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Evaluation of Soil Micronutrients in Madagali Local Government Area of Adamawa State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study was carried out to evaluate soil micronutrients in Madagali Local Government area. The importance of micronutrients in plant nutrition is high, and they should not be neglected, although they are needed in minor quantities. Twenty (20) soil samples from each selected five wards were collected which gave a total of one hundred samples used for the study. The collected soil samples were analyzed in the laboratory using appropriate methods and were subjected to descriptive statistics to ascertain their variability across the study area. Based on the laboratory outcome, iron was high with the mean values 5.11mg/kg and 4.86mg/kg for surface and sub-surface, while molybdenum was low with the mean of 0.06mg/kg and 0.04mg/kg. On the other hand, molybdenum (Mo) had the highest which was 75.6% coefficient of variation, while iron (Fe) had the lowest percentage of 30.27% coefficient of variation for surface soils. In sub-surface, manganese (Mn) had the highest percentage value which stood at 59.28% while zinc had the lowest percentage of

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28.42% coefficient of variation. To achieve maximum crop production in the study area, it was recommended that addition of organic matter, liming and proper soil management practices should be adopted.

Keywords: Micronutrients; nutrition; coefficient; management; variation.

1. INTRODUCTION

Dwindling soil quality is anticipated to deepen as further growers are embracing ferocious soil cultivation to meet the agrarian food demand of the ever- adding population and husbandry as a means of livelihood to ameliorate their means of living and as a source of income. As a result, high pressure on soil and soil covers to achieve similar demand leads to prostration of those nutrients essential for plant growth. In order to prevent soil degeneration, empirical soil data and proper land evaluation are the most important precondition for applicable crop cultivation and soil management practices. Soil productivity depends upon its ability to supply essential nutrients to the growing plants in an applicable amount.

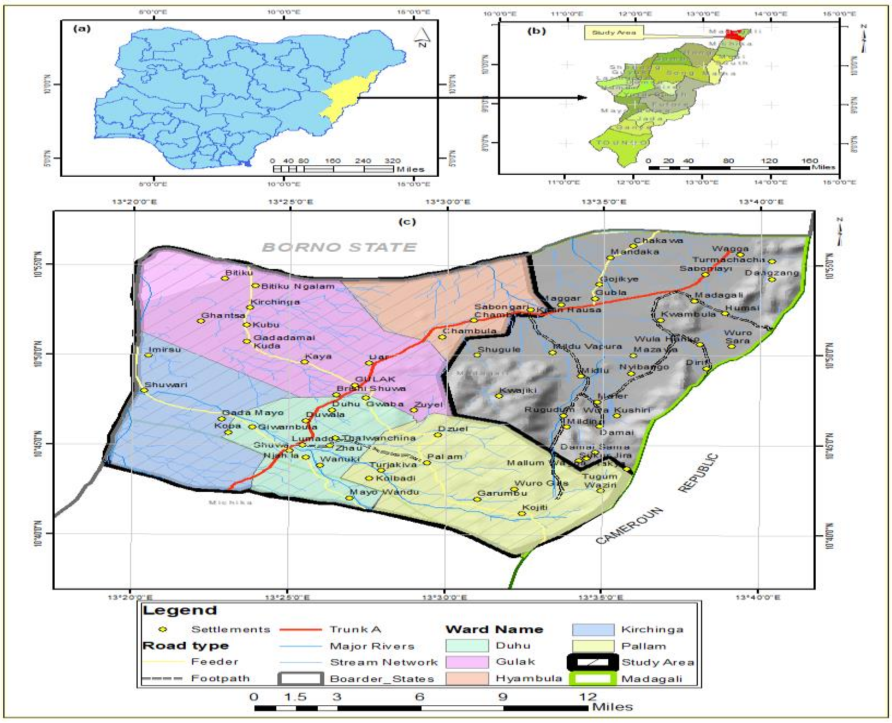
According to Orobator et al., [1], soil micronutrients are very important for crop cultivation because they help in the formation of vitamin A, and are essential for proper pollination, enable the conformation of ethylene in ripening fruit, help regulate metabolic responses in plants, activate and regulate enzymes, responsible for chlorophyll synthesis, regulates respiration and photosynthesis, increase water holding capacity in crop plants and others. These elements are used in small quantities, but they're just as important to plant development and profitable crop production as the major nutrients [2]. As important as the elements and are needed by the plants in small amounts, vital factory metabolism is impaired or limited if the rudiments are unavailable, therefore leading to plant growth dysfunction and reduced yield. This also could lead to poor soil fertility status that wholly determines crop productivity position. Still, the significance of micro-elements in plant nutrition is high, and they shouldn't be neglected, although they're demanded in minor amounts, numerous field trials conducted in different areas have shown that the insufficiency of micronutrients in soils has become a major limitation to the productivity and sustainability of soil [3,4,5]. According to Adamu et al,. [6], large hectares of arable land in Nigeria have been reported to be deficient in both macro and micronutrients and these deficiencies were brought about by numerous factors similar as non-stop use of inorganic fertilizers particularly nitrogen, phosphorus, and potassium by growers, limited use of organic coprolites as well as non-recycling of crop residues.

Madagali Local Government Area is one of the largest producers of food crops such as cereals and legumes. It's endowed with varied soil types and capabilities in which both legumes and cereals are continuously cultivated leading to severe soil nutrient reduction and general prostration. In addition, due to hilly terrain in the study area, the soils are exposed to severe erosion, inordinate loss of organic matter due to low vegetation cover and high temperature. Again, these soil types are infrequently estimated to determine the amount and concentrations of their soil micronutrients which play a veritably vital role in crop production as their macronutrient counterpart as well. Presently, limited data about the soil micronutrients are available in the study area. As a result, this study geared toward the evaluation of some named micronutrients in the study area.

2. MATERIALS AND METHODS

2.1 Location of the Study Area

The Study was carried out in five wards (Hymbula, Gulak, Duhu, Kirchinga and Palam) of Madagali Local Government Area of Adamawa State, Nigeria. Madagali Local Government Area is located in the Northern Senatorial Zone of Adamawa State. The local government is located between longitude 13^0 37'42''to East of Greenwich Meridian and Latitude $10^0$53'31'' North of the Equator. It is bordered with Borno State to the North, Cameroun Republic to the East, Michika Local Government Area to the South and Askira/Uba Local Government Area to the West. Majority of the population are farmers that produce different varieties of crops such as sorghum, maize, groundnuts, cowpea, rice, sugarcane, sweet potato and vegetables as well as tree crops of various species and types.



Map 1. Map of Nigeria showing Adamawa State and map of the study area

2.2 Climate of the Study Area

The study area has a tropical climate which is determined by the movement of the Inter Tropical Convergence Zone (ITCZ), as well as the effect of relief [7]. Rainfall in the study area begins in April, progressing and reaching its peak in August/September and stops most of the time in October. The driest month is January with 0 mm of rainfall. Most precipitation falls in August, with annual rainfall of 854mm. The warmest period of the year is April, with an average temperature of 29.3ºC. In August, the average temperature is 23.4ºC. It is the lowest average temperature of the whole year. The difference in precipitation between the driest month and the wettest month is 258 mm. The lithological units of the study area are predominantly Pan-African granites, gneiss and schist. The vegetation of the study area and its environs falls within the Sudan savannah belt of Nigeria. About 70% of the vegetation is grasses and weeds with few scattered woody plants which make up part of the natural vegetation and the exotic which were brought from other areas into the region.

2.3 Soil Sampling Technique

A reconnaissance soil survey was conducted in the study area which was aided by topographic maps and vital information. Ten auger point soil samples from each ward were collected at depths of 0-20 cm and 20-50 cm using a digger, hoe, spade, and polyethylene bag. For each surface and sub-surface, ten samples were collected, making twenty samples representative of each ward. The twenty auger points collected from each ward were sealed in clean polyethylene bags, labeled, and then taken to the laboratory for analysis.

2.4 Sample Preparation and Laboratory Analysis

The soil samples collected were air-dried, and crushed using pestle and mortar to pass through a 2mm mesh sieve, some of the samples were further passed through 0.5mm for chemical analysis. The soil samples collected were analysed for the physical and chemical properties using standard laboratory procedures at the Department of Soil Science Laboratory, Modibbo Adama University, Yola.

Micronutrients which were determined include Cu, Fe, Mn, Mo and Zn. Micronutrients were determined as described by Jaiswal [8]. The measurement of all micronutrients were carried out on atomic absorption spectrometer (AAS) equipped with hollow cathode lamp as the radiation source.

2.5 Data Analysis

Descriptive statistics, such as mean, minimum, maximum, coefficient of variation (CV), and standard deviation, were used for calculation to characterise the soil parameters.

3. RESULTS OF THE MICRONUTRIENTS OF THE STUDY AREA

The results of the micronutrients are presented in Table 1. The values of copper ranged from (0.07-0.33mg/kg), (0.07-0.55mg/kg), (0.09-0.57mg/kg), (0.09-0.90mg/kg) and (0.02-0.59mg/kg) in the surface of Hymbula, Gulak, Duhu, Kirchinga and Palam respectively as shown in Table 1. While the corresponding sub-surface, ranged from: (0.09-0.33mg/kg), (0.04-0.40mg/kg), (0.04-0.64mg/kg), (0.09-0.46mg/kg) and (0.04-0.53mg/kg) respectively as shown in Table 1. The values of copper obtained were generally low in both surface and sub-surface of the studied area. This could be due to high pH content and sandy nature of the study area and low organic carbon. Kiran et al., [9] also reported that sandy soils with low organic matter are deficient of Cu because of leaching losses.

The values of zinc ranged from (0.44-1.933mg/kg), (0.34-1.42mg/kg), (0.41-0.82mg/kg), (0.27-1.10mg/kg) and (0.32-1.15mg/kg) in the surface of Hymbula, Gulak, Duhu, Kirchinga and Palam respectively as shown in Table 1. While the corresponding sub-surface values ranged from (0.39-0.99mg/kg), (0.31-0.85mg/kg), (0.37-0.80mg/kg), (0.32-1.03mg/kg) and (0.35-0.66mg/kg) respectively as shown in Table 1. The zinc values in both the surface and sub-surface were low to moderate. This might be due to low organic matter and sandy nature of the soils of the study area, Tuma et al*.,* (2014).

The values of manganese ranged from (0.07-4.8mg/kg), (0.06-5.22mg/kg), (1.92-4.50mg/kg), (0.98-5.25mg/kg) and (0.02-9.66mg/kg) in the surface layers of Hymbula, Gulak, Duhu, Kirchinga and Palam respectively as shown in Table 1. While the corresponding sub-surface values ranged from (0.87-4.80mg/kg), (0.05-5.04mg/kg), (0.24-4.80mg/kg), (0.13-3.54mg/kg) and (0.18-3.51mg/kg) respectively as shown in Table 1. The values of manganese of the soil of the study area varied from medium to high in both the surface and sub-surface soils. This implies that, the soil of the study area contains sufficient amount of manganese for optimum agricultural production. This might be due to high fraction of sand, the high sand content improves aeration and drainage, thus preventing manganese reduction. This result corroborates those of Maniyunda et al. [10] and Kparmwang et al*.* [11].

The values of iron ranged from (5.83-6.85mg/kg), (1.98-7.18mg/kg), (5.65-6.63mg/kg), (3.15-4.18mg/kg) and (1.80-5.20mg/kg) in the surface layers of Hymbula, Gulak, Duhu, Kirchinga and Palam respectively as shown in Table 1.

While the corresponding sub-surface values ranged from (5.93-6.95mg/kg), (3.05-6.65mg/kg), (0.23-6.88mg/kg), (0.45-5.83mg/kg) and (2.04-6.38mg/kg) respectively. The content of iron was rated high above the limiting value (2.5mg/kg) for crop production. Correspondingly, Maniyunda et al. [12] and Kparmwang et al*.* [11] reported available iron values were generally above critical limit, this suggest that deficiency of iron is not likely for crops grown in theses soils. The high content of iron may be due to parent material from which the soils were formed and moderately acidic condition of the soils of the study area.

Molybdenum is a transition metal, which occurs in the lithosphere at an average abundance of 1.2 mg kg^{-1} and represents one of the scarcest trace elements in biological systems. The molybdenum values ranged from (0.031-0.279mg/kg), (0.024-0.06mg/kg), (0.023-0.250mg/kg), (0.023-0.074mg/kg) and (0.027-0.084mg/kg) respectively as shown in Table 1. While the corresponding sub-surface layers ranged from: (0.027-0.093mg/kg), (0.023-0.082mg/kg), (0.021-0.086mg/kg), (0.025-0.093mg/kg) and (0.023-0.053mg/kg) respectively as shown in Table 1. Molybdenum values varied from low to moderate in both surface and sub-surface. The value of molybdenum obtained in this study is similar to that of Sandabe et al*.* [13] who reported that available Mo in soils of Damboa/Chibok plains ranged from (0.01 to 0.38mg/kg) with a mean value of (0.17mg/kg). This finding also corroborate the findings of Bapetel et al. [14] who reported on molybdenum availability and some physico-chemical properties of the soils of different parent materials in Adamawa State, Nigeria.

Table 1. Surface and sub-surface micronutrients of the study area

Surface (0-20cm)	**Mo**	**Cu**	**Zn**	**Mn**	**Fe**
			(mg/kg)		
HYMBULA1	0.062	0.11	1.933	0.069	6.75
HYMBULA2	0.033	0.088	0.44	1.635	6.6
HYMBULA3	0.097	0.066	1.817	0.87	5.825
HYMBULA4	0.086	0.088	0.585	2.055	6.075
HYMBULA5	0.065	0.22	0.572	4.8	6.45
HYMBULA6	0.050	0.172	0.505	0.885	6.525
HYMBULA7	0.085	0.265	0.513	1.89	6.55
HYMBULA8	0.031	0.33	0.568	4.41	6.85
HYMBULA9	0.045	0.286	0.651	3.555	6.75
HYMBULA1	0.279	0.308	0.445	0.93	6.25
Sub-surface (20-50cm)					
HYMBULA1	0.054	0.154	0.545	2.865	6.25
HYMBULA2	0.031	0.132	0.988	4.11	6.95
HYMBULA3	0.093	0.088	0.552	2.055	6.65
HYMBULA4	0.064	0.242	0.659	4.8	6.875
HYMBULA5	0.045	0.172	0.554	3.375	5.925
HYMBULA6	0.043	0.242	0.454	3.255	6.175
HYMBULA7	0.084	0.264	0.721	4.065	6.85
HYMBULA8	0.045	0.264	0.555	1.425	6.25
HYMBULA9	0.034	0.246	0.385	2.4	6.375
HYMBULA10	0.027	0.33	0.483	0.87	6.4
Surface (0-20cm)					
GULAK1	0.064	0.286	0.502	1.275	6.225
GULAK2	0.024	0.484	0.478	4.17	6.825
GULAK3	0.063	0.374	0.545	0.585	6.075
GULAK4	0.045	0.396	0.36	4.38	6.655
GULAK5	0.034	0.374	0.429	2.37	5.925
GULAK6	0.064	0.55	0.338	0.64	5.8
GULAK7	0.050	0.098	0.427	0.57	5.825
GULAK8	0.064	0.198	1.423	5.22	7.175
GULAK9	0.054	0.066	0.378	0.06	1.975
GULAK10	0.045	0.088	0.54	1.89	3.25
Sub-surface (20-50cm)					
GULAK1	0.049	0.308	0.44	2.13	4.553
GULAK2	0.065	0.36	0.313	0.671	6.1
GULAK3	0.045	0.325	0.41	0.39	6.2
GULAK4	0.082	0.396	0.467	0.915	6.425
GULAK5	0.024	0.396	0.602	3.705	6.2
GULAK6	0.052	0.132	0.501	0.045	6.65
GULAK7	0.050	0.044	0.312	0.825	5.975
GULAK8	0.054	0.132	0.586	1.95	3.05
GULAK9	0.024	0.22	0.525	1.605	3.875
GULAK10	0.023	0.088	0.851	5.04	3.85
DUHU1	0.062	0.572	0.409	2.31	5.65
DUHU2	0.065	0.154	0.67	3.54	6.55
DUHU3	0.064	0.22	0.659	3.333	6.425
DUHU4	0.250	0.232	0.57	4.2	6.625
DUHU5	0.054	0.322	0.527	1.92	6.3
DUHU6	0.052	0.44	0.734	4.085	6.575
DUHU7	0.024	0.088	0.821	2.145	6.4
DUHU8	0.023	0.132	0.632	2.895	6.375
DUHU9	0.024	0.172	0.461	4.5	6.475
DUHU10	0.026	0.132	0.435	2.49	6.6
Sub-surface (20-50cm)					
DUHU1	0.021	0.638	0.554	3.885	6.175
DUHU2	0.065	0.308	0.686	0.67	5.825

Surface (0-20cm)	Mo	Cu	Zn	Mn	Fe
			(mg/kg)		
DUHU3	0.065	0.044	0.481	2.19	5.8
DUHU4	0.033	0.421	0.64	3.855	6.625
DUHU5	0.048	0.562	0.486	3.285	6.12
DUHU6	0.086	0.224	0.683	4.085	6.775
DUHU7	0.025	0.044	0.497	0.73	0.23
DUHU8	0.023	0.154	0.505	0.24	5.975
DUHU9	0.021	0.154	0.802	4.795	6.75
DUHU10	0.025	0.244	0.365	2.19	6.875
Surface (0-20cm)					
KIRCHINGA1	0.065	0.088	0.851	5.04	3.85
KIRCHINGA2	0.068	0.132	0.527	1.575	3.5
KIRCHINGA3	0.074	0.902	0.71	2.685	3.35
KIRCHINGA4	0.052	0.154	0.405	2.19	3.15
KIRCHINGA5	0.050	0.198	0.513	2.865	3.45
KIRCHINGA6	0.024	0.286	0.464	0.975	3.525
KIRCHINGA7	0.023	0.088	0.273	3.11	3.765
KIRCHINGA8	0.024	0.396	1.096	3.27	4.175
KIRCHINGA9	0.063	0.44	0.427	2.205	3.275
KIRCHINGA10	0.055	0.682	0.672	5.25	3.675
Sub-surface (20-50cm)					
KIRCHINGA1	0.093	0.132	0.543	2.19	3.325
KIRCHINGA2	0.065	0.198	0.465	1.95	3.575
KIRCHINGA3	0.066	0.088	0.405	0.405	2.65
KIRCHINGA4	0.065	0.308	0.686	0.67	5.825
KIRCHINGA5	0.033	0.132	0.872	3.075	3.95
KIRCHINGA6	0.025	0.242	0.502	3.54	3.675
KIRCHINGA7	0.065	0.308	1.034	3.42	0.45
KIRCHINGA8	0.045	0.286	0.632	1.8	3.475
KIRCHINGA9	0.045	0.462	0.322	0.132	2.1
KIRCHINGA10	0.031	0.264	0.564	1.74	3.175
Surface (0-20cm)					
PALAM1	0.081	0.022	1.15	5.58	3.84
PALAM2	0.045	0.088	0.454	0.765	2.61
PALAM3	0.034	0.11	0.316	0.015	1.8
PALAM4	0.050	0.132	0.59	0.69	3.21
PALAM5	0.084	0.154	0.702	1.785	3.63
PALAM6	0.064	0.594	0.785	9.66	4.08
PALAM7	0.027	0.286	0.491	1.005	3.435
PALAM8	0.054	0.44	0.659	2.94	3.81
PALAM9	0.045	0.506	1.123	7.83	4.05
PALAM10	0.084	0.462	0.648	2.28	5.2
Sub-surface (20-50cm)					
PALAM1	0.024	0.044	0.346	0.18	2.04
PALAM2	0.024	0.198	0.48	3.135	3.225
PALAM3	0.024	0.132	0.491	2.085	3.705
PALAM4	0.045	0.176	0.491	1.305	3.555
PALAM5	0.054	0.242	0.491	3.51	3.57
PALAM6	0.023	0.308	0.485	2.265	3.27
PALAM7	0.054	0.44	0.659	2.94	3.81
PALAM8	0.024	0.356	0.451	2.04	3.57
PALAM9	0.052	0.22	0.529	1.875	3.735
PALAM10	0.042	0.528	0.448	2.52	6.375

KEY: Mo= Molybdenum, Cu= Copper, Zn= Zinc, Fe= Iron, Mn= Manganese and milligram per gram

Table 2. Descriptive statistics of micronutrients for surface and sub-surface soils of the study area

Surface (0-20cm)	Mo	Cu	Zn	Mn	Fe
			(mg/kg)		
Mean (mg/kg)	0.06	0.27	0.64	2.64	5.11
SD	0.05	0.19	0.34	1.97	1.55
Max. (mg/kg)	0.28	0.90	1.93	9.66	7.18
Min. (mg/kg)	0.02	0.02	0.27	0.02	1.80
CV (%)	75.60	69.57	52.42	74.64	30.37
Sub-surface					
Mean (mg/kg)	0.04	0.25	0.55	2.32	4.86
SD	0.02	0.14	0.15	1.38	1.79
Max. (mg/kg)	0.09	0.64	1.03	5.04	6.95
Min. (mg/kg)	0.02	0.04	0.31	0.05	0.23
CV (%)	48.13	57.24	28.42	59.28	36.85

KEY: SD= standard deviation, Max= maximum, Min= minimum, CV= coefficient of Variance, mg/kg= milligram per kilogram

3.1 Descriptive Statistics for Micro Nutrients of the Study Area

Table 2 shows the descriptive statistics for micronutrients of the study area. Data obtained showed that the mean values for molybdenum, copper, zinc, manganese and iron were 0.06mg/kg and 0.04mg/kg, 0.27mg/kg and 0.25mg/kg, 0.64mg/kg and 0.55mg/kg, 2.71mg/kg and 2.26mg/kg, and, 5.11mg/kg and 4.86mg/kg respectively. Mo and Zn, values were rated low for surface and sub-surface soils, Mn and Cu values were moderate, while the values of Fe were rated high according to Adamu et al. [6]. The highest mean values of Fe recorded in both surface and sub-surface of the study area might be due to type of soils and slightly acidic nature of the soils of the study area.

Generally, the coefficients of variation for micronutrients were 75.6% and 48.1%, 69.6% and 57.24%, 52.5% and 28.4%, 74.6% and 59.3% and 30.4% and 36.9% for Mo, Cu, Zn, Mn and Fe for surface and sub-surface soils. These results of coefficients of variation were significantly high for all the micronutrients for both surface and sub-surface soils of the study area except Zn at sub-surface which has moderate coefficient of variation. This implies that the micronutrients varied moderately to high across the sampling points of the study area. The high coefficients of variation exhibited by micronutrients might be associated with heterogeneous farming practise, such as fertilizer application carried out by farmers and soil types of the study area.

4. CONCLUSION

Obviously, it could be observed that soil micronutrients were influenced by different soil type, depth, as well as differences in their soil management practices. From the foregone study, it could be observed that the laboratory result obtained in this study showed iron (Fe) high content, while zinc (Zn), molybdenum (Mo) and copper (Cu) were low, which might be due to low organic matter and soil types of the study area. It could also be observed that micronutrients varied from moderately - high in the study area. This might be due to heterogeneous farming practise, such as fertilizer application carried out by farmers and soil types of the study area. In conclusion, cultivation of arable crops in the study area need to be accompanied with the addition of organic matter, mineral fertilizer and proper soil management practices.

5. RECOMMENDATIONS

1. Addition of organic matter, liming and proper soil management practices should be adopted
2. Status of soil micronutrients should be checked from time to time to know their availability and content in the soil.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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