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Soil Fertility Analysis in Two Oil Palm Plantation Towns in Assin North District of the Central Region of Ghana

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Abstract: Macronutrients, micronutrients, pH and salinity were determined in soil samples from two palm plantation towns in Assin North District in the Central Region of Ghana. Neutron Activation method was used for the elemental analysis. The pHs were within the acidic range. The top soil 0-5cm had the highest pH followed by soil at the depth of 5-30cm and soil at the depth of 30-40cm that is the pH decreased with depth and were higher than the preferred pH. The salinity increased with depth. For the soil samples from Assin Akonfudi iron concentration was the highest and molybdenum was the least in the soil. Manganese and Mg concentrations in soil decreased as the depth in soil increased. Potassium, Ca, Zn and Cu concentrations in soil rather increased as the depth in soil increased. Iron and Na concentrations in soil were highest at 5-30cm depth and lowest at 0-5cm depth and Cl concentration in soil was highest at 30-40cm and lowest at 5-30cm depth. Cobalt concentration in soil was highest at 0-5cm and 30-40cm which have the same concentration and lowest at 5-30cm and Mo concentration in soil was highest at 0-5cm and lowest at both 5-30cm and 30-40cm of which were below detection limit. For the soil samples from Assin Bereku iron concentration again was the highest and again Mo was the least in the soil. Manganese and Mg concentrations decreased as the depth in soil increased. Potassium, Ca, Fe, Na, Zn and Cu concentrations rather increased as the depth in soil increased. Chlorine concentration in soil was highest at 5-30cm and lowest at 30-40cm depth and Co concentration in soil was highest at 30-40cm depth and lowest at 5-30cm.

Key word:

INTRODUCTION

Agricultural land is primarily required for the production of food for human and animal consumption, agricultural activities also include the growing of plants for fiber and fuels (including wood), and for other organically derived products (pharmaceuticals, etc) for use by humans and his animals. (Kenk and Cotie, 1983).

One of the most important natural resources that cover much of the earth's surface is soil. Most life on earth depends upon the soil as a direct or indirect source of food. Plants are rooted in the soil and obtain nutrients from it. Animals also get nutrients from eating the plants on the soil. Soil is home of many organisms such as seeds, spores, insects, and worms. The contents of soil change constantly and there are many different kinds of soil. It forms very slowly and is destroyed easily, so it must be conserved in order to continue to support life. (goorganic @soilassociation.org).

The study of the soil has been fostered by people's interest in plant growth and food production. (Hinrieh *et al.,* 1985). The ability to produce food is the fundamental factors in societal development therefore need to know the kind of element or nutrient for a better production.

Our soil resource can be compared to a bank where continued withdrawal without repayment cannot continue indefinitely. As nutrients are removed by one crop and not replaced for subsequent crop production, yields will decrease accordingly. Accurate accounting of nutrient removal and replacement, crop production statistics, and soil analysis results will help the producer manage fertilizer applications.To grow good crops, most farmers need to fertilize the soil. Fertilizing increases crop yield, and the improved crop growth maintains and even builds soil structure and the quality of the soil. If things aren't done properly, however, there can be negative impacts," says Ross McKenzie, agronomy research scientist with Alberta Agriculture and Food, Lethbridge. "Over fertilizing with nitrogen, for instance, can potentially lead to nitrate leeching into the ground

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water or erosion can cause phosphorus to enter surface water. Environmental considerations and the high cost of nitrogen and fertilizers have made it even more important for farmers to use good management practices. Soil analysis is used to determine the level of nutrients found in a soil sample. As such, it can only be as accurate as the sample taken in a particular field. The results of a soil analysis provide the agricultural producer with an estimate of the amount of fertilizer nutrients needed to supplement those in the soil. (Baker *et al.,* 1956).

High yields of top-quality crops require an abundant supply of 19 essential nutrient elements which are classified into four groups which are.

(1) Major non-mineral macronutrients: these are 90-95% of dry plants weight and are supplied to the plant by water adsorption and photosynthesis are carbon (C), hydrogen (H), oxygen (O)
(2) Primary macronutrients are nitrogen (N), phosphorus (P) and potassium (K)
(3) Secondary macronutrients are calcium (Ca), magnesium (Mg) and sulfur (S).
(4) Micronutrients are boron (B), chlorine (Cl), cobalt (Co), copper (Cu), iron (Fe), manganese (Mn), zinc (Zn) and molybdenum (Mo). (Stanley and Barber, 1995).
(5) Beneficial elements in the soil that are sodium (Na), and selenium (Se). (Samuel *et al.,* 1985).

Of these nutrients only 11 will be studied that is potassium (K), calcium (Ca), magnesium (Mg), chlorine (Cl), cobalt (Co), copper (Cu), iron (Fe), manganese (Mn), zinc (Zn), molybdenum (Mo) and sodium (Na).

Study Area:

The area chosen under this study was the Assin North District. The Assin North District is among the thirteen (13) districts of the Central Region of Ghana. It lies within Longitudes 1° 05' East and 1° 25 West and Latitudes 6 ° 05' North and 6° 40 South, Fig 1.

Assin North District falls within the moist tropical forest, mainly deciduous forest. The area has an annual rainfall between 1500 to 2000mm. Annual temperatures are high and range between 30°C from March to April and about 26°C in August. Average relative humidity is high ranging from 60% to 70%.

The District is characterized by undulating topography and has an average height of about 200m above sea level. Flood-prone plains of rivers and streams lay low below sea level.

The land area is underlain by geological strata of Cape Coast Granite Complex belonging to the pre-Cambrian Platform. It comprises basically granites, grandiosities and adamellites. It is schistose in some communities and very massive in others. It also includes several components ranging in composition from grandiorites to granites and their migmatitic varieties. The predominant mica minerals are muscovite and biotite. 60% of the communities however are underlain by the lower Birrimian Phyllites, which are often associated with extensive decomposition basins and thick weathering mantles. (Ghana Districts website).

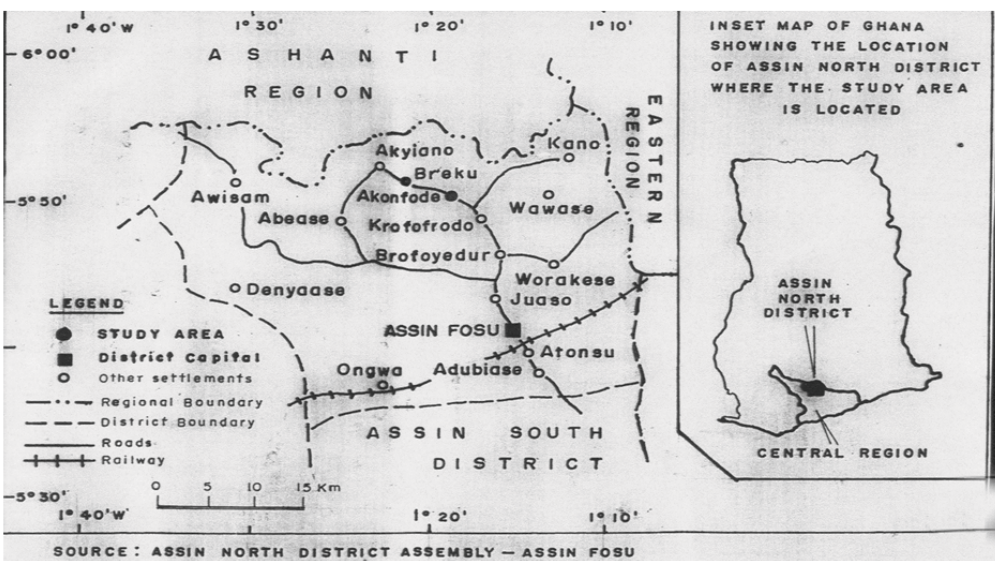

Fig. 1: A map of Assin North District showing Assin Akonfodi and Assin Bereku as the study area

Experimental Work:
3.1. Sampling:

The soil samples were collected from Assin Akonfodi and Assin Bereku in the Assin North District. Soil samples of (0-5cm) depth, (5-30cm) depth, and (30-40) depth were taken from these farms. Each sample comprised of composite of 5 sub samples taken across a $5\times5m^2$. The samples were collected with a hand auger (a stainless steel screw) and hand spade and transferred into a clean polyethylene bags to avoid any contaminations. 15 samples were taken from each farm.

3.2. Sample Preparation:

The samples were then brought to the laboratory and then air dried for 72 hours (3 days) and the desaggregated, sieved to 0.5mm. The fine soil was used for analysis. One hundred milligrams (100mg) of each of these fine samples were weighed onto ultra clean polyethylene sheets wrapped nicely and heat sealed. Each sample was weighed thrice; one to be for short lived nuclides, the second for medium-lived nuclides and the last for the long-lived nuclides. The samples weighed for medium-lived and long-lived nuclides were packed into rabbit capsules (they were packed as many as the capsule could contain) and heat sealed for irradiation. The samples weighed for short lived nuclides on the other hand were packed singly into rabbit capsules (stocking the space left in the rabbit capsule with cotton wool to make sure that the sample does not move in the capsule) and heat sealed for irradiation. Some were also used to check for the pH and salinity of the soil since they play an important row to absorption of nutrients by plants.

3.3. Reference Material:

Two certified standard reference soil materials SOIL-7 and GBW07106 were similarly prepared, weighed and heat sealed for irradiation. The certified reference materials were used as quality control to validate the analytical technique.

3.4. Sample Irradiation, Counting and Analysis:

Irradiation of the samples was done using the Ghana Research Reactor-1 (GHARR-1) facility operating at half power of 15kW and at a neutron flux of 5.0×10^{11} neutrons /cm^{2-s1}. The scheme for irradiation was chosen according to the half-lives of the elements of interest, samlpe metrix and the major elements present. Radionuclides with half-lives ranging from seconds to minutes were given short irradiation of 10s. Radionuclides with half-lives ranging from hours to about 3 days were given medium time of irradiation of 1 h. Radionuclides with half-lives above the medium category received long irradiation for 6 h.

Samples given short irradiation were allowed to decay for a limited period of time before the gamma spectral intensities were measured to determine the elemental compositions. The gamma spectral intensities for medium and long half-life radionuclides were also measured after 2 days and between 2-4 weeks decays period respectively.

After irradiation, the samples were counted for 10 minutes for both short and medium and 10 hours for the long radionuclides on a PC-based gamma-ray spectrometry system. The spectrometry system consists of high purity germanium (HPGe) N-type coaxial detector, an Ortec multi-channel analyzer (MCA) emulation software card and a Pentium II computer for spectrum and data evaluation and analysis. During counting, the samples were placed at a distance of 7.2 cm from the surface of the detector. The areas under the photopeaks of the identified elements were integrated and converted into concentration using the single relative comparator method.

RESULTS AND DISCUSSION

4.1. Validation of the Analytical Methods:

The results were validated using IAEA-Soil-7 and GBW 07106 Certified Reference Material as shown in Table 1 and Table 2. The experimental data compared favourably well with the certified data.

Table 1: Analysis of IAEA-Soil-7 by INAA

Element	This Work	Certified Values
K	12090±363	12100±363
Ca	163009±4890	163000±4890
Mg	11306±339	11300±339
Cu	18±0.54	11±0.33
Mn	639±19	631±18
Mo	3.1±0.09	2.5±0.08
Na	247±7	240±7

Table 2: Analysis of GBW07106 by INAA

Element	This Work	Certified Values
Cl	50±10	44±9
Cu	15±1	19±2
Mn	147±9	155±10
Mo	0.99±0.22	0.76±0.21

4.2. Concentrations of the Nutrient Studied from the Two Palm Plantation

Table 3: Average concentrations and concentration ranges (mg/kg) of elements at various depths in soil from a Palm plantation in Assin Akonfudi (AABP)

Element	Average concentrations at various depths in soil			Concentrations ranges at various depths in soil		
	0-5cm	5-30cm	30-40cm	0-5cm	5-30cm	30-40cm
K	757.95±38	1015.08±51	1096.05±55	578.37-1093.91	795.56-1393.36	765.05-1627.31
Ca	2224.75±111	2439.75±122	3230.41±162	1516.92-2657.80	1487.73-3164.72	1098.33-4976.69
Fe	3907.50±195	4093.30±204	3995.20±199	3115.50-4560.50	3684.50-4730.00	2346.00-4789.00
Na	219.02±11	233.54±12	231.20±12	170.62-249.96	197.53-263.05	187.17-280.55
Mn	67.80±3.39	64.72±3.24	53.01±2.65	50.95-77.85	43.10-81.30	34.85-68.40
Mg	10.48±0.52	10.46±0.52	9.80±0.49	7.60-11.60	9.70-11.30	8.40-10.9
Zn	3.44±0.17	3.93±0.20	4.20±0.21	1.80-5.40	2.05-6.25	0.85-6.75
Cu	8.68±0.43	10.03±0.50	10.55±0.53	4.90-12.60	7.30-16.10	5.20-17.90
Cl	35.73±1.79	28.50±1.42	42.30±2.12	9.69-75.59	8.46-60.40	9.03-113.02
Co	1.56±0.08	1.22±0.06	1.56±0.08	1.00-2.20	0.03-2.60	0.55-2.85
Mo	0.21±0.01	<0.01	<0.01	<0.01-1.05	<0.01	<0.01

Table 4: Average concentrations and concentration ranges (mg/kg) of elements at various depths in soil from a Palm plantation in Assin Breku (BBP)

Element	Average concentrations at various depths in soil			Concentration ranges at various depths in soil		
	0-5cm	5-30cm	30-40cm	0-5cm	5-30cm	30-40cm
K	535.78±27	753.50±38	867.43±43	323.64-850.89	592.03-893.63	686.47-958.12
Ca	2001.22±100	2301.65±115	2688.23±134	1389.32-2492.78	1293.93-2862.93	993.54-3928.92
Fe	2630.71±132	2923.38±146	2932.97±147	1046.79-3802.83	2058.44-3591.89	1903.22-3986.52
Na	207.22±10.36	211.51±10.58	221.07±11.05	194.50-230.34	170.53-242.93	189.32-259.10
Mn	53.36±2.67	51.27±2.56	39.95±1.20	40.24-63.02	38.92-63.99	20.58-59.43
Mg	10.13±0.51	9.73±0.49	8.87±0.44	6.50-11.91	8.30-11.67	7.30-10.56
Zn	3.09±0.15	3.84±0.19	3.99±0.20	1.85-4.78	2.19-5.95	1.57-6.83
Cu	7.18±0.36	8.19±0.41	9.52±0.48	3.06-9.56	6.92-9.34	8.93-10.56
Cl	26.36±1.32	28.79±1.44	25.39±1.27	14.93-53.53	10.53-50.43	14.46-48.03
Co	1.17±0.06	0.90±0.05	1.20±0.06	0.93-1.82	0.29-1.56	0.31-2.56
Mo	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

4.3. pH and Salinity values:

The average pH values measured in the soil at the various depths in the two palm plantation farms are presented in Table 3, while the average salinity values in the soil at the various depths from the two cocoa farms are presented in Table 4.

Table 5: pH of samples taken from the two palm plantation farms

Sample name	Average pH at various depth			pH ranges at various depth			PreferredpH
	0-5cm	5-30cm	30-40cm	0-5cm	5-30cm	30-40cm	
AABP	6.00	5.90	5.73	5.49-6.36	5.41-6.25	4.90-6.44	5-5.5
BBP	5.90	5.87	5.73	5.46-6.21	5.31-6.22	4.96-6.43	

Table 6: Salinity of samples taken from the two palm plantation farms

Sample name	Average salinity at various depth			Salinity ranges at various depth			Preferred salinity
	0-5cm	5-30cm	30-40cm	0-5cm	5-30cm	30-40cm	
AABP	0.91	1.03	1.16	0.31-1.56	0.41-1.54	0.69-1.78	0-2
BBP	1.48	1.65	1.80	1.23-1.75	1.43-1.83	1.63-1.96	

Discussion:

The pH and salinity are as shown in Tables 5 and 6. Although the pH of the sample falls within acidic range, the pH of the top soil (0-5cm) were slightly higher than those of the sub soils, at the depth of 5-30cm and 30-40cm. pH of soil samples at the depth of 5-30cm were also slightly higher than those at the depth of 30-40. In all the pH decreased as the depth increased.

The average pH of soil samples from palm plantation in Assin Akonfudi (AABP) were 6.00 at 0-5cm, 5..90 at 5-30cm and 5.73 at 30-40cm which were all higher than the preferred pH and ranged from 5.49-6.36 at 0-5cm, 5.41-6.25 at 5-30cm and 4.90-6.44 at 30-40cm as shown in Table 5

The average pH of the soil samples from palm plantation in Assin Bereku (BBP) were 5.90 at 0-5cm, 5.87 at 5-30cm and 5.73 at 30-40cm which were all within the preferred pH and ranged from 5.46-6.21 at 0-5cm, 5.31-6.22 at 5-30cm and 4.96-6.43 at 30-40cm as shown in Table 5

For the salinity, the top soil (0-5cm) were slightly lower than that of the sub soils, that was those at the depth of 5-30cm and 30-40cm. Salinity of soil samples at the depth of 5-30cm was also slightly lower than those at the depth of 30-40. In all the salinity increased as the depth also increased.

The average salinities of soil samples from palm plantaion in Assin Akonfodi (AABP) were 0.91 (dS/m) at 0-5cm, `1.03 (dS/m) at 5-30cm and 1.16 (dS/m) at 30-40cm, all of which were within the preferred salinity in soil and ranged from 0.31-1.56 (dS/m) at 0-5cm, 0.41-1.54 (dS/m) at 5-30cm and 0.69-1078 (dS/m) at 30-40cm as shown in Table 6.

The average salinities of the soil samples from palm plantation in Assin Bereku (BBP) were 1.48 (dS/m) at 0-5cm, 1.65 (dS/m) at 5-30cm and 1.80 (dS/m) at 30-40cm which were all within the preferred salinity of soil and ranged from 1.23-1.75 (dS/m) at 0-5cm 1.43-1.83 (dS/m) at 5-30cm and 1.63-1.96 (dS/m) at 30-40cm as shown in Table 6.

The concentrations of elements in soil from palm plantation in Assin Akonfodi are as shown in Table 3. Of the elements iron (Fe) recorded the highest concentration in the soil and molybdenum (Mo) recorded the least concentration in the soil as shown in Table 3.

From the average concentrations, manganese (Mn), and magnesium (Mg) concentrations insoil decreased as the depth in soil increased. These elements were highest in 0-5 cm and lowest at 30-40cm as shown in Table 3

From the average concentrations, potassium (K), calcium (Ca), zinc (Zn) and copper (Cu) concentrations in soil rather increased as the depth in soil increased. These elements were highest at 30-40cm and lowest at 0-5cm as shown in Table 3

From the average concentrations, iron (Fe) and sodium (Na) concentrations in soil were highest at 5-30cm depth and lowest at 0-5cm depth and chlorine concentration in soil was highest at 30-40cm and lowest at 5-30cm depth as shown in Table 3

From the average concentrations, cobalt (Co) concentration in soil was highest at 0-5cm and 30-40cm which have the same concentration and lowest at 5-30cm and molybdenum (Mo) concentration in soil was highest at 0-5cm and lowest at both 5-30cm and 30-40cm of which were below detection limit as shown in Table 3.

The concentrations of elements in soil from palm plantation in Assin Breku are as shown in Table 4. Of the entire element iron recorded the highest concentration in the soil and molybdenum recorded the least concentration in the soil.

From the average concentrations, manganese (Mn) and magnesium (Mg) concentrations decreased as the depth in soil increased. These elements were highest in 0-5 cm and lowest at 30-40cm as shown in Table 4
From the average concentrations, potassium (K), calcium (Ca), iron (Fe), sodium (Na), zinc (Zn) and copper (Cu) concentrations rather increased as the depth in soil increased. These elements were highest at 30-40cm and lowest at 0-5cm as shown in Table 4

From the average concentrations, chlorine (Cl) and selenium (Se) concentrations in soil were highest at 5-30cm and lowest at 30-40cm depth and cobalt (Co) concentration in soil was highest at 30-40cm depth and lowest at 5-30cm depth as shown in Figure Table 4

The palm plantation soil at Assin Akonfodi recorded the highest concentrations of the nutrients as compared to that of the soil from Assin Breku.

Conclusions:

INAA with conventional counting system has been used to analyze soil samples from palm plantation from both Assin Akonfodi and Assin Bereku in the central region. The concentrations of K and Fe in soil samples from both farms were far above the preferred concentration needed for plants growth (i.e. 100-400mg/kg and 50-250mg/kg respectively (Rai, 1977; Robinson, 1946) and this may be due to the geology of the place which is rich in mica.

In the same way the concentrations of Mn in soil from both farms were slightly higher than the preferred concentrations needed for plant growth and even fell within range at 30-40 cm depth in Assin Breku (i.e. and 10-50mg/kg (Rai, 1977; Robinson, 1946) and this may also be due to the geology of the place which is rich in Birrimain phyllites and mica. But for Mn the concentration only becomes toxic to plants when the concentration exceeds 300mg/kg (Doberman and Fsirhurst, 2000) which the concentrations from soil from both farms fell below.

For Ca the concentrations in soil from both farms were also above the preferred concentration needed for plant growth (i.e. 20-100mg/kg (Rai, 1977; Robinson, 1946).

For Mg and Na the soil from cocoa farm from Assin Akonfodi were within the preferred concentration needed for plant growth. (i.e. 10-40mg/kg and 1-1000mg/kg respectively (Rai, 1977; Robinson, 1946)

For Cu all the concentrations in soil from both farms were within the preferred concentration needed for plants growth except concentration of soil at 0-5cm from Assin Bereku which was slightly below the preferred concentration (i.e. 5-20mg/kg (Rai, 1977; Robinson, 1946).

For Zn, and Co, all the concentrations in soil from both farms were within the preferred concentration needed for plants growth (i.e. 2.5-150mg/kg, and 0.02-5mg/kg respectively (Rai, 1977; Robinson, 1946).

For Cl, all the concentrations in soil from both farms were within the preferred concentration needed for plant growth except of concentrations in soils at 5-30cm and 30-40cm depths from Assin Bereku which were within the preferred concentration (i.e. 20-200mg/kg (Rai, 1977; Robinson, 1946).

The soil pH and salinity were all normal range and will not have any adverse effect on plants.

From the results obtained it is recommended that no fertilizer be added to the soil as at now since all the nutrient needed for plant growth were at an appreciable concentration or even more except for Mo with was lacking in the soil so therefore the need to add a Mo fertilizer. Any addition of nutrient to the soil could bring problems to the plants.

With this result more studies can be extended to other regions where farming is one of the major occupations for a better yield.

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