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# IMPACT OF LANDUSE ON SOIL QUALITY IN SULEJA, NIGER STATE, NIGERIA

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## ABSTRACT

**A study was conducted to assess the impact of land use types on soil quality in Suleja area of Niger State, Nigeria. Composite soil samples were taken from five different land use types; farmland (FL), industrial land (IL), Residential land (RL), Mechanic land (ML), and virgin land (VL) for physical and chemical analyses. The soil quality parameters assessed include bulk density, porosity gravimetric moisture content, soil texture, soil pH, organic matter content, exchangeable bases, available phosphorus, total nitrogen, and cation exchange capacity. Similarly, test for heavy metals such as Cu, Zn, Pb, Mn, and Fe was also carried out. Physical properties of the soils revealed none significant difference ($p>0.05$) in all land use types. Chemical properties of the soil revealed none significant difference in pH, Organic matter and Total Nigeria. The soils are generally neutral to slightly alkaline with pH range of 6.13 to 7.75. Calcium, cation exchange capacity (CEC), and Available P showed a significant difference**

Land is a commodity that is much treasured by everybody as it forms the basic natural and non renewable resources for agriculture and forestry and other uses (Dedzoe, 1999). In the past, industrial, urban and or agricultural development in many countries appears to be undertaken as a matter of expediency and also as a result of availability of raw materials rather than on the basis of any careful appraisal of the effect of these activities on the environment (Abrokwa-Ampadu and Ampadu Agyei, 1987). With low population pressure and extensive land use, there is little or virtually no effect on the inherent characteristics of land (Verheye, 1998). However with increased competition for land, reserved of fertile areas are reducing at an alarming rate as new production needs are met by either encroaching on existing crop land or opening up new lands. Soil properties deteriorate with change in land use especially from forest to arable land (Oguike and Mbagwu, 2009). The cropping system may lead to erosion and leaching of soil nutrients which in turn adversely affect the physico-chemical properties of the soil. Land use change is also known to be an important factor controlling soil organic matter storage. The capacity of soil to function can be reflected by measured soil physical, chemical and biological properties, also known as soil quality indicators (Shukla et al., 2006). Soil properties that can be changed in a short time by land use dynamic are considered as soil quality indicators (Carter et al., 1997). For evaluation of soil quality, it is desirable to select indicators that are directly related to soil quality. Rapid population growth in Suleja town from 167,420 in 1996 to 216,518 (NPC, 2006) which has been attributed to urban spill from the Federal Capital Territory (The Nigerian capital) has led to increased urban activities with attendant changes in land use. It is envisaged that the changing land use might have affect the quality of the soils of the area. It is against this background that the research was designed to find out the effect of different land use on soil quality in Suleja town.

## MATERIALS AND METHODS

### Study Area

The study was conducted in Suleja town, the Headquarters of Suleja Local Government Area of Niger State, Nigeria. It is located on Latitude $09^{0}31$N and Longitude $07^{0}58$E and about 20 km north of Abuja the Federal Capital of Nigeria. It is about 100 km North East of Minna the administrative headquarters of Niger State (Figure, 1). Suleja Local Government Area has a population of 216,578 (NPC, 2006). Suleja enjoys sub-humid climatic condition with mean annual rainfall and temperature of 1640mm and a raining season of over 7 months in the year. There is a single maxima in the rainfall regime usually in the month of August. Temperatures are generally high in the summer months, but cool during the Hamattan months

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which last from November to March, Suleja master plan (1987-2006).

**Sample and Sampling Procedure**

Soil samples were taken from five (5) different land use types viz, farmland (FL), Industrial Land (IL), Residential Land (RL), Mechanical Workshop Land (ML) and Virgin Land (VL). The location and description of the nature of landuse type is given below.

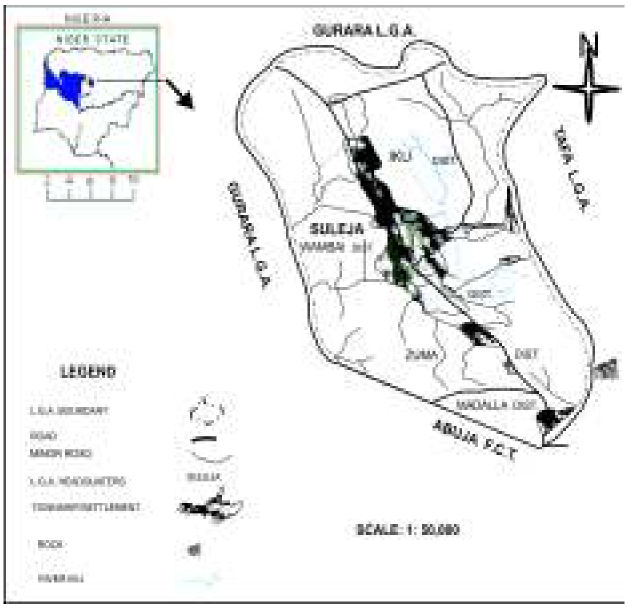


**Figure 1: Map of The Study Area**

**Farmland (FL)**

The Farm Land is located on latitude $09^0 12\ ^1$N and longitude $07^0 27^1$E near Government Technical College Suleja. The Farmland has been in cultivation for over 20 years. Crops grown in that land include yam, maize and sorghum.

**Industrial Land (IL)**

The Industrial Land is located on latitude $09^0 11^1$N and longitude $07^0 81^1$E. Industry located around the place named Tommy Company Limited, Suleja along Bakin Iku Kaduna Road, Tommy Company Limited started operation Seven (7) years ago. They produced pure water, polythene bags and other polythene products.

**Residential Land (RL)**

The Residential Land is located on latitude $09^0 12^1$N and longitude $07^0 11^1$E. The land was previously cultivated to a host of crops before it was converted to residential use in 1979. This comprises of housing units built by the government for civil servants.

**Mechanical Workshop Land (ML)**

The Mechanical Workshop is also located on latitude $09^0 11^1$N and longitude $07^0 41^1$E in Farin Ruwa area behind First Bank Suleja. It was established in 1985. The types of vehicles repair in this workshop include Benz, Toyota and Honda product. There are five units in the workshop which include mechanic unit, panel beater unit, painter unit, and bronze smith.

**Virgin Land (VL)**

The Virgin Land is located on latitude $09^0 13^1$N and longitude $07^0 50^1$E behind Alhali filling station along Maje Road. The Virgin Land is covered with dense trees and grasses. The land is uncultivated are enriched with fertile soil. Ten (10) core samples were taken at the depth of (0 30cm) from each land use type to form a composite sample giving a total of five (5) composite samples. In addition bulk density samples were taken using core samplers for bulk density determination.

**Soil Analysis**

The soil analysis conducted includes both physical and chemical analysis.

**Physical Analysis**

Particle size analysis was determined by the hydrometer method (Bouyoucos, 1951) while bulk density of the soil was determined by the use of core sampler method. Total porosity was calculated from particle and bulk densities using the relationship established by Vomocil (1965) i.e. $N = 100 \{1 \quad Db/pd\}$, where N = porosity, Db = bulk density, pd = particle density. Gravimetric moisture content (%) was determined by direct method as described by Hillel (1971).

**Chemical Analysis**

Soil pH was determined in soil water suspension (1:1) using the glass electrode pH meter. The organic carbon content of the samples was determined by the modified Walkley & Black Method, (1934). Total nitrogen was determined by the macro-kjeldahl digestion distillation methods (Juo, 1979). Available phosphorus was determined by the Bray and Kurtz (1945) No.1 method. Exchangeable bases were determined by extracting the cations with 1N


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ammonium acetate (1N NHOAC), buffered at pH 7. Calcium and Mg were determined using the EDTA method while Na and K were determined using the flame photometer. Heavy Metal Content (Cu, Fe, Mn, Pb and Zn) were determined by flame photometry using diethylenetriaminepenta-acetate (DTPA) or determined by atomic absorption spectrophotometer.

**Statistical Analysis**

The data obtained was analyzed using Bonferroni test to compare means.

## RESULTS AND DISCUSSION

**Physical Properties of the Soils**

Mean and standard error of some selected physical properties of the soils of Suleja area as influenced by different land use are presented in Table, 1. The results are statistically similar (P>0.05) in all the different land use.

**Particle Size Distribution (Texture)**

Particle size distribution (texture) revealed highly variable values of sand, silt and clay. Farmland soil had more sand content (90.5%) and more variable (SE±3.5) than soils of other land uses. Silt separate is more in soils of the Residential area (14.5%) with least variability in Industrial area (SE±0.5) but more variable in Farmland and Mechanic area (SE±4.0). Clay separate on the other hand is higher in Mechanic site (17.65%) with high and least variability in Residential area (SE±4.0) and Farmland soil ((SE±0.00) respectively. The soils are generally sandy with textural classes ranging from Sand (Farmland, Industrial and Virgin land) to Sandy loam (Mechanic and Industrial area). Soil texture is important because it affects and is related to several soil properties such as soil structure, aeration, water holding capacity, nutrient storage, water movement, and bearing strength (Brady and Weil, 2002).

**Bulk Density And Porosity**

There is no significant difference (p>0.05) in Bulk density and Porosity values across land use. Despite the not significant difference, Mechanic site had higher Bulk density (1.79 mg/m$^3$) while Industrial land had the least (1.28 mg/m$^3$). Bulk density variability is more variable in Farmland (SE±0.16). The high Bulk density value in Mechanic site may be attributed to trampling by heavy vehicles. Bulk density > 1.6 Mgm$^{-3}$ may inhibit root growth and development and also slow movement of water. This property may limit the use of these soils for agriculture. Good plant growth is best in bulk densities below 1.4 Mg/m$^3$ for clay soil and 1.6 Mg/m$^3$ for sands (Donahue et al., 1990). Consequent upon this, the bulk density values of the soils may therefore be a problem to crop growth with the exception of the Industrial area. Sandy nature of the soils may have also contributed to the high bulk density. Porosity

**Table 1: Mean and Standard error of some Physical Properties of the Soils of Suleja Area as Influenced by Land use**

| Sampled Areas | Physical parameters | | | | | |
|---|---|---|---|---|---|---|
| | Sand (%) | Silt (%) | Clay (%) | Bulk Density (mg/m$^3$) | Porosity (%) | Gravimetric Moisture (%) |
| Farm land | 90.50(3.50) | 5.00(4.00) | 4.00(0.00) | 1.62(0.16) | 39.00(6.00) | 10.50(1.50) |
| Mechanic site | 77.35(2.65) | 5.00(4.00) | 17.65(1.35) | 1.79(0.12) | 32.50(4.50) | 23.75(23.25) |
| Industrial area | 89.50(2.50) | 8.50(0.50) | 3.00(2.00) | 1.28(0.07) | 47.50(6.50) | 21.00(1.00) |
| Residential area | 73.50(0.50) | 14.50(3.50) | 12.00(4.00) | 1.66(0.05) | 37.50(1.50) | 5.50(0.50) |
| Virgin land | 90.00(3.00) | 7.50(2.50) | 2.50(0.50) | 1.45(0.05) | 45.00(2.00) | 8.50(2.50) |

Significant difference in column * at p=0.05, ** p=0.01(Bonferroni test) of the soil is generally low with values less than 50% in all the land use. Porosity is relatively higher in Virgin land (45%) and the least in Mechanic site (32%). The low porosity value in Mechanic site may be attributed to the high bulk density nature of the soils. Variability in Porosity is higher in Industrial area (SE±6.5) and least in Residential area (SE±1.5).

**Soil moisture**

Gravimetric moisture content of the soils in different land uses shows statistically similar result. Mechanic site and Residential area had higher (23.75%) and least (5.50%) moisture content respectively. The relatively higher moisture content in Mechanic site could be attributed to the high clay content of the soils. This has been buttressed by Brady and Weil, (2002) that fine texture soils hold more moisture than coarse-textured soils. Variability in moisture content is higher in soils of Mechanic site (SE±23.5) than in soils of the other land use.

**Chemical Properties of the Soils**

Result of some selected chemical properties of the soils as influenced by different land use is presented in Table, 2.

**Soil pH**

Soil pH is statistically similar in all the land use types. Despite the non significant difference ($p>0.05$) in soil pH between the control (Virgin land) and other land use and Farmland had the least pH value (6.13) while Mechanic site and Residential Area had the highest pH values (7.75). The soils are neutral to slightly alkaline in reaction according Landon (1991) classification of soil reaction. Burning of materials and crop residues leaving ashes may have contributed to the slightly alkaline nature of soils of Mechanic site and Farmland respectively.

**Soil Organic Matter**

Organic matter of the soils of the different land use is statistically similar. Soil organic matter in agro ecosystems is regarded as an important source of soil nutrients and determining factor in the availability of majority of nutrients to crops and plants (Agboola and Corey, 1973). Despite the statistical similarities of organic matter content of the soils, the Virgin land and Residential area had the highest (3.39%) and least (1.57%) soil organic

**Table 2 : Mean and Standard Error of Some Selected Chemical Properties of the soils of Suleja Area as influenced by land use**

| Samples Area | pH | Organic Matter | Total N | Exchangeable Bases (cmol/kg) | | | | CEC | Av.P (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|
| | | ---------> | % <------- | Ca | Mg | K | Na | Cmol/Kg | |
| Farm land | 6.13(0.01) | 1.93(0.01) | 0.05(0.01) | 2.59(0.05) | 3.07(0.01) | 0.19(0.01) | 1.61(0.01) | 7.97(0.07) | 70.26(1.51)** |
| Mechanic site | 7.75(0.01) | 3.31(0.40) | 0.21(0.01) | 20.65(0.05)** | 14.77(0.18)** | 0.68(0.01) | 1.23(0.02) | 37.29(0.05)** | 35.42(1.51)** |
| Industrial area | 7.17(0.01) | 3.06(0.03) | 0.12(0.01) | 15.77(0.09)** | 8.72(0.22) | 1.08(0.01) | 1.77(0.02) | 28.00(0.10)** | 13.76(5.00)** |
| Residential area | 7.75(0.01) | 1.57(0.02) | 0.11(0.02) | 10.73(0.04)** | 7.50(0.14) | 0.19(0.01) | 3.14(0.01) | 21.70(0.14)** | 19.75(1.50)** |
| Virgin land | 6.42(0.02) | 3.39(0.05) | 0.02(0.01) | 2.28(0.04) | 6.00(0.46) | 0.21(0.01) | 1.24(0.02) | 9.98(0.42) | 21.89(0.59) |

Significant difference in column * at $p=0.05$, ** $p=0.01$ ( Bonferroni test) matter content respectively. The relatively high organic matter content of Virgin land may be attributed to continuous deposition of litter with little or no soil disturbance over time while Continuous cultivation may have caused the relatively low organic matter in soils of the farmland.

**Total Nitrogen**

There is no significant difference ($p>0.05$) in Total N of the soils. Mechanic site and Virgin land had the highest (0.21%) and least (0.02%) values respectively. Virgin land with the highest organic matter content was expected to have highest Total N because of their positive relationship but reverse was the case. Total N content of the soil is rated moderate.

**Exchangeable Bases**

Some exchangeable bases showed significant difference between land use and control (Virgin land) while others are statistically similar. Result of Ca showed significant difference ($p<0.01$) between land uses and control (Virgin land) with the exception of farmland. Magnesium is significantly different (($p<0.01$) in Mechanic site and statistically similar in all other land uses. Potassium and Na are statistically similar between all the land uses. Despite the statistical similarities, industrial and Residential areas had the highest values of K (1.08 cmol/kg) and Na (3.14 cmol/kg) respectively. Exchangeable bases in the soils are in the order of Ca>Mg>Na>K. The dominance of Ca and Mg in soils of the Savanna has been previously stresses by Jones and Wild , (1975).

**Cation Exchange Capacity (CEC)**

Cation Exchange Capacity is significantly different ($p<0.01$) between control (Virgin land) and other land uses with the exception of farmland. The soils are generally moderate to high in CEC with Mechanic site having the highest (37.29 Cmol/kg) and Farmland with the least value of 7.97 Cmol/kg. The high CEC values are an indication that the soils are fertile and this may be attributed to the nature of the clay minerals present. The high CEC in soils of Mechanic site, Industrial area and Residential area may also be attributed to the moderate level of organic matter in the soils. This relationship, that Organic matter increases CEC has severally been stressed by many Authors (Lal and Greenland, 1979; Olaitan and Lombin, 1984).The low CEC in farmland soils may be attributed to clay type and content as well as previous land use (Jones and Wild, 1975). Cation exchange capacity of soil determines the fertility status of soils and with the values recorded for the soils, the soils could be said to be of moderate and high fertility.

**Available Phosphorus**

There is significant difference ($p<0.01$) in Available P between Control (Virgin land) and other land use types. Land use type has therefore greatly influenced the levels of phosphorus in the soils. Farmland soils had the highest value of Available P (70.26 mg/kg) while Industrial area had the least values (13.73 mg/kg). The variability of Available P is much higher in industrial area (SE±5.00) than in other Land uses. In accordance with levels given by FMANR (1990) for tropical upland soils of phosphorus greater than15.0 ppm, most of these soils contain high levels of available P. The high Available P in Farmlands could be the result of application of inorganic and organic P sources through the use of fertilizers. In general the status of available P in all the soils is high, contradicting the general observation of low P fertility and availability of tropical humid soils.

**Micronutrients (Heavy Metals)**

Result of some selected micronutrients of the soils as influenced by differences in land use is presented in Table,3.

There is significant difference ($p<0.05$), ($p<0.01$) in Zn content between control (Virgin land) and Farmland, Mechanic site and Industrial area while in Residential area the results are statistically similar ($p<0.05$) with the Virgin land. Variability in Zn content in soils of the different land use is much more in Industrial area (SE±0.03). Zn content in soils of the different land use is generally below

There is no significant difference ($p>0.05$) in Copper content of the soils of the different land use with the exception of soils of Mechanic site which is significantly different ($p<0.01$) from the control (Virgin land). Variation in Cu content of the soils is therefore not significant.

Iron (Fe) content is significantly different ($p< 0.01$) between Farmland area, Residential area and Virgin land. Fe content of Mechanic site and industrial area are statistically similar with those of the Virgin land. Fe content

**Table 3 : Mean and Standard Error of Some Selected Micronutrients (Heavy metals) in Soils of Suleja Area as Influence by Land use**

| Sampled Areas | Heavy metals | | | | |
|---|---|---|---|---|---|
| | Zinc (ppm) | Copper (ppm) | Iron (ppm) | Lead (ppm) | Manganese (ppm) |
| Farm land | 0.02(0.01)* | 0.01(0.01) | 0.70(0.00)** | 0.00(0.00) | 0.14(0.01) |
| Mechanic site | 0.43(0.00)** | 0.11(0.00)** | 0.81(0.00) | 0.02(0.00) | 0.11(0.00)** |
| Industrial area | 0.21(0.03)** | 0.08(0.01) | 0.78(0.03) | 0.01(0.00) | 0.13(0.01) |
| Residential area | 0.09(0.00) | 0.01(0.01) | 0.74(0.00)** | 0.00(0.00) | 0.12(0.00)* |
| Virgin land | 0.09(0.01) | 0.02(0.01) | 0.82(0.06) | 0.00(0.00) | 0.19(0.00) |

Significant difference in column * at p=0.05, ** p=0.01( Bonferroni test)

is higher and more variable in soil of the Virgin land than in other land use. Fe is an important element in tropical soil (Boul et al., 2003) and from the results it shows that it reduces with land usage.

Lead (Pb) in the soils shows statistically similar result ($p>0.05$). Only Mechanic site and Industrial area had traces of Pb with mean values of 0.02 and 0.01ppm respectively. Mechanical and Industrial waste may have accounted for the traces of Pb obtained in these soils. No Lead (Pb) was found in Farmland, Residential and Virgin land (mean 0.00ppm). Lead (Pb) is generally low in all the soils and may therefore pose no serious threat to human and plants. There has been a lot of attention paid to lead levels in soil because it is well-known to cause adverse health effects, and is relatively widespread as a result of its historical use in many commercial products, from gasoline to paint (Vern Grubinger and Don Ross,2011).

Virgin soil had the highest content of Manganese (Mn) (mean 0.19ppm) while Mechanic site had the least value (mean 0.11ppm) and is significantly different ($p<0.01$) from the Virgin soil. Mn content of the Residential area is also significantly different ($p<0.05$) from that of the Virgin soil. Manganese in all the soils shows little or no variability.

It could be observe that the heavy metals are generally low in all the soils compare to the limit of maximum set by (U.S. EPA, 1993. and USEPA, 1986). The low heavy metals may be attributed to the nature of the soil pH (near neutral) and high phosphorus level. This assertion has been supported by many Scientists (USDA/NRSCS, 2000; Vern Grubinger and Don Ross,2011) that neutral pH and maintaining optimal soil phosphorus levels can reduce heavy metal availability in soil. The low heavy-metals in soils is also an indication that urban land use in Suleja has not significantly affected soil quality.

## CONCLUSION AND RECCOMENDATION

Rapid population growth in Suleja town which has been attributed to urban spill from the Federal Capital Territory (The Nigerian capital) has led to increased urban activities with attendant changes in land use. The study shows that changing land use types have little impact on soil quality parameters. Results of soil physical and chemical properties revealed none significant difference with the exception of Ca, CEC and Available P. Heavy metals are generally low in all the soils indicating that land use has not affected soil quality significantly. Careful use of the soils to avoid future changes in soil quality is necessary.

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