

An investigation into microfungal diversity, antifungal susceptibility and soil fertility indicators in student residences of tertiary institution

Disegha G.C.¹ and Appah E.²

¹Department of Microbiology, Rivers State University, Port Harcourt, Nigeria.

²Department of Biological Sciences, University of Africa, Toru-Orua, Bayelsa State, Nigeria.

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ABSTRACT

This study examined the diversity of microfungal populations in relation to soil fertility indicators and public health implications within a female hostel in a tertiary institution. The findings revealed significant variations in fungal abundance over the course of one year. Airborne fungal levels ranged from 3.31×10^2 CFU/min/m² in August to 6.86×10^2 CFU/min/m² in January, while corresponding soil fungal populations ranged from 1.44×10^4 to 9.72×10^4 CFU/g. Air samples recorded higher mean fungal populations during the dry season (6.03×10^2 CFU/min/m²) compared to the wet season (4.37×10^2 CFU/min/m²). Similarly, soil samples showed higher mean fungal populations in the dry season (8.71×10^4 CFU/g) than in the wet season (6.76×10^4 CFU/g). The first quarter exhibited the highest airborne fungal population (6.03×10^2 CFU/min/m²). No significant differences were observed among quarters at $p \leq 0.05$, except between the first and third quarters. A diverse range of fungal species was identified, including potentially pathogenic strains such as *Alternaria alternata*, *Chrysosporium tropicum*, and various microfungi, including *Aspergillus* species. Although overall soil quality was considered suitable, deficiencies in nitrogen, potassium, and sulfate were observed. A weak correlation was found between fungal abundance and most soil quality parameters, except for nitrate (-0.64), calcium (-0.50), magnesium (-0.45), and zinc (-0.41). Additionally, the isolated fungal strains exhibited resistance to Nystatin and Griseofulvin but were susceptible to Ketoconazole. The study highlights the need for further research to better understand the mechanisms influencing these patterns and their implications for soil quality and public health.

Keywords: Microfungi, fungal diversity, soil fertility, *Aspergillus* species.

*Corresponding author. E-mail: ebidi.appah@uat.edu.ng.

INTRODUCTION

Microfungi are diverse groups of eukaryotic organisms that lack chlorophyll and obtain their carbon from external sources. They include yeasts, rusts, smuts, mildews, and molds, which are much smaller in size compared to mushrooms. Microfungi can be cultured on mycological media, where they exhibit a wide range of colors and textures (Disegha et al., 2024). Despite their microscopic nature, they are ubiquitous in terrestrial ecosystems. Some microfungi are beneficial in various ways, while others are harmful and pose public health concerns in both indoor and outdoor environments, particularly in densely populated settings such as female hostels (Bahram and Netherway, 2022).

Soil is a particularly rich medium and habitat for the growth and proliferation of fungi and other microorganisms (Jacoby et al., 2017). It is characterized by significant physiological and nutritional diversity, which supports the growth, development, and reproduction of both surface and subsurface flora. As one of the most abundant and widespread groups of microorganisms in soil, microfungi make soil a major reservoir for fungal populations, in addition to other microbial communities (Dellagi et al., 2020).

Air also serves as a medium for the dispersal of fungal spores, along with aerosols, dust, and other inorganic particles. Many infectious diseases affecting plants,

animals, and humans are caused by airborne fungi. Outdoor air is a major source of fungal contamination and plays a critical role in determining indoor fungal spore concentrations in environments such as classrooms, offices, laboratories, hospitals, conference rooms, greenhouses, and auditoriums (Al Hallak et al., 2023).

Human activities within the study area, combined with inadequate maintenance, poor building design, and irregular vehicular traffic, can contribute to adverse environmental conditions and associated epidemiological risks (Manisalidis et al., 2020). While microfungi are valuable in several sectors, including industry, medicine, and agriculture, and contribute to biogeochemical cycling, biotransformation, bioremediation, and environmental sustainability (Corbu et al., 2023), they can also pose health risks. Fungal spores originating from disturbed or dusty soils can become airborne and lead to various fungal-related diseases. Consequently, fungal infections represent an increasing environmental and public health concern, necessitating context-specific interventions to mitigate their spread (Manisalidis et al., 2020).

This study aimed to investigate microfungal diversity, antifungal susceptibility, and soil quality in a female hostel within a tertiary academic environment. The specific objectives were to enumerate, isolate, classify, and identify fungi from aeroterrestrial sources using standard mycological techniques; to determine their antifungal susceptibility; and to assess soil fertility indicators (e.g., nutrient availability) and examine their relationship with fungal populations.

MATERIALS AND METHODS

Study area

The study was conducted in the back gate area of Azikiwe Street, adjacent to Rivers State University, Port Harcourt, Nigeria. The external environment of Hostel A is characterized by a grass lawn with sandy soil and is subjected to regular maintenance, including mowing. The area experiences high pedestrian traffic, primarily from hostel occupants and individuals from neighboring areas.

The geographical coordinates of the study site are 4.793060° N and 6.984100° E. The location shares similar ecological and environmental characteristics with Port Harcourt, the capital of Rivers State. The university campus has a high population density due to academic, administrative, and commercial activities, as well as the regular hosting of external examinations and religious events. Surrounding landmarks include the university back gate, Hostel B, the Rivers State University Business School, and the campus motor park.

Sample collection

Composite soil samples were collected using a sterile

hand-held auger from a depth of 10–15 cm at six (6) designated substations within the Hostel A environment. Sampling was conducted monthly over a period of twelve (12) months, from July 2021 to June 2022, covering both wet and dry seasons.

Samples were collected into sterile zip-lock bags and transported to the Microbiology Laboratory for analysis. Soil samples from the six substations were thoroughly mixed to form composite samples. A total of 72 composite soil samples (approximately 50 g each) were analyzed.

Air samples were collected using the sedimentation (settle plate) method. Six (6) mycological media plates were used per sampling period, giving a total of 72 plates over the 12-month study period.

All culture media were sterilized in an autoclave at 121°C for 15 minutes at 15 psi. Glassware and pipettes were sterilized in a hot-air oven at 160°C for 30 minutes. Prepared culture plates were dried at 70°C for 10 minutes, and laboratory surfaces were disinfected with 75% ethanol prior to use.

Mycological analysis of soil and air

Mycological analyses were conducted in the Microbiology Laboratory, Department of Microbiology, Rivers State University, using standard techniques. The media employed included Sabouraud Dextrose Agar (SDA), Potato Dextrose Agar (PDA), and Malt Extract Agar (MEA), all prepared according to the manufacturers' instructions.

For soil analysis, the soil dilution and spread plate method was used. Ten grams (10 g) of soil was transferred into a 250 mL Erlenmeyer flask containing 100 mL of sterile normal saline and vortexed to obtain a uniform suspension, representing a 10^{-1} dilution. Serial ten-fold dilutions were subsequently prepared up to 10^{-3} .

Enumeration, isolation, and identification of aerial fungi

The sedimentation (settle plate) technique was used for sampling airborne fungi. A total of 72 plates were exposed monthly over the 12-month period, with six plates per sampling point (two plates each of MEA, PDA, and SDA).

During sampling, plates were placed on a flat rack at a height of 1.5 m above ground level and at least 6 m away from walls or obstructions. Plates were exposed for 10 minutes with lids removed and placed face-down beside them. After exposure, plates were carefully covered, sealed with non-dust adhesive tape, and transported to the laboratory.

Plates were incubated in an inverted position at ambient temperature (30°C) for 2–5 days. After incubation, discrete colonies were counted and recorded as total

fungal populations (Disegha and Nrior, 2021) using the formula:

$$\text{Log}_{10}\text{CFU}/\text{Min. M}^2 = \frac{\text{Number of Colonies}}{T \times \pi r^2}$$

Where:

Log_{10} = Logarithm to base 10

CFU = Colony Forming Units

T = Exposure time (minutes)

πr^2 = Surface area of the Petri dish (m^2) (Disegha and Nrior, 2021).

Fungal colonies were subcultured to obtain pure isolates and identified based on macroscopic and microscopic characteristics, supported by reverse image identification (Disegha et al., 2024).

Enumeration, isolation, and identification of soil fungi

An aliquot of 0.1 mL from the 10^{-3} dilution was aseptically spread onto duplicate plates containing mycological media supplemented with ampicillin to inhibit bacterial growth. Plates were incubated at 30°C for 2–5 days.

Colonies were counted and expressed as fungal population using the formula:

$$\text{Log}_{10}\text{CFU}/g = \frac{N}{V \times D}$$

Where:

Log_{10} = Logarithm to base 10

CFU = Colony Forming Units

N = Number of fungal colonies counted on plates

V = Volume plated (0.0 ml)

D = Dilution used for plating (10^{-3}) (Disegha and Nrior, 2021).

Preparation and identification of fungal isolates

Distinct fungal colonies from both air and soil samples were purified and identified based on macroscopic and microscopic features. Macroscopic examination included colony morphology, texture, pigmentation, and growth rate.

Microscopic examination involved staining with lactophenol cotton blue and observation under a light microscope at $\times 40$ magnification. Identification was carried out using *Koneman's Color Atlas and Textbook of Diagnostic Microbiology* (Koneman et al., 1997) and further supported by reverse image analysis tools.

Antifungal Susceptibility Testing (AFST)

Antifungal susceptibility testing was conducted using a

modified disk diffusion method (Obire et al., 2020). The antifungal agents tested included Ketoconazole (K), Nystatin (N), Fluconazole (F), and Griseofulvin (G).

Fungal inocula were prepared by suspending spores from 24-hour-old cultures in 5 mL of sterile 0.85% normal saline and adjusting turbidity to 0.5 McFarland standard (1×10^6 – 5×10^6 cells/mL).

Sterile swabs were used to inoculate the surface of agar plates, after which antifungal discs were applied. Plates were incubated at 37°C for 72 hours, with slower-growing isolates incubated up to 96 hours. Zones of inhibition were measured in millimeters and interpreted as Resistant (R), Intermediate (I), or Susceptible (S) according to NCCLS (2000) guidelines.

Determination of soil quality

Soil quality was assessed by measuring physicochemical parameters, including temperature, pH, moisture content, water-holding capacity, electrical conductivity, total organic carbon, soil organic matter, and concentrations of nitrogen, phosphorus, potassium, magnesium, calcium, sulfate, and zinc.

Soil samples were air-dried, ground, and sieved through a 2 mm mesh before analysis using standardized procedures (Yeboah et al., 2022).

Statistical analysis

Statistical analysis was performed using GraphPad Prism version 8, while data entry and organization were conducted using Microsoft Excel (2010).

Seasonal variations in air and soil fungal populations were analyzed using unpaired t-tests, with results expressed as mean \pm standard error and presented as bar charts. Quarterly comparisons were performed using one-way analysis of variance (ANOVA).

Monthly variations in soil fertility parameters were analyzed using the Excel Analysis ToolPak. Pearson correlation coefficients were used to assess relationships between soil fungal populations and soil quality parameters, with appropriate handling of missing data.

RESULTS

Results obtained from the mycological analyses of air (CFU/min/ m^2) and soil (CFU/g) at the study location are presented in Tables 1 and 2. These tables summarize the mean monthly fungal populations in air and soil over the sampling period, including log_{10} -transformed values, minimum and maximum counts, ranges, and mean \pm SEM values.

The mean monthly populations of airborne fungi at Hostel A are presented in Figure 1. The results show that

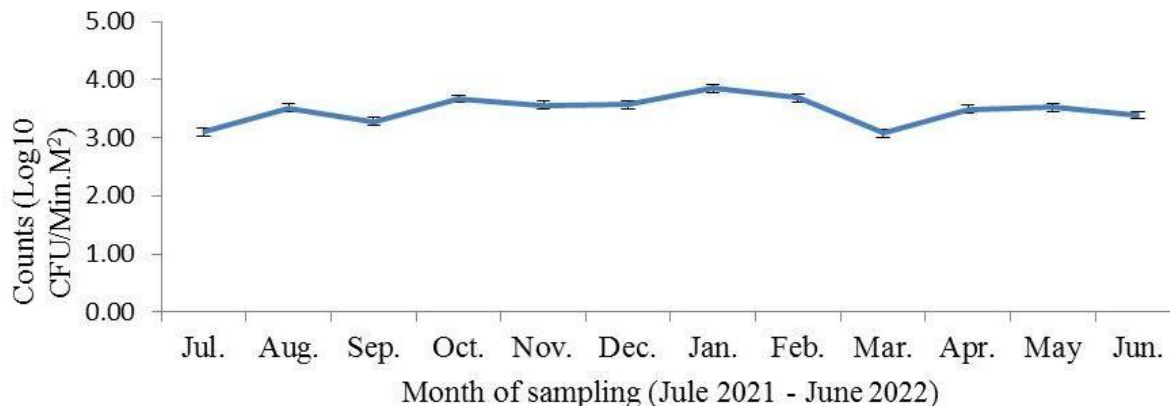
Table 1. Physiological categories of aeroterrestrial fungi isolated at Hostel A.

Sn	Fungi	Physiological Category
1.	<i>Alternaria alternata</i>	Saprophytic, Pathogenic, phytopathogenic, mycotoxic
2.	<i>Aspergillus niger</i>	Pathogenic, opportunistic,
3.	<i>Aspergillus oryzae</i> ;	Entomopathogenic
4.	<i>Chrysosporium tropicum</i>	chemoorganotroph.
5.	<i>Fusarium concentricum</i>	Phytopathogenic
6.	<i>Fusarium proliferatum</i>	Phytopathogenic
7.	<i>Fusarium solani</i>	Saprophytic
8.	<i>Penicillium aurantiogriseum</i>	Antibacterial, antifungal
9.	<i>Penicillium vanluykii</i>	Antibiotic producer,
10.	<i>Pythium myriotylum</i>	Phytopathogenic
11.	<i>Scedosporium aurantiacum</i>	Pathogenic, saprophytic
12.	<i>Trichoderma viride</i>	Saprophyte, Biocontrol agent
13.	<i>Trichosporon asahii</i>	Opportunistic pathogen

Table 2. Antifungal susceptibility of fungi treated with antifungal agents.

Fungi	K (10 µg/ml)	N (100 units)	F (25 µg/ml)	G (10 µg/ml)
<i>Alternaria alternata</i>	R	S	R	I
<i>Aspergillus niger</i>	R	R	S	R
<i>Aspergillus oryzae</i>	S	I	S	R
<i>Chrysosporium tropicum</i>	S	I	S	R
<i>Fusarium concentricum</i>	S	I	S	R
<i>Fusarium proliferatum</i>	S	I	S	R
<i>Fusarium solani</i>	S	I	S	R
<i>Penicillium aurantiogriseum</i>	S	I	S	R
<i>Penicillium vanluykii</i>	S	I	S	R
<i>Pythium myriotylum</i>	S	I	S	R
<i>Scedosporium aurantiacum</i>	S	I	S	R
<i>Trichoderma viride</i>	S	I	S	R
<i>Trichosporon asahii</i>	S	S	S	S

Key: S – Susceptible; I – Intermediate; R – Resistant; K – Ketoconazole; N – Nystatin; F – Fluconazole; G - Griseofulvin.

**Figure 1.** Mean values of monthly counts of air fungi Hostel A.

fungus populations ranged from 2.52 to 2.85 log₁₀ CFU/min/m², with the highest and lowest values recorded in January 2022 and August 2021, respectively. The

mean annual population was 2.68 log₁₀ CFU/min/m². Notable fluctuations in airborne fungal populations were observed throughout the sampling period.

Populations of soil fungi at Hostel A

The populations of soil fungi (\log_{10} CFU/g) are presented in Figure 2. The results indicate that mean fungal populations ranged from 4.6 to 6.4 \log_{10} CFU/g, with the highest and lowest values recorded in March and June,

respectively. The mean annual population was 5.26 \log_{10} CFU/g.

A relatively stable trend was observed from July to October, followed by fluctuations in subsequent months. Soil fungal populations peaked in March (6.4 \log_{10} CFU/g) before declining to 4.6 \log_{10} CFU/g in June.

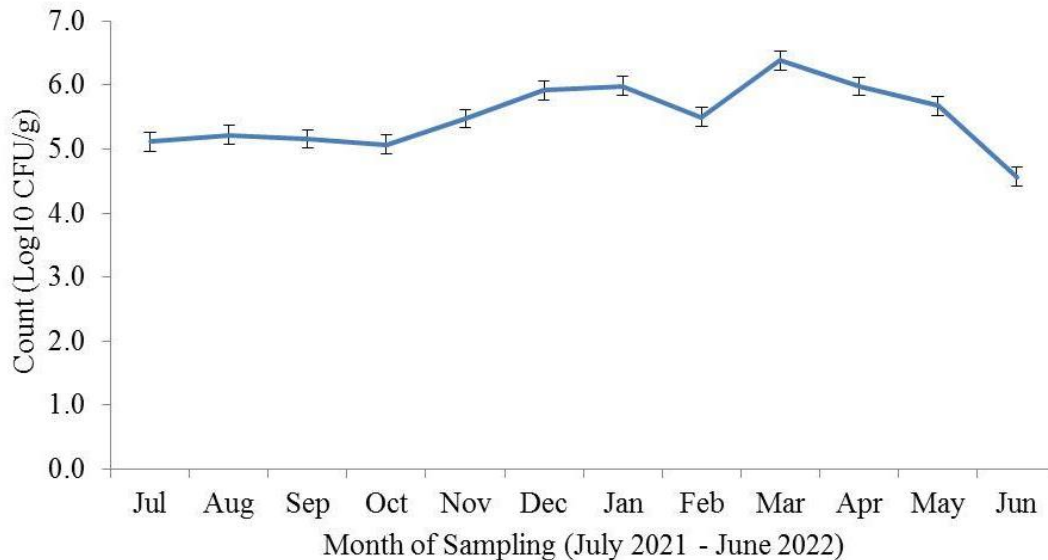


Figure 2. Mean values of monthly counts of soil fungi Hostel A.

Seasonal variations in fungal populations

The mean seasonal fungal populations in air (\log_{10} CFU/min/m²) and soil (\log_{10} CFU/g) are illustrated in Figures 3 and 4, respectively.

In air samples, the dry season recorded a higher mean population (2.78 \log_{10} CFU/min/m²), which was significantly different from the wet season value (2.64 \log_{10} CFU/min/m²) at $p < 0.05$.

In soil samples, the dry season also recorded a higher mean fungal population (4.94 \log_{10} CFU/g) compared to the wet season (4.83 \log_{10} CFU/g). However, this difference was not statistically significant.

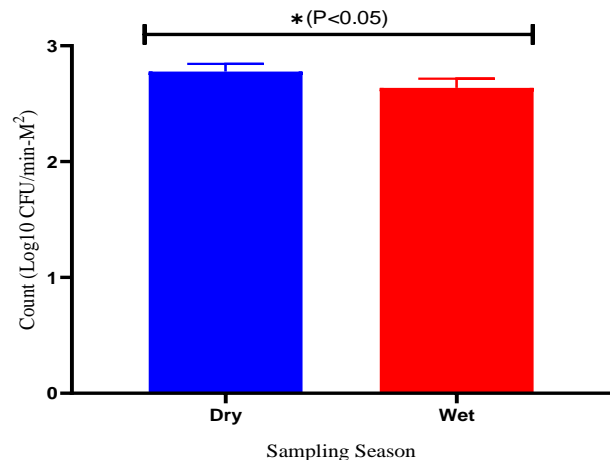


Figure 3. Mean seasonal counts of air (\log_{10} CFU/min.M²) during the sampling seasons.

Quarterly variations in fungal populations

Quarterly variations in air and soil fungal populations are shown in Figures 5 and 6, respectively.

For airborne fungi, the highest population (2.78 \log_{10} CFU/min/m²) was recorded in the first quarter (Q1), followed by the fourth quarter (Q4) with 2.69 \log_{10} CFU/min/m². The lowest value (2.60 \log_{10} CFU/min/m²) was observed in the third quarter (Q3). No statistically significant differences were observed among quarters except between Q1 and Q3 ($p \leq 0.05$).

In soil samples, fungal populations ranged from 4.49 to 4.96 \log_{10} CFU/g. The highest population was recorded in Q1, while the lowest occurred in Q4. Although there was a decreasing trend from Q1 to Q4 (4.96, 4.74, 4.50, and 4.49 \log_{10} CFU/g, respectively), these differences were not statistically significant ($p < 0.05$).

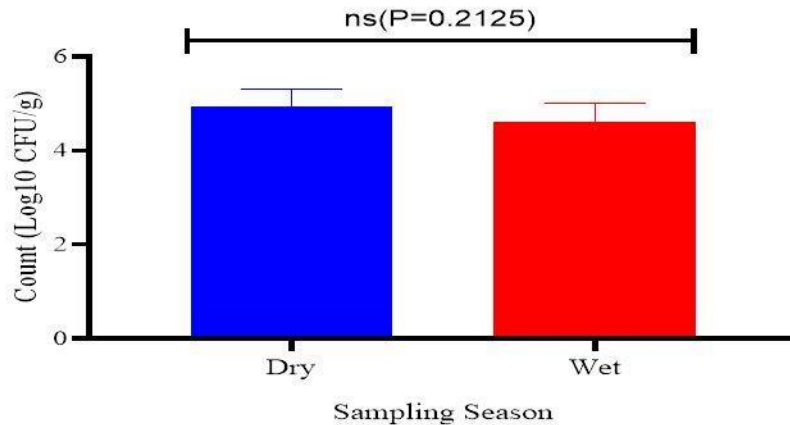


Figure 4. Mean seasonal populations of soil fungi (CFU/g) within the sampling period.

Key: ns – not significant; $P \leq 0.05$ (significant).

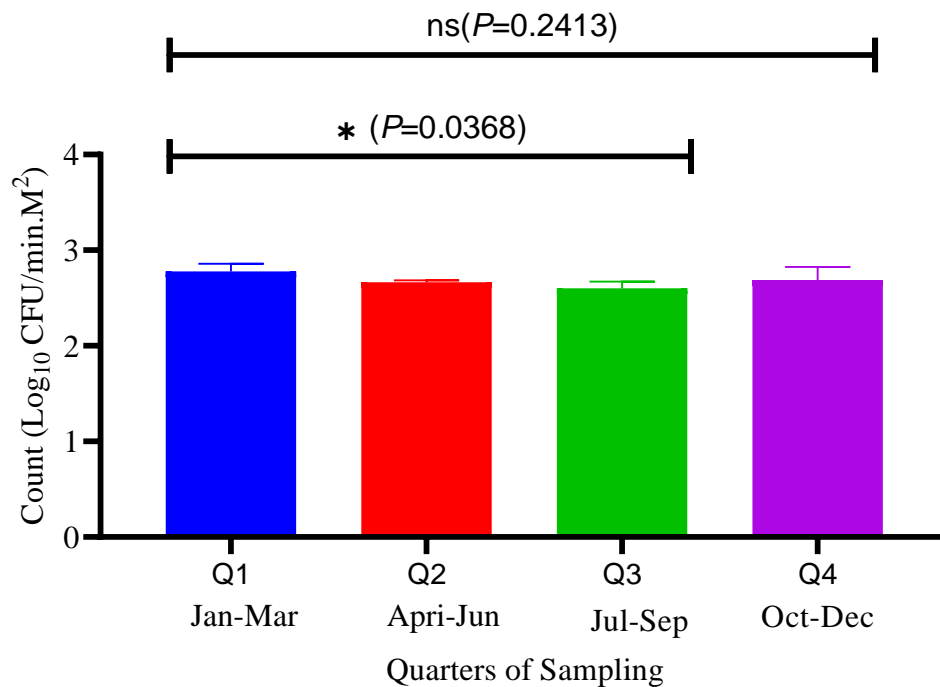


Figure 5. Quarterly values of air fungal populations at Hostel A.

Key: ns (not significant); $P \leq 0.05$ (significant).

Fungal species and physiological characteristics

The fungal species isolated and their physiological characteristics are presented in Table 1. A total of thirteen (13) species belonging to nine (9) genera were identified and classified into different physiological categories.

Alternaria alternata was identified as saprophytic, pathogenic, phytopathogenic, and mycotoxigenic.

Aspergillus niger was pathogenic and opportunistic, while *Aspergillus oryzae* was entomopathogenic. *Chrysosporium tropicum* was classified as a chemoorganotroph.

Fusarium concentricum and *Fusarium proliferatum* were phytopathogenic, whereas *Fusarium solani* was saprophytic. *Penicillium aurantiogriseum* exhibited antibacterial and antifungal properties, while *Penicillium vanluykii* was identified as an antibiotic producer.

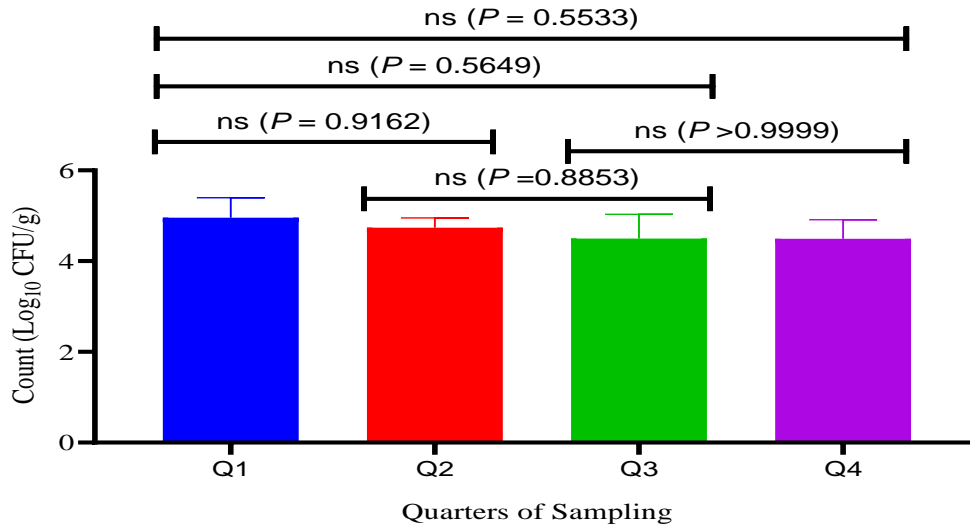


Figure 6. Quarterly values of soil fungal populations at Hostel A.
Key: ns (Not significant); $p \leq 0.05$ (significant).

Pythium myriotylum was phytopathogenic, *Scedosporium aurantiacum* was both pathogenic and saprophytic, and *Trichoderma viride* functioned as a saprophyte and biocontrol agent. *Trichosporon asahii* was identified as an opportunistic pathogen.

These findings highlight the diverse ecological roles of the isolated fungi, including pathogenicity, antimicrobial production, and environmental remediation potential.

Antifungal susceptibility patterns

Table 2 presents the antifungal susceptibility patterns of the isolated fungi against Ketoconazole (K), Nystatin (N), Fluconazole (F), and Griseofulvin (G).

Alternaria alternata was resistant to Ketoconazole and Fluconazole, susceptible to Nystatin, and showed intermediate susceptibility to Griseofulvin. *Aspergillus niger* was resistant to Ketoconazole, Nystatin, and Griseofulvin, but susceptible to Fluconazole. *Aspergillus oryzae* was susceptible to Ketoconazole and Fluconazole, intermediate to Nystatin, and resistant to Griseofulvin.

Most other fungi, including *Chrysosporium tropicum*, *Fusarium* spp., *Penicillium* spp., *Pythium myriotylum*, *Scedosporium aurantiacum*, and *Trichoderma viride*, were susceptible to Ketoconazole and Fluconazole, intermediate to Nystatin, and resistant to Griseofulvin. *Trichosporon asahii* was susceptible to all antifungal agents tested.

Distribution of antifungal responses

The percentage distribution of resistance, intermediate

response, and susceptibility among isolates is presented in Table 3.

For Ketoconazole, 66.7% of isolates were susceptible, while 33.3% were resistant. For Nystatin, 58.3% showed intermediate susceptibility, 16.7% were susceptible, and 25% were resistant.

Fluconazole demonstrated the highest efficacy, with 83.3% of isolates susceptible and 16.7% resistant. In contrast, Griseofulvin exhibited the highest resistance, with 75% of isolates resistant, 16.7% intermediate, and only 8.3% susceptible.

Overall, Fluconazole showed the greatest effectiveness, whereas Griseofulvin was the least effective antifungal agent.

Soil fertility parameters

Table 4 presents the mean monthly values of soil physicochemical parameters. Atmospheric and soil temperatures had mean values of 31.65°C and 32.05°C, respectively, with ranges of 25.9–36.1°C and 26.1–36.0°C. Peak values were observed in December, May, and February.

The mean soil pH was 6.85 (range: 6.2–7.6), with the highest value recorded in August. Soil moisture content averaged 7.14% (w/w), ranging from 2.0% to 22.5%, with a peak in November.

Electrical conductivity averaged 104.91 $\mu\text{S}/\text{cm}$ (range: 66.0–212.0 $\mu\text{S}/\text{cm}$), with the highest value in May. Total organic carbon (TOC) averaged 7.42% (range: 1.2–21.7%), while soil organic matter (SOM) averaged 12.83% (range: 2.1–37.4%), both peaking in November.

Macronutrients and micronutrients showed considerable variability. Nitrogen had a mean value of

Table 3. Percentage (%) distribution of resistance and sensitivity to antifungal agents among fungi isolated from air and soil of the sampling stations.

Antifungal Drug	Susceptible	Intermediate	Resistant
Ketoconazole (10 µg/ml)	66.7%	0%	33.3%
Nystatin (100 units)	16.7%	58.3%	25%
Fluconazole (25 µg/ml)	83.3%	0%	16.7%
Griseofulvin (10 µg/ml)	8.3%	16.7%	75%

Table 4. Mean Monthly detection of soil fertility parameters at the sampling station.

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
ATT°C	25.9	29.6	29.8	29.4	34.7	36.1	33.5	36.0	31.1	33.5	36.1	30.2
ST°C	26.1	30.4	28.3	29.3	33.8	35.1	32.9	35.5	31.4	35.5	36	30.2
pH	6.2	7.6	7.5	7.1	6.3	6.7	7.5	6.6	7.3	6.5	6.4	6.5
SMC(% WW)	3.5	3	13.5	3.3	22.5	5	7.5	3.7	10	4	2	4
EC (µS cm ⁻¹)		66	109	106	114	144	144	83	70	70	212	114
TOC(%)	2.7	2.2	12.7	2.5	21.7	4.2	6.7	2.9	9.2	3.2	1.2	3.2
SOM(%)	4.65	3.8	21.9	4.3	37.4	7.2	11.6	5.0	15.9	5.5	2.1	5.5
N(mg/Kg)	10	10	380	750	100	55	10	10	10	50	140	185
P (mg/Kg)	50	20	25	50	10	25	50	50	50	120	25	13
K(mg/Kg)	230	240	210	180	240	240	240	220	200	120	175	93
Ca(mg/Kg)	7.2	7.2	57.6	54	2.88	39.6	7.2	7.2	7.2	8.64	4.608	36.8
Mg(mg/Kg)	4	4	32	30	1.6	12.8	12	0.64	5.12	4.8	0.256	2.1
Zn(mg/Kg)	0.08	0.03	0.04	0.08	0.02	0.04	0.08	0.08	0.08	0.18	0.04	0.02
SO ₄ (mg/Kg)	42.7	17.1	21.3	42.7	36.4	21.3	18.2	36.4	0.2	18.2	15.5	31.1

Key: ST (Soil temperature); pH (Hydrogrn ion index; MoIC (Soil moisture content); EC (Electrical conductivity); SOM (Soil organic matter); N (Available nitrogen); P (Available phosphorus); K (available potassium); Zn (Zinc); SO³(Sulphate).

178.33 mg/kg (range: 10–750 mg/kg), with a maximum in October. Sulfate averaged 26.82 mg/kg (range: 0.2–42.7 mg/kg), with peak values in July and October.

Correlation between soil fungi and soil quality parameters

The correlation matrix (Table 5) shows relationships between soil fungal populations (SFP) and soil quality parameters.

SFP exhibited weak positive correlations with organic carbon parameters (ATT_oC: 0.0887; ST_oC: 0.1719), indicating a modest association with organic matter availability. A negative correlation with soil pH (-0.2303) suggests that slightly acidic conditions favor fungal growth.

Strong negative correlations were observed with nitrogen (-0.64581), calcium (-0.50615), magnesium (-0.45918), and sulfate (-0.42903). In contrast, positive correlations were observed with phosphorus (0.397012) and zinc (0.407271), suggesting their importance in fungal proliferation.

Strong inter-parameter relationships were also observed. For instance, ATT_oC and ST_oC showed a very strong positive correlation (0.961). Soil moisture content (SMC) exhibited a perfect positive correlation (1.0) with TOC, indicating a direct relationship between moisture

and organic carbon levels.

Nitrogen showed strong positive correlations with calcium (0.775582) and magnesium (0.785299), while phosphorus exhibited a very strong correlation with zinc (0.998874). Electrical conductivity showed moderate correlations with ATT_oC (0.486831) and ST_oC (0.337785). Potassium also correlated positively with SMC (0.32572) and SOM (0.326173).

The strong relationship between soil moisture and TOC may be attributed to enhanced microbial activity, improved organic matter retention, better soil structure, and increased plant biomass input (Azlan et al., 2011; Bogati et al., 2025; Rui et al., 2024; Azhar et al., 2025; Christoph et al., 2025; Yao et al., 2023). However, the observed perfect correlation suggests the possibility of additional influencing factors, warranting further investigation.

DISCUSSION

This study quantified airborne and soil fungal loads at a hostel site over a 12-month period, characterized seasonal and quarterly patterns, identified thirteen fungal species across nine genera, assessed antifungal susceptibility, and explored associations between soil fungal populations and soil physicochemical and fertility parameters.

Table 5. Correlation matrix of soil fungi population and soil quality parameters.

	SFP	ATT°C	SToC	pH	SMC (% W/W)	EC (S cm-1)	TOC (%)	SOM (%)	N (mg/Kg)	P (mg/Kg)	K (mg/Kg)	Ca (mg/Kg)	Mg (mg/Kg)	Zn (mg/Kg)	SO ₄ (mg/Kg)	
SFP	1															
ATToC	0.08	1														
SToC	0.17	0.99	1													
pH	-0.23	-0.22	-0.26	1												
SMC (% W/W)	-0.08	0.11	-0.01	0.03	1											
EC (S cm-1)	0.03	0.48	0.33	-0.30	-0.09	1										
TOC (%)	-0.08	0.11	-0.01	0.03	1	-0.09	1									
SOM (%)	-0.08	0.11	-0.01	0.03	0.90	-0.09	0.90	1								
N (mg/Kg)	-0.64	-0.28	-0.35	0.18	-0.01	0.075	-0.012	-0.01	1							
P (mg/Kg)	0.39	0.003	0.19	-0.07	-0.31	-0.37	-0.31	-0.31	-0.08	1						
K (mg/Kg)	0.01	0.07	-0.06	0.29	0.32	0.04	0.32	0.32	-0.24	-0.32	1					
Ca (mg/Kg)	-0.50	-0.26	-0.38	0.27	-0.02	0.03	-0.02	0.02452	0.79	0.21	-0.21	1				
Mg (mg/Kg)	-0.45	-0.30	-0.42	0.53	0.11	-0.01	0.11	0.11	0.79	0.009	0.09	0.84	1			
Zn (mg/Kg)	0.41	0.01	0.19	-0.08	-0.29	-0.36	-0.29	0.29	0.08	0.99	0.29	0.21	0.003	1		
SO ₄ (mg/Kg)	-0.42	0.24	-0.30	-0.48	-0.01	0.01	-0.01	-0.003	0.39	0.11	0.03	0.22	0.12	0.10	1	

Key: SFP - Soil fungal population; ATT - Atmospheric temperature; ST - Soil Temperature; pH - Hydrogen ion index; Moic - Moisture Content; WHC - Water Holding Capacity; TOC - Total Organic Carbon; EC - Electrical Conductivity; SOM - Soil Organic Matter; N - Nitrogen; K - Potassium; P - Phosphorus; Ca - Calcium, Mg - Magnesium; Z-Zinc; SO₃⁻ Sulphate.

Notable findings include: (1) mean airborne fungal concentrations ranged from approximately 2.52–2.85 log₁₀ CFU/min·m² (annual mean ≈ 2.68 log₁₀ CFU/min·m²), with pronounced month-to-month variability; (2) soil fungal counts ranged from approximately 4.6–6.4 log₁₀ CFU/g (peaking in March and lowest in June), showing a relatively stable mid-year trend before fluctuating; (3) dry-season airborne counts were significantly higher than wet-season counts (2.78 vs. 2.64 log₁₀, $p < 0.05$), whereas soil counts did not differ significantly by season; (4) the most frequently isolated taxa included *Alternaria*, *Aspergillus*, *Fusarium*, *Penicillium*, *Trichoderma*, *Scedosporium*, and *Trichosporon*, representing a mixture of saprophytes, phytopathogens, opportunistic pathogens, and organisms with antimicrobial or biocontrol properties; (5) antifungal testing revealed high susceptibility to fluconazole overall (83.3% susceptible) and high resistance to griseofulvin (75% resistant), with variable responses to ketoconazole and nystatin; and (6) correlation analysis showed associations between soil fungal populations (SFP) and several soil parameters, including a strong negative correlation with available nitrogen ($r \approx -0.65$), moderate positive correlations with phosphorus and zinc ($r \approx 0.40$), negative correlations with Ca, Mg, and SO₄, and complex relationships among total organic carbon (TOC), soil moisture, and temperature.

The observed airborne fungal concentrations (mean ≈ 2.68 log₁₀ CFU/min·m²) and marked month-to-month variability are consistent with previous reports demonstrating substantial temporal fluctuations in aeromycota across temperate

and tropical environments (Al-Saleh et al., 2025). Several studies have reported higher bioaerosol counts during dry, dusty periods or times of increased human activity, which aligns with the present finding of significantly higher airborne counts in the dry season. Conversely, other studies have documented higher counts during wet seasons, particularly in regions where moisture enhances spore production (e.g., basidiomycetes or plant pathogens), suggesting that local climate, vegetation, and human activity strongly influence seasonal patterns (Gallego-Cartagena et al., 2025).

Soil fungal loads in this study (4–6 log₁₀ CFU/g) fall within the ranges reported for agricultural and urban soils in previous studies (Rousk et al., 2010). The absence of a statistically significant seasonal difference in soil fungal load is consistent with findings that soil fungal communities are often buffered against short-term atmospheric changes due to substrate availability, microhabitat stability, and moisture retention (Zhang et al., 2025). The peak observed in March may reflect increased inputs of labile organic matter (e.g., plant litter and enhanced microbial activity) or favorable microclimatic conditions that promote sporulation and mycelial growth, a pattern also reported in tropical and subtropical soil studies (Chen et al., 2025).

The taxonomic composition (*Alternaria*, *Aspergillus* spp., *Fusarium* spp., *Penicillium* spp., *Trichoderma*, *Scedosporium*, *Trichosporon*, etc.) aligns with commonly reported fungal assemblages in urban, soil, and indoor environments (Adams et al., 2013). Several of these genera include opportunistic human

pathogens (e.g., *Aspergillus niger*, *Scedosporium aurantiacum*, *Trichosporon asahii*), allergenic species (e.g., *Alternaria alternata* and some *Penicillium* spp.), and phytopathogens (e.g., *Fusarium* spp. and *Pythium*). The detection of both opportunistic pathogens and allergenic taxa is consistent with environmental surveillance studies linking fungal exposure to respiratory allergies and opportunistic infections, particularly in immunocompromised individuals (Barnes et al., 2025). The presence of *Trichoderma* (a known biocontrol agent) and antibiotic-producing *Penicillium* species highlights the ecological complexity and functional diversity of soil fungi (Guzmán-Guzmán et al., 2025).

The observed susceptibility to griseofulvin partly aligns with previous environmental antifungal screening studies, which report variable resistance patterns across fungal genera and antifungal agents. Many filamentous fungi are intrinsically less susceptible to certain antifungals (e.g., griseofulvin primarily targets dermatophytes), whereas yeasts and some opportunistic fungi may exhibit sensitivity to fluconazole (Aris et al., 2022). However, resistance among *Aspergillus* and *Fusarium* species to azoles and other antifungals has been increasingly reported in both clinical and environmental settings, raising public health concerns (Yazgan et al., 2023). The present finding that some environmental isolates (e.g., *A. niger*) were resistant to ketoconazole, nystatin, and griseofulvin but susceptible to fluconazole underscores the taxon-specific nature of antifungal susceptibility and highlights the potential role of environmental reservoirs in harboring resistant strains.

The negative correlation between soil fungal populations and available nitrogen ($r \approx -0.65$) suggests that higher inorganic nitrogen levels may suppress fungal abundance or shift microbial community composition toward bacterial dominance. This observation is consistent with studies showing that nitrogen enrichment can alter microbial community structure and reduce fungal-to-bacterial ratios (Li et al., 2024). Positive correlations with phosphorus and zinc may reflect nutrient conditions that favor fungal growth or co-occurrence patterns driven by substrate quality. Negative correlations with Ca, Mg, and SO_4 may indicate indirect effects of soil properties (e.g., texture, salinity, or pH microgradients) that are less favorable for dominant fungal groups (Wu et al., 2022).

The strong associations observed among soil moisture, TOC, and soil organic matter (SOM) reflect well-established ecological relationships, as moist soils tend to retain organic matter and support microbial activity. However, the reported perfect correlation between soil moisture content and TOC ($r = 1.0$) is unusually high for environmental datasets and may indicate collinearity, measurement limitations, or data processing artifacts rather than a true biological relationship. Similar concerns have been raised in other soil studies where methodological constraints artificially inflate correlation

coefficients (Kalisa et al., 2023).

The presence of allergenic and opportunistic fungal pathogens in both air and soil samples raises important public health considerations for hostel residents, staff, and immunocompromised individuals. *Alternaria* and *Aspergillus* species are well-known triggers of allergic rhinitis and asthma exacerbations, as inhalation of spores can induce sensitization or acute respiratory responses in susceptible individuals (Oliveira et al., 2023). The detection of *Scedosporium* and *Trichosporon*, which are opportunistic pathogens in immunocompromised patients, suggests the existence of environmental reservoirs that may contribute to exposure risk, although infection depends on host susceptibility and exposure pathways (Neoh et al., 2024).

The antifungal susceptibility results further indicate that some environmental isolates exhibit resistance to commonly used antifungal agents (notably griseofulvin and, in some cases, ketoconazole and nystatin), which could complicate treatment if such strains are involved in human infections. These findings support the need for routine environmental monitoring and targeted interventions, such as improved ventilation, moisture control, and enhanced cleaning practices, in communal living environments to reduce fungal exposure.

The detection of phytopathogenic fungi (e.g., *Fusarium* spp. and *Pythium*) suggests potential implications for plant health in surrounding environments. Elevated soil fungal loads, combined with favorable environmental conditions, may facilitate plant disease cycles. Conversely, the presence of *Trichoderma* and antibiotic-producing *Penicillium* species indicates ongoing natural biocontrol and antimicrobial processes within the soil ecosystem, which may help suppress pathogenic organisms (Peng et al., 2021).

The observed negative relationship between soil fungal populations and available nitrogen further suggests that nutrient management practices (e.g., fertilizer application) could influence fungal community structure and ecosystem functions such as decomposition and nutrient cycling. Long-term nitrogen enrichment has been shown to reduce fungal biomass and diversity in various ecosystems, with downstream effects on soil carbon storage and plant-microbe interactions (Zhang et al., 2022).

This study has several limitations. Some reported correlations (e.g., the perfect correlation between soil moisture content and TOC) are unusually high and may reflect collinearity, small sample size, or data processing errors; these findings should be verified through independent replication. Additionally, the study was conducted at a single hostel site, which may limit the generalizability of the results to other locations or environmental conditions. Species identification relied primarily on morphological methods, which may lead to misidentification of closely related or cryptic taxa; molecular techniques would improve taxonomic accuracy

and strengthen susceptibility analyses (Zhang et al., 2025). Finally, in vitro antifungal susceptibility results for environmental isolates may not directly translate to clinical outcomes, and standardized interpretive breakpoints are lacking for many environmental fungi.

CONCLUSION

This study provides a comprehensive assessment of the diversity, distribution, and dynamics of aeroterrestrial fungi within a communal hostel environment at Rivers State University, Nigeria. The findings demonstrate significant temporal variations in fungal abundance, with higher airborne concentrations during the dry season and a diverse assemblage of fungal species with ecological, agricultural, and medical relevance.

Although soil quality was generally adequate, deficiencies in key nutrients such as nitrogen and potassium were observed, alongside notable associations between fungal populations and soil chemical properties, particularly phosphorus, zinc, sulfate, and nitrogen.

Importantly, the detection of opportunistic pathogens and antifungal-resistant strains, especially resistance to nystatin and griseofulvin, highlights potential public health risks. These findings underscore the need for routine environmental monitoring and targeted interventions in communal living spaces.

Further research incorporating molecular identification techniques and multi-site comparisons is recommended to better understand the mechanisms driving fungal distribution patterns and their implications for environmental and public health.

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