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Microbial Indoor Air Quality in a Secondary School in Port Harcourt City, Rivers State, Nigeria

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ABSTRACT: The microbial air quality of a Secondary School in Port Harcourt was investigated between 9-9:30am and 2-2:30am employing plate exposure and count method for bacteria and fungi estimation. Results obtained from the study showed that bacteria counts from the school for morning session ranged from 4.8 x 10^3 cfu/m^3 (Library) to 4.07 x 10^4 cfu/m^3 (Staffroom) and for the afternoon 9.8 x 10^3 cfu/m^3 (Library) to 4.66 x 10^4 cfu/m^3 (SS1A Classroom). Fungal counts ranged from 5.68 x 10^3 cfu/m^3 (Library) to 2.07 x 10^4 cfu/m^3 (SS3B Classroom) for the morning sessions and 6.56 x 10^3 cfu/m^3 (Library) to 2.59 x 10^4 cfu/m^3 (SS3B Classroom) for the afternoon session. Seven bacterial species, *Bacillus* spp., *Enterococcus* spp., *Escherichia coli*, *Micrococcus* spp., *Pseudomonas* spp. *Staphylococcus aureus* and *Serratia* spp and six fungal species, *Alternaria* spp., *Aspergillus niger*, *Candida* spp., *Mucor* spp., *Penicillium* spp., and *Rhizopus* spp were isolated. The bioaerosol concentrations were higher than recommended limit regardless of the sampling sessions. The high microbial counts and identified bacterial and fungal species may pose a serious problem to learning.

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Indoor air quality (IQA) is becoming an increasingly important issue for occupational and public health (Dudzinska, 2011). The quality of indoor air is one of the most significant factors affecting the health and well-being of people who inhale at least 10m of the air every day, and spend between 80-95% of their lives indoors (Dacarro *et al*., 2003). The air inhaled by people is abundantly populated with microorganisms which form so-called bioaerosol (Wojtatowicz *et al*., 2008). Major indoor biological air pollutants are bacteria and fungi (moulds and yeasts). Microbes are launched into the air via human, animals, vegetation and could be deposited on surface (Shiaka and Yakubu, 2013). According to Stryjakowska-Sekulska *et al*. (2007), indoor air microflora may be detrimental to human health and can induce allergies. Incidence of bacteria and fungi in large number in indoor reveals that air may cause irritation of mucous membranes, bad physical condition, tiredness, headaches, decrease of concentration, memory and intellectual work abilities (Moritz *et al*., 2001).

Microbial air quality in classrooms is of special concern for students, particularly those sensitive to poor air quality, since children spend a time period of nearly 7 to 8 hours in a day in the school environment. These problems can be subtle and do not always produce easily recognisable impacts on the health and welfare of population (Montgomery and Kalman, 1984).

Overcrowded classroom with students more than the prescribed are common sight in public schools within the city of Port Harcourt and tends to alter indoor air quality, which further effects students' health. Therefore, the goal of this study is to assess the microbial air quality in a Secondary School, in Port Harcourt, Rivers State, Nigeria

MATERIALS AND METHODS

The study was carried out in a Science Secondary School in Port Harcourt, Rivers State, Nigeria. In the school, the sampling areas are classrooms (SS1A, 1B, 1C, SS2A, 2B, 2C, SS3A, 3B), staffroom, corridor leading to offices, Library and entrance into building.

For the enumeration of bacteria, Nutrient Agar was used, while Sabouraud Dextrose Agar was used for fungi. The Petri dishes containing appropriate media were exposed to air for thirty minutes. The sample collection was done in two regular intervals of a day. The first set of Petri-dishes containing appropriate medium were exposed at the sampling area as class work commence (9-9:30pm) and the same was

repeated in the afternoon for the second set (2-2:30) (Mostafa *et al*., 2012). After exposing to the indoor air, the Petri dishes containing medium were transferred to the Laboratory and incubated at ambient temperature on the laboratory bench for 24 to 48 hours for bacteria and 3-5days for fungi. The average of colony forming units (cfu) of both bacteria and fungi was calculated and converted to organisms per cubic metre of air (Stryjakowska-Sekulska *et al*., 2007)

$$cfu/m3 = a10000/p.t.0.2$$

Where: a = the number of colonies on the petri dishes; p = surface of the petri dishes; t = the time of petri dish exposure

RESULTS AND DISCUSSION

The total heterotrophic bacterial count obtained from the Science School is shown in Table 1. The lowest count was 4.8 x 10^3 cfu/m^3 obtained for library while the highest count of 4.07 x 10^4cfu/m^3 was obtained for staffroom for the morning session. During the afternoon session, the highest count of 4.66 x 10^4 cfu/m^3 was obtained for Senior Secondary 1A (SS1A) classroom while the lowest count of 9.8 x 10^3 cfu/m^3 obtained for library. The high bacteria counts observed in the staffroom may be due to its busy nature, while the lowest count in the library may be due to little or no activity within the library, in addition to its location on the second floor of a separate building. The bacterial counts from this exceeds the recommended limit of 10^3 cfu/m^3 suggested by National Institute of Occupational Safety and Health (NIOSH), The American Conference of Governmental Industrial Hygienists (ACGIH) (500 cfu/m^3) (Kalogerakis *et al*., 2005) and Residential Limit Values of 250 cfu/m^3 for bacterial concentrations, (Gorny and Dutkiewiez, 2002). The variation of bacterial load in indoor environments might be due to environmental factors such as ventilation system of classroom, temperature, humidity, and particulate matter concentration (Andualem *et al*. 2019). In addition, the activities of students such as playing, running could also have contributed to bacterial counts. For fungal count in the Science School, the lowest count was 5.68 x 10^3 cfu/m^3 obtained for the library and the highest count of 2.07 x 10^4 cfu/m^3 was obtained in Senior Secondary 3B (SS 3B) Classroom for the morning session. During the afternoon session, the highest fungal count of 2.59 x 10^4 cfu/m^3 was obtained for staffroom while the lowest count of 6.56 x 10^3 cfu/m^3 was obtained for the library (Table 2).

Table 1: Concentration of Bacteria Population in Indoor Air of Niger Delta Science School, Port Harcourt (cfu/m^3)

Study Area	Sampling Time/cfu/m^3	
	Morning (9-9:30am)	Afternoon (2-2:30pm)
SS1A	2.32x10^4	4.66x10^4
SS1B	2.97 x10^4	4.23 x10^4
SS1C	2.54 x10^4	1.57 x10^4
SS2A	1.4 x10^4	2.91 x10^4
SS2B	3.29 x10^4	3.10 x10^4
SS2C	1.33 x10^4	2.75 x10^4
SS3A	2.68 x10^4	3.91 x10^4
SS3B	3.41 x10^4	3.00 x10^4
Staffroom	4.07 x10^4	3.27 x10^4
Corridor	3.85 x10^4	3.40 x10^4
Entrance	2.10 x10^4	2.20 x10^4
Library	4.80 x10^3	9.80 x10^3

Table 2: Concentration of Fungi Population in Indoor Air of Niger Delta Science School, Port Harcourt (cfu/m^3)

Study Area	Sampling Time/cfu/m^3	
	Morning (9-9:30am)	Afternoon (2-2:30pm)
SS1A	1.63 x10^4	1.70 x10^4
SS1B	1.65 x10^4	1.55 x10^4
SS1C	1.42 x10^4	1.66 x10^4
SS2A	6.96 x10^3	1.60 x10^4
SS2B	9.50 x10^3	1.16 x10^4
SS2C	1.63 x10^4	1.08 x10^4
SS3A	1.63 x10^4	2.59 x10^4
SS3B	2.07 x10^4	1.72 x10^4
Staffroom	1.30 x10^4	7.64 x10^4
Corridor	1.75 x10^4	1.52 x10^4
Entrance	2.42 x10^4	1.89 x10^4
Library	5.68 x10^3	6.56 x10^3

The dry season period might have influenced the high count recorded within the school. The fungal counts also exceed the recommended limit of 10^3 cfu/m^3 proposed for fungal concentrations in the air (Gony

and Dutkiewiez, 2002). Naga *et al*. (2014) traced the sources of classroom airborne contamination to several factors such as student's own normal floral, uniforms, bags, foot-wears as well as activities such like sneezing, coughing, talking and talking and yawning. Faustman *et al*. (2000) also reveals that materials in the classrooms and offices such as cupboards, books and files have been implicated as viable sources; and these were present in the school under study. The students and staff undertake a lot of housekeeping activities such as sweeping or applying dry mops can also create aerosols carrying particles that may contain microorganisms.

The identified bacterial general are *Bacillus* spp., *Enterococcus* spp., *Escherichia coli*, *Micrococcus* spp., *Pseudomonas* spp. *Staphylococcus aureus* and *Serratia* spp. The identified isolates are in part agreement with Udochukwu *et al*. (2015), who reported also *Bacillus* sp., *Enterococcus* spp., *Micrococcus* spp., *Serratia* spp. and *Staphylococcus* spp. Similarly, it agrees with the report of Kumar *et al*. (2015) on *Escherichia coli*, *Pseudomonas*, *Staphylococcus* species.

The identified fungal genera are *Alternaria* spp., *Aspergillus niger*, *Candida* spp., *Mucor* spp., *Penicillium* spp., and *Rhizopus* spp. These outcomes are in full agreement with Enitan *et al*. (2017). Still, it agrees with the reports of Solo *et al*. (2009) on *Alternaria* spp., *Aspergillus niger*, *Penicillium* spp., and *Rhizopus* spp. The study therefore opines that the occupants within the sampled enclosures are frequently exposed to health hazards associated with these bioaerosol.

In agreement with Enitan *et al*. (2019), the results of this work has shown clearly that notwithstanding the session of the day, the indoor environment seems to allow bioaerosols to build up and this could serve as possible risk factors for the quick spread of infections within the secondary school classrooms under study. This study also agrees with Andualem *et al*. (2019) that attention should be given to controlling any physical factor which will favours growth and multiplying of bacteria within the indoor environment of the classrooms under study with the aim of safeguarding the health of students and teachers in the secondary school.

Generally, the information on the microbial air quality in the Science Secondary School, Port Harcourt would aid in alerting the School Authority of potential hazards and its resultant effect on academic activities.

Conclusion: From this study, it is concluded that the bacterial and fungal counts were higher than stipulated guidelines notwithstanding sampling in the morning and afternoon sessions within the school, with the identification some pathogenic microorganisms.

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