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# MICROBIOLOGICAL ANALYSIS OF INDOOR AIR IN SELECTED PRIMARY SCHOOLS: HEALTH CONCERNS AND RECOMMENDATIONS

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## Abstract

The quality of indoor air in various buildings is crucial for maintaining the health and well-being of individuals. Exposure to airborne microorganisms can have detrimental effects on respiratory health. This study aimed to evaluate the microbiological quality of indoor air in selected primary schools in Aliero, Nigeria. Three primary schools were randomly chosen, air samples were collected using settle plates. Petri dishes containing different culture media were exposed twice daily (morning and noon). The number of organisms per cubic meter of air (CFU/m³) was recorded, and standard microbiological methods were used to identify bacterial and fungal isolates. The study revealed a wide range of bacterial and fungal contamination in classroom environments. Bacterial loads ranged from 543-165 CFU/m³, while fungal loads ranged from 146- 32 CFU/m³. Four bacterial species and five fungal genera were identified. The bacteria included Bacillus spp, Proteus spp, Staphylococcus aureus, and Micrococcus spp, while the fungal genera isolated included Aspergillus spp, Mucor spp, Fusarium spp, Penicillium spp, and Rhizopus spp. The most prevalent bacteria were Bacillus spp (34.38%) and Micrococcus spp (28.13%), while the most frequently isolated fungi were Fusarium spp (36.36%) and Penicillium spp (33.33%). The finding of this study has shed light on the indoor air quality of selected primary schools in Aliero. The present study also revealed the microbial diversity as well as the frequency of occurrence of various isolates. Measures such as improved ventilation, stringent cleaning protocols, and regular monitoring to ensure a healthier indoor environment for both students and staff.

**Keywords**: Indoor Air Quality, Bacterial Load, Fungal Load, Settle Plate Technique, Aliero.


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## INTRODUCTION

The presence of clean air is crucial for sustaining life on our planet (Gautam & B. Bolia, 2020). The scientific community has expressed growing concern over the impact of indoor air quality (IAQ) on human health due to the increasing amount of time people spend indoors compared to outdoors (Cincinelli & Martellini, 2017). The air we breathe contains not only nitrogen, oxygen, and carbon dioxide but also various gases, inorganic particles, and biological particles (Lacey & West, 2006; Monica, 2006). These biological particles, referred to as bioaerosols, primarily consist of microorganisms found in soil, water bodies, plants, rocks, and buildings. Wind erosion and splashing water are common processes that release these bioaerosol particles into the air. Bioaerosols encompass a wide range of entities, including viruses, bacteria, fungi, spores, fragments of lichens, protists (e.g., protozoa, algae, and diatoms), spores and fragments of plants, pollen, small seeds, invertebrates (e.g., nematodes, mites, spiders, and insects), as well as fecal matter (Kuske, 2006; Stetzenbach et al., 2004). Bioaerosol particulates typically range in diameter from 0.3 to 100 mm. However, the respirable size fraction, which falls within the 1-10 mm range, is of particular significance and raises significant concerns (Kandle et al., 2015).

Microorganisms present in indoor air can have diverse origins, originating from humans, organic dust, stored products, as well as being circulated through natural and artificial ventilation systems (Brągoszewska & Biedroń, 2018). The monitoring of bioaerosols has become a rapidly emerging area of interest. It entails measuring and evaluating both viable (capable of being cultured and nonculturable) and nonviable microorganisms present in different indoor and outdoor environments. These environments can range from industrial and office settings to residential spaces indoors, as well as agricultural and general outdoor air quality (Cox et al., 2020; Ghosh et al., 2015; Kirori et al., 2022). Indoor air quality is a critical factor that significantly influences our overall quality of life. On average, a human breathes in approximately 10 m3 of air every day. Additionally, we spend a significant portion of our lives indoors, with estimates ranging from 80% to 95% (Dacarro et al., 2003). The air quality within residential homes, offices, schools, and other private and public buildings plays a crucial role in ensuring a healthy and conducive environment for individuals. the quality of indoor air significantly influences people's well-being (WHO, 2010). Contaminants can enter the body through inhalation, ingestion, or dermal contact. Schools, being public places, accommodate a large number of students daily and typically have high levels of activity, leading to increased levels of airborne bacteria. The microbial

content present in the indoor air of schools is a vital parameter, as it directly impacts the mental health, physical development, and performance of students (Chithra & SM, 2018; Gautam & B. Bolia, 2020).

Ensuring good indoor air quality (IAQ) in classrooms is of utmost importance because it directly affects the health, performance, concentration, and comfort of both students and teachers. Classrooms are particularly critical built environments as poor indoor conditions can have negative effects on students' health, comfort, and academic achievements (Mendell & Heath, 2005). Children, being in a developmental stage, are especially vulnerable to environmental exposures, and prolonged exposure to subpar IAQ can lead to long-term health issues, including respiratory diseases and impaired cognitive function (Zhang et al., 2006). One significant concern in indoor environments, including classrooms, is the presence of bioaerosols, which are airborne microorganisms and their by-products. Exposure to bioaerosols can have harmful effects on human health, particularly affecting the respiratory system. Respiratory disorders such as infections, hypersensitivity pneumonitis, and toxic reactions have been linked to inhalation of bioaerosols and their interactions with the respiratory system (Górny et al., 2002; Méheust et al., 2014). Children are particularly vulnerable to the effects of environmental contaminants, including air pollution. Their respiratory, immune, reproductive, central nervous, and digestive systems are still developing and may be more susceptible to the harmful impacts of air pollutants (Perlroth & Branco, 2017; Tainio et al., 2021). Additionally, children's behavior, characterized by increased physical activity and exploration, may lead to greater exposure to air pollution. For example, they can come into contact with pollutants through crawling and being near floors. children spend a significant portion of their time indoors, with a substantial portion of their indoor time being at school (Annesi-Maesano et al., 2013). Therefore, ensuring good indoor air quality in schools and other indoor environments is crucial for safeguarding the health and well-being of children. This study aimed to evaluate the microbiological quality of indoor air in selected primary schools in Aliero, Nigeria.

## METHODS

### Study location and sampling sites

Aliero, located in Kebbi State, Northern Nigeria, is the administrative significance center for the Aliero local government. It is situated at coordinates 12°16'42"N 4°27'6"E within Kebbi State. Renowned for its agricultural contributions, Aliero is the largest onion market in northwest Nigeria and holds a prominent position as a major onion producer in the country. In this research project, the primary focus was on three primary schools in Aliero: Muhammadu Magawata Primary School, Hall Mark Academics, and Staff Primary School.

### Air sampling

The conventional settle plate method (a passive gravitational method) was used to collect air samples. Petri dishes with a diameter of 9cm were utilized for all sample collections. Nutrient Agar (NA) plates were employed for collecting airborne bacterial samples, while Sabouraud Dextrose Agar (SDA) plates supplemented with Chloramphenicol as a bacterial growth inhibitor were used for collecting airborne fungal samples. Agar plates were prepared under sterile conditions before air sampling. Each sample was collected in triplicate, and a separate set of plates was exposed in a clean-air environment as a control. The sampling process was conducted with aseptic techniques at an average height of 1.5 meters in each room. Petri dishes were exposed to the air for 10 minutes per sample, sealed with masking tape, and appropriately labeled. Bacterial growth was encouraged by incubating the plates aerobically at 37°C for 24 to 48 hours, while fungal growth was promoted by incubation at 25°C for 4-7 days (Gautam & B. Bolia, 2020; Moldoveanu, 2015).

### Determination of microbial load and identification of isolates

The microbial load and isolates were determined using the following procedures. After the incubation period, bacterial colonies were counted with the aid of a colony counter. Initial identification of microbial growth on agar plates was based on the visual examination of colony morphology. For bacteria, additional characterization was carried out through Gram staining and subsequent biochemical tests (Cheesbrough, 2003). Fungal samples were visualized using Lactophenol Cotton Blue stain (Cox et al., 2020). To calculate the concentration of bioaerosols in CFU/m3 (colony-forming units per cubic meter), the researchers employed the following formula (Moldoveanu, 2015):

$$CFU/m3 = (n \times 10{,}000) / (s \times t/5)$$

Where:

n = the number of colonies on the Petri plate,

s = the surface area of the Petri plate, and

t = the time of exposure for the Petri plate.

## RESULTS

Figure 1 provides data on bacterial and fungal loads at various sample collection points in three primary schools. The measurements are recorded for both morning (7:30 am) and afternoon (2:00 pm) time points. The collection points include different classrooms (labeled Classroom 1, Classroom 2, Classroom 3, and Classroom 4) as well as a staff room. The highest bacterial load across all schools is 543 (School 3, Classroom 1, morning), and the lowest bacterial load is 165 (School 2, Classroom 2, afternoon). The highest fungal load across all schools is 146 (School 3, Classroom 1, morning), and the lowest fungal load is 32 (School 2, Classroom 3, afternoon).

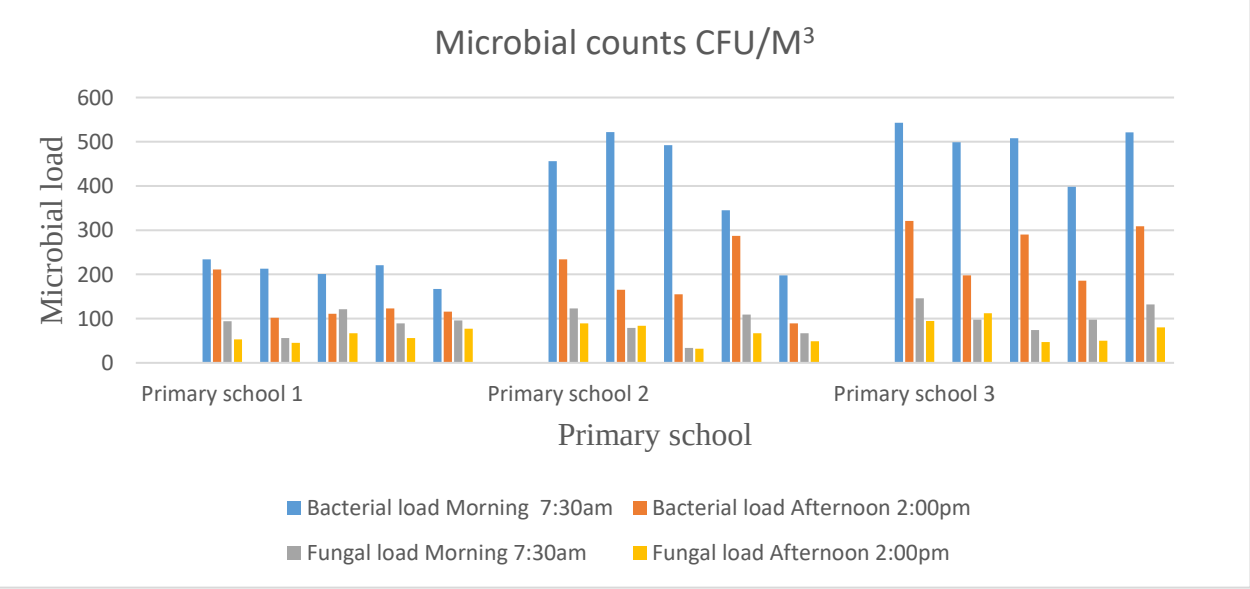



**Figure 1: Microbial count of the various primary schools**

**Table 1:** Mean concentration (CFU/$m^3$) of bacteria and fungi at the study location

| Sampling location | Bacterial load | Fungal load |
|---|---|---|
| Primary school 1 | 386.33 | 125.67 |
| Primary school 2 | 310.8 | 73.4 |
| Primary school 3 | 445 | 93.2 |

Four bacterial species and five fungal genera were identified. The bacteria species includes 3 gram-positive and one gram-negative. They are *Bacillus spp, Proteus spp, Staphylococcus aureus*, and *Micrococcus spp*, while the fungal genera isolated included *Aspergillus spp, Mucor spp, Fusarium spp, Penicillium spp,* and *Rhizopus spp*. Tables 2 and 3 provide a breakdown of the percentage occurrence of bacterial and fungal isolates in the indoor air samples, giving insights into the prevalence of different types of microorganisms. In the bacterial isolates, Bacillus spp has the highest percentage occurrence (34.38%), followed by Micrococcus spp (28.13%), Staphylococcus aureus (21.88%), and Proteus spp (15.63%). While In the fungal isolates, Fusarium spp has the highest percentage occurrence (36.36%), followed by Penicillium spp (33.33%), Rhizopus spp (15.15%), Aspergillus spp (9.09%), and Mucor spp (6.06%).

**Table 2:** Percentage occurrence of bacteria isolated from classrooms' indoor air

| Bacterial Isolates | Frequency | Percentage Occurrence |
|---|---|---|
| Bacillus spp | 11 | 34.38% |
| Proteus spp | 5 | 15.63% |
| Staphylococcus aureus | 7 | 21.88% |
| Micrococcus spp | 9 | 28.13% |
| Total | 32 | 100% |

**Table 3:** Percentage occurrence of fungi isolated from classrooms' indoor air

| Fungal Isolates | Frequency | Percentage Occurrence |
|---|---|---|
| Aspergillus spp | 3 | 9.09% |
| Mucor spp | 2 | 6.06% |
| Fusarium spp | 12 | 36.36% |
| Penicillium spp | 11 | 33.33% |
| Rhizopus spp | 5 | 15.15% |
| Total | 33 | 100% |

## DISCUSSION

Assessing indoor air quality is crucial for evaluating microbial air pollution. By gathering data on the quantity and types of airborne microorganisms, it becomes possible to estimate the potential health risks and establish air quality standards for both indoor and outdoor environments (Chatzidiakou et al., 2012; Gautam & B. Bolia, 2020). In this study, the focus was on investigating the microbial quality of indoor air in selected primary schools in Aliero. The sedimentation method (settle plate technique) was employed to collect air samples and analyze microbial content.

In the present study, the range for bacterial load is 543 - 165 CFU/$m^3$, and the range for fungal load is 146 – 32 CFU/$m^3$ (Table 1). The findings of the present study are in line with certain studies but differ from others. For instance, a study conducted in a school in Istanbul reported airborne bacterial concentrations ranging from 20 to 3300 CFU/$m^3$ and fungal concentrations ranging from 120 to 4340 CFU/$m^3$ (Sivri *et al.,* 2020). Similarly, an investigation into contamination levels in eight primary schools in Uppsala, Sweden, revealed bacterial concentrations ranging from 250 to 17,000 CFU/$m^3$ (Kim *et al*., 2007). However, other studies by Viegas et al. (2010) and Jo and Seo (2005) reported mean total indoor fungi concentrations (CFU/$m^3$) in school classrooms ranging from 92 to 505 colony-forming units (CFU). An interesting finding was that classrooms exhibited higher concentrations of airborne bacteria and fungi compared to staff rooms. This disparity may be attributed to the relatively better hygiene conditions observed in staff rooms as opposed to classrooms. During the sampling period, several factors contributed to the variability in the data obtained. The number of students and their activities during sampling, along with factors like ventilation rate, temperature, and relative humidity, could influence the levels of microorganisms in the air. Furthermore, it is essential to acknowledge that outdoor air pollution levels and meteorological conditions can significantly impact the indoor air quality of school buildings. External air quality can infiltrate indoor spaces, introducing various pollutants, including airborne microorganisms

The results of this study contrasted with those of a previous study conducted in a public school in Istanbul, where the most commonly detected fungal species was Penicillium spp. (Sivri *et al*., 2020). Additionally, the findings differed from a study conducted in a school in Baghdad city, where the predominant isolates were *Staphylococcus aureus* and Micrococcus (Badri, Alani, and Hassan, 2016). The Bacillus genus comprises Gram-positive bacteria

capable of forming spores. These bacteria are ubiquitous in nature and have a wide distribution (Rana *et al.,* 2020). Staphylococci, on the other hand, exhibit high resistance to dry conditions and harsh environments, which allows them to thrive in various settings, including the environment, and food, and facilitate their transmission (Sadigh *et al.,* 2021). Similarly, micrococci are known to be resistant bacteria that can survive in challenging environmental conditions, including the air (Naddafi *et al.*, 2009). The growth of fungi in indoor air is primarily influenced by moisture levels and the availability of carbon sources. Consequently, the most crucial strategies for mitigating or eliminating fungal growth involve controlling moisture and reducing the presence of organic contaminants indoors (Oppliger *et al.*, 2008). The evaluation of indoor air quality in schools encounters some limitations, including seasonal variations, interactions among pollutants, and limitations of the sedimentation method in providing precise quantitative measurements. This method relies on the settling of particles onto the agar plates, and it may not capture all the particles present in the air.

## CONCLUSION

In conclusion, this study assessed the microbiological quality of indoor air in selected primary schools in Aliero, Nigeria. The findings indicated a significant range of bacterial and fungal contamination in the classroom environments. These results highlight the importance of addressing indoor air quality in primary schools to safeguard the health and well-being of students and staff. Implementation of measures such as improved ventilation systems, rigorous cleaning protocols, and regular monitoring is crucial to create a healthier indoor environment. Further research and ongoing efforts are needed to develop and implement effective strategies for maintaining optimal indoor air quality in educational settings.

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