



Research Article

Evaluation of Fertility Status of Soils of Pella District, Hong Local Government Area Adamawa State, Nigeria, Using Parker's Nutrient Index Method

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ABSTRACT

The soil fertility status of the Pella District was assessed to determine some physical and chemical properties, where soil samples were taken from 11 units and subjected to standard laboratory procedures. Results showed that the soils were mostly sandy loam. Soil pH was slightly acidic to neutral, and electrical conductivity (EC), organic carbon, available phosphorus and calcium consistently showed both low to medium values. Sodium (Na) showed medium to high values, Potassium (K) and molybdenum (Mo) had low, medium and high values. Total exchangeable bases (TEB) and Sulphur (S) showed medium values, while total exchangeable acidity (TEA) and Effective cation exchange capacity (ECEC) were low. Nutrient Fertility index (NFI) of P, S and Mo indicates medium as per phosphorus (P) and molybdenum (Mo) with values of (1.9) and (1.9) respectively, while Sulphur (S) showed a low value of (1.0). The soil's fertility status of the study area was generally low with S as one of the limiting nutrients; therefore, site-specific soil management, including Sulphur fertilization, is recommended. Over-application of nitrogen, especially nitrate-based fertilizer, should be avoided.

Keywords: Fertility Index; Molybdenum; Pella; Phosphorus; Sulphur

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INTRODUCTION

Soil is the bank of nutrients for plant growth. Most soils in the tropical region are highly weathered and infertile due to lower organic matter content and open nutrient cycling systems. These led to soil fertility depletion and crop productivity reduction (Amare & Melkamu, 2020). Soil fertility, together with other production factors, is a key soil attribute that determines agricultural productivity and food security, particularly in developing countries (Kibret *et al.*, 2023). In spite of the importance of soil fertility to sustainable agricultural production, the decline in soil fertility has become a major problem in many sub-Saharan African countries (Bationo *et al.*, 2012). The decline in soil fertility, therefore, has been caused

by the increased withdrawal of plant nutrients from the soil without replenishment consequent to increase plant growth. Such nutrient depletion in soils adversely affects soil quality and reduces crop yield and consequently poses a potential threat to global food security and agricultural sustainability (Tan *et al.* 2005). To raise and sustain soil fertility and productivity in such areas, appropriate and holistic soil fertility management practices have to be developed and adopted by farmers. Previous studies have also shown that soil fertility in many parts of Nigeria is declining due to continuous cultivation without adequate sustainable soil management practices leading to low crops yield (Yusuf & Olawoake, 2019). This decline in soil fertility is

attributed to factors such as nutrient mining, soil erosion, and inadequate use of fertilizers (Aleminev & Alemayehu, 2020). Adamawa State North-East Nigeria is divided into several agro-ecological zones, each with distinct soil qualities and fertility levels. Most of the agriculture activities in the state is rain-fed, making it susceptible to changes in soil fertility and climate. According to earlier studies, the region's soils fertility varies significantly and are generally low due to a variety of factors, including land use, soil type, and management techniques (Maunde *et al.*, 2016; Jackson & Philip, 2023). Despite these challenges, efforts to raise agricultural output are hampered by the lack of thorough data on soil fertility and its spatial distribution in the State (Simon *et al.* 2025) However, there is limited or no data on soil

fertility status and distribution of Pella District, Hong Local Government Area. This study therefore intends to evaluate the fertility status of soils of Pella district, Hong local government area and to evaluate soil fertility index of Phosphorus, Sulphur and molybdenum in the area, to inform better land management practices that are needed to recommend fertilizers application rates and soil amendments for increase and sustainable agricultural productivity looking at Pella district as an area where legumes especially groundnut (*Arachis hypogea*) are highly cultivated. Therefore, evaluating the soil fertility status of the area especially in respect to phosphorus, molybdenum and Sulphur will serve as key for fertilizer recommendations.

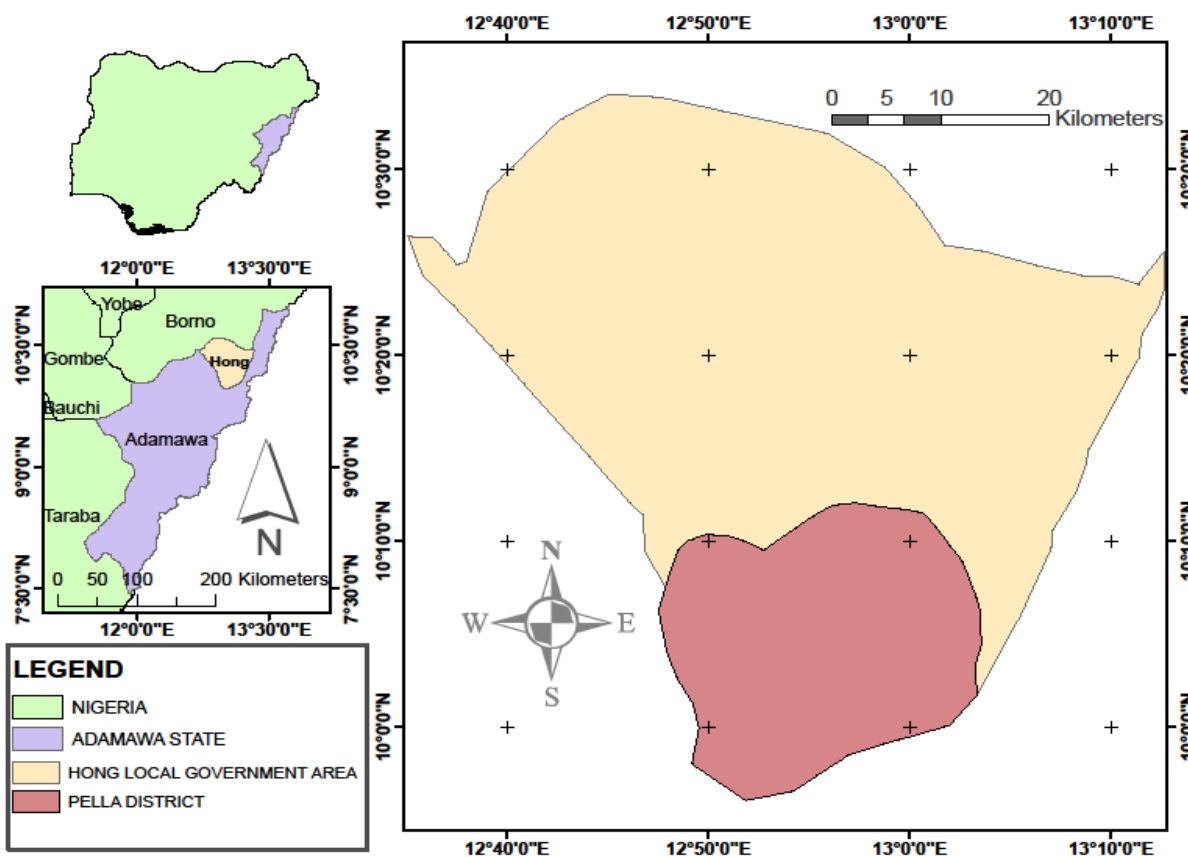


Figure 1: Map of Nigeria Showing the Location Adamawa State, Hong Local Government Area and Pella District

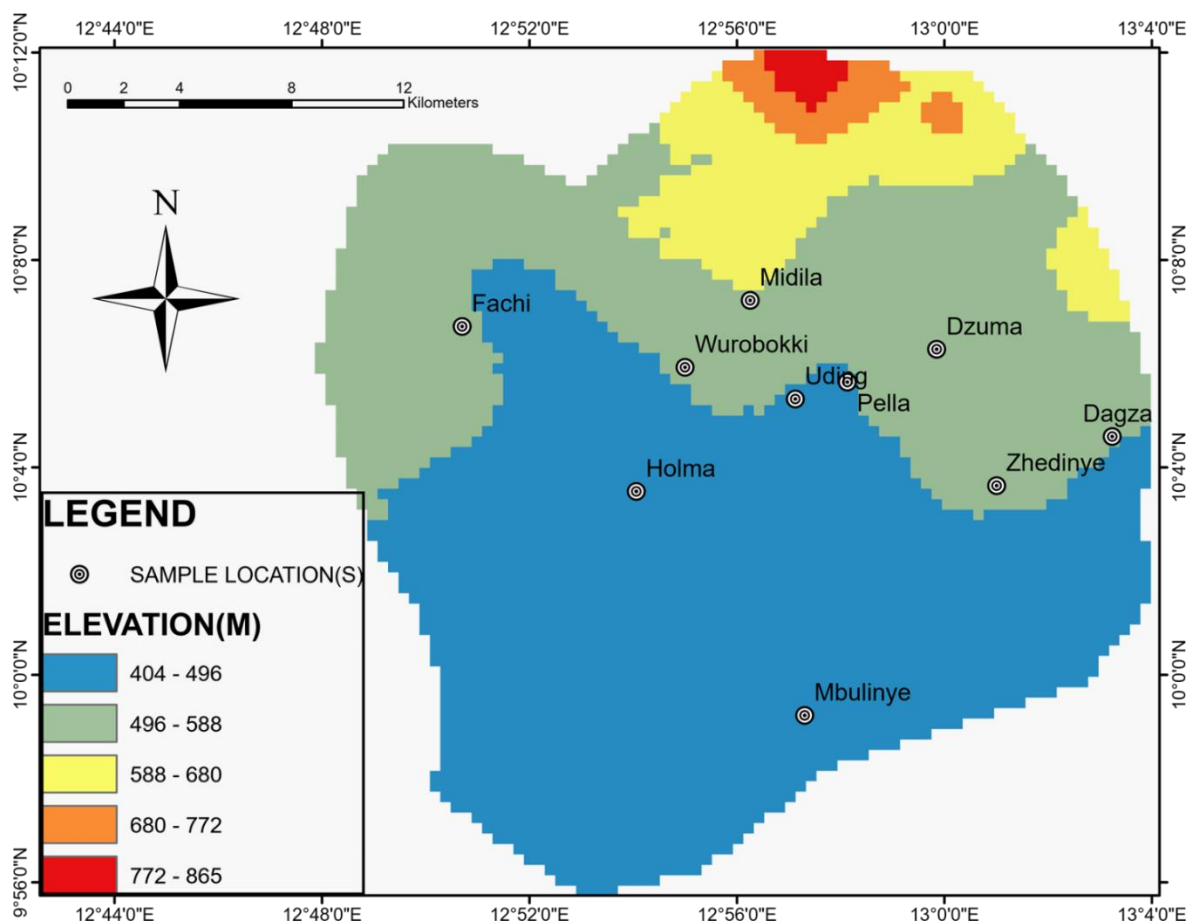


Figure 2: Map of Pella Districts Showing some Sampling Units

MATERIALS AND METHODS

Study Area

The study was conducted in Pella district of Hong Local Government Area, Adamawa State, North-East Nigeria. It lies between latitudes 9° 58' to 10° 35' N, longitudes 12° 35' to 13° 13'E with an approximate land area of 328.25km²(Zemba *et al.*, 2020). Mostly cultivated crops include groundnut and sesame, while food crops include corn, rice, beans, and sorghum. The soil in this area falls in to the category of lithosol (Ray, 2020) with parent material of undifferentiated basement complex represented by migmatite-gneisses, schists, quartzites aplite, medium and coarse-grained granites, pegmatite, diorite, and amphibolites (Udo, 1970).

Soil Sampling and Laboratory Analysis

Reconnaissance survey was carried out to have a general view of the soil variations of the area. Eleven units namely Pella, Dzuma, Midila, Zhedinye, Mbulnyi, Dagza, uding, WuroBokki, Fachi, PellaGwaja and Holma villages were demarcated base on areas under cultivation to sample soil; this was done to uniformly cover the sampling area, a total 88 surface samples were collected at (0 to 20cm) during the dry season, with 8 sample each from the demarcated units at

random from North, East, South and West of each of the demarcated units. The following laboratory analysis was carried for the 88 collected soil samples. Particle analyses of soils were determined using a Buoyoucouc hydrometer method (Jaiswal, 2003), Soil bulk density was determined from soil cores (Gautam *et al.*, 2023), total porosity was calculated by assuming a particle density of 2.65gcm⁻³ and then using the expression as given by Childs & Bybordi (1969). Soil pH and EC was determined in 1: 2 (Soil: Water) suspension using pH meter, and EC conductivity meter (Gautam *et al.*,2023). Soil organic carbon was determined using the Wet Oxidation method (Walkley & Black 1934). Organic matter was calculated by multiplying the organic carbon content of the soil by a factor of 1.724. Total nitrogen was determined by the kjeldahl wet oxidation method (Sabah *et al.*, 2022). Available phosphorus was determined using the Bray-1 method (Bray and Kurtz, 1945). Exchangeable cations; Calcium (Ca), Magnesium (Mg), Potassium (K) and Sodium (Na) were determined from the extract of soil treated with neutral normal ammonium acetate (pH 7.0), [1N neutral ammonium acetate (NH₄OAc)]. Calcium and Magnesium were determined by titration, whereas K and Na were determined using a flame

photometer (Gautam *et al.*,2023). Total Exchangeable Acidity (TEA) were determined by extraction from the soil samples with 1N, KCl and the extract was titrated with 1N Sodium hydroxide (Jaiswal, 2003). Effective Cation Exchange Capacity (ECEC) was determined by summing up all the exchangeable cations (Ca, Mg, K and Na) and exchangeable Al and H (Jaiswal, 2003). Percentage base saturation was calculated by dividing the sum total of the exchangeable base by the ECEC of the soil and expressed as a percentage (Gautam *et al.*,2023). Exchangeable sodium percentage (ESP) was calculated as the proportion of ECEC (NH₄OAc) occupied by sodium cations, i.e. dividing the exchangeable sodium content of the soil by the ECEC (soil) expressed as a percentage (Gautam *et al.*,2023). Micro nutrients (Cu, Fe, Mn, Zn, S and Mo) were Extracted using perchloric acid/Nitric acid and digested on a hot plate at about 200-225^oC until the unit of the mixture turn yellow or white, the digest was then dissolved in 0.1M HCl and filtered. Determination of Cu, Fe, Mn and Zn was carried out by Atomic Absorption Spectrophotometer. Sulphur (S) was extracted with CaCl₂ and determined turbidimetrically using spectrophotometer while, Molybdenum (Mo) was extracted with ammonium oxalate and determined by calorimetric method ((Gautam *et al.*,2023).

Data Analysis

The data obtained were analyzed using descriptive statistics and coefficient variability (CV) was used to explain the level of variability of the nutrients using SAS (2015). The variability levels were interpreted using the coefficient of variation (CV) classes: most (CV: >35%), moderate (CV: 15 to 35%) and least (CV: <15%) as described in Tabi and Ogunkule, (2007). Soil fertility index (NFI) of S, P and Mo was calculated using the expression of (Parker *et al.*, 1951) as presented in (Alhassan, 2019; Musa *et al.*, 2025). Parker's nutrient index is a three-tier system used to evaluate the fertility status of soil base on the percentage of samples in each of the three classes, i.e low, medium and high and multiply by 1, 2 and 3 respectively.

$$NFI = (NL \times 1 + NM \times 2 + NH \times 3) / TNS \quad (2)$$

Where NL = number of samples at low level of concentration in the soil.

NM = Number of samples at medium level of concentration.

NH =Number of samples at high level of nutrient concentration.

TNS= Total number of samples.

RESULTS AND DISCUSSION

The results of the soil physical properties analyzed were presented in Table 1. The mean value of sand fraction ranges between 62.42 to 69.90% with the highest percentage value found in Pella unit and the lowest in Fachi unit. Silt particles ranged between 16.48 to 20.39% with highest percentage in Zhedinye unit and the lowest in Pella gwaja unit. However, clay fraction ranges from the minimum (12.53%) in Pella unit and maximum (20.01%) in Fachi unit. It can be seen that most of the units have high sand percentage, with little coefficient of variability (13.39%), silt has about 31.39% CV which is moderate and a higher coefficient of variability (40.42%) was record in clay fraction within the unit. The highest variability in clay may be as a result of deposition by erosion and eluviation (Ray, 2020). The soil bulk densities of the entire unit were low, with values ranging from 1.46g/cm³ to 1.54g/cm³, these values are characteristic of loam and clay loam soil. According to Esu, (2005) the bulk densities of 1.3 -1.65g/cm³ are typical values for surface loamy soil that have granular structure. According to Nam *et al.* (2021) soils with a bulk density of less than 2.5 g/cm³ are assessed to have high humus content. The percentage soil porosity for all the units ranges from 41.88% to 44.50%, these values indicate moderate porosity. According to Afriawan *et al.* (2021) and Sani *et al.*, (2026), Soil porosity should be above 50% because, it improves plant growth conditions and boosts soil respiration and microbial activity, similar finding was recorded by Ahmed *et al.*, (2013) in Mubi South of Adamawa state Nigeria.

Soil Chemical Properties of the Study Area Pella District

The results of mean chemical properties of soil are presented in Table 2. The pH in all units was slightly acidic to neutral with range value of 6.18 to 7.0 and coefficient of variability (CV) of 4.63%. The low values of soil pH may be due to the depletion of cations during long cultivation, and the high use of inorganic fertilizers (Mulat *et al.*, 2021). Similar slightly acidic values were also recorded by Maunde *et al.* (2016) while evaluating soil fertility status of Song local government of Adamawa State Nigeria. Mean values of Electrical conductivity (EC) in all units were low, ranging from 0.027ds/m to 0.975ds/m with a very high CV (86.11%). The lower values of EC recorded in the area may be ascribed to leaching of salt to much lower horizon, considering light textured nature of the soil of the study area. Similar result was also reported in soils of Loko, Adamawa State by Musa (2015). The low EC value may also be due to the depletion of cations during long cultivation (Mulat

et al., 2021). Low mean values of soil organic carbon and organic matter were recorded with range from 0.01 to 1.10% and 1.38 to 1.91% for organic carbon and organic matter respectively, and varied moderately (26.29%) for organic carbon and (26.18%) for organic matter. These low values could be attributed to sandy-to-sandy loam texture of the soil which might facilitate high runoff and depletion of organic materials by rainfall in the area. The low organic matter can also be linked such as low biomass production in the cropping systems, removal of crop residues for fuel or fodder, or the effects of tillage practices on oxidation rates (Mulat et al., 2021). Mean values of available phosphorus range from

7.88mg/kg to 11.55mg/kg and varied within the units (16.2%). These low to medium value of AvP could be related to low organic matter recorded in the area, Similar result of lower value of AvP was reported by Jamala & Oke (2013) in the soils of some parts of Adamawa State Nigeria and attributed it to land use and inherent P deficiency of the soil of the region. minimum value of total nitrogen was recorded in Mbulinye unit while the maximum was found in Pella gwaja unit. The low nitrogen could also be attributed to low organic matter content of the soils and its sandy nature which can facilitate high infiltration that can leached down nitrogen (Brady & Weil, 2008).

Table 1: Mean: Soil Physical Properties of the Study Area. (0-20cm depth) Pella District

| Units | Sand % | Silt | Clay | BD (g/cm ³) | Porosity (%) |
|-------------|-----------|-------|-------|----------------------------|-----------------|
| Dagza | 66.11 | 18.53 | 15.36 | 1.51 | 43.12 |
| Dzuma | 68.61 | 16.89 | 14.50 | 1.52 | 42.75 |
| Fachi | 62.42 | 17.57 | 20.01 | 1.46 | 44.50 |
| Holma | 68.38 | 18.98 | 12.64 | 1.53 | 42.25 |
| Mbulinye | 65.70 | 18.74 | 15.56 | 1.50 | 43.50 |
| Midila | 69.35 | 17.22 | 13.43 | 1.53 | 42.38 |
| Pella | 69.90 | 17.57 | 12.53 | 1.54 | 41.88 |
| Pella gwaja | 69.27 | 16.48 | 14.25 | 1.53 | 42.12 |
| Uding | 68.86 | 17.75 | 13.39 | 1.53 | 42.50 |
| Wrobokki | 66.53 | 17.64 | 15.83 | 1.51 | 43.12 |
| Zhedinye | 63.91 | 20.39 | 15.70 | 1.50 | 43.75 |
| SE | 4.50 | 2.81 | 3.00 | 0.04 | 1.33 |
| CV (%) | 13.39 | 31.22 | 40.42 | 4.82 | 6.21 |

Table 2: Mean Soil Chemical Properties of the Study Area (0-20cm depth) Pella District

| Units | pH | EC (ds/m) | OC% | OM% | TN% | Av.N% | Av.P (mg/kg) |
|-------------|------|-----------|-------|-------|-------|--------|--------------|
| Dagza | 6.30 | 0.03 | 0.89 | 1.54 | 0.08 | 0.0008 | 11.52 |
| Dzuma | 6.64 | 0.05 | 1.10 | 1.91 | 0.09 | 0.0006 | 10.42 |
| Fachi | 6.93 | 0.03 | 0.93 | 1.60 | 0.08 | 0.0009 | 9.41 |
| Holma | 6.60 | 0.03 | 0.97 | 1.67 | 0.08 | 0.0010 | 9.82 |
| Mbulinye | 6.18 | 0.04 | 0.79 | 1.38 | 0.07 | 0.0007 | 7.88 |
| Midila | 6.83 | 0.10 | 1.03 | 1.79 | 0.09 | 0.0008 | 9.88 |
| Pella | 6.77 | 0.04 | 0.81 | 1.39 | 0.07 | 0.0007 | 10.00 |
| Pella gwaja | 7.00 | 0.03 | 1.08 | 1.87 | 0.09 | 0.0008 | 10.35 |
| Uding | 6.42 | 0.04 | 0.98 | 1.70 | 0.08 | 0.0007 | 11.48 |
| Wurobokki | 6.50 | 0.04 | 1.01 | 1.75 | 0.08 | 0.0012 | 9.65 |
| Zhedinye | 6.54 | 0.03 | 1.02 | 1.77 | 0.09 | 0.0008 | 11.55 |
| SE | 0.15 | 0.02 | 0.13 | 0.22 | 0.01 | 0.0002 | 0.825 |
| CV (%) | 4.63 | 86.11 | 26.29 | 26.18 | 26.81 | 42.44 | 16.2 |

Soil Sulphur and Some Micronutrients of the Study Area

The results of soil micronutrient of the study area are presented in Table 3. Soil sulphur (S) concentration ranged from low level (4.60 mg/kg) at Pella gwaja to medium level (6.75mg/kg) at Midila which varied moderately (26.66%), while the mean values of molybdenum ranged from

0.29 to 0.71mg/kg, with minimum value located in Zhedinye unit, and the maximum in Holma unit, slightly lower values were reported by Bapetel et al. (2013) for some soils in Adamawa State. The low to medium content of Mo in the soil might be as a result of nutrient interaction with soil pH, however the mean values of copper (Cu) ranged from 0.30 to 0.92mg/kg with the least value

recorded in Zhedinye unit and the highest mean value at Holma unit, with a high coefficient of variability (64.00%), Shehu *et al.* (2015) reported moderate value of Cu in Sudan Savanna of Nigeria. The values of iron Fe ranged from 3.59 to 6.80mg/kg with high coefficient of variability 42.93%.

Alhassan (2019) also reported adequate level of Fe in soils of Bade local Government Area, North eastern Nigeria. The mean values of manganese (Mn) ranged between 0.57 to 4.11mg/kg with high coefficient of variability (63.88), with about 30% of the values falls within low rating, while medium and high concentrations had 35% each. The high values were found in Fachi, Mbulinye, Pella and Pella gwaja units, while Dagza, Midila, and Wurobokki units had medium values and Dzuma, Holma and Uding with low ratings of Mn. The high values of Mn found could also be attributed to slight acidic nature of the soils of these areas. The soils should therefore be closely monitored to avoid Mn toxicity. The mean values of zinc (Zn) ranged from 0.80 to 1.73mg/kg with high coefficient of variability (50.1%). Most of the units had medium values of Zn, except at Uding and Wurobokki which showed high concentrations. Lower values were equally recorded in Pellagwaja unit. Specific fertilization in these low Zn rated areas could be required, for crops like corn, beans and some deciduous fruit trees that require Zn most. Low values of Zn were also reported by Alhassan (2019) in soils of Bade local Government Area, North eastern Nigeria.

Exchangeable Cations, Total Exchangeable Bases and Acidity, Percent Base Saturation and Exchangeable Sodium Percentage of the Soils, Pella District.

Table 4 present the mean exchangeable cation, total exchangeable bases and acidity, percentage base saturation and exchangeable sodium. Mean values of calcium across all units ranged between 5.3 to 6.12 cmol/kg and slightly varied (CV = 11.75%) which did not differ significantly within the units. The medium value of calcium recorded might be as a result of calcium containing weathered rocks and calcium containing mineral like calcite, apatite dolomite that are common in the study area (Ray, 2020). The values of Magnesium (Mg) ranged from 2.04 to 2.73 cmol/kg, with moderate CV (15.68%) while Potassium (K) and Sodium (Na) had moderate CV of (19.5) and 22.34% respectively, these values may be attributed to presence of potassium rich clay mineral like illite and feldspar as opined by Amadi *et al.* (2019) that granitic rocks domiciled in Pella, Hong local government showed quartz, feldspar, mica and some accessory minerals. Total

exchangeable bases (TEB) ranged from 8.88 to 9.82cmol/kg, with the minimum value found in Midila unit and the maximum mean value at Wurobokki unit. The TEB slightly varied within the units (CV8.49). However, total exchangeable acidity (TEA) values range from 1.09 to 2.30cmol/kg, with a moderate coefficient of variability (33.68%) which is generally indicating low levels, these low values could be attributed to the low level of exchangeable hydrogen, as most of the soil pH recorded were above 5.5, as increase in the soil pH reduces the exchangeable acidity (Mahmud *et al.*, 2022; Onwuka *et al.*, 2016). Mean values of effective cation exchange capacity (ECEC) also range from 10.11 to 12.02cmol/kg with a slight coefficient of variability (8.44%). The low ECEC values may be attributed to the low clay and organic matter contents of the soils. The values of percentage base saturation (PBS) indicated higher values in all the units, and ranged between 80.41 to 87.96% with slight coefficient of variability (5.07%). which might be as a result of some slight close to neutral value of pH recorded in the area). values of ESP also ranged from 4.53 to 6.39%, and varied moderately between the sampled locations (21.39%). It can be seen that values below 15% of ESP and less than 4dS/m EC of the soils is below threshold for salinity and sodicity problem.

Nutrient Fertility Index of P, S and Mo of Pella District

Table 5 present the nutrient fertility index of phosphorus (P), Sulphur (S) and molybdenum (Mo). Using the nutrient fertility index, soil nutrients were categorized into low (NI < 1.67), medium (1.67–2.33), and high (>2.33) fertility classes. This classification provides a practical basis for delineating management zones, ensuring that nutrient-deficient areas receive targeted inputs while avoiding over-application in nutrient-rich zones, thereby optimizing crop productivity (Alhassan, 2019). Therefore, the nutrient fertility index of soil of Pella district therefore were classified as moderate in phosphorus (1.9), low in sulphur (1.0) while molybdenum (Mo) had moderate (1.9) fertility index. The soil of the study area showed deficiency in S which could be due to lack of sulphur addition and continuous removal by crops (Balanagouudar, 1989), to remedy the situation, the soils may require S fertilization. Yasasvi *et al.* (2022) reported that deficiency of Sulphur has been increased due to using of sulphur-free fertilizers and decreasing in atmospheric inputs.

However, the moderate fertility index of P of the study area might be as a result of application of phosphate fertilizer mostly from the commonly

used fertilizers like nitrogen, potassium and phosphorus (NPK) or phosphorus rich organic materials which can slowly release the mineral nutrient (Brady & Weil 2008). In his work Abraham *et al.* (2018) also reported medium value of phosphorus in some soils of Adamawa state. The moderate fertility index of molybdenum could be as a result of Soil pH and mineralogical composition of the parent materials. According to

Bapetel *et al.* (2013) a wide range of total Mo content of soil for selected Nigerian soil profile tend to be low. Therefore, Mo fertilizer amendment is recommended, as response to applied Mo has been observed in groundnuts, cowpea, soya bean, maize and sugarcane, which is mostly cultivated, is the study area (Rana *et al.*, 2020).

Table 3: Mean Soil Sulphur and Some Micronutrients of the Study area (0-20cm depth)

| Units | S (mg/kg) | Mo (mg/kg) | Cu (mg/kg) | Fe (mg/kg) | Mn (mg/kg) | Zn (mg/kg) |
|-------------|-----------|------------|------------|------------|------------|------------|
| Dagza | 6.23 | 0.46 | 0.59 | 4.82 | 1.04 | 1.42 |
| Dzuma | 5.56 | 0.41 | 0.48 | 4.74 | 0.63 | 1.35 |
| Fachi | 4.72 | 0.50 | 0.59 | 6.80 | 3.14 | 1.49 |
| Holma | 6.33 | 0.71 | 0.92 | 4.82 | 0.59 | 1.31 |
| Mbulinye | 6.53 | 0.49 | 0.42 | 5.57 | 4.11 | 1.30 |
| Midila | 6.75 | 0.37 | 0.66 | 3.59 | 1.35 | 1.16 |
| Pella | 5.14 | 0.35 | 0.69 | 5.62 | 2.29 | 1.40 |
| Pella gwaja | 4.60 | 0.45 | 0.53 | 5.07 | 3.34 | 0.80 |
| Uding | 5.97 | 0.50 | 0.70 | 4.09 | 0.57 | 1.73 |
| Wurobokki | 5.46 | 0.41 | 0.89 | 4.08 | 1.78 | 1.53 |
| Zhedinye | 5.36 | 0.29 | 0.30 | 4.21 | 1.68 | 1.00 |
| SE | 0.76 | 0.13 | 0.20 | 1.04 | 0.60 | 0.33 |
| CV (%) | 26.66 | 57.57 | 64.00 | 42.93 | 63.88 | 50.14 |

Table 4: Mean Exchangeable Cations, Total Exchangeable Bases and Acidity, Percent Base Saturation and Exchangeable Sodium Percentage of the Soils (0-20cm depth), Pella District.

| Units | Ca | Mg | Na | K | TEB | Al | H | TEA | ECEC | PBS | ESP |
|--------------|----------------|-----------|-----------|----------|------------|-----------|----------|------------|-------------|------------|------------|
| | cmol/kg | | | | | | | | | (%) | |
| Dagza | 5.88 | 2.67 | 0.561 | 0.604 | 9.71 | 1.29 | 1.01 | 2.30 | 12.02 | 80.87 | 4.66 |
| Dzuma | 5.65 | 2.69 | 0.534 | 0.626 | 9.51 | 1.32 | 0.98 | 2.30 | 11.81 | 80.41 | 4.53 |
| Fachi | 5.87 | 2.51 | 0.618 | 0.654 | 9.65 | 0.70 | 0.67 | 1.37 | 11.02 | 87.65 | 5.62 |
| Holma | 5.65 | 2.37 | 0.641 | 0.733 | 9.39 | 0.67 | 0.64 | 1.31 | 10.71 | 87.84 | 5.99 |
| Mbulinye | 5.64 | 2.53 | 0.638 | 0.561 | 9.38 | 0.56 | 0.53 | 1.09 | 10.48 | 89.61 | 6.14 |
| Midila | 5.31 | 2.35 | 0.641 | 0.573 | 8.88 | 0.63 | 0.60 | 1.23 | 10.11 | 87.96 | 6.39 |
| Pella | 5.62 | 2.68 | 0.549 | 0.585 | 9.43 | 0.95 | 0.67 | 1.62 | 11.06 | 85.22 | 4.97 |
| Pella gwaja | 5.82 | 2.04 | 0.484 | 0.555 | 8.89 | 0.79 | 0.76 | 1.54 | 10.44 | 85.38 | 4.60 |
| Uding | 6.12 | 2.28 | 0.549 | 0.643 | 9.60 | 0.59 | 0.56 | 1.16 | 10.75 | 89.21 | 5.09 |
| Wurobokki | 5.88 | 2.73 | 0.543 | 0.656 | 9.82 | 0.90 | 0.87 | 1.78 | 11.59 | 85.16 | 4.73 |
| Zhedinye | 5.79 | 2.39 | 0.569 | 0.661 | 9.41 | 1.32 | 0.73 | 2.05 | 11.46 | 82.03 | 4.96 |
| CV (%) | 11.75 | 15.68 | 22.34 | 19.5 | 8.49 | 35.34 | 41.13 | 33.68 | 8.44 | 5.07 | 21.39 |

Table 5: Soil Nutrient Fertility Index of P, S, Mo and the Number of nutrient Soil Under Low, Medium and High Categories

| Nutrient | Fertility Index | No. of Soil Nutrients and Categories | | |
|-----------------|-----------------|--------------------------------------|--------|------|
| | | Low | Medium | High |
| Phosphorus (P) | 1.9 | 1 | 10 | 0 |
| Sulphur (S) | 1.0 | 11 | 0 | 0 |
| Molybdenum (Mo) | 1.9 | 1 | 10 | 0 |

Key:

| | |
|----------------------|---------|
| Nutrient Index Range | Remarks |
| <1.67 | Low |
| 1.67-2.33 | Medium |
| > 2.33 | High |

Parker *et al.* (1951) Adapted from Alhassan (2019)

Table 6: Critical limits for interpreting levels of soil fertility

| Parameter | Low | Medium | High | Units |
|------------|-------|-------------|------|-------|
| Avail. P | < 8.0 | 8 – 20 | > 20 | mg/kg |
| Sulphur | < 10 | 10 – 20 | > 20 | mg/kg |
| Molybdenum | < 0.3 | 0.30 - 1.00 | > 1 | mg/kg |

Source: Esu (1991) & Aduayi *et al.* (2002)

CONCLUSION

Soils of Pella district generally showed low level of fertility with varying coefficient of variability, with predominant sandy loam texture, moderate bulk density and slightly acidic to slightly alkaline. The nutrient fertility index of soil was classified as moderate for both phosphorus (P) and (Mo) respectively while sulphur (S), was deficient in the area. Therefore, good management strategy to sufficiently upgrade the level of fertility for sustainable crop production will be required, Sulphur (S) and molybdenum (Mo) fertilizer amendment is recommended to sites showing deficiencies, ie site - specific soil management, as response to applied S and Mo has been observed in groundnuts, cowpea, soya bean, maize and sugarcane in some related locations.

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