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Poultry Wastes Effect on Water Quality of Shallow Wells of Farms in Two Locations of Kwara State, Nigeria

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ABSTRACT

The study investigated poultry waste effect on water quality of shallow wells in Asa and Ilorin, south local government areas of Kwara State. The factors considered are the number of birds (N), years of existence of the farm (Y), and the distance between the shallow wells and the poultry dump sites (D). Physicochemical parameters of the water collected were analyzed. The data obtained were analyzed using SPSS Software (Version 16.0). For the number of birds, the result shows that the mean turbidity, Chemical Oxygen Demand COD, and fecal coliform were between 23.25 -101.92 NTU, 85.22-111.56 $mg.L^{-1}$, and 0.00-0.34 $cfu.mL^{-1}$ respectively. For the year of existence of the farm, the mean turbidity, phosphate, COD were between 14.10-56.6 NTU, 1.07-2.30 $mg.mL^{-1}$, 88.00-95.43 $mg.mL^{-1}$ respectively. The mean turbidity was found to be between 11.81 NTU and 58.85 NTU, phosphate 1.09-2.06 $mg.mL^{-1}$, COD 86.73-94.57 $mg.mL^{-1}$, and fecal coliform 0.00-0.24 $cfu.mL^{-1}$ for the distance between dumpsites and water source. The number of birds has a significant effect on turbidity, BOD, COD and fecal coliform at $p \leq 0.05$ compared to the measured control 400 m away from the dumpsites. As a result, there is evidence of pollution risks from poultry wastes. Proper treatment and the placement of farms far away from dumpsites will assist maintain the water's suitability and sustainability.

INTRODUCTION

The management of waste in large poultry facilities in rural and urban communities is crucial for the long-term expansion and sustainability of poultry production. It also ensures the protection of the environment, human health, and the quality of life of workers and people living close to the poultry facilities (Nahm & Nahm 2004). An increase in the demand for meat, eggs, and other poultry products has led to an increase in poultry production, which has caused an excessive generation of waste. The increase of poultry production and its spread across the country, as well as the potential environmental consequences, are major concerns. Poultry comprises broilers, layers, and turkeys that are grown using a combination of manure and bedding material (Collins 1996, Wilson et al. 1998, Zhao et al. 2008). Poultry waste includes a mixture of excreta, bedding material (e.g. wood shaving, straw), waste feed, dead birds, broken eggs, and detached feathers (Evers 1996, Weaver 1998, Kelleher et al. 2002). Poultry waste poses significant risks to the environment, including contamination of drinking waters, eutrophication, and odors due to poor management (Ezekoye et al. 2017). Water and living organisms are inseparable. Water is required for domestic and industrial purposes and can be obtained from a variety of sources, including groundwater, surface water, rainfall, boreholes, and wells (Kushreshtha 1998). Poultry wastes in surface water have led to an increase in nutrients, solids, and metals which in turn lead to algae production, increased turbidity, reduction in light penetration, toxic metals bioaccumulation, and thus causing interruption of the ecosystem (Adewale et al. 2013). Furthermore, most surface water is dirtier, more turbid, and contains more sediment, necessitating greater and more careful purification processes. Pathogens can be introduced into drinking water as a result of poor management, posing a health risk (Koelkebeck et al. 1999, Manning et al. 2007). Both wells and borehole water are less contaminated when they are located far away from any potential sources of pollution, and when they are constructed with good well design and disinfection. (Akpoveta et al. 2011).

However, depending on water environment management and temperature gradients, there is a risk of pollutant introduction (Frederick 1990, Kushreshtha, 1998). Hand-dug wells are shallow wells with diameters ranging from 0.9 to 1.8 m and depths ranging from 4.5 to 10 m, depending on the point where groundwater is found (Orebiyi et al. 2010). Water pollution is a result of suspended solid particles, insoluble liquid droplets (Plant et al. 2001). Groundwater gets polluted by land disposal of solid wastes, sewage disposal on land, and runoff (Jain et al. 1995). The destination and transit of nutrients and contaminants in variable saturated porous media are influenced by a multitude of interconnected physical, chemical, and biological processes (Jacques et al. 2008). Water quality can be degraded by contaminants contained in manure. Poultry wastes can contaminate water by leaching through the soil, runoff, and where wastes have been held for a long time due to poor waste management. Excessive discharge of these wastes can be caused by a large number of birds raised on the farm (Ezekoye et al. 2017). Large amounts of poultry waste are often a source of pollution in the environment. These are a serious threat, and the quality of surface and subsurface water has deteriorated as a result. The frequent discharge of untreated wastes at dumpsites without regard for the impact on nearby water bodies pollutes the ecosystem greatly. Since the sanitary state of drinking water varies considerably among farms, methods and strategies for identifying major contamination locations for the prevention of waterborne diseases must be found. Therefore, the aim of the study was to investigate the effect of poultry wastes on the water quality of shallow wells of selected farms in two local government areas (LGAs) of Kwara State, Nigeria. The outcomes of this study will be an effective tool for predicting the extent of water pollution on livestock farms and also serve as a guide for proper planning and designing of a farmstead.

MATERIALS AND METHODS

Description of the Study Area

The fields of research are Asa and Ilorin South Local Government Areas (LGAs) in Kwara State, Nigeria. Asa LGA is located on latitude 8^o00^1 and 9^o10^1 North of the Equator and longitude 2^o45^1 and 4^o15^1 East of the Greenwich meridian. It has its headquarters in Afon, and it is 27 km from Ilorin. It is about 1,525 sq.km and it stretches from the peri-urban fringes of the city of Ilorin to Oyo State. The average annual rainfall is between 1,000 mm-1,500 mm and the highest rainfall is between June and early August (Ajibade 2006). It falls within the tropical hinterland with a wet and dry climate. Their major occupations are farming and trading. Ilorin South Local Government has its headquarters situated in Fufu, latitude 8^o24' N and 8^o36' N and longitude 4°10' E and 4°36' E (Jimoh 2003). The temperature of the area ranges between 33°C and 35°C from November to January and 34°C-37°C from February to April. The average annual rainfall ranges from 990.3 mm to 1,318 mm (Ajibade & Ojelola 2004).

Water Collection Procedures, Quality and Data Analysis

Water samples from thirty (30) farms in the two LGAs were collected between June-August. The experimental layout was designed in a completely randomized experimental design (CRD) manner as shown in Table 1. The factors considered for each farm in the design of the experiment were the number of birds (N), year of existence (Y), the distance between dump sites and shallow wells (D), and hydraulic conductivity of soil (H). Three soil samples from each farm were also collected using a spiral soil auger (H-4250, 40 mm diameter cutting head, 600 mm long with a bayonet connector.) to a depth ranging from 0–40 cm and the average values were imputed into Soil Water Characteristics (SWC) software to estimate the hydraulic conductivity of the soil. The hydraulic conductivity of the soil was between 0.010–0.19 in/hr. The farms were denoted as S_1, S_2, S_3, S_4 … S_{30} with combinations of factors (N, Y, D) Samples of water from shallow wells at a distance of 400 m far away from the farms were used as controls. All the samples were analyzed at the Laboratory of the Department of Chemistry, the University of Ilorin, Ilorin, Nigeria for the following quality: pH, turbidity, phosphate, nitrate, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) using AOAC (1990) standard and Fecal coliform using Most Prob-

Table 1: Experimental design and layout.

$S_{25}(N_{5000}Y_5 D_{250})$	$S_{23}(N_{5000}Y_{15} D_{150})$	$S_{17}(N_{10000}Y_{15} D_{236})$	$S_{11}(N_{10000}Y_7 D_{50})$	$S_9(N_{1000}Y_7 D_{31})$	$S_{27}(N_{1000}Y_5 D_{216})$
$S_8(N_{1000}Y_7 D_{19})$	$S_1(N_{1000}Y_{10} D_{40})$	$S_4(N_{500}Y_5 D_{17})$	$S_7(N_{500}Y_5 D_{32})$	$S_{10}(N_{1000}Y_7 D_{36})$	$S_{22}(N_{500}Y_{15} D_{180})$
$S_{30}(N_{2000}Y_7 D_{120})$	$S_3(N_{500}Y_5 D_{10})$	$S_5(N_{2000}Y_3 D_{11})$	$S_{16}(N_{10000}Y_{15}D_{120})$	$S_{21}(N_{5000}Y_{15} D_{180})$	$S_{29}(N_{2000}Y_5 D_{100})$
$S_2(N_{1000}Y_{10} D_{38})$	$S_6(N_{1000}Y_5 D_{30})$	$S_{12}(N_{500}Y_{15} D_{62})$	$S_{26}(N_{5000}Y_5 D_{216})$	$S_{14}(N_{200}Y_4 D_{30})$	$S_{18}(N_{2000}Y_{15} D_{218})$
$S_{13}(N_{200}Y_3 D_{38})$	$S_{20}(N_{10000}Y_{15} D_{303})$	$S_{15}(N_{5000}Y_{20} D_{360})$	$S_{28}(N_{5000}Y_{10} D_{180})$	$S_{19}(N_{10,000}Y_{15} D_{218})$	$S_{24}(N_{5000}Y_5 D_{250})$

S-farm; N-number of birds per farm; Y-year of the existence of farm; D-distance between dumpsites and shallow wells.

able Number (MPN) technique. The quality levels of these samples were tested and compared with the control sample. The data obtained from the research conducted was subjected to the statistical analysis of variance (ANOVA) and multiple comparisons of means with Duncan's New Multiple Range Test (DNMRT) using Statistical Package for Social Sciences (SPSS) (version 16.0.).

RESULTS AND DISCUSSION

Effect of Number of Birds (N) on Water Quality

Table 2, indicates the analysis of the water sample during the studies indicated no significant changes in pH, DO, nitrate, and phosphate. From the table, it could be seen that the turbidity of water becomes significantly higher with a higher number of birds (2000) but reduces when the number of birds increases to (5000) birds. High turbidity values are a result of poor covering of wells. Mishra et al. (2009) reported that the closeness of dumpsites to where runoff and leaching occur could be the possibility of the presence of suspended particles and other contaminants in water. Higher turbidity levels are a result of disease-causing microorganisms such as bacteria, viruses, parasites (EPA 2020). Comparing the turbidity with the control (0.426 NTU), the water is highly polluted. Kulabako et al. (2007) and Pritchard et al. (2007) concluded that rainfall causes turbidity levels in well to increase due to transportation of colloidal particles into the wells, as high turbidity inhibit treatment. Also, the BOD of the water decreases progressively as the number of birds increases up to 2000 birds and slightly increased. The mean higher value of 8.41 mg.L^{-1} was observed at ≤500 birds. This could be attributed to a large number of wastes produced from the birds which are high in organic content thereby causing pollution. Comparing this with the control of (15.20 mg.L^{-1}), the BOD of the water is not polluted. The COD of the water increased with a higher number of birds but becomes significantly higher with 2000 birds (111. 56 mg.L^{-1}). This could be as a result of a high oxidizable organic pollutant from the birds that enter the water source. Comparing this with the control of 24.62 mg.L^{-1}, the wastes produced by birds have a pollution effect. Fecal coliform was found in water with a lower number of birds 500 or less and 100 birds respectively, 34.4 x 10^{-2} cfu.mL^{-1} with 1000 birds, this could be as a consequence of an increased number of birds. Fecal coliform is important in assessing the suitability of water and higher coliform indicates high contamination probably due to the presence of pathogens (Aderemi et al. 2013).

Effect of Year of Existence (Y) on Water Quality

Table 3 shows that the year of farm existence has a significant effect on turbidity, phosphate, DO, and BOD at $p \leq 0.05$. From the Table, turbidity steadily increases from 5 years to 10 years at 44. 6 NTU and 56.60 NTU respectively, (Nephelometric Turbidity Units) and later decreases as the year of the farm increases. The increase can be possibly due to the effects of run-off water which carries several compounds such as suspended solids (Rahmanian et al. 2015). Turbidity is caused due to the presence of particulate matter in water sources as a result of inadequate filtration (Harter 2003). Phosphate of water of ≤ 5 years increases progressively from 1.53 mg.L^{-1} to 2.29 mg.L^{-1} and decrease from year 15 but is not significantly different from others. Compared with the control of 0.68 mg.L^{-1} it indicated that the water is polluted. This could be as a result of dumping the wastes for a longer period on the sites which then percolates down. According to Adeoye et al. (2012), phosphate can enter groundwater due to the percolation of animal wastes as groundwater contain minimal phosphate due to low solubility and retention of phosphate by soil during percolation. Adewale et al. (2013) also reported that phosphate sources which are anthropo-

Table 2: Effect of the number of birds (N) on water quality.

	Number of Birds per Farm				
Water Quality	≤500	1000	2000	5000	Control
pH	6.721^{a}	6.681^{a}	6.789^{a}	6.731^{a}	6.90
Turbidity (NTU)	23.252^{a}	38.132^{b}	101.924^{c}	39.721^{b}	0.426
Phosphate (mg.L^{-1})	1.632^{a}	1.839^{a}	2.180^{b}	1.411^{a}	0.68
Nitrate (mg.L^{-1})	1.874^{a}	1.942^{a}	2.303^{b}	2.173^{b}	28.42
DO (mg.L^{-1})	28.190^{a}	24.457^{b}	17.668^{b}	24.282^{b}	46.84
BOD (mg.L^{-1})	8.414^{a}	5.969^{b}	3.569^{c}	6.762^{d}	15.20
COD (mg.L^{-1})	92.750^{a}	90.231^{a}	111.556^{b}	85.222^{d}	24.62
Faecal coliform (cfu.mL^{-1})	0.028^{a}	0.344^{b}	0.000^{c}	0.000^{c}	0.001

Means with the same alphabet in the same row are not significantly different from each other.

genic and non-point may also be a source of pollution apart from poultry farm operation. Quan et al. (2011) reported that phosphate in groundwater aid microbial growth. DO of the water increased from 26.01 mg.L^{-1} to 32.21 mg.L^{-1}. The higher value found in year 20 could be due to poor management practices of the farm. DO level indicates how well the water is aerated, as low level affects aquatic life (Singaraja et al. 2012). The lower concentration of (46.84 mg.L^{-1}) compared to the control indicates a level of organic pollution and is linked to bacterial activity, photosynthesis, land availability, and stratification (Vikal 2009). High DO could be ascribed to a high stream aeration flow rate at the time of collection and also due to pollution from poultry wastes (Ayoade et al. 2006). BOD of the water at 5 years or less was significantly higher from Table 4. It can be inferred that BOD increases progressively as the years of poultry increase from 15 years to 20 years respectively ranging between 7.28-8.97 mg.L^{-1}. This can be linked to the fact that the wells were unprotected and that the seasons varied. The percentage of biodegradable soil, organic matter is utilized to assess the organic strength of the water, according to Mocuba (2010). According to Lukubye & Andama (2017), high BOD can be caused by an increase in bacteria, which corresponds to increased microbial activity. Contamination is caused by the proximity of water sources to animal wastes, which easily reach the groundwater (Bello et al. 2013).

Effect of Distance Between Dumpsites and Shallow Wells (D) on Water Quality

Table 4 demonstrates that turbidity, DO, and BOD are all significant at p0.05. The turbidity of the water was lower in locations farther away from the dumpsite than in places closer to the dumpsite. This observation was in agreement with Sangodoyin & Agbawhe (1991) who found that turbidity of water decreases as the distance between the dumpsite and the water source increases and that leachates affect pollutant concentrations in shallow groundwater from a distance of 250 meters. High turbidity between 200 m and 400 m downstream poultry sampling points may be attributed to the dumping of poultry waste (Nduka et al. 2008). DO of the water progressively increases from distance ≤50 m to 200 m at 18.86-34.55 mg.L^{-1}. A higher value of DO was found in surrounding water in areas with higher distances of dumpsite to water sources. The highest value was found at a distance of 200 m. DO generally increases with higher distances of dumping sites from water sources. A somewhat high value of DO, according to Lukubye & Andama (2017), could be attributed to the well's slightly low temperature, which may or may not be related to the presence of photosynthetic activities that can reduce carbon dioxide. The water's BOD increased from 4.89 mg.L^{-1} at ≤500 m to 8.59 mg.L^{-1} at 500 m. The water is less polluted when compared to the control of 15.20 mg.L^{-1}. This is because the wells were protected, as well as seasonal variations. Contamination is caused by the proximity of water sources to animal wastes, which easily reach the groundwater (Bello et al. 2013).

Summary of Considered Factors

Table 5. shows the result of ANOVA of the effect of the number of birds per farm, the year of the existence of the farm, the distance between dumpsites and shallow wells, on the pH, turbidity, phosphate, nitrate, DO, BOD, COD, and fecal coliform of water from shallow wells of poultry farms from Asa and Ilorin South LGAs of Kwara state, Nigeria. From the table, the number of birds per farm, year of the existence of the farm have a significant effect on turbidity, BOD, COD, and fecal coliform. The year of the existence of the farm and the distance between dumpsite and shallow wells all had a significant effect on turbidity, phosphate, DO, and BOD at $p \leq 0.05$. The interpretation of the observation is that those factors that had significant effects on respective water quality should be given proper attention. This could

Table 3: Effect of the year of existence (Y) on water quality.

	Years of operation of the farm				
Water Quality	≤5	10	15	20	Control
pH	6.760^{a}	6.733^{a}	6.649^{a}	6.707^{a}	6.90
Turbidity (NTU)	44.611^{a}	56.601^{b}	32.536^{c}	14.100^{d}	0.43
Phosphate (mg.L^{-1})	1.530^{a}	2.294^{b}	1.516^{a}	1.067^{a}	0.68
Nitrate (mg.L^{-1})	1.835^{a}	2.123^{a}	2.106^{a}	1.330^{a}	28.42
DO (mg.L^{-1})	26.011^{a}	17.388^{b}	30.079^{c}	32.207^{d}	46.84
BOD (mg.L^{-1})	8.130^{a}	4.335^{b}	7.277^{a}	8.977^{c}	15.20
COD (mg.L^{-1})	88.069^{a}	95.433^{a}	93.233^{a}	88.000^{a}	24.62
Faecal coliform (cfu.mL^{-1})	0.042^{a}	0.249^{a}	0.153^{a}	0.000^{a}	0.001

Means with the same alphabet are not significantly different from each other at $p \leq 0.05$

Table 4: Effect of distance between dumpsites and shallow wells (D) on water quality.

	Distance from Source of Water				
Water Quality	≤50m	100m	200m	>200m	Control
pH	6.747[a]	6.746[a]	6.638[a]	6.634[a]	6.90
Turbidity (NTU)	55.209[a]	58.847[a]	21.837[b]	11.808[c]	0.43
Phosphate ($mg.L^{-1}$)	2.062[a]	2.014[a]	1.370[b]	1.091[b]	0.68
Nitrate ($mg.L^{-1}$)	2.087[a]	2.329[a]	2.105[a]	1.559[a]	28.42
DO ($mg.L^{-1}$)	18.864[a]	20.423[a]	34.551[b]	32.706[b]	46.84
BOD ($mg.L^{-1}$)	4.899[a]	5.693[b]	8.078[c]	8.591[c]	15.20
COD ($mg.L^{-1}$)	94.569[a]	95.958[b]	96.125[a]	86.733[a]	24.62
Faecal coliform ($cfu.mL^{-1}$)	0.244[a]	0.000[b]	0.050[b]	0.227[a]	0.001

Means with the same alphabet are not significantly different from each other at $P \leq 0.05$

Table 5: Result of ANOVA of effect of independent variables on water quality.

Water Quality	Number of Birds (N)	Years of Operation of Farm (Y)	Distance between Dumpsite and Water Source (D)	Control
pH	0.200	0.118	0.259	6.90
Turbidity (NTU)	0.000*	0.004*	0.000*	0.43
Phosphate ($mg.L^{-1}$)	0.290	0.011*	0.072	0.68
Nitrate ($mg.L^{-1}$)	0.260	0.241	0.217	28.42
DO ($mg.L^{-1}$)	0.430	0.017*	0.006*	46.84
BOD ($mg.L^{-1}$)	0.030*	0.000*	0.021*	15.20
COD ($mg.L^{-1}$)	0.010*	0.435	0.656	24.62
Faecal coliform ($cfu.mL^{-1}$)	0.000*	0.304	0.58	0.001

*Significant at $P \leq 0.05$

cause positive or negative effects on those water quality. The effect can either be an increase or decrease in the respective values of the aforementioned water quality.

CONCLUSION AND RECOMMENDATIONS

This study revealed the quality of water for poultry management can be affected by the number of birds, years of existence of the farm, the relative distance between the dumpsite of the farm, and the location of the water source. The water from shallow wells located within the farm site was of poor quality and below the recommended standard compared with the control; an indication that it is not fit for consumption. There is an urgent need for improved water resource management for continued suitability and sustainability. Shallow wells should be lined and sited upstream of the poultry dumpsite, water purification procedure is important in poultry farm site and further analysis work for proper testing of the sampled wells should be carried out.

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