International Journal of Pathogen Research

10(2): 22-28, 2022; Article no.IJPR.88658
ISSN: 2582-3876

Microbial Assessment of Indoor Air Quality of Selected Institutions in Rivers State, Nigeria

H. O. Stanley [a*] and I. F. Bamidele [a]

[a] Department of Microbiology, University of Port Harcourt, Rivers State, Nigeria.

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPR/2022/v10i230244

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/88658

Original Research Article

Received 01 May 2022
Accepted 05 July 2022
Published 07 July 2022

ABSTRACT

The aim of this study was to assess the microbial indoor air quality of primary and secondary schools in Obio- Akpor and Emohua Local Government Areas in Rivers State, Nigeria. Three public and three private schools were sampled. Air samples were collected using the gravitational sedimentation method. The samples were analyzed for the presence of bacteria and fungi, using Nutrient agar and Potato dextrose agar respectively. The bacterial population in the classroom and toilets ranged from 983-5899 CFU/m^3 and 786-2751 CFU/m^3 respectively, while the fungal population ranged from 1336-2319 CFU/m^3 and 786-2637 CFU/m^3. The bacteria isolated were identified as belonging to eight genera: Bacillus, Chromobacter, Escherichia, Lactobacillus, Micrococcus, Pseudomonas, Serratia and Staphylococcus, with Bacillus and Staphylococcus occurring more frequently. The fungal isolates were identified as belonging to eight genera: Alternaria, Aspergillus, Candida, Cladosporium, Microsporum, Mucor, Penicillium, with Rhizopus; Aspergillus and Mucor occurring more frequently. Some of the isolates identified in this study are of public health significance capable of causing respiratory disorders, bacteremia, pulmonary allergic diseases and gastrointestinal infections. Therefore, it is recommended that schools should maintain proper sanitary practices, maintain good ventilation systems and have less populated classrooms.

Keywords: Bacteria; fungi; classrooms; toilets; microbial indoor air quality.

**Corresponding author: Email: herbert.stanley@uniport.edu.ng;*

1. INTRODUCTION

Air is a carrier of particulate matter, dust and droplets which remain generally laden with microorganisms but not a natural medium for microorganisms. Airborne microorganisms originate from different sources such as soil, animals and humans [1]. Biological contamination of indoor air is mostly caused by bacteria, moulds and yeasts. Microbial pollution is a key element of indoor air pollution.

Microbial populations involve hundreds of species of bacteria and fungi that grows indoors when sufficient moisture is available. Microorganisms in air can be dangerous as pathogenic living cells or exert their injurious effects by their spores and secreted substances harmful such as mycotoxins [2,3]. Epidemiological studies have shown that too high concentration of microorganisms in the air can be allergenic; however, sometimes even low concentrations of some particular microorganisms can cause serious diseases [4].

Indoor air is important because populations spend a substantial fraction of time within buildings. In residences, day-care center, schools and other special environments, indoor air pollution affects population groups that are particularly vulnerable due to their health status or age [5]. Exposure to microbial contaminants in air is clinically associated with respiratory symptoms, allergies, asthma and immunological reactions [6,7].

Enclosed spaces with moisture are breeding grounds for moulds. All moulds have the potential to cause health effects, as they can produce potent toxins and allergens that can trigger allergic reactions or even asthma attacks in people allergic to moulds [4,8]. Harmful populations of microorganisms in occupied space of a modern building, may episodically produce or intensify what is known as Sick Building syndrome (SBS) [9]. Classrooms are prime spots for fungal colonization and can harbor population of bacterial cells and spores depending on the availability and maintenance of ventilation systems [10].

Children are still developing physically and are more greatly affected by pollutants [11]. The design of most public and primary schools in Rivers State, is such that does not place much attention to ventilation and humidity control. Besides, most public schools are in a state of infrastructural decay. This study aimed to assess the indoor air quality of selected primary and secondary schools in Obio/Akpor Local Government Area and Emohua Local Government Area in Rivers State, with respect to microbiological parameters.

2. MATERIALS AND METHODS

2.1 Sampling Location

This study purposively sampled six schools (2 primary and 4 secondary schools), three located in Obio-Akpor Local Government Area and three in Emohua Local Government Area, Rivers State, Nigeria. In each school, sampling was carried out in the classroom and toilet for sampled class. Table 1 shows the details of sampled locations.

2.2 Air Sampling

The settle plate technique also known as sedimentation method was used as sample collection method [12]. At each location, duplicates of Nutrient Agar (NA) and Potato Dextrose Agar (PDA) Plates were exposed to air for 20 minutes and were set up at height representative of the normal breathing zone. Enumeration was done using the Omeliansky's formula: $N=5a \times 10^4/bt$ (where a is actual plate count, b is the surface area of the Petri dish in cm^2 and t is the exposure time in minutes) and expressed in CFU/m^3.

2.3 Identification of Microorganisms

Identification of bacterial isolates was based on Gram reaction, biochemical tests (catalase, citrate, coagulase, indole, methyl red, Voges-Proskuer, triple sugar iron agar, sugar fermentation, motility and oxidase) and cultural morphologies with reference to Bergey and Holt [13] and Cheesbrough [14]. Identification of fungi was based on the microscopic and macroscopic characteristics of the isolates with reference to Harrigan and McCance [15].

3. RESULTS

Table 2 shows the genera of bacteria and fungi isolated from indoor air of classrooms and toilets of schools in Obio- Akpor and Emohua Local Government Areas of Rivers State, Nigeria. The isolated bacteria were identified as belonging to eight genera: Bacillus, Chromobacter,

Escherichia, Lactobacillus, Micrococcus, Pseudomonas, Serratia and Staphylococcus. The fungal isolates were identified as belonging to eight genera: Alternaria, Aspergillus, Candida, Cladosporium, Microsporum, Mucor, Penicillium and Rhizopus.

Fig. 1 shows that *Bacillus* sp. and *Staphylococcus* sp. occurred more frequently in sampled locations while *Micrococcus* sp. and Chromobacter sp., had the lowest frequency of occurrence. Fig. 2 shows that A*spergillus* sp. and Mucor sp. occurred more frequently in sampled locations while *Candida* sp., Rhizopus sp. and Microsporum sp. had the lowest frequency of occurrence.

Fig. 3 shows the bacterial population in the classrooms and toilets. Bacterial counts ranged from 983-5899 CFU/m^3 and 786-2751 CFU/m^3 in classrooms and toilets respectively. Fig. 4 shows that fungal population in classrooms and toilets ranged from 1336-2319 CFU/m^3 and 786-2637 CFU/m^3 respectively.

4. DISCUSSION

This study investigated the microbial indoor quality of selected public and private schools in Obio/Akpor Local Government Area and Emohua Local Government Area. The isolated bacteria were identified as belonging to eight genera: Bacillus, Chromobacter, Escherichia, Lactobacillus, Micrococcus, Pseudomonas, Serratia and Staphylococcus. The fungal isolates were identified as belonging to eight genera: Alternaria, Aspergillus, Candida, Cladosporium, Microsporum, Mucor, Penicillium and Rhizopus. *Bacillus* sp. and *Staphylococcus* sp. occurred more frequently in sampled locations while *Micrococcus* sp. and *Chromobacter* sp., had the lowest frequency of occurrence among the bacteria. A*spergillus* sp. and Mucor sp. occurred

Table 1. Details of sampled locations

School	Type	Class	Number of students
A	Public	JSS2	120
B	Private	JSS1	56
C	Private	Primary 6	40
D	Public	JSS2	120
E	Public	SSS1	lOO
F	Private	Primary 4	32

JSS=Junior Secondary School; SSS=Senior Secondary School

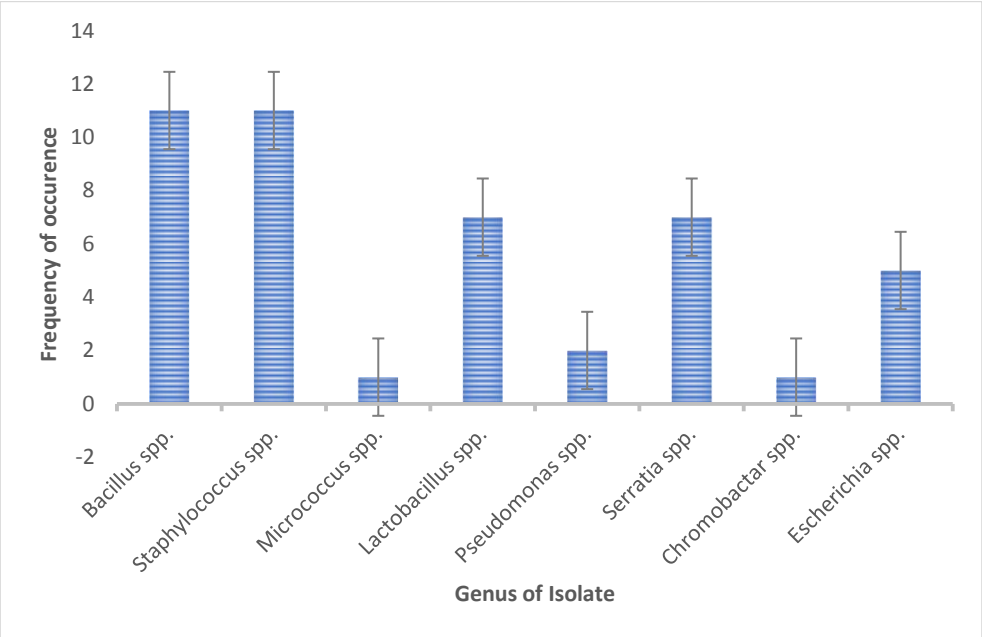

Fig. 1. Frequency of occurrence of bacteria Isolated from schools

Table 2. The genera of bacteria and fungi isolated from indoor air of classrooms and toilets of schools

School	Bacterial isolates	Fungal isolates
A	*Bacillus sp., Lactobacillus sp., Serratia sp., Staphylococcus aureus*	*Alternaria* sp., *Aspergillus* sp., *Mucor* sp., *Rhizopus* sp.
B	*Serratia* sp., *Lactobacillus* sp., *Micrococcus* sp., *Pseudomonas* sp., *Staphylococcus aureus*, *Bacillus* sp.	*Penicillium* sp., *Aspergillus* sp., *Mucor* sp. *Cladosporum sp*
C	*Bacillus* sp., *Lactobacillus* sp., *Serratia* sp., *Staphylococcus aureus*, *Pseudomonas* sp., *Escherichia coli*	*Penicillium* sp., *Aspergillus* sp., *Mucor* sp.
D	*Bacillus sp., Lactobacillus sp., Serratia sp., Staphylococcus aureus., Escherichia coli*	*Penicillium* sp., *Aspergillus* sp., *Mucor* sp., *Microsporum* sp.
E	*Bacillus sp., Lactobacillus sp., Serratia sp., Staphylococcus aureus., Escherichia coli., Chromobacter* sp.	*Penicillium* sp., *Aspergillus* sp., *Alternaria* sp., *Cladosporum* sp., *Candida* sp.
F	*Bacillus* sp., *Staphylococcus aureus*	*Mucor* sp.

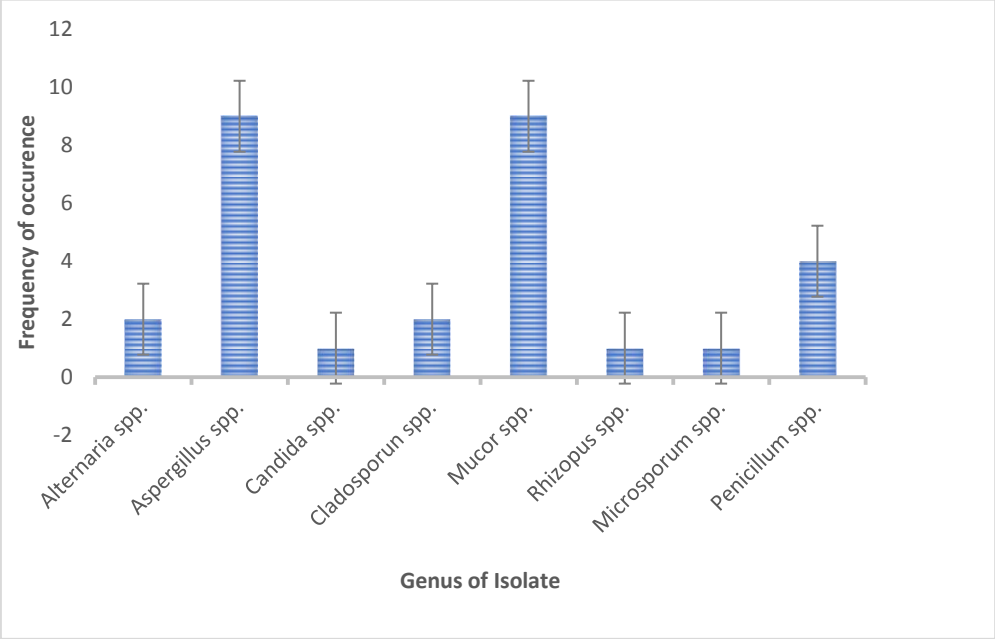

Fig. 2. Frequency of Occurrence of Fungi Isolated from the Schools

more frequently in sampled locations while *Candida* sp., *Rhizopus* sp. and *Microsporum* sp. had the lowest frequency of occurrence among the fungi. Dick and Wekhe [10] in their study on microbial air quality of a secondary school in Port Harcourt, Rivers State Nigeria, likewise isolated *Bacillus* spp., *Enterococcus* spp., *Escherichia coli*, *Micrococcus* sp., *Pseudomonas* sp. *Staphylococcus aureus* and *Serratia* sp. and six fungal species, *Alternaria* sp., *Aspergillus* sp., *Candida* sp., *Mucor* sp., *Penicillium* sp., and *Rhizopus* sp. The study by Enitan et al. [6] reported *Staphylococcus* sp., *Micrococcus* sp., *Aspergillus* sp., *Mucor* sp., *Penicillium* sp., *Candida* sp., *Microsporum* sp. and *Rhizopus* sp. in indoor air of primary schools in Ilishan-Remo, Ogun State, Nigeria.

The two dominant bacteria isolates (*Bacillus* sp. and *Staphylococcus* sp.) found in indoor air of the schools sampled are commonly found in air. Emojevwe et al. [16] reported that *Staphylococcus* sp. is the most commonly found pathogen in air. According to Kim et al. [17] *Staphylococcus* sp. is found in all individuals and usually expelled from the respiratory tract through the nose and mouth which may also account for their presence in the environment

and they can cause bacteremia and gastrointestinal infections. *Bacillus* species are persistent and resistant in the environment because of the formation of spores [18] and may improve their chances to be present in high numbers in the air [19]. *Escherichia* sp. can be found in the normal intestinal flora of humans and animals but can also be an important cause of enteric illness and constitute the major etiologic agent of sporadic and epidemic diarrhea both in children and adults [20]. Previous studies have shown that people occupying or visiting enclosed spaces play a dominating role in the creation of indoor microbiological environment [21]. Therefore, it could be alluded to that the staff, pupils/students were the carriers of the microorganisms that permeate the indoor air of the classrooms and toilets.

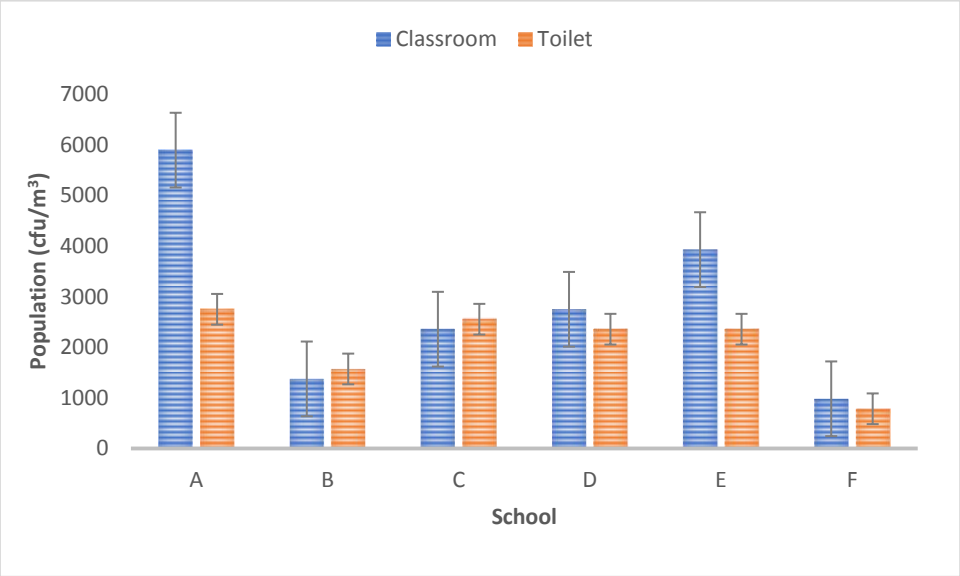

Fig. 3. Population of bacteria in indoor air of schools in Rivers State

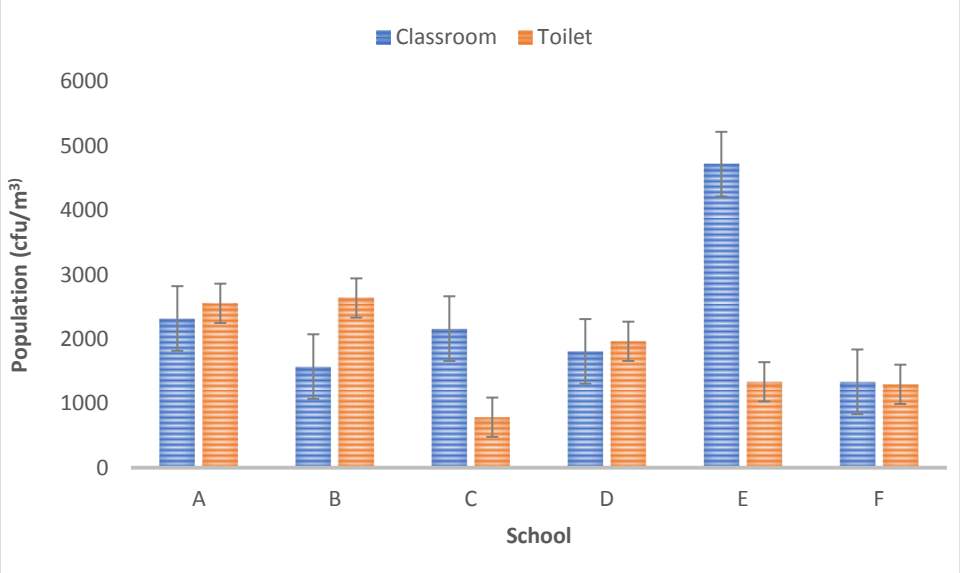

Fig. 4. Population of fungi in indoor air of schools in Rivers State

The laboratory analysis also showed that *Alternaria* sp., *Aspergillus* sp., *Cladosporium* sp., *Penicillium* sp., *Candida* sp., *Mucor* sp., *Rhizopus* sp. and *Microsporum* sp., were isolated from the indoor air, with *Aspergillus* sp. found to occur more frequently. According to Recer et al. [8], *Aspergillus* sp. are widely distributed in the environment and airborne asexual conidia serve as the main mode of transport, which could lead to pulmonary lung infection.

The bacterial population in the classroom and toilets ranged from 983-5899 CFU/m^3 and 786-2751 CFU/m^3 respectively, while the fungal population ranged from 1336-2319 CFU/m^3 and 786-2637 CFU/m^3. The bacterial counts in indoor air of classroom was more than that of the toilet, except in location C and E. This could be as a result of the cleaning detergent used in the toilet, which is assumed to be more inhibitive to the bacteria. The microbial population in the school was general high (500-2000 CFU/m^3) or very high (>2000CFU/m^3) according to the European Commission sanitary standards for non-industrial premises [22]. In an earlier study by Dick and Wekhe, [10] the bacterial count in classrooms ranged from 1.33 x10^4- 4.66x10^4 CFU/m^3 while fungal counts ranged from 1.08 x10^4-2.59 x10^4 CFU/m^3, which is equally high or very high. Hayleeyesus and Manaye [23] likewise reported high to very high microbial counts in indoor air of universities libraries in Ethiopia. Then again, the mean fungal count recorded in this study was found to be higher than fungal count of 178.93 CFU/m^3, reported by Enitan et al. [6].

Results obtained showed higher levels of indoor air microbial contamination in public schools than in private schools. This could be attributed to higher population of students in public schools compared to private, poor ventilation in classrooms, poor sanitation and deteriorated buildings in the public schools. High fungal contamination was also likely due to high atmospheric moisture and humidity in the schools.

5. CONCLUSION

The bacterial and fungal counts in the sampled schools were higher than stipulated guidelines for indoor air for none industrial premises. Some of the genera of bacterial and fungal isolates are of public health significance. These microorganisms pose threats to students as they accumulate overtime and are inhaled.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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