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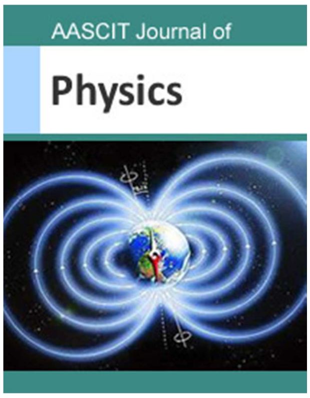

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Distribution Pattern of Element and Physicochemical Characteristics of Soils from Haji Kogi Farms in Agwan Jaba Area of Zaria, Nigeria

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Abstract

X-Ray fluorescence spectroscopy (XRF) and physicochemical test have been applied in the analysis of soil samples that were collected from the area of study. In this work, the distribution pattern and properties of the soil samples were determined. The elements determined include Al, Si, P, K, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, Ba, Rb and S. 83% elements obtained were uniformly distributed. The mean values of pH, EC and CEC were: 5.59±0.65, 0.09±0.06 and 0.09±0.06. In general, the elements (Al, Si, K, Ca, Ti, V, Cr, Fe, Ni, Cu, Zn,) were evenly distributed while the elements (P, Mn, Ba, S and Rb) were not evenly distributed and the soils were characterised by good physical and chemical properties, which supports plants survivals. The soils have a good distribution pattern and physicochemical properties; hence plant/crops will thrive.

1. Introduction

Elements in the soil are the source of plant nutrients. The distribution pattern and Physiochemical characteristic of elements in soils are of great importance to farmers, herbal medicine practitioners, and scientists, as it helps them to understand the type of inputs and the type of crop to be expected from a particular farm land, for health and in the management and treatment of diseases.

Soil has many purposes and applications. Structures are built on soil and crops are also cultivated on soil. Plants derived their nutrients from the soil, and man depends on plants for his survival. Plants grow and derived their nutrients from the soil, and man gets most of his nutrients of survival from the plants.

Soil supports food production, controls water storage and ground water recharge, and shapes the biogeochemical cycles for essential nutrients in the environment [1] Soils below the surface i.e., sub-soils are typically waterlogged having little aeration facility which reduces with depth and contain a lot of organic matter [2]. The interactions between the cycle of soil N and P with the soil carbon cycle affect the distribution of Soil Organic Carbon and then affect the environmental effects of riparian zone [3].

Although there are many uses of soil, farmers are more concerned with soil characteristics because it supports plant growth and affects supply of food, fibers, drug, and other needs of man [4].

Generally, any soil without nutrients will be worthless to mankind for food crop production [5].

The pH is a way of determining the levels of acidity or alkalinity of soils. The soil pH, Cation exchange capacity and soil conductivity are the main properties determinant of the survival and the production or the output farmers will get during their harvest.

The germination, growth and survival of crops is a function of the soil pH, Cation exchange capacity and soil conductivity.

Soil characteristics such as Cation exchange Capacity and Electrical conductivity are the main features that determine the conduction or flow of charges in soils. They actually aids in exchange and in conduction of cations and anions in soils, during plants absorption of nutrients.

Soil pH is an indication of the acidic or alkalinity of soil and is measured in pH unit [6]. Most plants grow best where the soil is slightly acidic in the range of 5.8-7.0 [7]. Soil pH is very important because soil solution carries in it nutrients such as Nitrogen (N), Potassium (K) and Phosphorus (P) that plants need in specific amounts to thrive and fight for diseases [8].

Electrical conductivity is a measure of the electric current generated by charged ions in the soil solution [2]. Electrical conductivity of a soil varies depending on the amount of moisture held in soil particles [6]. Sands have a low conductivity, silk have a medium conductivity and clay have a high conductivity. Consequently EC (electrical conductivity) correlates strongly to soil particles sizes and textures [8, 10]. Soil Electrical conductivity is one of the soil properties which have a good relationship (correlate) with the other soil characteristics such as soil pH, Cation exchange capacity etc. [8, 9, 10].

Soil Cation Exchange Capacity is the total of the exchangeable cations that a soil can hold at a specific pH and other physical conditions.

Soils components know to contribute to soil CEC (Cation exchange capacity) are clay, and organic matter to lesser extent, [11, 12]. Cation Exchange capacity is the quantity of negative charges in the soil existing on the surfaces and organic matter. The CEC is an indication of nutrient holding capacity of soil. The negative charge attracts positively charged ions, or cations. Many essential plant nutrients exist in the soil as cations and are accumulated by the grass plant in this form, examples are potassium (K^+), calcium (Ca^{2+}) and sodium (Na^+) etc. [13]. A higher pH value gives rise to more negative charges, which leads to a higher CEC value [14]. Increased in pH increases CEC, [15, 16]. A higher (increase) pH value gives rise to more negative charge, which lead to higher CEC value [10, 13]. Generally, increase in value of pH increases the CEC [13, 14, 15, 17].

The nutrients in the soil are in the form of elements (ions), [5, 15, 13, 17]. Elemental distribution pattern and contents are relevant to the assessment of Agricultural, animal and human health, water quality and land use planning [5].

Historically, we depend on the local environment for our food and water supply [18].

Almost all foods are of either plant or animal origin. It consists of carbohydrates, fats (lipids), proteins, mineral elements, vitamin and water [19, 20]. The plants are the major source of natural protein, mineral etc. Therefore life depends upon soil for their food [5, 21]. However, many elements can be present in foods naturally, or through human activities, such as processing, storage, farming activities and industrial emission [22, 23].

In recent years, many different physical and chemical techniques have been developed for the determination of the elemental composition of soil [18]. One of the widely used techniques is X-Ray fluorescence spectroscopy (XRF), which was applied in the analysis of soil samples that were collected from the area of study. It is among the most widely used industrial methods of chemical elemental analysis and therefore covered in most University-class on materials characterization for students of Chemistry and Physics [24]. XRF is a non-destructive nuclear technique that is used for quantitative and qualitative elemental analysis of both liquids and solids of environmental, geological, biological and industrial samples, [25].

Distribution pattern is related to the physicochemical, hence it is very important to discuss or consider both in this research.

Hence, there is therefore, need to determine the distribution pattern of element and the physiochemical characteristics of soils in Haji Kogi farm area, since the land area is used for farming, were majority of food that consumes in Zaria Kaduna, Nigeria is produced.

2. Field Work

Soil samples were collected from Haji Kogi farm area at a sampling density of 1/500m (one per 500 meter distance in the transect). Top soil or upper horizon were sampled at depth 0-25cm using a hand auger and plastic trowel and put into clean polyethylene bags. Thirty (30) samples were collected for analysis. The following equipment was used: soil auger, hand trowel and clean sample bag.

3. Laboratory Work

3.1. Samples Preparation

The soil samples were dried at room temperature, ground manually with agate mortar and pestle into a homogeneous grain size of less than 125µm. Pellet of 19mm diameter were prepared from 0.3- 0.5g powder was mixed with three drops of organic liquid binder, Toluene ($C_6H_5.CH_3$) and pressed afterwards at 10 tons with a hydraulic press and pressed into pellets to fit the scheme. This is known as PELLETIZING. The sample cup was pressed in a cylindrical disc to form a supported pellet which ideally has a smooth, homogeneous sample surface and good physical stability. The samples were normally prepared as a flat disc typically of diameter 20-50mm. XRF equipment in CERT ABU Zaria, Kaduna was used.

3.2. Soil Physiochemical Properties

3.2.1. Soil pH

The pH metre was used to determine the soil pH. The pH values were determined using soil to water ratio of 1: 2.5. 10g of sieved air dry soil was weighed into a 50ml plastic beaker, 25ml of distilled water was added, and the suspension was stirred for thirty minutes. The soil suspension was then left for 30 minutes undisturbed. The pH meter was calibrated using pH buffers 4, 7, 9. The electrode was immersed into the soil (but did not touch the bottom of the beaker). The values were taken after 30 seconds for each soil sample.

3.2.2. Soil Electrical Conductivity

The soil samples solution was left overnight. The following day, the electrical conductivity was determined at room temperature with the Conductivity meter, using a soil to distilled water ratio of 1:2. The readings were taken accordingly.

3.2.3. Cation Exchange Capacity

In the determination of CEC, 40ml of 1N Ammonium of pH 7.0 acetate was added to 10g of 2mm sieved soil in plastic beaker, the mixture was stirred with a glass rod and left over night. The next day, the soil sample was filtered with light suction using a 55mm Buchner funnels. The leacheate from the soil was tested if it was calcium free with a few drop of 1N NH_4Cl 10% of ammonium oxalate and dilute NH_4OH. The soil sample was then leaching with 1N NH_4Cl pH 7.0 four times with 25mls portion at a time and once with 25ml of 0.25N pH 7.0 NH_4Cl. The electrolyte was wash with 150ml of isopropyl alcohol or ethanol. 0.1N of Silver Nitrate ($AgNO_3$) was used to test for chloride in the leacheate till the leacheate becomes negligible. The soil sample was allowed to drain thoroughly. The soil was then leached gradually with acidified (NaCl) sodium chloride to a volume of 250mls. 50ml of 2% Boric acid was then added into 250ml conical flask and add few drops of mixed indicator. The acidified NaCl leacheate was poured into 500ml Kjeldahl flask and the flask was connected to the distillate. Some anti-bump and 10mls 1N NaOH was added into the flask and then distilled over the boric acid in the conical flask. After condensing in Cation Exchange Capacity (CEC) distillation apparatus, 150ml of distillate was collected and titrated NH_4 -borate with a standard acid 0.1 HCl. The readings were taking. The CEC was calculated for each of the soil samples with the formula of Black and Madison, (1965). [26] Equation (1) bellow.

$$\text{CEC} = \frac{(T-B)\times NA \times 100}{W_t} \quad (1)$$

Where T = titre value of sample (mol dm^{-3})
B = control (mol dm^{-3})
NA = normality or concentration of acid (mol dm^{-3})
Wt = weight of soil (Kg)

4. Results and Discussion

4.1. Elemental Distribution

The following elements were determined from the study area: Al, Si, P, K, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, Ba, Rb and S.

The elements: Al, Si, K, Ca, Ti, V, Cr, Fe, Ni, Cu and Zn were 100% present in all the sample points in the soil samples, this shows that they were evenly or uniformly distributed. Elements like P, Mn, and Ba, were present in 60%, 90%, and 73% of the samples and were not evenly distributed. While elements like S and Rb were 13% and 10% present in the samples, this shows that they were poorly distributed. This shows that the soils where rich in major, minor and trace elements which were uniformly distributed. This result has proven that the elements needed for agricultural production of plants and foods which were available, were uniformly distributed in Haji Kogi farm. From the elements determined, Haji Kogi farm contains K, P, and Ca which are basic plant nutrients requirement for plant growth. K and Ca were uniformly distributed while P was not evenly distributed.

The farmers should apply more P in the soil to make the soil enrich in P, like K and Ca.

Table 1. *Elemental Abundance in Haji Kogi Farm, all in unit of percent (%).*

ELEMENTS	CONCENTRATION (%)
Al	6.04±1.80
Si	31.56±3.49
P	0.38±0.46
K	3.50±0.56
Ca	0.55±0.28
Ti	1.14±0.36
V	0.08±0.19
Cr	0.05±0.02
Mn	0.06±0.03
Fe	7.57±3.38
Ni	0.03±0.02
Cu	0.09±0.16
Zn	0.04±0.02
Ba	0.45±0.17
S	0.08±0.04
Rb	9.11±1.82

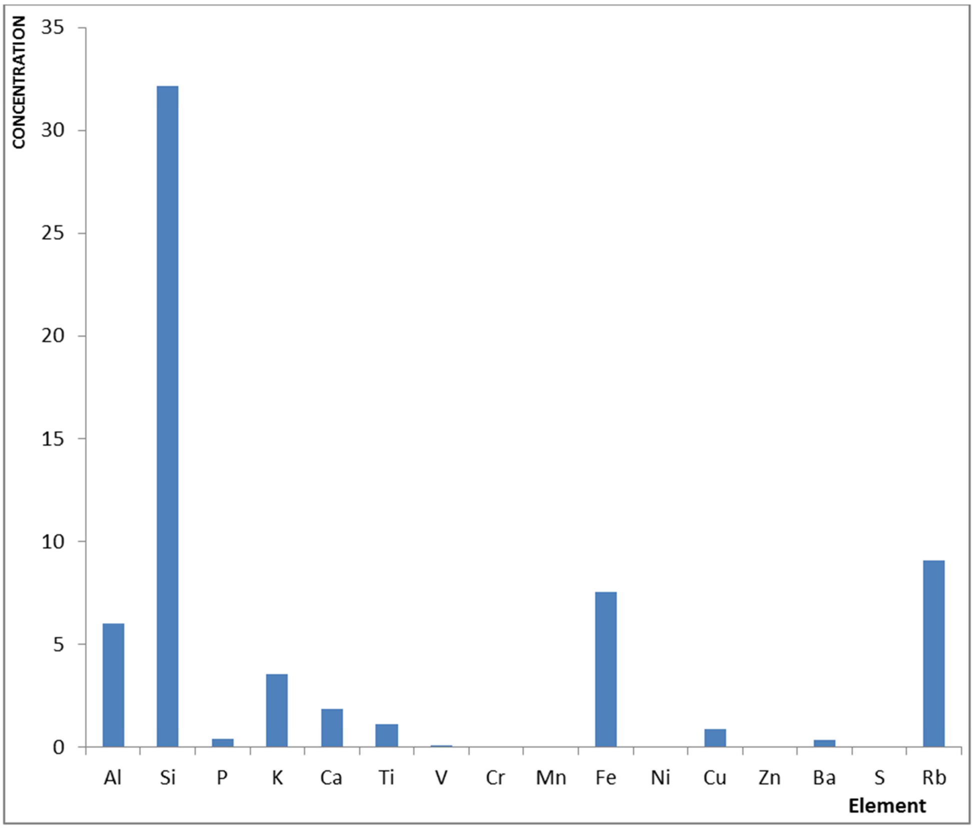

Figure 1. *Bar Chart of Elements and their Concentration.*

From Figure 1 above, silicon had the highest concentration, followed by rubidium, iron, aluminum, potassium, calcium, titanium, cupper, phosphorus and barium. While other elements falls within the same range of concentration. Their increasing other is: Si > Rb > Fe > Al > K > Ca > Ti >Cu > P > Ba > S = Zn = Ni = Mn = Cr = V.

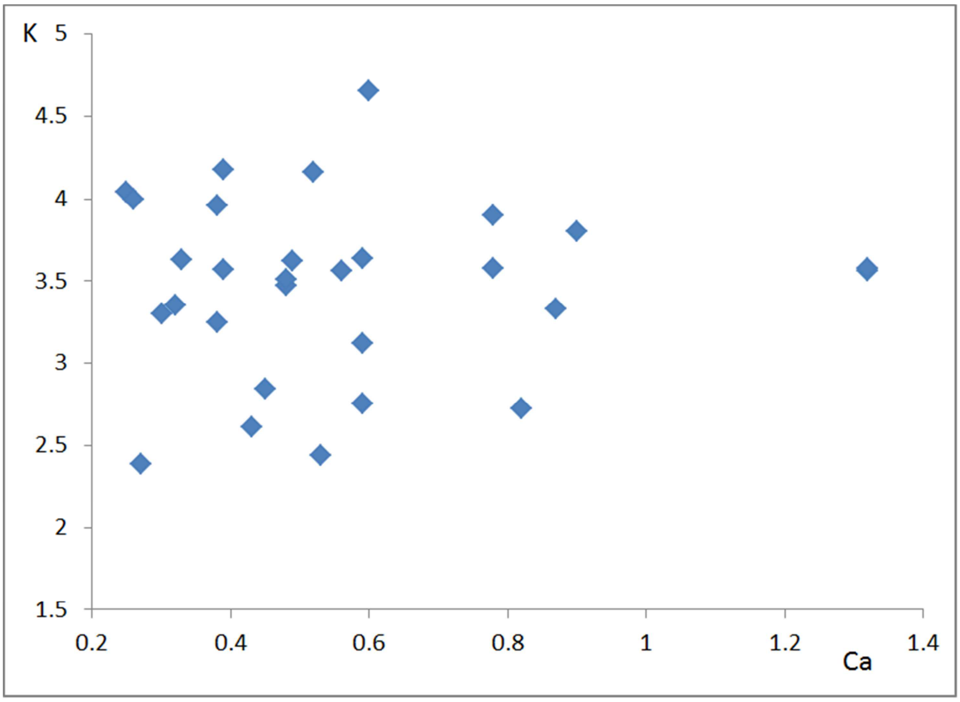

Figure 2. *Correlation of k and Ca.*

Figure 2 is the correlation of k and Ca. r^2 = 0.001, therefore low negative correlations exist between Ca and K. The graph shows that as the K is increasing the Ca decreases slightly. Hence there is a balance.

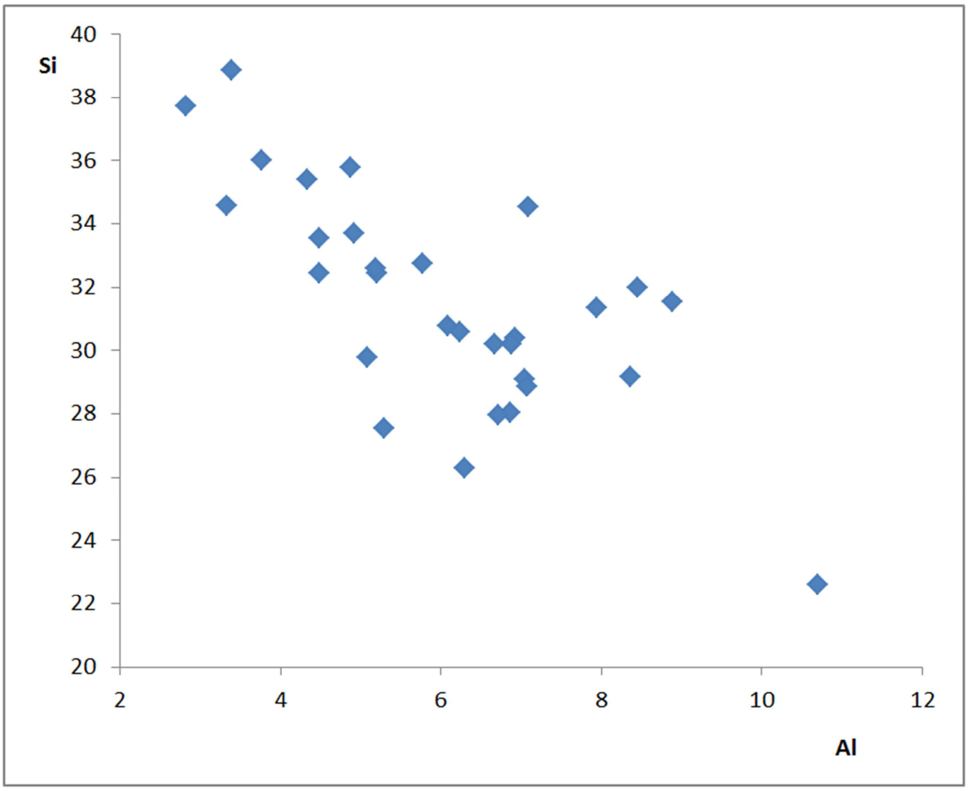

Figure 3. *Correlation of Si and Al.*

Si and Al are crystal elements of aluminum silicate, the basic frame work of clays. From Figure 3 the correlation of Si and Al. The value of r^2 = 0.52 which indicates average correlation between these element in the soil. Hence as Si is decreasing, Al also increases in equal amount. Hence there is balance.

4.2. Physicochemical Properties

Below are the results of characteristics of soil of Haji Kogi farm area.

4.3. Soil pH

The significance of soil pH is that it affects various soil properties including soil conductivity, soil mineral formation and soil structure etc. [26]. Crops performance is usually best between pH 5.6 -7.3 [17].

Table 2 bellow, shows that soil sample numbers S_1B, S_{13}B, S_{15}B, S_{16}B, S_{18}B, and S_{30}B were very strong acidic. This could be as a result of the following: either leaching, high temperature during the arid months leading to evaporation of soil water leaving residues of strong undiluted salt, acid parents materials, or even the type of fertilizer farmers applied in the farm, organic matter decay and harvest of high yielding crop [27]. This can be corrected by the addition of lime (CaO) [28]. The soil sample number S_{29} is slightly alkaline. Others fall into the same range of pH, where plants can survive. The result shows that the soil is more acidic, since most of the pH values are below 7 except sample number S_{29e}. This result shows that the pH is within the range were plants can survive. This result also shows that there is continuous flow of H^+ (concentration) in the soil solution. The majority of the soil pH fall between pH of 5.5 – 7.2, hence the crops are expected to perform well. The mean pH of the soil is 5.5933±0.6468. The value of this pH is closes to the moderately acidic pH determined by Osakwe and Okolie (2015) in the soil of of Delta state in Nigeria.

[29] Osakwe S. A. and Okoliel. P. Physicochemical Characteristics and Heavy Metals Contents in Soils and Cassava Plants from Farmlands alongA Major Highway in Delta State, Nigeria. Journal of Appllied Science Environ. Manage. 2015 Vol. 19 (4) 695-704

Table 2. *Soil pH.*

Sample Number	pH Ratio 1:2.5 of Water
S_1B	4.50
S_2B	6.10
S_3B	5.90
S_4B	6.00
S_5B	5.60
S_6B	6.20
S_7B	5.50
S_8B	5.10
S_9B	5.10
S_{10}B	5.00
S_{11}B	6.10
S_{12}B	5.00
S_{13}B	4.80
S_{14}B	5.20
S_{15}B	4.90
S_{16}B	4.90
S_{17}B	5.10

Sample Number	pH Ratio 1:2.5 of Water
$S_{18}B$	4.90
$S_{19}B$	5.90
$S_{20}B$	5.30
$S_{21}B$	5.30
$S_{22}B$	5.30
$S_{23}B$	6.60
$S_{24}B$	5.80
$S_{25}B$	5.60
$S_{26}B$	5.90
$S_{27}B$	6.80
$S_{28}B$	5.80
$S_{29}B$	7.20
$S_{30}B$	4.80

The mean pH, 5.59330±0.6468.

4.4. Soil Electrical Conductivity (EC)

Soil electrical conductivity is one of the soil chemical properties which have good relationship with the other soil characteristics [6, 7, 8].

Miller and Donahue, (1977) in Karans (2007) [29] give the range of electrical conductivity as it effects growth of plants in the soils as shown in Table 3. Also Dahnke and Whitney, gives the interpretation of Salt salinity as shown in table 4, [31]. Hence, the soil conductivity was non-saline and was also generally less than two (2). This is the range of value were plants can survive. This is an indication of good soil conductivity. This is because (0-2 dSm^{-1}) is the range of non-saline, were plants can survive, as shown in table 3. Therefore, the values of soil conductivity indicate nutrient efficiency. Hence, plants will survival.

Table 3. *Range of Soil Conductivity.*

Conductivity (dSm^{-1})	Growth reduction by salt in soil
0 – 0.02	Few plant are affected
0.02 -0.04	Some sensitive plant is affected
0.04 -0.08	Many plants are affected
0.08 -0.16	Most crop plants are affected
0.16 and above	Few plants grow well

SOURCE: (Karans, S. A., 2007) [26]

Table 4. *Interpretation of the Saturated Paste Soluble Salts Test.*

Degree of Salinity	Electrical Conductivity
mmhos (cm^{-1})	
Non-saline	0.0 - 2.0
Slightly Saline	2.1 - 4.0
Moderately Saline	4.1 - 8.0
Strongly Saline	8.1 - 16.0
Very Strongly Saline	16.1 +

Source (Dahnke and Whitney, 1988) [27]
Non-Saline:- No problem
Low or weak Saline: - There may or may not be very small salt, which will not inhibit plant development and growth.
Moderate: - There may be small salt that may affect plants.
Strongly Saline or High:- There is high level of salt like calcium sulphate ($CaSO_4$), manganese sulphate ($MgSO_4$) and potassium chloride (KCL).
Very Strongly Saline or Severe:- There is a very high level of salt like calcium sulphate ($CaSO_4$), manganese sulphate ($MgSO_4$) and potassium chloride (KCL).

Table 5. *Soils Electrical Conductivity.*

Sample Number	Conductivity (dSm^{-1})
S_1B	0.055
S_2B	0.100
S_3B	0.095
S_4B	0.060
S_5B	0.180
S_6B	0.100
S_7B	0.070
S_8 B	0.013
S_9B	0.040
$S_{10}B$	0.090
$S_{11}B$	0.060
$S_{12}B$	0.060
$S_{13}B$	0.100
$S_{14}B$	0.140
$S_{15}B$	0.080
$S_{16}B$	0.060
$S_{17}B$	0.100
$S_{18}B$	0.070
$S_{19}B$	0.050
$S_{20}B$	0.026
$S_{21}B$	0.150
$S_{22}B$	0.110
$S_{23}B$	0.200
$S_{24}B$	0.140
$S_{25}B$	0.150
$S_{26}B$	0.007
$S_{27}B$	0.006
$S_{28}B$	0.220
$S_{29}B$	0.190
$S_{30}B$	0.010

The mean soil conductivity, 0.0911±0.0588dSm^{-1}

4.5. Cation Exchange Capacity (CEC)

Generally, the CEC of most soils increases with an increase in soil pH [10, 11, 12, 13] and Kim [31] as shown in figure 4 and 5. The results of CEC, Table 3 shows that the soils have good nutrient holding capacity, this is because CEC increases as pH increases. Hence there is assurance that the soils are fertile. Secondly the pH value indicates optimum CEC. The observed CEC values for the soils, where high enough for good plant growth for the soil to be considered fertile.

Table 6. *Soils CEC.*

Sample Number	CEC in (Cmol/Kg)
S_1B	8.80
S_2B	6.00
S_3B	5.20
S_4B	6.40
S_5B	7.30
S $_6B$	6.60
S_7B	6.70
S_8B	8.40
S_9B	5.20
$S_{10}B$	6.80
$S_{11}B$	5.50
$S_{12}B$	10.50
$S_{13}B$	8.50
S_{14} B	11.50
S_{15} B	12.90
$S_{16}B$	11.50
$S_{17}B$	5.90

Sample Number	CEC in (Cmol/Kg)
$S_{18}B$	11.30
$S_{19}B$	10.20
$S_{20}B$	6.00
$S_{21}B$	5.50
$S_{22}B$	11.40
$S_{23}B$	8.00
$S_{24}B$	6.00
$S_{25}B$	9.70
$S_{26}B$	9.20
$S_{27}B$	10.50
$S_{28}B$	11.30
$S_{29}B$	13.10
$S_{30}B$	5.80

The mean values of CEC, 8.3900± 2.5161 Cmol/kg

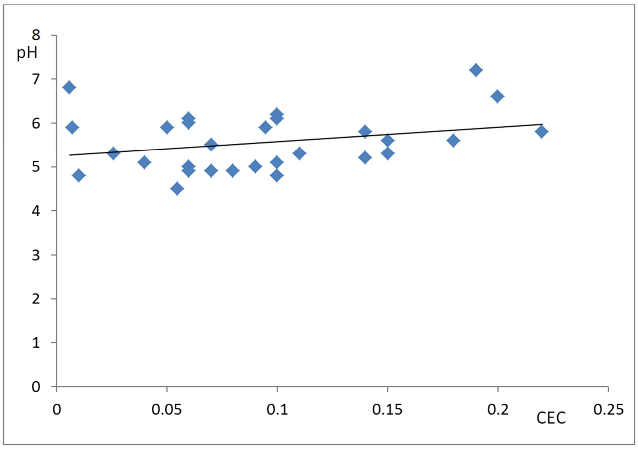

Figure 4. *Graph of pH Vs CEC.*

This graph shows that as soil pH increases, the CEC also increases. The CEC falls within the range of pH where plants can survive. That is, pH 5.6 and pH 7.2, as shown in figure 4 above.

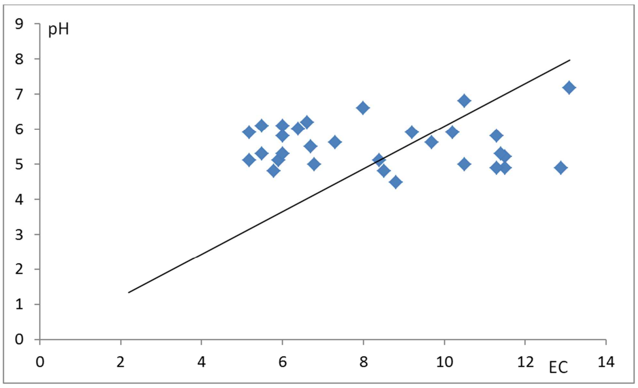

Figure 5. *Graph of pH Vs EC.*

Similarly, figure 5 above shows that as soil pH increases, the CEC also increases. The soil pH falls within the range of pH where plants can survive. That is, pH 5.6 and pH 7.2, as shown in figure 5 above.

5. Conclusion

The following elements were determined: Al, Si, P, K, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, Ba, Rb and S. The elements were present in all the samples and were evenly distributed except: P, Mn, Ba, S, and Rb which were not evenly distributed.

Ninety per cent (90%) of the soil samples falls within the same range of pH where plants perform best. The electrical conductivity (0-2 dSm^{-1}), have good soil conductivity within the range of non-saline, were plants survives. The CEC values also show good Cation exchange capacity.

Both CEC and EC increased as pH increased. This agrees with the works of: Christy S, 2011, Robert, B. G. et al, 2009, Lunda, E. U. et al 1999, James J. C., 2001, Chi M. A. and A. E. 1991, Lines-Kelly R., 2002 and Tree Fruit Soil and Nutrition Research and Extension Centre, 2004.

The ranges of pH, EC and CEC are within the range were plants can survive. Hence, the soils have good nutrient holding capacity. The results of this work show that the soils from haji-Kogi Farms have good Distribution Pattern and Physicochemical Characteristics.

Recommendations

(a). The farmer should apply N P K fertilizers or a fertilizer that has high content of nitrogen to introduce nitrogen in the soil.

(b). The farmers should apply fertilizer containing ammonium, to maintain a good Ph.

(c). The soil should be lime or adding organic manure to maintain good physicochemical properties of the soil.

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