



Evaluation Of Geospatial Distribution Of Top Soil Quality In Lapai And Its Environs, Niger State Nigeria

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ABSTRACT

This study evaluate the top Soil Quality in Lapai and its Environs using geographical information system (GIS) by identifying the geospatial distribution of soil types in the study area; evaluate the physical component of the soils obtained and nutrient fertility in Lapai. Systematic sampling technique was adopted by demarcating the study area into five categories in search of soil physical properties. Soil samples were taken from five different land use types; Farmland (FL), Industrial Land (IL), Residential Land (RL), Mechanic Workshop Land (ML) and Uncultivated Land (UL) respectively. The Soil properties assessed include Bulk Density, Moisture content, Porosity and Soil Texture. It is revealed that Mechanic sites has (1.98mg/m³), Residential land had (1.85mg/m³) of weight. Similarly, Farmland had higher moisture content of (11.659mg/m³) and Uncultivated land had least of (0.049mg/m³), The Uncultivated land had higher porosity value at (39%) and Mechanic workshop is least with (25%). Similarly, result of particle size distribution (Texture) showed that Mechanic Workshop had higher particle size with (137.7g) and the least is Residential land with (91.8g) respectively. Therefore the land use types have a negative impact on soil quality of the study area. Government should provide a workshop for mechanics in order to avoid depreciation of land fertility. Proper land use evaluation and land use planning should be enforced in order to minimize adverse effects of degradative land uses on the soil quality of fragile or sensitive parcels of land. Also, Individual should avoid pollution of land in other to make the land fertile for geographical use.

Keywords: Bulk density, Soil moisture, Porosity, and Soil texture

INTRODUCTION

Soil is a biologically active complex mixture of weathered minerals, organic matter, organisms, air and water which provides the foundation for life in terrestrial ecosystem. Soil however, is not merely the sum of minerals; organic matter, water and air but a product of their interactions (Ibrahim and Ibrahim, 2014). It can be considered as non-renewable natural resources because it develops over very long timescales. A soil is distinguished from weathered parent material by the vertical differentiation it inhibits due to biological activity, so that the properties that are singled out in most system of soil classification must be displayed in the soil profile (Glover, et al 2000).

Some important functions of soil include provision of medium through which agriculture is practice to provide food for man, provide plants with the needed nutrients for their continuous existence. It also act as reservoir for air, water needed by soil-living

organism to survive. However, plants cannot grow without the support of nutrients from the soil which also serve as bases of vegetation. It also serve as sources of material for construction work, furthermore, soil provides the habitat for most organisms especially bacteria. The quality of a soil controlled by its properties, like the structure of soil, types and size of soil particles extent to void (controlling it water holding capacity) etc, which ultimately decides, as to what kind vegetation can grow effectively on the given soil under the given climatic condition? In view of these reason the quality of soil and maintaining it in good condition becomes extremely important, since the fertility of the soil will decide the quantum of production of crops and other vegetation. However, over time, soil quality has been affected by various processes (caused

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by both natural and anthropogenic factors). This had led to soil degradation in various part of the world. Soil degradation can be described as the process by which one or more of the potential ecological function of the soil is harmed. These functions relate to biomass production such as nutrient, air, water supply, root support for plants (Andrew and Moorman, 2002). Carter (2002) define soil degradation as the process in which soil losses its fertility and its productive capacity caused by agricultural mismanagement, over use, population pressure and over grazing. It has adverse effect on soil and leads to a decline in soil quality.

Top soil quality affects and is affected by food, feed, and fiber production practices. It is also directly linked to environmental quality (i.e. water and air quality, global warming, and energy use for production practices). Unfortunately, moderate to severe soil degradation through erosion, compaction, leaching, and loss of biodiversity, structure, and titre continues in Nigeria and around the world due to previously unrecognized consequences of traditional soil and crop management practices (e.g., intensive tillage, excessive nutrient and pesticide applications, and over-consumption of fossil fuels). Reports on the state of our land suggest that soil (deposited off-site as sediment or dust), nutrients, and organic matter have been lost at rates far exceeding a sustainable level. Soils types are influenced by the geospatial position such as slope, vegetal location. Obviously soils are distributed across the land base on their exposure to the climatic conditions. Soil quality (SQ) is the capacity of a specific soil to function within natural or managed ecosystem boundaries to sustain plant and animal productivity, maintain or enhance water and air quality and support human health and habitation (Mohammed, 2012). The concept of Soil Quality is particularly crucial given the high rates of soil degradation, prevalent in Niger state especially in Lapai environs. Currently, detection and monitoring of soil degradation and evaluation of management impacts are based on measurement of degradative fluvial processes like annual soil loss (Glover et al., 2000), and individual soil properties such as topsoil depth and nutrient contents (Arshad et al., 1996; Brejda et al., 2000; Andrew et al., 2004). The former are implicit indications of the Soil quality whereas the latter yield a disaggregated view of Soil

quality that ignores interactions between and among soil properties/processes, with respect to its capacity to support crop growth and yields. These weaknesses may be overcome through monitoring crop vigour and yields on a given soil (Brejda et al., 2000). However, different crops respond differently to a given set of soil properties, processes and their interactions. Furthermore, this approach is subject to temporal variations in weather conditions in a given area.

Location of the Study

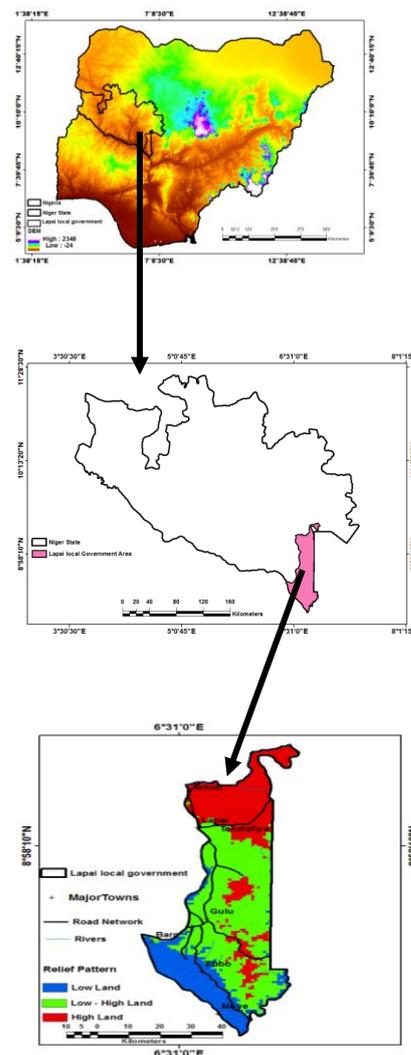


Figure 1: Map of Nigeria inset Niger state and Lapai local government area

METHODOLOGY

Lapai is the Local Government head quarter, located within Latitude $9^{\circ} 04' N$, $9^{\circ} 05' N$ and Longitude $6^{\circ} 34' E$, $6^{\circ} 35' E$. Lapai covers an area of about 3730km^2 with a population of about 18,600 people (National Bureau of statistics 2014). Lapai local Government Area

is bounded by the North by Paikoro Local Government, Agaie Local Government by the West; Gurara Local Government is at the eastern part while Federal Capital and Kogi State occupies the Southern part of Niger State, Nigeria.

Lapai Local Government experiences two distinct seasons of dry and wet seasons. The annual rainfall varies from about 1,600mm in the South to 1,200mm in the northern part of Lapai Local Government Area of Niger State. The duration of the rainy season ranges from 150 to 210 days or more diminishing from northward from the south respectively. The rainy season begins from the month of April or May and ends in November. The season is characterized by little cold, average rainfall with thunder storm and strong wind capable of mass destruction, meanwhile the dry season begins from the month of September or October and ends with the coming of rainfall in April or May. It is also characterized by excessive heat and hot sun shine dry winter wind and harmattan dust. The study area is predominantly covered with the ferruginous

tropical soil which is basically derived from the Basement complex rocks, as well as from old sedimentary rocks. Such ferruginous tropical soils are ideal for the cultivation of guinea corn, maize, millet and groundnut. The entire landscape is covered Guinea Savannah Vegetation which is characterized by woodlands and tall grasses dense species.

Lapai town is systematically selected due to her population and land use diversity. A systematic technique was adopted in calibrating the town of Lapai base map in to 2.5 cm² from which 25 cells were sampled. Soil samples for laboratory analysis were taken using traversing across different Land used Land Cover Type (LLCT) and subjected to physical parameter test for soil quality in the study area.

Soil samples were taken from five (5) different land use types, these are farmland (FL), Industrial Land (IL), Residential Land (RL), Mechanical Workshop Land (ML) and Uncultivated Land (UL). Samples were obtained from these land use locations for the study.

Table 1: Sampling location and LULCT description

LULCT	Description and location of sampling point
Farmland (FL):	FL is located on latitude 09 ⁰ 01'N and longitude 06 ⁰ 35'E along Government day Secondary School close to Mararaba village. The farmland has been under cultivation for several years ago. Crops that are grown on the land include yam, maize, melon, groundnut and sorghum.
Industrial Land (IL)	IL is located on latitude 09 ⁰ 05'N and longitude 06 ⁰ 34 E. The sample was obtained from Namiye Block Industry opposite Ibrahim Badamasi Babangida University, Lapai.
Residential Land (RL)	RL is located on latitude 09 ⁰ 03'N and longitude 06 ⁰ 34'E. The land had been converted to residential since 1980 and beyond.
Mechanic Workshop Land (ML)	ML is located on latitude 09 ⁰ 02'N and longitude 06 ⁰ 34'E Lapai. These land use was selected systematically from various types based on its peculiarity and coverage of where auto-mobile mechanics carry out the repairs of vehicles.
Uncultivated Land (UL):	UL is located on latitude and 09 ⁰ 02'N longitude 06 ⁰ 33'E Opposite Junior Secondary School Lapai. The land area is covered with dense tress and grasses due to its undisturbed nature by human activities.

The soil analysis conducted includes physical analysis and different laboratory techniques were used to carrying out the analysis.

Physical analysis

The physical properties of the soil determined or analyzed includes: Soil texture, Bulk density, Moisture content, Porosity.

Particles Size Distribution

Sieve analysis method was used in determining the particles size. This method is the simple shaking of the sample in the sieves until the amount retained becomes more or less constant. Alternatively, the sample was washed thoroughly with a non-reacting liquid (usually water) before the soil sample is purred into the sieve. This process is called sieve washing.

Bulk Density Determination

The determination was done by oven drying and weighing known volume of soil samples (core method). The bulk density values were calculated using the formula below.

$$Bd = \frac{\text{weight of oven dried soil}}{\text{total volume of soil}}$$

Measurement of Soil Moisture Content

The soil moisture content may be expressed by weight as the ratio of the mass of water present to the dry weight of the soil samples, or by volume as ratio volume of water to total volume of the soil sample. To determine any of these ratios for a particular soil sample, the water mass must be determined by drying the soil to constant weight and measuring the soil samples as after and before drying. The water mass or weight is the difference between the weights of wet and oven dry samples. The criterion for a dry soil sample is the soil sample that has been dried to constant weight in oven at temperature between 100-110⁰ C (105⁰ C is typically) it seems that this temperature range has been based on water boiling temperature and does not consider the soil physical and chemical characteristics (Mohammed, 2012).

Porosity Determination Methods

There are many different porosity determination methods. The simplest one is the determination of porosity by saturated method. In this method, the beakers are first filled to the same mark with gravel, sand, silt

or mixture of these three materials. Then the water is poured into each of the beakers until it reaches the top of each material.

Porosity is determined by dividing the volume of water that you were able to pour into material by the total volume of that material. The result is expressed as a percentage. The formula below was used to calculate the porosity percentage.

$$\text{Porosity} = \frac{\text{amount of water added to sample}}{\text{total sample volume}} \times 100$$



Plate 1: Field assistant sourcing for soil samples in the field

RESULTS AND DISCUSSION

Sieve analysis method was used to determine the particle size distribution; sieve analysis was used because of its simplicity, cheapness and ease of interpretation. This method may be simple shaking of the sample in sieves until the amount retained becomes more or less constant. Alternatively, the sample was washed thoroughly with a non-reacting liquid (usually water). This process is called sieve washing.

This technique is well adopted for bulk materials. A large amount of materials can be readily loaded into 8-inch diameter (200mm) sieve trays. Particle size distributions are conserved with particles too small for separation by sieving to be practical. A very fine sieve, such as 37mm sieve, is exceedingly fragile and it is very difficult to get materials to pass through it. Another disadvantage is that the amount of energy used to sieve the sample is arbitrary determined. Over energetic sieving causes attrition of the particles and thus changes particle size distribution, while insufficient energy fails to break down loose agglomerates. Although manual sieving

procedures can be ineffective, automated sieving technologies using image sieve analysis can be time consuming, accuracy becomes compromised when preliminary sieving technique is not properly handled (Pavel & Gavrilescu, 2008). This according to Laborda *et al.*, (2016) significantly influence application and designed especially in construction management.

Particle size distribution (texture) revealed highly variable of sand, silt and clay. Mechanic workshop land had. Higher particle size of (137.7g) the next is industrial land with (121.8g) then Uncultivated land with (120.7g) followed by farmland with (93.9g) and the least is Residential land with (91.8g). The soils are generally sandy with textural classes ranging from sand (Mechanic workshop land, Industrial land and Uncultivated land) to sandy loamy (Residential and farmland). Soil texture is important because it is related to several soil properties such as soil structure, aeration, water holding capacity, nutrient storage and water movement and bearing strength (Carter, 2002). In addition, they are important for agricultural planning and development especially crop production. In light of the current trend of food demand and the needs for optimization of agricultural production process towards achieving food security, knowledge of soil properties becomes necessary.

Particle Size Distribution

Particle size distribution from textural analysis revealed highly variable of sand, silt and clay. Mechanic workshop land had. Higher particle size of (137.7g) the next is industrial land with (121.8g) then Uncultivated land with (120.7g) followed by farmland with (93.9g) and the least is Residential land with (91.8g). The soils are generally sandy with textural classes ranging from sand (Mechanic workshop land, Industrial land and Uncultivated land) to sandy loamy (Residential and farmland). The result of spatial analysis as presented in Figure 2 shows the presence of four category of soil particles size across the study area. The finest particles are between the ranges of 91.81-113.47_g. Areas with this kind of soil particles include the Lapai main town, Takalafiya and some part of Gulu. Soil of this particle size is known for high infiltration with low permeability, thus suitability for agricultural production is largely a function of the layer

thickness (Wilkinson *et al.*, 2009; Nocentini *et al.*, 2010; Khot *et al.*, 2012).

The next class of soil particles has a weight of 113.47-136.55g cutting across Ebbo, Gulu and Baro with some few isolated spot around Takalafiya. Hydrological assessment of these locations indicates presence of large water bodies making the soil heavier due to compartment from sediment. Adjourning the 113.47-136.55g is region of particles weight between 136.55-170.46g. Areas of this particles size are characterized of gentle slope rising from the river banks. The responsible factor for the rise in the particles weight has a strong correlation with the river alluvium deposit over time along the river banks which gradually block the bank forming a gentle sloping land.

The last class of soil particle weight in the study area is weight between 170.46-200.90g making it the most heavily among all regions. Particles of such weight exist at the extreme end of the eastern part and the western part of the study area covering Muye community. The soil particles of this magnitude serve as an import factor required for infiltration and recharge of groundwater. They are formed from the silting and sedimentation of a river due to rapid drop in the potential energy of a flowing water body. Although this region might be very suitable for agricultural production especially swamp rice especially when underlay by loamy clayed soil with tighter spore space which enable it minimize water loss to transmission.

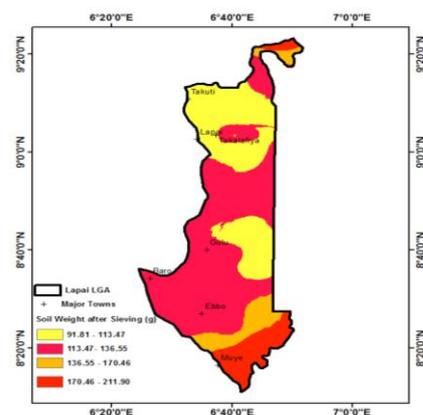


Figure 2: Particle size distribution in Lapai

Moisture Content Distribution

The basic method in determining moisture content is to carefully weigh the sample in its

original state as shown in Figure 3, drying the water contained in the sample, and then re-weighing. This was done in a large oven like chamber at a temperature above the boiling point of water. The main procedure to weight a small metal pan and write down the weight, place a 300g of soil into the pan and write down the weight. Dry the sample of soil in an oven for 24 hours at 110 to 120 degree Fahrenheit. Then place the dried sample in the metal pan again and weight the sample. Subtract the container weight from the total initial weight of 300g to get solution A. then subtract the container from the dried sample to get solution B.

The following equation was used to arrive at the total moisture content of the sample.

$$\frac{C-B}{B-A} \times 100 = C$$

Where A = Weight of Can, B = Weight of dry Soil, C = Weight of wet Soil.

The result obtained and presented in Figure 3 shows the existence of four (4) categories of moisture distribution in the study area. The first region is classified into low moisture content region covering Ebbo and a small part of Taka-lafiya. Next to the low moisture content area is the low to moderately elevated areas which cover substantial part of the study area which comprises; Gulu, Lapai and part of Taka-lafiya. This followed by the moderate moisture content area especially the southern and the Eastern part of Lapai. The high moisture contents region in the study are a smaller in landmass compare to moderate and moderate to high moisture regions. The high moisture areas are confined within the riverside which moisture is available throughout the year. Water from the river especially the river Niger at the western part of the study area is a great feeder to moisture recharge of the prevalent soil along the bank. When porosity, permeability and transitivity are related, the large deposit of porous material at this part might significantly influence the moisture content of the soil. This large moisture content can provide a framework through sustainable groundwater exploration can effectively be developed. In terms of agriculture, they can provide a suitable site for swamp rice and sugar cultivation to ensure food secure and available of raw material for industrial conversion to finish goods.

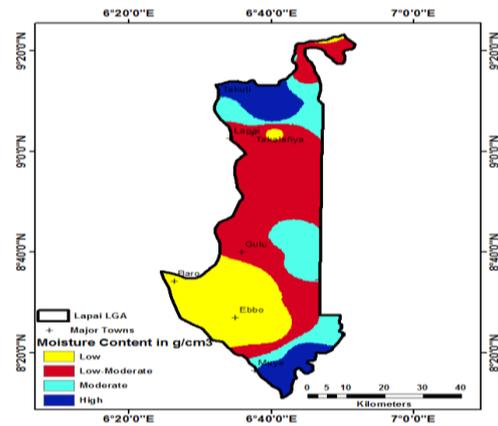
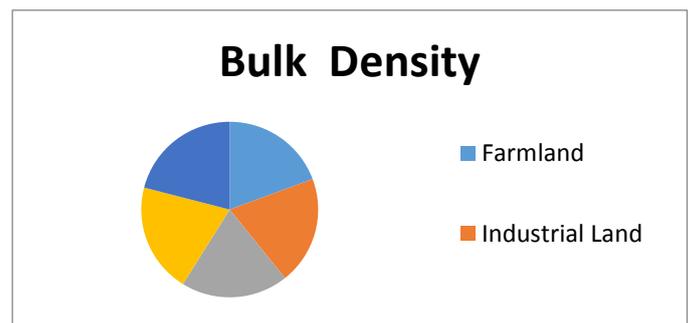


Figure 3: Moisture Distribution in Lapai

In other words, subtract solution A from solution B and divide the total by solution B and solution A then multiply the answer by 100. The total received is the moisture content of the sample. The moisture content is reflected as percent moisture on a weight basis. Farmland had higher (11.659) and uncultivated had the least (0.049) moisture content respectively the relatively higher moisture content in farmland could be attributed to high clay content of the soil. This has been buttressed by Andrew et al, (2004) that fine texture soil hold more moisture than coarse texture soils. Variability in moisture content is higher in soils of farmland than in soils of other land.

Bulk Density



Source: Research Fieldwork 2014

The laboratory result of bulk density, in determining bulk density a soil core was obtained by clearing any vegetation from the soil surface, then knocking a metal cylinder of known dimension into the ground. The soil core is then excavated from the ground assuring that the cylinder is full of soil, while at the same time flush with the end of the cylinder assuring the total volume of the

cylinder is full but not overflowing. Once soil core was collected, it was bagged so that the soil does not get dried and lose any moisture.

Lab analysis of soil core starts with the soil core being weighted as it was found in the field. The weight is recorded and the core is placed into oven at 105⁰C to obtain oven dry (OD) whereby soil moisture has been removed. The oven dry soil is weighted and the water content can then be calculated by the volume of water (cm³) divided by the total volume of soil (cm³). Bulk density will be calculated by the mass of oven dry soil (g) divided by the total volume of soil (cm³).

The equation used in calculating bulk density is

$$\text{Bulk density (P)} = \frac{\text{mass of oven dried soil}}{\text{total volume}}$$

Soil that has a well-developed structure will become less dense as porosity increases thereby resulting to increase in bulk density. Soil which show massive structures and less porosity will show higher bulk density ranging from 1.6 to 1.7gcm-3, water movement will be hindered at this point down the profile. Mechanic site had higher bulk density of (1.98mg/m³) while residential had the least of (1.84) bulk density variability is more variable in farmland. The high bulk density value in mechanic site may be attributed to trembling by heavy vehicles. Bulk density of 1.6mgm⁻³ may inhibit root growth and development and also slow the movement of water in the soil. This property may limit the use of those soils for agriculture. Good plant growth is best in bulk densities below 1.4mg/m³ for clay soils and 1.6mg/m³ for sands. According to Andrew and Moorman (2000), bulk density value of the soils may could become 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.

Conclusion and Recommendation

The study revealed that the soils in Lapai are generally sandy. Particle size distribution (texture) revealed highly variable of sand, silt and clay. Mechanic workshop land have higher particle size of (137.7g) the next is industrial land with (121.8g) then Uncultivated land with (120.7g) followed by farmland with (93.9g) and the least is Residential land with (91.8g). The soils are generally sandy with textural classes ranging from sand (Mechanic

workshop land, Industrial land and Uncultivated land) to sandy loamy (Residential and farmland). Bulk density value of the soil was used generally, soil with highest value of (1.98mg-m³) and the least value of (1.85mg-m³). The highest bulk density values of the soil were attributed to the sandy nature of the soils and compaction caused by human activities. The moisture content of the soil was generally low in all the samples of the soils used. The lowest is Uncultivated (0.049mg/m³) while the highest is Farmland with (11.659mg/m³) moisture content respectively. The relatively highest moisture content in farmland could be attributed to high clay content of the soil that is why the soil is suitable for cultivation. The porosity of the soils was also low and are found to be lower than 50% in all the soils. Porosity is relatively higher on uncultivated land with (39%) and the least in mechanic workshop land with ((25%). The low porosity value in mechanic workshop land was attributed to the high bulk density nature of the soils. Variability in porosity is higher in industrial land and least in residential land.

- i. Government need to provide a specified area for mechanics workshop in order to avoid depreciation of fertile land.
- ii. Proper land use evaluation and land use planning should be enforced in order to minimize adverse effects of degradative land uses on the soil quality of fragile or sensitive parcels of land.
- iii. Individual should avoid pollution of land in other to make the land fertile for geographical use.

REFERENCES

- Andrews S.S, Moorman T.B. (2002), Introduction. *Agronomy Journal* 94, 1-2.
- Andrews S.S, Karlen D.L, Cambardella C.A. (2004), The soil management assessment framework: A quantitative soil quality evaluation method. *Soil Science Society of America Journal* 68, 1945-1962.
- Arshad M.A, Lowery B, Grossman B. (1996). Physical tests for monitoring soil quality. p. 123-141. In: Doran JW, Jones AJ,

- Editors, *Methods for Assessing Soil Quality*. Soil Science Society of America Special Publication 49, SSSA, Madison, WI. Biomass carbon and nitrogen in soil quality. p. 203-215.
- Brejda J.J, Moorman TB, Smith JL, Karlen DL, Allan DL, Dao TH. (2000). Distribution and Variability of surface soil properties at a regional scale. *Soil Science Society of America Journal* 64, 974-982.
- Carter M.R. (2002). Soil quality for sustainable land management: Organic matter and Aggregation interactions that maintain soil functions. *Agronomy Journal* 94, 38-47.
- Colorado State University Website: Estimating soil moisture. Department of sustainable natural resources PDF: Soil moisture content.
- Glover J.D, Reganold J.P, Andrews, P.K. (2000). Systematic method for rating soil quality of
- Conventional, organic, and integrated apple orchards in Washington state. *Agriculture, Ecosystems and Environment* 80, 29-45.
- Ibrahim, S. I and Ibrahim N. I. (2014), Farmer's attitudes towards the use of organic waste to improve soil fertility in Niger State Nigeria. *Development of Science and Technology Research*, 3(1)154-164.
- Mohammed A.A. (2012). The impact of types of landuse on soil quality in Suleja local Government area, Niger State Nigeria. Unpublished B. Sc. Project presented to Department of Geography. Ibrahim Badamasi Babangida University Lapai.
- Khot, Lav R, Sankaran, Sindhuja, Maja, Joe Mari, Ehsani, Reza, & Schuster, Edmund W. (2012). Applications of nanomaterials in agricultural production and crop protection: a review. *Crop protection*, 35, 64-70.
- Laborda, Francisco, Bolea, Eduardo, Cepriá, Gemma, Gómez, María T, Jiménez, María S, Pérez-Arantegui, Josefina, & Castillo, Juan R. (2016). Detection, characterization and quantification of inorganic engineered nanomaterials: a review of techniques and methodological approaches for the analysis of complex samples. *Analytica chimica acta*, 904, 10-32.
- Nocentini, Caterina, Certini, Giacomo, Knicker, Heike, Francioso, Ornella, & Rumpel, Cornelia. (2010). Nature and reactivity of charcoal produced and added to soil during wildfire are particle-size dependent. *Organic Geochemistry*, 41(7), 682-689.
- Pavel, Lucian Vasile, & Gavrilescu, Maria. (2008). OVERVIEW OF EX SITU DECONTAMINATION TECHNIQUES FOR SOIL CLEANUP. *Environmental Engineering & Management Journal (EEMJ)*, 7(6).
- Wilkinson, Marshall T, Richards, Paul J, & Humphreys, Geoff S. (2009). Breaking ground: pedological, geological, and ecological implications of soil bioturbation. *Earth-Science Reviews*, 97(1-4), 257-272.