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Assessment Of Available Macronutrients And Micronutrients Status Of Soil In Benue North-West (Zone B), Benue State, Nigeria

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Abstract
This study was carried out in 2024 to estimate the level of selected macro and micro-nutrients in the soils of the study area. The properties assessed include particle size distribution, soil pH, organic matter (OM) content, total nitrogen, available phosphorus, exchangeable cations, base saturation, cation exchange capacity (CEC) and the micro nutrients concentration (Copper, Iron, Zinc and Manganese). The textural composition of the soils across the study areas ranged from sandy loam to clay. The soil pH ranged from 5.4 –6.8 which is rated as strongly acidic to neutral. The organic matter content ranged from 2.20 – 9.0% corresponding to low and medium organic matter. The primary macronutrients (Nitrogen, Phosphorus and Potassium) were in the range of 0.14 – 1.0%, 4.0 – 8.8ppm and 0.2 – 0.9 Cmol/kg respectively. The total nitrogen is rated low to high, while available phosphorus was rated low to moderate. Potassium was found to be adequate for crops across the locations in the study area. The concentration of calcium, magnesium and sodium in the study area was in the range of 2.5 to 5.4 Cmol/kg, 0.4 to 4.0 Cmol/kg and 0.2 to 0.7 Cmol/kg respectively. This is rated as low to moderate, exchangeable cations, cation exchange capacity (CEC) is rated as low to moderate. The CEC has a moderate negative correlation with pH across all locations. The micronutrient concentration for copper, iron, zinc and manganese were in the range of 0.40 – 0.64, 3.20 – 7.30, 0.30 – 0.62 and 5.0 – 6.2mg/kg respectively. Copper has a nutrient index of 2.0 which is classified as medium fertility as well as iron (1.86) and manganese (1.86). Zinc content in the soil was low needing zinc based fertilizer to address the low fertility status.

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I. Introduction

Soil is the basic natural resource which plants depend upon for the supply of macronutrients and micronutrients for support of their growth, life cycle and biological functions. Macronutrients (Nitrogen, Phosphorus, Potassium, Calcium, Magnesium and Sulphur) are elements needed by plants in large amounts, while micronutrients (Copper, Zinc, Boron, Manganese, Chlorine and Molybdenum) are required in relatively small quantities (Jimoh*et al*., 2015). The availability of these nutrients in the soil promotes soil health and crop critical growth and production factor (Dhortare*et al*., 2018). Deficiency of any of the nutrients may hamper plant growth and development (Mousavi, 2011). The fertility of soil is determined by the ability of soil to hold and supply in available forms, adequate plant nutrients in considerable amounts as required for growth and production that is void of any form of toxicity (Osman, 2012). Optimum plant growth is only possible when macro and micro-nutrients are available in a balanced proportion (Effiong*et al*., 2006).

These nutrients perform complex roles in plants. The specific roles vary, they are important for gene expressions, chlorophyll formation and secondary metabolic activities, metabolism of carbohydrates and lipids, etc (Gao *et al*., 2008). Most arable lands in the world have low availability of these nutrients, and many of these deficiencies were brought about by the increase in demand for more rapidly growing crops. These deficiencies are critical factors in crop production. The lack of these nutrients can severely affect soil health and productivity (Naidu *et al*., 2019).

Excessive concentration of any nutrient may cause the uptake of certain plants which afterwards can affect the overall productivity of the soil.The tropic level of soils depends on many factors that land users must know. A fertile soil is rich in organic matter that retains water and provides the nutrients that plants need. It must also have an equilibrated texture for easy water drainage (Matthews, 2024).

II. Materials And Methods

The Study Area

The study area is Benue North-West of Benue State (Zone B), Benue North-West has seven local government areas which include Gboko, Tarka, Buruku, Makurdi, Gwer, Guma and Gwer West. Benue North-West is situated in the middle belt region of Nigeria. The area has a tropical wet and dry season. The wet season starts from April to October and the dry season starts from November to March. The minimum temperature is 25ºC and maximum is 35ºC.

The vegetation in the area is guinea savanna type characterized by grasses and scattered trees and shrubs. The land is used mainly for the cultivation of yams, cassava, potatoes, millet, soyabean, rice,citrus, palm trees and other economic trees. The area is drained with river Benue and Katsina – Ala and their tributaries.

Sample Collection and Preparation

Soil samples were collected randomly from each of the seven local government areas. Five (5) soil samples were taken from each local government area. A total of thirty five (35) soil samples were collected. This was carried out in the month of September, 2024. Soil augur was used to a depth of 0 – 30cm for the collection of the samples. The soils samples collected were packed and labeled in soil sampling bags. All soil samples obtained were dried at room temperature. The air dried samples were pounded using pestle and mortar to ensure homogeneity. The crushed samples were sieved through a 2mm mesh sieve and packed for further analysis.

Laboratory Analysis

Particle Size Analysis

Particle size analysis was carried out using the Bouyoucos hydrometer method (1951). The soil textural classes were determined using the textural triangle chart developed by the United States Department of Agriculture (USDA, 1996).

Soil pH

The pH of the soil was measured using the soil/water ratio. A digital pH meter was used to determine the pH values (Mathieu and Pieltain, 2003).

Soil Organic Matter (OM)

Soil organic matter was detrmined using the wet oxidation method of Walkley and Black (1934) as modified and described by Jackson (1967).

Total Nitrogen

A micro-Kjeldhal distillation method (Jackson, 1967) was used.

Available Phosphorus (P)

Bray – 1 method (Bray and Kurtx, 1945) was used in the determination of available phosphorus.

Cation Exchange Capacity (CEC)

The cation exchange capacity was determined by IN ammonium acetate method.

Exchangeable Cations

Calcium and magnesium were determined by EDTA titration method. The EDTA extracts of sodium and potassium were determined with the flame photometer.

Base Saturation (BS)

Base saturation was calculated by dividing the sum of exchangeable bases by CEC and multiplying by 100.

Micronutrients

Micronutrients were determined using the Atomic Absorption Spectrophotometer (AAS).

Statistical Analysis and Result Interpretation

The data collected was subjected to statistical test of mean, and correlation coefficient to assess variation in the various samples. The results were also interpreted using the interpretation guide for evaluating analytical data (FAO, 2004).

Table 1: Interpretation guide for Evaluating Analytical Data

Exchangeable Cations

Ca^{2+}	Mg^{2+}	K^{+}	Na^{+} (Cmol/kg)	Class
<2	<0.3	<0.2	<0.1	Very low
2 – 5	0.3 – 1	0.2 – 0.3	0.1 – 0.3	Low
5 – 10	1 – 3	0.3 – 0.6	0.3 – 0.7	Moderate
10 – 20	3 – 6	0.6 – 1.2	0.7 – 2.0	High
>20	>8	1.2 – 2	>2	Very high

Cation Exchange Capacity

Cmol/kg	
Range	Class
<6	Very low
6 – 12	Low
12 – 25	Moderate
25 – 40	High
>40	Very high

Percentage Based Saturation

(%)	
Range (%)	Class
0 – 20	Very low
20 – 40	Low
40 – 60	Moderate
60 – 80	High
>80	Very high

Organic Matter

Rating byMetson (1961)	
Range (%)	Class
<2	Very low
2 – 4	Low
4 – 10	Moderate
18 – 20	High
>20	Very high

Soil pH

Range	Rating
<4.5	Extremely acidic
4.5 – 5.0	Very strongly acidic
5.1 – 5.5	Strongly acidic
5.6 – 6.0	Moderately acidic
6.1 – 6.5	Slightly acidic
6.6 – 7.5	Neutral
7.6 – 7.8	Slightly alkaline
7.9 – 8.4	Moderately alkaline
8.5 – 9.0	Strongly alkaline
>9.0	Very strongly alkaline

Total Nitrogen

Rating by Metson (1961)	
Range (%)	Class
<0.1	Very low
0.1 – 0.2	Low
0.2 – 0.5	Moderate
0.5 – 1.0	High
>1.0	Very high

Available Phosphorus

Rating by Enwezor (1989)			
Bray 1		Bray 2	
Range (ppm)	Class	Range (ppm)	Class
<8		<15	Low
8 – 20		15 – 25	Moderate
>20		>25	High

Sources: Special Programme for Food Security, Federal Ministry of Agriculture and Rural Development (SPFS, FMARD), FAO (2004)

III. Results And Discussion

Particle Size Distribution

The particle size distribution and texture classes in the study area are presented in Table 2. The textural classes varied from sandy loam to clay. The percentage sand fractions decreased at Guma Local Government Area (45.88% - 70.40%), while there was a significant increase in the clay fraction (14.9% - 33.2%). These changes can be attributed to some of the soil forming factors as pointed out by Brady and Weil (2008) that soils formed from granite tend to have a higher proportion of sand – sized particles, while those formed from basalt tend to have more clay – sized particles. From the data available, it can be said that, the particle size distribution falls within the range of fertile soil (Brady and Weil, 2008).

Soil pH

The values of soil pH in the study area are presented in Table 3. The pH values across the different locations range from 5.4 – 6.8 indicating an acid nature of the soils in the study area. This shows that the soils are strongly acid to neutral. According to Brady (1986), the optimum range of pH for the growth of most crops is between 5.5 to 7.2. The soils in the study area fall within the range. It can be concluded that the soils in the study area are suitable for most of the crops growing the area.

Statistical analysis carried out here show that soil pH have a strong positive correlation with Ca^{2+} (r = 0.72), and Mg^{2+} (r = 0.65). There was a moderate positive correlation with available phosphorus (r = 0.60).

Organic Matter Content (OM)

The result for the percentage organic matter is presented in Table 3. The result varied from location to location. In Gboko, organic matter ranges from 2.30 – 3.5%, Tarka 3.5 – 4.8%, Buruku, 4.2 – 6.0%, Makurdi, 4.20 – 9.0%, Gwer 4.2 – 8.8%, Guma, 4.4 – 8.5% and Gwer West, 4.8 – 6.2%.

According to the interpretation guide for evaluating analytical data, the soil in Gboko Local Government Area is rated as low, while in the rest of the other areas the percentage organic matter is rated as medium. This finding is in agreement with the findings of Harpstead (1973), who concluded that low organic matter content is commonly associated with savannah soils, which could be due to high temperatures that rapidly breakdown organic residue. Over cultivation of soils may also be a contributing factor.

Total Nitrogen (N)

Total Nitrogen in the study area as presented in Table 3 has shown that percentage nitrogen in Gboko ranges from 0.14 – 0.39%, Tarka 0.23 – 0.5%, Buruku 0.27 – 0.6%, Makurdi 0.4 – 1.0%, Gwer 0.25 – 0.5%, Guma 0.28 – 0.50%, and Gwer West 0.3 – 1.0%. From the ratings, total nitrogen is rated as high in Makurdi and Gwer West. On the other hand, the remaining areas are rated low to moderate. There was a weak positive correlation (r = 0.21) with pH of the soils. Nitrogen is rated as one of the key nutrients in plant growth, development and reproduction and also most limiting throughout the world, most especially in the tropics (Agbede, 2009). Total Nitrogen and Available Phosphorus has a weak relationship (r = 0.35).

Available Phosphorus (P)

Table 3 shows that the available phosphorus ranges from 4.0 – 8.8ppm. This can be rated as low to moderate. This low to moderate available phosphorus could be attributed to the weak positive correlating with pH of the soils (r = 0.27). There is a slight tendency that available phosphorus can increase with pH

Cation Exchange Capacity (CEC)

The cation exchange capacity of soils in the study area as presented in Table 3 has shown that it is low to moderate. Statistical analysis has shown that there is a consistent moderate negative correlation with pH across all locations, indicating that as pH increases, cation exchange capacity (CEC) tends to decrease. The low organic matter content of the soils could be a factor (Brady and Weil, 2008) for the low CEC.

Exchangeable Cation

Result for exchangeable cation is presented in Table 3. Calcium was rated low across the locations with the exception of Gwer West where it was low to moderate. Magnesium, potassium and sodium were all rated low to moderate in the study areas. The low to moderate exchangeable cations could be attributed to intense leaching because of the high rainfall in the study areas.

On the basis of nutrient index, most of the study locations have a medium fertility classification for potassium, indicating that potassium levels are generally adequate but may require supplementation for crops with high potassium demands.

Base Saturation (BS)

The base saturation as presented in Table 3 (36 – 80%) in Gboko is rated low to high. In Tarka, it is rated moderate to high. The same applies to Buruku, Guma and Gwer, Makrudi was rated moderate while Gwer West rated moderate to very high (56.97 – 90.83%). Optimal base saturation (50 – 80%) has been associated with increase crops yields, nutrient uptake and enhanced soil structure (Brady and Weil, 2008; Marschner, 2012).

Micronutrients in the Soil

The concentration of the micronutrients in the study area is presented in Table 4.

Copper (Cu) Content

The concentration of copper (Cu) was found in the range of 0.43 – 0.64 mg/kg with a mean of 0.53mg/kg in Gboko. In Tarka, the concentration was in the range of 0.41 to 0.52 mg/kg with the mean value of 0.47 mg/kg. Buruku has copper concentration of 0.45 to 0.60 mg/kg with the mean value of 0.52 mg/kg. Makurdi has a range of 0.42 to 0.58 mg/kg with a mean value of 0.52 mg/kg. Gwer has a range of 0.40 to 0.50 mg/kg with the mean value of 0.49 mg/kg. In Guma the copper concentration ranges from 0.40 – 0.50 mg/kg with a mean value of 0.43 mg/kg. Gwer West has a range of 0.40 to 0.45 mg/kg with a mean value of 0.42 mg/kg.

Iron (Fe) Content

The concentration of Iron (Fe) was found in the range of 4.2 to 6.2 mg/kg in Gboko with a mean value of 5.22 mg/kg. The range in Tarka was 3.6 to 5.00 mg/kg with a mean value of 4.0 mg/kg. In Buruku Local Government Area, the range was 4.5 to 6.2 mg/kg with a mean value of 5.08 mg/kg. The Iron concentration in Makurdi ranges from 3.8 to 5.1 mg/kg with a mean value of 4recast this and make corrections where necessary but keep all references:.36 mg/kg. The highest concentration of Iron was recorded in Gwer West with a range of 4.5 to 7.2 mg/kg with a mean value of 6.0 mg/kg. In Gwer the concentration of Iron ranges from 4.5 to 4.7 mg/kg with a mean value of 4.58 mg/kg, whereas in Guma the range was 4.9 to 5.8 mg/kg with a mean of 5.32 mg/kg.

Zinc (Zn) Content

The concentration in the study area was found in the range of 0.30 to 0.58 mg/kg across the locations. Gboko has a mean value of 0.49 mg/kg, Tarka 0.55 mg/kg, Buruku 0.5 mg/kg, Makurdi 0.54 mg/kg, Gwer 0.53 mg/kg, Guma 0.53 mg/kg and Gwer West has a mean value of 0.52 mg/kg.

Manganese (Mn) Content

The manganese concentration was found in the range of 5.0 to 5.82 mg/kg in Gboko with a mean value of j5.42 mg/kg. In Tarka, the range was 5.1 to 5.72 mg/kg with a mean value of 5.42 mg/kg. In Buruku the manganese concentration was found in the range of 5.0 to 5.72 mg/kg, with a mean value of 5.20 mg/kg. The concentration in Makurdi was found in the range of 5.7 to 6.2 mg/kg with a mean value of 5.92 mg/kg. In Gwer the manganese concentration ranges from 5.0 to 6.1 mg/kg with a mean value of 5.58 mg/kg . The Guma area has a range of 5.2 to 6.2 mg/kg with a mean value of 5.74 mg/kg. In Gwer West, the manganese concentration was found in the range of 5.3 to 5.8 mg/kg with a mean value of 5.56 mg/kg.

Relationship Among the Micronutrients

Analysis of correlation of the various micronutrients (Cu, Fe, Zn and Mn) are given in Table 5. From the table, copper vs Fe has a weak positive correlation (r = 0.12). There was a moderate positive correlation (r = 0.45) between copper and zinc. On the other hand a negative correlation coefficient (r = –0.23) was observed between copper and manganese. Iron (Fe) and Zn have a positive correlation of r = 0.34. There was a negative correlation (r = –0.50) between Iron and Manganese. Zinc and Mn had a positive correlation (r = 0.18) which is regarded as weak. The correlation analysis reveals that Zinc tends to increase with copper levels. Manganese tend to decrease with Iron levels. Other micronutrient pairs show weak or no significant linear relationship.

Nutrient Index

According to Parker *et al*. (1951), the nutrient index values less than 1.5 are classified as low, 1.5 to 2.5 as medium while higher than 2.5 as high nutrient status. Based on the data presented in Table 6, nutrient index for copper is 2.0 (medium fertility). Iron has a nutrient index of 1.86 (medium fertility). Zinc has a nutrient value of 1.57 indicating low fertility, while Manganese has 1.86 (medium fertility). Copper levels in all the locations are generally adequate.

Table 2: Particle Size distribution in the Study Area

Location / Sample No		Depth (0 – 30cm)	Particle Size Distribution			Textural Uses
			Sand (%)	Silt (%)	Clay (%)	
Gboko	1		70.80	16.20	13.72	Loamy sand
	2		73.20	11.00	15.80	Loamy sand
	3		77.00	13.00	10.00	Loamy sand
	4		74.00	15.00	11.00	Sandy loam
	5		68.00	20.00	12.00	Sandy loam
Tarka	1		75.00	15.00	10.00	Sandy loam
	2		70.00	20.00	10.00	Sandy loam
	3		71.00	12.00	17.00	Sandy loam
	4		75.00	13.00	12.00	Sandy loam
	5		75.60	13.20	11.20	Loamy sand
Buruku	1		65.00	17.00	18.00	Clay loam
	2		64.20	15.50	20.30	Clay loam
	3		76.00	12.00	12.00	Loamy sand
	4		75.00	15.00	10.00	Loamy sand
	5		70.00	15.00	15.00	Sandy loam
Makurdi	1		76.60	12.40	10.00	Loamy sand
	2		61.40	16.20	22.40	Clay loam
	3		70.20	13.10	16.70	Sandy loam
	4		75.00	13.00	12.00	Loamy sand
	5		62.30	17.30	20.40	Clay loam
Gwer	1		70.00	12.00	18.00	Sandy loam
	2		78.00	12.00	10.00	Loamy sand
	3		61.00	21.00	18.00	Loam
	4		75.00	10.00	15.00	Loamy sand
	5		64.00	16.00	20.00	Clay loam
Guma	1		50.24	16.56	33.20	Sandy clay loam
	2		63.40	15.20	21.40	Clay loam
	3		55.00	15.00	30.00	Clay loam
	4		45.86	21.06	33.08	Clay
	5		70.40	14.90	14.70	Loamy sand
Gwer West	1		70.80	16.40	12.80	Loamy sand
	2		70.80	5.40	23.80	Sandy clay loam
	3		73.40	5.40	20.20	Sandy clay loam
	4		72.40	17.60	10.00	Sandy loam
	5		75.40	10.90	13.70	Loamy sand

Table 3: Soil Chemical Properties in the Study Area

Location / Sample No		pH (in water)	OM (%)	Exchangeable Cations				BS (%)	CEC (Cmol/kg)	Total Nitrogen (%)	Available Phosphorus (ppm)
				Ca^{2+}	Mg^{2+}	K^+	Na^+ (Cmol/kg)				
Gboko	1	6.2	2.50	2.8	1.3	0.5	0.4	51.16	10.36	0.18	8.2
	2	6.5	2.20	3.0	1.2	0.5	0.5	63.80	8.15	0.29	8.5
	3	5.5	2.47	2.5	0.9	9.6	0.4	36.30	12.12	0.14	5.2
	4	5.4	3.50	2.5	1.4	0.9	0.3	80.44	6.34	0.39	4.8
	5	5.8	3.20	2.5	0.8	0.7	0.2	60.56	7.14	0.28	5.0
Tarka	1	6.4	4.50	3.0	1.2	0.8	0.7	46.68	12.21	0.50	8.3
	2	6.7	4.80	3.2	1.3	0.8	0.6	58.36	10.11	0.27	8.3
	3	6.5	4.60	3.5	1.0	0.6	0.6	60.57	9.41	0.25	8.1
	4	6.2	4.20	2.9	1.1	0.5	0.5	68.31	7.32	0.23	7.0
	5	5.7	3.50	2.2	0.8	0.4	0.5	59.62	7.38	0.31	5.2
Buruku	1	6.3	4.20	3.5	0.4	0.9	0.6	41.22	13.10	0.40	8.8
	2	6.2	5.00	3.0	0.5	0.7	0.6	68.97	6.96	0.50	7.3
	3	6.1	5.30	3.4	1.0	0.8	0.5	46.99	12.13	0.60	8.0
	4	5.8	5.60	2.9	2.0	0.5	0.5	45.04	13.10	0.30	5.5
	5	5.4	6.00	2.8	0.8	0.5	0.4	72.35	6.22	0.27	5.6
Makurdi	1	6.5	9.00	3.8	1.9	0.6	0.4	55.83	12.00	0.46	8.2
	2	5.7	7.60	3.2	0.7	0.5	0.3	56.56	8.31	1.00	6.0
	3	6.2	7.50	3.4	0.8	0.5	0.2	59.76	8.20	1.00	8.0
	4	5.8	4.70	3.1	0.6	0.4	0.2	42.53	10.11	0.50	5.3
	5	6.4	6.80	3.2	1.0	0.6	0.4	50.98	10.20	0.40	7.9
Gwer	1	6.1	8.80	3.7	1.2	0.7	0.3	63.44	9.30	0.32	8.0
	2	5.9	6.50	3.5	1.0	0.6	0.3	63.53	8.10	0.50	6.5
	3	5.8	4.90	3.2	0.8	0.4	0.2	44.60	10.30	0.30	5.4
	4	6.2	5.70	2.5	0.7	0.8	0.5	69.23	6.50	0.25	7.5
	5	5.8	4.20	3.3	0.6	0.5	0.2	72.33	10.59	0.40	5.5
Guma	1	6.8	8.50	3.2	1.4	0.5	0.6	56.36	11.00	0.30	8.0

	2	6.7	7.60	3.3	0.8	0.3	0.6	53.08	9.42	0.40	8.0
	3	6.4	5.40	3.8	1.0	0.2	0.2	63.34	8.21	0.50	5.2
	4	6.6	5.60	3.7	0.5	0.3	0.2	56.49	8.32	0.29	6.2
	5	5.9	6.60	3.6	2.8	0.4	0.6	70.48	10.50	0.28	4,0
Gwer West	1	6.5	6.20	5.4	3.8	0.8	0.4	85.46	12.17	1.00	8.3
	2	6.2	5.70	5.2	4.0	0.7	0.3	90.83	11.23	0.50	7.5
	3	6.0	6.00	4.3	2.2	0.5	0.4	70.08	10.56	0.30	6.8
	4	6.3	5.60	4.6	2.0	0.4	0.6	56.97	13.34	0.60	7.4
	5	6.4	5.80	3.9	2.5	0.3	0.4	57.72	12.30	0.40	7.5

Table 4: Micronutrients Content of the Study Area

Location / Sample No		Cu	Fe	Zn	Mn
		(mg/kg)			
Gboko	1	0.50	5.40	0.30	5.82
	2	0.43	4.20	0.54	5.50
	3	0.64	5.10	0.50	5.20
	4	0.52	6.20	0.60	5.00
	5	0.55	5.20	0.53	5.60
Tarka	1	0.51	3.60	0.52	5.10
	2	0.41	3.90	0.62	5.20
	3	0.48	3.20	0.54	5.72
	4	0.44	5.00	0.53	5.63
	5	0.52	4.30	0.55	5.45
Buruku	1	0.45	4.60	0.41	5.20
	2	0.47	5.40	0.52	5.70
	3	0.50	6.20	0.57	5.00
	4	0.56	4.50	0.49	5.10
	5	0.60	4.70	0.53	5.30
Makurdi	1	0.52	4.30	0.52	5.80
	2	0.58	5.10	0.56	5.90
	3	0.54	4.50	0.58	6.00
	4	0.56	4.10	0.52	6.20
	5	0.42	3.80	0.50	5.70
Gwer	1	0.44	4.60	0.58	5.90
	2	0.45	4.50	0.45	5.20
	3	0.50	4.50	0.52	5.00
	4	0.40	4.60	0.51	5.70
	5	0.50	4.70	0.60	6.10
Guma	1	0.42	5.70	0.57	5.80
	2	0.40	4.90	0.50	5.70
	3	0.40	5.00	0.52	5.80
	4	0.42	5.80	0.51	5.20
	5	0.50	5.20	0.55	6.20
Gwer West	1	0.41	7.20	0.54	5.60
	2	0.40	6.50	0.50	5.40
	3	0.45	4.50	0.50	5.80
	4	0.42	6.40	0.52	5.30
	5	0.40	5.40	0.53	5.70

Table 5: Correlation Coefficient among the Micronutrients

Micronutrient Pair	Correlation Coefficient(s)	Interpretation
Copper vs Iron	0.12	Weak positive
Copper vs Zinc	0.45	Moderate positive
Copper vs Manganese	0.23	Weak positive
Iron vs Zinc	0.34	Weak to moderate positive
Iron vs Manganese	-0.56	Moderate negative
Zinc vs Manganese	0.18	Weak positive

Table 6: Nutrient Index for Micronutrients

Micronutrient	Nutrient Index	Classification
Copper (Cu)	2.0	Medium fertility
Iron (Fe)	1.86	Medium fertility
Zinc (Zn)	1.57	Low fertility
Manganese (Mn)	1.86	Medium fertility

IV. Conclusion

The study has evaluated some of the physico-chemical properties of soils in the study area. The study provides a useful insight to guide the farmers towards soil nutrient management and better productivity.

The textural classes of the soils in the study area were found to be suitable for most of the crops that are grown in the study area. The pH range was found to correspond to recommended limits for better nutrient availability and utilization.

The organic matter content can be improved by the use of organic manure and other sources.

The chemical properties of the soils were low to moderate across the locations. Micronutrients were within permissible limits.

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