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Study on Soil pH, Organic Carbon and Organic Matter along Gamboru Ngala Road in Bornostate, Nigeria

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Abstract: **- This study was aim at assessing the level of pH and organic matter in agricultural environment along Gamboru Ngala LGA in Borno state of Nigeria. Soil samples of varying depth 2000 metre) were collected in five local governments along Gamboru Ngala Road Borno state. At each of the sample sites, roadside soil were collected for a period of three months, at different distance from the edge of the main road 30, 60 and 90metre as well as varying depth of 0-5cm, 5-10cm and 10-15cm respectively, 200 metres serves as control points. pH, organic matter and organic carbon were determined using standard procedures. Mean pH value was showed in Jere at ranged between 6. 33 - 7.77. The organic matter varies considerably from 0.12 to 2.17% within the sampled area, while electrical conductivity ranged between 0.03 to 1.76mscm^{-1}. the mean value of electrical conductivity (EC mscm^{-1}), and percentage of Organic carbon and Organic matter with respect to distance and depth from the road within Marte L.G.A in Borno state. The mean value of electrical conductivity (EC mscm^{-1}) ranged between 0.07 to 1.2mscm^{-1}, organic carbon 0.5 to 0.8% and organic matter 0.8 to 1.4%. Figure 4.2.3 present the mean value of electrical conductivity (EC mscm^{-1}), and percentage of Organic carbon and Organic matter with respect to distance and depth from the road within Dikwa L.G.A in Borno state. The mean value of electrical conductivity (EC mscm^{-1}) ranged between 0.04 to 0.3mscm^{-1}, organic carbon 0.1 to 0.3% and organic matter 0.2 to 0.6%. Figure 4.2.4 present the mean value of electrical conductivity (EC mscm^{-1}), and percentage of Organic carbon and Organic matter with respect to distance and depth from the road within Jere L.G.A in Borno state. The mean value of electrical conductivity (EC mscm^{-1}) ranged between 0.04 to 0.4mscm^{-1}, organic carbon 0.1 to 0.5% and organic matter 0.2 to 0.8%. Figure 4.2.5 present the mean value of electrical conductivity (EC mscm^{-1}), and percentage of Organic carbon and Organic matter with respect to distance and depth from the road within Mafa L.G.A in Borno state. The mean value of electrical conductivity (EC mscm^{-1}) ranged between 0.2 to 1.7mscm^{-1}, organic carbon 0.3 to 0.5% and organic matter 0.5 to 1.0%.**

I. INTRODUCTION

Soil pH is determined by the concentration of hydrogen ions (H^+). It is a measure of the soil solution's (soil water together with its dissolved substances) acidity and alkalinity, on a scale from 0 to 14. Acidic solutions have a pH less than 7, while basic or alkaline solutions have a pH greater than 7. By definition, pH is measured on a negative logarithmic scale of the hydrogen ion concentration [H^+], i.e., pH = -log [H^+]. Therefore, as hydrogen ion concentration (and acidity) goes up, pH value goes down. Also, because pH is a logarithmic function, each unit on the pH scale is 10 times more acidic than the unit above it. For example, a pH 6 solution has a 10 times greater concentration of H^+ ions than a pH 7 solution, and a 100 times higher concentration than a pH 8 solution. Soil pH is influenced by both acid and base-forming cations (positively charged dissolved ions) in the soil. Common acid-forming cations are hydrogen (H^+), aluminum (Al^{3+}), and iron (Fe^{2+} or Fe^{3+}), whereas common base-forming cations include calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^+) and sodium (Na^+). Most agricultural soils have near-neutral to basic conditions with average pH values of 6.5 to 8. This is primarily due to the presence of base-forming cations associated with carbonates and bicarbonates found naturally in soils and irrigation waters. Due to relatively low precipitation amounts, there is little leaching of base-forming cations, resulting in pH values greater than 7.

Soil organic matter serves multiple functions in the soil, including nutrient retention, water holding capacity, and soil aggregation and is a key indicator of soil quality. Soil organic matter levels have declined over the last century in some soils as a result of over-grazing grasslands and the conversion of grasslands to tilled farmland. The organic matter in soil derives from plants and animals, for example, leaf litter and woody material falls to the point in which it is no longer recognizable. When the organic matter has broken down into a stable substance that resists further decomposition it is called humus, the advantage of humus is that it helps the soil to stick together which allows nematodes, or microscopic bacteria, to easily decay the nutrients in the soil. Thus, soil organic matter comprises all of the organic matter in the soil exclusive of the material that has not decayed (George, 2002). All living organisms are composed of organic compounds. In life they secrete or excrete organic materials such as feces into soils, shed body parts such as leaves and roots and after the organism dies, its body begins to decompose, broken down by bacterial and fungal action. Larger molecules of organic matter can be formed from the polymerization of different parts of already broken down matter. Natural organic matter can vary greatly, depending on its origin, transformation mode, age, and existing environment, thus its bio-physico-chemical functions vary with different environments (George, 2002).

Soil organic matter is the combination of plant and animal residues at various stages of decomposition and cells and tissues of soil organisms. The consistent benefit of soil organic matter is that it buffers soil pH change. Soil organic matter offers many negatively charged sites to bind H+ in an acidic soil, or from which to release H+ in a basic soil, in both cases pushing soil solution towards neutral. Whether soil organi matter changes soil pH in the long term depends on many factors. When organic matter first begins to decay, it releases anions and cations. Plant foliage and stems generally contain more anions, so the initial decay over the first few weeks causes a soil pH increase. This initial increase in soil pH, especially from high nitrogen plant residue, could be used to reduce H^+, aluminum or manganese toxicity in the seedling rooting zone long enough for seedling establishment. Soil microbes further break down the plant material to ammonium (mineralization) which temporarily increases pH. The ammonium gets converted to nitrate (nitrification) which causes pH to instead go down. If the nitrate is lost to leaching, pH drops even more. In the very long term, microbial decomposition decreases pH. The net effect of organic matter addition on soil pH depends on the rate at which all these processes occur and what happens with the nitrogen produced (e.g., nitrate plant uptake vs. leaching loss), the quality and quantity of plant material, and initial soil pH. Soil pH will likely increase with decomposition of plants growing on basic soils, and manure derived from such plants, deep rooted plants that draw anions from deep soil layers to the soil surface, and, plant residue high in nitrogen. Higher residue amounts increase soil pH.

Organic matter is an organic compounds obtained from the remains of living organisms such as plants, animals and their waste products in the environment. Organic matter is present throughout the ecosystem. After degrading and reacting, it can then move into soil and mainstream water via water flow. Organic matter forms molecules that contain nutrients as it passes through soil and water. It provides nutrition to living plant and animal species (James *et al*., 2004). Organic matter acts as a buffer, when in aqueous solution, to maintain a less acidic P^H in the environment. The buffer acting component to be crucial for neutralizing acid rain of once-living organisms such as plants and animals and their waste products in the environment. Basic structures are created from cellulose, tannin, cutin, and lignin, along with other various proteins, lipids, and sugars (Green Fact, 2007).

Borno state is located latitude 1300^0E and longitude $11^0 30^0$N. Ngala is a local government area of Borno State, Nigeria. Its headquarters are in the town of Gamboru Ngala. It has an area of 1,465 km² and a population of 237,071 at the 2006 census. Ngala has been situated at the east central of the state is not much far from the Chad Basin has apparently been a structural depression since yearly tertiary time. It is blessed with a vast fertile land of sandy-loam to clay soil types, where crops like wheat, rice, and vegetables are grown under irrigated conditions. The land is characterized by a sandy flat plain land with scanty vegetation from the central to the northern part, while to the south the soil is sandy loam to heavy clay, with uneven topography characterized sand dust. The vegetation is moderate. The level of agricultural land been pollutant is over whelm. Many studies were carried out in developing countries such as Nigeria and data on pollutant metal concentrations and distribution in such country is extremely scarce (Francek, 1992). Hence, this research work was carried out to ascertain the level of Soil pH and organic matter as a result of heavy metal concentrations in roadside soils of major roads of Gamburo Ngala. The environment mobility and bioavailability of metals in soil is dependent upon the physiochemical forms in which the metal is associated with the soil. Wilson *et al*., 2003 reported that the chemical association Pb, Cd, Mn, Cu, and Zn in soil as investigated by a sequential extraction procedure showed that Pb and Zn are predominantly associated with carbonate and Fe, Mn oxide. Cu is largely present in organic association, only Cd is found in exchangeable fraction. (Chaney *et al*, 2003)

The source of heavy metals in the soil is the deposition of atmospheric aerosol particles but in the urban environment, these particles originate mainly from traffic emission from industrial construction activities and from the flaking of paint. (Radjevic and Bashin, 1999). Dust in urban environment is of great concern because of the presence of much toxic substances like heavy metals some heavy metals are pollutant with harmful influence on natural ecosystem and human health. Although others are essential nutrients heavy metal pollution of terrestrial ecosystem is of great concern. Among the major heavy metal that poses as hazard to the natural ecosystem and human health are Hg, Pb, Cd, Ni, As, Se, Cr, Co, Cu, Zn, and Fe (Botkin and Killer, 1995). The effect of heavy metals pollution on terrestrial systems, bacteria are frequently isolated from such environments and metal tolerance of metal salts, further many soil bacteria are intrinsically resistant to high concentration of heavy metals. Thereby precluding the need to adapt to metal concentration of heavy metals, regards of whether or not the soil were contaminated with metals (Cheney, *et al*.,, 1993).

Objectives of the study are to.,

I. Determine the pH and Electric Conductivity of soil sample along Gamboru Ngala Road.
II. Determine the level of organic matter and organic carbon in soil samples along Gamboru Ngala Road.

Fig 1. The map of Borno state showing the study area

II. LITERATURE REVIEW

Roads are important infrastructure that plays a major role in stimulating social and economic activities. However, road construction has also resulted in heavy environmental pollution (Bai *et al*., 2008).Several researchers have indicated the need for a better understanding of trace metal pollution of roadside soils (DeKimple and Morel, 2000; Manta *et al*., 2002).Trace metals in roadside soils may come from various, human activities, such as industrial and energy production, Construction, vehicle exhaust, waste disposal, as Well as coal and fuel combustion (Li *et al*., 2001).

According to Adefolalu (1980) and Mabogunje (1980), in developing countries like Nigeria, improved road accessibility creates a variety of ancillary employment which range from vehicle repairs, vulcanizes and welders to auto-electricians, battery chargers and dealers in other facilitators of motor transportation. These activities send trace metals into the air and the metals subsequently are deposited into nearby soils, which are absorbed by plants on such soils. The report shows that there was a close relationship between trace metal concentration in roadside soil and those in the dust falls (Sakagami *et al*., 1982). Tracemetals in the soils can also generate airborne particles and dusts, which may affect the air quality (Gray *et al*., 2003). Among the numerous environmental pollutants, an important role is ascribable to heavy metals whose concentration in soils, water and air are continuously increasing in consequence of anthropogenic activity (Francek, 1992).

Soil is a natural body comprised of solids (mineral sand organic matter), liquid, and gases that occurs on the land surface, occupies space, and is characterized by one or both of the following; horizons, or layers, that are distinguishable from the initial material as a result of additions, losses, transfers, and transformations of energy and matter or the ability to support rooted plants in a natural environment. Soil the unconsolidated mineral or organic material on the immediate surface of the Earth that serves as a natural medium for the growth of land plant. The unconsolidated mineral or organic matter on the surface of the Earth that has been subjected to and shows effects of genetic and environmental factors of climate (including water and temperature effects), and macro-and microorganisms, conditioned by relief, acting on parent material over a period of time. A product-soil differs from the martial that it is derived in many physical, chemical, biological and morphological properties and characteristics. Soil is composed of four major components; minerals, organic matter, water and air. In general, the soil minerals provide physical support for the plants while the organic matter contains many of the nutrients essential for growth (Patricia, 2003).

Soil formation, is the combined effect of physical, chemical, biological and anthropogenic processes on soil parent material. Soil is said to be formed when organic matter has accumulated and colloids are washed downward, leaving deposits of clay, humus, iron oxide, carbonate and gypsum's, as a result, horizons form in the soil profile. These constitutions are moved (translocated) from one level to another by water and animal activity, the alteration and movement of materials within a soil causes the formation of distinctive soil horizons, the soil formation proceeds influenced by at least five classic factors that are intertwined in the evolution of a soil, they are parent material, climate, topography (relief), organisms and time. When reordered to climate, relief, organisms, parent material and time, they form the acronym (Milford *et al*., 2001).

There are several ways to quickly increase the amount of humus, combining compost, plant or animal materials/waste, or green manure with soil will increase the amount of humus in the soil. Compost, it decomposed organic material. Plant and animal, material and waste, the dead plants or plant waste such as leaves or bush and tree trimmings, or animal manure. green manure, Plants or plant material that is grown for the sole purpose of being incorporated with soil. These three materials supply nematodes and bacteria with nutrients for them to thrive and produce more humus, which will give plants enough nutrients to survive and grow (Jaradat and Momani, 2004).Organic matter uses all these different phases (soil, sediment, water, and groundwater) to move throughout the environment, this action of movement creates a cycle. Things decompose into organic matter, travel through water flow or soil, and then are free to spread through the phases, (George, 2002).

III. METHODOLOGY

Sample Collection Point

Soil Samples were collected using Per-cleaned plastic container into polythene bags to minimize sample contamination. Samples were collected from five different sites associated with heavy traffic and labelled as (A, B, J, D and M) along Gamboru Ngala Road, Borno State, Nigeria. A represents Ngala local government area, B represents Marte local government area, Drepresents Dikwa local government area, J represents Jere local government area and Mrepresents Mafa local government area. Surface soil samples were collected at various depths of(0-5cm, 5-10cm and 10-15cm) as well as of distance of 30, 60 and 90meters from the main road, while samples at 2000meter from main road serve as control.

Sample Preparation

All roadside soil samples were dried and sieved using mesh sizes 2mm in diameter, the samples were then placed in clean plastic bags, sealed and labeled.

Digestion of soil samples

One gram (2g) of the sieved samples was being weighed in to a 125ml flask. The samples were digested using conc. Perchloric acid (4ml), conc. Nitric acid (10ml) and sulphuric acid (2ml). The content were thoroughly mixed and digested on hot plate and heated gently at low temperature of 55^0C, while heating continued until white dense fume is observed. The solutions were allowed to cool and 40ml of distilled water were added to it, then it was further boiled for about 1 minute at a moderate temperature of 55^0C. The solution were allowed to cool finally and then filtered into a 100ml volumetric flask and made up to the mark with distilled water. The digested samples were kept in plastic bottle with cover and refrigerated.

Determination of pH and Electrical Conductivity

10g of soil samples was weighed into a 50ml beaker and 25ml of distilled water was added. The suspension was allowed to stand for 30 minutes with occasional stirring using a glass-rod. The pH meter was calibrated using buffer solution of pH 7.0 and pH 4.0 before being immersed into the supernatant of the solution. The reading was taken when it was fairly stable without further stirring. The reading was then recorded as 'the electrodes of the pH meter were then rinsed with distilled water and wiped dry with a clean tissue before being immersed in distilled water prior to each subsequent measurement. The suspensions were then stirred for EC determination which was taken in the same manner with the use of an EC meter. The result were recorded in $MSCM^{-1}$ or $USCM^{-1}$

Determination of Organic Carbon and Organic Matters

1g of air-dried (passed through 0.5 mm sieved) soil samples was weighed into a 250ml conical flask. 10ml of 1N potassium dichromate was added with help of a clean pipette, using a clean measuring cylinder. 20ml of concentrated sulphuric acid was added, after cooling, 100ml of distilled water was added followed by 10ml of orthphosphoric acid and 0.2g of NAF (sodium fluoride) and 5 drops of diphenylamine indicator was added which turned the colour to deep violet. The excess chromic acid was then titrated with 0.5 N ferrous sulphates. The end point was recorded as the colour changed from deep violet to deep green, the samples procedure was repeated on the blank (without soil). The amount of soil sample was then recorded and the strength of the $FeSO_4$ was determined and finally, the %OC oxidized by potassium dichromate was calculated using formulae below; %OC = B-T*F/W *0.39s

Where;

B= Amount of 0.5N $FeSO_4$ solution required in blank titration of samples.

T= Amount of 0.5N $FeSO_4$ solution required in the titration of samples.

F= Strength of ferrous sulphate.

W= Weight of soil sample used.

Data Handling

Data collected were subjected with one-way analysis of variance (ANONA) to assess whether heavy metals varied significantly between location and distances from the road, possibilities less than 0.05 ($p<0.05$) will be considered statistically significant.

III. RESULTS

Table 4.1 presents the value of P^H with respect to distance and depths from the road within Jere, Mafa, Dikwa, Marte and Ngala local government in Borno state are as presented in Table 4.1.The mean value of pH range with respect to distance and depth from Ngala local government range between 6.85 to 7.38% in all the distance and the depth in Ngala. The value of pH with respect to distance and depths from the road within Marte local government range between 6.63 to 7.77%, the value of pH with respect to distance and depths from the road within Dikwa local government range between 6.89 to 7.38%, the value of pH with respect to distance and depths from the road within Jere local government range between 6.33 to 7.43% and the value of pH with respect to distance and depths from the road within Mafa local government range between 6.33 to 7.61%.

Table 4.1 presents the pH value of soil sample from Jere, Mafa, Dikwa, Marte and Ngala Local Government Area.

Distances metre	Samples label	Ngala LG	Marte LG	Dikwa LG	Jere LG	Mafa LG
	0-5cm	6.93	7.16	7.11	6.89	7.31
	5-10cm	6.93	7.43	6.98	7.06	7.47
	10-15cm	6.99	7.77	7.38	7.11	7.13
60 metre						
	0-5cm	7.04	7.03	6.96	7.05	6.69
	5-10cm	7.38	6.95	7.20	6.33	6.33
	10-15cm	7.03	7.23	7.20	7.25	7.01
90metre						
	0-5cm	6.97	6.63	7.09	7.28	7.61
	5-10cm	6.85	7.19	7.21	6.76	7.44
	10-15cm	6.96	7.06	7.08	6.99	7.03
2000metre						
	0-5cm	6.91	7.10	7.18	6.95	6.99
	5-10cm	6.85	7.20	7.23	7.43	7.23
	10-15cm	6.88	7.14	6.89	7.43	6.59

Electrical conductivity (EC $mscm^{-1}$), Organic carbon (%OC) and Organic matter (%OM) of Roadside soil sample

The figure 4.2.1 presents the mean value of electrical conductivity (EC $mscm^{-1}$) and percentage of organic carbon and organic matter with respect to depth and distance from the road within Ngala L.G.A in Borno state. The value of electric conductivity ($ECmscm^{-1}$) of 0.09 to 0.8, Organic carbon of 0.1 to 2.1% and Organic matter of 0.2 to 3.78%. Figure 4.2.2 present the mean value of electrical conductivity (EC $mscm^{-1}$), and percentage of Organic carbon and Organic matter with respect to distance and depth from the road within Marte

L.G.A in Borno state. The mean value of electrical conductivity (EC mscm^{-1}) ranged between 0.07 to 1.2mscm^{-1}, organic carbon 0.5 to 0.8% and organic matter 0.8 to 1.4%. Figure 4.2.3 present the mean value of electrical conductivity (EC mscm^{-1}), and percentage of Organic carbon and Organic matter with respect to distance and depth from the road within Dikwa L.G.A in Borno state. The mean value of electrical conductivity (EC mscm^{-1}) ranged between 0.04 to 0.3mscm^{-1}, organic carbon 0.1 to 0.3% and organic matter 0.2 to 0.6%. Figure 4.2.4 present the mean value of electrical conductivity (EC mscm^{-1}), and percentage of Organic carbon and Organic matter with respect to distance and depth from the road within Jere L.G.A in Borno state. The mean value of electrical conductivity (EC mscm^{-1}) ranged between 0.04 to 0.4mscm^{-1}, organic carbon 0.1 to 0.5% and organic matter 0.2 to 0.8%. Figure 4.2.5 present the mean value of electrical conductivity (EC mscm^{-1}), and percentage of Organic carbon and Organic matter with respect to distance and depth from the road within Mafa L.G.A in Borno state. The mean value of electrical conductivity (EC mscm^{-1}) ranged between 0.2 to 1.7mscm^{-1}, organic carbon 0.3 to 0.5% and organic matter 0.5 to 1.0%.

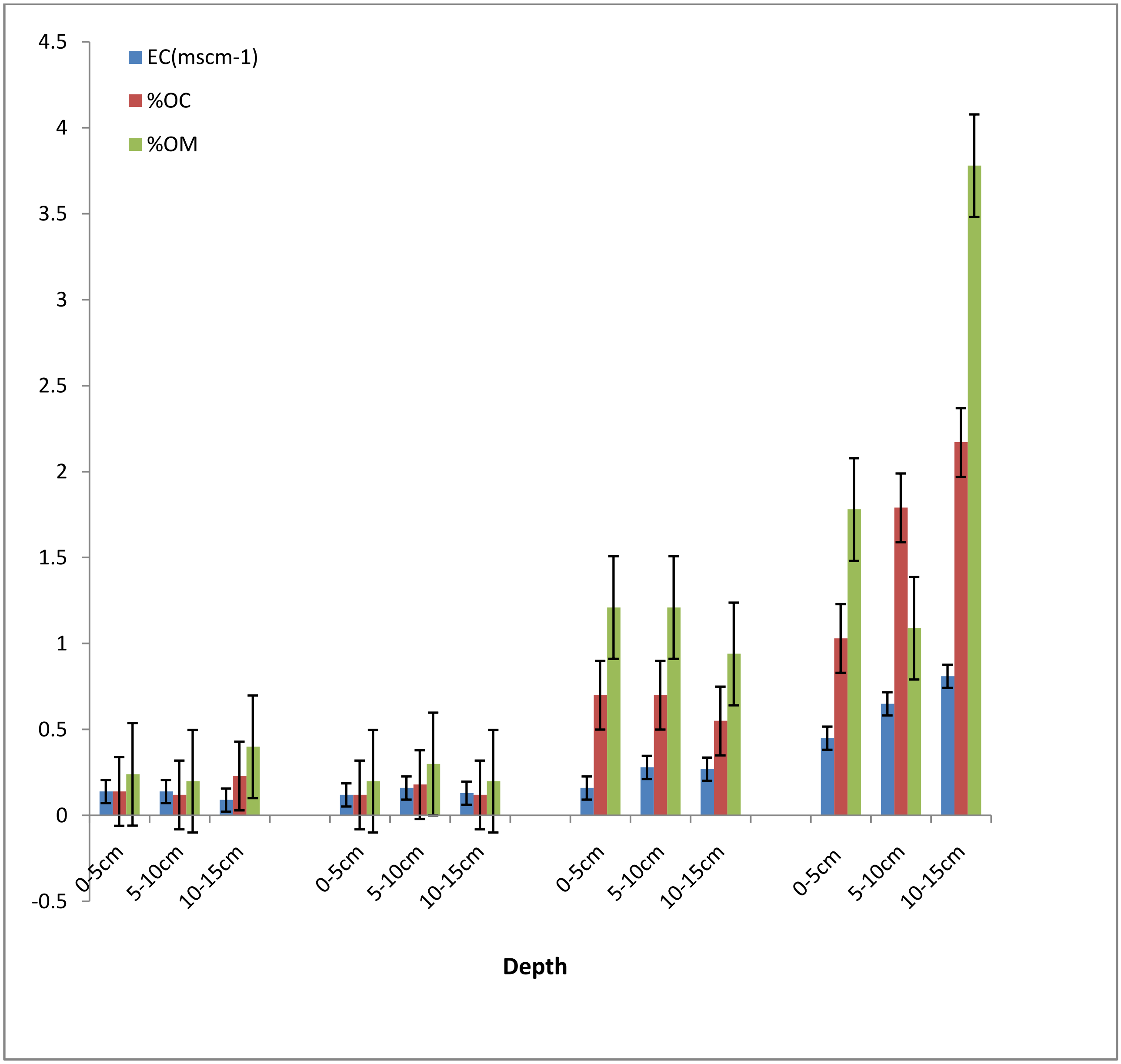

Fig 4.2.1 Result of Electrical Conductivity (mscm^{-1}), %Organic carbon and %Organic Matter in Ngala L.G.A Borno State

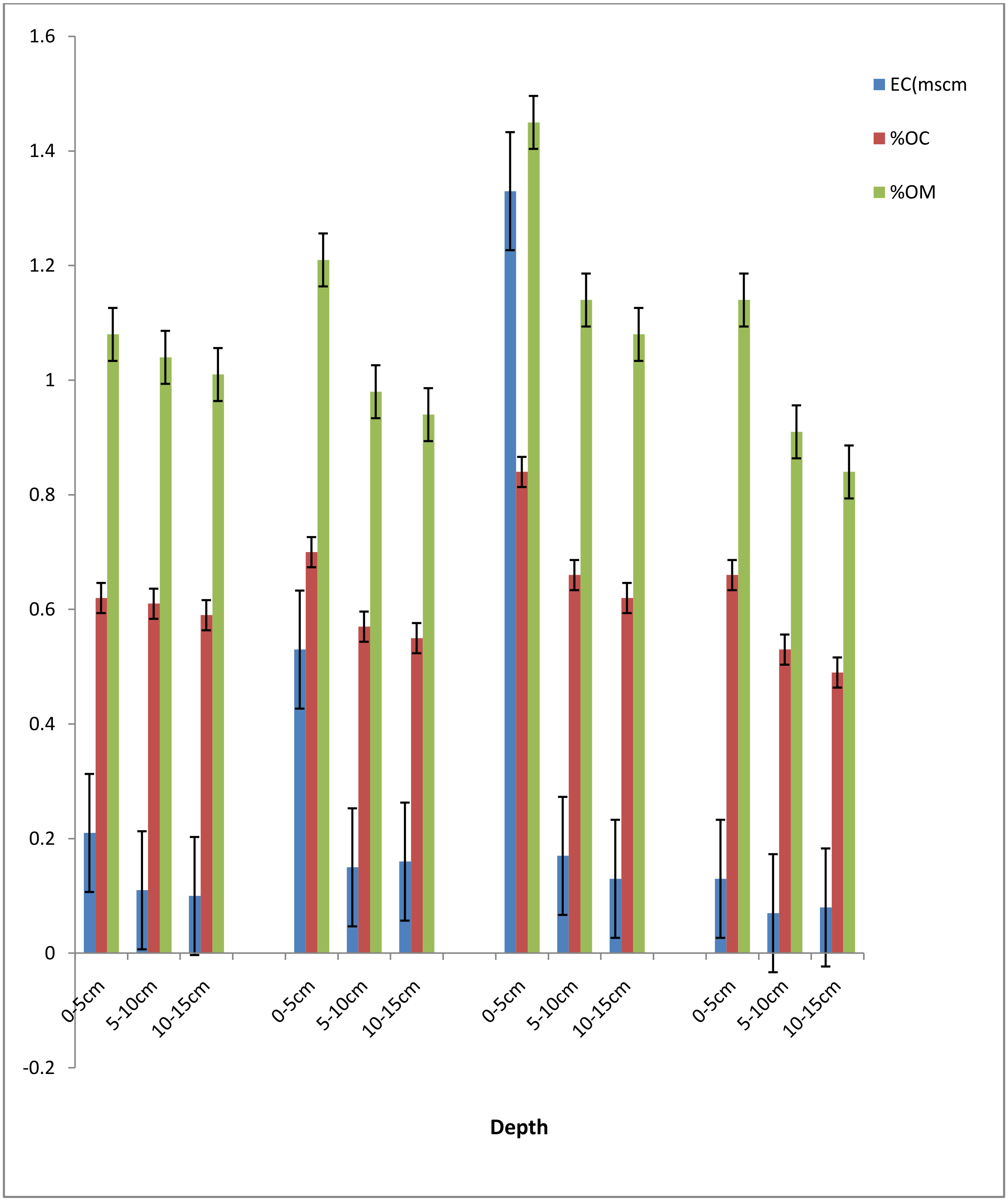

Fig 4.2.2 Results of Electrical Conductivity (mscm^{-1}), Organic carbon % and Organic Matter% in Marte L.G.A Borno State.

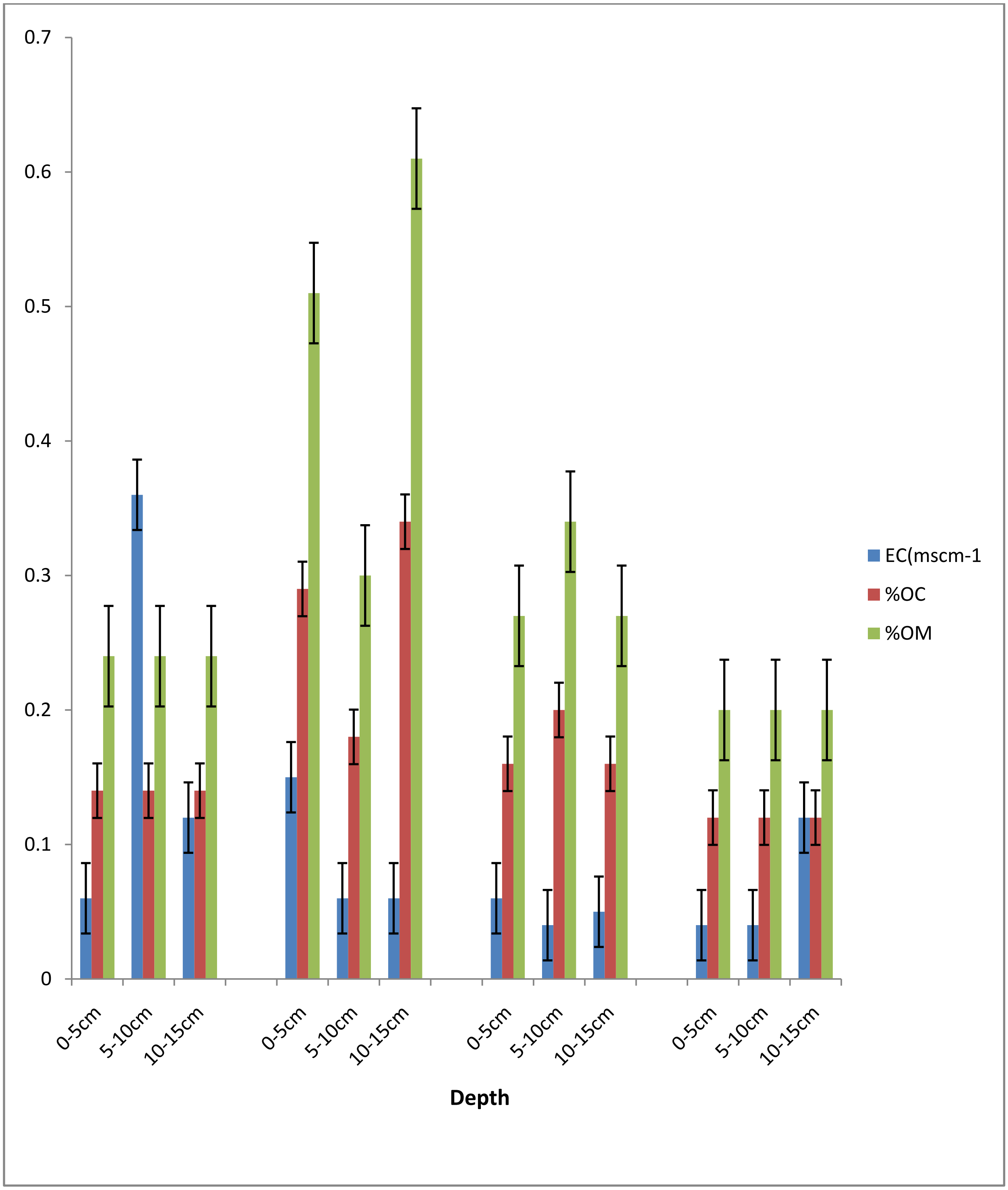

Fig 4.2.3 Results of Electrical Conductivity (mscm^{-1}), Organic carbon % and Organic Matter % in Dikwa L.G.A Borno State

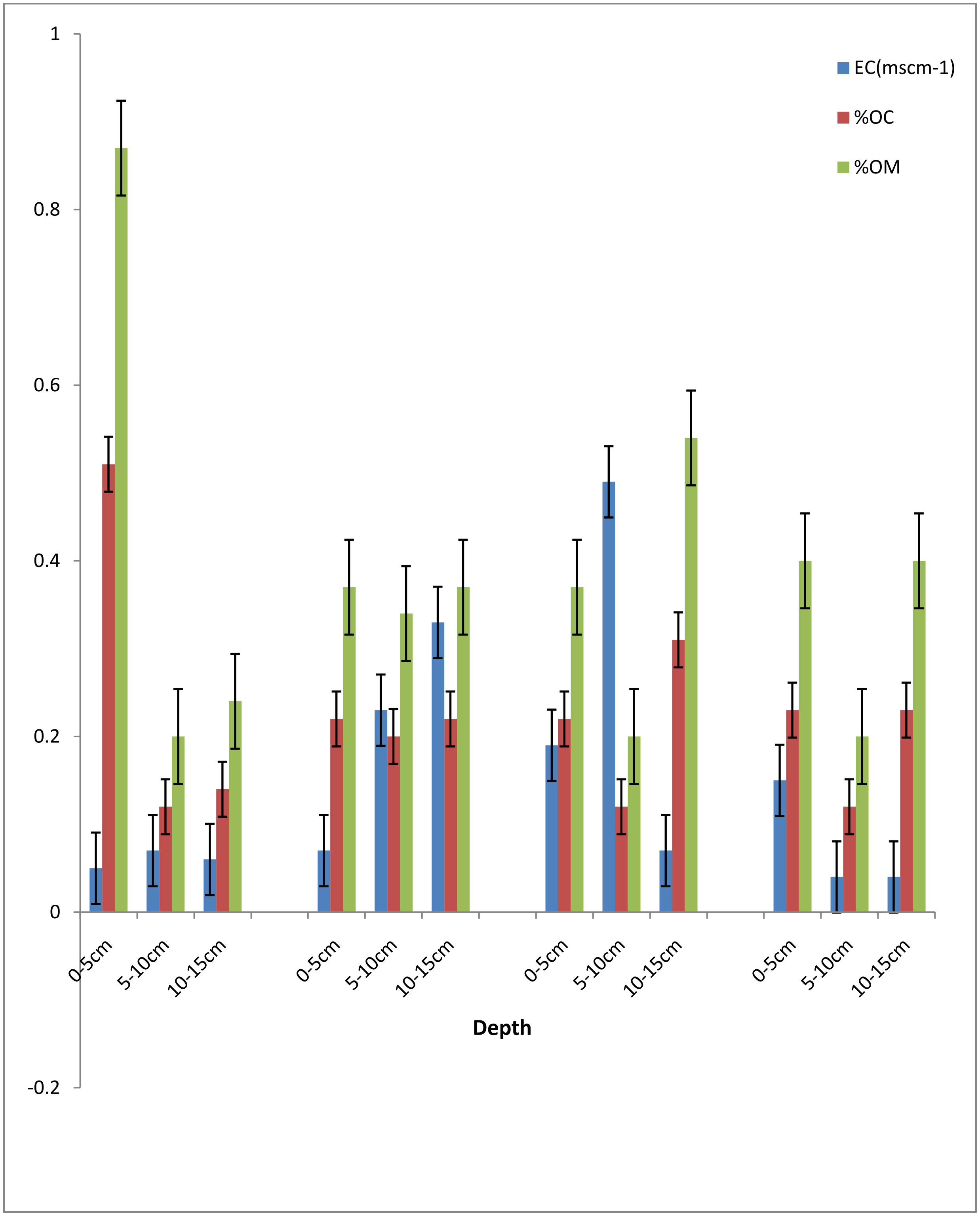

Fig 4.2.4 Results of Electrical Conductivity (mscm^{-1}), Organic carbon % and Organic Matter % in Jere L.G.A Borno State.

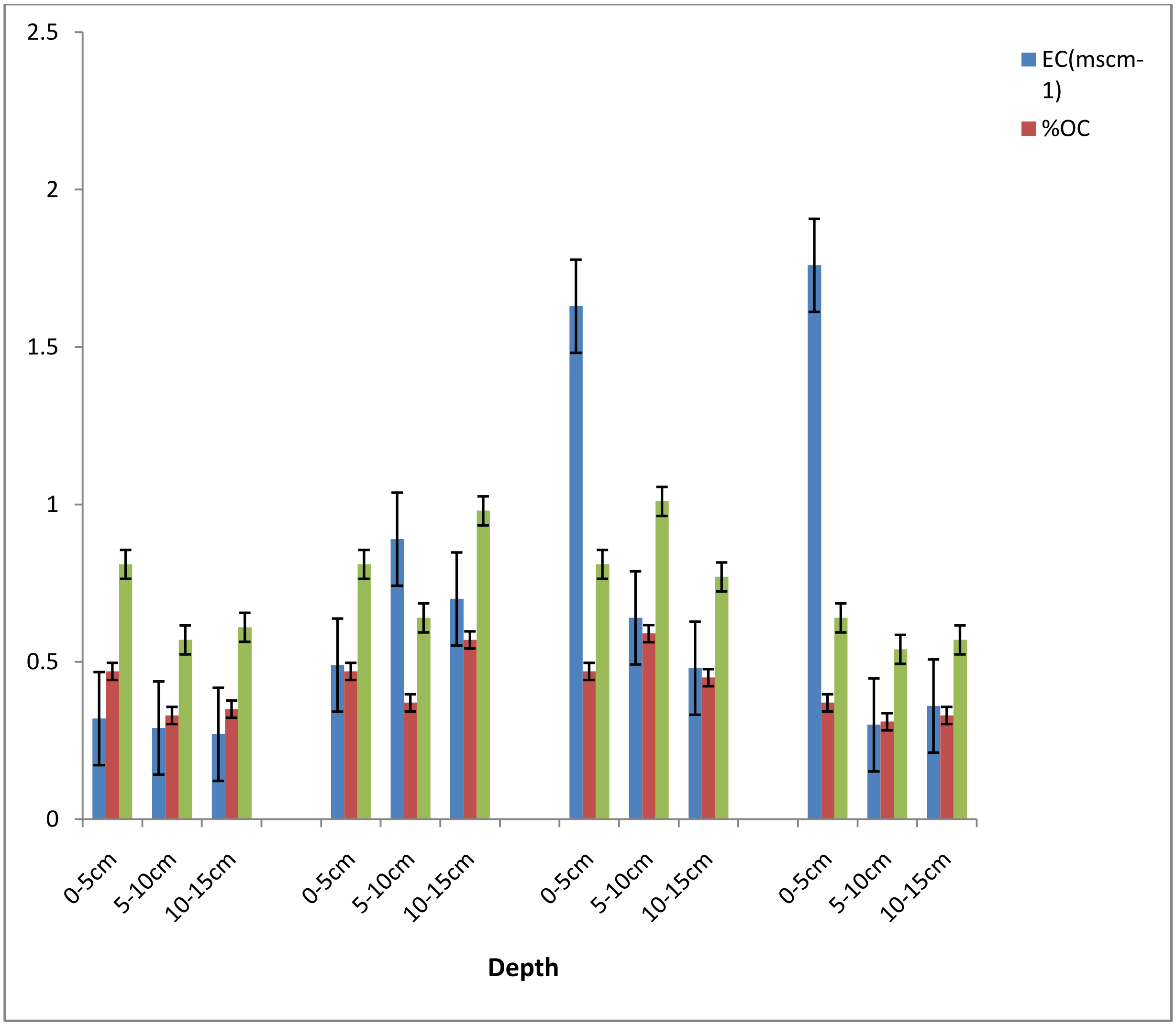

Fig 4.2.5 Results of Electrical Conductivity (mscm^{-1}), Organic carbon % and Organic Matter %in Mafa L.G.A Borno State.

IV. DISCUSSIONS, CONCLUTION

The pH of roadside soil in all the sampling point is in acidic range. Organic matter varied from 0.24 to 3.78% 0.04 to 1.76mscm^{-1} and decreased with increased in depth, organic carbon also increased with depth. The effect of pH on heavy metal availability to plants has been reported by many researchers and it is accepted that as pH decreases, the solubility of cationic forms of metals in the soil solution increases and therefore, they become more available to plants (Evans *et al*., 1995). Evans *et al*., (1995) explained that pH has a major effect on metal dynamics because it controls adsorption and precipitation, which are the main mechanisms of metal retention to soils. Metals solubility in the solution depends on the solubility product of the solid phase (precipitate) containing the metal. Since organic matter plays an important role in metal binding. Some researchers have tested whether organic carbon (OC) compounds influence metal leaching. Fotovat *et al*., (1996) reported that metals such as Cd, Ni, and Zn may be influenced in their solubility characteristics from the presence of OC. They found a significant movement of Cd, Ni, Pb and Zn to a depth of 10cm. also Smith and Giller, (1992) reported that heavy metals had a uniform distribution in the soil profile to a depth of 0-5cm, due to their movement. Results such as these tend to agree with the present study, were movement of heavy metals down the soil profile (leaching) to a depth of 5cm were observed throughout the sampling point. pH is one of the factors which influence the bioavailability and the transport of heavy metals in the soil and according to Smith and Gillar, (1992) heavy metal mobility decreases with increasing soil pH(8 and above) due to precipitation of hydroxides, carbonate or formation of insoluble organic complexes. In the present study, it was observed that heavy metals increased significantly due to the acidic nature of the soil pH. The soil electrical conductivity (EC) also differed significantly among sampling points ($p<0.05$). By comparisms, Smith and Giller, (1992) classified EC of soils as non saline <2, moderately saline 2-8, very saline 8-16 extremely saline >16. From the result of the study, the EC is classified as moderately saline.

From the results of this study, the pH of the roadside soils from all the sampling points ranged from 6.33 to 7.77, which enhanced increased of heavy metals down the soil. Organic carbon content ranged of 0.12 to 2.17% across all the sampling point.

Conclusion

The pHof the roadside soils from all the sampling points ranged from 6.33 to 7.77 which give rise to metal solubility down the soil profiles. The values of the metals in the present study suggest that traffic activities are major source of these metals in the roadside soil. Also with exception of Pb, Cd and Zn, the level of Fe, Cr Cu and Mn in the present study were lower as compared with result found by other researchers in various countries worldwide.

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