International Journal of Engineering and Information Systems (IJEAIS)
ISSN: 2643-640X
Vol. 4, Issue 5, May – 2020, Pages: 18-26

Determination of Physical, Chemical and Heavy Metals Properties of Soil Sample in Department of Science Laboratory Technology (SLT) Farm, Esa Oke

Abideen Adeyinka Adekanmi [1], Sherifdeen Adeniyi Adekanmi [2], Opeyemi shafiu Adekanmi[3]

[1]Raw Materials Research and Development Council, Abuja, Nigeria
[2]Lautech Teaching Hospital, Osogbo, Osun State, Nigeria
[3]Centremog Limited, Lagos, Nigeria

Abstract: *Success of the farming activities is based on soil meant for crops cultivation and the fertility of the soil where farmers are growing their crops. Soil fertility refers to the inherent capacity of a soil to supply essential nutrients to sustain at a high level to produce adequate food to feed its burgeoning population. Proper management of soil fertility required careful identification of problems of current nutrient deficiencies and adequate monitoring of changes in soil fertility to predict its deficiency. Despite huge roles attributed proper and constant management of soil fertility, proper consideration and adequate attention were not given to it by farmers and there is lack or no awareness from government to sensitization. As part of effort to correct this menace, this study focus on determination of physical, chemical and heavy metals properties of soil sample in department of science laboratory technology farm, Osun State College of Technology, Esa Oke. Soil sample was collected from Science Laboratory Technology farm at 15 cm depth with the aid of soil auger. Samples were prepared and analyzed for physical and chemical properties. Micronutrients, macronutrients and selected heavy metals were analyzed by standard methods. Data generated from laboratory analysis were subjected to statistical analysis. Results obtained showed that irrespective of the land use, soil of the study area was neutral with high sand fraction (> 70%) resulting to poor physical condition such as poor moisture retention and total porosity. The properties showed Soil texture (Loamy sand) , Soil pH (7.4±0.02), Electrical Conductivity (0.45±0.03), Organic carbon (0.70±0.02), Organic matter (27.87±0.09), Total porosity (63.8±0.40%), Bulk density (1.14±0.03g/cm^3), Cation Exchange Capacity (12.51±0.15 Cmol/kg), Available nitrogen (208.45±0.03mg/kg), Phosphorous (22.47±0.11mg/kg), Potassium (650.41±0.30 mg/kg), Sulphur (15.05±0.03), Zinc (0.85±0.03), Iron (8.47±0.05 mg/kg), Manganese (3.69±0.04 mg/kg), Copper (6.89±0.04 mg/kg), Cadmium (0.22±0.02), Chromium(20.45±0.03), Manganese (65.37±0.06), Lead (15.58±0.07) and Zinc(125.21±0.03). There is urgent need to adopt strategic management measures and agronomic guidelines to improve the quality and level of fertility.*

Keywords: Soil, Physico-chemical property, Heavy metals, fertility, Nutrient index, Organic matter, land use.

INTRODUCTION

The quality of soil in a particular farm is determinant of yield of agricultural production and products. For effective yield of agricultural products during harvesting, then high quality of soil is required. The loss most farmers suffer and complaints of poor yields of the crops care mostly linked to poor quality soil in agricultural farmland. Like other living beings, plants require food for their growth, development and reproduction which will go in long to enhance maximum output during harvesting season (Njoyim *et al*., 2016a).

The current challenges and problems facing agriculture today is to meet the world's increasing demand for food in a sustainable way and possible declining of soil fertility; however the task is more undaunted as a result of mismanagement of plant nutrients (Yaser and Rahim, 2013). Nutrient content, amongst other physico-chemical factors such as soil pH are determinant of richness of a soil for agricultural activities. Thus, evaluation of the the quality of soils (nutrient content) involves in agricultural practices is paramount and beneficial for the maintenance and sustenance of required optimum growth conditions by plants for maximum yields (Njoyim *et al*., 2016a).

The major agricultural and environmental problem in the world presently is linked to Soil degradation (Ruqia *et al*., 2015; Njoyim *et al*., 2016b). There is urgent need for greater understanding of soils in relation to management of its fertility so as to enhance agricultural productivity while nurturing soil health and preventing water pollution. Another serious problems facing quality of soil for agricultural practices that call for serious concerns is contamination of farmland by heavy metals (Njoyim *et al*., 2016c). As a result of toxic effect exerted on plants by their high concentrations, heavy metals are distinguished as a special group of element by soil chemistry (Vodyanitskii, 2016).

One of the global challenges facing food production and the sustainability of life is Heavy metals pollution in agricultural soils. Studies has traced pollution of agricultural soils to long-term farming, excessive use of agrochemicals, wash away of chemicals from nearby industry by rainfall and dumping of used chemicals containers to nearby farm (Osobamiro and Adewuyi, 2015). The accumulated contaminants in the plants affected the growth of plant, quality of crops and also threaten the health of consumers (Cheng and Huang, 2006). Cadmium(Cd), Arsenic (As), Chromium (Cr), Copper (Cu), Silver (Hg), Lead (Pb), Nickel (Ni), and Zinc (Zn) are most known common heavy metal contaminants, while metals like Zn, Cu, Mn, Ni, Co are micronutrients necessary for plant growth, others such as Cd, Pb, As, and Hg have no history of biological functions and are very toxic to human health.

Anthropogenic activities like draining of sewerage, dumping of hospital wastes and recreational activities are one of the sources of heavy metals. Naturally, metals occur in small amounts and through leaching of rocks, airborne dust, forest fires and vegetation may enter into aquatic system (Ruqia et al., 2015). In the form of mobile ions present in the soil solution through their roots, plants grown on land polluted with municipal, domestic or industrial wastes can absorb heavy metals. These absorbed metals get bio-accumulated in the roots, stems, fruits, grains and leaves of plants (Oluyemi et al., 2008).

Agriculture is the backbone of the economy of any country. The essence of the Science Laboratory Technology (SLT) farms by department of SLT at Osun State College of Technology Esa Oke is borne out need to meet requirement of National Board of Technical Education (NBTE) for awards of Ordinary National Diploma (OND) and desires of department to raise her Internal Generated Revenue and make food abundant for the staffs. Hence, it is pertinent to evaluate soils used for crop production and suggest methods to improve on agricultural yields, while preventing water pollution in all its forms. There is no previous works carried out to evaluate the potentials of these soils for agricultural practices. For successful crop production by soil , an adequate supply of all necessary nutrients that plants need are not enough guarantee but must also be totally free from toxic heavy metals. Due to the fact that practices in this farm involves the use fertilizers (which are sources of heavy metals) to improve on their agricultural yields; it is therefore necessary to test the soil in order to ensure not only high productivity but its quality as well (Njoyim et al., 2016c).

Based on aforementioned problem, the current study was to determine the objective of the physic-chemical, quality, and heavy metal properties of soil in SLT farm at Osun State College of Technology (OSCOTECH), Esa oke, in order to provide information on the nutrient status and the level of heavy metal contamination of the soils.

2. MATERIALS AND METHODS

2.1 Samples collection and Preparation

The soil samples were collected from department of Science Laboratory Technology (SLT) farm, Osun State College of Technology, Esa-oke, Osun state. This was done at depth of 15 cm with the aid of soil auger. The geographical coordinates of the place are 7° 46' 0" North and 4° 54' 0" East. The sample was collected in a sterile polythene bag and taken to departmental laboratory for analysis.

2.2 Soil texture

This was carried out by hydrometer method described by Gee and Bauder (1986). To 50 ml of the dispersing agent (sodium hexa-metaphosphate), 50g of air-dried soil sample and 200 ml of distilled water were added. The soil suspension was shook at 150 rpm overnight on a reciprocating shaker in a horizontal position. The suspension from the bottle was transferred to a sedimentation cylinder (a liter) and with distilled water, the volume of mixture was made to one litre. After five minutes as well as after five hours, hydrometer readings were taken and the relative size proportions (i.e. sand, silt and clay) were calculated. This was followed by establishing the textural classes using the USDA textural triangle.

2.3 Physical and Chemical properties

i. Determination of soil pH

Twenty grams of the soil sample was weighed and put in a 100-ml beaker and 20 ml of distilled water was then added and left for 20 minutes with occasional stirring with a glass rod to enable it reach equilibrium. The pH was determined with a pH meter (Pramer and Schmidt, 1984).

ii. Determination of electrical conductivity

The soil suspension for pH determination was allowed to settle down and conductivity of supernatant liquid was determined by using conductivity meter (Piper, 1950). The result was expressed in dSm^{-1} at 25ºC.

iii. Organic carbon and total nitrogen

Organic carbon was determined by the wet digestion method of Walkley-Black (Moberg, 2000). Total Nitrogen was determined by micro-Kjeldahl digestion followed by distillation as described by Bremner and Mulvaney (1982).

iv. Determination of Organic Matter Content

Four crucibles were dried in the oven at 105^{o}C for 24 hours for the soil sample. They were then cooled in a desiccator and their weights taken separately. Five grams of each of oven-dried soil samples were weighed with each of the four crucibles. The samples were transferred into furnace and dried at 600^{o}C for 3 hours and weight of each sample was again taken. The percentage of organic matter in each sample was then calculated with the following formula.

Loss in weight of sample

Initial weight of sample x 100% (Pramer and Schmidt, 1984)

iv. Determination of Total Porosity of the Soil

a. Particle Size Analysis (PSA)

This was determined using hydrometer method with Sodium hexametaphosphate (Calgon) as dispersal agent according to Gee and Or (2002) and the textural class was determined using textural triangle

b. Bulk Density (BD)

This was estimated using the core method according to Grossman and Reinsch (2002) using the formula which is calculated mathematically as follows:

Bulk density (BD) = V / V ………………………………… equation 1

Where,

V = Mass of oven-dried soil and V = Volume of core sampler.

c. Total Porosity (P)

This was calculated from bulk density as

P = 1 (Bd / P*d*) x 100 ………………………… equation 2.

Where,

P*d* = particle density (2.65)

vi. Bulk density
Bulk density was determined using minimally disturbed core samples (7cm x 7cm) for each depth as described by Blake and Heritage (1986).

2.4 Determination of exchangeable bases and cation exchange capacity

The Cation exchange capacity was determined by the ammonium acetate saturation methods as described by Chapman (1965). Exchangeable Calcium and Magnessium in the ammonium acetate lechate was determined by atomic absorption spectrophotometry while exchangeable potassium and sodium was determined using the flame photometer method.

2.5 Macronutrients in the Soil

i. Available Nitrogen

It was determine by alkaline permanganate method (Subbiah and Asija, 1956). 20g of soil sample was taken in I litre flask and to it added 100 ml of 0.32% KMno4 and 2.5% NaoH each. The flask was immediately connected to distillation assembly and heated. The distilled ammonia was collected in 0.1N H2So4 using methyl red indicator. The excess of sulphur acid was titrated against 0.1N NaoH. Results have been expressed in N kg/ha.

ii. Extractable phosphorus

Extractable Phosphorous was determined according to the Bray-1 method (Moberg, 2000) followed by colour development by the ascorbic acid method of Murphy and Riley, (1962). Absorbency was measured by a Spectrophotometer at 884 nm wavelength after the blue colour had fully developed with appropriate standards (Moberg, 2000). The absorbency was used to calculate percentage phosphorus.

iii. Available potassium

One gram of soil was shook with 100 ml of neutral normal ammonium acetate solution as an extractant in 200 ml conical flask for 30 minutes and then filtered through Whatman number 40 filter paper. The amount of potassium present in extract was determined by flame photometer as described by Black (1965). The result was calculated as K kg/ha.

iv. Extractable Sulfur and Zinc

The sulfur content in soil was determined by colorimetric method and the quantity determined using spectrophotometer at 535 nm as described by Motsara and Roy (2008). About 0.05M DTPA – extractable Zinc was determined by atomic absorption spectrophotometer **(**Moberg, 2000).

2.6. Available micronutrients

The micronutrients Cupper, Iron and Manganese were extracted by using 0.005 M diethylenetriaminepenta acetic acid, 0.01 M calcium chloride dehydrate and 0.1 m trithanol amine buffered at pH 7.3 (Lindsay and Norvell, 1978) and concentrations were analyzed by atomic absorption spectrophotometer 4129.

2.7 Trace and Heavy Metals

Trace and heavy metals determination were carried out by collection of soil samples into clean and well-labelled 2- litre plastic containers at a maximum depth of 1 meter. Soil samples were preserved in plastic bags. All the samples collected were placed in ice and rushed to the laboratory where they were kept in an ice-box at –20 °C until analyzed. The samples were mineralized by the Microwave Digestion System 2000 using HNO_3 (65%) and H_2O_2 at 180 °C and a pressure of 1300 psi. The solution obtained after sample digestion were diluted, filtered onto paper and analyzed for heavy metals by the Inductive Coupled Plasma – Mass Spectrometry (ICPMS). This technique permits the measurement of a series of elements at the same time. The instrument sensitivity is 1 ppb for almost all the elements investigated. Sample volume will range from 10 to 50 ml and will be injected by a nebulizer, (A.P.H.A. 2002 and Ravera *et al*., 2003). Samples were analyzed for Cadmium, Cromium, Manganese, Lead and Zinc concentrations.

2.7 Statistical Analysis

Data are expressed as mean± standard deviation of triplicates

3. Result and Discussion

3.1 Soil Texture

The textural class of the soil was loamy sand for the soil sample with soil separates percentage of Silt (5%), Clay (10%) and Sand (85) Table 1.

3.2 Physical and Chemical Properties of the Soil

i. Soil reaction (pH):

The pH of soil collected from SLT farm is 7.4±0.02 Table 2. This was similar to work of Sudharani and Jayasree (2012), they reported pH of between 5.5 to 8.5in the soils of Nalgonda district. In general, the pH appeared to be influenced by parent material, rainfall and topography (Thangaswamy *et al.* 2005). The higher pH could be due to increase in accumulation of exchangeable sodium and calcium carbonate.

ii. Electrical conductivity:

Electrical conductivity was in safe range in the soil (0.45±0.03) Table 2 which indicated that the black soil pedons were less leached. In the soils studied, the electrical conductivity generally increased with depth. The upper Colum was relatively low in salts than in the lower Colum. This might be due to leaching of salts from the soil surface to lower depths due to irrigation and their accumulation in lower depths.

iii. Organic carbon

Organic carbon content of the soil sample is 0.70±0.02 mg/kg Table 2. The lower contents of organic carbon apparently resulted because of high temperature which induced rapid rate of organic matter oxidation, while the declining trend towards the accumulation of crop residues every year, without substantial downward movement. observations in the line with the present findings have been reported by Nazif *et al.* (2006) They showed that majority of the soil sites were medium in organic carbon content.

Low organic carbon in the soil is due to low input of FYM and crop residues as well as rapid rate of decomposition due to high temperature. The organic matter degradation and removal takes place at faster rate coupled with low vegetation cover there by leaving less changes of accumulation of organic matter in the soil. High temperature and good aeration in the soil increases the rate of oxidation of organic matter resulting reduction of organic carbon content. The high temperature prevailing in the area is responsible for the rapid burning of organic matter, thus resulting in medium organic carbon content of these soils.

iv. Soil Organic Matter

The value recorded for soil organic matter in this study is 27.87±0.90 (Table 2). The positive impacts of soil organic matter result from a number of complex, interactive edaphic factors; a non-exhaustive list of soil organic matter's effects on soil functioning includes improvements related to soil structure, aggregation, water retention, soil biodiversity, absorption and retention of pollutants, buffering capacity, and the recycling of storage of plant nutrients. It increases soil fertility by providing cation exchange sites and acting as reserve of plant nutrients, especially nitrogen (N), phosphorus (P), and sulphur (S), along with micronutrients, which is slowing released upon soil organic matter mineralization. As such, there is a significant correlation between soil organic matter and soil fertility.

v. Soil Total Porosity

Soil total porosity of the soil in this study is 63.8±0.40 Table 2. Increase in soil bulk density resulted to a decrease in soil total porosity which could be attributed to compaction of soil macro and micro pore spaces (Onweremadu, 2007). The high moisture content was recorded in this soil with 476.8 g/kg of moisture retention.

vi. Soil Bulk Density

The soil had the bulk density of 1.14 g/cm^3 Table 2. The high bulk density recorded could be attributed to tillage activities. The value of bulk density is below the critical limit of 1.3g/cm3 recommended for tuber and cereal crops (Kayombo and Lal, 1984).

vii. Soil Cation Exchange Capacity

Cation exchange capacity measures the soil's ability to hold nutrients such as calcium, magnesium, and potassium, as well as other positively charged ions such as sodium and hydrogen. According to A and L laboratories (2005), the CEC of a soil is dependent upon the amounts and types of clay minerals and organic matter present. The CEC of the soil in this study is 12.51±0.15 Cmol/kg Table 2. According to UGA, (2014), CEC of loam soil ranges between 5 Cmol/kg and 15 Cmol/kg.

Table 1: Soil Texture of Soil Sample Collected from SLT Farm

Texture	Soil separates (%)	Texture Class
Silt	5	Loamy sand
Clay	10	
Sand	85	

Table 2: Physical and Chemical Property of the Soil

Physical and Chemical Properties	Soil Sample
pH	7.4±0.02
Electrical Conductivity	0.45±0.03μScm^3
Organic Carbon	0.70±0.02g/kg
Organic Matter	27.87±0.90g/kg
Soil Porosity	63.8±0.40%
Bulk Density	1.14±0.03 g/cm^3

Cation Exchange Capacity	12.51±0.15 Cmol/kg

3.3 Fertility status

i. Available Nitrogen Content

The available nitrogen content in this study is 208.45 kg ha^{-1}(Table 3). Kumar *et al.* (2009) and Nayak *et al.* (2015), observed a similar trend of nutrient status in the study area soils. Fertility status of N, P, K and S are interpreted as low, medium and high and that of zinc, iron, copper and manganese interpreted as deficient, sufficient and excess by following the criteria given below.
The available N content (Table 3) of the soil is 208.45 kg ha^{-1}. Considering the soil test rating for available N (<250 as low, 251-400 as medium and >400 as high in the status of N) the soils fall under low status (<250 kg ha^{-1}) in available N content. This might be due to low organic matter content in these soils. The reason for low content of available nitrogen might be due to the fact that N is lost through various mechanisms like volatilization, nitrification, denitrification, microbial fixation, leaching and runoff (De Datta and Buresh, 1989) which resulted in low amount of available N in soil. The total nitrogen content in the soils is dependent on temperature, rainfall and altitude. Another possible reason may also be due to low organic matter content in these areas due to low rainfall and low vegetation facilitate faster degradation and removal of organic matter leading to nitrogen deficiency.

ii. Available phosphorous

The value recorded for phosphorous is 22.47±0.11 kg ha^{-1} Table 3. The variation in available P is quite large, which might be due to variation in soil properties *viz*., pH, organic matter content, texture and various soil management and agronomic practices adopted by the farmers of the region.
Phosphorus is present in soil as solid phase with varying degree of solubility. When water soluble P is added to the soil, it is converted very quickly to insoluble solid phase by reacting with soil constituents. These may include calcium carbonate (olsen, 1953), Fe and Al oxides (Chu *et al.* 1962) and partly organic matter. These reactions affect the availability of P and as a result of these reactions, a very small amount of total P is present in soil solution at any time reflected by soil testing. However, a low to medium range of soil available P under study area may be mostly affected by past fertilization, pH, organic matter content, texture various soil management and agronomic practices (Verma *et al*., 2005).

iii. Available Potassium

The available potassium content in the study area was under high (650.51 kg ha^{-1}) category (Table 3). The high in K status might be due to predominance of K rich micaceous and feldspars minerals in parent material. In addition Kaolinite type of clay mineralogy is the causes for their medium and low rating. Adequate (medium or high) available K in these soils may be attributed to the prevalence of potassium-rich minerals like *Illite* and *Feldspars* (Sharma *et al.,* 2008).

iv. Available Sulphur

Considering the soil test rating for available S (< 10mgkg^{-1} as low, 10-20mg kg^{-1} as medium and >20mg kg^{-1} as high in the status of S), the soil sample in this study fall under medium (15.05±0.03) Table 3 status in available S content.

3.4 Available micronutrients:

i. Available zinc:

Considering the soil test rating for available Zn (< 0.6 mg/kg as deficient, 0.6- 1.2 mg/kg as sufficient and >1.2 mg/kg as high in the status of Zn), the soil in this study fall under sufficient (0.85±0.03 mg/g) Table 4 in available Zn content. In well drained aerated calcareous soils zinc exists in oxidized state and their availability becomes low. The results are in conformity with the finding of Sharma and Chaudhari (2007) in soils of Solan district in North-West Himalayas and also similar findings by Rajeswar*et al* (2009).

ii. Available iron

The iron content recorded in this study is 8.47±0.05 mg/kg Table 4. The soil pH had reverse effect on the availability of Fe content in soil. Low Fe content may be due to precipitation of Fe^{2+} by CaCo3 and decrease the availability. The available iron in surface soils has no regular pattern of distribution as reported by Nayak *et al.* (2002). This type of variation may be due to the soil management practices and cropping pattern adopted by different farmers.

iii. Available manganese:

The value recorded for manganese Mn in this study is 3.69±0.04 mg/kg Table 4. In the study, the available manganese was found sufficient in the sample analyzed. This may be due to neutral pH and nature of the parent material as reported by Prasad and Sahi (1989). Sufficient content of manganese due to high organic matter content was observed in Upper Krishna Command Area by Yeresheemi *et al.* (1997).

iv. Available copper:

The value recorded for copper in this study is 6.89 ±0.04 mg/kg Table 4. Singh *et al*. (2001) reported that available copper content in Madhya Pradesh soils ranged from 0.12 to 5.77 mg/kg. Similar results were also observed by Singh and Raj (1996) in flood plains of Himachal Pradesh.

Table 3: Available Macronutrients (Fertility status) in Soil Sample Collected from SLT Farm

Available Macronutrients	Value Obtained (mg/kg)
Nitrogen	208.45±0.03
Phosphorous	22.47±0.11
Potassium	650.41±0.30
Sulphur	15.05±0.03

Table 4: Available Micronutrient in Soil Sample Collected from SLT Farm

Available Micronutrients	Value Obtained (mg/kg)
Zinc	0.85±0.03
Iron	8.47±0.05
Manganese	3.69±0.04
Copper	6.89±0.04

3.5 Soil Heavy Metals

The results of the metals concentration of the soil sample was shown in Table 5. The levels of the metals; Cd, Cr, Mn, Pb, and Zn present in the soil were relatively tangible, but far below the permissible limits. This is as a result of the past and present irrigation and fertilizer application pattern practice, of using untreated wastewater and organic manure on the farmland.

The concentrations of the heavy metals on the soil sample varied between 0.22 ±0.02mg/kg Cd, 20.45±0.03mg/kg Cr, 65.37±0.06mg/kg Mn, 15.58±0.07 Pb and 125.21±0.03mg/kg Zn Table 5. The trend of the heavy metals investigated in the soil revealed that Zn>Mn>Cr>Pb>Cd. The values recorded for all heavy metals examined in the soil sample are within the required regulatory standard .The values fell within FAO, WHO AND EU recommended maximum limit.

Table 5: Concentrations of Heavy Metals in the Soil Samples Collected from SLT Farm

Heavy Metals	Heavy metal Concentration in mg/kg	FAO/WHO RML	EU RML
Cadmium	0.22±0.02	3	3
Manganese	65.37±0.06	2000	2000
Lead	15.58±0.07	100	100
Zinc	125.21±0.03	300	300
Chromium	20.45±0.03	50	100

4. Conclusion

From the study, it can be concluded that, soil of SLT Farm are low in soil available organic matter content, available nitrogen, available sulphur, low to medium in available phosphorus high in available potassium. In respect of available micronutrients, zinc, and iron deficiency is there in this soil. Soil organic carbon, available N, P and S are important soil fertility constraints indicating their immediate attention for sustained crop production. The deficient micronutrient may be replenished to avoid the crops suffering from their deficiency and for optimum utilization of other nutrients. Soil nutrient management holds the key for sustainable soil fertility management. The concentration of heavy metals in the soil sample was within the recommended threshold by FAO/WHO.

References

APHA. "Standard Methods for Examination of Water and Wastewater", American Public Health Association WWA, Washington, D.C. 2002

Black. C.A. (1965). Methods of Soil Analysis. *American Society Agronomy Journal.* Madison, Wisconsin U. S. A: 1-19.

Blake, G.R., Hartge, K.H., 1986. Bulk density. In: Methods of Soil Analysis Part 1 Physical and Mineralogical Methods. 2nd Edition, Klute, A., (Ed). ASA-SSSA. Madison, Wisconsin, USA. pp. 363-375.

Bremner, J.M. and Mulvaney, C.S. (1982) Nitrogen-Total. In: Page, A.L., Ed., Methods of Soil Analysis. Part 2. Chemical and Microbiological Properties, American Society of Agronomy, Soil Science Society of America, 595-624.

Cheng, S. and Huang, C. (2006). Influence of cadmium on growth of root vegetable and accumulation of cadmium in the edible root. International Journal of Applied Science and Engineering, 4(3): 243-252.

Emmanuel Uzoma Onweremadu , 2007. Soil Mercury Distribution in a Forest-Savanna Mosaic in Relation to Soil Fertility. Research Journal of Environmental Toxicology, 1: 158-166.

Gee, G.W. and J.W. Bauder, 1986. Particle Size Analysis. In: Methods of Soil Analysis, Part A. Klute (ed.). 2 Ed., Vol. 9 nd . Am. Soc. Agron., Madison, WI, pp: 383-411

Gee, G.W. and Or, D. (2002) Particle Size Analysis. In: Dane, J.H. and Topp, G.C., Eds., Methods of Soil Analysis, Part 4, Physical Methods, Soils Science Society of America, Book Series No. 5, Madison, 255-293.

Grossmans, R. B and Reinch, T. G. (2002). “Bulk density and linear extensibility”. In: *methods of soil analysis. Part 4 Physical Methods. Dane, J.H and G.C Topp (eds.)*. Soil Science Society of Am. Book Series, No 5 ASA and SSA Madison, W. I, pp 201- 228.

Kayombo, B and Lal, R. (1984). Cited by Lal, R. (1986). “Land clearing and development in the tropics”.In: *Bulkerma Publications*, pp 299 - 308.

Kumar, R., Sarkar, A. S., Singh, K. P., Agarwal, B. K. and Karmakar, S. (2009) Appraisal of available nutrients status in Santhal Paraganas region of Jharkhand. *J. Indian Soc. Soil Sci.*57(3): 366-369.

Lindsay, W.L. and Norvell, W.A. (1978) Development of a DTPA soil test for zinc, iron, manganese and copper. Soil Science Society America Journal, 42, 421-428

Moberg GP 200Biological response to stress: Implications for animal welfare In: Moberg GP Mench JA eds. *Biology of Animal Stress: Implications for Animal Welfare* Wallingford, Oxon, UK CAB Int (Forthcoming).

Motsara, M. and Roy, R.N. (2008) Guide to Laboratory Establishment for Plant Nutrient Analysis. Food and Agriculture Organization of the United Nations, Rome.

Murphy, J. and Riley, J.P. (1962) A Modified Single Solution Method for the Determination of Phosphate in Natural Waters. Analytica Chimica Acta, 27, 31-36.

Nayak, R. K.,Sahu,G. C. and Nanda, S. S. K., (2002) Characterization and classification of the soils of Central Research Station, Bhubaneswar. *Agropedology*, 12 : 1-8.

Nazif, W., S. Perveen and I. Saleem, 2006. Status of micronutrients in soils of District Bhimber (Azad Jammu and Kashmir). J. Agric. Biol. Sci., 1: 35-40

Njoyim, E.B.T, Donfack, A., Mofor, N.A. and Tchiaze, F.G. (2016c). Phytoextraction of cadmium by beans and sweet potatoes from soils. *International Journal of Research and Reviews in Applied Sciences*, 28 (2): 65-70.

Njoyim, E.B.T., Mvondo-Zé, A.D., Mofor, N.A. and Onana, A.A. (2016a). Phosphorus adsorption isotherms in relation to soil characteristics of some selected volcanic affected soils of Foumbot in the West Region of Cameroon. *International Journal of Soil Science*, 11: 19-28

Olsen, S. R.(1953) Estimation of available phosphorus in soil by extraction with sodium bicarbonate. USDA, Circ. 939

Oluyemi, E.A., Feuyit, G., Oyekunle, J.A.O. and Ogunfowokan, A.O. (2008). Seasonal variations in heavy metal concentrations in soil and some selected crops at a landfill in Nigeria. *African Journal of Environmental Science and Technology*, 2 (5): 089-096.

Onweremadu, E. U. (2007). “Lithosequential variability in phosphorus (P) forms in the humid tropics”. *International Journal of Soil Science*, 2(3): 182 187.

Osobamiro, M.T. and Adewuyi, G.O. (2015). Levels of heavy metals in the soil: effects of season, agronomic practice and soil geology. *Journal of Agricultural Chemistry and Environment*, 4:109-117.

Piper, C.S.(1950). Soil and Plant Analysis.University of Adelaide

Pramer, D.E. and E.L. Schmidt, 1984. Experimental Soil Microbiology. Burges Publishing Company, Minneapolis, MN., USA., Pages: 106.

Prasad, S. N. and Sahi, B. P. (1989) Distribution of manganese in relation to soil properties in some typical soil profiles. *J. of Indian Soc. of Soil Science.* 37: 567-570.

Rajeswar, M.,Rao, C. S.,Balaguravaiah, D. and Khan, M. A. A. (2009) Distribution of Available Macro and Micronutrients in Soils Garikapadu of Krishna District of Andhra Pradesh. *J. Indian Soc. Soil Sci*.57(2): 210-213.

Sharma, P.K., Anilsood, Setia, R.K., Tur, N.S., Mehra, D and Harpindersingh, (2008). Mapping of macro nutrients in soils of Amritsar district (Punjab) –A GIS approach. *Journal of the Indian Society of Soil Science.* 56 (1): 34-41.

Singh, V. S., Agrawal, H. P. and Prasad, S. (2009) Distribution of DTPA-extractable micronutrients in the soils of District Ghazipur, Utter Pradesh. *J. Indian Soc. Soil Sci.*57(3): 370 – 372.

Singh, V.P., Chauhan, R.P.S. and Sharma, J.S. (1995) Effect of saline water irrigation through drip system on the salt build up in soil profile around trunk of kinnow (*Cinars reticulate). J. of the Indian Society of Soil Science*, 43: 155-160.

Subbiah, B.V. and Asija, G.L. (1956) A Rapid Procedure for the Estimation of Available Nitrogen in Soils. Current Science, 25, 259-260.

Sudharani, Y and Jayasree, G. (2012) Fertility status of rice growing soils of Nalgonda district in Andhra Pradesh. *Journal of Research. ANGRAU*. 40(3): 14-17.

Thangasamy, A.; Naidu, M. V. S.;Ramavatharam, N. and Raghava Reddy, C.,(2005) Characterization, classification and evaluation of soil resources in Sivagirimicro-watershed of Chittoor district in Andhra Pradesh for sustainable landuse planning. *J. Indian Soc. Soil Sci.*, 53: 11–21.

Verma, V. K., Setia, R. K., Sharma, P. K., Singh, C. and Kumar, A. (2005) Pedospheric variations in distribution of DTPA-extractable micronutrients in soils developed on different physiographic units in central parts of Punjab,India. *International J. Agric. and Biology* 7: 243-246.

Vodyanitskii, Y.N. (2016). Standards for the contents of heavy metals in soils of some states, *Annals of Agrarian Science*, 14: 257-263.

Yaser, H. and Rahim, D.T. (2013). Comparison of phosphorus adsorp-tion isotherms in soil and its relation to soil properties. *Interna-tional Journal of Agricultural Research Reviews*, 3: 163-171.

Yeresheemi, A.N., Channal, H.T., Patagundi, M.S and Satyanarayana, T. (1997) Salt affected soils of upper Krishna Command, Karnataka. I. Physical and chemical characteristics. *Agropedology.* 7:32.33

Abideen Adeyinka Adekanmi was born in Ede, Osun State Nigeria on 7th March, 1983. He was awarded Ph.D. degree in Industrial Microbiology on “Physiological Characterisation and Optimisation of culture conditions of fresh water Microalgae for Biodiesel Production” in 2019 from University of Ibadan, Oyo state, Nigeria, under the supervision of Prof. Anthony Abiodun Onilude, Head of Department, Dept. of Microbiology, University of Ibadan, Ibadan, Oyo State, Nigeria. Currently, He is working as scientific officer 1 at Raw Materials Research and Development Councils (RMRDC). He has published papers in International journals

Sherifdeen Adeniyi Adekanmi was born in Ede, Osun State Nigeria, 2nd of February, 1982. Sherifdeen obtained her Master’s degree in Medical Microbiology and Parasitology in 2018 at Ladoke Akintola University of Technology, Ogbomoso, Oyo state. He is pursuing his Ph.D.on the topic Clinical studies on action of combination of Mitracarpus scaber, Ocimu, gratissimum, Senna alata and Jatropph multifida herbal extracts in the management of fungal Infection. at the same university under the guidance of Prof. Lateef Agbaje. Currently, he is Quality Assurance Manager of Lautech Teaching Hospital Drug, Osogbo, Osun state, Nigeria He has a lot of published papers in International journals

Opeyemi Shafiu Adekanmi was born in Ede, Osun State Nigeria, 20th of May, 1985. He obtained her Bachelor degree in Microbiology in 2010 at Olabisi Onabanjo University, Ago-1woye, Ogun state. He is pursuing his Masters at the same university. Current, he is the head of Centremog Limited Research Unit, Lagos, Nigeria