



## **Fungal Pollution of Indoor Air of Some Health Facilities in Rivers State**

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### **Authors' contributions**

*This work was carried out in collaboration between both authors. Author SID supervised the study. Author VKR designed the study, performed the work, statistical analysis, wrote the protocol, managed the analyses and literature searches of the study and wrote the first draft of the manuscript. Both authors read and approved the final manuscript.*

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### **ABSTRACT**

**Aims:** Investigating the fungal pollution within the indoor air of two government health facilities.  
**Study Design:** The study sites (wards) were the four most used wards. One hundred and ninety-two air samples were collected in two sampling periods (morning and evening).  
**Place and Duration of Study:** Samples were collected from four study sites (wards) each of two different primary Health centres; the Orowurukwo Primary Health centre and the Rumuigbo Primary Health centre. The GPS of these areas are 4.806°N, 6.992°E and 4.850°N, 6.991°E respectively. The study sites were the postnatal, children, injection and outpatient wards. This was a three months study (January-March).  
**Methodology:** The plate exposure technique was used in the collection of air samples. Freshly prepared Sabouraud Dextrose agar plates in duplicates were left open above one meter in the various study sites for 15 minutes. Collected samples were transferred to the Microbiological Laboratory and incubated at 20-25°C for 3-7 days. After incubation, fungal populations were enumerated and distinct isolates were purified by subculturing onto fresh SDA plates. The purified isolates were used for characterization.

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**Results:** Five fungal genera which include *Aspergillus*, *Candida*, *Penicillium*, *Rhizopus*, and *Mucor* species were isolated and identified. The fungal loads in  $\log_{10}\text{sfu/m}^3$  ranged from 2.42 to 2.51 and 2.23 to 2.55 for morning and evening sampling hour in the Oroworukwo Health centre respectively. While those of the Rumuigbo ranged from 2.23-2.39 and 2.37-2.50 in the morning and evening sampling hours respectively. The statistical insignificant difference was reported in the  $\text{sfu/m}^3$  of the two sampling hours at  $P=0.05$ .

**Conclusion:** The fungal load in this study was very high when compared with other studies. Also, the species of fungi in this study are pathogenic and could cause delay recovery especially in immuno-compromised patients.

**Keywords:** Health facility; fungi; indoor air; plate exposure; fungal pathogens; nosocomial infections.

## ABBREVIATIONS

CHW : Children Ward,  
OPW : Outpatient Ward,  
PNW : Postnatal Ward,  
IJW : Injection Ward,  
A : *Aspergillus*,  
Sp : Species  
ANOVA : Analysis of Variance

## 1. INTRODUCTION

Changes in ways of life have led to a drift from an open air environment to an enclosed environment that is supported by energy efficient systems in our homes and work places [1]. Sick building syndrome which is a condition where inhabitants within the building suffer serious health problems due to the amount of time spent within this environment has been attributed to poor building design, lack of maintenance of buildings as well as the activities within such environments [2,3]. A complex environment such as the health care facilities require proper or adequate ventilation not just for the comfort of patients or staffs but also to aid in controlling the emission of hazardous biological substances [4,5]. The microbiological quality of air in these environments should be a major concern to all since patients could be the source through which pathogenic microbes are transmitted to staffs, visitors including fellow patients [6]. The air is not a natural medium for microorganisms. It serves as a carrier of particles, dust and droplets which contaminates it [7]. The closest environment to human is the indoor environment. This area is characterized by daily interactions since most of the time is spent within this environment. In some parts of the world, our homes, schools as well as offices have been reported to be contaminated with airborne moulds including other biological contaminants such as fungi, bacteria, viruses, pollen, etc. many species of fungi are able to

proliferate in any environment that is moist and has an organic substrate [8]. The ceiling tiles, wood, paints, carpet rugs, are building and finishing materials which present good room for fungi growth [8]. Good air quality within an indoor environment especially in healthcare institutions is very much important and should be given much attention. According to Mahmoud et al. [9], good air quality will protect workers as well as patients from contracting nosocomial infections. Health challenges ranging from respiratory abnormalities, hypersensitivity, pneumonia and toxic reactions have been reported to arise when by products of biological materials come in contact with man [10]. Studies conducted by various researchers have revealed that presentation to *Aspergillus* species and *Fusarium* species could cause respiratory infections in people with traded off immune system. [6,11,12,13,14,15]. Also, immune impaired persons who spend lots of time in an indoor environment which is contaminated with fungi could develop serious fungal infections [16,1]. The evaluation of the fungal pollution in health centres in Rivers state, Nigeria is scarce. Thus, this study is justified.

## 2. MATERIALS AND METHODS

### 2.1 Study Area

The study was carried out in two locations (Primary Health care centres in Rivers state). The two health centres included in this study are the Oroworukwo Model Primary Health care and the Rumuigbo Primary Health care. The GPS coordinates are given as 4.806°N, 6.992°E and 4.850°N, 6.991°E respectively. The Oroworukwo Primary Health care is located behind the mile 3 market in Port Harcourt City Local Government. The Rumuigbo Primary Health care is located in Rumuigbo of Obio-Akpor Local Government. There are about 8 wards of which 4 are the most



**Plate 1. Overlaid plates of fungal genera on Sabouraud dextrose agar plate**

used. These wards which represent the study sites include postnatal ward, outpatient ward, injection/immunization ward and the children ward.

## 2.2 Microbiological Analysis of Indoor Air

The plate exposure method as described by Wemedo and Robinson [7] was adopted. A total of 192 freshly prepared plates of Sabouraud Dextrose Agar (SDA) (TM media, India) containing tetracycline were used to collect air samples. Duplicate plates were exposed to the atmosphere of the various study sites 1 m above the ground for 15 minutes. After sampling, plates were covered and transported to the Microbiology Laboratory for incubation at 20-25°C for 3-7 days. The study was for a period of three months and samples were collected between two sessions of the day (morning and evening periods). The morning session is the peak of work activities while the evening was after work activities. This was done to compare the microbial loads between the morning and evening periods.

## 2.3 Enumeration of Fungal Population

After incubation, respective plates showing fungal growth were properly counted and the spore forming unit per cubic meter (Sfu/m<sup>3</sup>) was evaluated using the Koch's sedimentation formula adopted by Latika and Ritu [17], Wemedo and Robinson [7]. The formula is described below;

$$A = \frac{a \times 10^4}{0.2 \times \pi r^2 \times t}$$

A= Sfu/M<sup>3</sup>

a= average number of colonies

r = radius of Petri dish

t = time of exposure of the plate

## 2.4 Isolation and Identification

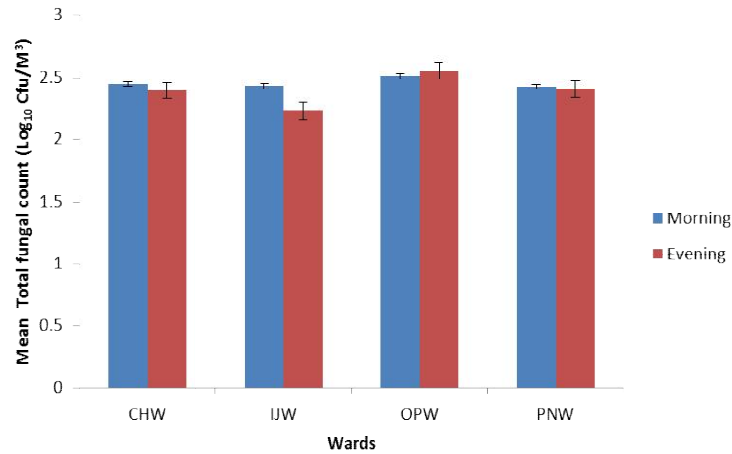
Discreet colonies were further subcultured onto freshly prepared SDA plates. This was used for identification. Cultural characteristics (appearance on plates) and microscopy were adopted for identification of various fungal genera. Mycological text books and manuals were also used to enhance proper identification [8].

## 3. RESULTS AND DISCUSSION

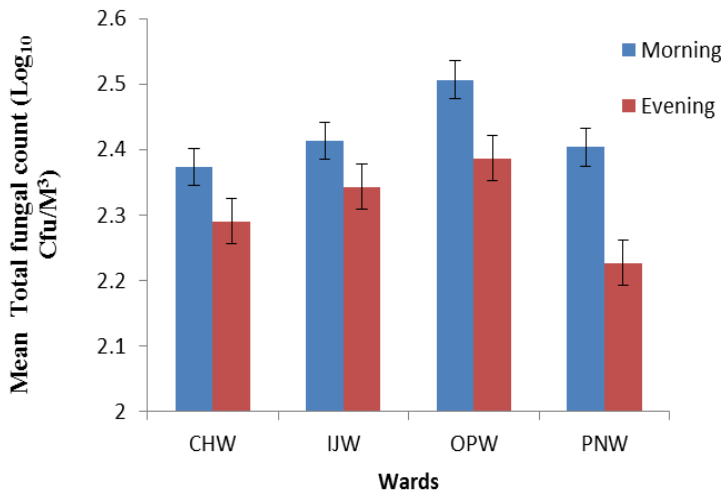
The quality of indoor air in health institutions as regards to its microbiological quality is of much concern due to the potential severity of the impact of nosocomial infections [18]. In this study, approximately one hundred and ninety-two air samples were analyzed to evaluate the fungal loads as well as the types of fungi found within the various study sites. The result from this study revealed high fungal loads both in the morning and evening sampling periods in the two different locations. The fungal loads were not uniform in all the study sites (Fig. 1). It was also observed that higher fungal counts were recorded in the morning sampling hours from the children ward, injection ward and postnatal ward than in the evening sampling hours (Fig. 1). The mean fungal count in log<sub>10</sub> Sfu/m<sup>3</sup> of the morning sampling hour (10 am) ranged from 2.42 to 2.51 and the evening (6 pm) ranged from 2.23 to 2.55 (Fig. 1), while for the second location, the fungal loads ranged from 2.23 to 2.39 for the morning sampling hour and 2.37 to 2.50 for the evening

sampling hours respectively (Fig. 2). In the second study location, higher fungal loads were recorded during the morning sampling hours than the evening sampling hours (Fig. 2). The high fungal loads observed in the morning sampling hours in both locations could be attributed to the continuous and varying activities taken place. The morning sampling hours was observed to be the peak of work activities in which sensitization is being carried out while some patients are being attended to others including visitors are settling in. this is in conformity with other studies that reported that increased microbial loads or populations is related to the number of persons within such building, their activities, as well as

their health conditions [19,20] as normal or transient flora, could be disseminated into the ambient air of such building. Also the equipment used for cleaning and the type of cleaning products, ventilation systems and also personal activities could contribute to the fungal load [17]. ANOVA without replication revealed no statistically significant differences between the  $S_{fu}/m^3$  of the morning and evening sampling hours of the various study sites in the two locations at  $P = 0.05$ . This is in conformity with Quidiesat et al. [18] who reported that no significant difference was observed between the mornings and evening sampling hours of fungal loads in a private hospital.



**Fig. 1. Mean fungal load of morning and evening sampling hours in the Orowurukwo health centre**



**Fig. 2. Mean fungi load of the morning and evening session of the Rumuigbo PHC**

**Table 1. Frequency of occurrence of fungi in the four wards of the Orowurukwo primary health care (%)**

Isolates	CHW	OPW	PNW	IJW
<i>Aspergillus niger</i>	14.3	35.7	21.4	28.6
<i>Aspergillus fumigatus</i>	0	50	16.7	33.3
<i>Aspergillus flavus</i>	13.6	27.3	18.2	40.9
<i>Candida</i> species	0	0	70	30
<i>Mucor</i> species	11.1	38.9	27.8	22.2
<i>Penicillium</i> species	17.4	43.5	13.0	26.1
<i>Rhizopus</i> sp	13.0	47.8	8.7	30.4

Keys: CHW: children ward, OPW: outpatient ward, PNW: postnatal ward, IJW: injection ward

**Table 2. Table Frequency of occurrence of fungi in the four wards of Rumuigbo primary health care (%)**

Isolates	CHW (%)	OPW (%)	PNW (%)	IJW (%)
<i>Aspergillus niger</i>	20	40	13.3	26.7
<i>Aspergillus fumigatus</i>	0	33.3	16.7	50
<i>Aspergillus flavus</i>	10	30	20	40
<i>Candida</i> species	25	0	41.7	33.3
<i>Mucor</i> species	0	50	25	25
<i>Penicillium</i> species	11.1	33.3	22.2	33.3
<i>Rhizopus</i> species	33.3	25	0	41.7

Keys: CHW: children ward, OPW: outpatient ward, PNW: postnatal ward, IJW: injection ward.

*Aspergillus niger*, *Aspergillus flavus*, *Aspergillus fumigatus*, *Candida* sp, *Mucor* sp, *Penicillium* sp, and *Rhizopus* sp were the fungi isolated from the various study locations (Tables 1 and 2) respectively. The percentage occurrence of the fungal isolates is represented in Tables 1 & 2. In Table 1, *Aspergillus niger*, *Aspergillus flavus*, *Mucor*, *Penicillium* sp, and *Rhizopus* sp were all present in the four study sites while *Candida* sp was heavily present in the postnatal ward and the injection ward. *Aspergillus fumigatus* was the dominant fungi in the outpatient ward. Likewise, in Table 2, *Candida* sp was the dominant fungi in the postnatal ward. This was anticipated in the sense that *Candida* sp are normal flora of the vagina, there dominating presence in this area could be attributed to the activities in this ward. The fungi isolates in this study have been isolated by previous scholars [17,18]. The fungal isolates in this study could be pathogenic and serve as a cause of nosocomial infections. These species have been reported by previous scholars [17,18,21,22]. The presence of fungi in the inhaled air is not new and many persons could inhale it without falling ill due to their immune strength. But in patients or persons with compromised immune system, infections could occur. Hospital mortality caused by invasive aspergillosis (acquired by inhalation of dust particles contaminated with fungi spores) has been reported [23]. *Candida* species could also

cause candida infections. Also *Penicillium*, *Mucor* and *Rhizopus* could also invade patients and cause serious infections or allergies.

#### 4. CONCLUSION

Knowing the quality of indoor air especially of the Health Facilities is very vital as this could help in assessing the cleanliness and the infrastructure used in this areas. The fungal species in this study are known pathogens associated with nosocomial infections. Also, the fungal loads in the various study location are very high. Proper ventilation, good hygiene and good cleaning agents as well as decentralizing crowded space could increase the quality of indoor air.

#### CONSENT AND ETHICAL APPROVAL

Ethical approval to undertake the study was sort and obtained from the Rivers State Primary Health Care Management board and the informed consent form was obtained from the medical officer of Port Harcourt City Local Government and Obio/Akpor Local Government area.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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