WORLD ENVIRONMENTAL CONSERVATION CONFERENCE 2023

CLIMATE CHANGE PARTNERSHIP ACTIONS FOR SUSTAINABLE FUTURE AND RESTORING LIFE ON EARTH

Proceedings of the 6th edition of World Environmental Conservation Conference

18th – 21st October, 2023

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Production of Proceedings
Netlink Environmental Conservation Organisation
Room 21 Abubakar Adamu Bulding
Federal University of Technology, Akure.
Design amd Printing of Proceedings
Maryj Printing Press
ACAD Fagbote Filling Station Akure-Ilesha Expressway
Phone number: +23407063411658

Copies of Proceedings
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ISSN: 2705-2850

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PREFACE

There is a growing concern on the adverse impacts of climate on biodiversity. This phenomenon is greatly manifested in form of shifting weather patterns threatening global food security, health and species existence. Humanity is at the receiving end of the consequences of climate change hence there is a need to step up actions on all fronts- overtime, everywhere all at once.

This calls for collaboration, partnership and networking to strengthening synergy among relevant stakeholders in a bid to tackling climate change menace. This forms the basis for the theme of this year world Environmental conservation conference: **CLIMATE CHANGE PARTNERSHIP ACTIONS FOR SUSTAINABLE FUTURE AND RESTORING LIFE ON EARTH.** The theme is conceived with a view to create an interface for information sharing and offer opportunities for participants to refine their commitments and pledges in the quest to achieving Sustainability in the face of climate change.

This year World Environmental Conservation Conference is memorable in the sense that it received overwhelming funding from the host - West African Science Service on Climate Change and Adapted Land use). WASCAL is posed to provide information and knowledge at the local, national and regional level to cope with the adverse impacts of climate change. Thus, this conference will offer opportunities for participants to learn from good practices demonstrated and showcase by WASCAL during the course of the conference. It will also strengthen staff-student exchange and provide prospect for Doctorate Research Doctoral Research in West Africa Climate System Programme (DRP WACS) – WASCAL among others.

Special appreciation goes to the management of The Federal University of Technology, Akure the host institution, National Park Service and African Regional Center for Space Science and Technology Education-English (ARCSSTE-E) that co-host this conference. We equally acknowledge other private, individual and corporate organizations that have contributed towards the success recorded in this event.

All the submitted articles were subjected to strict double blind peer-review process by the reviewers that are experts in the area of the particular submitted manuscript. The accepted manuscripts are published in WECC 2023 proceedings and also available for download on the organization website (www.necorng.org).

The accepted manuscripts fall within the underlisted subthemes:

- Climate change adaptation strategies in Agriculture, Forestry and Other Land Use (AFOLU)
- Climate smart city and architectural landscape design
- Retrofitting and decarbonization in tourism and hospitality industry
- Indigenous knowledge and local innovation in climate change adaptation
- Climate risk management, health, safety and hygiene
- Carbon credit-offset marketing/circular economy
- ICT development in environmental conservation (image processing and acquisition, computer vision, graphics, speed, interface technology, HMD devices, GIS: Body Tracking, AI and IOT, VRT, IVE).

We commend our keynote speaker Prof. Douda Kone Director Capacity Building Department, WASCAL Headquarter, Ghana and other guest speakers Prof. Babatunde Rabiu, Director General, Chief Executive Office, African Regional Centre for Space Science and Technology Education-English (ARCSSTE-E) and Dr. Goni I. M., Conservator General National Park Service.

It is hoped that researchers, students and policy makers will find the papers in this book very useful. Even though all the papers were reviewed and edited, the content and option expressed remain essentially that of the authors and not necessarily that of Netlink Environmental Conservation Organization.

Dr. Oladeji S. O.

President Netlink Environmental Conservation Organization

Convener World Environmental Conservation Conference

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NUTRIENT ASSESSMENT AND FERTILITY CAPABILITY CLASSIFICATION OF SOILS IN RAINFOREST AGROECOLOGICAL ZONE OF SOUTHWEST NIGERIA

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ABSTRACT

Sustainable use of soils and environment-friendly management for optimum crop production, requires understanding to ensure that land is not allocated for uses that will adversely hinder its productivity. The study was carried out to assess the nutrient status and evaluate the fertility capability of the soils in rainforest zones of southwest Nigeria employing the Fertility Capability Classification (FCC) approach. A total of 16 composite soil samples at different physiological position across the study area from a depth of 0-15cm and 15-30cm were collected and subjected to routine laboratory analysis for selected physical and chemical properties. The soils were evaluated using the FCC systemfor nutritional limitations and constraints for agricultural practices. The findings revealed that soils of the studied sites were dominated by loamy sand in texture with higher accumulation of exchangeable bases and organic matter at the surface soils. Exchangeable acidity values ranged from 0.36 – 2.28 cmol (+)kg^{-1} with Low Nitrogen level less than 1g/kg across board. Nutrients status shows minimal spatial variation across the physiographic position and falls under LSkeh fertility capability classes. The major constraints are the texture eof the soils, low organic carbon and exchangeable bases. The study provided information of the potentails of soils of the study area for agricultural production providedthat land management strategies that will conserve the soil and improve carbon sequestration potential are applied at each point along the physiographic position as evidenced by the fertility capability classes.

***Keywords**: Agro-Climatic Zone, Physiographic position, Fertility Capability Classification, Spatial Variation, limitations*

INTRODUCTION

Soil's importance with respect to crop production cannot be overlooked as it is the main source of nutrients that crops depends on for optimum production. Due to the world's rapid population growth, there is an increasing need for food production, which necessitates the development of croplands into certain formerly uncultivated areas that were thought to be marginal grounds for rain-fed agriculture (Ojanuga, 2006). Planning and accomplishing sustainable agricultural operations still heavily rely on basic soil knowledge, which necessitates direct as well as indirect understanding of resource capacity together with nutritional makeup of the soils (Ekwoanya and Ojanuga, 2002; Dickson *et al.,* 2002).Soils, on the other hand, degrade rapidly, sometimes irreversibly, if they are misused or poorly managed, occasionally irrevocably. As a result of this, a productive land itself may become unproductive (Dent, 1990).

More than 10% of the planet's vegetative land has seen serious degradation in the previous ten years as a result of human involvement with the environment, according to inventories of the soils' productive capacity (Wood *et. al.,* 2010). In the majority of Nigeria, soil nutrient deficiency caused by dominance of low activity clays and soil fertility decline are identified as a major problem facing smallholder farmers. Mutsaers (1990). The advantage of soil inventories and land appraisal reports before crop cultivation and or other land uses has been stressed (Dickson *et al*., 2002; Orimoloye, 2011).

Doran and Parkin (2004; 2006) define soil quality as "the inherent nature of soils to operate within the constraints of land use and ecosystem boundaries, to promote biological efficiency, improveenvironmental sustainability, and maintain health of plant, animal, and human. The fertility capability classification of soil (FCC) system was introduced to soil classification as a technical system of bringing together soils that pose similar agronomic management problemsin terms of nutrient supply capacity. This widely accepted and practiced system in the tropics stipulate quantifiable topsoil parameters as well as subsoil properties that are of great importance to plant growth and yield performance (Buol *et al.,* 1975; Sanchez *et al.,* 1982, 2003). As a result, soil's name provided by the soil FCC class, is critical for the management of soil fertility, and it appears to be of great importance for agronomic soil taxonomy that is acceptable to both Agronomists and Pedologists (Lin, 1989). Farmers can thus recogniseproductivity and other Land restrictions for specific crops through knowledge of FCC classes and organize their activities in order to avoid production declines as described by Sanchez *et al.* (2003). Land assessment utilizing a scientific method such as FCC is importantto examine a certain piece of land's capabilities and limitations for agriculture, and knowledge of limitations from its report is targeted at providing on the field approaches to overcome such limitations before or during cropping period (Lin *et al.,* 2005), also to place soils with properties that are similar enough that soil management decisions are made in the same way. However, sustainable agricultural production that is environmentally friendly is possible when data on soil behavior is carefully collected, assembled, and interpreted. This is critical because it is expected to be a solution to farmer's problems on the field. Against this backdrop, this study was conducted to assess soil nutrient status and perform the Fertility Capability Classification in order to evaluate the agricultural productivity potentials of the soils studied.

MATERIALS AND METHODS

The Study Area

The study site is Alaye village in Irewole Local Government Area of Osun State, south west Nigeria. It is located within the rainforest zone.The area is in a region underlain by Precambrian Basement complex rocks, with agriculture as the primary land use (Rahaman, 1988). The climate of the area is that ofa humid tropical climate with dry and wet seasons and high humidity. All year round, average daily atmospheric temperature ranges between 25 (Low) and 35 (High) degrees Celsius. As a result of human intervention, the vegetation pattern of the area is currently a mosaic of farmland (arable crop farms), admixture of bush regrowth, and tree crop plantations (FMANR, 1990).

Using the base map produced of the studied area as a guide, andconsidering the geological and geomorphological parameters, the free method of soil surveywas employed on the field for soil unit's identifications and the system ofSmyth and Montgomery (1962) for soil observations based on soil-landscape relationship was employed. Random sampling was carried out across the study areawithin each of the identified physiographic unit to assess the nutritional composition of the top and subsoil. This sampling strategy was used to ensure that samples collected throughout the area were comparable (Aweto, 1978) using the vegetation pattern, slope and observed physiological characteristics as an indicator of the variations. Within each identified physiographic position, five (5) replicate samples were collected and bulked to create a composite sample that represented each sampling point. In total, sixteen (16) composite soil samples were collected from the designated areas and taken to the laboratory for routine physical and chemical analyses.The particle size distribution was determined by the Bouyoucos hydrometer method as reported by (Gee and Or, 2002), (Thomas, 1996) methods of soil pH determination was used toevaluate the acidity level of the soil samples in both water and 1.0 M KCl solution employing a 1:1 soil/solution mixture. Total exchangeable acidity together with the soil Al status were evaluated by titration using 1.0 M KCl solution for extraction (Sims, 1996) then titrated with 0.05N NaOH solution (Bertsch and Bloom, 1996 and Sims, 1996). Extraction of the soil samples with 1.0 N ammonium acetate (NH4OAc) solution was used to determine exchangeable cations (Thomas, 1982). The concentrations of Ca, Na, and K in the extract were determined using a flame photometer, while Mg was determined using atomic absorption spectrophotometer (AAS). The Walkley-Black method (Nelson and Sommers, 1996) was used to determine soil organic carbon, the Kjeldahl method (Bremner, 1996) was used to determine total nitrogen in the soil samples, and the Bray-1 method was used to determine available phosphorus (Kuo, 1996). Selected extractable micronutrients (Cu, Zn, Mn, Fe and Co) contents in the soil samples was evaluated by extracting the soils with 0.5 sodium-ethylenediaminetetraacetic acid (Na-EDTA) solution and the concentrations of the elements in the filtrate were then determined with the use of atomic absorption spectrophotometer (AAS). The results of the soil physical and chemical properties (Table 1) were then used to assess the soils' nutrient level as well as their fertility capability classes in the studied area. Sanchez *et al.* (2002) classification procedures that employed the criteria in Fertility Capability Classification version 4 (Table 2) were used to place the soils under investigation to their Fertility Capability classes. Following that, recommendations on soil use and management for optimum production and long-term sustainability were made.

RESULTS AND DISCUSSION

Presented in Table 1, is the physical and chemical characteristics of representative samples of soil of study area. The soils are locally classified as Ondo associations at the upper slope area and Jago associations at the valley bottom positions, with several soil series distributed throughout the area (Smyth and Montgomery, 1962). These soils were correlated as Lixisol and Fluvisol respectively (World Reference Based) and are further classified as Ultisols and AquicPsament (USDA Soil Taxonomy). The Soils textural properties revealed that soils in the two locations are dominated by loamy sand regardless of their physiographic position. The variation in soil composition separates to a large extent within the soil catena and across landscapes reflect the degree of relationship among the parent materials. In the upland areas, the surface soils are mostly loamy sand and sandy loam formed on colluvial and sedentary parent materials. This demonstrates the inherent heterogeneity associated with basement complex soils, especially when a large area is covered (Uzu *et al.*, 2007). The ability of the soils to retain water and nutrients varies, which influences their potential for agricultural use.Except for rare circumstances as seen from the soils under research, where a dramatic spike in pH was occasionally seen at the sub soils, the pH generally declined as the soil depth increased. The pH (H_2O) values of the soils under study ranged from 5.2 to 6.8 while the pH (1M KCl) values ranged from 4.1 to 6.1, placing them in the neutral to slightly acid class (Soil Survey Staff, 2003). Accumulation of bases was observed on the soil's surface and it ranged from 3.51- 4.70cmol (+) kg^{-1}, and does not follow any definite pattern. Leaching losses and plant absorption may be the reason for the trend. The exchangeable sites of the soils under study were dominated by exchangeable calcium and sodium, as is the case in the majority of tropical soils. Similar findings were reported by Fasina *et al*. (2007) in some selected cocoa soils of southwestern Nigeria. The exchangeable sodium percentage (ESP) in all soils is typically low (15%), which is the critical limit for sodicity (Brady and Weil, 2004). As a result, the soils are not sodic. The low exchangeable cation values observed indicate that the soil has a low capacity to retain plant nutrients, requiring adoption and use of improved soil management practice. The soil's organic matter (SOM) content ranged from 2.00 to 3.60%. The SOM of the subsurface soils were from 1.13 to 1.81%. Percentage SOM was categorised into low (0 - 1.5%), medium (1.5 - 2.5%), and high (>2.5%) categories by Sobulo and Adepetu (1987). The SOM concentration was higher in the soil surface than in the subsurface, presumably because there are more decomposable plant materials on the surface soil and because soil surface is where organic materials are broken down and humified. The overall organic matter content of the soils under study was typically under 2%, with a few exceptions where higher values were found at the subsoil. These higher values were most likely caused by pedoturbation in the subsoil and the movement of organic materials from one area of the topography to another, resulting in erosional deposition at the valley bottom. The low organic content may be due in part to the high temperature and relative humidity, which promotes the rapid mineralization of organic matter (Fashina *et al.*, 2007), the degradation caused by farming and other land use and management practices, such as burning farm waste frequently, which tend to remove a lot of the organic matter that could have been added to the soil. The majority of soils' average low levels of organic matter cannot support crop production programs. Thus, by efficient crop residue management, the organic matter content must be significantly enhanced.The exchangeable acidity ranged from 0.36 to 2.28 cmol (+) kg-1 soil. The exchangeable acidity (Al^{3+} and H^{+}) values in all of the investigated soils were essentially constant with respect to depth.

The soil's total nitrogen level is critically low, with all values less than 1g/kg. Surface soils had total nitrogen contents ranging from 0.08 to 0.12% and subsurface soils from 0.06 to 0.10%. Total nitrogen percentages were classified as low (0.10%), medium (0.10 - 0.20%), and high (>0.20%) by Sobulo and Adepetu (1987). Low nitrogen values in soils are most likely caused by a rapid rate of soil organic matter decomposition, a high rate of leaching, and loss due to soil erosion (Solarin and Ayolagha, 2006). Total nitrogen values in the area varied irregularly with depth, which could be attributed to the influence of continuous cultivation, a common practice on Nigerian soils caused by crop residue removal. (Noma *et al*., 2011).

The distribution of extractable Micronutrients contents was erratic. Fe concentrations (193.20 and 361.60 ppm) were found to be higher; this may be caused by the mineral makeup of the transported materials and/or the underlying rock, by the uptake of vital nutrients through plants, by the leaching of exchangeable cations caused by excessive rainfall or erosion, or by a combination of these causes. The higher levels seen may be the reasons for some plant nutrients being occluded, such as phosphorus, rendering them unavailable for plant uptake. This can be handled with an adequate soil management system. Aside from the Fe concentration in the soil, it is assumed that the soil contains an adequate level of other micronutrients for plant growth.

Table 1: Average Physical and Chemical properties of the composite soil samples along the toposequence

Depth	Sand	Silt	Clay	Silt/Clay Ratio	Textural Class	pH (H_2O)	pH (KCl)	ΔpH	Exchangeable bases (CmolKg^{-})				Total (N)	OM (%)	Avail. P	Exchangeable Acidity		Sum of bases	Extractable micronutrients (ppm)				
									Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}				Al^{3+}	H^{+}		Mn	Co	Fe	Cu	Zn
Average Physical and Chemical properties of the composite soil samples along the toposequence in the Derived savanna zone																							
Upper Slope Position																							
0-15	86.4	8.8	4.8	2.36	LS	5.62	4.52	-1.09	2.04	0.34	0.30	0.65	0.12	1.01	24.24	1.02	1.30	3.33	20.62	4.46	193.20	1.72	0.90
15-30	83.2	8.4	8.4	1.03	SL	5.68	4.12	-1.56	2.14	0.31	0.23	0.80	0.09	0.85	26.54	1.02	1.20	3.48	16.20	4.87	224.40	2.30	0.59
Mid Slope Position																							
0-15	86.8	8.8	4.4	2.7	LS	5.85	4.71	-1.13	1.85	0.32	0.20	0.70	0.13	0.99	23.29	0.84	2.40	2.40	0.30	11.40	280.00	4.40	0.48
15-30	82.4	9.6	8	1.9	LS	5.53	4.56	-0.99	1.81	0.34	0.18	0.47	0.09	0.88	20.08	0.98	0.90	2.78	8.34	5.08	210.80	2.16	0.72
Lower slope																							
0-15	89.2	8.4	2.4	3.7	LS	5.63	4.61	-1.02	1.38	0.27	0.15	0.62	0.12	1.21	23.02	0.72	2.30	2.41	8.76	6.49	240.00	2.32	0.68
15-30	86.8	9.2	4	2.6	LS	5.54	4.64	-0.5	1.43	0.37	0.18	0.63	0.08	1.22	21.73	0.78	1.38	2.61	3.12	6.81	236.80	2.55	0.76
Valley bottom																							
0-15	87.6	8.8	3.6	2.7	LS	6.11	4.65	-1.46	1.33	0.40	0.16	1.08	0.10	0.94	20.08	0.72	1.64	2.98	4.02	6.69	251.60	1.20	0.67
15-30	87.2	7.6	5.2	2.2	LS	6.08	4.62	-1.46	1.47	0.35	0.14	0.57	0.07	0.74	21.19	0.78	0.80	2.54	2.54	5.73	202.00	2.50	0.64
Average Physical and Chemical properties of the composite soil samplesalong the toposequence in the Rainforest zone																							
Upper Slope Position																							
0-15	76.8	12.4	10.8	2.46	SCL	6.7	5.78	-0.92	2.71	0.58	0.60	0.43	0.12	2.65	27.58	0.36	0.42	4.31	3.38	9.38	257.60	2.60	1.22
15-30	78	11.8	10.2	2.48	SL	6.46	5.84	-0.62	2.52	0.64	0.52	0.38	0.09	1.81	22.41	0.31	0.54	4.05	1.70	9.55	233.20	1.30	1.28
Mid Slope Position																							
0-15	79.6	13.6	6.8	2.72	LS	6.44	6.04	-0.40	2.8	0.70	0.76	0.45	0.09	2.27	35.39	0.50	1.41	4.7	1.46	8.62	361.60	2.28	1.00
15-30	80.2	13.4	6.4	2.98	LS	6.54	6.11	-0.43	3.04	0.59	0.59	0.39	0.06	1.63	20.62	1.10	1.22	4.61	3.48	7.88	268.00	1.50	1.07
Lower slope																							
0-15	82.6	11.4	6	3.5	LS	6.57	5.91	-0.69	2.71	0.54	0.43	0.35	0.11	2.00	22.44	1.64	1.62	4.02	1.62	7.16	296.40	2.40	0.86
15-30	81.4	14.4	4.2	6.28	LS	6.55	5.89	-0.67	2.95	0.49	0.22	0.26	0.07	1.27	21.53	0.64	2.28	3.91	2.46	6.47	366.40	2.28	1.17
Valley bottom																							
0-15	82.8	13	4.2	4.2	LS	5.94	5.5	-0.44	2.38	0.44	0.31	0.39	0.08	3.60	22.37	1.02	1.00	3.51	5.74	8.49	316.80	2.28	0.82
15-30	86.8	9.4	3	3.8	LS	6.03	5.65	-0.38	2.9	0.47	0.27	0.34	0.10	1.13	16.29	0.84	1.40	3.98	2.78	9.14	221.60	1.46	1.35

Fertility Capability Classification of soil units

Table 2 shows the subdivision of the representative mapping units using the Sanchez *et al.* (2003) Fertility Capacity Classification scheme into different FCC units.Fertility Capacity Classificationunits are divided into categorical levels based on fertility constraints.They include three basic classification criteria and levels: Type (top soil texture), Substrata (sub-soil texture), and Modifiers. As a result, the class designations for each of these three levels are combined to form an FCC unit. Textural properties of the soils as shown in (Table 1) informed that the soils are primarily composed of loamy sand and sandy loam. The soils in the lower part of the physiography are poorly drained, necessitating drainage operations together with tillage activities, or rather restricting cropping activities to seasons of the year when there is less moisture from rainfall.The chemical properties of almost all soils reveal that they are deficient in soil nutrients. This is most likely due to the area's land use pattern or the chemical nature of the rocks that give rise to the soils. Gleying properties, as well as acidic soil reactions, were observed in low land areas, this may warrant liming activitieswhen acid sensitive crops are put into consideration.Table 2 shows the division of representative soil units into different FCC units in accordance with the Fertility Capacity Classification scheme proposed by Sanchez *et al.* (2003) based on fertility related limitations. As a result, the soils were classified based on whether or not a characteristic was present. As a result, the soil belongs to the LSkeh fertility capability class, which includes loamy sand textures with low nutrient reserves, low cations exchange capacity, and acidic soils. The general fertility constraints of the soils were their loose nature (texture), inherently low nutrient capacity, acidic nature, and topography.

Table 2: Fertility Capability Classification (FCC) units of the examined soils.

Depth	Top soil	Sub soil	G	K	E	H	FCC Units
1	LS	LS	-	+	+	+	LSkeh
2	LS	LS	-	+	+	+	LSkeh
3	LS	LS	-	+	+	+	LSkeh
4	LS	LS	+	+	+	+	LSgkeh
5	LS	SL	-	+	+	+	LSkeh
6	LS	LS	-	+	+	+	LSkeh
7	LS	LS	-	+	+	+	LSkeh
8	LS	LS	+	+	+	+	LSgkeh

Keys:

S = Sandy, L= Loam, h = acidic reaction, e = low cations exchange, k=low nutrient reserve, n = natric, g = gleying, d = dry, + = present, and - = absent

CONCLUSIONS AND RECOMMENDATIONS

The soils of Alaye village in Irewole LGA, Osun State, south west Nigeria located in the rain forest zone, was evaluated for nutrient status and fertility classification. Fertility Capability Classification was thus performed to produce useful data regarding the characteristics of the soils, agronomic restrictions, and management requirements for sustainable production.

The study's landscape shows an entire toposequence with each physiographic position clearly shown. The soils are mostly arable due to the nutrient status of the soils, which can be further improved if properly managed and recommended soil conservation practices are strictly followed. The major constraints of the soil, which are its texture, inherently low nutrient capacity, acidic nature, poor drainage at the valley bottom, and location on the topography, can be overcome by applying fertilizers, both organic and inorganic. For arable crops to perform well, as shown by the fertility capability classes, other management techniques like drainage, liming, and perhaps cross slope farming should be encouraged. These techniques would ease the key production-related restrictions in this region. This study showed that it is possible to pinpoint the precise nutrient deficiencies of the soils under consideration at each sampled location, as indicated by the agronomic constraints of the soil, and it provided proof that it is necessary to adopt various management techniques to accommodate each soil type at various physiographic positions, as indicated by the fertility capability classes.

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