Nigerian Journal of Pharmaceutical and Applied Science Research
Vol. 13 (1): 55-64; March 2024 ISSN: 2971-737X (Print); ISSN: 2971-7388.
Available at www.nijophasr.net; https://doi.org/10.60787/nijophasr-v13-i1-547

Comparing Poultry and Rabbit Dung for Soil Enhancement in Vegetable Planting

Benefit Onu

Biology Department, Faculty of Science, Federal University Otuoke, Nigeria.

ABSTRACT

Background: This study compared the effectiveness of poultry dung and rabbit dung as soil enhancers for vegetable cultivation.

Methods: Rabbit and Poultry dungs were collected in a clean plastic plate from three animal kernel (Blomfree, Miebi and Dakoru animal husbandry poultry farm) within Otuoke. Soil samples collected were weighed and mixed with the rabbit and poultry dungs. Three varieties of vegetables (*Abelmoschus esculentus, Telfairia occidentalis, Talinum triangulare*) were cultivated in the prepared soil samples. The physicochemical parameters (pH, Nitrogen, Potassium, Phosphorus, and conductivity) and total bacteria count of the soil samples were calculated and monitored over a period of five weeks.

Results: The results showed that organic manure have significantly impacted on the parameters required for the plants cultivated to grow. The findings also showed a gradual increase in the number of leaves, plant height and stem width for the soil sample containing poultry dungs, followed by the control (clay soil) while the soil sample containing rabbit dung had the lowest growth rate (in terms of plant height, stem width and leaf number) and this may be due to the low rate of some physicochemical parameters analyzed in the soil containing rabbit dungs (having 50.02 ± 0.2 value of Potassium, acidic pH value of 4.9 ± 0.01, and high Phosphorus 195 ± 0.05).

Conclusion: The study indicated that the soil containing poultry dung met the soil requirements for the plants cultivated, thus, its plants grew well over the period of the research. Poultry manure when compared with rabbit dungs was more effective for planting of the vegetables under study.

Keywords: Poultry Dung, Rabbit Dung Soil Enhancement, Cultivation of Vegetables (Okra, Ogu, Water Leaf)

1. INTRODUCTION

Agriculture is a critical sector in the global economy, contributing significantly to food security, employment, and GDP in many countries [1]. This sector is particularly important in developing countries, where it often represents a significant portion of the national economy and is a primary source of livelihood for many people [2]. The Food and Agriculture Organization (FAO) [2] estimates that over 2.5 billion people worldwide depend on agriculture for their livelihoods, highlighting the sector's importance in global food security and poverty reduction [2]. One of the essential aspects of successful agriculture is soil fertility. Soil fertility is a complex concept that involves the availability and balance of essential nutrients in the soil, as well as other factors such as soil structure, pH, and organic matter content [3]. Soil fertility is crucial for plant growth and agricultural productivity, as it influences the ability of plants to take up the nutrients they need to grow and produce yield [4]. Soil fertility is often enhanced using organic manure, a practice that dates back to the earliest days of agriculture [5]. The use of organic manure is based on the principle of recycling nutrients from animal waste back into the soil, thereby improving soil fertility and reducing the need for synthetic fertilizers [5]. This practice is not only beneficial for soil fertility, but also contributes to sustainable agriculture by reducing the environmental impacts associated with synthetic fertilizers, such as nutrient runoff and greenhouse gas emissions [6, 7]. Organic manure, such as poultry dung and rabbit dung, are commonly used by farmers due to their rich nutrient content [8]. These manures are not only rich in primary nutrients like Nitrogen,

* **Corresponding author: Email: benefitonu28@gmail.com; Phone: +2347061525785**

Phosphorus, and Potassium, which are essential for plant growth, but also contain secondary and micronutrients, such as calcium, magnesium, and trace elements, that are important for plant health and productivity [9]. Moreover, these manures have been found to improve soil structure, increase water-holding capacity, and enhance overall soil fertility [5]. They contribute to soil organic matter, which is vital for soil health and function [10]. Soil organic matter improves soil structure, increases soil water-holding capacity, enhances nutrient retention and availability, and promotes soil biodiversity, all of which are important for soil fertility and plant growth [10, 11]. However, despite the widespread use of poultry dung and rabbit dung as soil enhancers, the comparative effectiveness of these two types of manure in enhancing soil fertility, particularly for vegetable cultivation, has not been extensively studied. This is a significant knowledge gap, given the importance of soil fertility for agricultural productivity and the potential differences in the nutrient content and other properties of different types of dung [8, 12]. This study aims to address this gap by comparing the viability of poultry dung and rabbit dung on soil fertility and vegetable growth. This research will focus on the use of poultry and rabbit dung as soil enhancers for vegetable cultivation. The study will involve laboratory analysis of the dung samples, field trials to observe their effects on soil and vegetable growth, and data analysis to compare their effectiveness.

2. MATERIALS AND METHODS

2.1 Materials

The following equipment/apparatus were used for this study: Atomic absorption spectrophotometer (AAS), Spectrophotometer, pH meter (Hanna's instrument model 96207, Electrical conductivity (EC) meter (Hannas Instrument Model 96302), weighing balances, spatula, retort stand, funnel, extraction bowls, measuring cylinders, Beakers (250ml Pyrex), volumetric flasks, pipette, orbital shaker, water-bath, filter papers. Other materials include Soil samples rabbit dungs, poultry dung's, seedlings of Okra, Ogu and Water Leaf. Filter Paper (Whatmann no.1), Paper tape and meter rule, Tissue paper Water, Plastic (polyethylene bags), Hand gloves. Planting material: measuring tape, planting bags, weight scales and Hand gloves.

2.2 Methods

2.2.1 Study Area

Otuoke terrestrial habitat in Ogbia Local Government Area of Bayelsa State Nigeria was used as the study area. The major occupation of the people in this area is farming, fishing and trading. Otuoke is located at coordinates of 4°42'23.418"N 6°19'44.472"E. Otuoke has a lowland terrain with adjoining water bodies. The vegetation is completely a secondary forest habitat with most of its area partially or completely swampy. The temperature is humid averaging about 30^0 C with a mean minimum monthly temperature ranging from 25°C to 34°C [13].

2.2.2 Sample Collection

The soil samples were gotten from Okpuorein compound in Otuoke community in three replicates. The rabbit and poultry dung samples were collected in clean plastic plates from different Animal kernel (Blomfree, Miebi and Dakoru Animal Husbandry) and Poultry farm, all within Otuoke Community. The samples of the vegetable seedlings used for the study were gotten from vegetables farmers in Otuoke.

2.2.3 Preparation of Samples

The control (clay soil) was collected and weighed at 3kg, then the control soil was collected again and mixed with the rabbit and poultry dung and weighed at 3kg. Each of these samples were collected two more times, having three samples from the control, rabbit dung and poultry dung.

2.2.4 Physico-Chemical Analysis

The physicochemical parameters such as pH, conductivity, total dissolved solids, salinity, turbidity, total suspended solids, Phosphorus, Potassium, Sodium, Carbonate and Bicarbonate, Chloride, Sulphate, Nitrate, of the soil samples were analysed following standard laboratory techniques and procedures.

2.3 Statistical Analysis

The mean values derived from triple replicated readings were employed to calculate the standard error, thereby ensuring robustness in the data analysis. Subsequently, a comprehensive analysis of variation (ANOVA) was conducted on the data set enabling the exploration of the significant variations among the mean.

3. RESULTS

Table 1 shows the physicochemical and biological properties of samples used for this study. The table revealed that the control (clay soil) has the highest pH (7.2 ± 0. 09), followed by the soil containing poultry dung (5.0 ± 0.11) while the soil sample containing rabbit dungs has the least (4.9 ± 0.01). The soil sample containing rabbit dung has the highest conductivity value (25 ± 0.10), followed by the control (19 ± 0.04) while the lowest value was recorded at the sample containing rabbit dungs (18 ± 0.11). The soil sample containing poultry dung has the highest Nitrogen value (46 ± 0.04) followed by the control (30 ± 0.12) while the sample containing rabbit dung has the lowest (28 ± 0.08). Additionally, the highest Phosphorus value (195 ± 0.05) was recorded under the soil sample containing rabbit dung while the control had the lowest value (65 ± 0.09).

Table 1: Physiochemical and Biological properties of samples

Parameter	Rabbit dungs + clay soil	Poultry dungs + clay soil	control (clay soil)	Soil requirement		
				Waterleaf	Okra	Ugu
pH	4.9±0.01	5.5 ±0.11	7.2±0. 09	6-7	6-7.5	5.5-6.5
Conductivity (S/m)	25±0.04	18±0.10	19±0.11	10-25	12-25	8-15
Nitrogen (mg-N/kg)	28±0.08	46±0.04	30±0.12	15-20	25-35	7.5-10
Phosphorus (ppm)	195±0.05	147±0.07	65±0.09	30-50	60-100	120-150
Potassium (mg/kg)	50.02±0.2	124±0.12	94±0.15	120-100	200-300	350-450
Total bacteria count(cfu/g)	3.9×10^{-4}	3.1×10^{-4}	$2.0\text{x}10^{-4}$	$5\text{-}10\text{x}10^{4}$	$4\text{-}8\text{x}10^{4}$	$2\text{-}6\text{x}10^{4}$

Values are recorded as mean ± standard error of mean (SEM) @p<0.05 compared with the values, n=5 (Source of soil requirement: FAO, [2]; El-mogy *et al.*, [14]).

Soil sample containing poultry dungs has the highest Potassium value (124 ± 0.12) followed by the control (94 ± 0.15) while the sample containing rabbit dungs has the lowest value (50.02 ± 0.2). The soil sample containing rabbit dungs has the highest total bacteria count (3.9×10^{-4}) while control has the lowest (2.0×10^{-4}).

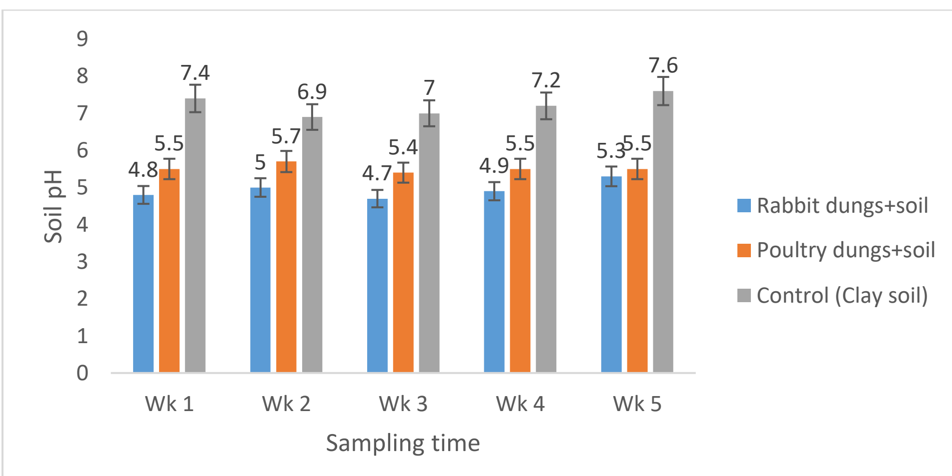

Figure 1: pH content of control, rabbit dungs + soil, and poultry dungs + soil

The result shown in Figure 1 revealed that the soil pH ranges from 4.7 to 5.3 for the soil sample containing rabbit dung, making it strongly acidic, while the soil sample containing poultry dung has a pH close to that of the soil containing rabbit dung (5.5 to 5.7) across the five weeks of the experiment. Similarly, the control (clay soil) sample was totally neutral giving room for the thorough growth of the plants cultivated and studied in this work. The rabbit manure in this work has the lowest values while the control (clay soil) has the highest value of pH. Despite this, plants grow more in the soil sample containing poultry dungs, and this may be due to the fact that application of poultry manure to soil enhances concentration of water-soluble salts in soil [15]. More so, poultry manure has high concentration of macro-nutrients [16].

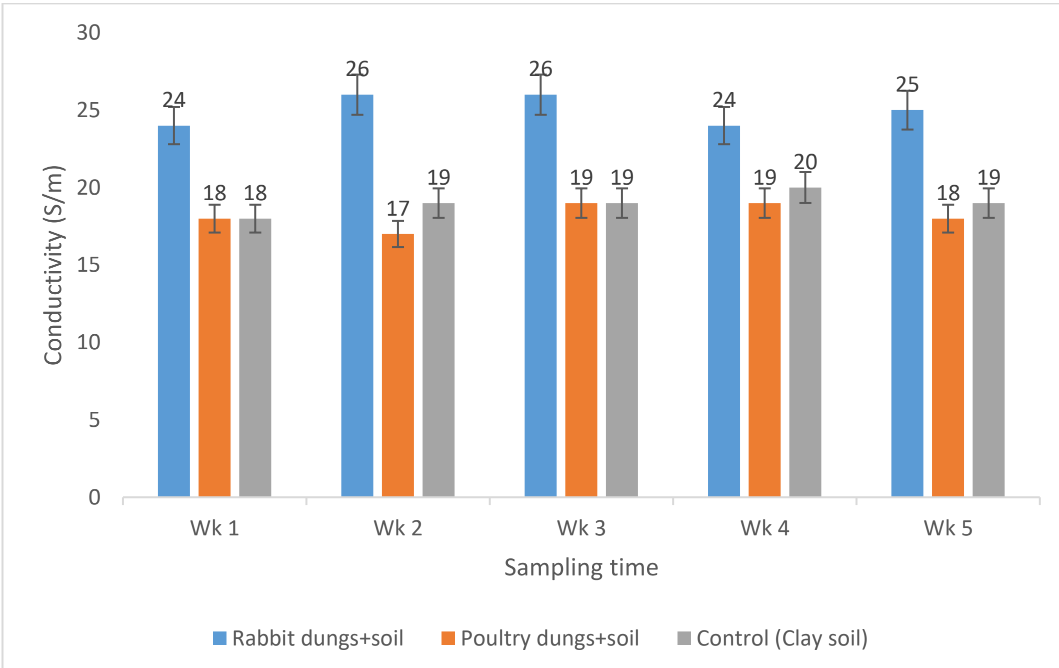

Figure 2: Conductivity content of control, rabbit dung + soil, and poultry dung + soil

Figure 2 shows the conductivity level of the soil samples used in the study. Among these, the soil sample containing rabbit dung has the highest across the five weeks while that of the soil sample containing poultry dung has the lowest value although the values are almost the same as that of the soil sample containing rabbit dung. Meanwhile, there is no significant change in the conductivity values from week 1 to the last week of the experiment.

Results shown on Figure 3 reveal the rate of nitrogen present in the soil samples across the five weeks of the experiment. From this, soil samples containing rabbi dung were within a specific range all through the period of the experiment while both the sample containing poultry dung and the control (clay soil) were not totally stable, giving room for the plant to utilize the available nitrogen in a way that increases or support their growth. For instance, in a finding carried out by Cheschair *et al.* [17], an increase in Nitrogen levels was observed from 40 to 60% and 17% to 38% which is in line with the findings of this study in which the Nitrogen increase from 30 ± 0.12 to 46 ± 0.04.

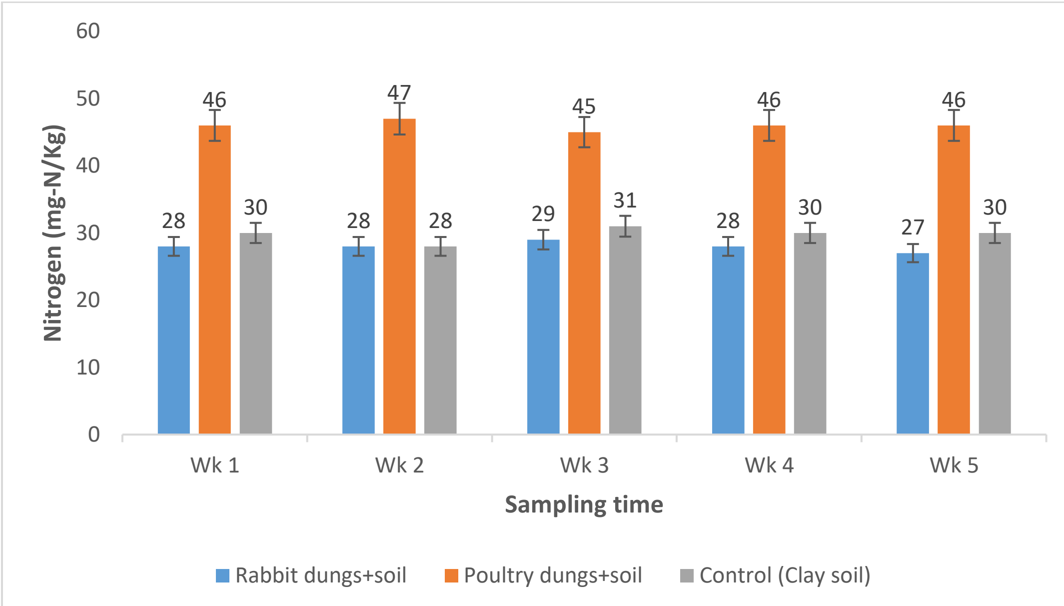

Figure 3: Nitrogen content of control, rabbit dungs + soil, and poultry dungs + soil

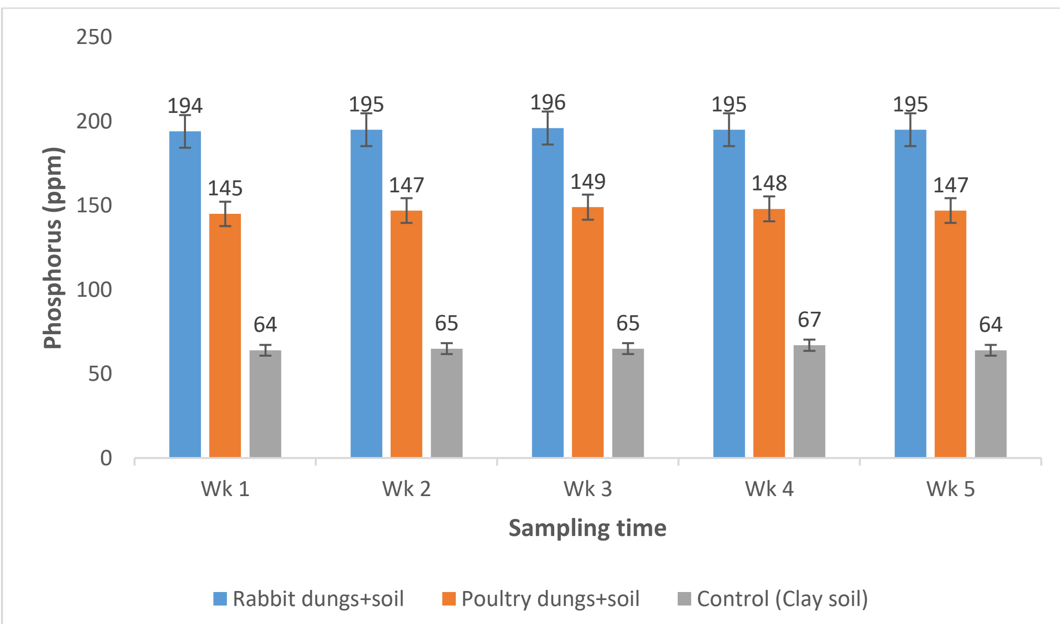

Figure 4: Phosphorus content of control, rabbit dungs + soil, and poultry dungs + soil

Figure 4 show the rate of Phosphorus present in the various soil samples used for this experiment. The report on the bar chart shows that soil sample containing rabbit dung has the highest value of Phosphorus (194 to 196), making it practically difficult for the plants cultivated to thoroughly grow as the range of the element present is beyond the sustainable quantity for the vegetables, thus the insignificant growth was observed on the sample. However, the control (clay soil) and sample containing poultry seems to support the growth of the plant since the range is within a considerably quantity for the survival of the plants.

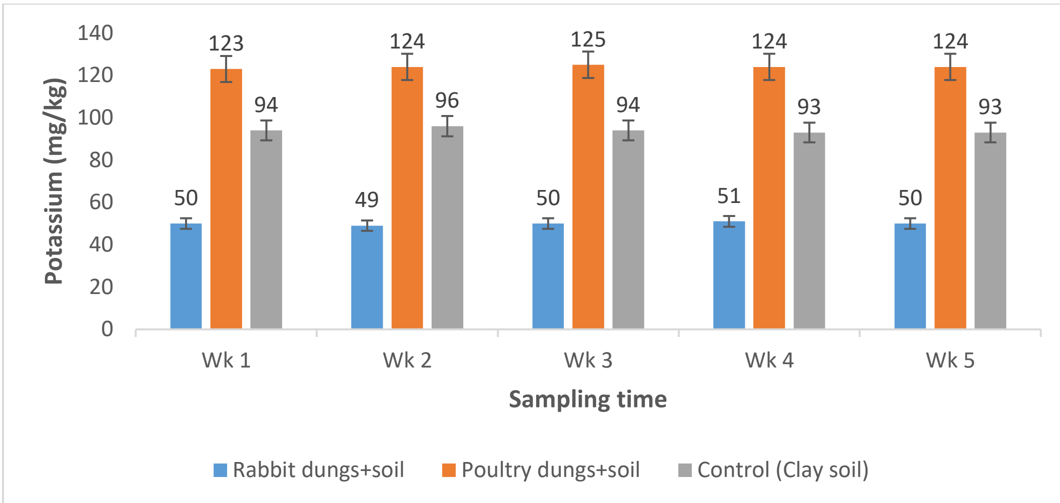

Figure 5: Potassium content of control, rabbit dungs + soil, and poultry dungs + soil

The quantity of potassium present in the different soil samples understudied in this work is shown on Figure 5. From this, it is evident that the soil containing rabbit dungs has the lowest potassium value (ranging from 49 - 51) which is not up to the value in which water leaf naturally survive in (78 -100mg/kg) same as that of Okra (80 - 95mg/kg). However, the highest value was recorded in the soil sample containing poultry dungs (ranging from 123 to 125mg/kg) followed by the control (clay soil) which have potassium content ranging from 93 to 96 which is within the range needed by the plants under study. This, support the findings of Place *et al*., [18] in which poultry manure significantly influence the growth of different plants as they possess high Nitrogen, Phosphorus and Potassium. Hence, it is advisable to use soil containing poultry dungs for cultivating various vegetables.

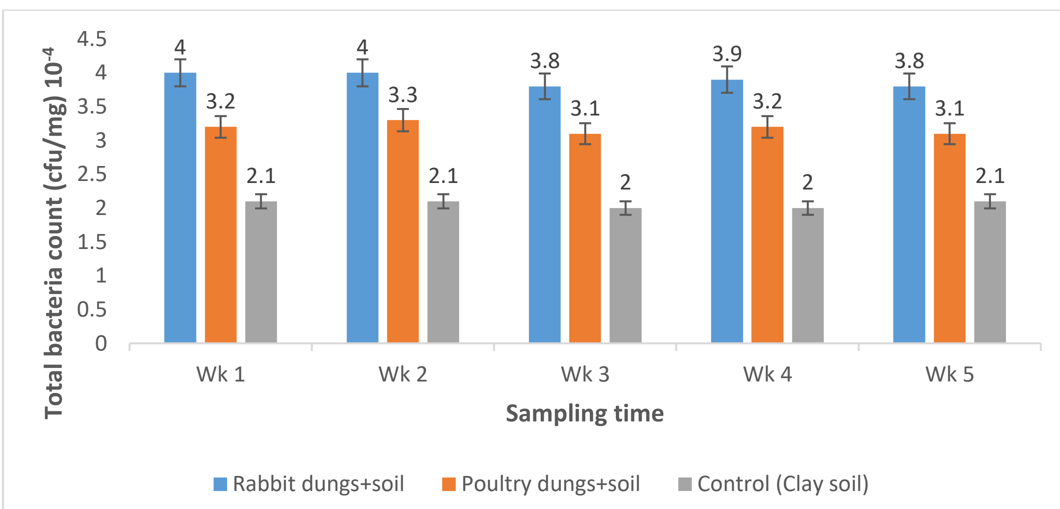

Figure 6: Total bacteria count of soil samples

The result of the total bacteria count shown on Fig 6 reveal that the bacteria load of the samples subject to this study were uniform for each sample with the soil sample containing rabbit dungs having the highest value. (Ranging from 3.8×10^{-4} to 4.0×10^{-4}). This show that no significant difference was observed in the microbial load of the samples.

Table 2: Growth performance of Water leaf (*Talinum triangulare*) in each of the soil samples

Parameter/Variables	Plant height (cm)	Stem width (cm)	Number of leaves
Poultry dungs+soil			
Wk 1	7	0.6	4
Wk 2	10	1.9	14
Wk 3	18.5	2.2	22
Wk 4	26	2.6	34
Wk 5	36	2.8	42
Rabbit dungs+soil			
Wk 1	5	0.5	3
Wk 2	6.5	0.6	3
Wk 3	9.5	0.9	5
Wk 4	11	1.0	7
Wk 5	13	1.2	11
control (clay soil) (Clay			
soil)	6.5	0.6	3
Wk 1	10	1.7	9
Wk 2	1.6	1.9	14
Wk 3	21.52	2	19
Wk 4	24	2.2	25
Wk 5			

Result shown on Table 2 reveal the performance of water leaf subjected to different soil samples (soil containing poultry dungs, soil containing rabbit dungs and clay soil serving as the control (clay soil), The various samples show a related growth pattern for week one, this change from week three with week five having the highest growth rate. Precisely, soil containing poultry dungs has the highest growth performance among the samples followed by the control (clay soil) while the sample containing rabbit has the lowest. This may be due to the physicochemical properties of the poultry dungs as shown in Table1. The properties of the soil sample containing poultry dungs clearly stand out and meet the various requirements of the plants grown (generally, their pH range from 5.5 to 7, conductivity range from 10-25S/m, Nitrogen range from 7.5 to 35 mg N/kg, Phosphorus from 30 to 50 for waterleaf, 60 to 100 for okra, and 120 to 150 for Ugu while total bacteria count range from $2x10^4$ to $10x10^4$).

Table 3: Growth performance of Ugu (*Telfairia occidentalis*) in each of the soil samples

Parameter/Variables	Plant height (cm)	Stem width (cm)	Number of leaves
Poultry dungs+soil			
Wk 1	3	0.4	-
Wk 2	5.5	0.5	4
Wk 3	12	0.8	7
Wk 4	23	1.5	12
Wk 5	31	2	17
Rabbit dungs+soil			
Wk 1	3	0.4	-
Wk 2	5.5	0.5	3
Wk 3	10.10	0.5	7
Wk 4	14.5	0.7	10
Wk 5	21	0.8	12
control (clay soil)			
Wk 1	3	0.4	-
Wk 2	6.5	0.5	3
Wk 3	12.4	0.5	7
Wk 4	16.1	0.7	10
Wk 5	22.1	0.8	12

Table 3 show the performance of Ugu subjected to different soil samples (soil containing poultry dungs, soil containing rabbit dungs and clay soil serving as the control (clay soil). The plant growth for all the samples was stable for week 1, but changes become eminent from week 4 where the soil sample containing poultry dungs exhibit a hug difference in plant height, stem width and number of leaves from that of the control (clay soil) and rabbit dungs. The highest growth performance was noticed on the soil sample containing poultry till week 5 while both the control (clay soil) and the soil sample containing rabbit dungs tend to have similar growth rate.

Table 4: Growth performance of Okra (*Abelmoschus esculentus*) in each of the soil samples

Parameter/Variables	Plant height (cm)	Stem width (cm)	Number of leaves
Poultry dungs+soil			
Wk 1	3	0.5	2
Wk 2	5.4	0.5	2
Wk 3	8.6	0.5	4
Wk 4	12.5	0.6	7
Wk 5	17	0.6	9
Rabbit dungs+soil			
Wk 1	1	0.2	2
Wk 2	0	0	0
Wk 3	0	0.	0
Wk 4	0.	0	0
Wk 5	0.5	1.3	1
control (clay soil)			
Wk 1	3	0.5	2
Wk 2	5	1.5	2
Wk 3	8	3	4
Wk 4	11.5	5	4
Wk 5	15.6	0.6	4

Table 4 show the growth performance of Okra cultivated on different soil samples (clay soil, soil containing poultry dungs and soil containing rabbit dungs). Both control (clay soil) and soil samples containing poultry show a related growth pattern for week one, till week four with the sample containing poultry dungs having the highest growth rate for week five. Generally, soil containing poultry dungs has the highest growth performance among the samples followed by the control (clay soil) while the sample containing rabbit dung has the lowest. This may be due to the physicochemical properties of the poultry dungs shown on Table1 which depict the fact that the difference between the sample's properties used for this study; wherein sample containing poultry dungs were clearly sense to have high conductivity, Nitrogen and Potassium which all fall within the optimal requirement for water leaf, ugu and Okra.

4. DISCUSSION

Plants are important to organisms as they serve different vital purposes, ranging from provision of nutrient to treatment of different health challenge people experience in Nigeria and other parts of the world as a result of various bioactive components or other substances embedded in them [19]. However, the impact of organic manure from animals are examined in this study. Table 2 to Table 4 show the growth rate of water leaf (*Talinum trianulare*), Ugu and Okra across the five weeks period of the experiment. The findings show a gradual growth/increase in the number of leaves, plant height and stem width for the soil sample containing poultry dungs (having the highest growth rate observed). Followed by the control (clay soil) while the soil sample containing rabbit dungs has the lowest growth rate (in terms of plant height, stem width and Number of leaves) and this may be due to low rate of some physicochemical parameters analyzed in the soil containing rabbit dungs (having 50.02 ± 0.2 value of Potassium). Result shown on Table 2 to Table 4 reveal the performance of the plants subjected to different soil samples (soil containing poultry dungs, soil containing rabbit dungs and clay soil serving as the control soil. The various samples show a related growth pattern for week one (for water leaf and ugu with a difference in that of okra; where control and soil sample containing poultry dungs. With week five having the highest growth rate. The soil that was mixed with rabbit dung in this work experiences the least values while the control (clay soil) has the highest value of pH. Despites this, plants grow more in the soil sample containing poultry dungs, and this may be due to the fact that application of poultry manure to soil enhances concentration of water-soluble salts in soil [15]. More so, poultry manure is said to have high concentration of macro-nutrients [16]. Overall, soil containing poultry dungs has the highest growth performance among the samples followed by the control (clay soil) while the sample containing rabbit has the lowest (the okra plant tends to even die off at week two) although the plant was attacked by pest causing a reduction in size and length. This may be due to the physicochemical properties of the poultry dungs as Table1 shows the difference between the samples' properties where the soil sample containing poultry dung clearly stands out and meets the various requirements of the plants grown. This is in line with the findings of (Agnieszka *et al*..[20] that reveal the impact of low Potassium value on the growth of plants. This further shows the impact of high or low physicochemical parameters (which pH, conductivity, Potassium and Phosphorus levels all play a vital role) that support the growth of plants; with vegetables striving well under pH value that range between 5 to 6.5 but can tolerate 4.5 to 7 pH, likewise 78g to 100g of Potassium. Soil containing poultry dungs used for this study is seen to possess the necessary requirements needed by the plants thus the level of growth observed in the findings. Additionally, the Phosphorus content of the soil sample containing rabbit dungs was significantly high 195 ± 0.05 compared to the 150 to 160ppm that happens to be the natural Phosphorus rate for growth/yield of Okra and 155 to 170ppm that is the natural Phosphorus rate for water leaf and other vegetables. This is evident in the growth rate on the different experimented samples with the control (clay soil) and soil containing poultry dungs having a significant rate of 65 ± 0.09 and 147 ± 0.07 respectively. This result supports the findings reported by El-mogy*et al.,* [14] in which rabbit and poultry dungs were used as manure to grow Lettuce plants significantly affect yield and rate leads to improvement in head quality. The report of this finding shows that water leaf and Ugu grow on the soil sample containing poultry dungs, noticeably from week 1 to week 5, showing the ability of the poultry dung to help boost the soil natural composition unlike that of the soil sample containing rabbit dungs. Figure 4 show the rate of phosphorus present in the various soil samples used for this experiment. The report on the chat show that soil sample containing rabbit dung has the highest value of Phosphorus (ranging from 194 to 195), making it practically difficult for the plants cultivated to thoroughly grow as the range of the element present is beyond the sustainable one for the vegetables thus the insignificant growth observed on the sample. However, the control (clay soil) and sample containing poultry seems to support the growth of the plant since the range is within a considerably quantity for the survival of the plants. This in turn supports the findings of Place *et al*., [18] in which poultry manure significantly influence the growth of different plants as they possess high Nitrogen, Phosphorus and Potassium.

5. CONCLUSION

Animal farming on a large scale raises several problems related to the disposal of feces (solid wastes) produced in large quantities. However, the reuse of animal residues can generate added value and provide benefits to soil, including a high amount of nutrients, organic matter and microbial biomass, as well as increased plant yields. This study shows that manure, natural and organic fertilizers from animals, positively impact the physicochemical parameters of soil alongside the microbial community. Thereby, increasing how fertile soil samples can be and enhance the growth and yield of plants. Vegetables, such as Okra, Ogu and Water leaf, which were studied in this work, can be fertilized with both rabbit manure and poultry manure. However, this study indicate that poultry manure is the best for plant yield as there was significant increase in leaf number, stem width and plant length examined over the period of five weeks. Therefore, poultry manure when compared to conventional rabbit dungs is more effective for planting of the vegetables used as samples in this study.

6. REFERENCES

[1] World Bank. (2021). *World Development Report 2021: Data for Better Lives*. The World Bank.

[2] Food and Agriculture Organization of the United Nations. (2018). *The State of Food and Agriculture 2018: Migration, agriculture and rural development*. FAO.

[3] Marschner, H. (2012). *Mineral nutrition of higher plants* (3rd ed.). Academic Press.

[5] Edwards, C. A., Lal, R., Madden, P., Miller, R. H., and House, G. (2004). *Soil fertility and nutrient management*. CRC Press.

[6] Carpenter, S. R., Caraco, N. F., Correll, D. L., Howarth, R. W., Sharpley, A. N., and Smith, V. H. (1998). Nonpoint pollution of surface waters with phosphorus and nitrogen. *Ecological Applications*, 8(3), 559-568.
[7] Steinfeld *et al*., 2006 Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M., and de Haan,

C. (2006). *Livestock's long shadow: Environmental issues and options*.

[8] Nahm, K. H. (2002). Evaluation of the nitrogen content in poultry manure. *World's Poultry Science Journal*, 58(1), 77-88.

[9] Hue, N. V., and Liu, J. (1995). Predicting compost stability. *Compost Science & Utilization*, 3(2), 8-15.
[10] Lehmann, J., and Kleber, M. (2015). The contentious nature of soil organic matter. *Nature*, 528(7580), 60-68.

[11] Brady, N. C., and Weil, R. R. (2008). *The nature and properties of soils* (14th edition.). Prentice Hall.

[12] Bolan, N., Szogi, A. A., Chuasavathi, T., Seshadri, B., Rothrock, M. J., and Panneerselvam, P. (2010). Uses and management of poultry litter. *World's Poultry Science Journal,* 66(4), 673-698

[13] Bayelsa State Media Team News, 2012

[14] El-mogy, M.M., Parmer, A., Ali, M.R., Abdel-aziz, M.E. and Abdeldaym, E.A. (2020). Improving postharvest storage of fresh artichoke bottoms by an edible coating of Cordia myxa gum. *In Postharvest Biology and Technology*, 163:11114.

[15] Duncan, J. (2005). Composting chicken manure. WSU Cooperative Extension, King County Master Gardener and Cooperative Extension Livestock Advisor.

[16] López- Masquera, M. E., Cabaleiro, F., Sainz, M. S., López- Fabal A. and Carral E. (2008). Fertilizing value of broiler litter: Effects of drying and pelletizing. *Bioresource Technology,* 99: 5626-5633.

[17] Cheschair G.M, Westerman P.P.W and Safley J.I.M (1986) Laboratory method for estimating availablenitrogen in manure and sludge. *Agricultural Wastes*,18:175-195.

[18] Place, F., Swallow, B. M, Wangila, J. W. and Barrett C. B. (2002). Lessons for natural resource management technology adoption and research. In Barrett (Eds.). Natural Resources Management in African Agriculture: Understanding and Improving Current Practices. Oxon and New York: CABI publishing. pp. 275-285.

[19] Ugbogu E. A., Nwoku C. D., Ude V. C and Emmanuel O. (2022) Evaluating bioactive constituents and toxicological effects of aqueous extract of fermented Pentaclethra macrophylla seeds in rats, *Avicenna Journal of Phytomedicine*, v.10(1)

[20] Agnieszka I. M., Brosse S. M. and Narwani A. (2022) Linking human impacts to community processes in terrestrial and freshwater ecosystems, DOI: 10.22541/au.165944361.14048694/v1