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Comparative Mycological Analysis of Different Indoor Floor Types in Bayelsa State, Nigeria.

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ABSTRACT

Background: Fungal contamination in indoor environments has been associated with various adverse health effects, particularly respiratory diseases.

Methods. This study aimed to determine the populations of the fungal species related with four different floor types (rug, carpet, tile, and vinyl) in an indoor environment. A total of sixteen (16) samples were examined. The total fungal population was enumerated using the pour plate method on Potato Dextrose Agar.

Results: The mean (mean ±STD) fungal population in the tile samples ranged from 4.0± 1.52 to 19± 1.52. The carpet samples ranged from 6.0 ± 4.16 to 19 ± 1.52; the vinyl samples ranged from 3.33 ± 1.52 to 16 ± 1.15. The rug samples ranged from 7.3 ± 1.152 to 18 ± 3.00. The analysis of variance (ANOVA) indicates positive and significant statistical differences between the fungal populations on the various floor types. In this study, seven different fungal species were identified: *Penicillium* spp, *Yeast spp., Aspergillus* spp., *Rhizopus* spp., *Fusarium* spp., *Trichophyte* spp., and *Mucor* spp. These species were detected in almost all the floor types. However, *Fusarium* spp. was not found on carpet floors, while *Trichophyte* spp. was not found on carpet, vinyl, or rug floor types. The seven species detected recorded varying degrees of occurrence. *Aspergillus spp.* (33%), *Yeast spp.* (16%), *Penicillium* spp. (13%), *Rhizopus spp.* (13%), *Mucor spp.* (13%), *Fusarium spp.* (11%), and *Trichophyte spp.* (1%).

Conclusion: This study demonstrates that the populations and types of fungal species on floors depend on the type of floor covering. Therefore, floor coverings should be properly cleaned at regular intervals to reduce the accumulation of dust and fungal species.

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INTRODUCTION

People spend much time indoors, especially in residential and commercial settings. Therefore, indoor air quality (IAQ) is essential for their health and comfort. Fungal contamination can negatively impact indoor air quality (IAQ) and is a significant source of indoor air pollution. There are several potential internal and external sources of fungal contamination in indoor environments. According to Mendell *et al*. (2011), internal sources of moisture problems include water leaks, condensation, and high humidity levels, which foster the perfect environment for the growth of fungi. By permitting the buildup of dust and organic waste, which act as nutrients for fungal development, poorly maintained ventilation systems can also lead to fungal contamination ((Daokoru-Olukole and Olanbiwoninu, 2019; Burge, 2014; Kembel *et a*l., 2012).

According to Hospodsky *et al*. (2014), outside air, dirt, and organic materials transported inside by windows, ventilation systems, and human activity are outside sources of fungal contamination. Many fungal spores can be found in the outside air, penetrating indoor environments and adding to the overall fungal load (Mendell *et al*., 2011). Additionally, soil and organic materials can bring fungal propagules into indoor environments, especially in structures near outside vegetation or with direct ground contact (Adhikari *et al*., 2016; Daokoru-Olukole, 2019).

Several factors foster an environment conducive to fungal growth and determine the survival and growth of fungal species in indoor environments (Adams *et al*., 2013) These include temperature, availability of nutrients, moisture and relative humidity, occupancy and human activity, indoor air quality (IAQ) factors (ventilation, air exchange rates, and air filtration), and building materials (Mendell *et al*., 2011).

Numerous health consequences, including allergic reactions and respiratory issues, can result from indoor exposure to fungal pollutants. In vulnerable people, inhaling fungal spores and mycelial fragments can cause allergic rhinitis, exacerbations of asthma, and hypersensitivity pneumonitis (Pasanen *et al.,* 2011; Green *et al.,* 2007). People with weakened immune systems, including those receiving chemotherapy or living with HIV/AIDS, are more vulnerable to *Aspergillus* species-caused invasive fungal infections (Mendell *et al*., 2011).

These infections have significant rates of morbidity and mortality and can present as severe lung infections, sinusitis, or disseminated infections. Furthermore, human health may suffer from exposure to mycotoxins generated by specific fungal species, such as *Aspergillus.* For instance, the potent carcinogens known as aflatoxin generated by *Aspergillus flavus* and *Aspergillus parasiticus* have been connected to the onset of liver cancer (Bennett & Klich, 2003). Other mycotoxins linked to nephrotoxicity, immunosuppression, and other adverse health effects include gliotoxin and ochratoxins (Samson *et al*., 2014).

The degree of indoor fungal contaminants in the air is related to the kind of floor used in interior spaces (Hedayati *et al*., 2010; Viegas *et al.,* 2014). Therefore, this study was conducted to investigate the fungal populations in four different floor types: tiles, carpet, vinyl, and rug. This study will provide insight on the types of fungal species and their concentrations on different floor types, thereby creating a baseline data for analysing the potential health risks associated with indoor dust.

MATERIALS AND METHODS

Sampling

This study was conducted in Ekeki, Amassoma, Kpansia, and Swali, Bayelsa State, between April and May 2023, just at the onset of the rainy season. Four floor types were sampled: tiles, carpet, vinyl, and rug. All the floor types were collected in each location. A total of sixteen (16) samples were collected from this study.

Mycological Analysis

One (1) gram of the dust samples was weighed using ab electronic weighing balance. The samples were poured into test tubes containing 100ml of 0.85% normal saline. After that, a ten-fold serial dilution was performed up to the fourth dilution. The fungal populations were cultivated on Potato Dextrose Agar using the second dilution. The plates were incubated at 30ºC temperatures for five days. After incubation, the plates were observed for the number and types of fungal colonies.

Identification of Fungal Species

The plates were examined for the morphological characteristics of the fungal colonies. The macroscopic observation used a hand lens aimed at determining the fungal culture's shape, growth, and color. The examination and microscopic examination of fungal isolates require the observation of microscopic features such as shape, size of hyphae, shape of sporangia, conidia, conidiophores, and spores.

Using a flamed inoculating needle, the edge of each colony is picked, and slides of the different colonies are made. A drop of lacto-phenol cotton blue stain is added to the slides, covered with a cover slip, and examined under the microscope using x100 and x400 magnification starting from the third day of the culture. The microscopic characteristics observed were recorded accordingly.

Statistical Analysis

The population of fungal species in the various floor types was assessed using descriptive statistics (mean) and analysis of variance (ANOVA) at a level of p<0.05 to determine a positive significant statistical difference. The prevalence of fungal species was described using frequency and percentage of occurrence.

RESULTS

The results show that the fungal population in the different floor samples varies Table 1. Four different floor types were analyzed in four different locations. A total of sixteen (16) samples were examined. The fungal population in the tile samples ranged from 4.0 ± 1.52 to 19 ± 1.52. The carpet samples ranged from 6.0 ± 4.16 to 19 ± 1.52; the vinyl samples ranged from 3.33 ± 1.52 to 16 ± 1.15. The rug samples ranged from 7.3 ± 1.152 to 18 ± 3.00. The analysis of variance (ANOVA) indicates positive and significant statistical differences between the fungal populations of the various floor types.

Table 1: Comparison of Fungal Populations between Flooring Materials

Locations	Tiles Mean ± STD	Carpet Mean ± STD	Vinyl Mean ± STD	Rug Mean ± STD	p-Value
Ekeki	4.0 ± 1.5^{a}	19 ± 1.5^{b}	2.0 ± 0.0^{c}	10 ± 1.1^{ab}	.00
Amassoma	19 ± 1.5^{a}	6 ± 4.1^{b}	7.0 ± 2.6^{c}	11 ± 1.1^{ab}	.00
Kpansia	14 ± 3.7^{a}	4.0 ± 2.5^{b}	3.33 ± 1.5^{c}	16 ± 1.1^{ab}	.00
Swali	12 ± 3.7^{a}	18 ± 3.0^{b}	7.3 ± 1.1^{c}	9.3 ± 1.5^{ab}	.00

Mean in the same row bearing different alphabets indicates significant statistical difference (p<0.05) and vice versa.

The seven species were detected, and varying degrees of occurrence were recorded. *Penicillium spp* (13%), *Yeast spp* (16%), *Aspergillus spp* (33%), *Rhizopus spp* (13%), *Fusarium spp* (11%), *Trichophyte spp* (1%), and *Mucor spp* 13%) respectively. Therefore, *Aspergillus spp* (33%) recorded the highest percentage of occurrence with two species, *A. niger* and *A. flavus*; while the least was recorded by *Trichophyte spp* (1%).

Table 2: Identification of fungal species.

Fungal species	Cultural Features	Microscopic Features
Penicillium spp	Woolly green colony	Hyphae septate, branched conidiophores
Yeast spp	Flat, smooth, glistering cream colony	Blastoconidia present. Hyphae is absent
Aspergillus niger	Woolly colonies appear white then Turn dark,	Flask shaped conidiophores conidio surface is very rough irregular.
Aspergillus flavus	Yellow to green colony surface spherical	Smooth finely roughened conidia surface
Rhizopus spp	White and cotton-like colonies	Aseptate mycelium
Fusarium spp	White cottony colonies	Smooth mycelium branches and cylindrical. Septate
Trichophyte spp	Brown Suede-like colonies	Slender clavate microconidia
Mucor spp	whitish colonies	hyphae are septate

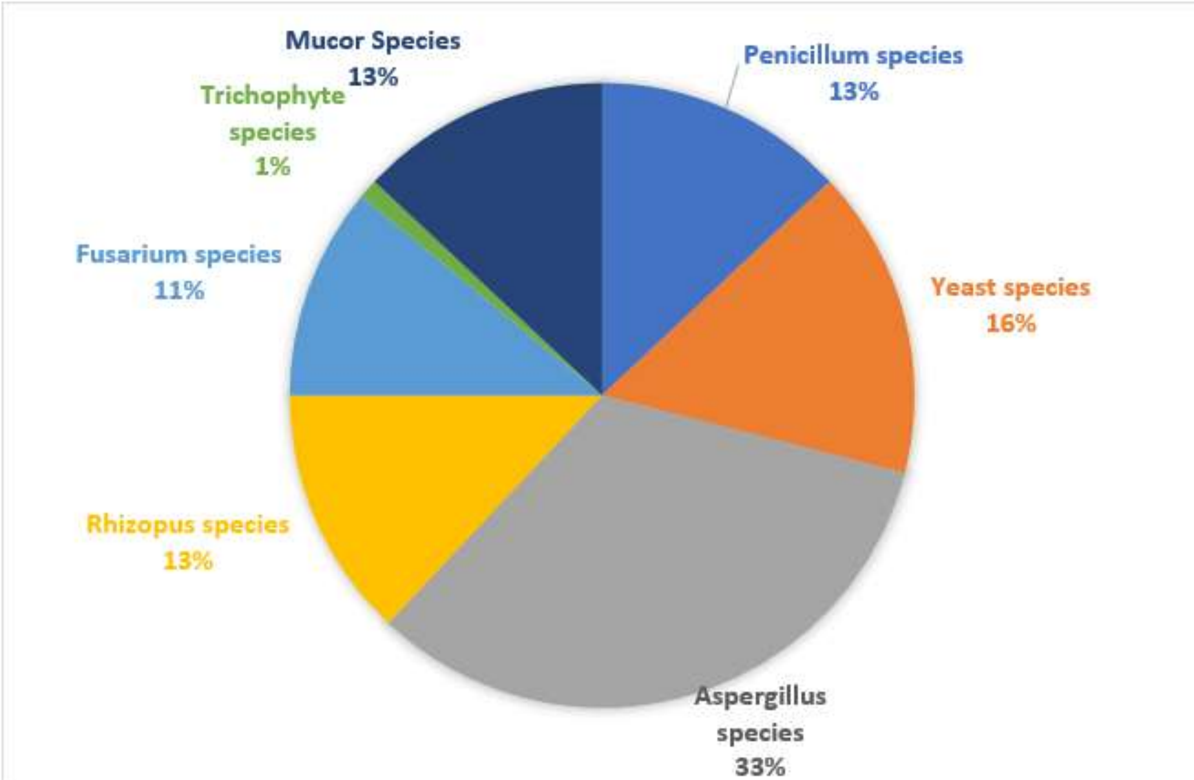

Figure 1: Percentage of occurrence of fungal isolates.

The identification of the fungal species was done based on the cultural features and microscopic features. Seven different fungal species were identified; *Penicillium* spp*., Yeast* spp*., Aspergillus* spp*., Rhizopus* spp*., Fusarium* spp*., Trichophyte* spp*.,* and *Mucor* spp*.*

DISCUSSION

This study aimed to ascertain the number of fungus species present in different types of floors. The findings indicate notable differences in the fungal populations among the various floor samples. However, we also noticed geographical differences in the fungus species populations linked to floor types. For instance, the largest fungal population (19 ± 1.52) was found in the dust collected from carpets in locations 1 and 4, whereas the highest fungal population (19 ± 1.52) was found in the tile samples in locations 2 and 3. The analysis of variance (ANOVA) results show that the fungal populations of the different floor types differed statistically in a positive way.

The variances observed in the fungal population may be due to several factors. According to Mendell *et al*. (2011), a significant number of fungal spores can be found in outdoor air, which can penetrate indoor environments and increase the overall fungal load. Additionally, soil and organic materials can bring fungal propagules into indoor environments, especially in structures near outside vegetation or with direct ground contact (Adhikari *et al*., 2016).

Furthermore, there have been reports that the kind of floor may affect the number of fungus species. As a result, we propose that the greater the floor type's capacity to retain dust, the greater the number of fungi that will grow there since more dust particles will provide abundant nutrients for their growth. Hospodsky *et al*. (2014) found that *Aspergillus* species need organic resources to proliferate, which is consistent with this theory. Building materials, including wood, and plasterboard, can act as a source of nutrients for the growth of fungi (Burge, 2014). Fungi can also obtain nutrients from organic waste, dust, and biofilms that are present on surfaces of house furniture's (Ahmed *et al*., 2011) and floor coverings (Hospodsky *et al.,* 2014).

Seven distinct fungal species were identified: *Penicillium,* Yeast, *Aspergillus*, *Rhizopus,* Fusarium, *Trichophyte*, and *Mucor.* These species were found on practically every kind of floor. However, *Trichophyte* species were not detected on carpet, vinyl, or rug floor types, whereas Fusarium species were not detected on carpet floors.

The seven species that were found were noted in different levels of occurrence. *Aspergillus* spp. (33%), *Rhizopus* spp. (13%), *Fusarium* spp. (11%), *Trichophyte* spp. (1%), *Penicillium* spp. (13%), and Yeast spp. (16%), in that order. As a result, *Aspergillus* species (33%) had the highest percentage occurrence and *Trichophyte* species (1%) recorded the lowest percentage of the occurrence. A variety of factors can explain the combined frequency of *Aspergillus* species.

The result of our study is in agreement with the findings of Diba et al., (2007) that showed the higher amount of air borne spore of *Aspergillus* species in all the floor types. *A. niger* and *A. flavus* were the two *Aspergillus* species isolated from floor types and our study data showed *A. niger* as the most predominantly isolated species.

Aspergillus species can flourish in various environments, including soil, decomposing plants, indoor dust, and organic materials, according to Araujo and Rodrigues (2004). They also have a wide range of growth requirements. According to Hedayati *et al.* (2010), they are incredibly tolerant to high moisture or humidity levels (Dannemiller, 2017), creating the perfect environment for their proliferation and sporulation. In light of this, we hypothesize that floor types will best favour *Aspergillus* species development with the highest humidity and moisture retention levels. In a similar study, the presence of *Aspergillus* species in dust samples taken from Portuguese school libraries was examined by Madureira et al. (2017). *According to the study, A. fumigatus* and A. *versicolor* were the most frequently found species gathered air samples from several rooms in residential buildings for a different study. The findings demonstrated the prevalence of *Aspergillus* species in indoor air, with *A. fumigatus* and *A. versicolor* being the most often detected species which is contrary to our findings where *A. niger* and *A. flavus* were most detected in our study.

The detection and monitoring of *Aspergillus* species in indoor environments are crucial for assessing the risk of exposure and putting appropriate control measures in place. Exposure to fungal contaminants in indoor environments can result in various health effects (Alshareef *et al*., 2019), particularly respiratory problems and allergic reactions. This is because different types of floors are more likely to contain different fungal species (Daokoru-Olukole and Olanbiwoninu, 2019). In vulnerable people such as immunocompromised patients inhaling fungal spores and mycelial fragments can cause allergic rhinitis, exacerbations of asthma, and hypersensitivity pneumonitis (Pasanen *et al*., 2011; Green *et al*., 2007).

The predominance of *Aspergillus* species on all the floor types is of high pathological importance, and are known for their ability to secrete biologically active chemical compounds such as mycotoxins, antibiotics, and immune-suppressants (Goldman and Osmani, 2007). *A. niger*, also known as black mold can contaminate fruits and vegetables. During sweeping or cleaning of the floor covers dust particles can be re-suspended and will eventually settle on any uncovered food where hygienic practice is not strictly adhered to. *A. niger* produces ochratoxin A and are known to cause otomycosis- an infection of the ear.

Various strategies can be implemented to maintain good indoor air quality and minimize fungal contamination. Proper moisture control is crucial in preventing fungal growth, as moisture is a key factor for fungal colonization (Mendell *et al.,* 2011). This can be achieved through regular inspection and maintenance of buildings, including prompt leak repair, adequate ventilation, and appropriate humidity control measures (Pasanen *et al.,* 2011). Routine cleaning of the floor covers must not be compromised.

CONCLUSION

This comparative mycological analysis of different indoor floor types in Bayelsa State, Nigeria, reveals the presence of various fungal species, highlighting the importance of proper floor maintenance and hygiene practices. The study's findings can suggest ways for reducing fungal contamination and promoting healthier indoor environments in the region.

Based on the study's findings, it is recommended that residents in Bayelsa State prioritize regular cleaning and disinfection of floors, particularly in high-traffic areas. Additionally, the use of mold-resistant materials and proper ventilation systems can help reduce fungal growth and improve indoor air quality, ultimately contributing to a healthier environment for occupants.

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