

## MICROBIAL ASSESSMENT OF INDOOR AIR QUALITY OF SELECTED INSTITUTIONS IN RIVERS STATE, NIGERIA

### 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<sup>3</sup> and 786-2751 CFU/m<sup>3</sup> respectively, while the fungal population ranged from 1336-2319 CFU/m<sup>3</sup> and 786-2637 CFU/m<sup>3</sup>. 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 and 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, toilet, microbial indoor air quality

### Introduction

Air is a carrier of particulate matter, dust and droplets which remain generally laden with

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microorganism 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 yeast. 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 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 mould [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 harbour population of bacterial cells and spores depending on the availability and maintenance of ventilation system [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

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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.

## Materials And Methods

### Sampling location

This study 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.

### Air sampling

The settling 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  $\text{cm}^2$  and t is the exposure time in minutes) and expressed in  $\text{CFU}/\text{m}^3$ .

### Identification of microorganisms

Identification of bacterial isolates was based on Gram reaction, biochemical test 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].

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**Comment [j7]:** Why these schools are selected? Is there any criteria they followed or is there any outbreak reported from those school

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**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	100
F	Private	Primary 4	32

## Results

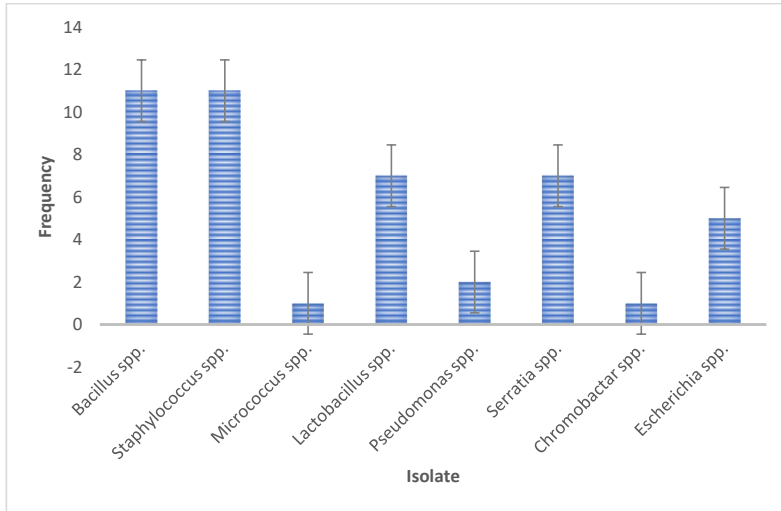
Table 2 shows the bacteria and fungi isolated from indoor air of classrooms and toilets of schools in Obio- Akpor and Emohua Local Government Areas of Rivers State, Nigeria. The bacteria isolated were identified as belonging to eight genera: *Bacillus*, *Chromobacter*, *Escherichia*, *Lactobacillus*, *Micrococcus*, *Pseudomonas*, *Serratia* and *Staphylococcus*. The fungal isolates were identified as belonging to eight genera: *Alternaria*, *Aspergillus*, *Candida*, *Cladosporium*, *Microsporium*, *Mucor*, *Penicillium* and *Rhizopus*.

Figure 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. Figure 2 shows that *Aspergillus* sp. and *Mucor* sp. occurred more frequently in sampled locations while *Candida* sp., *Rhizopus* sp. and *Microsporium* sp. had the lowest frequency of occurrence.

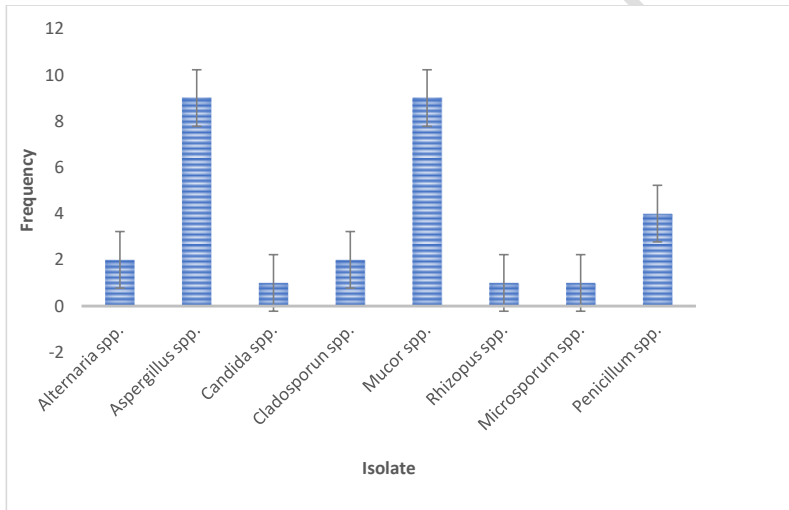
Figure 3 shows the bacterial population in the classrooms and toilets. Bacterial counts ranged from 983-5899 CFU/m<sup>3</sup> and 786-2751 CFU/m<sup>3</sup> in classrooms and toilets respectively. Figure 4 shows that fungal population in classrooms and toilets ranged from 1336-2319 CFU/m<sup>3</sup>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

**Table 2: Bacteria and fungi isolated from indoor air of classrooms and toilets of schools**

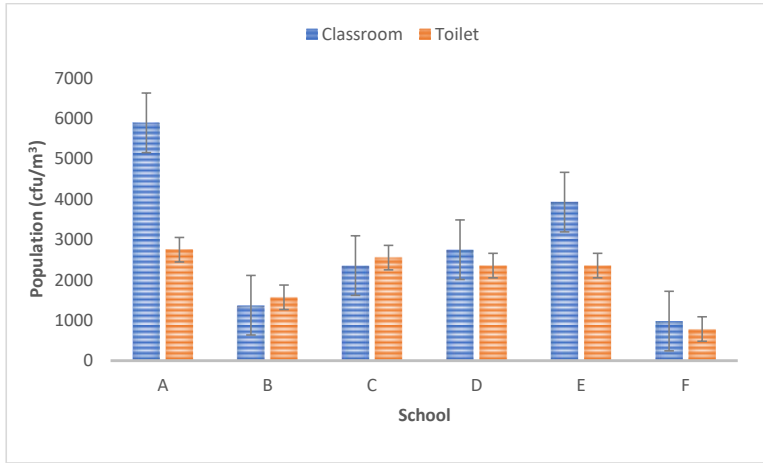
<b>School</b>	<b>Bacterial isolates</b>	<b>Fungal isolates</b>
A	<i>Bacillus sp.</i> , <i>Lactobacillus sp.</i> , <i>Serratia sp.</i> , <i>Staphylococcus aureus</i>	<i>Alternaria sp.</i> , <i>Aspergillus sp.</i> , <i>Mucor sp.</i> , <i>Rhizopus sp.</i>
B	<i>Serratia sp.</i> , <i>Lactobacillus sp.</i>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



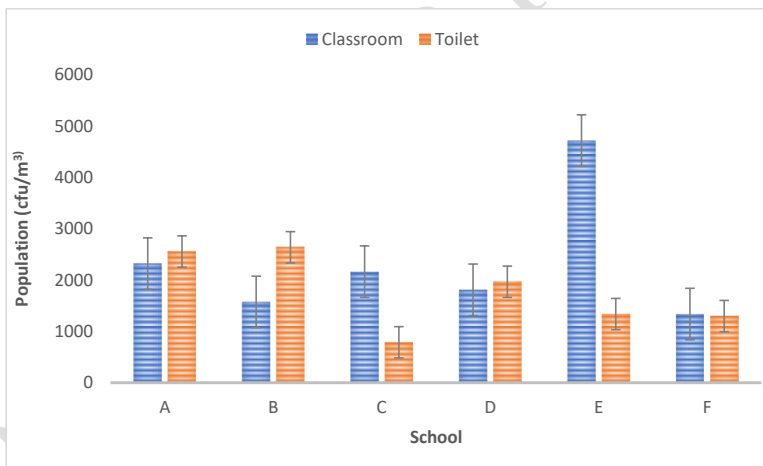
**Figure 1: Frequency of occurrence of bacteria Isolated from schools**



**Figure 2: Frequency of Occurrence of Fungi Isolated from the Schools**



**Figure 3:** Population of bacteria in indoor air of schools in Rivers State



**Figure 4:** Population of fungi in indoor air of schools in Rivers State

### 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 bacteria isolated were identified as belonging to eight genera: Bacillus, Chromobacter, Escherichia, Lactobacillus,

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Micrococcus, Pseudomonas, Serratia and Staphylococcus. The fungal isolates were identified as belonging to eight genera: Alternaria, Aspergillus, Candida, Cladosporium, Microsporium, 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. *Aspergillus* sp. and Mucor sp. occurred more frequently in sampled locations while *Candida* sp., *Rhizopus* sp. and *Microsporium* 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., *Microsporium* 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.

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 *Aspergillus* sp. was found to occur more frequently in the indoor air. 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<sup>3</sup> and 786-2751 CFU/m<sup>3</sup> respectively, while the fungal population ranged from 1336-2319 CFU/m<sup>3</sup> and 786-2637 CFU/m<sup>3</sup>. The microbial population in the school was general high (500-2000 CFU/m<sup>3</sup>) or very high (CFU/m<sup>3</sup>) according to the sanitary standards for non-industrial premises [22]. In an earlier by Dick and Wekhe, [10] the bacterial count in classrooms ranged from 1.33 x10<sup>4</sup>-4.66x10<sup>4</sup> CFU/m<sup>3</sup> while fungal counts ranged from 1.08 x10<sup>4</sup>-2.59 x10<sup>4</sup> CFU/m<sup>3</sup>, which is equally high or very high. Hayleeyesus and Manaye [23] likewise reported high to very 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<sup>3</sup>, 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

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buildings in the public schools. High fungal contamination was also likely due to high atmospheric moisture and humidity in the schools.

### 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 microbial and fungal isolates are of public health significance. These microorganisms pose threats to students as they accumulate overtime and are inhaled.

**Comment [j13]:** Non-industrial  
Please mention the guideline in discussion section with reference

### References

1. Ogugbue CJ, Aniebo M, Akubuenyi C, Felix C. Assessment of microbial air contamination of post processed garri on sale in markets. *African Journal of Food Science*, 2011; 5:500-512.
2. Crow SA, Ahearn DG. Fungal colonization of solid surfaces and the sick building syndrome. Universal Medical Press, San Francisco. 2001; 216-220.
3. Mostafa AM, Al-Fifi ZI, Alawlaqi MM, Al Abboud AM. Indoor air borne fungi in Faculty of Science in Aboarish, Jazan University, Saudi Arabia. *J. Jazan Uni. Appl. Sci. Br.* 2012; 1(2): 26-35.
4. Bayer CW, Downing CC. Indoor humidity in schools with insufficient humidity control, *In: Indoor Air Quality*. American Society of Heating, Refrigerating and Air-Conditioning Engineers Atlanta. 2000;197-200.
5. Naga K, Mohan M, Ramprasad S, Maruthi YA. Microbiological air quality of indoors in primary and secondary schools of Visakhapatnam, India. *Int. J. Curr. Microbiol. App. Sci.* 2014; 3(8):880-887.
6. Enitan SS, Ihongbe JC, Ochei JO, Effedua HI, Adeyemi O, Phillips T. Microbiological

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assessment of indoor air quality of some selected private primary schools in Ilishan-Remo, Ogun state, Nigeria. International Journal of Medical and Health Research. 2017; 3(6): 08-19.

7. Graudenz GS, Oliveira CH, Tribess A, Mendes C Jr, Latorre MR, Kalil J. Association of air conditioning with respiratory symptoms in office workers in tropical climate. Indoor Air. 2005; 15: 62-66.

8. Recer G, Browne M, Hom E, Hill K, Boehler W. Ambient air levels of *Aspergillus fumigatus* and *Thermophilic actinomycetes* in a residential neighborhood near a yard-waste composting facility. Aerobiologia. 2001; 17: 99-108.

9. Schwab CJ, Straus DC. The roles of *Penicillium* and *Aspergillus* in sick building syndrome. Adv Appl Microbiol 2004; 55: 215-238.

10. Dick AA, Wekhe CJ. Microbial Indoor Air Quality in a Secondary School in Port Harcourt City, Rivers State, Nigeria. Appl. Sci. Environ. Manage. 2020; 24 (7) 1289-1292.

11. Faustman EM, Silbernagel SM, Fenske RA, Burbacher TM, Ponce RA. Mechanisms underlying children's susceptibility to environmental toxicants. Environ. Health. Perspex. 2000; 108:13-21.

12. Mbakwem-Aniebo C, Stanley HO, Onwukwe C.D. Assessment of the Indoor Air Quality of Majors' Biological Laboratories in Ofrima Complex, University of Port-Harcourt, Nigeria. J Pet Environ Biotechnol. 2016; 7:4. DOI: 10.4172/2157-7463.1000285.

13. Bergey DH, Holt JG. Bergey's Manual of Determinative Bacteriology. 9<sup>th</sup> Ed. The Williams and Wilkins Company Baltimore. 1994.

14. Cheesbrough M. District Laboratory Practice in Tropical Countries, part 2, second edition, Cambridge University press. New York. 2006.

15. Harrigan WF, McCance ME. Laboratory Methods in Food and Dairy Microbiology",

Academic Press, Cambridge, 1976.

16. Emojevwe V, Okeremeta O. Aerial microbiology of the science building (Ofrima complex) in the University of Port Harcourt. *Advances in Agriculture, Sciences and Engineering Research*. 2013; 3: 809-815.

17. Kim KY, Kimb HT, Kim D, Nakajimad J, Higuchi T. Distribution characteristics of airborne bacteria and fungi in the feed stuff manufacturing factories. *Journal of Hazardous Material*. 2009; 169: 1054-1060.

18. Wayne L, Nicholson N, Munakata GH, Melosh J, Peter S. Resistance of *bacillus* endospores to extreme terrestrial and extraterrestrial environment. *Microbiology and Molecular Biology Reviews*. 2000; 64: 548-572.

19. Whyte P, Collins JD, McGill K, Monahan C, O' Mahony H. Distribution and prevalence of airborne microorganisms in three commercial poultry processing plants. *Journal of Food Protection*. 2001; 64: 388-391.

20. World Health Organization (WHO). *Programme for control of diarrhoeal diseases. 5th Programme Report (1984- 1985) Geneva, WHO Bulletin*. 1984.

21. Boone SA. Significance of fomites in the spread of respiratory and enteric viral disease". *Applied and Environmental Microbiology*. 2007; 73: 1687-1696.

22. Commission of the European Communities. Indoor air quality and its impact on man. Report No. 12. Biological particles in indoor environments. Luxembourg: Commission of the European Communities; 1993.

23. Hayleeyesus SF, Manaye AM. Microbiological quality of indoor air in university libraries. *Asian Pac J Trop Biomed* 2014; 4(Suppl 1): S312-S317.