ASSESSMENT OF HEAVY METAL CONTENTS INTHREE DIFFERENT LAND USEDSOILS IN OHAJI/EGBEMA IMO STATE, NIGERIA

ABSTRACT

This assessment of some heavy metal contents in soils of different land used in Ohaji/Egbema, Imo State was conducted between June, 2019 and May, 2020. Three land used namely; the grass land, continuously cropped and forest land were studied. Soil profile representations were established in each of the physiographic units and soil samples collected from the pedogenetic horizons for the analysis of some heavy metals like Lead (Pb), Copper (Cu), Manganese (Mn), Zinc (Zn), and Iron (Fe). The heavy metals observed in this study were Cu, Mn, Zn and Fe while Pb was not detected in this study. The results of this study showed that the grass land, continuously cropped and forest land had no Pb detected. The heavy metal contents (Cu, Mn, Zn and Fe) detected decreases with depth from 0.15cm depth to 60-90 cm depth in grass land and continuously cropped and forested land, respectively. The occurrence of Fe was high in forested land which ranges from 7.8-6.3 Mg/Kg with mean value of 7.0 Mg/Kg than continuous cropped land and grass land with lower values. The forest land had high sodium content with mean value of 0.74 and high electrical conductivity with a mean 4.91 dsm^{-1}. The results showed low to moderate heavy metal load in forest land and high to moderate load of heavy metals in the grass land and continuously cropped land.

Keywords: land Uses, Heavy Metals, Soils, Assessment, Imo State.

1.1 INTRODUCTION

Nigeria is Africa's most populous country and is among one of the world's leading oil producers due to the vast oil and gas reserves in the Niger Delta [1]. With much of its reserves of oil and gas still untapped, the Niger Delta region of Nigeria produces 2.2 million barrels of oil per day [2]. The Niger River is the principal river of West Africa with a length of approximately 4,180 km and a drainage basin encompassing 2,117,700 km2. Over millennia, the mighty Niger River created the vast Niger Delta at its confluence with the Atlantic Ocean's Guinea and Benguela Currents [3].

Nigeria is enormously blessed with abundant human, agricultural, petroleum, gas and other unexploited solid mineral resources [4]. However, due to the political instability experienced since her independence in 1960 from British rule, it has experienced decades of political instability; therefore, creating social tension and an unpredictable market for businesses [5]. It is worthy to mention that the Nigerian economy is profoundly reliant on the oil and gas sector and classed as the fifth largest oil exporter to the United States [6]. The Niger Delta region of Nigeria literally covers about 36,000 kilometers (14, 000 square miles) of marshland, creeks, tributaries, and lagoons which drain the Niger River into the Atlantic [7]. About 12,000 square kilometer of Niger Delta is fragile mangrove forest, and this is arguably the largest mangrove forest in the world. It is also the largest wetland in the world. The biodiversity is very high and the area contains diverse plant and animal species, including many exotic and unique flowers and birds. Implied in this ecology is that the Niger Delta is an easily dis-equilibrated environment. The environment is mostly salt water and associated with shortage of arable land and freshwater. Furthermore, transportation through this ecosystem is very difficult.

Today, crude oil is produced in nine States in Nigeria, namely, Rivers, Bayelsa, Delta, Edo, Imo, Abia, Akwa-Ibom, Cross-River, and Ondo. Due to this fact and other political reason, the present-day Niger Delta is technically made up of these nine States as depicted in Figure 2, and covers an area of about 41,000 square miles (106,189.50 km2) and habours Nigeria's proven oil and gas reserves. According to NMA [8], 70% of Nigeria's proven gas reserves are situated on land, while the rest 30% are offshore.

Nigeria's Niger Delta is characterized by high biological diversity, abundant natural resources, and extreme poverty. A survey of current knowledge on the biological diversity of the Niger Delta reveals striking global significance across the full range of biological diversity at the genetic, species and ecosystems levels. Biological diversity is the variety of the world's plant and animal life (in this case, the Delta's), including their genetic diversity and the assemblages they form. The Niger Delta region of Nigeria is one of the world's largest wetlands and includes by far the largest mangrove forest in Africa. Its biological diversity is of global significance.

Within the extremely valuable ecosystem, oil activities are widespread [9]. Particularly, the community which is Eleme is a community in Rivers State and it's one of the oil producing and agro-ecological areas in the Niger-Delta region of Nigeria, a region with abundant natural resources including good weather and fertile land for agriculture.

Although the level of agricultural production in that region is very low given the abundant resource endowment, it is the largest oil producing zone in the country. It is the base of Nigerianoil and gas industry, generating over 90% of the nation`s economy [10]. Oil exploration and activities have been concentrated in this Niger-Delta region which has over 1000 production oil-wells and over 47,000 km of oil and gas flow lines [11]. These negative impacts of this oil activities include destruction of wild life, loss of fertile soil, pollution of air and water and damage to the ecosystem of the host communities [12]. The ecological problems observed as a result of oil spill include a brownish vegetation and soil erosion, diminishing resources of the natural ecosystem, fertile land turned barren and adverse effect on the life, health and economy of the people [13].

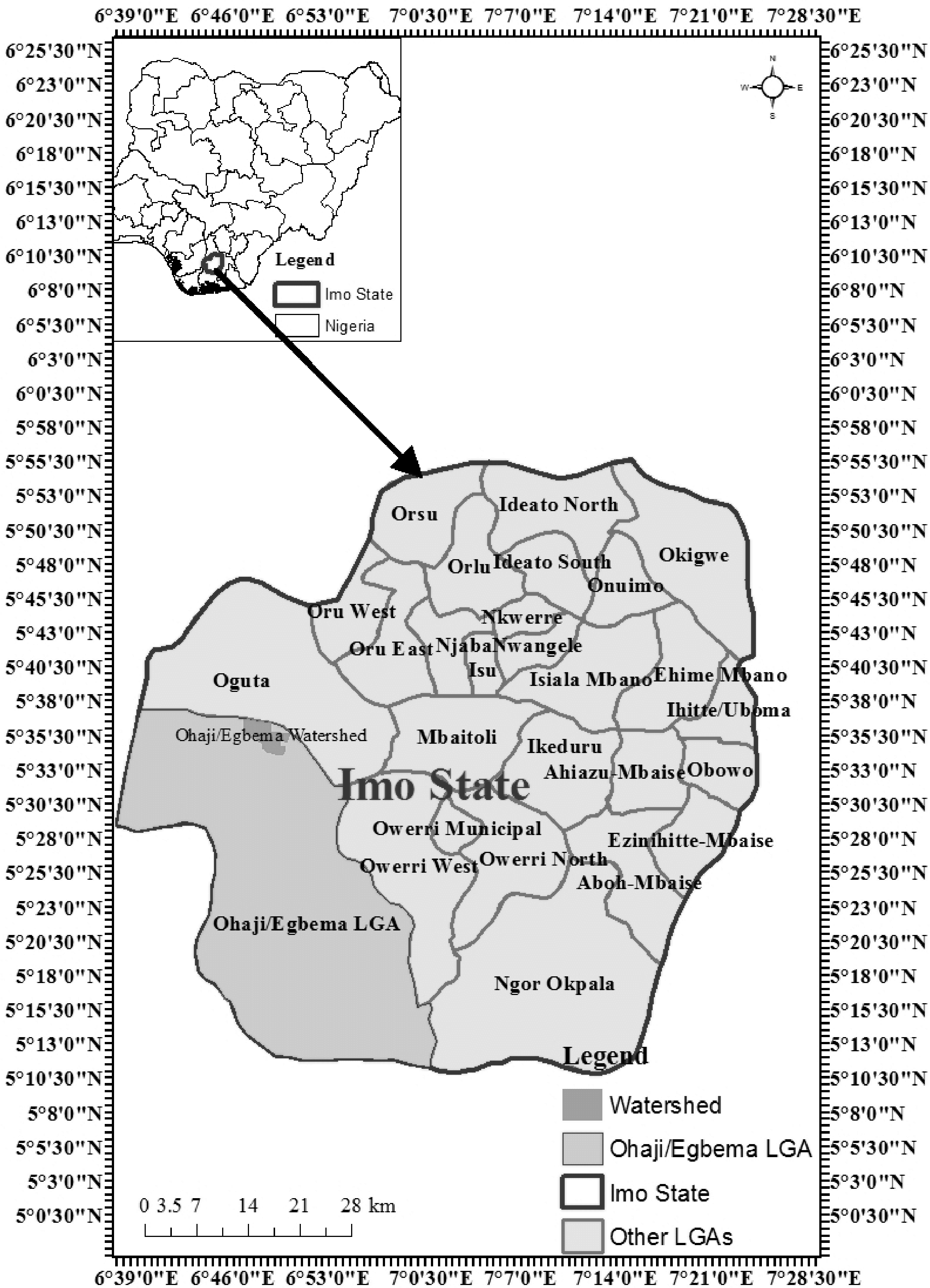
The differences in field management, land use conversion, which involves change in biomass production and nutrient cycling, have influence on soil properties [14]. Change in land use from agriculture to forest brought the development of a large tree biomass and increased the availability of plant nutrient [15]. This type of conversion increased soil organic carbon, microbial biomass and potential nitrogen mineralization rate and reduced the soil bulk density [16]. Land use induced changes in nutrient availability and may influence secondary succession and biomass production, reduce crop production and environmental quality. The changes directly affect some physical chemical and biological properties, such as water retention availability, nutrient cycling, plant root growth and soil conservation [17]. These soils are also known to possess unique morphological characteristics that are strongly influenced by temporary or permanent water saturation and adopted vegetations. This study therefore is to assess the soil heavy metal contents of some land uses in Imo State.

2.0 MATERIALS AND METHODS

2.1 STUDY AREA

The study was carried out in Obinze area of Imo State which lies between latitudes 05^0 21^1 and 05^0 42^1N and longitudes 07^0 48^1 and 06^0 53^1 E. The region consists of tropical rainforest zone with average annual rainfall distribution of 2,250-2800mm. The annual temperature ranges 26-30^0C with annual relative humidity range of 85-90% [18].

Human activities such as continuous cropping, grazing and bush burning has transformed the natural forest of the area into secondary and grassland soils, but there are some scattered distributions of forest lands in the area. The identified land uses were grass land, continuously cropped land and forest land.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Isu
Isiala Mbano
Ehime Mbano
Oguta
Ihitte/Uboma
Ohaji/Egbema Watershed
Mbaitoli
Ikeduru
Ahiazu-Mbaise
Obowo
Imo State
Owerri Municipal
Ezinihitte-Mbaise
Owerri West
Owerri North
Aboh-Mbaise
Ohaji/Egbema LGA
Ngor Okpala
Legend
Watershed
Ohaji/Egbema LGA
Imo State
Other LGAs
0 3.5 7 14 21 28 km

Figure 1: Map of Imo State Showing the Study Area

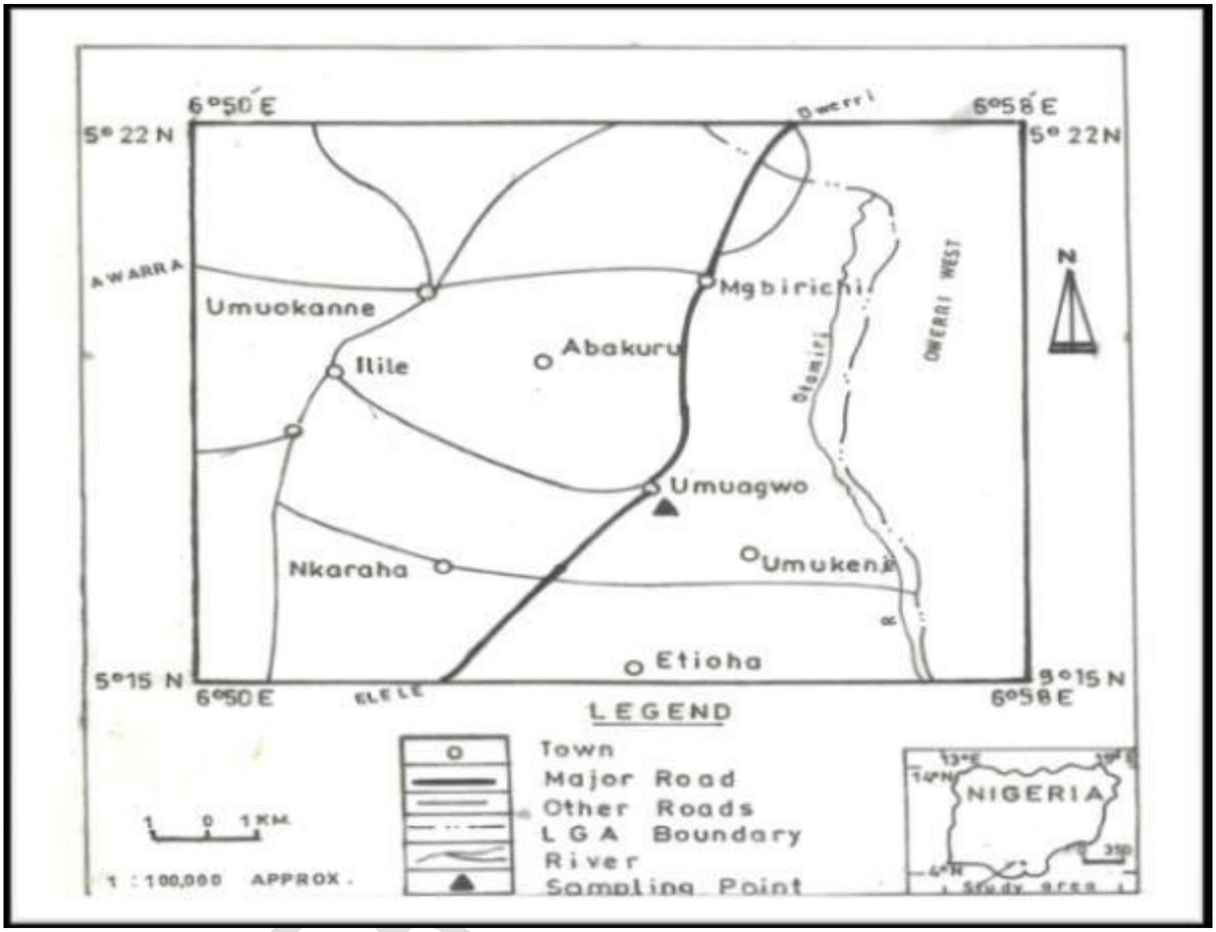

Figure 2: Map of the Study Area (Ohaji/Egbema L.G.A in Imo State).

2.2 FIELD STUDY

Three mapping units were chosen to represent soils that occurred under grass land, continuously cropped land and forest land. In each of the mapping units, representative profile pits were drug up to 90cm delineated and soil samples collected from each of the pedogenetic horizons.

2.3 LABORATORY ANALYSIS

Routine laboratory analyses were conducted after collection of samples. Soil pH was determined by electrometric method as described by IITA (2010). The walkley and black methods as described by [19] were used in the analysis of organic carbon. Total nitrogen was analysized using the procedures as described by [20].

The Bray 1 method as described by IITA (2010) was used for extractable phosphorus, exchangeable based were determined from the soil samples through normal ammonium acetate solution [21]. The EDTA titration method was used to determine calcium (Ca) and magnesium (mg), while flame photometer was used in the determination of sodium (Na) and potassium (K). The cation exchangeable capacity (CEC) was determined by ammonium acetate saturation method [21]. The electrical conductivity (EC) was determined by measuring the electrical resistance between parallel electrodes immersed in the soil samples using electrical conductivity meter.

The results of some chemical properties of the soils were shown in Table 1 which represented the grass land, continuously cropped and forest land soils. The soils across the pedons were generally acidic. The grass land and continuously crop.

2..4 HEAVY METAL DETERMINATION

Heavy metals like Mn, Fe, Cu, and Zn were determined using double acid method of extraction and extraction acid read out with AAS.

The samples were mixed gently and homogenized and sieved through 2 mm mesh - sieve. The samples were first dried, and then placed in electric oven at a temperature of 40 °C approximately for 30 minutes. The resulting fine powder was kept at a room temperature for digestion.

2.4.1 Digestion of Soil Samples

Ig of the oven dried sample was weighed using a top loading balance and placed in 250ml beakers separately to which 15ml of aqueousregia (35% HC1, and 70% high purity HNOs in 3:1 ratio) was added. The mixture was then digested at 70% till the solution became transparent The resulting solution was filtered through Whatman filter paper no 42 and into a 50ml dilute 50ml volumetric flask and diluted to mark volume using deionized water and the sample solution was analysed for concentration of Cu, Pb, Mn, Zn and Fe using an atomic absorption spectrophotometer (Perkin-ElmerAAnalyst400).

2.4.2 Analysis of Soil Samples

AAS A Analyst 400 model was used in determining the content of metals in the previously digested soil samples. The nitrous oxide, acetylene gas and compressor were fixed and compressor turned on and the liquids trap blown to rid of any liquid trapped. The extractor and AAS control were turned on. The slender tube and nebulizer piece were cleaned with purifying wire and opening of the burner was cleaned with an arrangement card. The worksheet of AAS programming on the joined PC was opened and the empty cathode light embedded in the light holder. The light was turned on, beam from cathode adjusted to hit target zone of the arrangement card for ideal light throughput, at that point the machine was touched off. The fine was set in a10ml graduated chamber containing deionizer water and yearning rate was estimated. The analytical blank was prepared and a series of calibration solutions of known amounts of analyte element (standard) were made. The blank and standards were atomized in turn and their responses were measured. A calibrator graph was plotted for each of the solutions after which the sample solutions were atomized and measured. The various metals concentration from the solution were determined from the calibration based on the absorbance obtained for the unknown samples

2.5 STATISTICAL ANALYSIS

Coefficient of Variation (CV) was used to estimate the degree of variability existing among land uses in the study area as outlined by wilding (1985). The means were separated using least significant difference (LSD) test at 0.05 level of significant incorporated in the statistical analysis system (SAS) package of 9.1 versions (2006).

3.0 RESULTS AND DISCUSSIONS

The results of some chemical properties of the soils were shown in Table 1 which represented the grass land, continuously cropped and forest land soils. The soils across the pedons were generally acidic. The grass land and continuously cropped were slightly acidic. The forest land was medium acidic with a mean pH value of 5.65. Available phosphorus was high in grass land and continuously cropped with mean values of 12.20mgkg^{-1} and 12, 4mgkg^{-1} (Table 1). Organic matter and total nitrogen decreased down the profile in all land uses and were low being less than critical limits of < 1% for 0M and < 0.9g/kg for N as described by [22-26].

In this study, grass land soils organic matter decreased from 0.64 to 0.25, continuous cropped land from 0.55 to 0.21 while in forest land from 0.96 to 0.66%. The organic matter were low in three land studied, but continuously cropped soils were the lowest.

Erosion, leaching, and increased intensive agriculture in the area may have depleted the nutrient reserve of the soils. The available phosphorus distributions were very high at the surface horizons and decrease down the profile in all soils studied. The chemical indicator used with the assigned relative weight is shown in this investigation. The soil pH is a critical factor in crop production as it affects the mobility of many pollutants in the soil by way of influencing the rate of their biochemical breakdown, solubility and absorption to soil colloids [27] The results showed moderate acid condition in the continuously cropped soils and medium acid in grass land and forest land respectively. The implications of these are that, the nutrient availability of the soils may be affected. High pH in relation to the forest land soils could cause the released of some toxic amounts of aluminum into the soils [28]. This suggests that these soils were low in nutrient elements composition especially the continuously cropped soils and needs to constantly be supplemented to support productivity.

Low values of exchangeable sodium and electrical conductivity (EC) associated with the three land use soil are major soil chemical potentials of the soils as most tolerable tropical plants can be cultivated in them.The organic matter content in the grass land and continuous cropped land were low with mean value of 0.43gkg^{-1}, and 0.41gkg^{-1}. The forest land was higher in organic matter content with mean value of 0.82gkg^{-1}. The low organic matter content associated with the grass land and continuous cropped land were due to the intensive cultivation of the soils, and seasonal bush burning which are more of animal farming ritual in the study areas. The moderate to high organic matter associated with the forest land has been attributed to microbial activities of the soils due to good aeration and decomposition rate of flitters or litters, [24].

Heavy metals (Pb. Cu, Mn, Zn and Fe) contents in the three land use soils shows that the concentrations of Cupper (Cu) and Manganese (Mn) were moderate and were below WHO permissible limit. Cu with mean value of 33.4 mg/kg, Mn with mean value of 18.2mgkg, for grass land and continuous cropped land 32.9mg/kg, 17.6mg/kg, while forest land with mean values of 30.7 mg/kg, 17.8mg/kg of Cu and Zn respectively. Cu, Ma and Zn concentrations in grass land and continuous cropped land were significantly higher ($P.<0.05$) than the Fe concentration has a mean value of 1.6mg/kg, while continuous cropped land with mean value of 1.5mg/kg and forest land with a higher mean value of 7.8mg/kg. However the mean value of Mn, Fe in the land use soils was at tolerable limit and Pb was not found in this study while Zn exceeded the maximum tolerable limit in soil for crop production according to [29].

Table 1: SOME CHEMICAL PROPERTIES OF LAND USE SOILS

Soil depth (CM)	Soil pH	Om	N $(mgkg^{-1})$ $(mgkg^{-1})$	P	Ca	Mg	K (mgkg-1)	Na	CEC	EC dsm^{-1}
Grass land										
0-15	5.64	0.64	0.84	12.74	2.07	0.84	0.18	0.24	6.57	0.93
15-30	5.52	0.49	0.80	12.64	2.06	0.70	0.18	0.24	6.34	0.62
30-60	5.43	0.35	0.76	12.20	2.05	0.65	0.17	0.13	6.32	0-52
60-90	5.13	0.25	0.40	11.23	2.04	0.55	0.16	0.12	5.64	0.42
Mean	5.43	0.43	0.70	12.20	2.06	0.69	0.17	0.18	6.22	0.50
CV%	12.86	10.18	22.30	23.18	10.84	44.77	14.12	23.45	15.15	3.64
Continuous cropped land										
0-15	5.62	0.55	0.88	12.21	1.67	1.07	0.17	0.24	6.89	0.48
15-30	5.53	0.48	0.84	12.20	1.52	1.04	0.16	0.20	6.75	0.47
30-60	5.22	0.38	0.84	12.08	1.45	0.76	0.14	0.16	6.70	0.44
60-90	5.14	0.21	0.83	12.05	1.43	0.74	0.11	0.15	5.45	0.44
Mean	5.38	0.41	0.85	12.14	1.52	0.90	0.13	0.19	6.45	0.46
CV%	13.08	10.64	20.20	20.57	13.03	16.34	19.86	20.54	7.62	13.78
Forest land										
0-15	5.83	0.96	0.98	12.74	4.73	2.10	0.17	0.86	12.32	5.62
15-30	5.64	0.88	0.98	12.68	4.72	2.07	0.15	0.75	12.09	5.03
30-60	5.61	0.76	0.93	12.66	4.72	2.07	0.14	0.70	11.84	4.60
60-90	5.52	0.66	0.89	12.64	4.65	2.04	0.11	0.65	11.25	4.40

Mean	5.65	0.82	0.96	12.68	4.71	2.07	0.14	0.74	11.88	4.91
CV%	12.12	10.81	11.14	25.28	21.01	10.68	19.0	11.77	3.16	16.50

CEC = Cation exchange capacity, EC = Electrical Conductivity, OM = Organic matter

The results on heavy metal contents in different land use soils were shown in Table 2. At the grass land soils Cu decreased from 36.1-31.0, at the continuously cropped it decreased from 35.6 – 30.1 and forest land, Cu decreased from 30.1 – 29.8mg/kg, means were 2.7, 3.2 and 0.2 mg/kg for GL, CC and FL respectively. Mn had means of 3.5, 1.9 and 0.6 mg/kg in GL, CC and FL, respectively. Although the Cu and Mn were low in the three land soils investigated, forest land soils were however very low in Cu and Mn. Zn and Fe decreased from 56.8 – 48.7 and 2.2 – 1.2 mg/kg in GL. In CC land 56.2 – 45.4 and 1.5 – 1.3 mg/kg decreased. Similar trend also occurred in forest land. There was no Pb found in the three land uses investigated.

Table 2: **HEAVY METAL CONTENTS IN DIFFERENT LAND USE SOILS**

Soil Depth (cm)	Heavy Metals in mg/kg (WHO/FAO Limit)				
	Pb(85)	Cu (36)	Mn (20)	Zn (50)	Fe(0.5-10)
Grass land					
0 – 15	ND	35.1	20.4	56.8	2.2
15 – 30	ND	33.4	19.4	50.1	1.7
30 – 60	ND	32.9	17.8	50.0	1.3
60 - 90	ND	31.0	15.1	48.7	1.2
Mean	0.	33.4	18.2	51.4	1.6
C.V%	0	2.7	3.5	3.1	0.9
Continuous cropped land					
0-15	ND	35.6	18.3	56.2	1.5
15-30	ND	34.7	18.2	52.1	1.5
30-60	ND	31.2	17.5	48.7	1.5
60-90	ND	30.1	16.2	45.4	1.3
Mean	0	32.9	17.6	50.6	1.5
C V%	0	3.2	1.9	5.6	0.2
Forest land					
0-15	ND	32.5	18.0	56.1	7.8
15-30	ND	30.3	17.8	54.4	7.4
30-60	ND	30.1	17.7	49.8	6.5
60-90	ND	29.8	17.6	47.4	6.3
Mean	0	30.7	17.8	51.9	7.0
C.V%	0	0.8	0.6	4.2	0.1

Pb = Lead, Cu = Copper, Mn = Manganese, Zn = Zinc, Fe = Iron, ND = Not detected, CV = Coefficient of variation

4.0 CONCLUSION

The investigated soils were sandy with highest occurring at the grass lands. The chemical quality assessment of the soils using the soil management framework (SMAF) showed that the grass land and continuously cropped soils were low to moderate in nutrient reserves and slightly to medium acidic. The forest land soils have good chemical qualities in terms of organic matter; total nitrogen and some high electrical conductivity are among chemical properties. However, the use of both organic and inorganic fertilizers and efficient liming are some of the measures that can improve the efficient use of the soils for crop production. However the mean value of Mn, Fe in the land use soils was at tolerable limit and Pb was not found in this study while Zn exceeded the maximum tolerable limit in soil for crop production according to [30] The main soil factors having impact on the mobility of these elements and the total content in the soil are the cation exchange capacity (CEC,) pH of the soil solution, mechanical composition of the soil humus content and the interaction (Competition) among them [31]. The high concentrations of these heavy metals (Cu, Mn, Zn and Fe) occurring in the land use soils strongly indicate that heavy metals pollution of these soils were due to mineralization of these heavy metals as a result of mining activities in the areas[32-35].

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