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# Aero-microbiology of Selected Poultry Farms in Imo State, South Eastern, Nigeria

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***Authors' contributions***

*This work was carried out in collaboration among all authors. Author JEE designed the study, carried out the field and the laboratory analyses of the study with the help of author VON. Authors JCO and JEE performed the statistical analysis, wrote and proof-read the manuscript. Authors NCN, CNO, IN & DMS managed the literature searches and wrote the protocols. All authors read and approved the final manuscript.*

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## ABSTRACT

The aero-microbiology of selected poultry farms in Imo State, South Eastern Nigeria was investigated by microbial analysis. Result revealed that in Owerri poultry farm, $Pm_{2.5}$ had a range of 8-36±1.4 ug/$m^3$, $PM_{10}$ had a range of 19-55±1.4ug/$m^3$, a temperature range of 34.1-37.8±4.2$^oC$ and a relative humidity of 63.3-81.6±0.0%, while poultry farm at Okigwe had $Pm_{2.5}$ range of 8±1.4-21±1.4ug/$m^3$, $PM_{10}$ had a range of 20±1.4- 88±2.8ug/$m^3$, a temperature range of 28.6±1.2-38.1±0.0$^o$c, and a relative humidity of 63.4±0.0-87.0±1.4%. Total heterotrophic bacterial count (THBC), total coliform count (TCC), Total *Staphylococal* count(TSC) and total fungi count (TFC)

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examined showed that THBC group had the highest counts with a range of 1.2-20.8cfu/plate/mins along the distances at 15minutes, 2.7-21.4cfu/plate/mins at 30minutes and 3.5-21.8cfu/plate/mins at 45minutes. While in Okigwe, THBC which was also the highest had a range of 09-22.5 along the distances at 15minutes, 1.2-24.8cfu/plate/mins at 30minutes and 1.0-4.0cfu/plate/mins at 45 minutes. Bacteria isolated were *Staphylococcus aureus, Escherichia coli, Proteus* and *Streptococcus* species while the fungi isolated were *Aspergillus, Penicillium, Fusarium Mucor* and *Rhizopus* Species. Temperature, particulate matter and microbial counts were highest during the dry season, while relative humidity was highest during the rainy season respectively. It was observed that as time increased along the distances examined, microbial load also increased. The aero-microbiology of the farms studied showed that the air contained presence of bacteria and fungi of medical importance in both seasons, hence, there is the need to always ensure proper management and evaluation of poultry farms to avoid micro-organisms from exceeding their permissive limits.

*Keywords: Aero-microbiology; poultry farms; Owerri; Okigwe; Nigeria.*

## 1. INTRODUCTION

Aero-microbiology is the study of living biomaterials which are suspended in the air, these living biomaterials are referred to as bioerosols [1]. When the numbers of organisms are compared to that of the soil and water, one can say that there is less in the air even though there is still so much that could affect the atmosphere [2]. Since we all breathe air, the microbial population in air is in constant interaction with human and animal life, both directly as a source of pathogenic and beneficial microbes [3] and indirectly through biological effects on atmospheric processes [4]. Once suspended in the air column, these microbes have the opportunity to travel long distances with the help of wind and precipitation increasing the occurrence of diseases by these microbes. Typically, microbes will be suspended in clouds where they are able to perform processes that alter the chemical composition of the cloud and might induce precipitation [2]. The quality of air is usually determined by measuring the concentration of pollutants in the air. When the pollution of the air concentration is low, the air quality is better [5]. Confined feeding operations can affect air quality through the emission of gases (ammonia and $H_2S$), particulate matter, volatile organic compounds and particulate matter. The emissions from these confined feeding operation (CFO) come basically from three main sources which are manure storage facilities, animal housing and land application of manure [5]. Before the impact of these emissions can be felt, some factors such as temperature, ventilation type and rates, relative humidity, wind speed and direction, type of building, number of animals and animal characteristics (species and size) must be evaluated. Therefore, the effective reduction of overall emissions of pollutants must involve several control strategies and not just one. Good air qualities in animal farms are of uttermost importance since it could impact effectively on the health of not just the animals but farmers (humans). Maintaining good air quality does not just increase productivity of the farm animals, but also improves animal welfare. More so, it is a concern to the producers and people living close to these facilities. The major factor that has greatly contributed to air quality in livestock is the weather, others could be the livestock facilities and its management [6]. Weather constitutes the atmosphere that acts as an agent of transportation in pollutant dispersal between source and destination (receptors). Air quality gets worse during the light wind conditions, which are times when these pollutants cannot be blown away. Livestock facilities come to play since building hygiene is one of the most important factors affecting air quality and livestock. The adoption of more strategic management system is important for air and hygiene improvement in both new and existing livestock buildings [7,8]. The objective of this study was to determine the aeromicrobiology of selected poultry farms in Imo state, South Eastern, Nigeria.

## 2. MATERIALS AND METHOD

### 2.1 Sampling

The largest poultry farm in Okigwe having 2500 birds and one large farm in Owerri having 1700 birds was used for this study, they were both above 10years in operation. The Okigwe farm was located away from residential buildings but the Owerri farm was located in proximity to residential buildings. The farms were visited in the two seasons experienced in Nigeria, rainy (May - July) and dry (October - December)

seasons. Samples were collected twice a month during the periods of high activity on the farms, (mornings and evenings).

### 2.2 Collection of Air Samples for Bacteria and Fungi

Air sampling were conducted using a hand held device ( particle colony counter ). This device was turned on and allowed for 1minute to set, then the parameters to be tested were then displayed on the screen. It was held up at the nose level and set to run for 60 seconds. Parameters sampled were temperature, relative humidity and particulate matter ($PM_{2.5}$ & $_{10}$). Air samples for microbial analyses were collected using settle plate technique as described by [9]. Each medium was prepared in triplicates per distance and time. The freshly prepared sterile glass plates (55mm) of nutrient (NA; OXOID), MacConkey(MA; OXOID), Blood Agar (BA; OXOID) Manitol Salt Agar (MSA; OXOID), Eosin-Methylene Blue Agar (EMB; OXOID) and Sabouraud Dextrose Agar (SDA; OXOID) were exposed for 15minutes, 30mins and 45mins respectively, at varying distances of 0m, 100m, 300m and 500m respectively from the edge of the farm. Thereafter, NA ,BA, MSA and MA were incubated at $37^0$C for 18 - 24hours, EMB was incubated at $35^0$C for 24 hours while SDA was incubated at $25^0$C for 5 days aerobically.

### 2.3 Colony Count

This was done using a colony counter and recorded as cfu/plate/mins as described by [9]. Total heterotrophic count was read on NA, total coliform count was read on MA, total staphylococccal count was read on MSA, After 18 hours while Total fungi count was read on SDA after 72 hours and results recorded accordingly.

### 2.4 Characterisation and Identifiation of Isolates

Resulting colonies were characterized and representative colonies were selected and purified by successive sub-culturing. Identification of bacteria was done based on their morphological, Gram staining, cultural and biochemical tests. Different biochemical tests used for gram negative include triple sugar iron agar, indole, urea, simon's citrate agar, lysine iron agar, and motility. Gram positives were identified based on their different physiological tests such as catalase, coagulase and haemolysis following standard procedures [10,11].Fungi isolates were identified following the methods of [12] based on their macroscopy and microscopy.

### 2.5 Data Analysis

The data collected were pooled and analyzed using descriptive statistics which included percentages, means and standard deviations. All analyses was done using SPSS version 20 statistical package. Results were then presented as tables.

## 3. RESULT

This study showed that $PM_{2.5}$was higher at the 0m (9±1.4 µg/$m^{3'}$; 12±3.5µg/$m^{3'}$) which is the point of highest activity, followed by 100m(10±2.8 µg/$m^3$; 10±2.8µg/$m^{3'}$) which was closest, then 300m (7±0.0µg/$m^3$; 9±1.4µg/$m^{3'}$) and 500m (7±0.0µg/$m^3$; 8±1.4µg/$m^{3'}$) the least in both Owerri and Okigwe poultry farms respectively. Temperature and relative humidity was also observed to be high in Owerri than was observed at Okigwe, along the distances during the rainy season. Owerri poultry farm had a temperature of 34.1±0.0 at 0m, 34.8±1.4 at 100m, 34.8±0.0 at 300m and 34.3±0.1 at 500m with a humidity of 72.1±0.0 at 0m, 66.0±0.0 at 100m, 64.6±1.1 at 300m and 63.3±0.0 at 500m while Okigwe had a temperature of 28.6±1.2 at 0m, 29.2±1.4 at 100m, 29.7±0.0 at 300m and 29.7±0.0 at 500m with a relative humidity of 87.0±1.4 at 0m, 85.1±1.3 at 100m, 84.9±1.1 at 300m and 81.1±0.0 at 500m (Table 1). During the dry season , Owerri poultry farm had a $PM_{2.5}$ of 55.0±1.4 at 0m, 53±6.3 at 100m, 46±0.0 at 300m and 28±2.1.8 at 500m and $PM_{1o}$ of 55.0±1.4 at 0m, 33.3±1.4 at 100m, 32±2.8 at 300m and 42±2.8 at 500m. A temperature range of 37.4±0.0 to 37.8±4.2 across the distances and a relative humidity of 81±1.2 at 0m, 81.6±0.1 at 100m, 81.0±0.1 at 300m and 81.0±0.0at 500m. Okigwe poultry farm however had lower $PM_{2.5}$ and a lower relative humidity than the Owerri poultry farm. Okigwe poultry farm had a $PM_{2.5}$ of 21±1.4 at 0m, 20±2.8 at 100m, 18±2.8 at 300m and 16±0.0 at 500m. $PM_{10}$ was 88.±2.6 at 0m, 69±1.4 at 100m, 64±6.2at 300m and 52±1.4 at 500m. Temperature had a range of 38.1±0.0 - 38.9±0.1 with a relative humidity of 68.±0.7 at 0m, 67.3±0.7 at 100m, 65.4±1.3 at 300m and 63.4±0.1 at 500m (Table 2).

The microbial load of the air during the dry season at Owerri poultry farm was examined according to time of exposure (15 – 45mins) and

distance (0m - 500m). Result obtained showed that THBC had the highest count, this was followed by TCC and TSC while the least was TFC. At 15mins, the microbial count was low but an increase was observed at 30mins and further increased at 45mins. This trend was observed for all the microbial groups examined. At the varying distances, it was observed that as distance increased from 0m to 100m, there was an observed decrease in microbial counts and further decrease at 300m and 500m, (Table 3). While during the rainy season, lower counts were observed. Similar trend was observed however, as THBC had the highest microbial counts and this was followed by TCC then TSC, the least was also TFC. At the varying distances, it was observed that as distance increased from 0m to 100m, there was an observed decrease in microbial counts and further decrease at 300m and 500m (Table 4).

Okigwe poutry farm had higher microbial counts than was observed in the Owerri poultry farms in both seasons. During the dry season in the Okigwe poultry farm, THBC group had the highest count and this was followed by TCC then TSC, while the lowest count was observed with TFC microbial group. This study also showed that as distance increased, there was a decrease in the counts but as time increased from 15miutes through 45 minutes, there was an increase in microbial counts in all the groups assessed (Table 5). During the rainy season, lower counts were observed , though a similar trend as during the dry season was observed. THBC had the highest microbial count, followed by TCC then TSC, while the lowest count was observed with TFC. The Exposure time also showed that as the time increased from 15mins to 30minutes, there was an increase in all the microbial groups assessed and further increase was observed at 45mins.(Table 6).

Fungi and bacteria isolated from the air in these farms were similar but having different occurrences. Fungi isolated were Aspergillus, Penicicllium, Fusarium , Mucor and Rhizopus species. *Aspergillus* spp had the highest occurrences in Owerri (33.6%) and Okigwe (35.6) poultry farms. This was followed by *Penicillium* spp (30.2% Owerri; 35.6% Okigwe ) while the least was *Rhizopus* species (4.1% Owerri; 8.1% Okigwe ). Bacteria species isolated included *Escherichia coli, Staphylococus , Bacillus, Proteus, Streptococcus* Species. *Staphylococcus* spp had the highest occurrence of 30.96% in Owerri and 26.4% in Okigwe, this was followed by *Bacillus* species, 27.1% in Owerri and 24.7 % in Okigwe and *E.coli*, 25.8% in Owerri and 25.3% in Okigwe poultry farms. The least isolated bacteria was Proteus (5.8% and 5.8%) in Owerri and Okigwe respectively (Table 7).

## 4. DISCUSSION

Particulate matter which is one of the environmental issues connected with animal farms showed that suspended particles were higher in the dry season than in the rainy season. As sampling moved away from the point source (0m), to 100m there was an observed decrease in the poultry farms and additional decrease was observed as distance increased, hence 0m > 100m > 300m > 500m. Particulate matter ($PM_{2.5}$) was lower in the rainy season and Particulate matter 10($PM_{10}$) were observed to be low during the rainy season in the farms. Ambient air limits as given by [12] under the clean air act is 12 $\mu g/m^3$ for $PM_{2.5}$ and $PM_{10}$ standard of 150 $\mu g/m^3$. However [13] gives ambient air guidelines of fine particulate matter ($PM_{2.5}$) as 10$\mu g/m^3$ annual mean and 25 $\mu g/m^3$ 24-hour mean while Coarse Particulate Matter ($PM_{10}$) is 20 $\mu g/m^3$ annual mean and 50 $\mu g/m^3$ 24-hour mean. When this was compared to the values obtained in the poultry farms (Okigwe and Owerri) it was observed that $PM_{10}$ & $PM_{2.5}$ during the rainy season in poultry farm were within the permissible limits having a range of 7-10 $\mu g/m^3$ and 8-12 $\mu g/m^3$ respectively. In the dry season $PM_{2.5}$ of the farms were all within the permissible varying limits of both the EPA and WHO while $PM_{10}$ where all above the WHO permissible limits. In Poultry farm, the values obtained during the rainy and dry seasons were higher than the permissible limits. This therefore shows that there could be even an imminent issue for people who live in the same environment with their poultry farms. [14] revealed that micrometeorological parameters such as temperature, atmospheric pressure and relative humidity have immense effect on the movement of PM as well as the concentration level at any particular area, this was also in agreement with our findings. [15] in their book titled perspectives of urban ecology, wrote that deposition rates are governed by meteorological factors ( relative humidity), particle characteristics (size and shape), and surface characteristics (friction velocity, microscale roughness and temperature). Meteorological parameters which cause the dilution of pollutants rates of chemical reactions and the removal processes such as dry

and wet deposition are significant factors affecting the particle concentration in the ambient [15]. There was also a relationship between the number of birds and particulate matter as was observed in Okigwe poultry farms compared to Owerri poultry farm, having the highest PM and this could be ascribed to the high number of birds present in Okigwe poultry farm which had 2500 birds compared to Owerri which had 1700 birds. This created room for more droppings, wing flappings and increased temperatures that could help multiply the presence of Bioerosols. Air quality is reduced in livestock farming areas, due to emissions of both coarse and fine particles and the size of particles is directly linked to their potential for leading to health issues. Fine particles ($PM_{2.5}$) pose the utmost health concern and can get deep into lungs while some may even get into the bloodstream. Exposure to these particles can affect a person's lungs and heart. Coarse particles ($PM_{10}$) are of less concern, although they can irritate a person's eyes, nose and throat, these observations are in agreement with the work done by [16] on the comparisons of indoor and outdoor fungi particles in poultry units. Children and infants are vulnerable to harm from inhaling pollutants such as Particulate matter because they inhale more air per pound of body weight than do adults because they breathe faster, spend more time outdoors and have smaller body sizes. In addition, children's immature immune systems may cause them to be more vulnerable to PM than healthy adults. $PM_{2.5}$ and $PM_{10}$ particles easily go in into the airways and lungs where they may produce destructive health effects such as the aggravation of heart and lung diseases [17]. The risk of these health effects is utmost in the elderly and the very young. Temperature and relative humidity are major factors that determine the presence, survival and how long microbes could be suspended in the air. The temperature and relative humidity of the air around the farms were also assessed and there was an effect of seasonality on these parameters tested. As temperature increased, relative humidity decreased and vice versa. This finding is in conformity with the work done by [18]. Hence, during the dry seasons, higher temperatures were recorded than was observed in the rainy season, also relative humidity decreased in the dry season but was high in the rainy season. Total heterotrophic bacteria count (THBC), Total coliform count (TCC), Total Staphylococcal count (TSC), Total fungi count (TFC), were assessed in this study in the poultry farms and were recorded as cfu/plate/mins. It was observed that as time increased the microbial load increased but as distance increased the microbial load decreased. Result showed that at 0m, highest microbial loads were recorded in all the farms and this was followed by 100m, then 300m and least microbial load was observed at 500m. [16] agrees with our findings which was observed in his work on the comparison of indoor and outdoor fungi and particles in poultry units, although he did not consider distances but he observed that animal confinement tend to increase the overall microbial load in the animal immediate production environment due to increased volumes of feed and animals anthropogenic activities. However the indoor and outdoor air quality of poultry farms at Bangalore studied by [18] showed that outdoor air is the main source of airborne microbes within the animal production unit and this does not agree with our findings. Time was observed to be vital in determining microbial load in the poultry farms and time of exposure was between 15mins to 45mins. This range of time was considered because the farm workers and visitors within these farms spend 15 to 45mins daily within the farm environment, results showed that as the exposure time increased, microbial densities increased, hence 45mins was higher than 30mins and also 15mins. This findings are in line with the work done by [19] on the microbial analysis of outdoor air quality of poultry and hatchery farms in Ebonyi state University, Abakiliki, Nigeria. The highest occurrence of *S. aureus* (30.96%), *Bacillus cereus* (27.1%) and *E.coli* (25.8%) were in agreement with the findings of [20] whose study showed that the isolates with the highest occurrence were *S. aureus, E. coli* and *Bacillus* sp and also with the findings of [21] who revealed that in the hatchery unit, highest bacteria count was *S. aureus*. [21] showed through their study also that from the bacteria found in the air, the most predominant groups were 3 gram positive (cocci, spore forming bacilli and *corynebacter*) and one gram negative rod(*E.coli*). These microbes isolated were also found to be in line with the findings of [20] and [22] who also isolated same organisms in their various study of air quality. They noted that bioerosols may contain representatives of gram positive bacteria, *S. aureus, Streptococcus* sp and some gram negative pathogens such as *E. coli*. Although not much work has been done on the fungi aspect in the air around poultry farms, these fungi isolated when in contact with immuno-compromised individuals around the farms, fungi such as *Fusarium* and *Aspergillius* species could cause ailments ranging from mild throat irritations to severe life threatening pulmonary infections [23].

**Table 1. Analysis of some physical parameters of the poultry farms during rainy season**

| | OWERRI | | | | OKIGWE | | | |
|---|---|---|---|---|---|---|---|---|
| **DISTANCE** | **$Pm_{2.5}$** | **$Pm_{10}$** | **TEMP$^0$C** | **RH%** | **$Pm_{2.5}$** | **$Pm_{10}$** | **TEMP$^0$C** | **RH %** |
| 0m | 9±1.4 | 27±1.4 | 34.1±0.0 | 72.1±0.0 | 12±3.5 | 45±2.8 | 28.6±1.2 | 87.0±1.4 |
| 100m | 10±2.8 | 25±1.4 | 34.8±1.4 | 66.0±0.0 | 10±2.8 | 37±2.8 | 29.2±1.4 | 85.1±1.3 |
| 300m | 7±0.0 | 20±1.4 | 34.8±0.0 | 64.6±1.1 | 9±1.4 | 24±1.4 | 29.7±0.0 | 84.9±1.1 |
| 500m | 7±0.0 | 19±1.4 | 34.3±0.1 | 63.3±0.0 | 8±1.4 | 20±1.4 | 29.7±0.0 | 81.1±0.0 |

*Key: Value represents mean ± standard deviation*
*Pm Particulate matter; TEMP Temperature; RH Relative Humidty*

**Table 2. Analysis of some physical parameters of the poultry farms during dry season**

| | OWERRI | | | | OKIGWE | | | |
|---|---|---|---|---|---|---|---|---|
| **DIST** | **Pm2.5** | **Pm10** | **TEMP** | **RH** | **Pm2.5** | **Pm10** | **TEMP** | **RH** |
| 0m | 36.0±1.4 | 55.0±1.4 | 37.8±4.2 | 81.0±1.2 | 21.0±1.4 | 88.0±2.6 | 38.1±0.0 | 68.0±0.7 |
| 100m | 33.3±1.4 | 53.0±6.3 | 37.6±0.0 | 81.6±0.1 | 20.0±2.8 | 69.0±1.4 | 38.9±0.1 | 67.3±0.7 |
| 300m | 32.0±2.8 | 46.0±0.0 | 37.5±0.0 | 81.0±0.1 | 18.0±2.8 | 64.0±6.2 | 38.2±0.8 | 65.4±1.3 |
| 500m | 28.2±1.8 | 42.0±2.8 | 37.4±0.0 | 81.0±0.0 | 16.0±0.0 | 52.0±1.4 | 38.6±0.1 | 63.4±0.1 |

*Key: Value represents mean ± standard deviation*
*Pm Particulate matter; TEMP Temperature; RH Relative Humidity*

**Table 3. Microbial load of the air during the dry season at owerri poultry farms**

| **Distances / time** | **Microbial group counts at different time intervals** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **THBC** | | | **TCC** | | | **TSC** | | | **TFC** | | |
| | **15Mins** | **30mins** | **45mins** | **15mins** | **30mins** | **45mins** | **15mins** | **30mins** | **45mins** | **15mins** | **30mins** | **45mins** |
| 0m | 20.8 | 21.4 | 21.8 | 12.0 | 6.4 | 8.0 | 8.2 | 8.7 | 8.9 | 1.6 | 2.1 | 3.1 |
| 100m | 19.0 | 18.2 | 19.0 | 6.0 | 6.2 | 6.9 | 7.3 | 7.6 | 8.2 | 0.9 | 1.4 | 1.9 |
| 300m | 11.6 | 12.4 | 10.7 | 1.0 | 2.2 | 1.3 | 6.6 | 6.9 | 7.2 | 1.8 | 1.1 | 1.5 |
| 500m | 1.2 | 2.7 | 3.5 | 0.8 | 1.1 | 1.1 | 3.5 | 3.7 | 4.2 | 0.5 | 0.7 | 1.1 |

*Key: Unit of measurement=cfu/plate/mins; Values are mean of duplicates*
*THBC Total Heterotrophic Bacteria Count; TCC Total Coliform Count; TSC Total Staphylococcal count; TFC Total Fungal count; M meters; MINS Minutes; CFU Coliform forming units*

**Table 4. Microbial load of the air during the rainy season at owerri poultry farm**

| Distances / time | Microbial group counts at different time intervals | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | THBC | | | TCC | | | TSC | | | TFC | | |
| | 15Mins | 30 Mins | 45 Mins | 15 Mins | 30 Mins | 45 Mins | 15 Mins | 30 Mins | 45 Mins | 15 Mins | 30 Mins | 45 Mins |
| 0m | 9.5 | 10.5 | 10.7 | 5.9 | 8.0 | 8.6 | 1.4 | 1.6 | 2.0 | 1.2 | 1.5 | 1.5 |
| 100m | 5.3 | 6.0 | 9.0 | 3.4 | 3.6 | 4.9 | 0.9 | 1.3 | 1.7 | 1.0 | 1.4 | 1.1 |
| 300m | 3.6 | 4.4 | 8.1 | 3.0 | 4.3 | 5.5 | 0.9 | 1.1 | 0.8 | 0.8 | 1.0 | 1.1 |
| 500m | 2.6 | 3.6 | 5.1 | 0.4 | 0.6 | 0.9 | 0.6 | 0.6 | 1.0 | 0.5 | 1.0 | 1.2 |

*Key: unit of measurement=cfu/plate/mins; Values are mean of duplicates.*
*THBC Total Heterotrophic Bacteria Count; TCC Total Coliform Count; TSC Total Staphylococcal count; TFC Total Fungal count; M meters; MINS Minutes; CFU Coliform forming units*

**Table 5. Microbial load of the air during the dry season at Okigwe poultry farm**

| DISTANCE/ TIME | THBC | | | TCC | | | TSC | | | TFC | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 15mins | 30 mins | 45 mins | 15 mins | 30 mins | 45 mins | 15 mins | 30 mins | 45 mins | 15 mins | 30 mins | 45 mins |
| 0m | 22.5 | 24.8 | 26.8 | 6.6 | 7.8 | 9.6 | 2.1 | 3.3 | 4.7 | 1.6 | 3.3 | 4.0 |
| 100m | 10.7 | 23.4 | 27.2 | 5.4 | 6.6 | 7.0 | 1.9 | 3.4 | 4.1 | 0.8 | 2.1 | 3.2 |
| 300m | 8.4 | 11.2 | 19.4 | 5.2 | 6.2 | 6.4 | 1.3 | 1.9 | 2.8 | 0.8 | 1.2 | 2.1 |
| 500m | 2.8 | 4.8 | 6.6 | 2.0 | 2.3 | 2.8 | 0.8 | 1.3 | 1.7 | 0.2 | 0.3 | 1.0 |

*Key: unit of measurement=cfu/plate/mins; Values are mean of duplicates*
*THBC Total Heterotrophic Bacteria Count; TCC Total Coliform Count; TSC Total Staphylococcal count; TFC Total Fungal count; M meters; mins Minutes; CFU Coliform forming units*

**Table 6. Microbial load of the air during the rainy season at Okigwe poultry farm**

| Distance/ time | THBC | | | TCC | | | TSC | | | TFC | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 15 mins | 30 mins | 45 mins | 15 mins | 30 mins | 45 mins | 15 mins | 30 mins | 45 mins | 15 mins | 30 mins | 45 mins |
| 0M | 8.2 | 8.7 | 9.1 | 7.4 | 7.6 | 8.3 | 1.1 | 1.3 | 1.3 | 3.2 | 3.3 | 3.3 |
| 100M | 7.0 | 7.6 | 8. | 5.3 | 5.7 | 6.3 | 1.1 | 1.1 | 1.0 | 1.9 | 2.4 | 2.5 |
| 300M | 1.0 | 1.9 | 2.2 | 0.9 | 1.3 | 1.7 | 0.5 | 0.8 | 0.7 | 1.1 | 1.3 | 1.9 |
| 500M | 0.9 | 1.2 | 1.5 | 0.4 | 0.7 | 0.8 | 0.2 | 0.6 | 0.7 | 0.8 | 1.0 | 1.8 |

*Key: Unit of measurement=cfu/plate/mins; Values are mean of duplicates.*
*THBC Total Heterotrophic Bacteria Count; TCC Total Coliform Count; TSC Total Staphylococcal count; TFC Total Fungal count; M meters; minsMinutes; CFU Coliform forming units*

**Table 7. Occurrence of microorganisms in the farms**

| ISOLATES | OWERRI OCCURRENCE(%) | OKIGWE OCCURRENCE(%) |
|---|---|---|
| **Fungi** | | |
| *Aspergillus* spp. | 41(33.6) | 48(35.6) |
| *Penicillium* spp. | 37(30.2) | 48(35.6) |
| *Fusarium* spp. | 18(14.8) | 16(11.9) |
| Mucor sp | 11(9.0) | 12(8.8) |
| Rizopus sp | 5(4.1) | 11(8.1) |
| | 122(100) | 135(100) |
| **BACTERIA** | | |
| *Staphylococcus* spp | 48(30.96) | 48(26.4) |
| *Bacillus* spp | 42(27.1) | 45(24.7) |
| *Proteus* spp | 9(5.8) | 12(C) |
| *Streptococcus* spp | 16(10.3) | 31(17.0) |
| *Escherichia coli* | 40(25.8) | 46(25.3) |
| | 155(100) | 182(100) |

*N=48*

## 5. CONCLUSION

The aeromicrobiology of these farms shows that the air contained presence of bacteria and fungi of medical importance in both seasons, hence, there is the need to always ensure proper hygienic management and regular evaluation of poultry farms to avoid microbes exceeding the permissive limits.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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