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Assessment of Soil Depth and Different Land Use Systems on Some Soil Chemical Properties in Selected Teaching & Research Farms in Maiduguri

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***Abstract**: This study evaluates the influence of soil depth and various land use systems on key soil chemical properties in selected teaching and research farms in Maiduguri, Nigeria. The investigation was conducted at three institutions: Ramat Polytechnic, Borno State University, and the University of Maiduguri. Soil samples were collected from three land use types—cattle waste areas, fish water discharge zones, and control sites—at depths of 0-15 cm, 15-30 cm, and 30-45 cm. Laboratory analysis assessed properties such as pH, electrical conductivity (EC), organic carbon, organic matter, available phosphorus, total nitrogen, cation exchange capacity (CEC), and exchangeable bases. Results indicated that land use types significantly influenced soil chemical properties. Cattle waste areas recorded the highest EC, CEC, and total exchangeable bases (TEB) due to nutrient-rich organic waste deposits. Conversely, control sites exhibited lower values, reflecting minimal anthropogenic impact. Soil pH and base saturation percentage (PBS) remained relatively stable across land use types, showing limited sensitivity to land management practices. Soil depth also played a crucial role, with deeper layers showing higher nutrient retention capacities. This trend was particularly notable in CEC and TEB, suggesting enhanced fertility at greater depths. However, EC values decreased with depth, indicating reduced salt accumulation. The stability of pH and PBS across depths underscored their resilience to environmental changes. It was concluded that land management practices, including organic waste application and depth-specific soil management, in maintaining soil fertility and ensuring long-term agricultural productivity. Effective land use strategies can mitigate soil degradation and enhance agricultural sustainability in semi-arid regions like Maiduguri*

***Keywords:** Land use, Soil depth, Soil chemical, Research farms. .*

Introduction

In urban areas, activities such as agriculture, industry, and transportation generate significant amounts of waste, categorized into agricultural, industrial, municipal, or nuclear types. These wastes are often deposited on soil surfaces, along waterways, or released into the atmosphere as solid matter. This disposal affects the soil ecosystem's delicate balance, impacting factors like nutrient availability, soil structure, water retention, and microbial activity. Consequently, effective agricultural practices and the long-term sustainability of integrated farms are closely tied to managing cattle farmyard waste and its influence on the physicochemical properties of soils. Soil quality plays a crucial role in food safety, influencing the potential composition of food and feed from the beginning of the food chain. Maintaining or enhancing soil quality is essential for analyzing and sustaining healthy soil ecosystems (Schoenholtz, 2000). Soil quality assessments involve examining factors and processes that enable soil to function effectively as a component of a robust ecosystem (Tale & Ingole, 2015). Over time, inadequate waste disposal in a population can lead to a decline in public health and overall living standards, as people adapt to suboptimal environmental conditions. Historically, waste disposal received limited attention in developing countries. However, with growing awareness of environmental risks, there is now increased focus on managing waste. Rapid urbanization and migration from rural to urban areas have intensified waste production in cities. Waste collection is just one of many challenges faced by developing countries in managing waste in environmentally sound ways (Oguneleka, 2009; Oguche, 2013).

When pollutants enter the soil, they interact with soil particles, altering its chemical and physical properties. Soil's capacity to support safe, nutritious crop production and enhance human and animal health over the long term—without depleting natural resources or harming the environment—is critical (Parr et al., 1992). Soil’s ability to maintain biological productivity, environmental quality, and support plant and animal health within ecosystem boundaries (Doran and Parkin, 1994) as well as to fulfill intended functions (Karlen et al., 1997; Schjønning et al., 2003) highlights the importance of managing soil quality to meet agricultural and ecological needs. Soil chemical properties, such as nutrient content, pH, and organic matter, are crucial indicators of soil health and productivity. Soil depth and land use systems—such as agriculture, grazing, and fallow land—can greatly influence these chemical properties, impacting soil fertility and sustainable land management. However, limited research exists on how variations in soil depth and different land uses specifically affect soil chemistry in Maiduguri's teaching and research farms. Understanding these relationships is essential for developing effective land management strategies and optimizing soil resources to support agricultural productivity, sustainability, and ecological balance. In Maiduguri, where agricultural activities are an integral part of the economy, the need for a comprehensive assessment of soil depth and land use impacts on soil chemical properties is critical. Teaching and research farms, serving as centers for agricultural education and experimentation, require a detailed understanding of these variables to guide best practices and inform the curriculum. Yet, a knowledge gap exists in evaluating how specific land use types across varying soil depths influence key chemical properties of soils in this region. Therefore, this study aims to assess the effects of soil depth and different land use systems on soil chemical properties in selected teaching and research farms in Maiduguri. The findings will provide insights to support soil management decisions that promote sustainable land use, soil fertility, and long-term agricultural productivity in Maiduguri and similar environments. The study aims to analyze the effects of various land use types and soil depth on soil chemical properties and assess their interactive impact in the study area.

MATERIALS AND METHODS

Study Area

The experiment will be conducted at the Teaching and Research Farm located on the premises of Ramat Polytechnic, Borno State University and University of Maiduguri all located in Maiduguri, Borno State. The climate is dry and sub-humid in nature as described by Ojanuga (2006). The mean daily temperature ranged between 23.6 and 34.8^{o}C during the cropping season (January to December) and annual average rainfall in the zone ranges between 508 to 762mm (NIMET, 2009). The soil in the study area was classified as Typic Ustipsamment.

Techniques of Data Collection

Soil samples will be collected during the field sampling while analysis will be conducted during the laboratory analysis.

Sampling Locations

After the reconnaissance visit, three sampling locations will be identified and used for the study Sampling location. It is expected that; one is situated at the Fisheries water discharge Area. Sampling location two is at the Farm yard site while the third location is at the Farm Area which was used as a control.

Soil Sample Collection

Soil sampling will be carried out in January 2025. A total of 18 soil samples were collected two samples from each of the three sites' Fisheries water discharge Areas, Farmyard, and a control site (C) that is farm Area. Soil samples will be collected with a spade, soil auger and a trowel at depths: 0 - 15cm, 15 -30cm, and 30 – 45cm, from each of the three sites. Soil samples will be placed in labeled Polyethene bags.

Laboratory Analysis

Sample Preparation

Soil samples will be air–dried, and sieved with a 2mm mesh sieve. The finer soil particles will be packed in sample containers and labeled accordingly for laboratory analysis

Determination of Soil pH

Air dried sample will pass through a 2mm sieve and afterwards, 10g of it will be placed in 50ml beaker. 40ml of distilled water will be added to it and the mixture will be mechanically shaken and allowed to stand for 30 minutes. pH meter will be calibrated using a buffer at a pH of 6.86. The electrode will be immersed into the soil suspension and pH will be noted when the equilibrium is reached

Determination of Organic Carbon

Organic carbon will be determined by the wet digestion method (Nelson and Sommers, 1982). This method involved adding 10ml of 0.1667M $K_2Cr_2O_7$ and 20ml of concentrated H_2SO_4 to weighed soil sample (5g) in an Erlenmeyer flask (500ml) and heated to a temperature of 150^0C, allowing it to cool at room temperature. 20ml of water will be added and 4 – 5 drops of ferroin indicator titrated with 0.5M ferrous sulphate. i.e organic carbon (%) = (Meq of $K_2Cr_2O_7$ - Meq of $FeSO_4$)/Oven dry soil (g) x 100

Determination of Electrical Conductivity (EC)

5.0 grams of each soil sample will be added to 50 ml of distilled water. The lump of the soil will be stirred to form homogenous slurry, and then the EC meter (Jenway 4010 Model) probes will be immersed into the sample and allowed to stabilize at 250C and EC will be recorded.

Determination of Organic Matter

The percentage of organic matter will be calculated by multiplying the values of organic carbon by a factor of 1.724 (Van Bemmelen factor). i.e Organic matter (% OM) = Organic Carbon (OC) x 1.724

Determination of Phosphorus (P)

Available P will be determined using the Bray II method (Olson and Sommers (1982)). Using a spectrophotometer of absorbance at 882nm, the P concentration of the soil sample will be determined through a calibration curve relating the readings of the absorption unit to concentration in µgP/ml. Thus Pµg/g soil = P(µg/ml) × 50ml/10ml × 100ml/5g soil

Determination of Soil Nitrogen

This will be determined by the Kjeldahl digestion method (Bremmer 1996). It will be calculated thus: Kjeldahl N (%) = (T - B) x M x 2.8/S Where; T = ml of standard acid with sample titration B = ml of standard acid with blank titration M = Molarity of Sulphuric acid S = Weight of soil sample in g.

Soil Exchangeable Bases (Cations)

The exchangeable bases in the soil will be extracted with 1N neutral ammonium acetate (NH4OAC) buffer according to Helmke and Sparks (1996). The concentrations of Na and K will be determined with the flame photometer while that of Ca and Mg by Atomic Absorption Spectrophotometer (AAS)

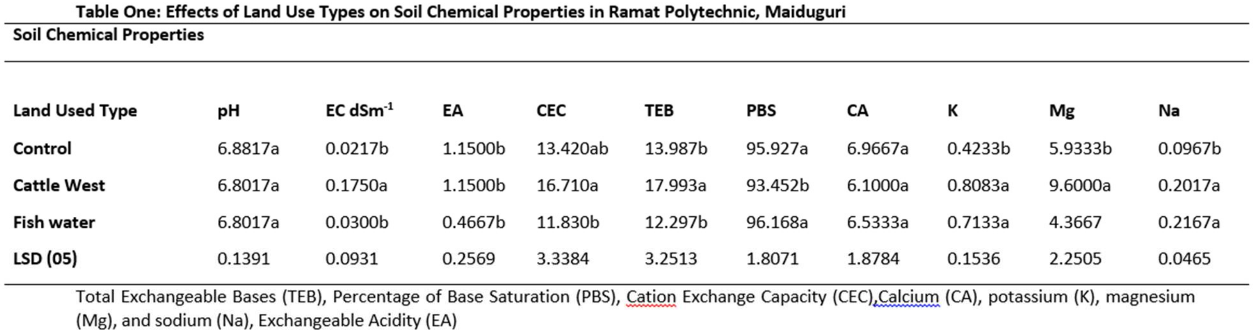

Table One: Effects of Land Use Types on Soil Chemical Properties in Ramat Polytechnic, Maiduguri

Soil Chemical Properties									
Land Used Type	**pH**	**EC dSm^{-1}**	**EA**	**CEC**	**TEB**	**PBS**	**CA**	**K**	**Mg**	**Na**
Control	6.8817a	0.0217b	1.1500b	13.420ab	13.987b	95.927a	6.9667a	0.4233b	5.9333b	0.0967b
Cattle West	6.8017a	0.1750a	1.1500b	16.710a	17.993a	93.452b	6.1000a	0.8083a	9.6000a	0.2017a
Fish water	6.8017a	0.0300b	0.4667b	11.830b	12.297b	96.168a	6.5333a	0.7133a	4.3667	0.2167a
LSD (05)	0.1391	0.0931	0.2569	3.3384	3.2513	1.8071	1.8784	0.1536	2.2505	0.0465

Total Exchangeable Bases (TEB), Percentage of Base Saturation (PBS), Cation Exchange Capacity (CEC),Calcium (CA), potassium (K), magnesium (Mg), and sodium (Na), Exchangeable Acidity (EA)

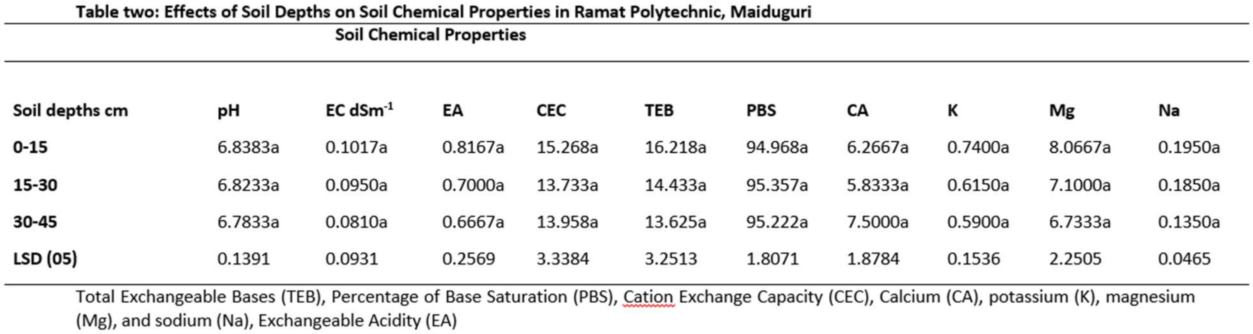

Table two: Effects of Soil Depths on Soil Chemical Properties in Ramat Polytechnic, Maiduguri

				Soil Chemical Properties						
Soil depths cm	**pH**	**EC dSm^{-1}**	**EA**	**CEC**	**TEB**	**PBS**	**CA**	**K**	**Mg**	**Na**
0-15	6.8383a	0.1017a	0.8167a	15.268a	16.218a	94.968a	6.2667a	0.7400a	8.0667a	0.1950a
15-30	6.8233a	0.0950a	0.7000a	13.733a	14.433a	95.357a	5.8333a	0.6150a	7.1000a	0.1850a
30-45	6.7833a	0.0810a	0.6667a	13.958a	13.625a	95.222a	7.5000a	0.5900a	6.7333a	0.1350a
LSD (05)	0.1391	0.0931	0.2569	3.3384	3.2513	1.8071	1.8784	0.1536	2.2505	0.0465

Total Exchangeable Bases (TEB), Percentage of Base Saturation (PBS), Cation Exchange Capacity (CEC), Calcium (CA), potassium (K), magnesium (Mg), and sodium (Na), Exchangeable Acidity (EA)

Table Three: Effects of Land Use Types on Soil Chemical Properties in Borno State University, Maiduguri

Soil Chemical Properties

Land Used Type	**pH**	**EC dSm^{-1}**	**EA**	**CEC**	**TEB**	**PBS**	**CA**	**K**	**Mg**	**Na**
Control	6.7817a	0.0017b	1.1400b	14.420ab	13.997b	96.927a	6.9767a	0.4243b	5.9333b	0.0977b
Cattle West	6.7017a	0.0750a	1.1500a	17.710a	17.993a	93.452b	6.1100a	0.8093a	9.7000a	0.3017a
Fish water	6.7017a	0.0200b	0.4667b	12.830b	12.397b	96.169a	6.5433a	0.7143a	4.4667	0.2267a
LSD (05)	0.1291	0.0831	0.2579	4.3384	3.2513	1.8081	1.8884	0.1546	2.3505	0.1465

Total Exchangeable Bases (TEB), Percentage of Base Saturation (PBS), Cation Exchange Capacity (CEC),Calcium (CA), potassium (K), magnesium (Mg), and sodium (Na), Exchangeable Acidity (EA)

Table Four: Effect of Soil Depths on Soil Chemical Properties in Borno State University, Maiduguri

Soil Chemical Properties

Soil depths cm	**pH**	**EC dSm^{-1}**	**EA**	**CEC**	**TEB**	**PBS**	**CA**	**K**	**Mg**	**Na**
0-15	6.6383a	0.1018a	0.8177a	15.268a	15.218a	96.968a	6.2667a	0.7400a	8.1667a	0.1750a
15-30	6.6233a	0.0959a	0.7010a	15.733a	15.433a	96.357a	6.8333a	0.7150a	8.1100a	0.1750a
30-45	6.6833a	0.0819a	0.6677a	15.958a	15.625a	96.222a	6.5000a	0.7200a	8.6333a	0.1650a
LSD (05)	0.0391	0.0932	0.2579	3.4384	3.2513	1.8071	1.8784	0.1436	2.0505	0.0565

Total Exchangeable Bases (TEB), Percentage of Base Saturation (PBS), Cation Exchange Capacity (CEC), Calcium (CA), potassium (K), magnesium (Mg), and sodium (Na), Exchangeable Acidity (EA)

Table Five: Effects of Land Use Types on Soil Chemical Properties in University of Maiduguri, Maiduguri

Soil Chemical Properties

Land Used Type	**pH**	**EC dSm^{-1}**	**EA**	**CEC**	**TEB**	**PBS**	**CA**	**K**	**Mg**	**Na**
Control	6.7827a	0.0017b	0.1200b	12.420ab	13.987b	96.937a	6.9667a	0.4233b	4.9333b	0.0967b
Cattle West	6.7037a	0.1450a	1.1500a	15.720a	18.983a	93.452b	6.9000a	0.8003a	9.6000a	0.2217a
Fish water	6.7027a	0.0300b	0.4667b	12.830b	13.297b	96.178a	6.9933a	0.8133a	4.8667b	0.2267a
LSD (05)	0.2391	0.0931	0.2469	3.3284	3.2413	1.8041	1.8704	0.1436	2.2305	0.0565

Total Exchangeable Bases (TEB), Percentage of Base Saturation (PBS), Cation Exchange Capacity (CEC),Calcium (CA), potassium (K), magnesium (Mg), and sodium (Na), Exchangeable Acidity (EA)

Table Six: Effect of Soil Depths on Soil Chemical Properties in University of Maiduguri, Maiduguri

Soil Chemical Properties

Soil depths cm	**pH**	**EC dSm^{-1}**	**EA**	**CEC**	**TEB**	**PBS**	**CA**	**K**	**Mg**	**Na**
0-15	6.8473a	0.1118a	0.7177a	13.265a	16.213a	95.968a	6.2667a	0.6430a	8.0657a	0.1940a
15-30	6.8173a	0.0590a	0.7070a	13.743a	14.483a	95.367a	5.8333a	0.6250a	8.1040a	0.1830a
30-45	6.7513a	0.0610a	0.6567a	13.758a	13.525a	95.232a	7.5000a	0.6900a	8.7353a	0.1550a
LSD (05)	0.1361	0.0831	0.2559	3.3374	3.1513	1.8081	1.8384	0.1436	2.2405	0.0445

Total Exchangeable Bases (TEB), Percentage of Base Saturation (PBS), Cation Exchange Capacity (CEC), Calcium (CA), potassium (K), magnesium (Mg), and sodium (Na), Exchangeable Acidity (EA)

Effects of land use types on some soil chemical properties observed in Ramat Polytechnic, Borno State University, and the University of Maiduguri.

Tables 1, 3, and 5 present the effects of different land use types on soil chemical properties at Ramat Polytechnic, Borno State University, and the University of Maiduguri, respectively.

At Ramat Polytechnic (Table 1), Electrical Conductivity (EC) varied significantly among land use types, with the cattle waste area recording the highest value (0.1750 dSm^{-1}) and the control site the lowest (0.0217 dSm^{-1}). This large difference indicates that EC is influenced by land use. Cation Exchange Capacity (CEC) and Total Exchangeable Bases (TEB) were also highest in the cattle waste area, reflecting greater nutrient accumulation due to organic waste input. All these chemical properties have statistically significant differences. While in contrast, pH values showed minimal variation across land use types with no significant difference.

Similarly, Table 3 from Borno State University shows distinct differences in EC, with the cattle waste area recording the highest value (0.0750 dSm^{-1}) compared to the control site (0.0017 dSm^{-1}) and its difference significantly. The cattle waste area also recorded the highest CEC (17.710 cmol/kg) and TEB (17.993 cmol/kg), indicating enhanced soil fertility due to organic manure application and is statisticallysignificant. However, pH values were consistent across land use types, with no statistically significant effect.

Table 5 from the University of Maiduguri shows a similar trend, with EC peaking in the cattle waste area (0.1450 dSm^{-1}) and being lowest in the control site (0.0017 dSm^{-1}) showing a statistical significant variation. AlsoCEC and TEB values were also considerably higher in the cattle waste area, confirming the fertility-enhancing effects of organic inputs and the differences are statistically significant. Conversely, pH and Percentage Base Saturation (PBS) remained stable, showing no significant differences. In summary, EC, CEC, and TEB are significantly influenced by land use types across all three locations, with the cattle waste areas consistently recording the highest values. On the other hand, pH and PBS showed no meaningful variations, indicating that these properties are less sensitive to changes in land use. Therefore, the results highlight the direct impact of organic waste application on improving soil fertility while emphasizing the need for sustainable land management practices.

Effects of Soil depth on some soil chemical properties observed in Ramat Polytechnic, Borno State University, and the University of Maiduguri.

Tables 2, 4, and 6 shows the influence of soil depth across the three study sites of Ramat Polytechnic, Borno State University, and the University of Maiduguri.

The pH levels across the sites showed minimal variation, remaining within a narrow range that indicates stability across soil depths. pH differences among depths are not statistically significant.

Electrical Conductivity (EC) exhibited notable variation, particularly at the University of Maiduguri, where deeper soil layers had lower EC values. This pattern indicates that soil depth significantly affects salinity at this site confirming that EC values change meaningfully with depth. In Ramat Polytechnic and Borno State University showed more consistent EC values, suggesting limited depth-related salinity variation.

Cation Exchange Capacity (CEC) was significantly higher in deeper soil layers at Borno State University, indicating greater nutrient retention capacity at these depths. This distribution strongly supports a statistically significant difference in CEC based on depth. In contrast, CEC values at the University of Maiduguri were comparatively lower, reflecting reduced nutrient-holding potential.

Total Exchangeable Bases (TEB) showed the highest values at Borno State University across all soil depths, particularly in deeper layers and are statistically significant, indicating that deeper soils retain more essential cations. This result underscores the fertility-enhancing potential of deeper soil profiles at this site.

Base Saturation Percentage (PBS) remained uniformly high across all locations and depths, with minimal variability with no statistically significant differences, suggesting that PBS values are unaffected by soil depth due to consistently high nutrient saturation levels.

These results conclusively demonstrate significant depth-related variations in EC, CEC, and TEB, particularly at Borno State University, while confirming stable pH and PBS values across all sites. These findings highlight the critical role of soil depth in determining key chemical properties essential for soil fertility and agricultural productivity.

Conclusion

The analysis of soil chemical properties across different land use types and soil depths at Ramat Polytechnic, Borno State University, and the University of Maiduguri reveals significant variations in key soil parameters. Organic fertilization, particularly cattle manure, enhances soil fertility, as evidenced by higher Cation Exchange Capacity (CEC), Total Exchangeable Bases (TEB), and Electrical Conductivity (EC) in cattle waste areas. Deeper soil layers generally exhibit higher nutrient retention and fertility, suggesting that soil depth plays a crucial role in nutrient availability. Although pH and Base Saturation Percentage (PBS) remained relatively stable, the findings highlight the importance of monitoring salinity and soil acidity to prevent degradation. Overall, sustainable land management practices, including organic amendments, depth-specific fertilization, and efficient irrigation, are essential for maintaining soil health and ensuring long-term agricultural productivity.

Recommendations

To enhance soil health and sustainability, organic fertilization, particularly with cattle manure, should be prioritized for improving soil fertility and nutrient retention. Depth-specific soil management is crucial, as deeper soils show better nutrient-holding capacity. Regular monitoring of salinity and pH levels will help prevent degradation and ensure optimal nutrient availability. Increasing organic matter through practices like crop rotation and compost application will improve soil structure and microbial activity. Sustainable land use practices, including reduced chemical fertilizers and efficient irrigation, are key to maintaining long-term soil productivity.

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