Agricultural Fadama Soils in Maikunkele-Minna, Southern Guinea Savanna Ecological Zone of Nigeria

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ABSTRACT
A study was carried out to assess the physical and chemical content in systematically selected soils of Maikunkele fadama farm southern Guinea Savanna ecological zone of Nigeria. To evaluate the different physical and chemical properties of the study area, the soils were sampled during the dry season of 2014 and early 2015. The study area was divided into five transects and soil samples were taken at every 10 meter along each transect of the 500 m^2 farmland which resulted into 50 sampling points. The samples were taken within a depth range of 0-20 cm depth. Each soil sample from heavily cultivated area was collected using an auger. Chemical and physical measures were performed on the various soil samples. Three types of soil textural class existed within the study area (loam, loamy sand, and sandy loam). The average sand, silt and silt content 81.18, 9.29 and 9.58 % respectively. It was observed from the data that the sand content of the various samples decreased with distance. pH of the soil/water solution ranged between 6.50 and 6.90 maintained a neutral condition while those between 6.28 and 6.48 maintained a slightly acidic condition while the pH in soil/Calcium Chloride solution ranged between 4.59 and 5.62. No traces of heavy metals such as, Zinc, Iron, Manganese, Cadmium and Copper, but Sodium and Potassium are detectable. Magnesium, Calcium and Phosphorus were also detectable for the five sampling stations. The soils of the study area as at present were therefore concluded to be free of heavy metals.

Keyword: *Agricultural soils, Fadama, heavy metals, soil quality index*

1 INTRODUCTION

The occurrence of chemicals in the environment can be through natural or anthropogenic processes, and their dispersion varies from one region to another, with spatial variations often based on their background concentrations (Khlifi and Hamza-Chaffai, 2010). The natural process involves phenomena such as flooding, geochemical weathering of rocks and/or volcanic eruptions of the earth crust, while the anthropogenic process occurs as a result of human induced activities. These activities include production of agrochemicals, mining and smelting operations, domestic and industrial solid waste disposal, urban runoff, application of agricultural machinery for farming operations, and discharges from untreated municipal sewage and industrial wastewater (Singh *et al.,* 2010; Tchounwou *et al.,* 2012). These operations are known to produce wide range of environmental pollutants among which is heavy metals. The solubility of metals in soil enables their ease of dispersion and bioaccumulation within the soil profile. However, this depends on a number of factors, which include: soil type, nature of metal, metal speciation, and transporting media (Covello and Merkhoher, 1993; Rattan *et al.,* 2005; Akbar Jan *et al.,* 2010; Khlifi and Hamza-Chaffai, 2010).

Soils are the primary reservoirs for metals in the environmental and they play vital roles in influencing the distribution of plant species and providing habitat for a wide range of organisms (Khan *et al*., 2013). Heavy metals (HM) in the environment can lead to fertility loss, quality degradation, and damage to the soil structure (Bhandari, 2014). The sources of heavy metals (HM) to plant materials vary, but their ability for translocation and bioaccumulation in different parts of the crop system depends on factors such as: climate, plant stage of maturity, plant genotype, agronomic management, and organic matter contents of the soil (Akbar Jan *et al.,* 2010; McLaughlin *et al.,* 1999). Other factors that influence HM uptake by plants are plant absorption efficiency and the pH of the growing media (Rattan *et al.,*2005). Cultivation of crops on polluted soil potentially leads to significant uptake and bioaccumulation of trace metals in the plants (Cabera *et al*., 1999; Chen *et al.,*2005). At elevated concentrations, HMs affect plant metabolism, photosynthesis, water and nutrient uptake abilities of the crops, leading to changes in the plant morphology (Das *et al.,* 1997; Singh *et al*., 2010).

Most HMs are known to have long decay half-lives, and once introduced onto the agricultural soils, they can persist for a long-term (Nedelkoska and Doran, 2000; Guala *et al.,* 2010).

Contamination of agricultural soils and crops by HMs was one of the earliest concerns due to their detrimental and long-term effects on human health and the environment (McLaughlin *et al.,* 1999). Several studies have been carried out to determine the effect of HMs on soils, and the evidence derived from such studies show how biological tissues are affected by increase in soil concentrations (Colborn *et al.*, 1993; Munns and Sharp, 1993; Nardi *et al*., 2002; Zayed and Terry, 2003). Therefore due to the adverse effects of HMs on biological and ecological systems, agricultural soils need critical evaluation of its chemical constituents to ensure that recommended thresholds of the interacting chemicals are not exceeded (Lebeau *et al*., 2008).

Agrochemicals stand out as one major development in modern day agriculture as they are used to save energy and labour, control pest and increase crop yields for the food demand of escalating population and control of vector-borne disease (Aktar *et al*., 2009; Fianko *et al*., 2011; Adeola, 2012; Adeoye *et al*., 2013; Bhandari, 2014). Pesticide are substance or combination of substance use for attracting, controlling, repelling or preventing pest either unwanted group of animals or plants, including fungicides, herbicides, insecticides, and other substances used to manage pests during storage, production, processing of food or farming produce, transport, and distribution (Damalas and Eleftherohorinos, 2011; Ikpesu and Ariyo, 2013). Several researchers have identified that agrochemicals are commonly used by farmers because of its wide range of benefits: their cheapness, their cleanliness and ease of handling, their ease of storage and transport (Muyunda 2003; Damalas and Eleftherohorinos, 2011). They further stated that the guaranteed composition of inorganic fertilizers makes it easier for users to determine the rate of application and to predict the effect upon yield. However, despite the contribution of agrochemicals to agricultural production, it has been shown in the last few decades that they could also cause negative effects to human beings and animals, such as cancers, birth defect, reproduction and respiratory problem, agrochemicals residues problems; destruction of environment such as global warming, depletion of ozone layer and pest migration and bioaccumulation (Tadesse and Asferachew, 2008).

The undermining of soil quality is usually gradual as it is not easily detectable as the soils acclimatize to the changes which later lead to occurrence of the alteration in their natural state. Thus, the objective of this study is to determine the physical and chemical parameters of the various available types of soil in the fadama area of Maikunkele farms, Southern Guinea Savanna Ecological Zone of Nigeria.

2 METHODOLOGY

2.1 STUDY SITE

The study was conducted in Maikunkele fadama soils in Bosso Local Government, Minna, Niger State. Maikunkele lies on Latitude 9.6533° North and Longitude 6.5161° East of the Greenwich Meridian. The average annual rainfall of Minna is 1,312 mm, temperature is 30 ^{o}C (Musa and Egharevba, 2009; Ahaneku and Sadiq, 2014). The stream water is a major source of water in area which is of agricultural and domestic significance. It supplies water for the fadama farmers along it bank for irrigation and for domestic purposes. Figure 1 shows the map of the study location and points where soil samples were collected.

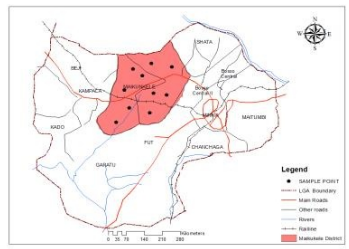

Figure 1: Map of Bosso showing Maikunkele and sample location

2.2 SAMPLE COLLECTION

To evaluate the different physical and chemical properties of the study area, the soils were sampled during the dry and dry seasons of 2014 and early 2015 respectively. The study area was divided into five areas and soil samples were taken at every 10 meter along each transect of the 500 m^2 farmland which resulted into 50 sampling points. The soil samples were taken within a depth range of 0-20 cm, depth. Each soil sample from heavily cultivated area was collected using 7 cm diameter depth core auger. The samples were dried at 60 ^{o}C for 48 hrs, using the 2 mm sieve and ground to pass through a set of mesh sieve (Moor, *et al*., 2001; Remon *et al*., 2005). This was done before running the physical properties of the soil samples. One-half was air-dried for subsequent physico-chemical analysis and the remaining soil was retained at field moisture level and stored at atmospheric temperature of 30 ^{o}C. This is in accordance with the works of Chen and Ma (1998) and Hinojosa *et al*., (2004). The samples were collected from the study area in accordance with the method employed by Fu *et al*., (2008); Chary *et al*., (2008) and Guala *et al*., (2010).

2.3 LABORATORY ANALYSIS

Physico-chemical analyses were performed as follows: pH in a 1:2.5 soil/$CaCl_2$ and soil/water solution; organic matter by measuring weight lost on ignition (Hinojosa *et al*., 2004). The USEPA method of analysis as described by Chen and Ma (1998) was employed. The nitric-perchloric acid digestion and quantified by inductively coupled plasma Atomic Emission Spectroscopy (model A6600 AVANTA PM) were also used for analysis. Potassium, calcium and magnesium were detected by using the ammonium acetate extraction method, whereas phosphorus was detected by means of the Bray PI method.

Cadmium and Lead were determined by Atomic Absorption Spectrophotometer (AAS) using the Graphite Furnace technique. 3g of soil sample was digested for 2 hours at 180 ^oC. Soil pH was determined by using the methods stated by Kuperman and Carreiro (1997). The recommended threshold limits for agricultural soils is presented in Table 1. This is primarily to protect soils against the toxicities of HMs. However, these thresholds are subject to periodic review according to new information.

TABLE 1. RECOMMENDED MAXIMUM CONCENTRATION THRESHOLD LIMITS OF HEAVY METALS IN AGRICULTURAL SOILS.

Element	Soil concentration threshold limit ($mgkg^{-1}$)
Sb (Antimony)	36.0
As (Arsenic)	8.0
Ba (Barium)	302.0
Be (Beryllium)	0.2
B (Boron)	1.7
Cd (Cadmium)	4.0
F (Fluorine)	635.0
Pb (Lead)	84.0
Hg (Mercury)	7.0
Mo (Molybdenum)	0.6
Ni (Nickel)	107.0
Se (Selenium)	6.0
Ag (Silver)	3.0
Tl (Thallium)	0.3
V (Vanadium)	47.0

Source: (CRWQCB, 2007)

3 RESULTS AND DISCUSSION

The datasets were categorized according to the primary depositional environments examined in the study. A large attention of this study was focused primarily on the <2 mm samples as this size range is more typical of the finest deposit present in the study area. This is similar to the works of Liang *et al*., (2011). The soil textural analysis particle sizes were carried out on all the samples obtained from the study area which were collected at depths ranging between 0 and 20 cm. Table 2 shows soil textural analysis carried out in the study area. The most visible characteristics of the study area were the vastness and uniqueness of the A Horizon around the study area. This is similar to the studies carried out by Remon *et al*., (2005) where they studied the Soil characteristics, heavy metal availability and vegetation recovery at a former metallurgical land. It was observed from our study location that three types of soil formation exist which are loam, loamy sand, and sandy loam. This is of course typical of fadama areas in the Southern Guinea Savanna ecological zone of Nigeria. This is similar to the works of Liang *et al*., (2011) which was carried out in Dunhua Sewage Irrigation Area. Soil texture classification was based on the fractions of separates present in the soil; the main constituents (sand, silt and clay) are given in Table 1. The average sand, silt and clay content 81.18, 9.29 and 9.58 % respectively. It was observed from the data that the sand content of the various samples decreased with time. Though, a slight increment was observed in the last month of the study. This was linked to the fact that some portion of the soil which is washed from the upper part of the farm accumulates at this end. The silt and clay content for the various samples were observed to be fluctuating which could be linked to movement of these fine soil particles from one point of the field to another.

Generally, pH values of soil were classified into three degrees, strongly acidic (pH < 5.0), slightly acidic (pH 5.0-6.5) and neutral (pH 6.5-7.5). As can be seen from results of the fadama area, the pH of the soil/water solution ranged between 6.50 and 6.90 maintained a neutral condition while those between 6.28 and 6.48 maintained a slightly acidic condition while the pH in soil/Calcium Chloride solution ranged between 4.59 and 5.62. Some of the values observed for pH values in Calcium Chloride were observed to be strongly acidic which falls in the first degree of classification. The average pH value in water solution for the study area was 6.59 which show that the value is within the recommended range of 6.5-7.5 while the average value of pH in Calcium Chloride is 5.19. This is similar to the works of Manta *et al*., (2002); and Liang et al., (2011) Iyaka and Kakulu (2012). The Cation Exchange Capacity (CEC) has been used by several researchers to determine the fertility and nutrient retention capacity of soils. The CEC for the soils within the study area ranged between 1.70 and 3.20 %, with an average value of 2.27%. A similar trend of change was observed when these results were compared with the pH values for the study area. This is similar to the works of Manta *et al*., (2002); Banerjee *et al*., (2003) and Liang *et al*., (2011).

TABLE 1. SOIL TEXTURAL ANALYSIS AND OTHER PARAMETERS OF THE STUDY AREA

Period	Sample	Sand (gkg^{-1})	Silt (gkg^{-1})	Clay (gkg^{-1})	Textural Class	pH in H_2O	pH in $CaCl_2$	CEC %
A	1	84.60	8.50	6.90	Loam	6.90	5.62	3.20
	2	78.20	10.90	11.10	Loam	6.43	5.57	2.84
	3	83.40	10.90	6.70	Loam	6.59	5.54	3.12
	4	85.30	8.10	6.70	Loam	6.60	5.60	2.25
	5	78.50	10.60	10.90	Loam	6.28	5.40	2.41
B	1	82.40	8.00	9.60	Loamy Sand	6.56	5.25	2.90
	2	80.96	8.70	10.34	Loamy Sand	6.61	5.18	2.88
	3	84.30	7.00	8.70	Loamy Sand	6.33	5.60	2.73
	4	80.90	9.00	10.10	Loamy Sand	6.42	5.20	2.60
	5	83.50	6.50	10.00	Loamy Sand	6.75	5.21	1.94
C	1	80.40	8.90	10.70	Sandy Loam	6.59	5.30	2.60
	2	82.00	8.80	9.20	Sandy Loam	6.73	5.27	2.42
	3	78.80	11.00	10.20	Sandy Loam	6.86	5.40	1.90
	4	80.60	10.60	8.80	Sandy Loam	6.48	5.33	1.90
	5	80.40	10.20	9.40	Sandy Loam	6.66	5.25	2.20
D	1	79.00	11.50	9.50	Sandy Loam	6.71	4.90	1.98
	2	80.50	9.80	9.70	Sandy Loam	6.67	4.96	2.02
	3	78.80	10.80	10.40	Sandy Loam	6.63	5.20	1.95
	4	76.90	10.40	12.70	Sandy Loam	6.58	4.75	1.80
	5	80.80	9.70	9.50	Sandy Loam	6.65	5.03	2.10
E	1	83.28	7.40	9.32	Loamy Sand	6.49	4.70	1.80
	2	81.26	7.80	10.94	Loamy Sand	6.75	4.92	1.95
	3	82.40	9.50	8.10	Loamy Sand	6.38	4.59	1.70
	4	82.10	7.50	10.40	Loamy Sand	6.55	4.86	1.70
	5	80.20	10.20	9.60	Loamy Sand	6.49	5.20	1.95

The concentration of the various chemical parameters varied greatly within the various locations with respect to the months during which the samples were collected and analyzed. The analysis performed showed no traces of heavy metals such as, Zinc, Iron, Manganese, Cadmium and Copper, but Sodium and Potassium are detectable. Magnesium, Calcium and Phosphorus were also detectable for the five sampling stations. Table 2 the descriptive statistical summary of the analyzed chemical parameters within the soils of the study area. The spatial distribution of all the sediment-metals in fadama area of Maikunkale, Nigeria revels that the primary contaminant problem is associated with the various agrochemicals which area applied the farm land. For example, the values of P had maximum and minimum values of 1.88 and 1.28 at sample point 1. It was observed that the other values of P from the other sample points were found to be within this range. A similar pattern of result was observed for Na^+, and K^+ with higher values of Mg^{2+} and Ca^{2+} were observed to have their maximum and minimum values at sample points 3. All the results were observed to be within the recommended CRWQCB (2008) limits.

TABLE 2: STATISTICAL SUMMARY OF PHYSICO-CHEMICAL PARAMETERS OF THE FADAMA SOIL

Sample Points	Statistical Tool	P $mgkg^{-1}$	Na^+ $Cmolkg^{-1}$	K^+ $Cmolkg^{-1}$	Mg^{2+} $Cmolkg^{-1}$	Ca^{2+} $Cmolkg^{-1}$
1	Mean	1.60	0.48	0.04	0.13	0.20
	Maximum	1.88	1.88	0.08	0.16	0.24
	Minimum	1.28	0.12	0.02	0.12	0.15
	SD	0.22	0.78	0.02	0.01	0.03
2	Mean	1.32	0.15	0.04	0.13	0.18
	Maximum	1.57	0.25	0.06	0.13	0.26

	Minimum	1.08	0.11	0.02	0.13	0.11
	SD	0.19	0.05	0.01	0.00	0.06
3	Mean	1.44	0.13	0.05	0.14	0.21
	Maximum	1.80	0.18	0.07	0.20	0.30
	Minimum	1.13	0.80	0.03	0.10	0.11
	SD	0.26	0.03	0.01	0.04	0.07
4	Mean	1.27	0.15	0.04	0.14	0.20
	Maximum	1.44	0.22	0.06	0.18	0.25
	Minimum	1.13	0.12	0.03	0.11	0.13
	SD	0.13	0.03	0.01	0.02	0.04
5	Mean	1.25	0.13	0.04	0.12	0.20
	Maximum	1.36	0.16	0.06	0.15	0.26
	Minimum	1.12	0.12	0.02	0.12	0.14
	SD	0.09	0.01	0.01	0.01	0.04
	WHO	20	0.6 - 1.2	0.7 - 1.2	3 - 8	10 - 20

3 CONCLUSION

The data obtained in this study demonstrate that the heavy metal concentrations in the top soil of the fadama area of Maikunkele where limited tuber crops are grown. The top soil samples that were analysed showed that the various agrochemicals that are applied to the study to either control growth of weeds, increase crop yield or prevent pesticides is reflected in the results that were obtained. Though the analysis showed that the metals discovered as at present do not indicate any influence on human health but over time may become a problem thus there is the need to regulate the use of these chemicals on the farm land. conclusion should review the main points of the paper and should state concisely the most important propositions of the paper. It should state the author's views of the practical implications of the results.in addition to the deductions that can be made from the results. Do not replicate the abstract as the conclusion. A conclusion might also elaborate on the importance of the work or suggest applications and extensions.

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