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Effect of different poultry wastes on physical, chemical and biological properties of soil

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ABSTRACT
The effect of poultry waste application on physicochemical and biological properties of sandy clay loam soil was investigated on a 7m X 7m plot of land. Plot was divided into four portions and 7.5kg each of broiler, cockerel and layers waste was applied to plot A, B, and C in slurry form while plot D was used as control(no application) for eight weeks with two weeks interval. After the fourth application, samples were taken from the plot for laboratory analysis. The results showed that all the wastes have effect on the soil properties with the cockerel waste having the highest effect on the electrical conductivity of the soil. It was between 121.0 and126.1mS. Cockerel waste has the highest BOD_5, porosity and organic matter content of the soil which were 52.00mg/l,0.67 and 27.50mg/l, respectively. What can be deduced from this is that while application of poultry wastes improves soil properties, it also increases soil salinity and cockerel waste is recommended because it has ability to increase the porosity and organic matter content of soil.

Keywords: Biological, Physicochemical, Poultry waste, Soil properties.

INTRODUCTION
Soil, the loose material that covers the land surface of the earth, is a loose combination of inorganic and organic materials. The organic materials are composed of debris from plants, decomposition of many tiny life forms which inhabit the soil and also manure that is applied to the soil. Organic fertilizers are usually wastes from industrial processing from parts of plants or animals. Organic manure on the other hand is composed mainly of waste and residue from plants and animals. Poultry waste, usually the fresh ones contain twice as much nitrogen as other farmyard manure (Barth, 1985). Soil organic matter has a positive effect on soil structure, tilth, and water holding capacity, aeration, pH buffering, cation exchange capacity and microbial activity (Bauer & Black, 1992). Poultry litter contains a considerable amount of organic matter due to manure and bedding materials. Litter can also have an impact on soil pH and liming due to varying amount of calcium carbonate in poultry feed. Poultry waste primarily is composed of nitrogen (N), phosphorus (P) and potassium (K); it also contains calcium, magnesium, sulphur and some micronutrients. Onsite waste sampling, testing, and data collection are valuable assets in waste management system planning and design and should be used where possible. Such sampling can result in greater certainty and confidence in the system design and in economic benefit to the owner (El- Hady, 2005).

Poultry waste has its advantages and disadvantages. It acts to cement soil aggregates and thus to increase their strength. Ammonia and hydrogen sulphide contents have proven to increase odour potential, contains significant amount of uric acid which is readily decomposable and can improve soil tilth (Meck & Westman, 2002). However, moist manure when exposed to the air undergoes significant loss of nitrogen as volatile NH_3. In area of intense poultry

production, excess manure poses a waste problem for producers and in some areas, over fertilizing pastureland with poultry manure has resulted in groundwater and surface water problems, these problems develop as excess nutrients wash off the land or leaches into groundwater supplies (Gupta & Larson, 1999). Manure stored outside and exposed to the weather will decompose rapidly; an ashy gray appearance indicates a loss of nutrient value. The nitrogen and organic matter will be greatly reduced and potassium may be lost due to leaching. High demand for white meat products has led to the expansion in the poultry industry and has come with its combined effect of waste accumulation (Agasimani & Hosmani, 1989).

Manuring is an invaluable way of improving soil water holding capacity and tilth but it could be a major pollutant if attention is not paid to how it works in the soil (Barth, 1985). Manure has several effects when added to the soil including manure contains nitrogen (as ammonium), phosphorus, potassium and micro-nutrients that can be used directly by plants. These compounds also trigger-off biological activities which make nutrients in the manure and organic matter available to plant. Soil is an often overlooked and abused natural resource. Just as life is dependent on air and water, life is also dependent on soil. Soil provides the nutrients needed for plant growth, houses micro organisms responsible for decomposition of organic matter, and retains and purifies water (May, *et al.*, 1993).

The physical properties of soil are those characteristics which can be seen with the eye or felt. They are the result of soil parent materials being acted upon by climatic factors (such as rainfall and temperature), and affected by topography (slope and direction,) and life forms (kind and amount, such as forest, grass, or soil animals) over a period of time. A change in anyone of these influences usually results in a difference in the type of soil formed (Tayel & El-Hady, 2005). The nature of the arrangement of primary particles into naturally formed secondary particles, called aggregates, is soil structure. Texture refers to the relative amounts of differently sized soil particles or the coarseness of the particles in the soil. Soil texture depends on the relative amount of sand, silt and clay. In each texture class, there is a range in the amount of sand, silt and clay that class contains (Stephenson *et al.*, 1989).

When soil is examined, colour is one of the first things noticed. It indicates extremely important soil conditions. Surface soil colours vary from almost white, through shades of brown and gray to black. Light colours indicate a low organic matter content and dark colours can indicate a high content. Organic matter plays a major role in moisture retention, helping crops withstand drought contributes to the chemical and biological properties of the soil and also a source of and exchange for nutrient, affects the fate of applied pesticides and contributes to the physical properties of the soil. Organic matter provides glue-like substances that act to stick individual particles together to form stable aggregates and good soil structures (Sharma & Bali, 1998). When manure that has a strong ammonia odour is spread on the surface and not incorporated into the soil, significant nitrogen will be lost. As much as 75% of the ammonium nitrogen could be lost within seven days after spreading if the weather is hot and dry and the manure is not incorporated into the soil. The objectives of this work are; to characterize poultry waste from broilers, layers and cockerels, using the wastes to amend the soil that is planted with maize and to study the effect of the added waste on physical properties of soil.

MATERIALS AND METHODS

The experiment was conducted at the Federal University of Technology Minna, research farm. A 7m x 7m plot of land was used for the experiment. The soil was pulverized very well and was leveled to reduce erosion menace. Pre-application sample of the soil was taken to laboratory for textural analysis using hydrometer method and to know the physicochemical parameters of the soil before application of manure. The physicochemical parmeters were determined using USDA, (1998) method. 30kg each of broilers, cockerel, and layers wastes were collected from the FUT, Minna poultry farm. Samples were taken from both deep litter and battery cage systems. Small portion of the samples were taken to laboratory for characterization using titration method. The plot of land was divided into four portions and 7.5kg of each waste was mixed with the soil. That is, plot A received 7.5kg of broilers

waste, plot B received 7.5kg of cockerel waste, plot C received 7.5kg of layers while the last plot D was left as control. After each application, each plot was irrigated using portable sprinkler system with clean water to make sure the applied wastes go into the soil. This was repeated four times at two weeks interval. Samples were also taken after the application of each treatment to know the cumulative effect of the waste samples.

RESULTS AND DISCUSSION

The tables 1-5 show the results from the analyses of the soil samples. From the textural analyses, it was discovered that the soil is sandy clay loam with 26.06% clay, 57.66%sand and 16.28% silt.

From the results, it was observed that the application of different poultry manures has different effects on the biological properties of the soil on the experimental plot. For instance, cockerel waste which has the highest BOD_5 and COD parameters during characterization has the biggest effect on these two properties of the soil after the first and the second treatments.

It also has the highest effect on the organic matter content of the soil. However, after the third and the fourth treatments, there is a sharp decrease in the COD value of the soil though BOD_5 and organic matter content are still high. Since the chief organic properties are BOD_5, DO and organic matter, it can be deduced that application of poultry manures has a cumulative effect on the biological properties of soil. Other biological parameters follow the same trend as depicted by the lowest value of organic parameter on the control plot. This means there is a direct relationship between the biological properties of the soil and the amount of poultry waste applied.

Table 1. Characterization of Poultry Waste Samples.

Component	$Cockerel_1$	$Layer_1$	$Broiler_1$	$Cockerel_2$	$Broiler_2$	$Layer_2$
Moisture (%)	75.00	78.00	74.80	76.00	75.70	76.00
Total solid (mg/l)	6.34	3.28	2.50	6.00	1.90	10.60
Volatile solid(mg/l)	5.40	2.92	2.13	5.40	1.70	8.80
Fixed solid(mg/l)	0.94	0.36	0.37	0.60	0.30	1.80
COD(mg/l)	19.06	13.12	19.37	15.73	19.37	16.80
BOD_5(mg/l)	5.08	4.08	4.83	4.00	3.65	3.40
Nitrogen(mg/l)	0.42	0.24	0.19	0.47	0.15	0.60
Phosphorus(mg/l)	0.16	0.08	0.06	0.15	0.05	0.25
Potassium(mg/l)	0.22	0.13	0.12	0.30	0.10	0.35
TDS(mg/l)	2.00	2.53	2.44	2.96	2.33	1.70
C:N ratio(mg/l)	7	9	6	8	6	8
NH_4-N(mg/l)	4.58	3.76	4.34	7.66	2.24	4.91

COD = chemical oxygen demand, BOD_5 = five day- biochemical oxygen demand, C: N ratio = carbon to nitrogen ratio, TDS = total dissolved solids, NH_4-N = ammoniacal nitrogen.
Subscript 1 and 2 represent deep litter and battery cage systems respectively.

Table 2. Biological Properties of Soil after First and Second Applications.

Sample Name	Crude protein (%)	Ash Content (%)	Lipid content (%)	Crude Fibre (%)	COD (mg/l)	BOD_5 (mg/l)	Organic matter (%)
Plot A_1	24.90	13.16	17.65	10.78	13.60	25.20	16.40
Plot B_1	22.25	14.17	16.33	15.30	13.20	52.00	27.50
Plot C_1	19.27	15.89	14.29	13.33	12.90	26.20	23.20
Plot D_1	14.00	9.46	11.21	11.30	7.26	11.32	24.44
Plot A_2	28.50	17.20	20.54	12.82	15.76	27.21	25.90
Plot B_2	25.26	19.25	18.31	17.45	14.40	53.22	34.56
Plot C_2	21.32	17.33	16.25	14.44	14.11	27.82	20.10
Plot D_2	14.10	9.22	10.21	11.26	7.42	10.90	23.33

Table 3. Biological Properties of Soil after Third and Fourth Applications.

Sample Name	Crude protein (%)	Ash Content (%)	Lipid content (%)	Crude Fibre (%)	COD (mg/l)	BOD_5 (mg/l)	Organic matter (%)
Plot A_3	29.46	17.33	22.61	11.78	13.60	29.00	27.40
Plot B_3	24.64	19.33	18.33	17.30	12.22	55.00	29.54
Plot C_3	21.37	20.82	18.27	18.33	11.94	27.25	29.20
Plot D_3	14.11	8.34	10.21	12.44	7.26	11.32	23.33
Plot A_4	30.50	17.34	23.14	13.82	18.76	27.21	28.90
Plot B_4	27.16	20.15	18.99	19.46	14.52	53.22	29.84
Plot C_4	24.67	10.33	16.25	16.34	14.95	27.82	20.97
Plot D_4	14.11	8.34	10.21	12.44	7.26	11.32	23.33

Table 4. Physico-chemical Parameters of Soil Samples after First and Second Treatments.

Sample Name	Bulk Density(g cm^{-3})	Particle Density(g cm^{-3})	Porosity	pH	Organic Carbon (%)	Ca^{2+} (mg/l)	Mg^{2+} (mg/l)	Na^{+} (mg/l)	K^{+} (mg/l)	EC × 10^{-5} (mS)
Plot A_1	1.57	2.86	0.53	5.85	10.75	6.72	7.36	0.57	1.57	82.3
Plot B_1	1.41	4.15	0.62	7.25	11.13	7.53	4.80	0.57	1.13	93.9
Plot C_1	1.34	2.24	0.37	6.77	11.35	4.80	9.38	0.52	1.69	121.0
Plot D_1	1.27	1.47	0.13	6.20	11.02	4.48	4.48	0.32	1.28	68.4
Plot A_2	1.57	2.84	0.55	5.85	17.90	10.11	7.26	0.55	1.57	111.21
Plot B_2	1.44	4.19	0.68	7.25	16.52	11.22	4.86	0.56	1.13	119.33
Plot C_2	1.32	2.25	0.34	6.77	15.55	9.54	9.31	0.54	0.69	112.4
Plot D_2	1.26	1.48	0.12	6.20	19.00	6.11	4.42	0.54	1.28	89.20

Note: subscript $_1$ and $_2$ represent first and second treatments respectively. *EC = electrical conductivity.*

Table 5. Physico-chemical Parameters of Soil Samples after Third and Fourth Treatments.

Sample Name	Bulk Density(g cm^{-3})	Particle Density(g cm^{-3})	Porosity	pH	Organic Carbon (%)	Ca^{2+} (mg/l)	Mg^{2+} (mg/l)	Na^{+} (mg/l)	K^{+} (mg/l)	EC × 10^{-5} (mS)
Plot A_3	1.47	2.86	0.61	5.65	10.75	6.72	7.36	0.57	1.57	89.21
Plot B_3	1.33	4.15	0.73	7.35	11.44	7.53	4.80	0.59	1.13	90.4
Plot C_3	1.45	2.24	0.54	6.54	12.45	4.80	9.38	0.52	0.69	126.09
Plot D_3	1.61	1.47	0.13	6.20	10.22	4.48	4.21	0.31	0.28	81.21
Plot A_4	1.57	2.84	0.56	5.88	17.88	10.11	7.26	0.73	1.57	124.52
Plot B_4	1.46	4.19	0.68	7.29	16.90	11.22	4.86	0.56	1.13	122.32
Plot C_4	1.39	2.25	0.57	6.71	22.55	9.54	9.31	0.63	0.69	136.10
Plot D_4	1.46	1.48	0.12	6.20	19.00	10.11	4.42	0.54	1.28	109.20

Note: subscript $_3$ and $_4$ represent third and fourth treatments respectively.

On the physico-chemical properties, the application of the manures has effects on virtually all the physical and chemical properties of the soil. For instance, in Tables 4 and 5, the electrical conductivity (EC) is highest on the soil treated with layers waste (121.0 and 126.09 mS respectively), this observation is supported by the findings of Barth, (1985) that the benefits of organic manures are due to their ability to improve soil physical characteristics and to supply micro and trace elements needed by plants but will increase the electrical conductivity of the soil. This can also be closely attributed to the type of feed these birds eat which will be high in oyster shell and other feed ingredients that are high in calcium, phosphorus and potassium. It can be concluded here that while the application of poultry manure has a positive influence on organic parameters of the soil, its continuous usage will increase the salinity of the soil and thereby render it useless after some years of cultivation. Cockerel waste is recommended more as it increases the organic properties most but recorded the least effect on the chemical parameters of the soil. From Table 5, the highest porosity was recorded from soil

treated with cockerel waste (0.62-0.68). This is good as it will improve the infiltration properties of the soil and the ease with which crop roots will penetrate the soil. It also support the earlier findings that application of organic manure enhances the promotion of biological activity which in turn increases the organic matter content of soil (Bauer & Black, 1992).

The results also revealed that application of organic manure increased nitrogen, phosphorus and potassium content of the soil. Organic manure enhanced the availability of certain elements and their supply to the plant during growth period. In addition, poultry manure increased the presence of P, K and Mg in the soil beside the solubility of Ca and Mg and NO as a result of the continuous lowering of the pH by manure applications and to the increase of electrical conductivity.

CONCLUSION

From this study, it was concluded that the application of different poultry waste has different effects on the physicochemical and biological properties of soil with cockerel waste having the highest effect on the physical and biological parameters while the layer waste has the highest effect on the chemical properties of the soil. More work can still be carried out on the poultry waste at different growth stages of the birds to know if the age of the birds has any effect on the type of waste they produce.

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