

# EFFECTS OF POULTRY DROPPINGS APPLICATION ON SELECTED PROPERTIES OF LATERITIC SOILS DERIVED FROM BASALTS ON THE JOS PLATEAU, NIGERIA

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## Abstract

*One of the greatest challenges confronting farmers on the Jos Plateau, as in other parts of the tropics, is soil fertility maintenance. In addition, lateritization the tropical soil forming process, has resulted into soils with very low inherent fertility. The high cost of chemical fertilizers has necessitated farmers to seek alternative sources of fertilizer material and poultry droppings application has found wide acceptance. This research was carried out to study the effects of poultry manure on selected soil properties on a lateritized basalt in Bokkos L.G.A. of Plateau State. Soils samples were collected from an area of highly ferruginized soils, not cultivated and where there has not been application of poultry manure and from two farms where the farmers had been applying poultry manure for over 10 years. A total of 3 profile pits were dug and 16 soil samples collected. Results of physical and chemical analyses showed that water content was higher for soils with poultry manure application with 18 and 20% and 28 and 16% for surface and subsurface horizons compared to 8 and 10% for soils without poultry droppings application respectively. The organic matter content for the surface soils with poultry droppings application were higher with values of 3.42 and 1.36% and 3.92 and 1.42% compared to 0.75 and 0.60% for soils without poultry droppings application. Another positive effect was found in the total nitrogen content of the soils. While it was 0.350 and 0.245 cmol/kg and 0.245 and 0.280cmol/kg soils with poultry droppings application, it was 0.210 and 0.140 cmol/kg for those without. Exchangeable Mg content was also higher for soils with poultry droppings application. Results of t test confirmed significant differences in contents of total nitrogen and organic matter between the two groups of soils. The study has shown that poultry droppings application is capable of building up the organic matter levels and general fertility of soils. The practice of liming was recommended to maximize the benefits of the high organic matter content of the soils in view of the generally low pH values obtained.*

**Keywords:** Lateritized basalts, Poultry droppings, Soil properties, Jos Plateau

## INTRODUCTION

One of the greatest challenges faced by local small holder farmers is soil fertility maintenance (Galadima et al, 2018). It has been observed that continual cultivation with inappropriate farming methods has resulted in severe decline in soil nutrients and organic matter thus posing a threat to agricultural production in sub-Saharan Africa. Inorganic fertilizer utilization by farmers has proven unsustainable due to high cost. This assertion applies to the Jos Plateau of Nigeria where the application of inorganic fertilizers has continued to decline.

Lateritization is a tropical pedogenic process that produces soils in which the horizons are dominated by iron and aluminium oxides, are reddish to dark reddish brown in colour and are

generally infertile and unproductive especially where natural vegetation has been cleared. Lawal et al (200) describe lateritic soils as products of highly weathered material under tropical and subtropical condition, rich in secondary oxides of iron and aluminium or both and which are void of bases and primary minerals. They further assert that their agricultural values depend largely on the thickness of overlying surface material with those having concretionary layers below 50cm depth being moderately productive for paddy and other cereal crops. In terms of their physical properties and nutrient content, Raychaudhuri (1980) observed that the highly weathered lateritic soils were mostly rated poor for agriculture because of their compacted B-horizon which inhibits root penetration with relatively

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low moisture. In agreement with this assertion, Ansa et al (2019) having reviewed the physical and chemical properties of lateritic soils stated that they have very low potential for arable and economic crop production while Seghal et al (1998) observed that surface crusting, poor inherent fertility, P-fixation, aluminium toxicity, soil erosion among others are the major constraints in these soils.

The lateritic soils occupy extensive areas of land on the Jos Plateau and they are found irrespective of soil parent materials, to form lateritic capping of many granitic and basaltic hill crests as well as ironstone gravels on the surfaces of various middle and lower foot slopes and gently undulating slopes (Olowolafe and Kazeem, 2007). Lateritic soils are now widely utilized in the study area for crop cultivation, grazing and constructional purposes. According to Olowolafe (1995), the total area affected by lateritization in the basaltic landscape is 16,952 ha (i.e. about 22% of the Jos Plateau area). Due to shortage of prime agricultural land, farmers have been forced to move into marginal lands such as those affected by lateritization to cultivate them in order to produce much needed food crops particularly in the basaltic areas. Because of the low fertility of such land's farmers have had to improvise on ways of increasing and maintaining soil fertility in order to productively make use of the land and one such method that has found great acceptance among the farmers in the study area is the use of poultry droppings as fertilizer material. The Jos Plateau is a predominantly agricultural area and is nationally noted for the production of Irish potatoes and various types of vegetables. Agricultural production in the area is becoming more intensive with all year-round production taking advantage of the numerous mining ponds left behind after a long period of tin mining as well as the perennial streams in the area to supply water for irrigation farming. Studies have shown that soils on the Jos Plateau are generally low in nutrient reserves and that this is one of the major constraints to crop production (Olowolafe, 2003, 2004, 2008). With the high cost of chemical fertilizers that has made crop production uneconomical, farmers in the study

area have looked for alternative means of augmenting soil fertility and one of the methods that have gained popularity is the use of poultry droppings.

The poultry industry has grown quite rapidly on the Jos Plateau with both large scale farms as well as small holdings sometimes in the homes of individuals. There is hardly any street that one passes through without a poultry farm at the back of a few homes and so the material is not in short supply. Many studies have been conducted to show the positive effects of poultry droppings on soil properties. According to Mandal et al (2013) composted poultry droppings contain several plant macronutrients and micronutrients and enhance soil fertility, organic matter, and tilth. They have further noted that the labile form of phosphorus increased following long-term sequential application of poultry litter. Davis et al (2017) have given the nutrient content of poultry litter of various types but those relevant to the study area are stock piled broiler and layer droppings. The values are nitrogen 36, ammonium 8, phosphorus 80 and potassium 34 lb/ton for broiler droppings while those for layers are nitrogen 38, ammonium 18, phosphorus 56 and potassium 30 lb/ton. It is therefore not surprising that farmers in the study area have adopted the use of poultry droppings as an alternative to chemical fertilizers. Soremi et al (2017) reported a significant increase in different P fractions such as organic P, residual and reductant soluble P with application over a two-year period. They also reported a significant decrease in occluded P in the soils. Bakayoko et al (2009) reported an increase in organic matter content of a sandy Ferralitic soil from 0.46 to 2.8%, CEC from 1.27 to 12.75me:100g and base saturation from 47 to 80% with poultry manure treatment.

Literature search has revealed that no study has been conducted on soils formed on lateritized basalts on the Jos Plateau where farmers have been using poultry droppings as fertilizer material for a considerable period of time. This study was therefore conducted to study the effects of poultry droppings application on

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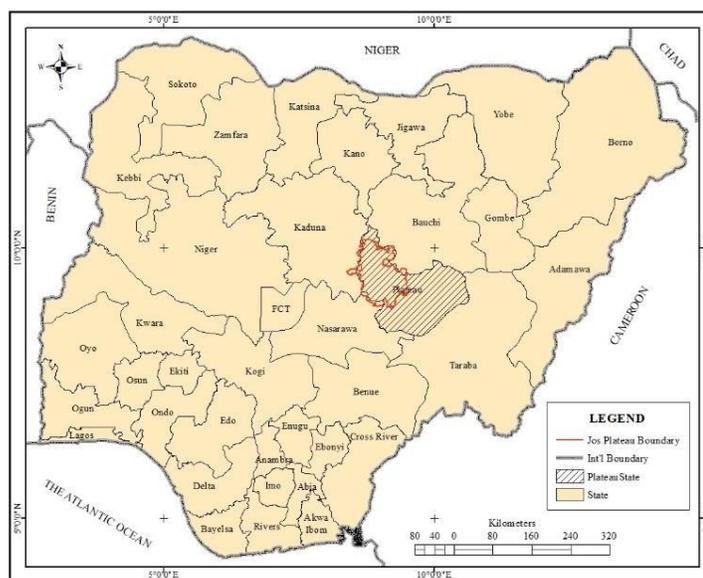
lateritized basalts on the Jos Plateau to assess their effects on selected soil properties.

### MATERIALS AND METHODS

#### Study Area

The Jos Plateau is found in central Nigeria with a latitudinal and longitudinal extent of between  $8^{\circ}30'N$  and  $10^{\circ}30'N$  and of  $8^{\circ}20'E$  and  $9^{\circ}30'E$  with total land area of about  $9,400\text{km}^2$ . The Plateau has an average elevation of about 1,250m above mean sea level and is over 600m above the surrounding plains. It experiences the Aw climate (Koppen's classification) characterized by

alternate wet and dry season. The main influences on the climate are the altitude of the area and the movement of the Intertropical Discontinuity (ITD). The mean annual rainfall is about 1,260mm lasting from April to October with the single maximum occurring between July and August when the moist tropical maritime air mass dominates the airspace while dry conditions persist between November and March with the tropical continental air mass moving in from the north east. Mean annual temperature is about  $22^{\circ}\text{C}$ .

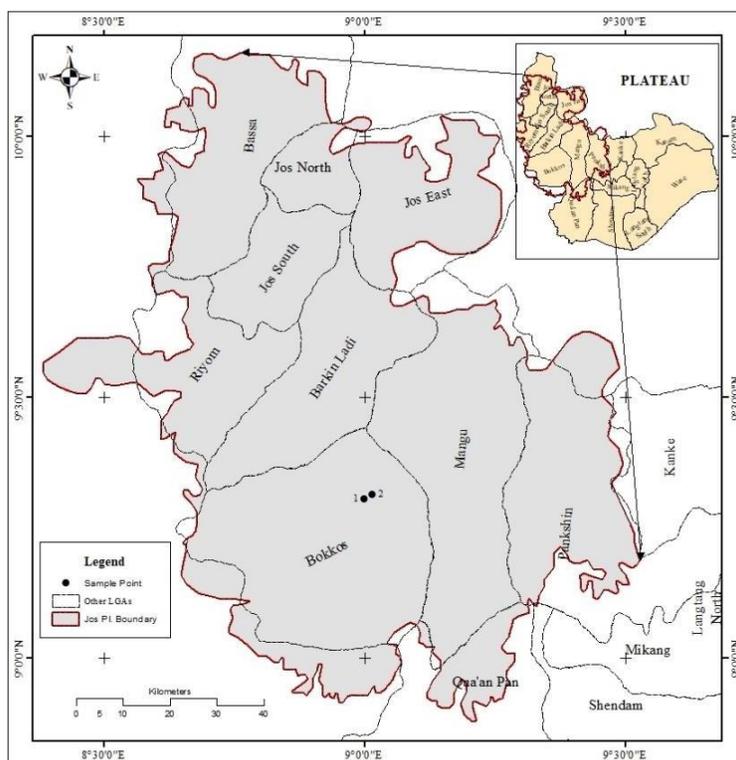


**Figure 1** Nigeria showing the Jos Plateau region

The vegetation is composed of open woodland and tall grasses characteristic of the northern Guinea Savanna but has been much altered due human activities like agriculture and tin mining (Keay, 1953). The geology of the area is made up of Precambrian basement complex rocks (migmatites, gneiss and older granites), the Jurassic younger granites (biotite- granites), the tertiary and quaternary volcanic rocks (basalts, pumice, lava flows and ash deposits) (Macleod et al, 1971). The varied geological and topographic features of the Jos Plateau have given rise to a variety of soil types.

Olowolafe and Dung (2000) have stated that the most prominent include Entisols, Inceptisols, Alfisols and Ultisols. Some of the soil parent materials have undergone lateritization as a result of high temperature and high seasonal rainfall (Macleod et al, 1971). The dominant soil type in the studied area are Ultisols developed under wet/dry conditions (Ustults). They are characterized with abundant plinthites in the horizons resulting into the dominant reddish colour that was observed.

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**Figure 2** Jos Plateau Region

### Data Collection

The study was conducted in an area of extensively lateritized basalts to the north of Bokkos town in the south-central part of the Jos Plateau. Soil samples were collected from three areas with the first being highly ferruginised and having abundant lateritic concretions on the surface and was not cultivated but given to rough grazing. The other two areas of sampling were cultivated with the addition of poultry droppings practiced for over ten years. The farmers usually broadcast the poultry droppings over the land in March to allow it to ferment before ploughing was done. Some bags of the poultry droppings are kept in the open and allowed to ferment and are later applied to the growing crops. Three profile pits were dug one was in the uncultivated area and served as the control while pits two and three were sited on a farm on the upper- and lower-foot slopes based on the local topography. Five samples were collected each from pits 1 and 2 and six from pit 3 giving a total of sixteen.

Soil profile pit description was based on the FAO (2006) method. Soil samples were collected from the identified horizons, air dried and passed through a 2mm sieve. **Particle size distribution** was determined using the hydrometer method (Bouyoucos, 1981). **Soil pH** was determined in a 1:2.5 soil to water suspension using a pH meter. **Organic carbon** was determined by wet oxidation method (Nelson and Sommers, 1982). **Total Nitrogen** was done by the Macro-Kjeldahl method and **available P** by Bray-1 method (Bray and Kurtz, 1945). **Exchangeable bases** were extracted with neutral  $\text{IM NH}_4\text{OAc}$  at a soil solution ratio of 1:10 and measured by flame photometry. Magnesium was determined with an atomic absorption spectrophotometer. **Exchangeable acidity** was determined by titration method (Maclean, 1982).

### RESULTS AND DISCUSSION

The results of analysis on the soil samples are presented in table 1. All the soils studied, for the profiles with and without poultry droppings

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application, were either sandy loam or sandy clay loam in terms of their texture. The percentage water content at the surface was least for profile pit 1 (the control) with 8 and 10% for the surface and subsurface horizons while it was 18 and 20% and 28 and 16% respectively for soils around profile pits 2 and 3. This is consistent with field observation where it was found that soils around profile pit 1 was highly ferruginised with abundant lateritic concretions while soils around profile pit 3 were poorly drained. The appreciably higher water content of the soils in profile pits 2 and 3 may be attributed to the higher organic matter content of these soils compared to those of profile pit 1. This is further borne out by the result of t test (at 0.05) which gave a significance of 0.014 indicating that difference in water content between the two groups of soils was significant. Baur and Black, (1994), Doran and Parkin, (1994) and Weil and Magdoff (2004) have reported on the importance of organic matter in water retention and availability in soil. Brady and Weil (1996) have observed that the water content causes soil particles to swell and shrink, to adhere to each other and to form structural aggregates. Higher water content of soils with application of poultry droppings have also been reported by Agbede et al (2017). Ewulo et al (2008) observed a reduction in soil bulk density and increase in soil moisture content with increase in poultry manure addition. They attributed this to the increased organic matter content and its mulching effect, improved moisture retention and water acceptance as a result of improved soil structure and microporosity.

Soil bulk density figures showed that soils around profile pit two at the surface soil was the highest ( $2.09\text{g/cm}^3$ ) while it was  $1.7\text{ g/cm}^3$  and  $1.8\text{g/cm}^3$  respectively for profile pits 1 and 3. In general, the bulk density values for the soils were high compared to those of basalts in Kerang area of the Jos Plateau (Galadima, 2018). This may be attributed to the much more weathered and lateritized status of the soils under study. The uneven spread of the poultry droppings as well as the rate of application by the farmers may have resulted in the site of the profile pits having had less applied.

Onyegbule and Asawalam (2015) and Duruigbo et al (2007) reported lower acidity with increasing poultry droppings application. They have cited the ability of organic manure to increase soil pH due to the presence of basic cations contained in poultry manure. However, the results in this study did not show any significant variation in pH for all the soils particularly at the soil surface. This may be attributed to leaching of basic cations in view of the higher pH values in the lower horizons of the profile pits 2 and 3. The available phosphorus for the soils was generally very low especially at the surface (Landon, 1991) with values of between 3.50 and 5.25ppm. The uncultivated soils around profile pit one (1) had higher values of available phosphorus at the surface and subsurface soils compared with the soils with poultry droppings application. This is in contrast to what has been reported by Soremi et al (2017)b and Onyegbule and Asawalam (2015). Soremi et al (2017)b reported an increase in total P from  $504.40$  to  $555.16\text{mg kg}^{-1}$  in the first cycle and from  $182.59$  to  $283.08\text{ mg kg}^{-1}$  in the second cycle of their study. Onyegbule and Asawalam (2015) also reported an increase in available P from  $16.9\text{ mg/kg}$  to  $32.8\text{mg/kg}$  with application of  $25\text{ t/ha}$  of poultry manure. The lower content of available P in the soils with poultry droppings application could be attributed to the high uptake of phosphorus by plants despite the higher rate of mineralization of the organic phosphorus. In addition, the higher content of the nutrient in the lower horizons particularly for profile pit 2 indicates downward movement through leaching. Total nitrogen content for the soils showed appreciable difference between soils with and those without poultry droppings application with values of 0.210 and 0.140, 0.350 and 0.245 and 0.245 and 0.280  $\text{cmol/kg}$  respectively for the three profiles at the surface and subsurface. This may be attributed to the increased microbial activities which could have resulted in enhanced decomposition of the organic forms of N. This is in agreement with Uwah et al (2014) and Bakayoko et al (2009) who reported higher nitrogen content of soils with application of poultry droppings.

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**Table 1** Physical and chemical properties of the soils

| S/No  | H   | Particle size distribution (%) |      |      |     | % WC | g/cm <sup>3</sup> BD | H <sub>2</sub> O pH | % OM | % TN  | ppm AP | Ca    | Mg   | cmol/kg |      | EA   | CEC   |
|---|-----|--------------------------------|------|------|-----|------|----------------------|---------------------|------|-------|--------|-------|------|---------|------|------|-------|
|   |     | Clay                           | Silt | Sand | TC  |      |                      |                     |      |       |        |       |      | K       | Na   |      |       |
| Profile pit 1: Area without poultry droppings application |     |                                |      |      |     |      |                      |                     |      |       |        |       |      |         |      |      |       |
| 1   | A   | 10                             | 18   | 72   | SL  | 8    | 1.70                 | 5.40                | 0.75 | 0.210 | 5.25   | 6.60  | 2.76 | 0.26    | 0.58 | 1.40 | 11.80 |
| 2   | B1  | 20                             | 16   | 64   | SL  | 10   | 1.40                 | 5.60                | 0.60 | 0.140 | 8.75   | 5.00  | 1.98 | 0.23    | 0.75 | 1.20 | 10.40 |
| 3   | B2  | 24                             | 12   | 64   | SCL | 20   | 1.62                 | 6.11                | 0.21 | 0.245 | 3.50   | 3.30  | 0.58 | 0.11    | 0.81 | 0.80 | 7.90  |
| 4   | B3  | 24                             | 12   | 64   | SL  | 23   | 1.70                 | 5.70                | 0.26 | 0.175 | 1.75   | 3.70  | 0.79 | 0.18    | 0.80 | 1.00 | 9.60  |
| 5   | C   | 24                             | 14   | 62   | SL  | 28   | 1.55                 | 5.40                | 0.36 | 0.105 | 3.50   | 3.60  | 1.86 | 0.12    | 0.78 | 1.40 | 9.90  |
| Profile pit 2: Area with poultry droppings application    |     |                                |      |      |     |      |                      |                     |      |       |        |       |      |         |      |      |       |
| 6   | Ap1 | 18                             | 12   | 70   | SL  | 18   | 2.09                 | 5.40                | 3.42 | 0.350 | 4.03   | 5.80  | 3.42 | 0.14    | 0.10 | 0.60 | 12.5  |
| 7   | A2  | 28                             | 12   | 60   | SCL | 20   | 1.26                 | 5.50                | 1.36 | 0.245 | 3.50   | 7.40  | 4.26 | 0.08    | 0.14 | 0.60 | 14.1  |
| 8   | B1  | 30                             | 18   | 52   | SCL | 21   | 1.81                 | 5.70                | 1.31 | 0.350 | 8.40   | 5.40  | 2.54 | 0.09    | 0.16 | 0.80 | 17.7  |
| 9   | B2  | 28                             | 16   | 56   | SCL | 22   | 1.64                 | 5.70                | 0.26 | 0.210 | 21.7   | 5.40  | 3.06 | 0.09    | 0.15 | 0.60 | 20.0  |
| 10  | C   | 32                             | 14   | 54   | SCL | 27   | 1.74                 | 5.80                | 0.41 | 0.175 | 12.43  | 11.00 | 5.10 | 0.08    | 0.15 | 0.40 | 19.0  |
| Profile pit 3: Area with poultry droppings application    |     |                                |      |      |     |      |                      |                     |      |       |        |       |      |         |      |      |       |
| 11  | Ap1 | 12                             | 28   | 60   | SL  | 28   | 1.80                 | 5.62                | 3.92 | 0.245 | 3.50   | 6.50  | 3.20 | 0.23    | 0.72 | 1.40 | 11.20 |
| 12  | A2  | 18                             | 22   | 60   | SL  | 16   | 1.65                 | 5.70                | 1.47 | 0.280 | 1.75   | 4.20  | 1.32 | 0.14    | 0.73 | 1.80 | 9.20  |
| 13  | B1  | 18                             | 18   | 64   | SL  | 21   | 1.57                 | 5.80                | 1.47 | 0.175 | 6.13   | 5.80  | 0.86 | 0.21    | 0.70 | 2.80 | 10.50 |
| 14  | B2  | 20                             | 18   | 62   | SL  | 19   | 1.71                 | 5.91                | 0.76 | 0.140 | 2.63   | 5.60  | 2.68 | 0.24    | 0.77 | 3.00 | 14.40 |
| 15  | B3  | 24                             | 14   | 62   | SCL | 20   | 1.67                 | 6.04                | 0.26 | 0.105 | 1.75   | 3.70  | 0.56 | 0.41    | 1.04 | 2.40 | 11.70 |
| 16  | C   | 20                             | 18   | 62   | SL  | 27   | 1.60                 | 6.02                | 0.29 | 0.105 | 3.50   | 4.40  | 2.42 | 0.43    | 0.74 | 1.80 | 12.20 |

H= Horizon, TC= Textural classes, WC= Water content, BD= Bulk density

**Table 2** Result of t test at 0.05%

|                | <b>f</b> | <b>sig.</b> | <b>t</b> |
|----------------|----------|-------------|----------|
| Water content  | 7.838    | 0.014       | 1.286    |
| Organic matter | 7.300    | 0.022       | 1.817    |

Researchers have reported the positive influence of poultry manure on organic matter and exchangeable bases content of soils (Uwah et al, 2014, Bakayogo et al, 2009, Soremi et al, 2017b and Kobierski et al, 2017). Ca content of the soils at the surface do not vary much (6.60, 5.80 and 6.50 cmol/kg respectively) but the higher values in the lower horizons of the soils with poultry droppings application (11.0, 4.40) indicates the downward movement of the nutrient with the finer fraction. For Mg there is an appreciably higher content of the nutrient in soils with poultry droppings with values of 3.42 and 4.26 cmol/kg (pit 2) and 3.20 and 1.32 cmol/kg (pit 3) compared to 2.76 and 1.98 cmol/kg for the soils without poultry droppings (pit 1) in the surface and sub surface horizons respectively. The content of exchangeable K showed a slight decrease at the surface for profile pits two (2) and three (3) compared to the control (0.26 to 0.14 and 0.23cmol/kg). This may be attributed to K fixation and leaching in pit three (3) in view of the much higher content in the bottom horizons. CEC values for the soils were only slightly higher for the soils with the application of poultry manure at the surface but were higher in the lower horizons (11.8 cmol/kg compared to 12.5 and 11.20 cmol/kg). Soremi et al (2017b) have stated that poultry manure is a rich source of exchangeable cations and that their reduced content could be attributed to their uptake by crops. This will be true of the soils under study as the areas of poultry droppings application were under continuous cultivation with two crops of Irish potatoes annually and sometimes intercropped with maize all of which are heavy consumers of soil nutrients. Organic matter content of the soils showed a sharp contrast between soils around profile pit one (1) where there was no cultivation and no addition of poultry droppings and those around pits two (2) and three (3) where the farmers have been

applying the fertilizer material for a very long period of time.

The organic matter contents of the surface and subsurface horizons were 0.75 and 0.60% while those for soils with poultry droppings application were 3.42 and 1.36% and 3.92 and 1.47% respectively. Profile distribution pattern showed a decline down the profile for all but while organic matter content was generally very low (for tropical soils, <5%) for soils around pit one (1), the first three horizons for pit two (2) and three (3) had much higher amounts. This pattern may be explained by the fact that consistently farmers apply the poultry droppings on the surface before ploughing and over time it accumulates in the surface and subsurface horizons compared to the lower horizons which have very low content. The organic matter content for the soils around profile pit one (1) is rated very low while those for pits two (2) and three (3) are rated medium to high (Landon, 1991). t test conducted (at 0.05) gave a significance of 0.022 indicating that the difference in OM content for the two groups of soil was significant. The results are in agreement with Kobierski et al (2017), Onyegbule and Asawalam (2015), and Soremi et al (2017) b who have all reported significant increases in soil organic matter with application of poultry droppings.

## CONCLUSION

The data obtained shows that poultry droppings can be effectively used to manage lateritized soils to make them more productive. Though the farmers applied the material purely as fertilizer for higher yields, the beneficial effect goes beyond adding to the fertility of the soils to changing the total soil environment. The higher organic matter content seems to have resulted into slightly lower acidity, higher organic matter, N, Mg, Na and CEC content for the soils. The residual effect of poultry droppings application

will ensure higher yields for the farmers and other benefits that come with higher organic matter content such as good tilth and higher moisture retention. The presence of organic material on the surface tends to maintain a level of productivity of the lateritized soils because removal of vegetation cover results into hardening of the surface and formation of lateritic crusts. The advantage of building up the organic matter levels of such soils is summed up by Walsh and McDonell (2012) who have stated that soil that is chemically and biologically fertile but which cannot physically support crop development will not fulfill its agronomic potential and that soil productivity is therefore determined by a combination of organic matter's influence on chemical, physical and biological properties of the soil.

The fertility status of the soils is quite high but could be even better if other management practices like liming are introduced. The CECs of the soils could be much higher than they are if liming is done to reduce acidity. Murphy (2014) has stated that when pH of soils falls below 5.0 many of the organic acids which make up the soil organic matter are not dissociated and so do not display a negative charge leading to low CEC while the best pH for increased CEC from organic matter is 6.0. The fear of shortage of poultry droppings for supply to farms does not exist for now based on the author's observation that more people are engaging in poultry farming.

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