POULTRY WASTE GENERATION, MANAGEMENT AND THE ENVIRONMENT: A CASE OF MINNA, NORTH CENTRAL NIGERIA

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ABSTRACT

To develop an acceptable manure management and pollution prevention plan in poultry production, accurate accounting of waste generation and nutrient concentration of the waste need to be ascertained. In view of this, a field study was conducted in Minna, Nigeria to assess quantity of waste generated and the quality of the wastes in selected registered poultry farms in the town. This is with a view to knowing present waste generation status and managements strategies with respect to environmental protection and to recommend appropriate management methods if the present practice is not acceptable. Questionnaires focusing on farm information, birds' information and waste management were administered in the farms. Fresh poultry waste samples (manure) were collected from layer, broiler and cockerel sections of three of the selected farms at birds growth stage of 6 and 12 weeks respectively. The samples were analyzed for nitrates, phosphates and bacteriological parameters. Findings from the questionnaires showed that a total of 2,131,400 layers, 1,224,840 broilers and 848,570 cockerels which amount to a total of 4,204,810 birds are raised annually in confinement in the farms covering an area of 170 hectares of land. From calculation, the farms generate 100.97 metric tons of dead birds over a brooding cycle with about 26,565 metric ton of waste excluding slaughter house litter and hatchery wastes. Laboratory analysis results showed that the waste samples contain values as high as 206.75mg/g and 34.21mg/g of nitrates and phosphates respectively. Bacteriological values recorded are 25767.21cfu/100mg, 48214cfu/100mg and 17647.9mg/g for faecal coliform, total coliform and faecal streptococci respectively. Management of the waste is poor in the farms visited as indiscriminate dumping on land and burning are major waste management systems in these farms. Only a few adopt re-feed method, dead birds are buried without minding the shallow water table of the area. None of the farm visited adopt modern green disposal as waste management strategy. This waste generation and management method need to be changed to safe Minna environment from imminent hazards. It is therefore recommended that the poor management system of land application should be replaced with modern management strategy like green disposal, gasification, composting and re-feeding. These methods are more environmental friendly and can generate of resources from the waste.

Keywords: Environmental protection, green disposal, manure management and poultry farms

INTRODUCTION

The poultry industry is a fast growing agro-based industry in the world today and reason may be attributed to population increase and rising demand for poultry meat and egg product probably because of poultry meat is low in cholesterol content (Bolan et al. 2010). Though, these farms produce

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meat and egg products and they also generate employment, however, one of the problems confronting the industry is the accumulation of waste which may pose pollution problems unless it is managed in an environmental friendly manner. Waste from poultry industries varies from litter from broiler and cockerel production, manure from layers for egg production to dead birds from the entire farms and poultry slaughter house waste. The rate of litter production from a farm and nutrient content of the litter is affected by many factors, type and amount of bedding materials, number of flock reared, feed types and rate of feeding, litter management strategy, collection frequency, stocking density and ventilation (Kelleher et al. 2002). Quantity and nutrient values of manure from layer house also depend on feed formulation, type of bird reared, waste collection and management plan, collection frequency and stocking density. Poultry waste contains high moisture content and other organic materials, which create environmental problem such as fly breeding, odour nuisance and greenhouse gas emission if not disposed of or managed appropriately (Coufal et al. 2006). Amount of dead birds in the entire farm is determined by stage of growth, climate, management efficiency and natural occurrence like disease outbreaks. All these waste generation avenues from a poultry farm need to be assessed carefully to be able to predict waste generation pattern and recommend effective waste utilization and management type.

In Nigeria, like any developing nation, there is a rapid expansion of small and medium scale poultry farms with the attendant effect of huge waste generation. The magnitude of this generated poultry waste has given rise to improper disposal which include over application to land, improper timing of application thereby creating pollution problem to soil water and air environment. Modern management methods for poultry waste like re-feeding to animals, green disposal, gasification and biogas production have not gained prominence in Nigeria probably due to level of awareness, lack of strict regulation from government in respect of poultry waste disposal and care-free attitude of the farm owners (Adeoye et al. 2004). It is still a common site in Nigeria to see huge deposit of poultry waste around the farm, flushing of the waste into water courses through open canals from farms are also common sites (Ojolo et al. 2007). These method is not only unsightly, it also create a lot of environmental nuisance and surface and groundwater pollution. Another poor management method for the poultry waste that has gained prominence in Nigeria is open burning after the waste has been subjected to sun drying to reduce the moisture content and thereby raising the calorific value. The open drying itself releases excessive ammonia and other emissions capable of creating climate change. The eventual burning leads to serious environmental hazards for the people living around the area.

Minna, a town in North central area of Nigeria is not an exception to revolution poultry farms emergence and poor poultry waste management systems. The management pattern in Minna is characterized by a low level of specialization. Most of the huge amount of poultry waste produced in Minna is either applied excessively to agricultural land, flushed into water courses thereby creating serious pollution of eutrophication and oxygen depletion for aquatic animal (Adeoye et al. 2012). Some percentage of the waste is burnt while the remaining is buried inside soil without any prior treatment. This process is known to be capable of causing groundwater pollution by nitrates, phosphates, heavy metal and pathogenic organisms. The volume of poultry litter and manure generated today may be a major obstacle to future expansion of the industry if urgent action is not taken to waste management strategies adopted at present. Researchers, (Sangodoyin and Adeyemo, 2003; Adeoye et al. 2004; Pagani et al., 2008) have tried to document poultry waste production and management pattern in some other state across Nigeria. However, since the waste constituents varies with locations and management systems, there is a need to conduct a study to determine the quantity of poultry waste generated annually in Minna, to assess its present management strategy with respect to environment. This is with a view to suggesting or developing a viable management plans that will be environmental friendly. The objectives of this work are therefore to determine the total quantity of waste generated in some registered poultry farms in Minna, to assess their current waste management methods and to evaluate the nutrients values or pollution potential of the generated waste.

Study Area

The study area for this work is Minna, capital of Niger State, a semi – arid town in North central Nigeria, Figure 1 which lies on latitude 90 36’ 50’’N and longitude 60 33’25’’. Minna has two local Governments, Chanchaga Local Government which has its headquarter in Minna and Bosso Local Government with its headquarter in Maikunkele. The population of Minna as at 2012 was 613,246 (NPC, 2012). River Chinchaga is the major river in Minna which drains into River Kaduna at about 45km Northwestern Minna. Geology of Minna belongs to basement complex rock of Precambrian in age though some of them are found in the early Paleozoic. The rock have been grouped into four lithological units by Shekwolo and Brisbe,(1999) as gneiss-quartzite complex, schist belts, granitoids and metamorphosed basic rocks. Minimum temperature in Minna is 19^0C while maximum is about 38^0C. Precipitation divides the town into two major seasons, wet season which spans from May to October and dry season from November to April. Average annual precipitation is 1300mm with highest rainfall in August. An average daily sunshine hour is 9.2 and evapotranspiration ranges from 25mm in august and 90mm in March. Annual groundwater recharge in Minna is about 13% of total annual precipitation (Edoga and Suzzy, 2008).

Methods of Data Collection

There are 43 large scale and 74 medium and small scale poultry farms in Minna (Ministry of Agriculture and rural development, Niger State). For the purpose of this assessment, twenty registered poultry farms were randomly selected, Figure 2. The farms were visited and two structured questionnaires were administered in each of the farms. The ques-

FIGURE 1
Map of Niger State of Nigeria Showing Minna

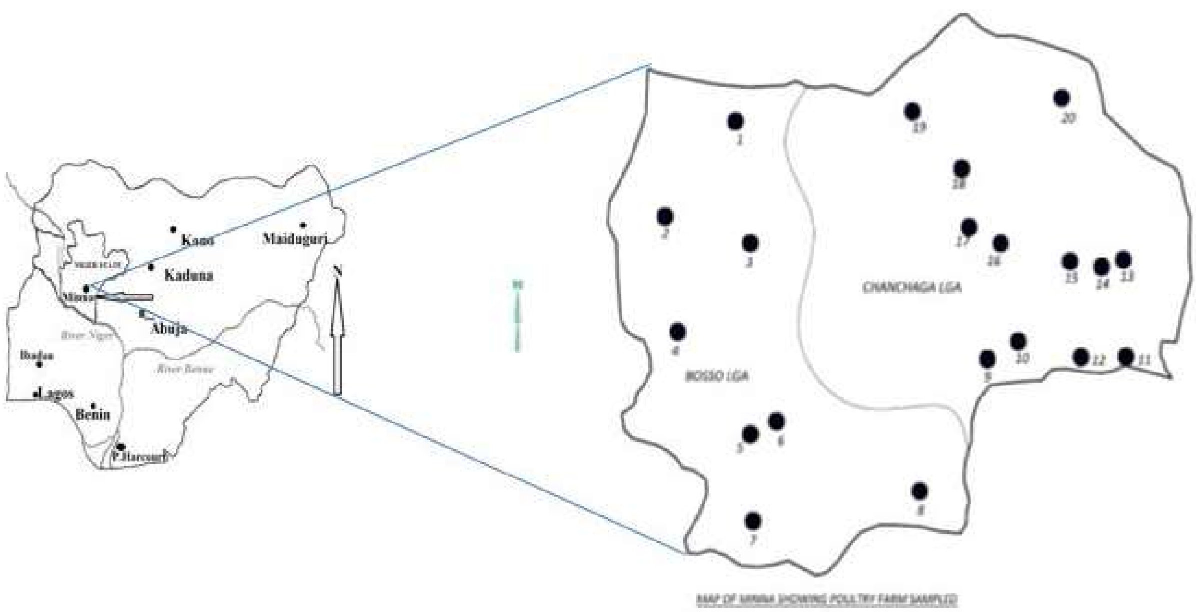

FIGURE 2
Map of Nigeria Showing Minna and map of Minna Showing Poultry Farms Visited

tionnaire has five segments, background information of the respondent, information about the size and ownership of the farm, number of birds in the farm, water sources in the farm and the method of waste management in the farm.

In order to determine the effect of location and feed types on component of poultry waste, fresh poultry waste samples were collected in three of the poultry farms and were taken to laboratory for analysis. Parameters tested were pH, phosphate, Nitrite, Nitrates, *faecal coliform*, *total coliform* and *faecal streptococci.* Variation in these parameters within bird's species was examined by testing for layer, broiler and cockerels dropping at a growth stage of 6 weeks (Body weight less than 1kg) and at 12 weeks (body weight greater than 1kg). The analysis was carried out by diluting 1g of fresh waste (manure) sample in 100ml of water. pH was determined with a pH meter, phosphate and nitrates were determined with Hach DR 2000 colorimeter. Phosphover 3 and Phosphover 5 reagent pillows were used as dilution chemical for phosphates and phosphorus pentoxide (P_2O_5) respectively while Nitraver 3 and Nitraver 5 reagent pillows were used to determine Nitrite and Nitrate respectively.

Membrane filtration technique was for bacteriological analysis. One gram of the waste sample was dilited in 100ml distilled water and was filtered through a membrane using vacuum pump. After one hour recovery period, the membrane was incubated on Slantez and Bartley media at 37^0C and 45^0C for 24hours for faecal and *total coliform* respectively and on Lauryl Sulphate broth (MLSB-OXOID MM0616) at 45^0C for 48hours for *faecal streptococci*. Tests were carried out in triplicate to minimize experimental error. The mean, standard deviation and test for significance were determined with SPSS 16.0. Questionnaires results were also subjected to statistical analysis.

RESULTS AND DISCUSSION

The findings from questionnaires administered were presented in Table 1. It can be seen from the table that 17 of the farms visited were owned by individual while government,

TABLE 1
Information about the farms visited

	Farm Name	Farm Ownership	Farm age (years)	Size of the farm (Ha)	Number of bird stocked in the farm house by species			Total number of birds
					Layers	*Broiler*	*Cockerel*	
1	Abdulahi	Private	12	13	131800	7000	3,600	142,400
2	Abu-Turab	Private	10	14	124,500	91000	105,000	320,500
3	Al-Amin	Private	8	3	18,000	8,600	6,040	32,640
4	Bache	Private	10	4	70,900	18,000	17,200	106,100
5	El-Kareem	Private	8	15	180,000	88,000	61,400	329,400
6	Fut. Minna	Institution	15	1.5	16,500	3800	8120	28,420
7	IK	Private	7	8	76,200	51,940	38500	166,640
8	Jamils	Private	5	33	160,000	150,000	161,000	471,000
9	Jamilla Ville	Private	17	10	90,000	63,000	41,000	194,000
10	Joe	Private	8	6	110500	62,000	12400	184,900
11	Jumik	Private	7	7.5	140,000	154,000	41,000	335,000
12	Jumra	Private	14	4	146,000	118,000	11,000	275,000
13	Limawa	Cooperate	10	6	186,000	65,000	43,000	294,000
14	Mil	Private	15	3	40,000	16,000	12,500	68,500
15	Na- Adama	Private	12	6	139800	67,000	82,000	288,800
16	Nabil	Private	16	8	158,000	31,000	18,700	207700
17	Nanas	Private	14	10	49,200	38,100	13,700	101,000
18	Natti	Private	18	6	45,000	35,400	26410	106810
19	Ng. State	Government	12	2	33,000	18,000	12,000	63,000
20	Sarki-Yakin	Private	6	10	216,000	139,000	134,000	489,000
		Total number of birds			2,131,400	1,224,840	848,570	4,204,810

cooperate body and institution own one each out of the farms. The oldest among the farm was 18 years. There is rapid increase in establishment of poultry farms especially when the country returns to democratic setting in 1999. This may be due to relative stability in agricultural policy and improvement in citizen standard of living.

This is evident from the result of poultry production in Minna for 15 years from state ministry of Agriculture and rural development as presented in Figure 3. From personal observations and interview during visitation, the farms raised exotic breeds like Brown Legon and Plymount Rock. Layers were raised in cages while broilers and cockerels were raised in deep litter system with saw dust used as litter in all the farms visited. Meanwhile, some of the farms raised their deep litter stock under elevated floor to allow easy package of the droppings without evacuating the birds.

Poultry Waste Production

There has been different submission in literatures with respect to waste production in poultry houses. For instance, Turnell et al. (2007) put the value as 3.0 ± 2kg per day per bird, Nicholson et al. (2004) estimated it based on liveweight of birds. For example layers and broilers are having 0.9kg/bird while cockerel is having 1.2kg/bird bodyweight. He therefore put manure production as 17.1kg/day/1000kg bodyweight for broilers and layers and 21.6kg/day/ 1000kg bodyweight for cockerels. This proposition was supported by ASABE, (2005) which put the waste generation as 16g/bird/day or 17.7kg/1000kg bodyweight for layers and broilers and 20.82kg/1000kg bodyweight/day for cockerels. Calculation of waste generated in the 20 visited in Minna was done based on ASABE, (2005) approximate value. Dead birds in poultry farms has been put by Leytem et al., (2007) as 4% of stock for entire brooding life whereas Salminen and Rintala, (2002) put it as 2 – 3% of the total flock. Therefore, 3% mortality rate for the total birds in the poultry farm in Minna would result in 105,120 dead birds which translate into 100.97 metric ton of dead bird per year. Manure production was calculated as 33104kg/day for layers, 19024kg/day for broiler and 20651kg/day for cockerel totaled as 72779kg/day. This puts annual poultry waste generation in Minna as 26,565 metric ton. This calculation excludes the litter value which Bernhart et al. (2010) put as 125% of the total manure produced and also excludes the poultry slaughter house and hatchery wastes. From the information received from State ministry of Agriculture, there are 43 large scale and 74 medium and small scale poultry farms in Minna, therefore, it is expected that about average of 75,000 metric ton of poultry waste would be produced in Minna in one year.

From the responses to the questionnaire, 50% of the farm owner remarked that they removed waste from battery cage house weekly, 35% removed it daily while only 15% removed the waste once in every two weeks from battery cage. In the deep litter house, 40% remove the litter once every three months, 35% remove it monthly, 15% remove it daily and 10% remove it weekly. It was concluded after Maguire et al. (2006) experiment that frequency of manure packing would have heavy effect on the nutrients value of the manure and if left unattended to for more than 72 hours, the rate of ammonia volatilization would be higher thereby creating environmental pollution for the birds, worker in the farm and people living close to the poultry farms. Figure 4 showed equipment to remove the manure from battery cage. Larger percentage of the respondents flush the waste into open gutter, about 28% use rake, shovel and trowel, 22% use belt conveyor packing system while a few among the farms pump from deep pit into open field.

In the deep litter house, scraping with shovel was the most common method and the wastes were packed inside jute bags and stack outside the farm building to allow it to degrade. A few of the poultry farms visited use automatic decaker machine to park while some farms where the floors of deep litter house were raised used automatic scraper to pack the wastes. There is high relationship between equipment being used to remove the litter and frequency of collection. The frequency increases as the method is becoming less

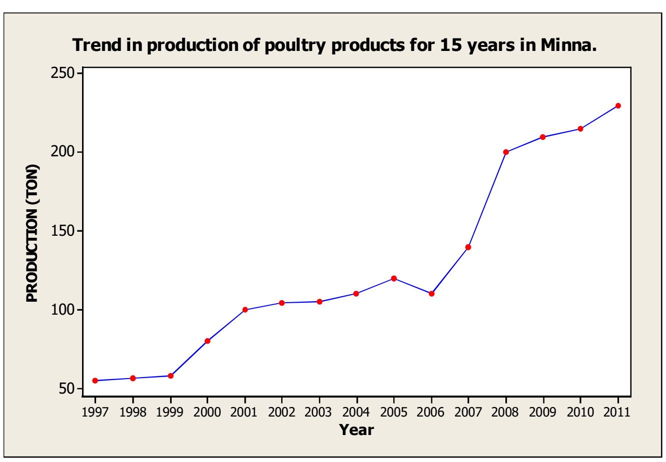

FIGURE 3
Trends in 15 Years Poultry Production in Minna

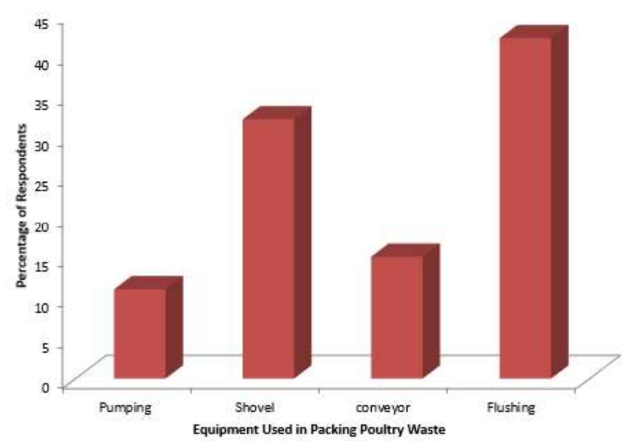

FIGURE 4
Methods of Waste Removal from Battery Cage House

drudgery. Therefore if all farms in Minna automate manure collection process in their farms, the problem of accumulation and unnecessary ammonia and other poisonous gas emission would be reduced.

Management and Disposal

Figure 5 showed major chemical applied to the poultry waste to minimize odour generation and to stabilize nitrate and phosphate in the wastes. 50% of the respondents do not treat the waste thereby allowing ammonia emission and odour generation at the highest rate especially in the afternoon. 30% use aluminum Sulphate 5% use ash while 10% use liquid alum. Moore et al. (2008) reported that ammonia emission from poultry manure can cause several problems as poor poultry performance, reduce the birds' immunity capacity, and damage the bird's respiratory systems. It may also cause acid precipitation, and nitrogen deposition into aquatic systems. He therefore suggested addition of alum to reduce the volatilization of ammonia and reduce the number of pathogen in the waste.

Sims and McCafferty (2002) also reported that aluminum sulfate amendment is a good management system for poultry manure because it reduces potential environmental effect, reduces NH_3 and decrease runoff of phosphorus and trace metals from soil amended with the litter. Faridullah et al. (2009) reported that ashing poultry manure can improve its nutrient content by increasing its phosphorus, potassium, calcium and magnesium. Addition of these chemicals is therefore a good practice to improve the waste properties and offer some environmental remedy; poultry farmers in Minna should be encouraged to treat the manure before spreading it on soil or releasing it to watercourses as they are currently doing.

Methods of waste disposal in the visited poultry farms were very unhygienic. The wastes were stored for about 4 – 6 weeks on farms before they were either return to land, heap them up and burn, flush them in to drain or dispose them of with other domestic refuse. As shown in the Figure 6, 50% of the farm owners spread the waste on nearby land, 40% burns the waste after subjecting them to sun drying while only 5% each compost and reefed the waste. The small percentage who engage in the relatively more environmental management of the waste were the instructional-based farm (FUT Minna) and the one own by the state government (Niger State Pilot farm). None of the farm visited use the waste for biogas generation or other green disposal methods which are more environmental friendly. Open gutter dumping and pit type collection and pumping are common in many farms visited. Plate 1 showed the open drain method a farm while Plate 2 showed layers waste being pumped to open field from 3m by 3m with depth of 5meters pit in another farm visited.

As regards dead bird management, from the calculation, the twenty farms visited produced 100.97 metric ton of dead birds per year. Figure 5 showed the method of the management. 50% bury the dead birds, 20% re - feed them to animals, 15% sell while 15% also burn them. Edwards and Daniel, (1992) opined that dead birds constitute an appreciable proportion of waste generated in poultry farms and listed the available but poor methods of management as pit disposal, incineration and burial. Though burial of mortality is acceptable option, technical specifications to prevent pollution of shallow aquifer recommended by Moreki and Chiripasi (2011) should be followed. The burial site must be located 90 meters from any well or neighbouring residences. The bottom should be at least 30m from flood plain and 60cm above seasonal high water table should be followed. It was argued that burning is not an acceptable disposal method as a result of air pollutants that will be released. The case of poultry farms in Minna is not conforming to the burial standards outlined above as location of some burial sites for dead bird was measured to be less than 8m from their water wells and the bottom of the pit are not too far from high water table of a typical farm in Minna.

It was suggested that shredding and composting are good management systems for dead birds to kill the microorganism

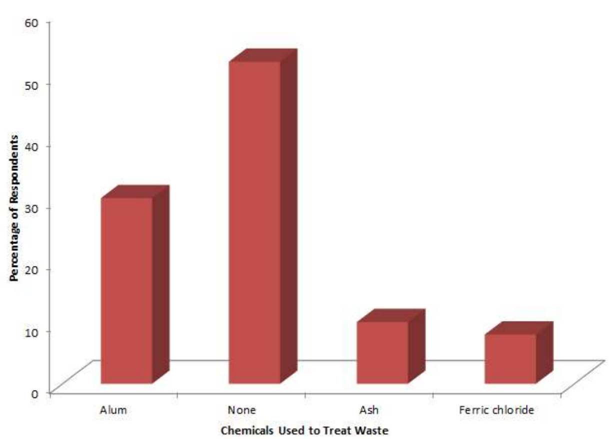

FIGURE 5
Ammonia Reduction Chemical from Poultry waste

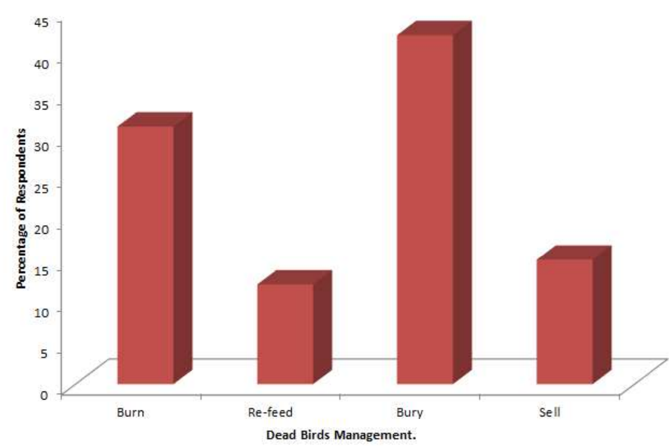

FIGURE 6
Management of Dead Birds in Farms Visited

through high composting temperature thereby reducing the odour. None of the farms visited adopts this method probably due to lack of awareness or lack of technical knowhow on how dead bird composting can be handled effectively. Generally, poultry farm owners in Minna do not care much about effective waste management and disposal methods. Though poultry production contributes meaningfully to Nigerian economy, the improper waste disposal method is a potential pollution hazard through emission of unpleasant and provocative odour. The waste can also emits dangerous gas like NH_3, CO_2 O_3, N_2O and other gases which contribute about 3 – 8% to global warming.

Properties of the poultry Wastes

Authors of this paper are working on the damaging effect of indiscriminate dumping of poultry waste will have on the phosphorus, nitrates and bacteriological properties of shallow groundwater around the farms, it is therefore essential to examine the presence of the parameters in the waste generated in the poultry farms. Edwards and Daniel, (1992) reported that, as with other organic wastes, elemental composition of poultry waste and other physical parameters it contains is a function of bird type, diet and dietary supplements, types of litter and handling and storage operations. This was supported by Bolan et al. (2010) who listed the factors affecting production and composition of poultry waste at a particular time and location as management, environmental and physiological factors. Turnell et al. (2007) also listed these factors as age, breed of birds, confinement density, rate of feed conversion and climatic conditions. To study the effect of the age, location, management and bird breeds on these parameters, fresh poultry waste sample was collected form broiler, layers and cockerel sections of three selected farms at two growth stages (6 weeks and 12 weeks) of the birds. The parameters examined are phosphates, nitrates and bacteriological. The results were presented in Tables 2 and 3.

From Tables 2, 3 and Figures 7, 8 and 9, variations exist significantly among the properties of the poultry waste tested. It varies from species to species, farm to farm and for the two age limits tested. In Table 2 and figure 9 for instance, significance difference exist between phosphates quantity of the three farms and for the three species respectively. Also from the Duncan Multiple Range Test (DMRT) nitrates and faecal coliform contents of the waste also varied with species, bird age and farms. There are also similar trends for other parameters like P_2O_5, Ammonium nitrogen and nitrite contents of the waste. Researchers (Bolan, et al., 2010, Turnell et al. 2007;

TABLE 2

Waste properties for birds at 6 weeks (< 1kg body weight) in the three farms visited

Parameters	Layers (Battery Cage management system)			Broilers (Deep Litter Management System)			Cockerels (Deep Litter Management System)		
	Al-Amin	*El-Kareem*	*Na- Adama*	*Al- Amin*	*El-Kareem*	*Na- Adama*	*Al-Amin*	*El-Kareem*	*Na- Adama*
pH	$7.37^{a} \pm 0.38$	$6.63^{a} \pm 1.38$	$8.61^{a} \pm 0.32$	$6.25^{a} \pm 0.07$	$8.83^{a} \pm 0.04$	$7.48^{a} \pm 0.58$	$6.02^{a} \pm 0.85$	$5.77^{b} \pm 0.38$	$7.14^{a} \pm 1.22$
PO_4^{-3} (mg/g)	$26.93^{a} \pm 0.25$	$19.30^{b} \pm 2.13$	$5.86^{c} \pm 0.66$	$25.03^{a} \pm 0.74$	$8.33^{c} \pm 1.08$	$7.31^{c} \pm 0.87$	$26.40^{a} \pm 0.44$	$16.63^{b} \pm 1.25$	$7.49^{c} \pm 0.84$
P_2O_5 (mg/g)	$17.43^{a} \pm 1.15$	$11.37^{a} \pm 0.87$	$5.24^{b} \pm 0.43$	$16.00^{a} \pm 0.72$	$10.56^{a} \pm 5.98$	$3.27^{b} \pm 0.04$	$14.30^{a} \pm 2.54$	$8.45^{b} \pm 0.14$	$8.98^{b} \pm 0.89$
NO_2^- (mg/g)	$0.63^{a} \pm 0.06$	$0.87^{a} \pm 0.25$	$0.67^{a} \pm 0.00$	$0.60^{a} \pm 0.31$	$0.60^{a} \pm 0.20$	$0.48^{a} \pm 0.00$	$0.87^{a} \pm 0.25$	$0.24^{b} \pm 0.25$	$0.77^{a} \pm 0.00$
NO_3^- (mg/g)	$155.36^{a} \pm 2.48$	$159.04^{a} \pm 4.11$	$87.98^{b} \pm 4.18$	$193.59^{c} \pm 3.33$	$206.75^{c} \pm 4.29$	$75.33^{b} \pm 4.18$	$173.97^{a} \pm 3.48$	$168.47^{a} \pm 6.15$	$81.22^{c} \pm 5.76$
$NO_3 - N$ (mg/g)	$35.07^{a} \pm 1.15$	$35.90^{a} \pm 2.88$	$19.86^{b} \pm 1.27$	$43.70^{a} \pm 1.77$	$46.67^{a} \pm 1.66$	$17.01^{b} \pm 2.38$	$39.27^{a} \pm 0.85$	$38.03^{a} \pm 0.81$	$18.33^{b} \pm 1.24$
$NH_4 - N$ (mg/g)	$21.60^{a} \pm 0.20$	$35.53^{b} \pm 2.18$	$4.65^{c} \pm 0.28$	$19.97^{a} \pm 1.70$	$36.97^{b} \pm 0.21$	$10.11^{c} \pm 1.93$	$19.33^{a} \pm 0.25$	$26.80^{a} \pm 2.95$	$14.33^{c} \pm 1.98$
Faecal Coli-form(cfu/100mg)	$14541.32^{a} \pm 0.05$	$25767.21^{b} \pm 0.16$	$9759^{c} \pm 17.80$	$10686.65^{c} \pm 0.03$	$17333.93^{a} \pm 0.04$	$8054^{c} \pm 11.84$	$12062.64^{a} \pm 0.06$	$14730.62^{a} \pm 0.05$	$10174^{c} \pm 19.73$
Total Coliform Cfu/100mg)	$37677.33^{a} \pm 0.19$	$48214.65^{a} \pm 0.27$	$28763^{b} \pm 16.4$	$24953.54^{b} \pm 0.01$	$40411.59^{a} \pm 0.08$	$22543^{b} \pm 11.28$	$27071.41^{b} \pm 0.20$	$38967.20^{a} \pm 0.02$	$30611^{a} \pm 13.90$
Faecal streptococci (cfu/100mg)	$10198.34^{a} \pm 0.08$	$12300.29^{a} \pm 0.08$	$4219^{b} \pm 23.76$	$10277.47^{a} \pm 0.03$	$9203.00^{a} \pm 0.05$	$7331^{b} \pm 9.04$	$864.47^{c} \pm 0.03$	$15222.67^{a} \pm 0.09$	$5430^{b} \pm 31.64$

Values are means of Triplicate reading ± standard deviation
Values on the same row for each parameter with different superscript are significantly different ($P \leq 0.05$) while those with the same superscript are not significantly different ($P \geq 0.05$) as assessed by Duncan's Multiple Range Test.

TABLE 3
Waste properties for birds at 14 weeks (> 1kg body weight) in the three farms visited

	Layers (Battery Cage management system)			Broilers (Deep Litter Management System)			Cockerels (Deep Litter Management System)		
Parameters	*Al-Amin*	*El-Kareem*	*Na- Adama*	*Al-Amin*	*El-Kareem*	*Na- Adama*	*Al-Amin*	*El-Kareem*	*Na- Adama*
pH	$8.27^{a} \pm 0.15$	$7.83^{b} \pm 0.32$	$7.99^{b} \pm 0.21$	$6.50^{b} \pm 0.26$	$5.65^{c} \pm 0.14$	$6.31^{b} \pm 0.34$	$6.25^{b} \pm 0.07$	$6.00^{b} \pm 0.17$	$6.04^{b} \pm 1.23$
PO_4^{-3} (mg/g)	$27.37^{a} \pm 1.63$	$23.73^{a} \pm 2.32$	$32.21^{a} \pm 1.23$	$25.87^{a} \pm 1.33$	$9.37^{b} \pm 0.27$	$34.21^{a} \pm 0.56$	$28.13^{a} \pm 2.00$	$13.57^{c} \pm 0.06$	$31.64^{a} \pm 2.43$
P_2O_5 (mg/g)	$17.33^{a} \pm 2.54$	$33.07^{b} \pm 3.75$	$39.66^{b} \pm 1.20$	$17.37^{a} \pm 0.21$	$7.90^{c} \pm 2.31$	$14.61^{a} \pm 0.49$	$11.33^{a} \pm 0.31$	$10.24^{a} \pm 0.12$	$11.39^{a} \pm 0.56$
NO_2^- (mg/g)	$0.67^{a} \pm 0.06$	$1.13^{b} \pm 0.12$	$0.24^{c} \pm 0.00$	$18.30^{d} \pm 0.56$	$1.23^{b} \pm 0.15$	$0.87^{a} \pm 0.00$	$0.62^{a} \pm 0.30$	$0.68^{a} \pm 0.06$	$0.71^{a} \pm 0.09$
NO_3^- (mg/g)	$130.82^{a} \pm 4.66$	$162.27^{b} \pm 3.91$	$68.21^{c} \pm 3.18$	$204.67^{d} \pm 6.32$	$185.17^{b} \pm 2.78$	$58.31^{c} \pm 3.09$	$140.30^{a} \pm 5.11$	$162.45^{b} \pm 3.99$	$102.11^{a} \pm 3.24$
$NO_3 - N$ (mg/g)	$29.53^{a} \pm 0.12$	$36.63^{a} \pm 0.58$	$15.40^{b} \pm 1.03$	$46.20^{c} \pm 0.10$	$41.80^{c} \pm 1.59$	$13.16^{b} \pm 0.47$	$31.67^{a} \pm 1.70$	$36.67^{a} \pm 0.25$	$23.05^{a} \pm 1.10$
$NH_4 - N$ (mg/g)	$22.27^{a} \pm 1.30$	$37.67^{b} \pm 1.78$	$11.34^{c} \pm 1.19$	$19.67^{a} \pm 0.59$	$35.60^{b} \pm 3.21$	$22.65^{a} \pm 2.76$	$21.80^{a} \pm 0.95$	$28.73^{a} \pm 0.29$	$21.48^{a} \pm 1.34$
Faecal Coli-form(cfu/100mg)	$14996.3^{a} \pm 0.06$	$24674.5^{b} \pm 1.21$	$16887^{a} \pm 16.8$	$10406.11^{a} \pm 0.04$	$24503.44^{c} \pm 0.31$	$6421^{d} \pm 6.77$	$12429.78^{a} \pm 0.05$	$15351.69^{a} \pm 0.01$	$8443^{d} \pm 22.31$
Total Coliform Cfu/100mg)	$35673.7^{a} \pm 0.06$	$43171.4^{b} \pm 0.26$	$23457^{c} \pm 12.1$	$25667.34^{c} \pm 0.40$	$41503.83^{b} \pm 0.31$	$25625^{c} \pm 24.3$	$25007.35^{c} \pm 0.25$	$37404.84^{a} \pm 1.73$	$29331^{a} \pm 21.46$
Faecal streptococci (cfu/100mg)	$11009.4^{a} \pm 0.04$	$17647.9^{b} \pm 0.07$	$4986^{c} \pm 6.99$	$10740.29^{a} \pm 0.01$	$10273.61^{a} \pm 0.01$	$5328^{c} \pm 11.90$	$9994.57^{a} \pm 0.08$	$14522.49^{a} \pm 0.03$	$4879^{c} \pm 10.10$

Values are means of Triplicate reading ± standard deviation
Values on the same row for each parameter with different superscript are significantly different ($P \leq 0.05$) while those with the same superscript are not significantly different ($P \geq 0.05$) as assessed by Duncan's Multiple Range Test.

Salminen and Rintala; 2002, Vizzier et al. 2003; Powers and Angel, 2008 and Keheller et al. 2002) have listed factors that may be responsible for this wide variation as management systems, geographical location or climate of the place where the samples are collected. Other factors listed were feed composition for the birds which varied from farm to farm depending on health challenges and the purpose for which the birds are raised. Metabolic activities of different species were also different at different growth stage and this will have effect on properties of the birds dropping. Stock density and ventilation condition also is said to have remarkable influence on the waste properties.

Therefore when determining the nutrient value, pollution potential of poultry waste, or to recommend appropriate management system for a particular poultry farms, it should not be handled as other conventional municipals waste where a system is recommended for different household. Rather, it was suggested that a representative sample for the waste to be treated or managed should be analyzed to ascertain its nutrient characteristics or pollution potential. From figure 7, total coliform was more for layers, 48214cfu/100mg when compare with two other bird species, 24953cfu/100mg and 27071cfu/100mg for broilers and cockerels respectively. This may be due to as suggested by (Sangodoyin and Adeyemo, 2003) the presence of broken eggs which is high in protein value, which would have mixed with the droppings before collection. *Faecal streptococci* values in layers and broilers are very close but were significantly low in cockerel probably as a result of management system in the cockerel house or the metabolic activities of the bird. Considering the variation in manure properties within farms in Figure 8, waste samples collected from *El-Kareem* farm seems to contain more faecal coliform value of 43171cfu/100mg than other farms while *Na- Adama* Farms recorded the lowest faecal coliform value of 23457cfu/100mg. This may not be unconnected with the reasons mentioned earlier as feed composition and other management systems in the farms. All these variations are pointing to the fact that even, the same species of bird can produce waste of different properties if they are reared under different conditions. From Figure 9, nitrate–nitrogen, ammonium nitrate, pH and Nitrate values are more for broilers than other species even in the same farm. This according to Salker,

FIGURE 7
Open drain Poultry waste disposal method

FIGURE 8
Deep pit poultry waste collection method

et al. (2009) may be due to type of feed given to the broilers which in most farms contain more protein than forother birds. This protein compound would eventually be converted into nitrogenous compounds and will be excreted with the bird's faeces. Phosphorus compounds, Phosphate and P_2O_5 are highest in layers probably as a result of egg formation compounds which would be added to their feeds and other additives that are responsible for hardening of egg shell, (Salker, et al. 2002).

Impact of Poultry Waste on Environment

Vizzier et al. (2008) reported that continuous dumping of poultry waste on land as the case in Minna could lead to microbial build up in the soil which could also lead to soil nutrient imbalance, eutrophication of surface water by phosphate and buildup of nitrate in the soil to 3m depth or even up to the

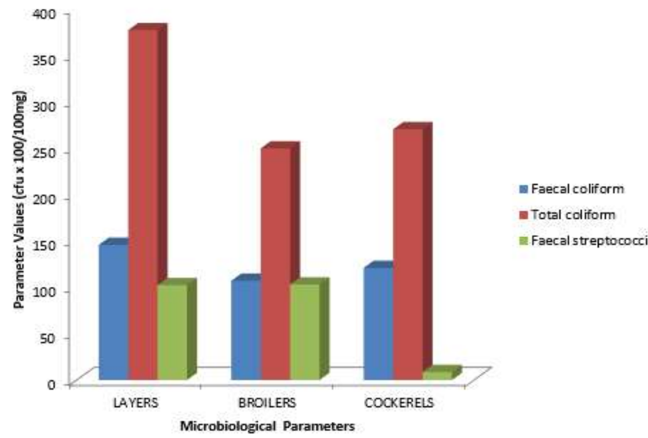

FIGURE 9
Variations in Microbiological Parameters within species for Al-Amin Farm 6 week's birds

bedrock. Poultry waste generated in Minna from initial characterization carried out contain parameters that are capable of polluting the surface water, groundwater and air environment at high level and continuous dumping can lead to serious health challenge. Moore et al., (2009) indicated that 32% of water wells in Sussex County in Delaware have high nitrate level due to dumping of poultry waste in open fields. In Botswana, Moreki and Chiripasi (2011) discovered faecal coliform in excess of national standards in 90% of surface water sampled and in about 67% of shallow wells around the poultry farms. It was also discovered from their finding that prior to the increase in poultry production in Botswana, coliforms were not present in either the river or shallow wells. The uncontrolled dumping can lead to air pollution as Ojolo, et al. (2007) reported that 57% of total nitrogen present in poultry waste is lost via volatilization within 14 day of dumping. This value may increase to over 65% of the total nitrogen before the waste is stabled. Ammonia volatilization is detrimental because it can cause suffocation, acid rain and greenhouse gas emission.

Powels and Angel, (2008) listed various challenges associated with indiscriminate poultry dumping as nitrates in groundwater which is hazardous to health if consumed. It could also lead to eutrophication of rivers and algae bloom from phosphorus introduced into them from runoff. Phosphorus can pollute groundwater if the water table is shallow and the soil is very high in hydraulic conductivity. Poultry waste dumping can also lead to influx of bacteria into shallow aquifer, cleaning up of which may not be possible in decades. Heavy metals like arsenic, copper and lead which are used as additives to poultry feed are very carcinogenic can be excreted with faeces and if dumped on land can pollute water bodies. All these environmental challenges are imminent in Minna if current poor method of poultry waste management is not checked.

CONCLUSION

The study showed from all assessment and analysis made so far that the way poultry waste is managed in Minna farms is very poor and not conforming to environmental standards. Majority of the farms still employ dumping as only viable option and none of them has adopted modern methods of poultry waste management which are beneficial for both the economy and the environment. According to this survey, large quantities of poultry waste are produced annually in Minna which if properly harnessed can contribute to economic development of the town and improve the living standard of the inhabitants of the city. The following managements systems are therefore recommended.

1. Poultry manure can still be used in agricultural land at a specified dosage. While adopting this method, Good Agricultural Practice (GAP) and Best Management Practices (BMP) concepts should be adopted. These involve, good site selection, it should be applied when crops need it most and should be incorporated into soil after application. The manure should not be applied immediately before or after heavy rain and should not be used on a farmland close to ponds, drainage systems and drainage pathway.
2. Large percentage of the poultry waste produced in Minna can be used in diets of swine, lambs, ewe, poultry cow and rabbit. Most farms visited are integrated where different farm animals are raised inside same farm. Literatures have supported it that if 20% of poultry feeds is applied to ruminant feed; it will meet the animal needs for crude protein, calcium and phosphorus.
3. Landfilling method for the poultry waste can also be adopted. However, all environmental technicalities involved should be strictly adhered to. It should be properly sited. The sides and bottom of the landfill pit should be lined with impermeable materials, there should be provision for leachate collection and monitoring device for gas emission should be incorporated into the landfill system design.
4. Composting is a very good management practice for poultry waste if carefully executed. Turnell et al. (2007) reported that composting immobilizes nitrogen and phosphorus in the waste and reduce their risk of entering water systems. Composing process converts ammonia nitrogen into organic nitrogen and reduces the volume of the waste. High heat produced during composting completely reduces the pathogenic organisms in the waste.
5. Green disposal is one of modern methods of poultry waste management. It involves biogas production, gasification process which produce fuel gas that can be stored and used later from the waste. It decreases greenhouse gas emission from the waste. Sarker et al. (2009) has reported that about 0.7Megawatt of electricity can be generated by burning 7000ton of poultry waste. Therefore, the current electricity challenges Minna is facing can be overcome by investing money in this area. It was affirmed from this research that more than 72,000metric ton of poultry waste is generated annually in Minna which would be sufficient enough for electricity generation.
6. It was discovered recently by Gou, et al. (2010) that poultry litter can be used to produce activated carbon which possesses higher adsorption ability and capacity for heavy metals than commercial activated carbon. It does not pose any secondary contamination risk for the water. The method can also be adopted in Minna to treat heavy metals contaminated water.

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REFERENCES

Adeoye, G.O., Shridar, M.K.C., Mohammed, O.E., 2004. “Poultry waste management for crop production: Nigerian experience.” *Waste Management and Research*. Volume 22: pp. 165–172.

Adeoye, P.A, Hasfalina, C.M, Mohammed, A.S., Thamer, A.M., Akinbile, C.O., 2012. Poultry waste effect on shallow groundwater quality in selected farms in Minna, North-central Nigeria. Proceedings of International Conference on Agricultural and Food Engineering for life. University Putra, Malaysia. pp. 554–565.

ASABE, 2005: Manure production characteristics. ASABE Standard D384.2. American Society of Agricultural and Biological Engineers. St. Joseph, Ml.

Bernhart, M, Fasina, O.O., Fulton, J. Wood, C.W., 2010. “Compaction of Poultry Litter.” *Bioresource Technology*, Volume 101: pp. 234–238.

Bolan, N.S., Szgozy, A.A., Chuasavathi, T., Seshadri, M.J., Rothrock, J.R Panneerselvam, P., 2010. “Uses and management of poultry litter.” *World’s Poultry Science Journal*, Volume 66: pp. 673–698.

Coufal, C.D., Chavez, C., Niemeyer, P.R., Carey, J.B., 2006. “Measurement of broiler litter production rates and nutrients content using recycled litter.” *Poultry Science Journal*, Volume 85: pp. 398–403.

Edoga, R. N., Suzzy, A.B.U., 2008. “Effect of Temperature changes on Evapotranspiration in Minna, Niger State.” *Journal of Engineering and Applied Science*, Volume 3 (6): pp. 482–486.

Edwards, D.R. Daniel, T.C., 1992. “Environmental impacts of on – farm poultry waste disposal – a review.” *Bioresource Technology*, Volume 41: pp. 9–33.

Fariduller, M., Irshad, M., Yamamoto, S., Eneji, A.E. Uchiyama, T. Honna, T., 2009. “Recycling of chicken and duck litter ash as a nutrient source for Japanese mustard spinach.” *Journal of Plant Nutrition*, Volume 32: pp.

1082–1091.
Guo, M., Qui, G., Song, W., 2010. "Poultry litter based activated carbon for removing heavy metals ions in water." *Waste Management*, Volume 30: pp. 308–315.
Kelleher, B. P., Leahy, J.J., Henihan, A.M., O'Dwyer, T.F., Sutton, D. Leahy, M.J., 2002. "Advances in poultry litter disposal technology - a review." *Bioresource Technology*, Volume 83: pp. 27–36.
Leytem, A.B., Plumstead, P.W., Maguire, R.O., Kwanyuen, P., Brake, J., 2007. "What aspect of dietary modification in broilers controls litter water soluble phosphorus; dietary phosphorus and, phytase, or calcium?" *Journal of Environmental Quality* Volume 36: pp. 453–463.
Maguire, R.O., Hesterberg, D., Gernat, A, Anderson, K, Wineland, M Grimes, J., 2006. "Liming Poultry manures to decrease soluble phosphorus and suppress the bacterial population." *Journal of Environmental Quality*, Volume 35 (3): pp. 849–857.
Moore, P, Miles, D Burns, R., 2009. "Reducing ammonia emissions from poultry litter with alum." *USDA Agricultural Research Service Bulletin*, Volume 115: pp. 18–20.
Moreki, J.C., Chiripasi, S.C., 2011. "Poultry waste in Botswana: A review." *Journal of Animal and Feed Research*. Volume 1(6): pp. 285–292.
Ojolo, S.J., Oke, S.A., Animasahun, K., Adesuyi, B.K., 2007. "Utilization of poultry, cow and kitchen wastes for biogas production: A comparative analysis." *Iranian Journal of Environment, Health Science and Engineering*, Volume 4 (4): pp. 223–228.
Pagani, P., Abimiku, J.E. Okolie, W.E., 2008. Assessment of the Nigerian poultry market chain to improve biosecurity. Technical Report on FAO Consultative Mission, Abuja Nigeria. pp. 3–54.
Powers, W., Angel, R., 2008. "A review of the capacity for Nutritional strategies to address environmental challenges in poultry production." *Journal of poultry Science*; Volume 87: pp. 1929–1938.
Salminen, E., Rintala, J., 2002. "Anaerobic digestion of organic solid poultry slaughterhouse waste – a review." *Bioresource Technology*, Volume 83: pp. 13–26.
Sangodoyin, A.Y., Adeyemo, O.A., 2003. "Poultry Manure production and nutrient content." *Nigerian Journal of Technological Development*, 8 (2): pp. 116–124.
Sarker, B.C, Alam, M.A., Rahman, M.M., Tariqul, A.F.M. Chowdhury, M.G.F., 2009. "Waste management of Commercial poultry farms in Bangladesh." *Journal of Innovation and Development Strategy*, Volume 3(1): pp. 34–37.
Sharpe, R.R., Schomberg, H.H., Harper, L.A., Endale, D.M., Jenkins, M.B., Franzlucbbers, A.J., 2004. "Ammonia volatilization from surface – applied poultry litter under conservation tillage management practices." *Journal of Environmental Quality*. Volume 33 (4): pp. 1183–1188.
Sims, J.T., McCafferty, N.J., 2002. "On-farm evaluation of aluminium sulfate (alum) as a poultry litter amendment effects on litter properties." *Journal of Environmental Quality*, Volume 31 (6); pp. 2066-2072.
Turnell, J. R., Faulkner, R.D. Hinch, G.N., 2007. "Recent advances in Australian broiler litter utilization." *World's Poultry Science Journal*, Volume 63: pp. 223–231.
Vizzier, T.Y, Bazli, C.L. Tankson, J.D., 2009. "Relationship of broiler flock numbers to litter micro flora." *Journal of Applied Poultry Research*, Volume 12: pp. 81–84.