IOSR Journal of Applied Chemistry (IOSR-JAC)
ISSN: 2278-5736.Volume 2, Issue 2 (Sep-Oct. 2012), PP 23-28
www.iosrjournals.org

Humic acid content and physico-chemical properties of cocoa *(Theobroma cacao)* farmssoil in Eri-pose, Nigeria.

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Abstract: *The physico- chemical properties of 50 years and 100 years old cocoa farms soils from Eri-Pose, Nigeria were analyzed for theirPH, EA, ECEC,PBS, OM, ON, total nitrogen, phosphorus, OC,OP, particle sizes and mineral analyzes.The PH values of both farms ranged from (5.49 ±0.01 to 5.63 ±0.04).The EA were also between(0.68cmol/kg ±0.07 to0.74cmol/kg±0.08). The ECEC of the farms were between (8.40cmol/kg±0.15 to 12.50 cmol/kg ±0.69).The PBS ranged from (90.74%±2.80 to 93.84% ±1.33). The TEB of the cocoa farms were between (7.66cmol/kg ±0.16 to 11.82cmol/kg ±0.71). The organic matter of both farms ranged from (17.02g/kg ±0.89) to (20.42g/kg ±1.39). The organic Phosphorus ranged from (75.27g/kg±3.75) to (81.27g/kg ±2.44). The organic carbon ranged from (9.88g/kg±0.49) to (11.82g/kg±0.81). Theorganic Nitrogen also ranged from (0.51g/kg ±0.02) to (0.60g/kg±0.04).The total Nitrogen ranged from(0.23%±0.08) to (0.60%±0.13).The clay soil ranged from (20.06%±0.14 to 25.19%±0.83), silt ranged from (8.85% ±1.22 to 12.41% ±0.55), sand sizes were between (65.96% ±0.73 to 67.53%±0.48), while the particle densities of the two farms were between (2.12g/cm3 ±0.05 to 2.22g/cm3 ±0.08). The mineralanalyses showed that the mineral contents for 50 yrs old soil ranged from (0.03mg/kg±0.00 to 0.50mg/kg ±0.02), while that of 100yrs old soil ranged from 0.04mg/kg±0.00 to 0.45mg/kg±0.01. The soilsamples showed traces of heavy metals like mn, Ni, Cd.The humic acid content of 50 yrs old soil was 5.86mg/g±0.01, while that of 100yrs old soil was 6.47mg/g±0.01.*

Keywords:*Eri-pose, PH, ECEC, EA,PBS,OM,ON, TN,Pb,Mn, Cd, humic acid.*

I. Introduction

Eri-pose, is a small village located in Idanre local Government area, in Ondo State, Nigeria. Their major activities in the town include farming(well Known for cocoa growing), fishing and rearing of animals. Agriculture plays an important and strategic role in the revival of Nigerian national economy and cocoa (Theobroma cacao) remains a major export crop in Nigeria. In 1998, a revenue of 7459.3545 million Naira (US$ 53,280 at 140 per US$) was derived from dried cocoa beans (half of the income attributed to the total export of major agricultural products)[1]. Cocoa was first cultivated in the western region of Nigeriain 1890[2]. Its cultivation gained prominence rapidly in Nigeria, such that by 1965, Nigeria became the second largest producer in the world[2].

In general, cocoa producing states lie within the rainforest zone of Nigeria which Include Ondo, Ogun, Oyo,Ekiti, Ogun, Edo, Delta, Cross-Rivers and Akwa-Ibom. However, over 50% of the total quantity of cocoa produced for export or utilized locally per annum comes from OndoState[2]. The production, however, has declined in recent years; a fact attributed partly to poor soil quality[3-4] In Nigeria, and elsewhere in the tropics, extensive studies have been carried out on many tree crops including cocoa[5-7]. Previous records on soil survey between 1951 and 1962, within the cocoa belts of Nigeria revealed that about 62% of Nigeria cocoa is grown on good or fairly good soils and the remaining thirty eight per cent on poor or very poor soil [8]. It has also been shown in Modern Applied Science

www.ccsenet.org/mas36experimentally by the Cocoa Research Institute of Nigeria (CRIN) thatcontinuous cultivation of cocoa at same farmland leads to appreciable decline in physical andchemical properties of the soil[9-10].Crop production involves a complex interaction betweenthe environment, soil parameters, and nutrient dynamics. Because of this fact, the soil must bestudied in terms of the productive potentials. Failure to understand these complexities hasresulted in lack of good crop production and management techniques; hence agriculturalproduction has tended to be low. Soil fertility decline is considered as an important cause for lowproductivity of many soils[11]. It has not received the same amount of research attention as soilerosion; probably because as soil fertility declines less visible and less spectacular, and more difficult to assess. Assessing soil fertility decline is difficult because most soil chemical properties either change very slowly or have large seasonal fluctuations. This decline includes; nutrient depletion, nutrient mining, acidification (decline in pH and or an increase in exchangeable Al), loss of organic matter and increase in toxic elements (e.g., Al, Mn)[12].

In the present study, physico-chemical properties of 50 years and 100 years old cocoa farm soilsnamely pH, organic matter, Total nitrogen, exchangeable acidity, effective cation exchangecapacity, phosphorus, moisture content, total exchangeable bases, mineral elements, organiccarbon and organic phosphorus will be examined.

II. Methodology

Study Area

50 years and 100 years cocoa farms were selected in Eri-pose, in July, 2010, these old cocoa farms were selectedbecause they are the predominant cocoa farms in the area and the armlet being one of the largestarea that produces cocoa in Ondo state.

Sampling

Sampling design was based on two principles: first, the need to spread sample sites objectivelyover the study area and second, the need to ensure that plant and site characteristics areadequately depicted. The entire plantation at each farm was divided into three plots from each ofwhich samples were collected. Soil samples were collected from sampling depth of0–10cm. The sampling was restricted to the zone because the zone provides the bulk of plant nutrients [13]. Samples were collected inside labeled polythene bags and random sampling technique was chosen.

Sample Treatment and Analysis

Soil samples were air-dried, sieved, mixed together and analyzed in the laboratory using standardtechniques. Particle size composition was obtained by hydrometer method [14]. Soil pH wasdetermined in water [15], Organic carbon content was found by the modified $K_2Cr_2O_7$ digestionofWalkley-Black method[16]. The cation exchange capacity (CEC) was determined by addingthe 1 M KCl extractable acidity to cations (Ca^{2+}, Mg^{2+}, Na^+, K^+) exchanged by neutral 1 $MNH_4C_2H_3O_2$ (pH 7) as described in Thomas[17]. The K^+ and Na^+ were measured with flamephotometer while the Mg^{2+} and Ca^{2+} were determined with atomic absorption spectrophotometer.The exchangeable acidity was determined by titration and the effective cation exchange capacity(ECEC) was obtained by summation of exchangeable cations, exchange acidity. The percentagebase saturation was done by calculation. The mineral analysis was done by soaking the soil indilute water and Atomic Absorption Spectroscopy machine was used, total nitrogen wasdetermined using digestion methods.[16]. The analyses were done in triplicate.

III. Results And Discussion

The physico- chemical properties of the two different cocoa farm soils were analyzed. The PHvalues of 50 years old cocoa farm (5.49±0.01) was lower than that of 100 years old cocoafarm(5.63±0.04). The effect of soil pH is profound on the solubility of minerals and nutrients andit is regarded as a useful indicator of other soil parameters and favours the growth of microbes in the soil. [18]. Particularly, it provides usefulinformation about the availabilities of exchangeable cations (e.g Ca^{2+}, Mg^{2+}, K^+, e.t.c) in soils.The PH values of both farms showed that the soil contains more exchangeable cations. Theexchangeable acidity(EA) of 50 years old cocoa farm(0.74cmol/kg ±0.08) was higher than that of100 years old cocoa farm (0.68cmol/kg±0.07).The effective cation exchange capacity(ECEC)of 50years old cocoa farm(8.40cmol/kg±0.15) was lower than that of 100 years old cocoafarm(12.50cmol/kg±0.69).The ECEC is a summation of total exchangeable bases andexchangeable acidity. It is highly needed for the estimation of contaminant transport potentialand sorption capacity for any soil location i.e. the total number of cations it can retain on itsadsorbent complex at a given pH..The presence of these high values of ECEC indicates thepresence of less clay and high organic matter. The percentage base saturation of 50 years oldcocoa farm (90.74% ±2.80) was lower than that of 100 years old cocoa farm(93.84% ±1.33).Thetotal exchangeable bases of 50 years old cocoa (7.66cmol/kg±0.16) was lower than that of 100 years old cocoa farm (11.82cmol/kg±0.71).These percentages are valuable indicators of the chemical richness ofthese locations, and will assist to determine the biological activity, the quality of its structureand reserves of nutrient element. The organic matter of 50 years old cocoa farm (17.02g/kg ±0.89)was lower than that of 100 years old cocoa farm(20.42g/kg±1.39). The level of organic mattersin soils influences a number of soil chemical and physical properties. The high organic mattercontent of 100years old and 50 years old cocoa farm in Eri-pose were responsible for the high yieldof cocoa, because of high decayed plants and animals. Organic matter is defined as a grouping of carbon containing compounds which have originated from living beings and been deposited on or within the earth's structural components. Soil organic matter includes the remains of all plant and animal bodies which have fallen on the earth's surface or been purposely applied by man in the form of organically synthesized pesticides. A fertile soil should contain from 2-8 percent organic matter [19].The organic Nitrogen of 50 years oldcocoa farm(0.51g/kg±0.02) was lower than that of 100 years old cocoafarm(0.60g/kg ±0.04).The total Nitrogen of 50 years old cocoa farm(0.23% ±0.08) was lowerthan that of 150 years old cocoa farm(0.60%±0.13), the total Nitrogen recorded in the twofarms were greater than 0.2% minimum requirement of nitrogen needed for plant growth andhigher than the world average nitrogen content(<0.15%)[20] .The organic carbon of 50 years oldcocoa farm(9.88g/kg±0.49) was lower than that of 100 years old cocoafarm(11.82g/kg ±0.81). The organic carbon content of a soil is a measure of valuable indication of the potential humic-chemistry of a soil [19].The organic Phosphorus of 50 years old cocoa farm (75.27g/kg±3.75)was lower than that of 100 years old cocoa farm(81.27g/kg±2.44). The clay soil of 50 yearsold cocoa farm(25.19%±0.83) was higher than that of 100 years old cocoa farm(20.06%±0.14).The silt of 50 years old cocoa farm (8.85%±1.22) was lower than that of 100 years old cocoafarm(12.41%±0.55). The sand of 50 years old cocoa farm (65.96%±0.73) was lower than that of100 years old cocoa farm (67.53%±0.48).However the soil contain significant percentage ofsand, in both farms. Soils composed small proportion of silt and clay don't compress (collapse)as they lose water. Such soils continue to have high permeability to oxygen during sub aerialexposure. Soils of intermediate grain size composition exhibit partial compression. Indeed,compressibility has been found to be linearly correlated to silt-clay content[20]. Thiscompressibility as experienced may be responsible for the high quality of cocoa in Eri-pose farms.The mineral element of of 50 years old cocoa farm were: Cu (0.04mg/kg±0.00),Fe(0.37mg/kg±0.01), Zn(0.46mg/kg ±0.01),Pb (0.00mg/kg ±0.00),Ni (0.03mg/kg ±0.00),Cd(0.05mg/kg ±0.00) and Mn (0.50mg/kg ±0.02). The mineral element of 100 years old cocoafarm were: Cu (0.04mg/kg ±0.00), Fe (0.34mg/kg ±0.01),Zn (0.36mg/kg ±0.01),Pb(0.00mg/kg ±0.00),Ni (0.04mg/kg ±0.00), Cd (0.06mg/kg ±0.00) andMn(0.45mg/kg0.01). In addition to the major nutrients-Nitrogen, Phosphorus, and Potassium, plants require small amounts of "trace minerals" such as copper, zinc, iron and manganese, these trace minerals, among other vital functions, are indispensable to the enzymatic control of plant. These have contributed immensely to the high yield of cocoa beans in these two areas, and also significantly responsible for high yield of crops planted in the farms like Plantain and Cocoyam. Trace-mineral deficiencies in soil, are reflected in lowered essential mineral content of foods, are worldwide, the presence of trace quantity of heavy metals like cadmium and zinc isan indication that the soil may be toxic for planting food crops. [21] and the nearby streams ofwater may contain high level of contaminants [22].The humic acid content of 50 years old soil (5.86mg/g±0.01) was lower than that of 100years old cocoa farm soil(6.47mg/g±0.01).Humic acid functions as an important ion-exchange and metal-complexing (chelating) systems, also to improve the soil's water holding capacity. It helps create a desirable soil structure that facilitates water infiltration and helps hold water within the root zone. Because of their large surface area and internal electrical charges, it also functions as water sponges. These sponges like substances have the ability to hold seven times their volume in water, a greater water holding capacity than soil clays [19], Water stored within the top-soil, when needed, provides a carrier medium for nutrients required by soil organisms and plant roots. Available water is without doubt the most important component of a fertile soil. Soils which contain high concentrations of humic substances hold water for crop use during periods of drought [19],humic substances buffer (neutralize) the soil pH and liberate carbon dioxide. Humic substances function to buffer the hydrogen ion (pH) concentration of the soil, also liberate carbon dioxide (CO_2) from calcium carbonates present within the soil. The released CO_2 may be taken up by the plant or it may form carbonic acids. And the carbonic acids act on soil minerals to release plant nutrients. These have contributed immensely to the high yield of cocoa beans and the beans are of high demand in all over the world being used for making many products like chocolates, beverages etc.

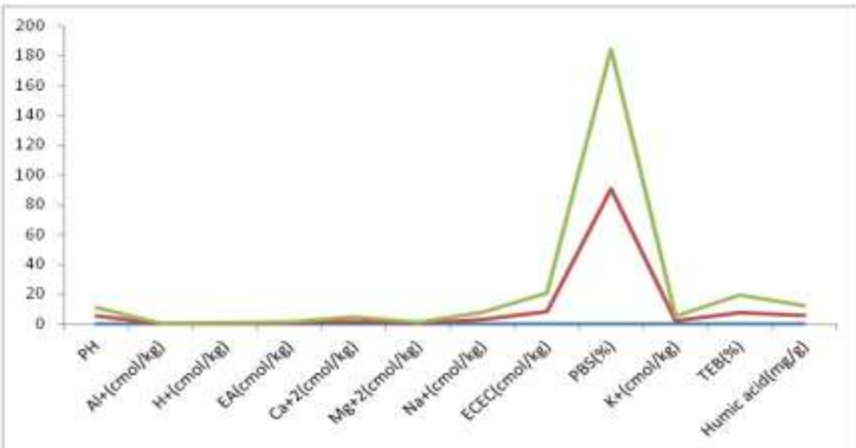

Fig1: A graph showing the mean of chemical properties of 50 and 100 yrs old cocoa farm soil.

Note: The green curve represent 100yrs old cocoa farm soil and Red curve represent 50 yrs old cocoa farm soil.

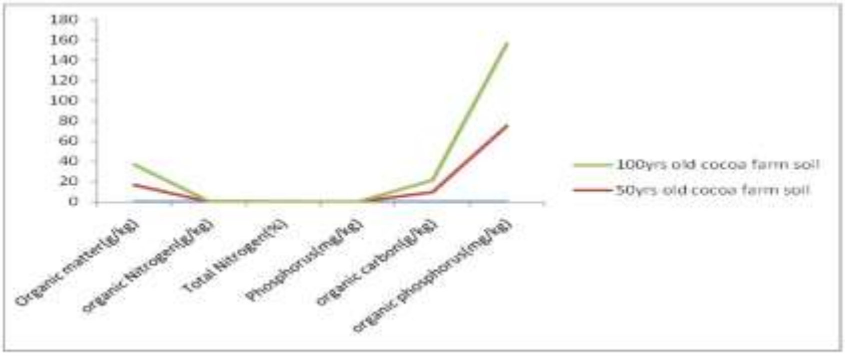

Fig.2: A graph showing the mean of chemical properties of 50 and 100 years old cocoa farm soil.

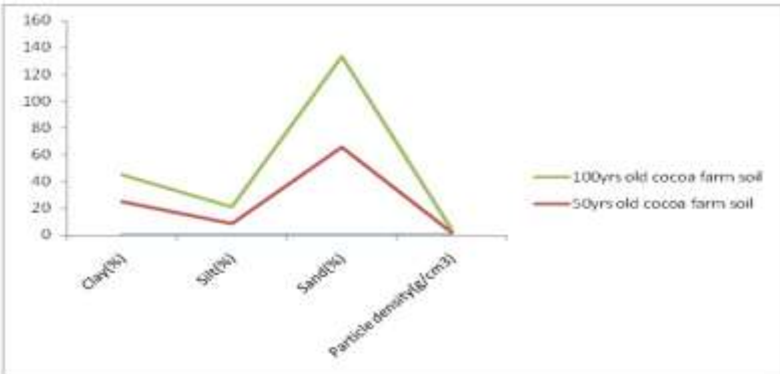

Fig.3 A graph showing the mean of physical properties of 50 and100 years old cocoa farm soil.

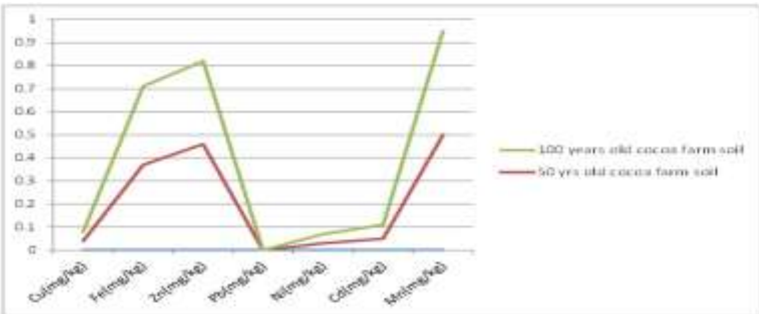

Fig.4: A graph showing the mean of mineral analysis of 50 and 100 years old cocoa farm soil.

Table 1: 95% Confidence for mean

Parameter	Farm (yrs)	Lower bound	Upper bound	Minimum	Maximum
PH	50	5.46	5.52	5.47	5.52
	100	5.61	5.65	5.61	5.65
Al^{+3}(cmol/kg)	50	0.11	0.44	0.10	0.40
	100	0.18	0.38	0.20	0.40
H^{+} (cmol/kg)	50	0.23	0.69	0.30	0.70
	100	0.22	0.58	0.20	0.50
EA (cmol/kg)	50	0.51	0.97	0.50	1.00
	100	0.50	0.86	0.50	0.90
Ca^{2+} (cmol/kg)	50	1.62	1.94	1.70	2.00
	100	1.68	4.52	1.80	4.50
Mg^{2+} (cmol/kg)	50	0.42	0.74	0.40	0.70
	100	0.07	1.47	0.10	1.70
Na^{+} (cmol/kg)	50	2.83	3.36	2.87	3.35
	100	4.75	5.02	4.78	5.04
K^{+} (cmol/kg)	50	2.04	2.36	2.05	2.41
	100	3.04	3.22	3.03	3.23
PBS	50	82.98	98.50	81.01	96.19
	100	90.13	97.54	90.01	97.77

Table 2: 95% Confidence for mean of chemical properties

Parameter	Farm (yrs)	Lower bound	Upper bound	Minimum	Maximum
Organic matter(g/kg)	50 100	14.68 16.55	19.37 24.30	14.65 15.38	18.60 23.30
Organic Nitrogen (g/kg)	50 100	0.45 0.48	0.56 0.71	0.43 0.45	0.54 0.68
Total Nitrogen(%)	50 100	0.01 0.22	0.45 0.97	0.07 0.12	0.53 0.87
Organic Phosphorus (g/kg)	50 100	64.85 74.50 0.50	85.69 88.04	61.95 73.35	82.35 88.35
Total exchangeable bases(cmol/kg)	50 100	7.21 9.84	8.11 13.80	7.25 9.98	8.21 13.76
ECEC (cmol/kg)	50 100	7.97 10.59	8.83 14.40	8.08 10.88	8.91 14.46

Table 3: 95% Confidence for mean of physical properties

Parameter	Farm (yrs)	Lower bound	Upper bound	Minimum	Maximum
Clay (%)	50 100	22.89 19.67	27.49 20.46	23.84 19.92	27.22 20.63
Silt (%)	50 100	5.46 10.87	12.24 13.95	6.43 11.06	11.77 13.73
Sand (%)	50 100	63.92 66.19	67.99 68.86	64.39 66.35	68.31 68.31
Particle density(g/cm^3)	50 100	1.98 2.00	2.27 2.43	1.99 1.97	2.23 2.39

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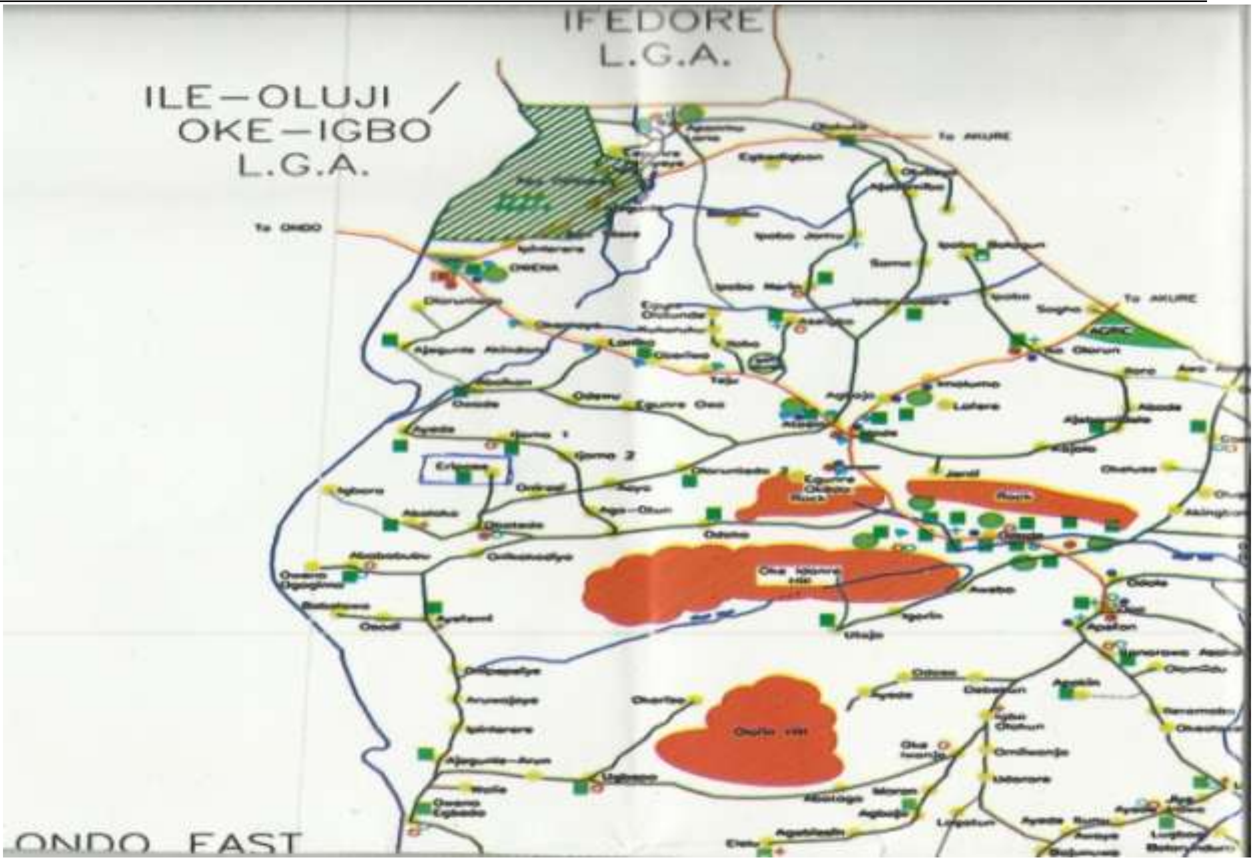

Fig 1: Map showing location of Eri-pose in idanre Local government area .
Source :Idanre Local Government Area,Ondo State, Nigeria