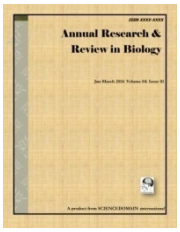

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Environmental Implication of Poultry Waste Generation and Management Techniques in Minna, Semi-arid Region of Nigeria

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Authors' contributions

Author PAA administered the questionnaires and analyzed the results. He also wrote the first draft of the manuscript. Authors CMH, MSMA and AMT validated the questionnaires and supervised the data analysis. Author COA designed the data collection technique with author PAA. All authors read and approved the draft manuscript that was sent for publication.

Short Research Article

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ABSTRACT

To develop an acceptable manure management and pollution prevention plan in poultry production, accurate accounting of waste generation and concentration of the waste need to be ascertained. In view of this, a study was conducted in Minna, Nigeria to assess quantity of waste generated and the quality of the wastes in selected registered poultry farms. This is with a view to knowing present waste generation status and managements strategies with respect to environmental protection and recommending appropriate management methods to protect air, surface and groundwater environments. Questionnaires focusing on farm information, birds' information and waste management were administered in the farms. 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

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hectares of land. From calculation, the farms generate 100.97 metric tons of dead birds over a brooding cycle with about 159,430 metric ton of poultry waste excluding slaughter house litter and hatchery wastes. 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. This waste generation and management method need to be changed to safe Minna environment from imminent hazards. Modern management strategies like green disposal, gasification and biogas production and composting are recommended for Minna poultry farmers because are more environmental friendly and can generate of resources from the waste.

Keywords: Environmental protections; green disposal; manure management; poultry farms.

1. INTRODUCTION

Recently, poultry industry has become a fast growing agro-based industry in the world. The 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 [1]. Though, these farms produce 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 [2]. 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 [3]. 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 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 [4]. 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 [5]. 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 greenhouse gas emissions capable of creating climate change [6].

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 [7]. Some percentage of the waste is burnt while the remaining is buried inside soil without any prior treatment. Researchers [8,4,9] 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, and assess its present management strategy with respect to environment. This is with a view to suggesting or developing viable environmental-friendly management plans. The objectives of this work are therefore to determine the total quantity of waste generated in selected 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.

1.1 Description of the Study Area

The study area for this work is Minna, capital of Niger State, a semi – arid town in North central Nigeria, located on latitude 9º36' 50''N and longitude 6º33'25'' Fig. 1. The population of Minna as at 2012 was 613,246 [10]. 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 rocks have been grouped into four lithological units by [11] as gneiss-quartzite complex, schist belts, granitoids and metamorphosed basic rocks. Minimum temperature in Minna is 19ºC while maximum is about 38ºC. 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 from25mm in august and 90mm in March. Annual groundwater recharge in Minna is about 17% of total annual precipitation [12].

Fig. 1. Map of Niger State of Nigeria Showing Minna

1.2 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, Fig. 2. Personal investigative and questionnaires approach was used for this research. The farms were visited and two structured questionnaires were administered in each of the farms. The questionnaire 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. The questionnaires were administered to the farms managers and other workers in the farms. Site inspections were done to assess methods of waste management and disposal in the farms visited. The results obtained were subjected to simple descriptive statistics analysis.

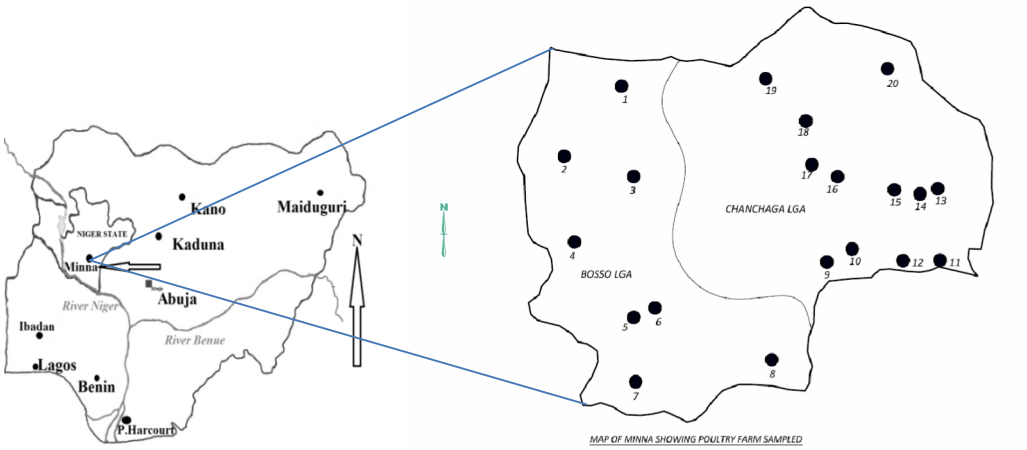

Fig. 2. Map of Nigeria Showing Minna and map of Minna Showing Poultry Farms Visited

2. RESULTS AND DISCUSSIONS

The findings from questionnaires administered were presented in Table 1. Seventeen of the farms visited were owned by individual while government, 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 Fig. 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.

Table 1. Information about the farms visited

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

Source: Field Study, 2012

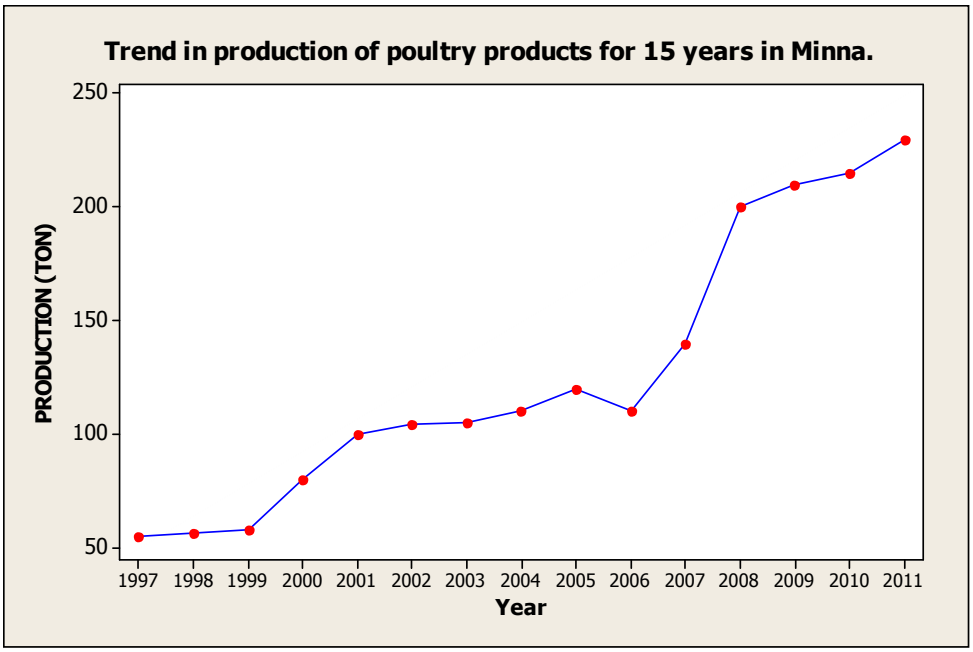

Fig. 3. Trends in 15 Years Poultry Production in Minna

2.1 Poultry Waste Production

There has been different submission in literatures with respect to waste production in poultry houses. For instance, [13] put the value as 3.0±2kg per day per bird, [14] estimated it based on live weight of birds. For example layers and broilers have 0.9kg/bird while cockerel has 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 [15] 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. Dead birds in poultry farms has been put by [16] as 4% of stock for entire brooding life though [17] put it as 2 – 3% of the total flock. Total average body weights of layer bird and cockerel have been put as 0.9kg while average body weight of a cockerel is put as 1.2kg, [15]. Therefore, 2.5% mortality rate for the total birds in the poultry farm in Minna was calculated as shown below would result in 100,972.5kg dead birds which translate into 100.97 metric ton of dead bird per year.

Layer Birds: 2131400 X 2.5% = 53285 birds X 0.9kg = 47956.5kg (1)
Broiler: 1224840 X 2.5% = 30621 birds X 0.9kg = 27558.9kg (2)
Cockerel: 848570 X 2.5% = 21211.25 X 1.2 kg = 25457.1kg (3)
Total Dead Birds = 100,972.5kg (4)

Manure production was calculated based on [15] value of 17.7kg of manure for 1000kg bodyweights for layers and cockerel and value of 20.82kgof manure for 1000kg bodyweight per day. Based on this, daily poultry manure generated in 20 poultry farms in Minna was calculated as shown below:

$$Layers\ Waste = \frac{2131400\ X\ 0.9\ X\ 17.7}{1000} = 33953kg \quad (5)$$

$$BroilersWaste = \frac{1224840\ X\ 0.9\ X17.7}{1000} = 19511.7kg \quad (6)$$

$$Coc\,\mathrm{ker}\,els\ Waste = \frac{848570\ X\ 1.2\ 20.82}{1000} = 21200kg \quad (7)$$

This puts the total daily manure generated in the 20 farms as 74665.7kg. Annual poultry waste generation would therefore be 27252988.5kg or 27,253 metric ton of poultry manure per year. From the information received from State ministry of Agriculture, there are 43 large scale and 74 medium and small scale poultry farms in Minna, making a total of 117 poultry farms. Therefore, it is expected that on the average about 159,430 metric ton of poultry manure would be generated in Minna in one year. This calculation excludes the litter value which [18] put as 125% of the total manure produced and also excludes the poultry slaughter house and hatchery wastes.

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 [19] 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. Fig. 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.

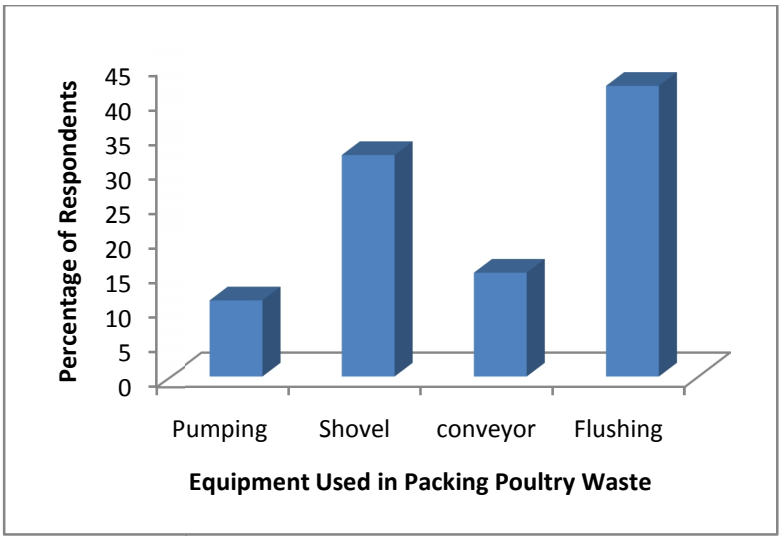

Fig. 4. Methods of Waste Removal from Battery Cage House

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 de-caker 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 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.

2.2 Management and Disposal

Fig. 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. It was reported by [20] 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.

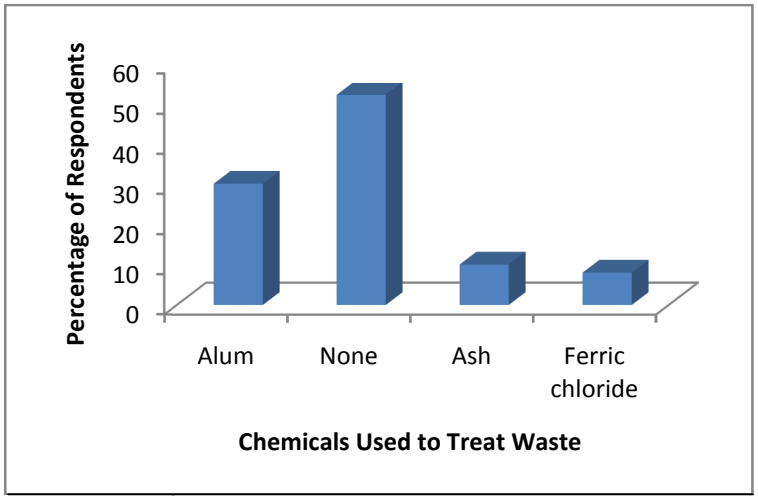

Fig. 5. Ammonia Reduction Chemicals from Poultry waste

It was also reported by [21] 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. As reported [22], 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 landspreading or releasing the waste watercourses.

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. 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 farms (FUT Minnafarm) 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 Fig. 6 and pit type collection and pumping Fig. 7 are common in many farms visited.

Fig. 6. Open gutter drain Poultry waste disposal method.

Fig. 7. Deep pit poultry waste collection method

Dead bird management systems were also poor in all the farms visited, from the calculation, the twenty farms visited produced 100.97 metric ton of dead birds per year. Fig. 8 showed the method of the management. 50% bury the dead birds, 20% re - feed them to animals, 15% sell while 15% also burn them. It was submitted by [23] 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 [24] should be followed. The case of poultry farms in Minna is not conforming to the burial standards as location of some burial sites for dead bird was measured to be less than 8m lateral distance from the water wells, the sides of the pits are not lined with impermeable materials and the bottom of the pit are close to water table of the farms area. Re-feeding dead birds to other birds or other vegetarian animals has been forbidden in Europe as it is considered non-ethical except for cats and dogs; therefore the practice should be discouraged.

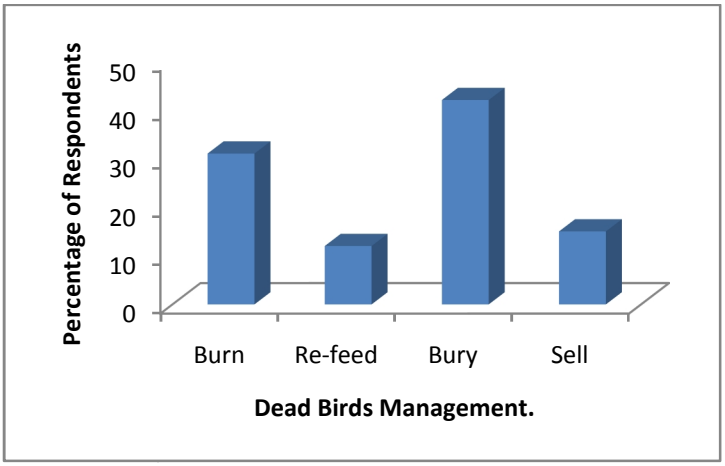

Fig. 8. Management of Dead Birds in Farms Visited

Burning is not an acceptable disposal method as a result of air pollution and climate change effect [6]. Shredding and composting are therefore suggested as good management systems for dead birds to kill the microorganism through high composting temperature thereby reducing the odour. None of the farms visited adopts these methods probably due to lack of awareness or lack of technical knowhow on how dead bird composting can be handled effectively. 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 [6].

2.3 Impact of Poultry Waste on Environment

From experiment of [25], 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 bedrock. Poultry waste generated in Minna from initial characterization carried outby [26] contains 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. From the research conducted by [20], 32% of water wells in Sussex County in Delaware have high nitrate level due to dumping of poultry waste in open fields. In Botswana, [24] 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 [5] 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.

Various challenges associated with indiscriminate poultry dumping as been reported by [27] 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.

3. 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.

(i) 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. It is also recommended that dumping of poultry waste should be limited to 170kg per hectare. The remaining waste can be used for biogas production.

(ii) 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.

(iii) Composting is a very good management practice for poultry waste if carefully executed. According to [13], composting immobilizes nitrogen and phosphorus in the

waste and reduces 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. Addition of saw dust or similar structuring material is also recommended before composting to improve the quality of the resulting compost.

(iv) 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. This is highly recommended as good waste management practice. It will not only solve the problem of environmental challenges created by poor poultry manure disposal, it will also augment current electricity supply in Minna.

(v) Keeping poultry in cages is forbidden in the EU since January, 2012 and in Austria since 2009 because the practice is considered to be non-adequate for domestic animals, they should have some space to move and exert some natural behavior.

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COMPETING INTERESTS

Authors declare that there are no competing interests

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