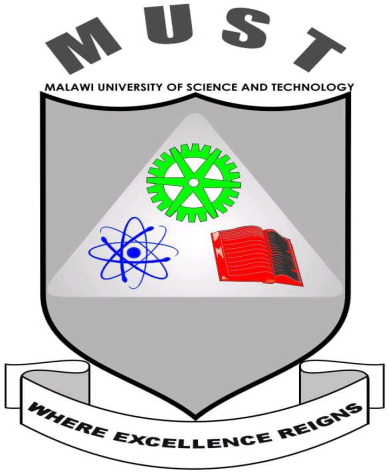
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GEOCHEMICAL AND PHYSICAL CHARACTERISTICS ANALYSIS OF SOILS AROUND NDATA AREA IN THYOLO DISTRICT

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ESC-026-17

Thyolo, Malawi

DISSERTATION SUBMITTED TO NDATA SCHOOL OF CLIMATE AND EARTH SCIENCES OF THE MALAWI UNIVERSITY OF SCIENCE AND TECHNOLOGY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF SCIENCE DEGREE IN EARTH SCIENCES

JULY, 2021

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ABSTRACT

Thyolo, is an area in southern Malawi where there is presence of different types of soil that have different soil chemical properties and physical properties. Particularly the area of interest is Ndata area found in Mmina Village where the main aim was to analyze the different types of soil and with their physical and chemical properties. The study was conducted using both non-random and random sampling technique of collecting data where nonrandom there was a use of grid sampling and random mainly it used zone sampling of data collection. The physical properties that were analyzed were soil texture that identified the main type of soil as sandy loam soil, soil porosity that identified that Ndata has low porosity and not necessary for agriculture until it is tilled but it is suitable for construction the same applied for index property the water content soil color where it identified that the soil had moderate organic matter present. Lastly the chemical properties that were done were soil pH in which it identified the pH as a neutral suitable for agriculture and the other one was the elemental composition analysis of macro elements Nitrogen ,Phosphorus and Pottasium where they are present in necessary amount hence less application of fertilizer.

ACKNOWLEDGEMENTS

Firstly, I would like to thank the Malawi University of Science and Technology through the Ndata School of Climate and Earth sciences for funding this research study. I also thank my supervisor Mr Mzee Wandembo Nyirongo and all supervisory committee for directing me the best approach to do this study.

ACRONYMS/ABBREVIATIONS

GPS: Geologic Positioning System

XRF: X-ray fluorescence

N: Nitrogen

P: Phosphorus

K: Potassium

pH; Power of Hydrogen

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GEOCHEMICAL AND PHYSICAL CHARACTERISTICS ANALYSIS OF SOILS AROUND NDATA AREA IN THYOLO

1. CHAPTER 1: INTRODUCTION

1.1 Background

Soil is the unconsolidated part that is found on the earth's surface. Soil serves many vital functions in the ecosystem and it is a fundamental resource for the human survival and development (Donahue, Shickluna, & Roberston, 1977). In general soil contains 40-45% inorganic matter, 5% organic matter and 25% water and 25% air. Therefore it is critical to protect it from pollution and ensure its sustainability in context to the geochemical and its physical properties. In recent years soil pollution has been accepted as an important environmental issue in developed and developing countries mainly because the changing of land uses patterns. The study area to be concentrated upon is found in southern Malawi specifically at Ndata area in Thyolo ,the climate of Thyolo is dry with savanna type of vegetation generally the terrain of the area is sloppy surrounded by mountains and river /streams (Habgood, Holt, & Walshaw, 1973) . Mostly the soil is loam clay and some parts are rocky. The study will concentrate on the physical properties and chemical properties with reference to their elemental composition in order to show their impact to the environment or the ecosystem. Soil sampling and testing can be highly informative because samples will be drawn from the actual ground therefore it can give a clear picture of the ground parameters.

1.2 Problem statement

A variety of factors can cause changes in geochemical and physical properties of soil. Among these are unsuitable cropping patterns, deforestation, agricultural expansion taking place at the area due to population growth, uncontrolled drainage, lack of adequate knowledge, wrong land management decisions, very poor construction hence these need to be addressed (Muche, Kokeb, & Molla, 2015). There is a lack of information on geochemical and physical properties of soil that need to be addressed hence this research will provide the information towards Ndata area on Thyolo Mmina

village. Ndata area is economically developing hence knowing the soil type it will help on what farming

1.3 Main Objective

To assess in detail the chemical and physical properties of soils around Ndata area in Thyolo district.

1.3.1 Specific Objectives

- To identify geochemical and physical properties of soil.
- To classify the main types of soils available in the area.
- To explore Ndata area if it is suitable for construction (soil index property i.e. cohesion in relation to its parameter water content and porosity).

1.4 Research Questions

- What are important geochemical and physical properties of soil around the Ndata area?
- How can the soil types lead to a sustainable development of the area?

1.5 Significance of the study

This study will help to identify the main soil type of Ndata that would recommend to increase farm production (fertilizer recommendations), it will also help to give an updated information on geochemical and physical properties of soil around Ndata area and the surrounding areas. Lastly it will give recommendation if Ndata area is suitable for construction by the study of some specific soil index properties that is to enable an adequate and economical design to be made.

2 CHAPTER 2: LITERATURE REVIEW

Soil is the complex loose material which is available over part of the earth, which mostly results in the formation of a rock (Bhaskar, Basha, & Andavan, 2018). It is the dynamic link between the biosphere and lithosphere. A study conducted in the Sabal area in East Malaysia, to evaluate the physical and geochemical properties of sandy-textured soils under smallholder agricultural land uses this showed that the sandy soils are not effective for any crop cultivation purposes unless on a soil profile

below the sand soils that is in this case they are the top soil overly the fertile soils which are suitable fo

Soil structure is another property too that needs to be taken into consideration. Individual particles of sand, silt, and clay tend to become clustered into units of various shapes. This clustered unit is referred to as soil structure, which is defined as the arrangement of soil particles. The resulting structural units are called aggregates or peds (Conklin, 2014). Soil structure creates a range of different-sized pores. Without structure, fine-textured soils would be one massive chunk (with mostly smaller diameter pores) or like loose beach sand (with mostly large diameter pores). Good soil structure means a large volume of pores as well. Good structure allows the soil to retain adequate water as well as drains excess water; promotes ease of seedling emergence, root penetration, and tuber growth, air movement, and erosion control. Structural arrangements result from biological, chemical, and physical forces that cause the soil particles to bond with each other. Clay and humus because of their small size, high surface area, and electrical charges serve as cementing agents in the bonding of particles within the aggregates. Microorganisms in the soil also play an important role in producing sticky substances that help cement particles together. Oxides of iron and several cations in salts help the bonding process. (Wang, Jidong, Zhang, Dong, & Zhang, 2019)

Physical forces also play a significant role in bringing particles closer together to form aggregates; among these forces are shrinking and swelling from wetting and drying, freezing and thawing, and the actions of expanding roots and of earthworms and other soil organisms. A sandy-textured soil does not have enough cementing agents to hold the soil together as aggregates. As a result these soils are like a sandy beach and are considered “structureless” or “single grained” (Eash, Sauer, O'Del, & Odoi, 2016). As structure is formed, pores are created within and between aggregates. The spaces within the aggregate (between individual soil particles) are small pores or micropores, and those between the aggregates are large pores or macropores. The larger pores allow water and air to move through the profile, while the small pores act as a sponge and retain water for use by plants. Soil structural units are classified according to shape and size. Soil porosity and density are considered too in soil property. The volume occupied by pores in soil is called porosity. As the parent material of soil becomes

weathered, loosened, and mixed by a variety of forces, pore space develops, providing a place for air

Density indicates the looseness or tightness of a soil. Density of soil, called bulk density, includes both the solid particles and the pore spaces among them. If a soil is compacted, the amount of pore space is reduced and the weight of a given volume of soil is increased. The measure of density is a comparison to water, which has a density of 1 g/cm^3. The mineral grains in the soil have a density of about 2.6 g/cm^3. The total volume of the soil is around 40– 60% pore space, so by using a mean value of 50% for porosity, bulk density would be 1.3 g/cm^3. This is one-half the density of the minerals in solid rock. Density can be expressed in the imperial system, such as pounds per cubic foot, but it is customary to express density in metric units. Soil temperature all plants need sunlight to grow. Light from the sun supplies the energy needed for photosynthesis and also warms the soil and air in which crops grow. Soil temperature affects almost every physical, chemical, and biological activity that occurs in the soil. Management decisions, such as when to plant, are often based on soil temperature. Knowledge of the flow of energy in the soil plant atmosphere system helps to understand how plants respond to climate conditions. Soil consistency also matters in soil properties. A description of soil consistence gives an indication of how soil will react to mechanical manipulation at various moisture contents (Lal & Shukla, 2004).

Lastly on physical property of soil that is taken into consideration is the soil color. The color changes reflect, for the most part, differences in the quantity of humus and the chemical form of the iron present. It is true, however, that the pigmentation of a given amount of humus is usually darker in grassland regions than in forested regions, particularly in warm areas.. In some cases, color is an indicator of iron, humus, carbonates, and/or sulfates. Varying shades of red, yellow, and gray in soils are usually due to the concentration and form of iron present. Red means that the iron is oxidized and not hydrated. Yellow indicates hydration and sometimes less oxidation. Gray indicates chemical reduction caused by wetness and lack of oxygen. An exception to this is the gray E horizon just below the surface of some well-drained soils. Gray colors in the subsoil or a combination of gray and blotches of yellow and red mottles are extremely important for interpreting the natural drainage condition of the soil. Mottles are found at a depth to which excess water accumulates due to lack of drainage or if the

water table rises periodically during the warm seasons. Even when the water table drops, telltale signs

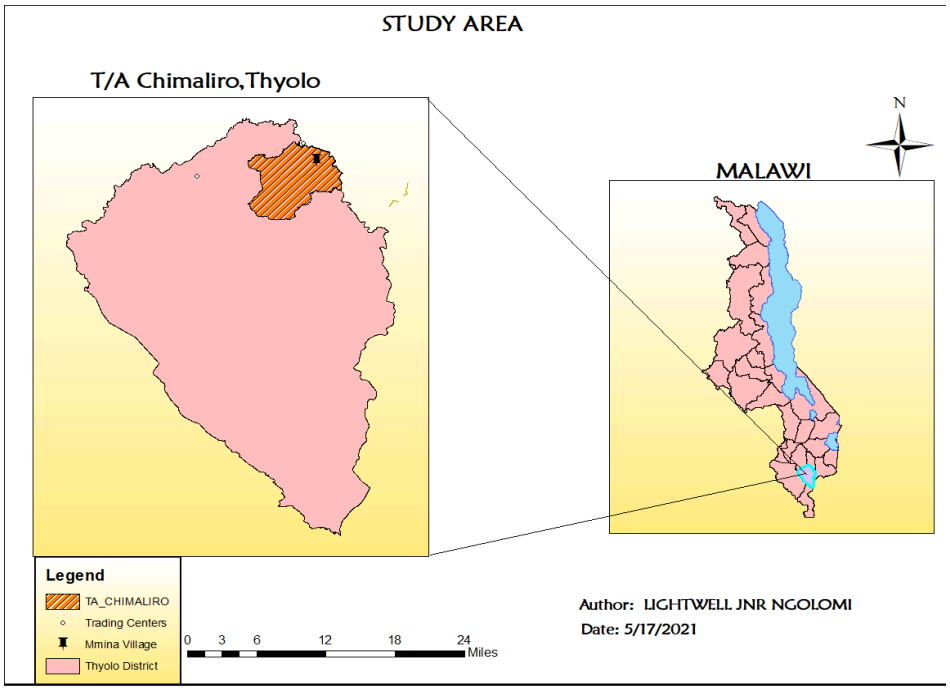
Now the chemical properties the first one to be considered are the chemical elements of soil. At least 17 elements, called plant nutrients, are essential for plant growth. And these are divided into three groups. The first group includes three elements —carbon, hydrogen, and oxygen—that are the basic building blocks of all plant compounds. These three are needed in much larger quantities than all others combined. The initial product of photosynthesis is the simple sugar $C_6H_{12}O_6$. The carbon and oxygen come from carbon dioxide, and the hydrogen comes from water respectively. The oxygen in the water is given off by plants and goes back into the atmosphere. This process assures us of a continuing source of oxygen. The second group of essential elements, called macronutrients, consists of nitrogen, phosphorus, potassium, sulfur, calcium, and magnesium. They are classified as macronutrients because they are used in relatively large quantities by plants. Another group of eight elements is called micronutrients because they are normally used in smaller quantities. This group includes iron, zinc, manganese, copper, boron, molybdenum, nickel, and chlorine (Lal & Shukla, 2004).

The second chemical property is the soil pH. Degree of acidity or alkalinity influences soil behavior physically, chemically, and biologically. To stabilize soil, engineers sometimes add hydrated lime to it, which raises the pH into the alkaline range (Eash, Sauer, O'Del, & Odoi, 2016).

3 CHAPTER 3: METHODOLOGY

3.1 Study Area

Below is the study area for Ndata area in Thyolo:


STUDY AREA
T/A Chimaliro,Thyolo
N
MALAWI
Legend
TA_CHIMALIRO
Trading Centers
Mmina Village
Thyolo District
0 3 6 12 18 24
Miles
Author: LIGHTWELL JNR NGOLOMI
Date: 5/17/2021

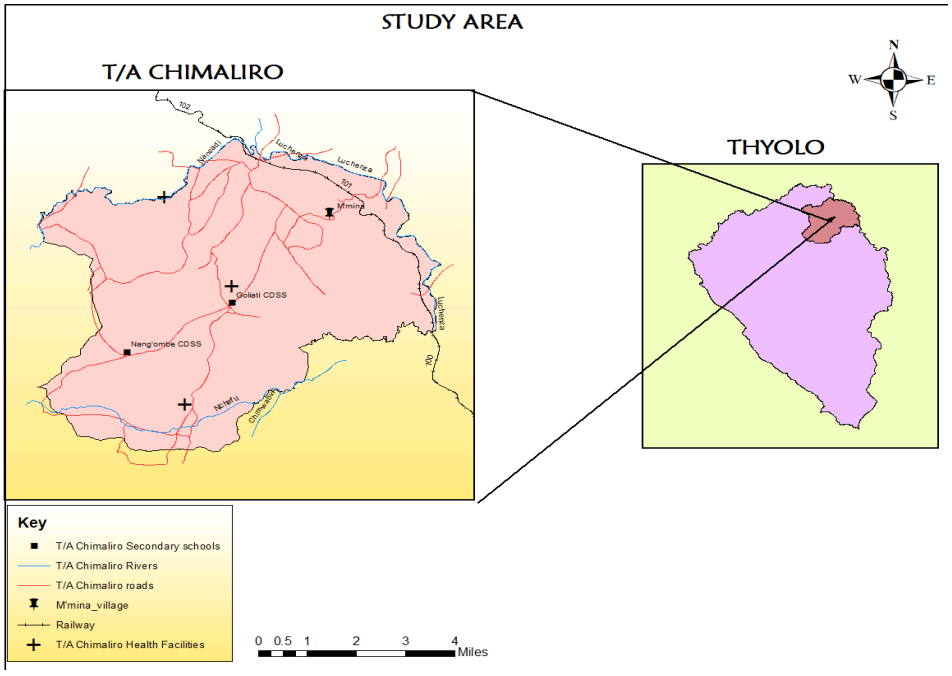

STUDY AREA
T/A CHIMALIRO
N
W
E
S
THYOLO
Goliati CDSS
Nang'ombe CDSS
Key
T/A Chimaliro Secondary schools
T/A Chimaliro Rivers
T/A Chimaliro roads
M'mina_village
Railway
T/A Chimaliro Health Facilities
0 0.5 1 2 3 4
Miles

Figure 1 map of Thyolo, source: Arc GIS Software

3.2 Location of study

The Thyolo area occupies approximately 2600 km^2 of the southern region of Malawi and it is bounded by Latitude: -16° 03' 60.00" S and Longitude: 35° 07' 60.00" E (Hadgood, Holt, & Walshaw, 1973).

3.3 Climate

In Thyolo, the wet season is muggy and mostly cloudy, the dry season is mostly clear, and it is warm year round. Over the course of the year, the temperature typically varies from *58°F* to *86°F* and is rarely below *55°F* or above *94°F*. The rainy period of the year lasts for 7.2 months, from October 3 to May 9, with a sliding 31-day rainfall of at least 0.0127m. The most rain falls during the 31 days centered on January 20, with an average total accumulation of 0.25m. The rainless period of the year lasts for 4.8 months, from May 9 to October 3. The least rain falls around August 31, with an average total accumulation of 0.00508m (Habgood, Holt, & Walshaw, 1973).

3.5 Geology

High grade, predominantly magmatic gneisses and granulites assigned to the Malawi basement complex underlie greater part of the area and form part of the extensive Precambrian to lower Paleozoic Mozambique belt. The basement complex has undergone regional metamorphism under amphibolite to granualite facies conditions. Superficial deposits of various types mask the metamorphic and igneous rocks particularly in the northeast of the area .Alluvial and colluvial deposits underlie the Shire valley plain. No concentrations of minerals of economic importance have been recorded although certain ultramafic bodies yield high base metal values and a small zone of copper mineralization has been reported at Ngala hill. (Hadgood, Holt, & Walshaw, 1973)

3.4 Topography

The Thyolo area is one of diverse relief. Elevations range from 53m above sea level to 1462m a

The Thyolo Highlands represent a mid-Tertiary erosion surface, slightly tilted away from the Rift Valley escarpment and falling gradually to approximately 610m to the southeast of Luchenza. The surface, however, is not uniform and there are significant variations in relief. Only in the extreme northeast does the surface approach that of a plateau characterized by only slight dissection. In that area it is mantled by widespread and generally thick residual soils. The Thyolo fault scarp zone dominates the eastern side of the Shire Valley and defines the faulted and dissected southwestern margin of the Thyolo Highlands surface. It comprises a number of discontinuous topographic steps that reflect a complex history of post-Stormberg rift faulting. Faulted spurs at the base of the escarpment rise sharply from the adjacent plain and possibly indicate Pleistocene movement along the Thyolo fault. The fault scarp zone as a whole remains one of instability and minor tremors are still experienced periodically'. The Shire Valley plain is relatively flat and featureless and lies between 53m and 91m above sea level (Hadgood, Holt, & Walshaw, 1973).

3.2 Research design

This study analyzed the geochemical properties (pH, elemental composition) and physical properties of soil (texture, porosity, and color), main types of soils including the index property (i.e. cohesion) and the corresponding parameter (porosity and water content). The samples were collected using both random and non-random sampling method. On non-random sampling grid sampling technique (mobile application was used to locate the samples) while on random sampling zone sampling technique was used. Samples were analyzed in laboratory while some samples were analyzed at the field. Geostatistical analysis of the collected data was used too.

3.3 Data collection tools

The following are the data materials that were used for the data collection:

- A soil probe

- A clean plastic bucket
- Permanent markers
- Sample bags
- Auger
- pH tester
- X-ray Fluorescence
- Soil sampler (mobile application)
- Arc Gis (kirging,variogram)
- Deluxe water and soil analysis kit (model 1024-G)

3.4 Sampling method

First a reconnaissance of the field was done to find different soil patterns to relate on how many samples will be collected on that area due to differences in the geo-chemical and physical appearances of the soil then samples were collected using Auger/probes. Zone sampling was used to collect the samples since it divides the area into zones according to their structure that is how the outcrop looks in a case of Ndata area it was divided due to differences in elevation, crop characteristics and crop yield history over the area (Carter & Gregorich, 2008; Mallarino & Wittry, 2001) variability in soil properties was expected over the areas that were prospected and explored.

Then the other soil samples were collected using the non-random grid sampling method by the auger. According to (Carter & Gregorich, 2008) grid sampling is whereby samples are taken in a grid system there was a uniform pattern for collecting samples in a case to the study area for every 9.144m a sample was collected on a 1 acre surface area on a depth of 0.15 m using the probe/auger the mobile application of soil sampler was used for this grid sampling in a way that it divided the area into the necessary grids for collection of the samples. The grid sampling was used because it provides the accurate spatial information over the whole field of soil sampling (Ackerson, 2018). The samples that were collected were then sealed in a container to reduce contamination and prevent water loss and were taken to the laboratory for analysis and some properties were analyzed on the field that is their physical properties.

Geostatistics assume that the value of soil property at any given location is function of the value

3.5 Data collection

The properties that were analyzed on the soil specifically in terms of physical properties are:

a) Soil texture the property was corrected randomly on different fields around Ndata area, to find the average texture of soil the sampling method of feel was used; soil samples were drilled at a depth of 15cm using hand auger. (the point coordinates of the samples were (1) S 15˚54.244' E 035˚13.204' (2) S 15˚54.129' E 035˚13.202' (3) S 15˚53.975' E 035˚13.092' (4) S 15˚54.010' E 035˚12.841' (5) S 15˚54.501' E 035˚12.934') namely Ndata 1, Ndata 2, Ndata 3, Ndata 4 ,Ndata 5 respectively. An approximate of 25 grams of soil was placed in the palm of the hand. Then water drops were added while kneading the soil to break aggregates. Water was not added when the soil was moldable. Thereafter the soil was shaped into a ball by squeezing it until a ball like form was made. Lastly the ball of soil was held soil between thumb and forefingers, pushing and squeezing upward to form the ball into a ribbon. The length of the ribbon formed then it was measured using a ruler. (Mcdonald, Isbell, Speight, Walker, & Hopkins, 1998)



Figure 1. 1 shows location of samples at Ndata area source Google Map

Sample Name	Length(mm)
Ndata 1	
Ndata 2	
Ndata 3	
Ndata 4	
Ndata 5	

Average	

Table 2.1 Indicates the name of the point coordinate with length of bolus formed

For the ex-situ analysis of soil texture, samples were taken to laboratory where a sieve method of the soils was used:

The randomly collected samples were left to dry on a direct sunlight for 5 hours , later they were then taken to laboratory. To conduct the sieve analysis first beaker used for filing in the samples was weighed on a balance 58.7g, the mass of the beaker was then recorded then the dry sample number 1 was filled in the beaker again the combination of the two was weighed on balance recording the mass, to find the mass of the dry sample the mass of the combination of the beaker and dry sample was subtracted from the beaker thereby knowing the mass.

The sieve numbers were then assembled in ascending order from bottom (0.002mm) to top on a stack (2 mm) the soil sample was then poured on top of the sieves then the sieve machine was turned on at a vibration number of 4 for 5 minutes, one by one the sieve was removed from the stack pouring the soil sample in a beaker recording the mass to obtain the mass of dry sample the initial mass of the beaker was subtracted from the mass of the beaker plus dry sample from the sieve.

Quantity passing on each sieve was found by:

Percent of mass returned was found by:

The procedure was repeated for the rest of the remaining sieves from the stack including the remaining 4 dry samples using the table below:

Diameter number	Mass of empty beaker	Mass of beaker + soil	Soil retained	Percent returned	Percent passing

(mm)		retained			
2					
1					
0.850					
0.425					
0.250					
0.106					
0.002					
< 0.002					
Total weight					

Table 1.2 shows the sieve analysis

b) The next property to analyze was soil porosity. Soil was drilled from the ground using an auger at a 15cm depth randomly around Ndata. Then the samples collected from the site through sampling bags were taken to the laboratory. First mass of a beaker was recorded on a balance (57g) then soil samples were transferred into the graduated beaker,(for accuracy a 70g constant mass of different soil samples were weighed on the balance from different point coordinates), then a 100ml of water was measured in a cylinder (for each soil sample on a different coordinate). Then water was poured into the graduated beaker until the soil was saturated. . Lastly the volume of water used from the cylinder was subtracted to that of initial water from the graduated cylinder (Kaliakin, 2017). The Volume of water used is equal to the Pore volume (V_p)

Total volume was founded by adding $V_{s.} + V_P$

Location	Ndata 1	Ndata 2	Ndata 3	Ndata 4	Ndata 5
Volume of Water (V_1)					
Volume of remaining water					

after pouring water(V_2)					
Volume of Water used (V_1-V_2)					
Porosity=					

Table 1.3 shows soil porosity

(c) Soil temperature too was be measured at a middle of the day at different sample point using a temperature probe whereby several points at a depth of 15 cm with a random sampling technique of zone sampling at different locations. This was done because the temperature of the soil is important but often overlooked variable, affecting root growth, water and nutrient uptake, root metabolism, microbial activity, decomposition of organic matter, soil chemistry, and soil moisture levels. Each type of crop plant responds differently to soil temperature, depending on its range of tolerance of soil temperatures and its temperature optimum hence affecting too the geochemical and physical properties of soil (Lal & Shukla, 2004). Below were the measured soil sample temperatures.

Table 1. 4 shows location and corresponding temperature

Location	Temperature in degrees
Ndata 1	
Ndata 2	
Ndata 3	
Ndata 4	
Ndata 5	

For the non-random sampling below is the table

d) Soil color too was observed this was done using an auger which collected samples at 15cm depth from the surface. Color of the subsoil gave a strong indication of soil organic matter. (Eash, Sauer, O'Del, & Odoi, 2016)

e) Soil pH. 18 Samples extracted from different coordinates their unique id name were calle

The pH collected data through kirging method was analyzed using the Arc GIs software where interpolation was done through it. Each sample was used to find out if the soil in acidic, neutral or alkaline whereby the samples were taken to laboratory using the samples bags deluxe water and soil analysis kit.

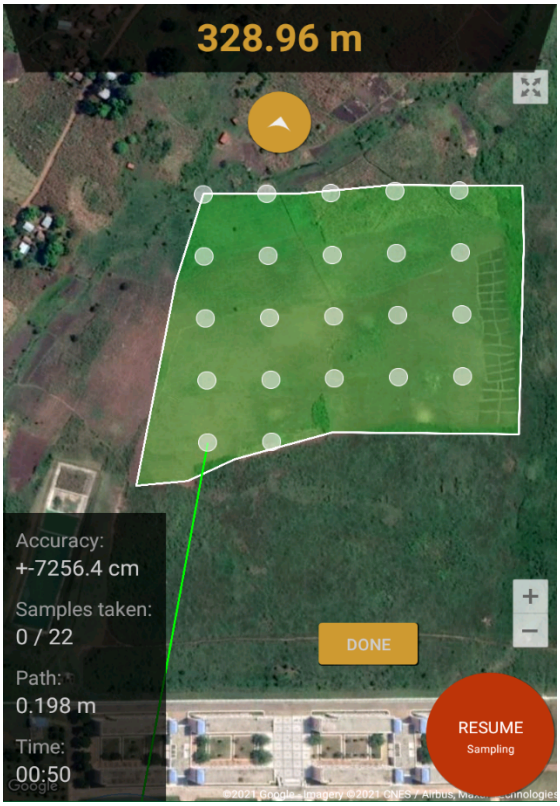


Figure 1.2 Shows soil Sampler application for data Collection

f) Soil elemental composition (macro elements i.e. nitrogen, potassium and

phosphorus) X-ray fluorescence was used to find the exact elemental composition of the soil.

Concentration of major elements in %			
	N	P	K
Ndata 1			
Ndata 2			
Ndata 3			
Ndata 4			
Ndata 5			

g) The index property that was analyzed was the cohesion property in relation to its parameter which was water content. The undisturbed soil sample was the one taken in laboratory where it was crumbled and placed into a container recording the mass (initial weight of beaker already recorded) thereafter the soil sample was placed on a piece of paper scattering it then it was heated for 45 minutes under a temperature of 180 degrees to remove the moisture then the dry samples were transferred into the beaker again it was recording the mass on the beam balance. (Mathur, Kuma, Pandey, & Choudhary, 2017). The table below shows the calculation of water content

Table 1.5 water content

	Weight in grams
Weight of container (W_1)	
Weight of the container + moisture(W_2)	
Weight of the container + dry soils(W_3)	
Weight of moisture($W_2 - W_3$)	
Weight of dry soils ($W_3 - W_1$)	
Water content =	

The results presented verify the generally known relation, which says that an increase in soil' moisture content causes a decrease in its shear strength values,

additionally the range of change is also related to shear velocity (ZydroĚ & Dąbrowska , 2012).

3.6 Data Analysis

a) Below shows the collected results for the field length of the bolus formed after the addition of water to the soil.

Table 1.6 shows the location and the indicated length

Sample Name	Length(mm)
Ndata 1	22.1
Ndata 2	16.5
Ndata 3	17.4
Ndata 4	18.5
Ndata 5	22.8
Average	16.2

For the cohesion and legitimacy of the data that is the reason why the ex-situ analysis of data in the laboratory with the sieve analysis for texture:

Calculations for Sieve analysis method

Soil retained =weight of beaker- (mass of beaker +soil returned from sieve)

First Percent passing = 100%- percent returned

Percent passing = percent from previous sieve –current percent retained

Sample number 1 (Ndata 1)

Total mass combined beaker and soil sample: 178.1g

Total Weight of soil = 178.1-58.7 =119.7g

Table 1.7.1 shows calculated soil texture for sample number 1 (Ndata 1)

Diameter number (mm)	Mass of empty beaker	Mass of beaker + soil returned	Soil retained	Percent returned %	Percent passing %

		from sieve			
2	58.7	66.9	8.2	6.9	93.1
1	58.7	68.1	9.4	7.9	85.2
0.850	58.7	61.4	2.7	2.3	82.9
0.425	58.7	73.6	14.9	12.4	70.9
0.250	58.7	80.5	21.8	18.2	52.3
0.106	58.7	89.5	30.8	25.7	26.6
0.002	58.7	77.1	18.4	15.4	11.2
< 0.002	58.7	68.7	10	8.3	2.9
Total			116.2	97.1	2.9

Sample number 2(Ndata 2)

Total mass combined beaker and soil sample: 189.1g

Total weight of soil =189.1-58.7 = 130.4 g

Diameter number	Mass of empty beaker(g)	Mass of beaker +soil retained from sieve (g)	Soil retained	Percent returned	Percent passing
2	58.7	61.9	3.2	2.5	97.5
1	58.7	68.4	9.7	7.4	90.1
0.850	58.7	61.5	2.8	2.1	88
0.425	58.7	79.5	20.8	15.9	72.1
0.250	58.7	84.7	26	19.9	52.2
0.106	58.7	88.9	30.2	23.2	29
0.002	58.7	75.7	22	16.9	12.1
<0.002	58.7	68.9	10.2	7.8	4.3
Total			124.9	95.7	4.3

Table 1.7.2 calculated soil texture for Sample number 2 (Ndata 2)

Sample number 3 (Ndata 3)

Total mass combined beaker and soil sample: 186g

Total weight of soil = 186g-58.7=127.3

Diameter number	Mass of empty beaker(g)	Mass of beaker + soil retained from sieve (g)	Soil retained	Percent returned	Percent passing
2	58.7	62.8	4.1	3.2	96.8
1	58.7	64.8	6.1	4.8	92
0.850	58.7	61.1	2.4	1.9	90.1
0.425	58.7	73.6	14.9	11.7	78.4
0.250	58.7	80.1	21.4	16.8	61.6
0.106	58.7	101.1	42.4	33.3	28.3
0.002	58.7	78.9	20.2	15.7	12.6
< 0.002	58.7	73	14.3	11.2	1.4
Total			125.8g	98.8	1.4

Table 1.7.3 calculated texture of sample number 3 (Ndata 3)

Sample number 4 (Ndata 4)

Total mass combined beaker and soil sample: 193g

Total weight of soil = 193g -58.7 =134.3 g

Diameter number	Mass of empty beaker (g)	Mass of beaker +soil retained from sieve (g)	Soil retained	Percent returned	Percent passing
2	58.7	62.9	4.2	3.1	96.9

1	58.7	69.5	10.8	8.04	88.86
0.850	58.7	62.4	3.7	2.8	86.1
0.425	58.7	78.5	19.8	14.7	71.4
0.250	58.7	80.6	21.9	16.3	55.1
0.106	58.7	101.2	42.5	31.6	23.5
0.002	58.7	73.8	15.1	11.2	12.3
< 0.002	58.7	71.8	13.1	9.8	2.5
Total weight			131.1	97.6	2.5

Table 1.7.4 calculated texture for sample number 4 (Ndata 4)

Sample number 5 (Ndata 5)

Total mass combined beaker and soil sample: 177.4g

Total weight of soil = 177.4g -58.7g =118.7 g

Diameter number	**Mass of empty beaker (g)**	**Mass of beaker +soil retained from sieve(g)**	**Soil retained**	**Percent returned**	**Percent passing**
2	58.7	67	8.3	6.9	93.1
1	58.7	71	12.3	10.4	82.7
0.850	58.7	62.1	3.4	2.9	79.8
0.425	58.7	85.6	26.9	22.7	57.1
0.250	58.7	86.3	27.6	23.3	33.8
0.106	58.7	77.2	18.5	15.6	18,2
0.002	58.7	73.8	15.1	12.7	5.5
< 0.002	58.7	62.8	4.1	3.5	2
Total weight			116.2	97.9	2

Table 1.7.5 calculated texture for sample number 5 (Ndata 5)

b) Soil porosity ,below is the soil porosity analysis table :

Location	Ndata 1	Ndata 2	Ndata 3	Ndata 4	Ndata 5

Volume of Water (V_1)	150ml	150ml	150ml	150ml	150ml
Volume of remaining water after pouring water(V_2)	122ml	126ml	120ml	128ml	130ml
Volume of Water used (V_1-V_2)	28ml	24ml	30ml	23ml	20ml
Porosity=	18.667%	16%	20%	15.33%	13.3%

Table 1.8 calculated porosity of the coordinated samples

c) Soil temperature

Location	Temperature in degrees
Ndata 1	29.1
Ndata 2	30.1
Ndata 3	28.6
Ndata 4	28.5
Ndata 5	29.5

Table 1.9 expresses soil temperature of the coordinates

d) Soil Color



Figure 3.1 shows the soil color

e) Soil pH

Table 3.5 Shows soil pH and the Location

Name	pH
Mmina 1	6.28
Mmina 2	5.38
Mmina 3	5.23
Mmina 4	5.78
Mmina 5	6.70
Mmina 6	5.19
Mmina 7	5.25
Mmina 8	6.35
Mmina 9	8.53
Mmina 10	5.32

Mmina 11	5.6
Mmina12	6.1
Mmina 13	5.6
Mmina 14	6.78
Mmina 15	6.1
Mmina 16	5.22
Mmina 17	7.3
Average	6.04

Table 1.10 shows the soil pH

f) Elemental composition

The composition of Nitrogen, potassium and phosphorus from the randomly corrected samples.

	Concentration of major elements in %		
	N	P	K
Ndata 1	0.10	2.90	5.22
Ndata 2	0.13	3.06	6.24
Ndata 3	0.08	4.67	1.93
Ndata 4	0.20	2.10	8.2
Ndata 5	0.07	4.3	1.90

Table 1.11 expresses the collected macronutrients

g) Water content

	Weight in grams
Weight of container (W_1)	57.094
Weight of the container + moisture(W_2)	164.449
Weight of the container + dry soils(W_3)	147.684
Weight of moisture($W_2 - W_3$)	16.765
Weight of dry soils ($W_3 - W_1$)	90.59
Water content =	

	=18.51%

Table 1.12 water content

4.0 CHAPTER 4: RESULTS AND DISCUSSIONS

a) Soil texture refers to the prominent size range of mineral particles, and is defined both qualitatively and quantitatively. Qualitatively, it refers to the feel of soil whether coarse and gritty or fine and smooth when rubbed between thumb and forefinger. Quantitatively, soil texture is the relative proportion of sand, silt and clay content on weight basis. The term soil texture is often used interchangeably with mechanical composition of soil. It is more or less a static property affecting almost all other soil properties. Land use capability and soil management practices largely depend on the texture.

b) The soil texture on the field was analyzed using the comparison to the standards below shows the length of sample and its sample name (modified from(Ritchey,McGrath,&Gehring,2015)).

Field texture Grade	**Behavior of moist Bolus**	**Ribbon Length**	**Approximate Clay content (%)**
Sand	Coherence to nil to very Slightly , cannot be moulded : single Sand grains adhere to fingers	Nil	<10% (Often <5 %)
Loamy Sand	Slightly coherence	≈5mm	5 -10 %
Clayey sand	Slight coherence, sticky when wet: many sand grains stick to fingers ,clay stains the hand	5 -15 mm	5-10 %
Sandy loam	Bolus just coherent but very sandy to touch ;dominant sand grains are medium size and are easily visible	15 -25 mm	10 -20 %
Loam	Bolus coherent and rather spongy ;smoth feel when	≈25	≈%

	manipulated , no obvious sandiness or silkiness ; may be greasy to touch, if much		
Silty loam	Coherent bolus; Very Smooth to silky when manipulated	≈25 mm	≈25 (with silt)
Sand Clay Loam	Strongly Coherent bolus , sandy to touch ,medium size sand grains visible in finer matter	25 -40 mm	≥25 %
Clay Loam	Coherent Plastic bolus ,Smooth to manipulate	40 -50 mm	20 – 30 %
Clay Loam Sandy	Coherent plastic bolus , medium size sand grains visible in finer matrix	40 – 50 mm	30 -35 %
Silty Clay Loam	Coherent smooth bolus ; plastic and often silky to the touch	40 -50 mm	30 – 35% (with silt)
Sandy clay	Plastic bolus ,fine to medium san grains can be seen , felt or heard in clayey matrix	50 -75 mm	35 -40 %
Light Clay	Plastic bolus ; smooth to touch	50 -75 mm (slight resistance to shear)	35 – 40 %
Light medium Clay	Plastic bolus ; smooth to touch	≈75 mm (slight – mod resistance to shear)	40 -45 %
Medium Clay	Smooth plastic bolus ; handles like pasticine ;can be moulded into rods without fracture	≥75 mm (slight – mod resistance to shear)	45 -55 %
Heavy Clay	Smooth plastic bolus ;handles like stiff plasticine ; can be moulded into rods without fracture	≥75 mm (firm resistance to ribbon shear)	≥ 50 %

Table 2.1 shows the length of bolus formed and soil type

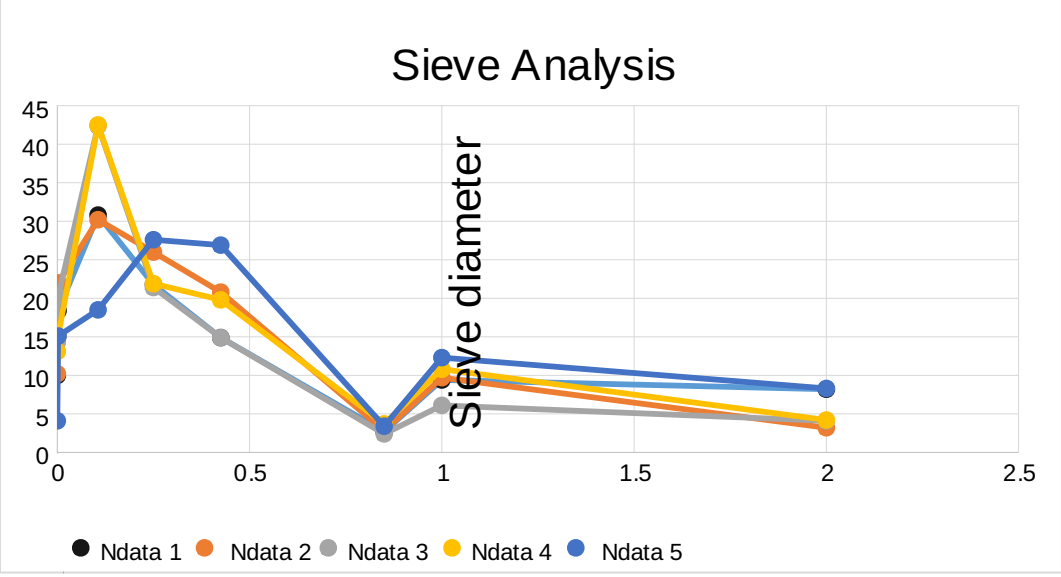
Sand grains were visible and felt with a strong coherent bolus and the length mean of the bolus

The presented above data of the 5 samples shows the weight of the soil that that was retained.

Below shows the average of the soil retained

Diameter number	Soil retained (Ndata 1)	Soil retained (Ndata 2)	Soil retained (Ndata 3)	Soil retained (Ndata 4)	Soil retained (Ndata 5)	Average of soil returned
2	8.2	3.2	4.1	4.2	8.3	5.6
1	9.4	9.7	6.1	10.8	12.3	9.66
0.85	2.7	2.8	2.4	3.7	3.4	3
0.425	14.9	20.8	14.9	19.8	26.9	19.46
0.25	21.8	26	21.4	21.9	27.6	23.74
0.106	30.8	30.2	42.4	42.5	18.5	32.88
0.002	18.4	22	20.2	15.1	15.1	18.16
< 0.002	10	10.2	14.3	13.1	4.1	10.34

Table 2.2 shows the average soil returned per sieve diameter



Graph 1 above shows retainable soil per sieve

The sieve with its diameter represented the type of soil according to the grain size below shows the standards:

Table 2.3 below shows soil type and particle size

Soil Separate	Particle size (mm)
Clay	<0.002
Silt	0.002 to 0.05
Sand	0.05 to 2.0
Very fine sand	0.05 to 0.10
Fine sand	0.10 to 0.25
Medium sand	0.25 to 0.5
Coarse sand	0.5 to 1.0
Very Coarse sand	1.0 to 2.0

(Ritchey, McGrath, & Gehring, 2015)

The highest average of soil retained on the sieve was 32.88 diameter of 0.106mm on the whole 5 samples according to the sieve standard above it is fine sand, seconded by 0.25mm which had 23.74g of medium sand then 19.46g which had a diameter of 0.425mm silt and clay were present the average of silt was 18.16g while for clay was 10.34g

According to the sieve method the soil diameters above were used to obtain from the sieves were used to find the main soil type .A soil triangle diagram was used, expressing each size particle percentage at each one corner. The soil type was then be determined from the soil triangle. At the top, a soil would be clay; at the left corner, it would be sand, and at the right corner it would be silt. Soils in the lower middle with less than 50% clay are loams. The figure below shows the soil type of the site.

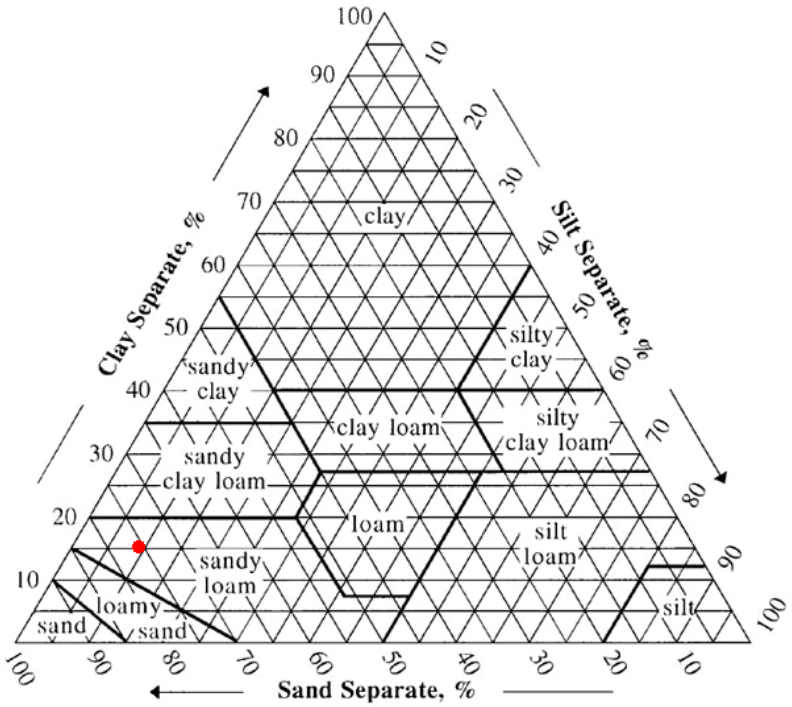


Figure 4 above shows soil triangle

The above soil triangle the red dot indicates the type of soil that was found in Ndata area which is Sandy loam soil. From agricultural point of view, loam soil is most favorable as its capacity to retain water and nutrients is better than sandy while its drainage, aeration and tillage properties are more favorable.

Limitations of the study

Some soil samples were not completely removed from the sieves when filling them into the beaker. As a result this affected the initial total weight of the

soil that was used.

c) Soil porosity

The average porosity the soil samples was found to be 16.6% which is not much effective for agricultural activities until it is tilled for farming this is so because there is compaction which resulted in a reduction in the number, size and continuity of the soil pores and also the rainfall and temperature diversity over the years due to change of climate has resulted to reduction of soil pores. Generally the macro pores were by destroyed in the formation of the sandy loam type of soil around Ndata and the drainage ability of the soil, the aeration of the soil and the ability of roots to penetrate the soil is limited . The lack of oxygen due to the same further reduces the grass roots ability to penetrate the soil. The more moist a soil the more easily it can be compacted because the water acts as a lubricant allowing the particles to move into closer arrangements (Sheard, 1991).

On constructions that sandy Loam is the best soil type for construction due to its ideal combination of silt, sand, and clay. It combines the best of all their qualities into the ideal balance for supporting a foundation. Loam generally does not shift, expand, or shrink drastically and handles the presence of water very well (Salim, Ndambuki, & Adedokun, 2014)

d) Soil temperature is one of the important factors that influence soil properties processes involved in plant growth. It governs the soil physical, chemical and biological processes. It also influences the interspheric processes of gas exchange between the atmosphere and the soil. The amount of radiation received by the soil affects soil temperature, biological processes such as seed germination, seedling emergence, plant root growth and the availability of nutrients. The temperature of the soil alters the rate of organic matter decomposition and the mineralization of different organic materials in the soil. Soil temperature also affects soil water retention, transmission and availability to plants. For the soil to be productive the range of the temperature has to be 10˚C to 30˚C as in the case of Ndata it has an average temperature of 29.16˚C that

means the temperature is favorable for agricultural activities (Onwuka, 2016).

e) Soil color, the color that was observed on site was brown color it is associated with moderate organic matter level and iron oxides. Brown soils are from decaying plant material. Soil organic matter serves as a reservoir of nutrients for crops, provides soil aggregation, increases nutrient exchange, retains moisture, reduces compaction, reduces surface crusting, and increases water infiltration into soil (PEI Analytical Laboratories, 2014)). This also concludes that the soils around Ndata area are suitable for agricultural activities because of the presence of the organic matter.

f) Soil pH

The non-random collected samples using Arc GIs then they interpolated using kirging method where unknown location of variable was known below shows the interpolated pH values.

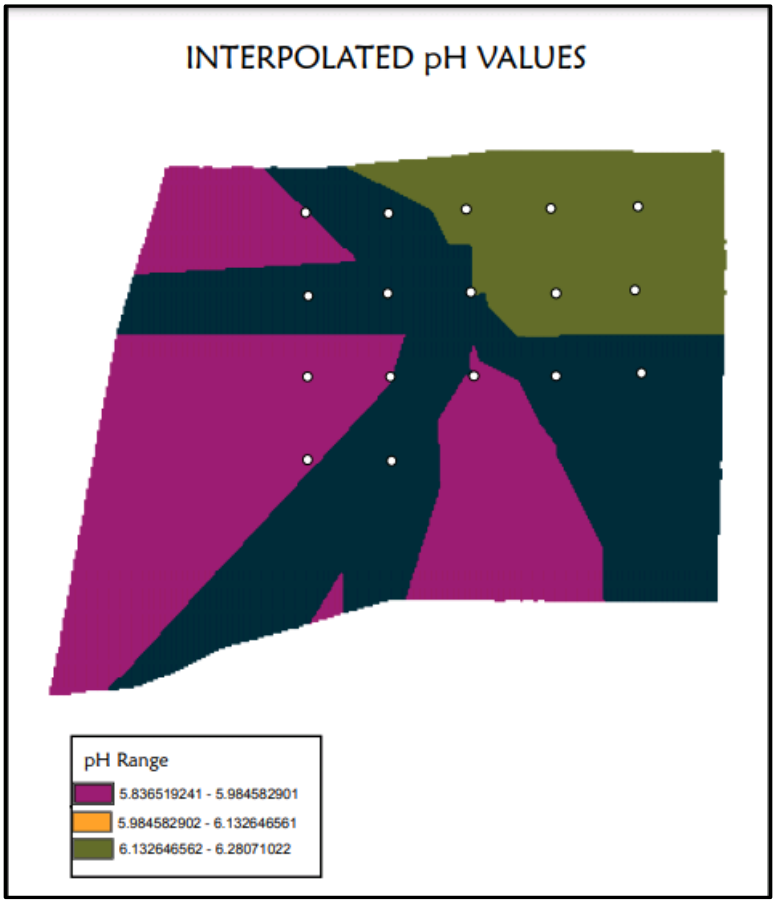
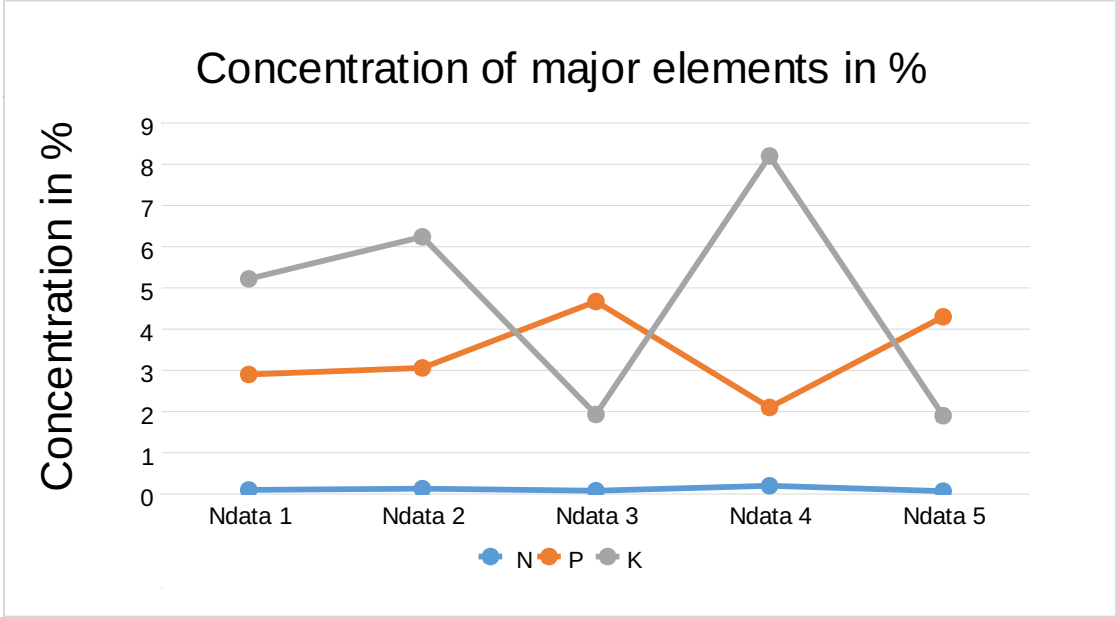


Figure 5 above shows the interpolated pH values

The pH is important because it influences the availability of essential nutrients.



Graph 2 above shows the concentration of macro nutrients on different locations

The elemental composition of soils around Ndata were

- Nitrogen that was found around Ndata is vital to plants because it is a major component of chrollophyl ,the compound by which plants use sunlight energy to produce sugars from water and carbon dioxide (i.e. photosynthesis) and it is also a major component of amino acids , the building blocks of proteins., by which it significantly increases and enhances the yield quality and its quality (Leghari, Laghari, Laghari, & Ahmed, 2016)
- Phosphorus is also vital to plant growth and it is mostly found in every living plant cell it is involved in several key plant functions including energy transfer, photosynthesis, transformation of sugars and starches, nutrient

movement around the plant and also it brings about healthy root growth. Phosphorus also p

– Potassium acts as an enzyme activation activates at least 60 different enzymes involved in plant growth K changes the physical shape of the enzyme molecule, exposing the appropriate chemical active sites for reaction, stomatal activity (Water Use) plants depend upon K to regulate the opening and closing of stomata the pores through which leaves exchange carbon dioxide (CO_2), water vapor, and oxygen (O_2) with the atmosphere, and lastly crop quality potassium plays significant roles in enhancing crop quality. (Prajapati, 2016)

The Ndata area has variable amounts of the mentioned above elements in which their percentages are worth to plant crops with less amount application of fertilizer because the natural presence of P increases (which has the average percent of 3.406) the N-fixing capacity of leguminous plants (mostly crops planted are peas ,maize and tomato) also high levels of available K improve the physical quality, disease resistance, and shelf-life of fruits and vegetables used for human consumption and the feeding value of grain and for crops.

g) On a point taken the water content was found to be 18.5% this indicates that the area is suitable for construction since the water will not affect the foundation of the buildings (Ganju, Rahman, Prezzi, Salgado, & Siddiki, 2016) while on agriculture it is not suitable since it has low water content hence needs to be heavily tilled for water to infiltrate underground and maintain the moisture. The exchange of gases is faster in tilled soils. A shallow tillage encourages CO_2 in the top soil in comparison to a deep tillage.

5.0 CONCLUSION AND RECOMMENDATIONS

The soil physical properties that were assessed around Ndata areas were

- Texture where it identified the main soil type is Sandy loam as shown on the soil triangle and by the method of feel
- Soil porosity this concluded on two aspects of agriculture and construction where

the porosity is not suitable for agriculture but worth for construction ,

- Soil temperature is suitable for agriculture where by it has negative impact on plant growth by influencing water and nutrient uptake
- Brown soil color indicate the presence of organic matter hence suitable for agriculture around Ndata area

The chemical property analyzed was

- Soil pH cannot affect agricultural processes also suitable for construction of buildings.
- Soil elemental composition the soil has variable amounts of Nitrogen , phosphorus and Potassium which are essential for plant growth and overall state of plants

Lastly the index property that analyzed was water content this indicated that the place is suitable for construction

Recommendation

There is a need to apply less amount of fertilizer per area since the soil is already fertile also irrigation is necessary to crops for survival

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