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Modelling the Potential of Poultry Farm as a Driver of Atmospheric Pollution in Delta State Using a Geo-statistical Approach

Edjere Oghenekohwiroro*, Mbaoma Oliver Chinonso, Oguori-Okodaso Ejiroghene

Department of Environmental Management and Toxicology, College of Science, Federal University of Petroleum Resources, Effurun, Nigeria

Email address:

Edjere.oghenekohwiroro@fupre.edu.ng (E. Oghenekohwiroro), Mbaoma.oliver@fupre.edu.ng (M. O. Chinonso)

*Corresponding author

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Abstract: Agricultural Livestock production contributes significantly to global emission such as Ammonia (NH_3) which has a resultant effect on climatic conditions with possible secondary impact on environment and human health. There has been an increase in urban poultry farming which raises concern to residents living close to farm buildings due to the risk associated with emissions produced by farm activities. Although the presence of poultry farms in rural and urban settlements on Delta State is very evident, there is no study on the environmental impact of poultry farms. This study was carried in some major towns and villages selected from four local government areas in Delta State. Primary Data were collected using structured questionnaires that were administered to farm staff and residents in the study area with focus on information about socio-economic characteristics of the respondents, level of acceptability of poultry production, farm management experience and waste management practices. Atmospheric concentration of Ammonia and Volatile Organic Compounds were sampled in each location where poultry farm was sited using Aeroqual Series 300 automated gas sensors. Statistical analysis of respondent's feedback suggested that farm management practices were reported to have an effect on how poultry farms impact air quality in the study area. Correlation results revealed that waste management practice significantly influenced the level of impact of poultry farms on air quality. Results from air quality analysis using in-situ data depicted that Ammonia concentration level collected across the poultry farm during investigation were above the acceptable level of 25ppm. Mofor which is highly urbanized with significant human presence and economic activities and has the poultry farm just less than 20m away from residential areas has the highest Ammonia concentration value of 594ppm which is way above accepted level of 25ppm. Also, Okuokoko which is just 20m from residential areas also have a significant level of ammonia concentration of 255ppm. Hazard ratio score which was obtained from computations using concentration of pollutants with distances of poultry farms from residential areas and then used to create continuous surface raster to show area of influence in the study areas using the interpolation method of geostatistics. Mofor, Okuokoko and Abraka which coincidentally are all located in densely populated residential areas had high hazard ratio scores. Ophori 3, Ophori 4 and Ophori 1 all rural areas had medium hazard ratios scores. Ewherhe 1, Aragba 1, Ugono 1, Ophori 2 and Ugono 2 had low hazard scores.

Keywords: Atmospheric Pollution, Poultry Farming, Geostatistics, Hazard Ratio

1. Introduction

1.1. Poultry Farming in Nigeria

Poultry has gradually become an agro-based industry in the world with a very fast growth. This could easily be attributed to an increased population and rising demand for poultry meat and egg product; poultry products being rated to be low in cholesterol content [1]. Apart from the production of poultry meat and egg products, poultry farms also generate employment, however one problem that could be attributed to this industry is the production and accumulation of waste, which could pose health risks and pollution problems if managed in a manner that is unfriendly to the environment. Waste from the poultry subsector of the economy varies from litter from broiler and cockerel production to dead birds from the entire farms and poultry products processing unit waste. In Nigeria, about 932.5 metric tonnes of commercial poultry manure were reported to be annually produced [1].

The poultry industry is currently undergoing rapid expansion and development in Nigeria. This is inextricably linked to rising living standards and dietary changes as earnings and urbanization rise. As the population grows, so will poultry production, necessitating a greater focus on farm management methods, particularly waste generation and its influence on the environment and climate [12].

1.2. Poultry and Environmental Pollution

Generally, agriculture is a major contributor to greenhouse gas emission and livestock production contributes between 15 and 24% of global emission such as nitrogen oxide of (N_2O), ammonia (NH_3), carbon dioxide (CO_2) and methane (CH_4) [11]. These emissions could result in changes in climatic conditions with possible secondary impact on human health, land degradation, increased frequency of wild fires, poverty and malnutrition with attendant policy implication on environmental sustainability, especially in the achievement of the Sustainable Development Goals [9].

Since it has been established that poultry farms activities can bring many pollution problems, it is important to maintain optimal conditions for poultry production with limited impact on the environment through reduction of emissions of harmful gases associated with them. While pursuing profit farmers must use the best practices and technological advances in order to achieve the most advantageous environment [3].

The global climate is changing rapidly and greenhouse emissions has been identified as a major determinant of resultant radiative forcing [20]. The livestock sector which includes poultry farming, contributes 14.5% of global GHG emissions with capabilities of inducing land degradation, air and water pollution and distortion in biological diversity [7].

Ammonia (NH_3), carbon dioxide (CO_2), nitrous oxide (N_2O) methane (CH_4) and VOCs are the major gasses emitted from poultry farm activities. Ammonia is a toxic gas with a direct negative effect on the environment. Methane, on the other hand, is a classic greenhouse gas with a direct negative effect on ambient air quality. Methane is a greenhouse gas that along with carbon dioxide (CO_2) and nitrous oxide (N_2O) causes warming of the atmosphere.

Aside GHG emissions, poultry farms also produce hazardous bioaerosols such as bacteria, fungi, allergic compounds and endotoxins which can have impact on the health of poultry farmers, workers, livestock and settlements at certain proximities from the farm [18]. The high stocking density in most modern poultry farms may lead to reduced air quality with high concentrations of organic and inorganic dust, pathogens and other micro-organism as well as harmful gases such as ammonia, nitrous oxide, Carbondioxide, Hydrogen Sulphide and methane [6]. Commercial poultry farms which usually high densities of animals compared to farm size is a significant source of bioaerosols, an air borne particle consisting of bacteria, fungi spores and endotoxins produced as a result of epithelial desquamation and from feed, manure, feces and other poultry litters [11].

1.3. Urban Poultry Farming and Waste Management

In recent years, there have been an increase in urban poultry farm establishment which raises concern to residents living close to farm buildings, due to the risk associated with emissions produced by farm activities. Reports have it that the level of odor pollution could be quite extreme in cases involving animal house (Poultry Farm) situated in densely populated areas, especially towns and cities (Urban Areas), with a permissible distance of 1500m and above from the nearest resident premises recommended for fitting of a poultry farm [18].

Innovative and sustainable poultry waste management practices such as conversion to feedstock for biogas production and gasification have not gained much traction in Nigeria, owing to a lack of awareness, a lack of strict regulation from regulatory authorities in regard to poultry waste disposal practices, and a careless attitude among farm owners, as well as farmers' perceptions of the costs associated with improper poultry waste disposal [1]. Huge accumulation of chicken excrement around farms, releasing waste materials into the water causes through open canals from farms, even any nearest open space, are still frequent sights in Nigeria [14]. Poor poultry waste disposal practices are not only unsightly but also create a lot of environmental nuisances, as well as, surface and groundwater pollution [1]. Thus, the impact of poultry waste on the ecosystem may result from direct atmosphere or indirect deposition of these constituents into groundwater. Migration from villages to towns and cities has led to growth in the number of urban poultry farms without recourse to corresponding environmental effects.

Researches on the impact of poultry waste and its management has mostly focused on the rural areas in Nigeria with less emphasis on those located in Urban areas that are currently experiencing population explosion. Moreover, the impact of poultry waste on air pollution, especially in densely populated areas have not been given the necessary attention by researchers as well as government regulatory agencies such as the Delta State Waste Management Board.

Hence this study will contribute to overall knowledge of the various consequences of poultry waste management practices to air quality, especially in urban areas. Results from the study will aid the provision of information for organizations, government regulatory agencies and town planning departments, in making adequate decisions and regulations as it relates to poultry waste management, especially in our densely populated urban areas.

Delta State which is a state in the Niger Delta is home to a very important mangrove forest ecosystem has several urban settlements which are densely populated and with a substantial amount of land dedicated to agricultural activities has also been plagued with environmental pollution and degradation due to the activities of petroleum industries making its climate vulnerable [15]. Although the presence of poultry farms in rural and urban settlements on delta state is very evident, findings from literature review reveals the absence of substantial studies on the environmental impact of poultry farming and poultry waste management in Delta State, hence the justification of this research.

1.4. Geostatistics for Atmospheric Pollution Modelling

Advances in computing and data analysis have provided geoscientists with a valuable tool in the form of Geostatistical approaches and processes which helps in characterizing spatiotemporal phenomena helping eliminate problems of scaling data obtained from field observations [5]. Geostatistics have been broadly applied across various fields that deals with analyzing environmental data including atmospheric pollution. The geospatial information system or GIS which is a data-process driven system with the capacity to capture, manipulate, store, retrieve, analyze and present geographically referenced data has been identified as an ideal system for predictive geostatistical modelling quite suitable for atmospheric pollution prediction [17].

2. Materials and Methods

2.1. Study Area

The study was carried in some major towns and villages selected from four local government areas in Delta State where poultry farming is predominantly practiced. The local government areas chosen could be consider either densely or moderately populated. Ophori, ewhere and Aragba all in Ughelli south LGA, Abraka, Ugono in ethiope East LGA, Okuokoko in Okpe LGA and Mofor in Udu local Government. The spatial distribution of the choices of study area was to give the research a broad coverage across Delta State.

2.2. Sampling Technique

The cross-sectional quantitative research method for data collection was chosen for this study as it is inexpensive, not time consuming and provides room to compare the differences between data from a large pool. The research strives to ensure data integrity with result reaching 95% confidence level with an alpha level of 0.5.

2.3. Sample Size Determination

When a sample size cannot be deduced due to unavailability of population size data, the sample size can be calculated using Cochran's formula for determining sample size for an infinite population [4]. The size of the sample was determined using Cochran's formula for determining sample size for an infinite population. Thus;

$$n = \frac{z^2}{4e^2} \tag{1}$$

Where, n is the size of the sample, z is the selected critical value of desired confidence level, P is the estimated proportion of the population. e represents the desired level of precision. Z is the value of reliability level found in statistical tables which contain the area under the normal curve. A 95% confidence level and ±5% precision was adopted, hence,

$$n = \frac{1.96^2}{4(0.05)^2} = 384.16$$

The result after calculating using the infinite population of the street food vendors at 95% confidence level and ±5% precision was 385 respondents. Hence the selected study sample was 385 to be representative in order to draw justifiable interpretations and to make provision for non-responses. However due to several challenges, only 114 questionnaires were retrieved.

2.4. Sampling

Primary Data were collected using structured questionnaires that was administered to farm staff and residents in the study area. A total of one hundred and thirty questionnaires were administered in total across the study area which cuts across urban and sub-urban and rural areas in Delta State. Questionnaires were administered to residents within close proximity from the poultry farms under observation. The questionnaire focused on obtaining information about socio-economic characteristics of the respondents, level of acceptability of poultry production, farm management experience and practices, and waste management practices. Also, atmospheric concentration of Ammonia and Volatile Organic Compounds were sampled in each location where poultry farm was sited using Aeroqual's series 300 automated in situ gas sensors.

2.5. Data Analysis

Microsoft Excel was used to compute collected data which was further analyzed using inferential and descriptive statistical functions in the Statistical Package for Social Science (SPSS) analytical tool. The questionnaires were filed in order to ease verification. To facilitate the analysis of the result, the observational data were coded and grouped. The grouped data was analyzed using frequency tables and graphs. The likert scale was used for rank designation which ranged from one to five.

The demographic characteristics of the respondents were analyzed by the use of frequency distribution table. Raw data collected on farm management practices, waste management practices and impact of poultry on air quality were computed on frequency tables and their aggregated mean taken. Correlation analysis was done to check for significant relationships between the three aggregated variables, with a p-value of <0.05 accepted to be statistically significant.

Hazard levels of each residential areas were calculated by obtaining the ratio between distance of residential areas from each farm and the corresponding level of ammonia gas detected in the farm. This ratio was converted into decimal and used to produce a continuous surface using ArcGIS software and a technique called interpolation.

3. Results

3.1. Demographic Characteristics of Respondents

Table 1. *Sex.*

		Frequency	Percent
Valid	Male	99	86.8
	Female	15	13.2
	Total	114	100.0

Table 1 shows the sex of respondent. 99 of them were males while 15 were females.

Table 2. *Age.*

		Frequency	Percent
Valid	Less than 18	20	17.5
	19 to 39	67	58.8
	40-59	19	16.7
	60 and above	8	7.0
	Total	114	100.0

Table 2 shows the age distribution of respondents. 20 were less than 18 years. 67 respondents were between 19 to 39 years. 19 respondents were between 40-59 years, while 8 respondents were above 60 years.

Table 3. *Education.*

		Frequency	Percent
Valid	Primary	24	21.1
	Secondary	81	71.1
	Tertiary	9	7.9
	Total	114	100.0

Table 3 shows the educational level of respondents. 24 of them only attended primary school. 81 respondents attended secondary school. Only 9 respondents had tertiary education training.

Table 4. *Years of Experience.*

		Frequency	Percent
Valid	1-5	53	46.5
	6-10	16	14.0
	11-15	11	9.6
	16-20	14	12.3
	over 20	20	17.5
	Total	114	100.0

Table 4 shows the years of experience of respondents. 53 respondents had between 1-5years of experience, 16 of them had between 6-10years of experience, 11 respondents had between 11 to 15 years of experience, 14 had between 16 to 20 years of experience and 20 had over 20years experience in poultry farming.

Table 5. *Registration of Farm with government Agencies.*

		Frequency	Percent
Valid	Not important	53	46.5
	Less important	11	9.6
	Neutral	23	20.2
	Somewhat important	14	12.3
	Very important	13	11.4
	Total	114	100.0

Table 5 shows respondent's perception about registration of farm with government agencies. 53 of the respondents saw this as not important, 11 saw this as less important, 23 were neutral in their answer, 14 saw this as somewhat important while 13 of respondents saw it as very important.

Table 6. *Production Type.*

		Frequency	Percent
Valid	Free range	38	33.3
	Combined	3	2.6
	Deep litter	60	52.6
	Battery cage	6	5.3
	Integrated farm	7	6.1
	Total	114	100.0

Table 6 shows the production type and system used in the various farms visited. As shown below, 38 respondents noted that they used free range system, 3 noted that they used combined system, 60 noted that they used deep litter system, 6 noted that they used battery cage system while 7 farms noted that they used an integrated farm system.

Table 7. *Age.*

		Frequency	Percent
Valid	Flushing	63	55.3
	Burning	8	7.0
	Composting	26	22.8
	PSP	6	5.3
	used as organic material	11	9.6
	Total	114	100.0

Table 7 shows the respondents' perception on waste disposal practices obtainable in their poultry farms. 63 choose flushing as their preferred method, 8 respondents choose burning as their preferred method. 26 respondents choose composting as their preferred method. 6 respondents choose PSP as their preferred method and 11 respondents choose PSP as their preferred method of waste disposal.

Table 8. *Dead bird Management.*

		Frequency	Percent
Valid	Sell	8	7.0
	Bury	53	46.5
	Burn	33	28.9
	PSP	19	16.7
	Re-feed	1	.9
	Total	114	100.0

Table 8 depicts respondents' preferred method of handling dead birds in their respective poultry farms. 8 respondents noted they preferred to sell off dead birds, 53 respondents opined they preferred to bury dead birds, 33 of them noted they preferred to burn dead birds, 19 preferred to dispose dead birds using PSP services while only 1 respondent noted they preferred to process dead birds to produce food for refeeding poultry animals.

Table 9. *Waste Evacuation frequency.*

		Frequency	Percent
Valid	Monthly	30	26.3
	Bi-monthly	15	13.2
	Bi-weekly	51	44.7
	Weekly	12	10.5
	Daily	6	5.3
	Total	114	100.0

Table 9 depicts the respondents' report on waste clearance and evacuation frequency in their farms. 30 respondents reported that waste was evacuated monthly, 15 reported that waste was evacuated bi-monthly, 51 reported that waste was evacuated bi-weekly, 12 reported that waste was evacuated weekly, while 6 reported that waste was evacuated daily.

Table 10. *Waste Odor During the day.*

		Frequency	Percent
Valid	Very Extreme	28	24.6
	Extreme	18	15.8
	Harsh	52	45.6
	Slightly harsh	11	9.6
	Mild	5	4.4
	Total	114	100.0

Table 10 shows the respondents' report on waste odour during the day. 28 respondents reported that the odour was very extreme, 18 reported that the odour was extreme, 52 reported that the odour was harsh. 11 reported that the odour was slightly harsh while 5 reported that the odour was mild.

Table 11. *Waste Odor at Night.*

		Frequency	Percent
Valid	Very Extreme	65	57.0
	Extreme	7	6.1
	Harsh	28	24.6
	Slightly harsh	4	3.5
	Mild	10	8.8
	Total	114	100.0

Table 11 displays the respondents' report on waste odour at night. 65 respondents reported that the odour was very extreme, 7 respondents reported that the odour was extreme, 28 reported that the odour was harsh. 4 reported that the odour was slightly harsh while 10 reported that the odour was mild.

Table 12. *Report on respiratory symptoms.*

		Frequency	Percent
Valid	Very frequent	37	32.5
	Frequent	5	4.4
	Few	60	52.6
	Rare	3	2.6
	None	9	7.9
	Total	114	100.0

Table 12 displays the respondents' report on respiratory diseases in their respective poultry farms. 37 reported diseases symptoms as very frequent. 5 reported diseases symptoms as frequent. 60 reported few respiratory diseases symptoms. 3 reported diseases symptoms as rare. 9 reported no disease symptoms.

3.2. Correlation Analysis Results

Correlation coefficient is defined in statistics as the measurement of the strength of the relationship between two variables and their association with each other. It is a bivariate analysis that calculates the effect of change in one variable when the other variable changes and varies between +1 and -1, where +1 is a perfect positive correlation, and -1 is a perfect negative correlation. 0 means there is no linear correlation at all.

For this research, Spearman's rank and Pearson's correlation were used respectively depending on the nature of the data analyzed. Before data was recomputed to find the mean aggregate of the variables under consideration, data was ranked as obtained in the questionnaire and spearman's rank which is a non-parametric test was used for correlation analysis. After re-computation and mean aggregation of the questionnaire data, Pearsons correlation which is a parametric test analysis was used for correlation analysis.

3.2.1. Pearson's Parametric Correlation Results

Pearson's Parametric correlation analysis which was done after aggregation of several variables combined was done to test for significant relationship between farm management practices, waste management practices and impact of poultry on air quality.

Table 13. *Parametric Correlations.*

		A	B	C
A	Impact on air quality	1	.446**	.724**
B	Farm Management Practices	.446**	1	.377**
C	Waste management practices	.724**	.377**	1

**. Correlation is significant at the 0.01 level (2-tailed).

From the table above, it can be deduced that correlation between impact of poultry on air quality with farm management practices is 0.446 which indicates a good correlation level. Also, impact of poultry on air quality and waste management practices has a correlation value of 0.724 which indicates a strong correlation. Farm management practices and waste management practices has a correlation value of 0.377 with a good relationship. All the correlated variables have significance level of 0.00 which is less than the set P value of 0.05.

3.2.2. Spearman's Rank Non-parametric Correlation Results

The variables tested comprises of feedback from questions No. 5, 8 and 11 which represented farm management practices, questions No. 14, 18, 19 and 20 which represents waste management practices and questions No. 22, 23, 24 and 25 which represents impact of poultry on air quality. Non-Parametric correlation analysis was done between these variables labelled A to J to test for significance in relationship.

Table 14. *Non-Parametric Correlations.*

	A	B	C	D	E	F	G	H	I	J
A	1.000	-.118	.042	.103	.122	.165	.040	.060	.127	.171
B	-.118	1.000	.120	.142	-.151	-.085	.066	.163	.051	.064
C	.042	.120	1.000	.705**	.149	.330**	.318**	.505**	.545**	.482**
D	.103	.142	.705**	1.000	.173	.505**	.401**	.745**	.707**	.721**
E	.122	-.151	.149	.173	1.000	.281**	.048	.165	-.072	.119
F	.165	-.085	.330**	.505**	.281**	1.000	.278**	.359**	.275**	.377**
G	.040	.066	.318**	.401**	.048	.278**	1.000	.306**	.269**	.293**
H	.060	.163	.505**	.745**	.165	.359**	.306**	1.000	.534**	.501**
I	.127	.051	.545**	.707**	-.072	.275**	.269**	.534**	1.000	.542**
J	.171	.064	.482**	.721**	.119	.377**	.293**	.501**	.542**	1.000

**. Correlation is significant at the 0.01 level (2-tailed).
Work experience on farm
Importance of registration
Production type
Waste disposal practices
Dead bird management system
Waste clearance / evacuation frequency
Waste odour during the day
Waste odour at night
Report of respiratory diseases
Complaint about air pollution.

3.3. Test of Hypothesis

Two hypotheses were developed and tested for this research. Each hypothesis was tested using the analysis of variance (ANOVA) which shows the degree of relationship between two or more variables. The variable table, model summary, ANOVA result and coefficient of regression were obtained.

3.3.1. Test of Hypothesis One

The hypotheses tested are as follows;

H_0 Farm management practices does not affect how poultry impacts on air quality.

H_1 Farm management practices does affects how poultry impacts on air quality.

As shown on Table 15, the linear regression yielded a coefficient of R= 0.446, R^2= 0.199, and 0.84509 which is the standard error of the estimate. This means that Farm management practices has a 44.6% relationship with impact of poultry on air quality in the study area. The calculated F-value was 27.7, with a significant value of 0.00 ($P<0.05$) which is lower than the chosen alpha value of 0.05, Hence the null hypothesis (H_0) is rejected and the alternate hypothesis (H_1) accepted. This indicated that the respondents' opined that farm management practices affect how poultry farms affect air quality in their study area.

Table 15. *Linear Regression Result for Hypothesis 1.*

Model Summary				
Model	**R**	**R Square**	**Adjusted R**	**Std. Error**
1	.446a	.199	.192	.84509

ANOVA[a]						
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
	Regression	19.833	1	19.833	27.771	.000b
1	Residual	79.987	112	.714		
	Total	99.820	113			

a. Dependent Variable: Poultry impact on air quality
b. Predictors: (Constant), Farm Management Practices

3.3.2. Test of Hypothesis Two

The second hypothesis tested are as follows;

H_0 Waste management practices does not affect how poultry farms impacts on air quality

H_1 Waste management practices does affects how poultry impacts on air quality

As shown on Table 16, the linear regression yielded a coefficient of R= 0.724, R^2= 0.524, and 0.65117 which is the standard error of the estimate. This means that waste management practices have a 0.726% relationship with impact of poultry on air quality in the study area. The calculated F-value was 123.4, with a significant value of 0.00 ($P<0.05$) which is lower than the chosen alpha value of 0.05, Hence the null hypothesis (H_0) is rejected and the alternate hypothesis (H_1) accepted. This indicated that the respondents' opined that waste management practices of poultry farms affects air quality in their study area.

Table 16. Linear Regression Result for Hypothesis 2.

Model Summary				
Model	R	R Square	Adjusted R	Std. Error
1	.724a	.524	.520	.65117

b. Predictors: (Constant), Waste Management Practices.

ANOVAa						
Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	52.329	1	52.329	123.410	.000b
1	Residual	47.491	112	.424		
	Total	99.820	113			

a. Dependent Variable: Poultry impact on air quality
b. Predictors: (Constant), Waste Management Practices.

3.4. Air Sampling Results

For this research, after the field campaign, ammonia was identified as the most prominent atmospheric contaminant in the study areas. The values for ammonia as collected from the field are shown below in the graph on Figure 1 below.

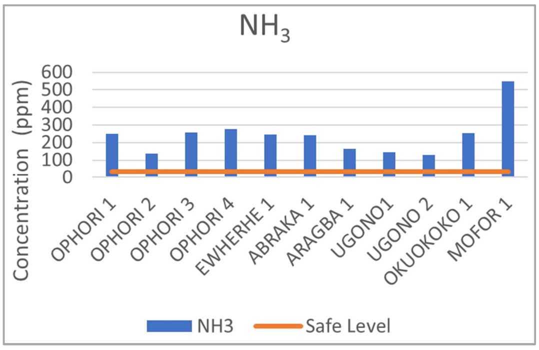

Figure 1. *Ammonia level for each location.*

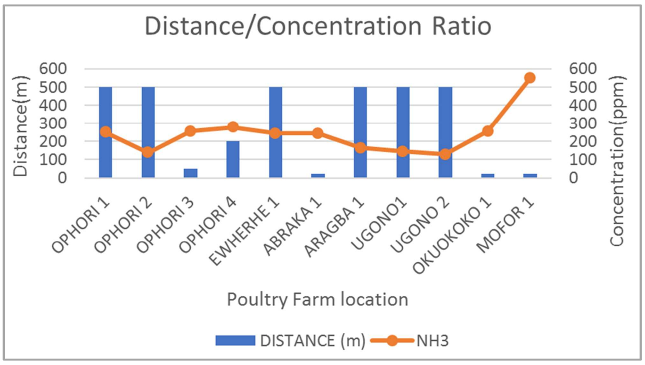

Figure 2. *Distance against Concentration of Ammonia Graph.*

4. Discussion

4.1. Significance Test Between Variables

Results from the parametric correlation analysis from our study shows a correlation between *impact of poultry on air quality and farm management practices with* a value 0.446 which indicates a good correlation level. Also, *impact of poultry on air quality and waste management practices* showed a correlation of 0.724 which indicates a strong correlation. Farm management practices and waste management practices has a correlation value of 0.377 with a good relationship. All the correlated variables have significance level of 0.00 which is less than the set p value of 0.05. This simply implies that farm management practices were reported to have an effect on how poultry farms impact air quality in the study area. Also, the second correlation implies that waste management practices have a strong influence on how poultry farms impact on air quality.

4.2. Hypothesis Test

For the first hypothesis, the regression analysis indicated that Farm management practices has a 44.6% relationship with impact of poultry on air quality in the study area. The calculated F-value was 27.7, with a significant value of 0.00 ($P<0.05$) which is lower than the chosen alpha value of 0.05, Hence the null hypothesis (H0) is rejected and the alternate hypothesis (H1) accepted. This indicated that the respondents' opined that farm management practices affects how poultry farms affect air quality in their study area.

The second hypothesis test results indicated that waste management practices have a 72.6% relationship with impact of poultry on air quality in the study area. The calculated F-value was 123.4, with a significant value of 0.00 ($P<0.05$) which is lower than the chosen alpha value of 0.05, Hence the null hypothesis (H0) is rejected and the alternate hypothesis (H1) accepted. This indicated that the respondents' opined that waste management practices of poultry farms affects air quality in their study area.

4.3. Impact of Poultry Farm on Air Quality

The impact of poultry farm on air quality investigated in this research has been studied previously by several scholars but in different directions. A study conducted by Alabi et al. [2] to investigate the environmental hazards associated with poultry production among poultry farmers in a state from the Niger Delta, Edo State, a total of 366 respondents made up of 122 poultry owners, 122 poultry farm workers and 122 poultry farm neighbors were randomly selected. Multiple regression and chi-square tests were the statistical tools used for the analyses. The results of the study revealed that only 12.3% of the farms were located at least 500 meters away from living houses as recommended by Environmental Protection Agency. The major complaint about poultry farms by neighbors (74.6%) were bad odor with majority of the farmers (55.7%) and workers (51.6%) adopting the use of covering of nose for protection from bad odor. The regression analysis indicated that age of the complainant had negative and significant relationship with frequency of environmental hazard complaint. The study was fair enough but neglected farm management practices of poultry farms and how they affect mode of waste management.

Previous studies have been carried out to evaluate waste disposal methods and farm location acceptability in neighborhoods where they are located, neglecting farm management level and the perceived impact of poultry related activities to air, water and soil contamination. A study was conducted by to evaluate the environmental effect of poultry farms located among residents of some metropolitan town of Nigeria, with study areas selected from three agro-ecological zones which are Sabon Gari Local Government of Kaduna State, Jos South Local Government of Plateau State and Ibadan Municipal Local Government of Oyo due to the high level of poultry farm concentration [10]. Pearson correlation was used to establish the relationships between mode of waste disposal and neighbors' acceptability of poultry farm location in their neighborhood. A large percentage (74.1%) of the residents found the activities of poultry production in their neighborhood very repulsive. Air (64.4%), Noise (31.1%) and water (4.4%) pollution were indicated by the neighbors as the major problems encountered. Adoption of technologies that can keep poultry litters dry and odorless was low (24.4%) among poultry farmers.

Distance from poultry farms is another important determinant on people's perception of poultry farms on air quality. Another study was carried out by [13] to investigate the perception of commercial poultry farm neighbors on environmental issues associated with commercial poultry farming in Kogi and Kwara states, Nigeria. A total of 500 respondents were purposively selected for the study. Primary data was collected with the use of structured questionnaire. Both descriptive and inferential statistics were employed for the study. Results of analysis revealed that 95% of the respondents opined that poultry farm was a source of atmospheric pollution. Commercial poultry farms' neighbors perceived knowledge on environmental issues was also high (mean=4.01 on a 5 scale). Level of complaints on environmental pollution among poultry farms' neighbors was high (54.6%) and environmental effects of commercial poultry farming activities on neighbors was also high (mean=3.02 on a 5 scale). The Multiple regression results revealed that neighbors' years in residence and distance between neighbor and farm were significantly related to perceived knowledge of commercial poultry farms' neighbors on environmental issues and they noted that distance of residents from farms was a key determinant for air quality in the study area.

Ammonia (NH_3) has been identified as a greenhouse gas which can influence climate and air quality, trigger acidification and eutrophication in terrestrial and aquatic ecosystems. Agricultural activities are the main sources of NH_3 emissions globally. The effects of meteorological factors in atmospheric pollution dynamics and attempt to quantify how climate change affects these emissions was investigated through a process-based model known as Ammonia–CLIMate model [7]. It was developed to simulate and predict temporal variations in NH_3 emissions from poultry excretion focusing on chicken farms and manure spreading. The model simulates the decomposition of uric acid to form total ammoniacal nitrogen, which then partitions into gaseous NH_3 that is released to the atmosphere at an hourly to daily resolution. NH_3 calculated using the model is found to be up to 3 times larger in humid tropical locations than in cold or dry locations.

According to Animal Husbandry department in India, a farm is expected be set up 500 meters away from a residential area, 100 meters from rivers, lakes, canals and drinking water sources, 100 meters from national highways and 10-15 meters from village footpaths and rural roads. Since there is no standard safe distance policy for Nigeria, the Indian standard was adopted. For this research, distances from residential areas were noted. Ammonia gas present in the atmosphere around poultry produced as a result of poultry litter decomposition and formation of Uric acid by bacteria present in it can be dangerous to human and even poultry birds when they are above safe levels of 25ppm over an eight hour per day period [19].

Table 17. *Air sample location with distance from residential areas.*

Location	Settlement Type	Distance (m)	VOC	NH_3
OPHORI 1	RURAL	500	270	250
OPHORI 2	RURAL	500	327	139
OPHORI 3	RURAL	50	295	256
OPHORI 4	RURAL	200	187	278
EWHERHE 1	URBAN	500	217	245
ABRAKA 1	URBAN	20	242	244
ARAGBA 1	RURAL	500	205	164
UGONO 1	RURAL	500	189	144
UGONO 2	RURAL	500	139	129
OKUOKOKO	URBAN	20	205	255
MOFOR 1	URBAN	20	618	549

From in-situ measurement of NH_3 level collected using automatic gas detection meter, Ophori 1 which is a rural settlement with a distance of over 500m from residential has a concentration level of 250ppm. Ophori 2 which is over 500m from residential areas have a concentration level of 139ppm. Ophori 3 which is just less than 50m from residential areas have a concentration level of 256ppm. Ophori 4 which is just less than 200m from residential areas have a concentration level of 278ppm. Ewherhe 1 which is just more than 500m from residential areas have a concentration level of 245ppm. Abraka which is an urban settlement and is less than 20meters from residential areas have a concentration level of 244ppm. Aragba, a rural settlement which is over 1000ft from residential areas have a concentration level of 256ppm. Ugono 1, a rural settlement which is 500m from residential areas have a concentration level of 144ppm. Ugono 2 a rural settlement which is over 500m from residential area have a concentration level of 129ppm. Okuokokoko which is just less than 20m from residential areas have a concentration level of 255ppm while Mofor, an urban area which is just less than 20m from residential areas have a concentration level of 594ppm.

Although all air contaminant concentration collected across the poultry farm during investigation were way above the acceptable level of 35ppm, Mofor which is highly urbanized with significant human presence and economic activities and has the poultry farm just less than 20m away from residential areas has the highest ammonia concentration value of 594ppm which is way above accepted level of 35ppm. Also, Okuokoko which is just 20m from residential areas also have a significant level of ammonia concentration of 255ppm.

4.4. Hazard Ratio

The hazard ratio which is the likelihood of residents being at risk of ammonia contamination was obtained by calculating the value of concentration against the distance of each poultry farm from residential areas. This indicator was important to obtain the rate at which residential areas are perceived to be at risk of a which poultry farms pose the highest risk empirically. This ratio was also used to perform spatial analysis using Interpolation to show the areas of influence of ammonia concentration in the various study areas.

Table 18. *Air sample location with Computed Hazard ratio score.*

Location	Distance (m)	NH_3	Ratio Score
OPHORI 1	500	250	0.5
OPHORI 2	500	139	0.278
OPHORI 3	50	256	5.12
OPHORI 4	200	278	1.39
EWHERHE 1	500	245	0.49
ABRAKA 1	20	244	12.2
ARAGBA 1	500	164	0.328
UGONO 1	500	144	0.288
UGONO 2	500	129	0.258
OKUOKOKO 1	20	255	12.75
MOFOR 1	20	549	27.45

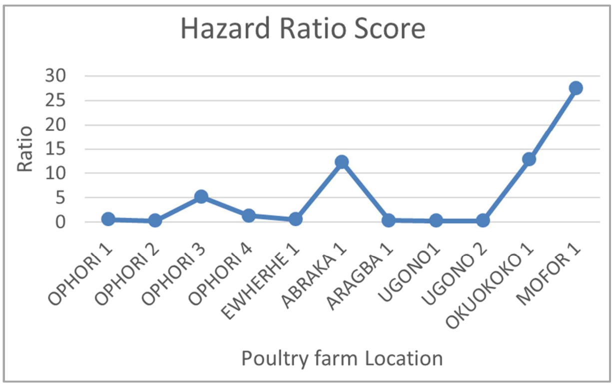

Figure 3. *Graph of Hazard Ratio Score.*

From the graph, Mofor, Okuokoko and Abraka which coincidentally are all located in densely populated residential areas all have hazard ratio scores of 27.45, 12.75 and 12.2 respectively and are classified as high. Ophori 3, Ophori 4 and Ophori 1 all rural areas with hazard ratios of 5.12, 1.39 and 0.5 are classified as medium. Ewherhe 1, Aragba 1, Ugono 1, Ophori 2 and Ugono 2, which all have scores of 0.49, 0.32, 0.288, 0.27 and 0.25 are seen as areas at low risk and poultry farms constitute low hazards.

4.5. Geostatistics and Spatial Analysis

Geo-statistics is a point-pattern analysis that produces field predictions from data points. Interpolation which is a type of geospatial statistics Interpolation is a geostatistical process by which a surface is created, and is used to predict unknown values for any geographic point data: elevation, rainfall, chemical concentrations, noise levels, and so on. Inverse distance weighting (IDW), a very popular approach to spatial analysis due to its simplistic nature uses values of known points to predict values of unknown locations with regards to proximity and other relationships as defined by the user making it an ideal approach to predictive modelling of pollutants concentration, height, depth etc. [16].

For this project, decimals of hazard ratio score obtained from computations using concentration of pollutants with distances of poultry farms from residential areas are used to create continuous surface raster to show area of influence in the study areas. IDW was used to predict values of unsampled location using data from hazard ratio computations to train the model applied in a GIS environment, which is one of the many machine learning capabilities of a GI System.

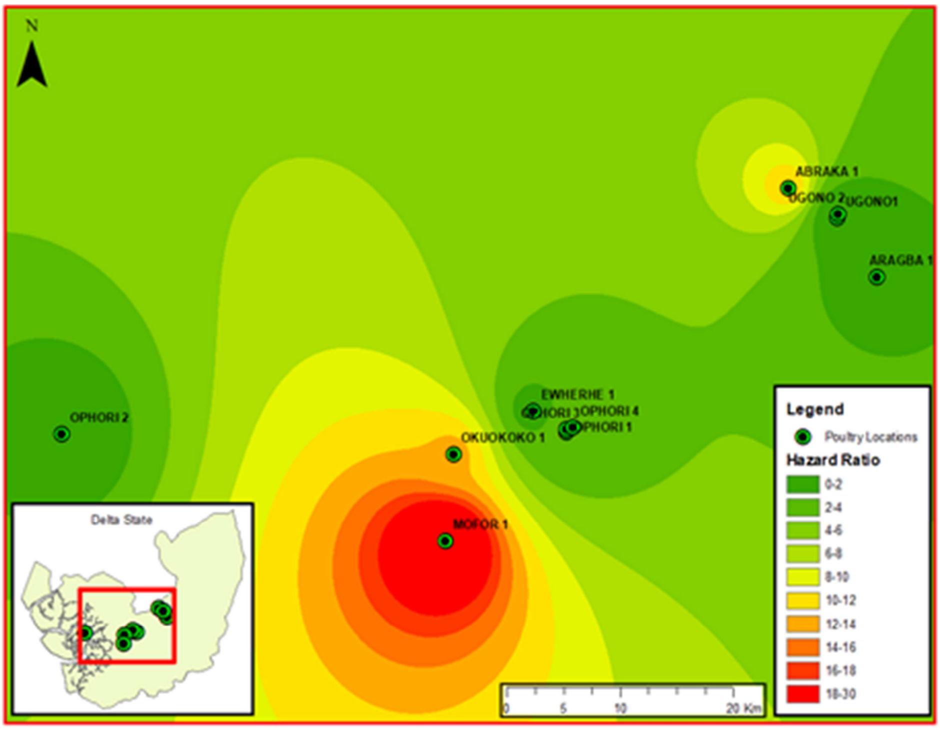

Figure 4. *Interpolated Surfaces of Locations under Air Pollution Threat.*

5. Conclusion

With the significant expansion of small and medium scale poultry farms in our study area, mismanagement of waste could be catastrophic with the potentials of triggering atmospheric, soil and water pollution.

Modern methods for poultry waste management have not gained much popularity in Nigeria, probably due to level of awareness as seen from our study also. Lags in regulation enforcements from regulatory authorities in respect of poultry waste disposal and care-free attitude of the farm owners, as well as, the perception of farmers concerning the damages associated with improper poultry waste disposal practice have also discouraged progress in poultry waste management. Finally, the continuous increase in population and migration from villages to towns and cities has led to a new common site of poultry built in populated area in our towns and cities without recourse to the antecedent environmental effects, hence the importance of this study.

From our result, it was deduced that impact of poultry farms on air quality has significant correlations with farm management practices, and waste management. It was also evident that all the areas had ammonia gas concentration levels way higher than the acceptable safe level of 35ppm. Also Hazard levels which was a ratio of distance of each poultry farm from residential areas showed that all the farms in urban areas constitute serious hazards, while some in the rural areas constitute medium and low hazard respectively.

6. Recommendations

From our results and observations, the following recommendations were made.

a) Government is advised to take up responsibilities of monitoring and enforcing policies regulating poultry industries and their practices.
b) Air contaminant levels should be monitored periodically to ensure safe levels are not exceeded and appropriate measures should be taken when necessary.
c) Poultry farmers should be educated on innovative waste management methods, decongest farms, evacuate and treat bird litters appropriately to reduce ammonia production drastically.
d) All farms located in the urban areas which pose serious environmental and health concern should be relocated to rural areas distant away from residential areas, water bodies and major roads.
e) Waste management and waste evacuation practices should be monitored closely by government agencies to ensure PSP and other waste evacuation stakeholders are efficient.
f) Regulatory and enforcement agencies obligated to monitor unsafe farm practices in poultries should be equipped and funded to ensure they deliver in their duties.

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