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Microbiological Indoor Air Quality within a Tertiary Institution in South East Nigeria

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ABSTRACT

With every breath, we inhale not only life sustaining oxygen but also dust, smoke, chemicals, microorganisms, and other particles and pollutants that float in air. The average individual inhales about 10 cubic meters of air each day. Indoor air pollution and poor urban air quality are listed as two of the world's worst toxic pollution problems in the 2008 Blacksmith Institute World's Worst Polluted Places report. The present study investigated the microbiological indoor air quality within lecture halls, laboratory, library and offices within Dr. Ogbonnaya Onu Polytechnic, Aba; a tertiary institution in south east Nigeria, using standard microbiological methods. The results of the study showed that the air quality within these environment were contaminated having colony counts ranging from 2.1 $\times 10^3$, 1.6×10^3, 1.1×10^3 and 1.2×10^3 (CFU/m^3) for lecture halls, laboratory, library and offices respectively for total aerobic count. 1.0 $\times 10^3$ to 2.1×10^3 for coliform count and 1.4 $\times 10^3$ to 4.8×10^3 for total fungi count. The bacteria count of indoor air in some areas were above the WHO recommended limit (1000 CFU/m^3 and 750 CFU/m^3). Seven bacterial strains (*Enterobacter, E. coli, Staphylococcus, Micrococcus, Pseudomonas, Serratia* and *Bacillus*) and five fungi (*Aspergillus, Penicillium, Rhizopus,* and *Cladosporium* sp) were isolated from the air within these environments. Over population, students and staff activities and poor ventilation systems have being reported to influence the quality of air in a closed setting as it promotes the spread and transfer of infectious organisms and diseases. It is therefore of a public health concern that ventilation indoors should be adequate, numbers of staff in some offices and over populated lecture halls and laboratory should be reduced to avoid the spread air borne disease.

Key word: Indoor Air quality, Offices, Laboratories, Tertiary Institution, Polytechnic, Over Population, Bacteria, Fungi.

Introduction

With every breath, we inhale not only life sustaining oxygen but also dust, smoke, chemicals, microorganisms, and other particles and pollutants that float in air. The average individual inhales about 10 cubic meters of air each day, roughly the volume of the inside of an elevator. Most of our life is spent indoors. Therefore, indoor air pollution may present a greater risk to human health than exposure to atmospheric air contaminants (Lis *et al.,* 2001). Air pollution occurs when harmful substances including particulates and biological molecules are introduced into Earth's atmosphere. It may cause diseases, allergies or death of humans, it may also cause harm to other living organisms such as animals and food crops, and may damage the natural or built environment. Human activity and natural processes can both generate air pollution.

Indoor air quality in working, dining and residential locations concerns a considerable number of people because they spend increasing fractions of their lives indoors (Lee and Chang, 2000; Zhao and Wu, 2007). Both scientific and public interest in indoor air pollutants have recently increased due to the negative impact of poor air quality on environmental and occupational health (Rajasekar and Balasubramanian, 2011). Indoor air is the most vital environment with respect to our health besides being a dominant source of contaminants. It contains a complex mixture of biological and non-biological particles incorporated with dust (Sundell, 2004). Among these, microbiological contaminants confer a considerable meaning in the elevation of indoor air pollution as they can be pathogenic or may cause allergic reactions, trigger the respiratory problems after inhalation and cause adverse health effects (Lignell *et al*., 2007).

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Air movements favor the maintenance of microorganisms in the aerial media while their deposition is barely affected by gravity due to their small size. The number of visitors that patronizes a restaurant and other factors such as location and position of toilet in a restaurant, the number of persons and the frequency at which people move from the hall to the toilet contributes to its indoor air quality. Other factors include temperature, humidity, light and nutrient availability which are determinants of microbial survival and abundance that affects the indoor air quality within the restaurant environment (Udochukwu *et al*., 2016)**.** The present study therefore seeks to investigate the microbiological indoor air quality within lecture halls, laboratory, library and offices within Dr. Ogbonnaya Onu Polytechnic, Aba.

Materials and Methods

Study Design and Study Sample

The study was carried out within lecture halls, laboratory, library and offices within Dr. Ogbonnaya Onu Polytechnic, Aba.

Method of air Microflora collection

For enumeration of air microflora, the Petri plates were exposed to air for thirty minutes. The sample collection was done in duplicates. The first sets of medium containing Petri plates were exposed at sampling rooms in the morning and the same was repeated in the afternoon for the second set (Mostafa *et al*., 2012). For Enumeration of Bacteria, Nutrient agar, Manitol Salt agar, McConkey agar and Eosine Methylene Blue Agar medium and for fungi, PDA medium plates were used. After exposing to Indoor air, medium containing petriplates were incubated at 37ºC for 24 hours for Bacteria and at 27ºC for five days for Fungi (Kavita and Jyothi, 2013). The average of colony forming units (CFU) of both bacteria and fungi was calculated and converted to organisms per cubic meter of air (Stryjakowska *et al*., 2007)**.**

$CFU/m^3 = a. 10000/ p.t.0.2$
Where
a-The number of colonies on the Petri plates
p-Surface of the Petri plates
t-The time of Petri plates exposure

The colonies that developed from each plate were observed for their morphological and physiological characteristics. Sub- cultures of discrete colonies from the plates was made and kept in stock for biochemical characterization and identification.

Characterization and Identification of Isolates

To identify the isolated bacteria; cultural, morphological and biochemical characteristics were studied carefully by comparing their reaction to different biochemical with comparison to known taxa of Bergey's Manual of Determinative Bacteriology, 9th Ed. (Holt *et al*. 1994).

Result

The result of the Mean values of total aerobic bacteria count (TABC), total coliform (TCC) and total fungal count (TFC) of air quality (CFU/m^3) within lecture halls are presented in Table 1.

Table 1: Mean total bacterial count of air quality (CFU/m^3) within lecture halls.

Hall	Bacterial count (CFU/m^3) of air quality		
	Total aerobic bacteria	**Total coliform**	**Total fungal**
Academic block (ABC)	2.2×10^3	1.1×10^2	2.2×10^3
School of business and management technology (SBMT)	3.3×10^3	1.6×10^2	2.6×10^3
School of science and engineering technology (SSET)	2.5×10^3	-	1.4×10^3
Science laboratory technology (SLT)	2.1×10^3	-	4.8×10^3
Book house (BKH)	3.3×10^3	1.1×10^2	4.0×10^3

Table 2 presents the results of the Mean values of total aerobic bacteria count (TABC), coliform (TCC) and fungal count (TFC) of air quality (CFU/m^3) within the laboratories. While the results of the Mean values of total aerobic bacteria count (TABC), coliform (TCC) and fungal count (TFC) of air quality (CFU/m^3) within the library are presented in Table 3.

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Table 2: Mean total bacterial count (CFU/m^3) of air quality within the Laboratories

Laboratory	Bacterial count (CFU/m^3) of air quality		
	Total aerobic bacteria	Total coliform	Total fungal
FST	2.0×10^3	2.1×10^2	1.3×10^3
SLT Biology	2.1×10^3	1.0×10^2	3.2×10^3
Microbiology	3.7×10^3	1.3×10^3	5.2×10^3
Biochemistry	2.4×10^3	1.2×10^3	3.4×10^3
SLT Chemistry	1.7×10^3	1.0×10^2	2.3×10^3
SLT Physics	1.6×10^3	1.3×10^2	2.1×10^3

Table 3: Mean total bacterial count (CFU/m^3) of air quality within the Library

Library	Bacterial count (CFU/m^3) of air quality		
	Total aerobic bacteria	Total coliform	Total fungal
Shelves	1.1×10^3	-	2.5×10^3
Reading Table	2.5×10^3	1.0×10^2	2.8×10^3
Floor	2.3×10^3	-	4.3×10^3
Staff Table	1.4×10^3	1.2×10^3	2.1×10^3

The results of the mean values of total aerobic bacteria count (TABC), coliform (TCC) and fungal count (TFC) of air quality (CFU/m^3) within offices are presented in Table 4.

Table 4: Mean total bacterial count (CFU/m^3) of air quality within offices.

Office	Bacterial count (CFU/m^3) of air quality		
	Total aerobic bacteria	Total coliform	Total fungal
ABC	1.2×10^3	-	2.7×10^3
SBMT	2.0×10^3	-	2.4×10^3
SSET	1.5×10^3	-	3.8×10^3
SLT	2.8×10^3	-	3.2×10^3
BKH	2.4×10^3	1.0×10^2	3.0×10^3

Table 5 presents the microscopic and biochemical profile of bacteria isolated from air environment. The seven bacterial strains identified were; *Enterobacter, E. coli, Staphylococcus, Micrococcus, Pseudomonas, Serratia* and *Bacillus*.

The result of the colonial morphology and microscopy of fungi isolated from the indoor air environments are presented in Table 6. The fungi identified were; *Aspergillus, Penicillium, Rhizopus* and C*ladosporium* sp.

Table 5: Microscopic and biochemical profile of bacteria isolated from air environment

Isolate Code	Gram reaction	Catalase text	Coagulase	Methyl red	Voges proskaeur	Citrate utilization	Oxidase text	Indole	Urease text	Glucose	Lasctose	Sucrose	Most probable organism
A	+	+	-	+	+	+	+	+	+	A	A	A	*Bacillus* sp.
B	+	+	+	-	+	+	-	-	-	A/G	A	A	*Staphylococcus aureus*
C	-	+	-	-	-	-	+	+	-	A	A	A	*Escherichia coli*
D	+	-	-	-	+	+		-	-	A	-	A	*Micrococcus* sp.
F	-	-	-	-	+	-	-	+	+	A	-	-	*Pseudomonas* sp.
G	-	+	-	-	-	-	+	-	-	AG	AG	A	*Enterobacter* sp.
H	-	-	-	-	+	+	-	+	-	-/-	A/-	A/-	*Serratia* sp.

Note: + =Positive, - = Negative, A= Acid production, A/G= Acid and Gas production.

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Table 6: Colonial morphology and microscopy of fungi isolated from indoor air environment

Colonial Morphology	Microscopy	Isolate
Brownish-black mycelium with dark spores on the surface. Conidiophore stipes are smooth-walled, hyaline or turning dark towards the vesicle.	Presence of septate hyphae; black long, smooth, erect conidiophores. Branched vesicle with round, radiate head.	*Aspergillus niger*
A bluish-green filament is seen which changes to powdery greenish brown. It has brush phialospores arrangement	Presence of red pigment with edges surrounded by whitish margin. Also the conidiophores are branched. Septate and fruity mycelium are observed	*Penicillium* spp
White swamy colonies with a dense cottony growth that is at first white becoming grey or yellowish brown with sporulation.	Oval spores with nonseptate mycelium and straight sporangiophores and root like hyphae (Rhizoids)	*Rhizopus* spp
Slow growing, olivaceous-brown to blackish brown, buff or brown, suede-like to floccose, becoming powdery due to the production of abundant conidia.	hyphomycete forming branched acropetal chains of conidia, each with a distinct hilum.	*Cladosporium* spp

Discussion

Most of our life is spent indoors. Therefore, indoor air pollution may present a greater risk to human health than exposure to atmospheric air contaminants. One kind of indoor air pollutant is airborne microorganisms – bacteria and fungi (Lis, 2001). They are factors of potential infectious, allergenic and immunotoxic effects. Indoor microflora is reported to be responsible for health problems, especially among children. Bioaerosols decrease air quality and affect human health, also causing some diseases such as tuberculosis, diphteria, legionellosis, fever, rhinitis, nausea and asthma. With the increase in secondary school leaver and admission into tertiary institution, convenience are major factors in the daily activities of people, the activity of people and equipment within enclosed spaces is thought to be the principal factor contributing to the buildup and spread of airborne microbial contamination (Maus *et al*., 2001).

In the present study, the microbial quality of Indoor air within the school environment (Dr. Ogbonnaya Onu Polytechnic, Aba) was investigated. The result revealed that different units within the school environment (lecture halls, laboratory, library and offices) harbored different microbial population.

A total of about seven bacterial strains (*Enterobacter, E. coli, Staphylococcus, Micrococcus, Pseudomonas, Serratia* and *Bacillus*) and four fungi (*Aspergillus, Penicillium, Rhizopus* and C*ladosporium* sp) were Isolated from the air, this finding as seen in the present study in similar to that reported by Udochukwu *et al*. (2016), Karwowska, (2003) and Keziah *et al*. (2016) who also reported similar findings. In their study, they were also able to identify similar Isolates including *Fusarium* and *Pseudomonas* in fast food restaurant at Lokoja metropolis, northern Nigeria.

The microbial population in the different unit of the school varied depending on the section. The laboratories and lecture halls had the highest microbial count. This is an evidence that humans population contributes to the indoor air quality of those areas and could pose a danger when the students population is not properly checked with proper sanitation and with good ventilation system to avoid contamination and spread of diseases. The study also shows that the organisms isolated varied from one study unit to another. This reflects the difference in the activities of students within the area. This observed differences supports the findings from a study by Karwowska, (2003) who also report a high incidence of air microflora in class rooms.

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Fungi isolates like *Cladosporium* sp, *Rhizopus*, *Penicillium* and *Aspergillus* sp. have been recognized as opportunistic pathogens for humans and often associated with clinical manifestations of some diseases. The control of the microbial load of the surrounding air is thus important to establish the quality and health condition of students and staff of the institution. Udochukwu *et al*, (2016) also stated that the microbial population can be explained by the number of persons that occupies the unit and the different unit sampled. They also stated that the characteristics of the room such as building maintenance, cleanliness, indoor temperature and relative humidity can be a contributing factor to indoor air quality. The fungal isolates from indoor air quality within the school were similar to that in some outdoor air quality.

In the case of staff offices, incidence of air microflora was less compared to the other study areas. The low incidence can be attributed to frequent cleaning and good hygiene practice by staff. According to a study by Stryjakowska *et al*. (2007) in a primary school, they stated that for the sake of the aesthetic sense, office room are always maintained neat and clean which reflects the low incidence in their study too. The room freshener's act as disinfectants but due to the frequent visit of students to office might be the reason for the occurrence of more air microflora in the study area.

Aspergillus sp was seen to be the most isolated fungus whose spores are usually distributed in the atmosphere, *Staphylococcus* and *Bacillus* species was the highest bacteria Isolate. Keziah, e*t al.* (2016) and Udochukwu, *et al.* (2016) reported that most of the bacteria Isolates are normal commensals of the human body while others are mainly associated with human which explains the possible sources of microbial contamination in the atmosphere. Poor ventilation systems have also being reported to influence the quality of air in a closed setting as it promotes the spread and transfer of infectious organism. It is therefore of a public health concern that people should avoid over populated environment. Also in the case of lecture halls and laboratory where high number of student are recorded, the management should double and improved on the level of sanitations and ventilation system in other to keep the student and lecturer safe from contamination and spread of air borne diseases.

Conclusion

The air quality within different units of Dr. Ogbonnaya Onu Polytechnic, Aba was surveyed and found that, the indoor air quality of some sections of the establishment was moderate while some was not. Based on the department of environment and department of occupational safety and health standards, indoor air quality is influenced by wind speed and temperature. The majority of bacteria detected were Gram positive and non pathogenic to human, with minute percentage of Gram negative bacteria, *Enterobacteria*. The presence of air borne and non bacteria indicated overcrowding and inadequate ventilation within the open-air environment. Wind speed is the sole ambient parameter to consider when trying to improve indoor air quality in open-air space.

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