

EFFECTS OF POULTRY SPECIES AND HOUSING TYPES ON THE POULTRY WASTES PHYSCO-CHEMICAL CHARACTERISTICS

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ABSTRACT

Adequate information on the characteristics of wastes generated from poultry production particularly in the tropical region is lacking. This study investigated and characterized the wastes of different poultry species which included broiler, cockerel and layer with each under battery cage and or deep litter housing systems. As part of waste management study, this work evaluated the physical and chemical characteristics of poultry waste which are needed in the planning and design of components of waste management systems such as handling, transport processing and storage. The results of the tests indicated that wastes collected from battery cage system contain higher values in chemical composition than those from deep litter houses. Physical components of wastes from deep litter are however, higher in values than that of battery cage systems. The broiler wastes recorded the highest values in parameters such as Total solid (14.0mg/l) , Fixed solids (9.1mg/l) and Total dissolved solid (3.9mg/l); for deep litter house; and then dissolved oxygen (2.0mg/l), biochemical oxygen demand (120.7mg/l), chemical oxygen demand (241.3mg/l), Nitrogen (432.3ppm), phosphorus (233.3ppm), potassium (343.3ppm) and Ammoniacal Nitrogen (56ppm) , under battery cage system. Layer wastes recorded the highest values for moisture contents (45.3%), volatile solid (9.4%) and pH (8.2) under battery cage system. The results of the analyses of variance (ANOVA) indicate that poultry species and housing systems have high significant effect on all the parameters tested at 1% probability level.

KEYWORDS: Poultry waste, characterization, housing types, bird species, physico-chemical properties

1. INTRODUCTION

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). Research has shown that deposition of animal wastes on soil increases soil organic matter and carbon fractions and enhances soil quality and productivity (Kingery

and others, 1994; Ahmed and others, 2013). The benefits of applying animal wastes to increase nutrient supplying capacity of the soil have been reported (Webster and Gouiding, 1989; Rochette and Gregorich, 1998). Animal wastes favour vegetative and reproductive performance of plants (Azam Shah and others, 2009; Suthar, 2009, Maftoun and Moshiri, 2008 and Sawyer and others, 2006). According to Yuksel and Orhan, (2004), enhance moisture retention capacity and infiltration rate (Erikson and others, 1999), physical conditions of soil such as bulk

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density, aggregate stability and aeration can be improved by the application of animal wastes (Yuksel and Orhan, 2004) and the pH of an acid Ultisol reduced (Bauer and Black, 1994) as well as crusting and runoff (Rochette and Gregorich, 1998). Animal wastes are deposited on soil due to their nutrient value (Jackson and Bertsch, 2001; Garbarino and others, 2003).

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 pollution, in form of excess nutrients wash off from the land or leaches into groundwater supplies (Gupta & Larson, 1999). 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 and Hosmani, 1989). Manuring is an invaluable way of improving soil quality but it could be a major pollutant if attention is not paid to how it works in the soil (Barth, 1985). An oversupply of nutrients such as nitrogen (N), phosphorus (P), and others in the soil has been found in regions heavily treated with poultry litter. This condition has created potential for transport of waste-released Nitrate-Nitrogen (NO₃-N) to groundwater in concentrations exceeding the maximum contaminant level of 10 mg/L set by the U.S. Environmental Protection Agency (NASS, 2006). Elevated NO₃-N concentrations in groundwater supplies used for human and/or livestock consumption may pose health hazards. Recommended application rate of animal manure is therefore necessary as oversupply of nutrients create undue pollution. This should benefit farmers because their efficient use could reduce mineral fertilizer requirements.

The main objective of this study is to characterize poultry wastes from broilers, layers and cockerels, under deep litter and battery cage systems and specifically to study the effects of poultry types and housing systems on the waste physical and chemical parameters.

2. MATERIALS AND METHOD

Wastes samples of Broilers, Cockerels and layers used for this experiment were collected from the University of Agriculture, Makurdi research poultry farm and from both deep litter and battery cage systems.

2.1 Experimental Programme

The methods used to determine the physical and chemical properties of the poultry waste were described by Moffit (1999) for manure characterization. A randomized complete block design in factorial experiment was adopted, that is 2×3×3 resulting in 18 observations for each parameter tested.

- **Determination of Moisture Content (%)**

This was carried out by the standard method for moisture contents determinations. The samples were oven dried for 24 hours at a temperature of 102°C ± 1°C until constant weight was attained. The moisture content is calculated using the following formula:

$$\% \text{moisture} = \frac{W_2 - W_3}{W_2 - W_1} \times 100 \dots \dots \dots (1)$$

Where: W₁ = initial weight of empty can

W₂ = weight of can + sample before drying

W₃ = final Weight of Can + Sample after drying

- **Determination of Total Solids (mg/l)**

This was determined by evaporation of free water and drying in an oven at 102 ± 1°C for 24 hours until constant weight was attained. The weight of the residues remaining after water was removed from the waste sample were measured.

- **Determination of Fixed and Volatile solids (mg/l)**

The total solids were heated in a furnace at 600°C for over 1 hour, and then weighed. The mass obtained gave the total fixed solids, while the difference between total solids and fixed solids gave the total volatile solids.

- **Determination of Total Dissolved solids (mg/l)**

This was carried out by filtration of 20g of each waste sample which was first poured into water and stirred to dissolve. The mixture was passed through a 0.45 micron filter and the filtrate was collected. The filtrate was evaporated until constant weight was attained at 102°C ± 1°C. The dry residue was weighed as total dissolved solids.

- **Determination of Biochemical Oxygen Demand (BOD) (mg/l)**

Two dissolved oxygen (DO) measurements were taken; the initial dissolved oxygen reading and the second reading after five (5) days of incubation at 20°C. The biochemical oxygen demand at five days (BOD₅) was then obtained using the equation;

$$BOD_5 = \frac{DO_0 - DO_5}{P} \dots\dots\dots (2)$$

Where:

DO_0 = initial dissolved oxygen reading

DO_5 = Second dissolved oxygen reading after 5 days

$$P = \frac{5}{300} = 0.0166$$

- **Chemical Oxygen Demand (COD) (mg/l)**

The chemical oxygen demand (COD) was measured by wet chemistry method. This chemical test was carried out using a strong oxidizing agent (potassium dichromate) for digestion of the organic matter at high heat under acidic conditions.

- **Determination of pH**

pH was measured potentiometrically using pH meter with dual electrode system in buffer solution in accordance with the standard AOAC (1984) methods.

- **Determination of Other Elements (N, P, K and $NH_4 - N$)**

Nitrogen was determined by the method of combustion as described by Watson and others (1996). The Potassium concentration was determined by Atomic Absorption spectrophotometric (AAS) as described by (Kover, 1996) while phosphorus concentration was determined by colorimetric method as described by Clesceri and others (1989). Ammonium – Nitrogen was measured by colorimetry as described by Peters and others (1996).

2.2 Experimental Design and Data Analysis

The tests were carried out using a randomized complete block factorial design to study the effects of Bird species and housing

system types on the concentration of manure physical and chemical characteristics. The bird species formed the levels of one factor while the housing system types formed the levels of the other factor. The two factors had three and two observations per experimental cell. With three replications for each combination a total of 18 observations were made for each measured parameter. Data obtained were subjected to Analysis of Variance (ANOVA) to detect treatment effects.

3. RESULTS AND DISCUSSION

The results of the determinations obtained for each of the physical and chemical characteristics are presented in Table 1. The summary of the results of analysis of variance for different components of poultry wastes are presented in Tables 2-14.

3.1 Effects of bird types and housing systems on the moisture content of poultry wastes

From Table 1 it was observed that the moisture contents of the poultry waste from the battery cage system was higher than that of deep litter system. The layer waste has the highest value of 45.3% and 39% of moisture contents under battery cage house and deep litter house, respectively. This was followed by that of cockerels with 44% for battery cage and 35.7% for deep litter house. The broiler waste recorded the least value of 36.7% and 26.3% in battery cage and deep litter house, respectively.

In Table 2 it was observed that the effect of both housing system and the birds specie were highly significant ($P < 0.01$) while the interaction between the two factors was not significant.

Table 1: Physical and Chemical characteristics of Poultry wastes

Component	Deep litter floor			Battery cage		
	Broilers	Cockerels	Layers	Broilers	Cockerels	Layers
1. Moisture content (%)	26.3	35.7	39	36.7	44	45.3
2. Total solids (mg/l)	14.0	12.6	12.2	12.7	11.2	10.6
3. Volatile (mg/l)	6.2	7.4	7.8	7.3	8.8	9.4
4. Fixed solids (mg/l)	9.1	5.1	4.3	5.4	2.7	1.4
5. TDS (mg/l)	3.9	2.9	2.5	2.4	1.6	1.3
6. DO (mg/l)	1.6	1.6	1.5	2.0	1.9	1.7
7. BOD ₍₅₎ (mg/l)	98.7	95	89.3	120.7	112	105.3
8. COD (mg/l)	197.3	190	178.7	241.3	224	210.7
9. pH	6.6	6.82	8.41	6.9	7.0	8.2
10. Nitrogen, N (ppm)	375.3	320.7	316.7	432.3	338	214.7
11. Phosphorus, P (ppm)	222	214.3	193.7	233.3	222.3	203.3
12. Potassium, K (ppm)	314	272.3	223.3	343.3	292	252.7
13. Ammoniacal Nitrogen NH ₄ -N (ppm)	50	40	34.7	56	43.3	35.3

Table 2: Summary of ANOVA for the effects of house type and bird species on the moisture contents of Poultry waste

Source of Variation	df	SS	MS	F _{cal}	F _{tab}	
					5%	1%
Blocks	2	1.44	0.72	0.402 ^{ns}	4.10	7.56
Bird Type	2	373.44	186.72	104.37 ^{**}	4.10	7.56
House type	1	304.22	304.22	170.05 ^{**}	4.96	10.04
Interaction	2	12.12	6.06	3.387 ^{ns}	4.10	7.56

df = degree of freedom, SS = sum of square, MS = mean square, F_{cal} = F_{calculated}, F_{tab} = F_{table},
 * = significant (P<0.05), ** = highly significant (P<0.01), ns = not significant.

3.2 Effects of bird types and housing systems on the Total solid of poultry wastes

It was observed from Table 1 that the total solid contents of waste in deep litter house were higher than that of battery cage systems. The broiler waste recorded the highest value of 14.0mg/l and 12.7mg/l in deep litter and battery cage house, respectively. Then cockerels waste followed with 12.6mg/l and 11.2mg/l under deep

litter and battery cage, respectively. The lowest value was obtained with the layer waste having 12.2mg/l in deep litter house and 10.6mg/l in battery cage house. In Table 3 it was clearly observed that the housing types and bird species have high significant effect on the total solid of the poultry wastes at the probability level of 1% while the interaction between the two factors was not significant.

Table 3: Summary of ANOVA for the effects of housing systems and bird species on the total solid of Poultry wastes.

Source	df	S.S	M.S	F _{cal}	F _{tab}	
					5%	1%
Blocks	2	0.302	0.151	4.314*	3.33	7.56
Bird type	2	13.04	6.52	186.286**	4.10	7.56
House type	1	8.96	8.96	256**	4.96	10.04
Interaction	2	0.02	0.01	0.286 ^{ns}	4.10	7.56

df = degree of freedom, SS = sum of square, MS = mean square, F_{cal} = F_{calculated}, F_{tab} = F_{table},
* = significant (P<0.05), ** = highly significant (P<0.01), ns = not significant.

3.3 Effects of bird types and housing systems on the volatile solid of poultry wastes

Table 1 shows that higher value of volatile solid was obtained with poultry waste under battery cage than deep litter system. The results of Table 1 also indicate that layer waste has the highest value of 9.4mg/l of volatile solid and 7.8mg/l in deep litter house. This was followed by cockerel waste having 8.8mg/l in battery cage and 7.4mg/l in deep litter system. Then the broiler wastes recorded the least value of 7.3mg/l in battery cage and 6.2mg/l in deep litter house. The results of the ANOVA in Table 4 indicates that both bird species and housing system as factors have high significant effect on

the volatile solid of poultry wastes (P<0.01) while the statistical interaction between the factors was not significant.

3.4 Effects of bird types and housing systems on the Fixed Solids of poultry wastes

It is observed from Table 1 that the value 9.1mg/l obtained for the fixed solids is highest for broiler waste under deep litter housing system. This was followed by the cockerel waste which is 5.1mg/l and 2.7mg/l for deep litter and battery cage, respectively. The layer waste has the lowest value of 4.3mg/l and 1.4mg/l for deep litter and battery cage systems, respectively.

Table 4: Summary of ANOVA for the effects of house type and bird species on the volatile solid of Poultry waste

Source	df	S.S	M.S	F _{cal}	F _{tab}	
					5%	1%
Blocks	2	0.45	0.225	1.692 ^{ns}	4.10	7.56
Bird type	2	10.78	5.39	40.526**	4.10	7.56
House type	1	8.27	8.27	62.180**	4.96	10.07
Interaction	2	0.19	0.095	0.714 ^{ns}	4.10	7.56

df = degree of freedom, SS = sum of square, MS = mean square, F_{cal} = F_{calculated}, F_{tab} = F_{table},
* = significant (P<0.05), ** = highly significant (P<0.01), ns = not significant.

In Table 5 it was observed that the effects of housing systems and bird species are highly significant on the fixed solid ($P < 0.01$). The

statistical interaction of the two factors was also highly significant.

Table 5: Summary of ANOVA for the effects of housing systems and bird types on the fixed solid of Poultry waste

Source	df	S.S	M.S	F_{cal}	F_{tab}	
					5%	1%
Blocks	2	0.24	0.120	3.33 ^{ns}	4.10	7.56
Bird type	2	63.37	31.685	880.14 ^{**}	4.10	7.56
House type	1	39.90	39.90	1108.33 ^{**}	4.96	10.04
Interaction	2	1.07	0.535	14.86 ^{**}	4.10	7.56

df = degree of freedom, SS = sum of square, MS = mean square, $F_{cal} = F_{calculated}$, $F_{tab} = F_{table}$,
* = significant ($P < 0.05$), ** = highly significant ($P < 0.01$), ns = not significant.

3.5 Effects of bird types and housing systems on the Total Dissolved Solid (TDS) of poultry waste

The wastes under deep litter show highest values of total dissolved solids for all the bird species than that under the battery cage system. The broiler waste recorded the highest value of total dissolved solid, 3.9mg/l, while cockerel is 2.9mg/l and layer waste, 2.5mg/l;

which are higher than the values of 2.4mg/l for broiler; 1.6mg/l for cockerel and 1.3mg/l for layer obtained under the battery cage system. The ANOVA results presented in Table 6 indicate that bird species and housing systems have high significant effect ($P < 0.01$) on the total dissolved solid of poultry wastes. The interaction between the two factors was not significant.

Table 6: Summary of ANOVA for the effects of house type and bird types on TDS of Poultry wastes

Source	df	S.S	M.S	F_{cal}	F_{tab}	
					5%	1%
Blocks	2	0.02	0.01	0.303 ^{ns}	4.10	7.56
Bird type	2	4.64	2.32	70.303 ^{**}	4.10	7.56
House type	1	8.82	8.82	267.27 ^{**}	4.96	10.04
Interaction	2	0.07	0.035	1.061 ^{ns}	4.10	7.56

df = degree of freedom, SS = sum of square, MS = mean square, $F_{cal} = F_{calculated}$, $F_{tab} = F_{table}$,
* = significant ($P < 0.05$), ** = highly significant ($P < 0.01$), ns = not significant.

3.6 Effects of bird types and housing systems on the Dissolved Oxygen (DO) of poultry wastes

The broiler wastes under battery cage recorded the highest value of dissolve oxygen, 2.0mg/l, followed by cockerel waste, 1.9mg/l and then layer waste, 1.7mg/l. The trend pattern

observed in deep litter house was different with broiler and cockerel waste recording 1.6mg/l, each and then layer waste, 1.5mg/l. The ANOVA results in Table 7 indicate high significant effect at ($P < 0.01$) for both bird species and housing types. The interaction of the two factors was also highly significant.

Table 7: Summary of ANOVA for the effects of house type and bird species on DO of Poultry waste

Source of Variation	d.f	SS	M.S	F_{cal}	F_{tab}	
					5%	1%
Blocks	2	0.001	0.0005	0.25 ^{ns}	4.10	7.56
Bird type	2	0.17	0.085	42.5 ^{**}	4.10	7.56
House type	1	0.3	0.3	150 ^{**}	4.96	10.04
Interaction	2	0.05	0.025	12.5 ^{**}	4.10	7.56

df = degree of freedom, SS = sum of square, MS = mean square, $F_{cal} = F_{calculated}$, $F_{tab} = F_{table}$,

* = significant ($P < 0.05$), ** = highly significant ($P < 0.01$), ns = not significant.

3.7 Effects of bird types and housing systems on the Biochemical Oxygen Demand (BOD) of poultry waste

The battery cage system showed the highest value of BOD₅ contents for broiler waste (120.7mg/l), followed by cockerel (112mg/l) and that of layer (105.3mg/l) in that order of decreasing magnitude. The trend of occurrence of BOD₅ was the same in deep litter housing with the broiler waste recording the highest value of

98.7mg/l followed by cockerel with (95mg/l) and then layer with the least value of 89.3mg/l. This indicate higher rate of waste degeneration in battery cage than the deep litter system. In Table 8 it was observed that the effect of both housing system and bird species were highly significant ($P < 0.01$) while the interaction between housing system and bird species showed significance at 5% probability.

Table 8: Summary of ANOVA for the effects of house type and bird type on the BOD of Poultry waste

Source of Variation	df	SS	M.S	F_{cal}	F_{tab}	
					5%	1%
Blocks	2	9.0	4.5	2.076 ^{ns}	4.10	7.56
Bird Type	2	456.33	399.97	105.29 ^{**}	4.10	7.56
House type	1	1,512.5	228.165	697.97 ^{**}	4.96	10.04
Interaction	2	31	15.50	7.153 [*]	4.10	7.56

df = degree of freedom, SS = sum of square, MS = mean square, $F_{cal} = F_{calculated}$, $F_{tab} = F_{table}$,

* = significant ($P < 0.05$), ** = highly significant ($P < 0.01$), ns = not significant.

3.8 Effects of bird types and housing systems on the Chemical Oxygen Demand (COD) of poultry waste

It was observed from Table 1 that COD contents of waste in battery cage system were

higher than that of deep litter system with the broiler waste having the highest value of 241.3mg/l and 197.3mg/l in battery cage house and deep litter house, respectively. This was followed by cockerel with 224mg/l for battery

cage and 190mg/l for deep litter house. The layer waste recorded the least value of 210.7mg/l and 178.7mg/l in battery cage and deep litter, respectively. It was observed (Table 9) that both

housing system and bird species effect were highly significant ($P < 0.01$). The statistics interaction between housing and bird species showed significance at 5% probability.

Table 9: Summary of ANOVA for the effects of house type and bird types on the COD of Poultry waste

Source of Variation	df	SS	M.S	F _{cal}	F _{tab}	
					5%	1%
Blocks	2	36	18	2.076 ^{ns}	4.10	7.56
Bird Type	2	1,825.3	912.65	105.27 ^{**}	4.10	7.56
House type	1	6,050	6,050	697.81 ^{**}	4.96	10.04
Interaction	2	124	62	7.15	4.10	7.56

df = degree of freedom, SS = sum of square, MS = mean square, F_{cal} = F_{calculated}, F_{tab} = F_{table},
* = significant ($P < 0.05$), ** = highly significant ($P < 0.01$), ns = not significant.

3.9 Effects of bird types and housing systems on the pH of poultry waste

Table 1 shows that the order of occurrence of pH varies in decreasing magnitude from layer waste to that of cockerel and then broiler in both housing systems. The layer waste in deep litter house however, has the highest value of 8.41 and in battery cage, 8.2. The trend of occurrence of pH however, varied in

magnitude with cockerel waste having the higher value of 7.0 for battery cage than that of deep litter house with value of 6.82. The broiler waste which recorded the least value of 6.9 is greater for battery cage than deep litter with the value of 6.6. Table 10 showed that housing type effect is significant ($P < 0.05$) while the bird species was not significant. The interactions between the two factors are highly significant at 1% probability.

Table 10: Summary of ANOVA for the effects of housing systems and bird types on the pH of Poultry waste

Source	df	S.S	M.S	F _{cal}	F _{tab}	
					5%	1%
Blocks	2	0.01	0.005	1.250 ^{ns}	4.10	7.56
Bird type	2	9.04	4.52	1.130 ^{ns}	4.10	7.56
House type	1	0.03	0.03	7.50 [*]	4.96	10.04
Interaction	2	0.22	0.11	27.50 ^{**}	4.10	7.56

df = degree of freedom, SS = sum of square, MS = mean square, F_{cal} = F_{calculated}, F_{tab} = F_{table},
* = significant ($P < 0.05$), ** = highly significant ($P < 0.01$), ns = not significant.

3.10 Effects of bird types and housing systems on the Nitrogen of poultry waste

The broiler waste has the highest value of Nitrogen in both housing systems (see Table 1). The highest value of 432.3ppm was recorded for broiler waste in battery cage system and

375.3ppm in deep litter system. This was followed by that of cockerel with 338ppm in battery cage and 320.7ppm in deep litter system. The trend of Nitrogen occurrence in layer waste changed with deep litter system showing greater value of 316.7ppm than that of battery cage with 214.7ppm. The high Nitrogen contents in broiler

wastes may be due to higher protein contents in the broiler feed than that of cockerel and layers. In Table 11, it was observed that both housing system and bird species have very high

significant effect ($P < 0.01$). The statistical interaction between bird species and the housing system also showed high significance effect at 1% probability.

Table 11: Summary of ANOVA for the effects of housing systems and bird types on the Nitrogen contents of Poultry waste

Source	df	S.S	M.S	F _{cal}	F _{tab}	
					5%	1%
Blocks	2	42.11	21.055	0.2208 ^{ns}	4.10	7.56
Bird type	2	57387.44	28693.72	300.880 ^{**}	4.10	7.56
House type	1	382.72	382.72	382.72 ^{**}	4.96	10.07
Interaction	2	19797.12	9898.56	103.795 ^{**}	4.10	7.56

df = degree of freedom, SS = sum of square, MS = mean square, F_{cal} = F_{calculated}, F_{tab} = F_{table},
 * = significant ($P < 0.05$), ** = highly significant ($P < 0.01$), ns = not significant.

3.11 Effects of bird types and housing systems on the Phosphorus of poultry waste

The Phosphorus content was highest in broilers wastes (233.3 and 222 ppm), followed by cockerels wastes (222.3 and 214.3ppm) with least values from layers waste (203.3 and 193.7ppm) all under battery cage and deep litter systems, respectively (see Table 1). However, the housing system and bird species effect were highly significant ($p < 0.01$) while the interaction of the two factors was not significant (see Table 12).

3.12 Effects of bird types and housing systems on the Potassium of poultry waste

It was observed from Table 1 that similar to Nitrogen and phosphorus, potassium content was highest (343.3 and 314ppm) for broiler wastes, followed by that of cockerels (292 and 272.3ppm) and layers (252.7 and 223.3ppm) from battery cage and deep litter systems, respectively. Table 13 showed that the effect of both factors (house types and bird species) were highly significant ($P < 0.01$) while the statistical interaction of the two factors was not significant.

Table 12: Summary of ANOVA for the effects of housing systems and bird types on the Phosphorus contents of Poultry waste

Source	df	S.S	M.S	F _{cal}	F _{tab}	
					5%	1%
Blocks	2	134.33	67.165	3.239 ^{ns}	4.10	7.56
Bird type	2	2662.33	1331.165	64.205 ^{**}	4.10	7.56
House type	1	420.50	420.50	20.282 ^{**}	4.96	10.07
BH Int.	2	8.337	4.169	0.201 ^{ns}	4.10	7.56

df = degree of freedom, SS = sum of square, MS = mean square, F_{cal} = F_{calculated}, F_{tab} = F_{table},
 * = significant (P<0.05), ** = highly significant (P<0.01), ns = not significant.

Table 13: Summary of ANOVA for the effects of housing systems and bird types on the Potassium contents of Poultry waste

Source	df	S.S	M.S	F _{cal}	F _{tab}	
					5%	1%
Blocks	2	154.83	77.415	1.571 ^{ns}	4.10	7.56
Bird species	2	24666.83	12333.42	250.338 ^{**}	4.10	7.56
House type	1	3088.11	3088.11	62.681 ^{**}	4.96	10.07
Interaction	2	93.387	46.6935	0.948 ^{ns}	4.10	7.56

df = degree of freedom, SS = sum of square, MS = mean square, F_{cal} = F_{calculated}, F_{tab} = F_{table},
 * = significant (P<0.05), ** = highly significant (P<0.01), ns = not significant.

3.13 Effects of bird types and housing systems on the Amomiacal Nitrogen (NH₄-N) of poultry waste

This also had its leading values of 56, 50 for broilers wastes, 43.3, 40 for cockerel wastes and 35.3, 334.7 ppm for layers wastes under

battery cage and deep litter systems, respectively. Table 14 indicated that bird species effect is highly significant (P<0.01) while housing system effect is significant (P<0.05). There is no significant effect due to the interaction of the two factors.

Table 14: Summary of ANOVA for the effects of housing systems and types of birds on the NH₄-N of poultry waste

Source	df	S.S	M.S	F _{cal}	F _{tab}	
					5%	1%
Blocks	2	23.44	11.72	2.344 ^{ns}	4.10	7.56
Bird type	2	993.78	496.89	99.378 ^{**}	4.10	7.56
House type	1	49.999	49.999	9.999 [*]	4.96	10.07
Interaction	2	21.331	10.666	2.133 ^{ns}	4.10	7.56

df = degree of freedom, SS = sum of square, MS = mean square, F_{cal} = F_{calculated}, F_{tab} = F_{table},
^{*} = significant (P<0.05), ^{**} = highly significant (P<0.01), ns = not significant.

4. CONCLUSION

This research study had shown that physical and chemical characteristics of poultry wastes vary with bird species and housing systems. This finding is in agreement with the reports of several researchers (Alabadan, et al., 2009; CIGR Handbook). Local data therefore, will always be required in the planning and design of any component of poultry waste management systems. The experimental results can be used as reference in the waste management programme. The ANOVA results indicate that both housing system and bird species have significant effect on the various waste parameters tested.

5. REFERENCES

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