recommendation

This study focused on a few soil minerals and nutrients, it is therefore recommended that more research be carried out on the two vegetation types that will expand the scope of the soil physicochemical properties to include other nutrients such as total organic carbon, total nitrogen, nitrate and sulphate that contribute to soil fertility.

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