Trop J Nat Prod Res, November 2020; 4(11):985-989 **ISSN 2616-0684 (Print)**
ISSN 2616-0692 (Electronic)

Tropical Journal of Natural Product Research

Available online at https://www.tjnpr.org

Original Research Article

The Microbial Burden of Interior Surfaces and Spaces in Main Administrative Buildings of Covenant University

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ARTICLE INFO

Article history:
Received 28 August 2020
Revised 21 October 2020
Accepted 23 November 2020
Published online 30 November 2020

ABSTRACT

The microbial population within working environments contribute greatly to employee efficiency and health. This study was carried out to investigate the distribution of microorganisms in indoor spaces of key administrative buildings within Covenant University. Microbial species from indoor air and surfaces of six administrative buildings were isolated using standard laboratory procedures. Isolates were then identified following standard biochemical tests for bacteria and microscopy for fungi. Antibiotics susceptibility profile of the pure bacterial isolates was determined. Total aerobic plate count (TAPC) and fungal count for air samples ranged from 5.4 x 10^1 - 1.1 x 10^2 CFU/mL and 4.9 x 10^1 – 1.3 x 10^2 CFU/mL respectively. For surface samples TAPC and fungal counts ranged from 4.5 x 10^1 - 1.2 x 10^2 and 2.3 x 10^1 – 1.0 x 10^2 CFU/mL, respectively. Bacterial species isolated include members of *Staphylococcus*, *Streptococcus* and *Bacillus* genera while fungi isolates belonged to *Aspergillus*, *Penicillium*, *Alternaria*, *Neurospora* genera as well as unidentified yeast and *Mucor* sp. The bacterial isolates were mostly resistant to Ceftazidime n=23 (76.7%) and equally susceptible to Ofloxacin and Gentamycin n=19 (63.3%). Findings from the study showed that the minimum microbial population correlated with the office least visited by students.

***Keywords*:** Microbial population, Indoor air, Work environments, Total aerobic plate count (TAPC).

Introduction

Indoor air quality is becoming an important focus, given that large number of people spend most of their time indoors.[1] While indoors, humans interact with several indoor microbes which may be present on virtually every solid surfaces. Indoor air can serve as a vehicle for transmission of microorganisms which can be pathogenic to humans.[2] Many factors have been identified as key contributors to the microbiome of indoor environments such as location and architectural design of the building, type of ventilation used but mainly by the living inhabitants (humans, animals, and plants), as the significant source of microorganisms.[3] Also, microorganisms from soils can likewise be transmitted by office workers or carried on dust particles from the open air.[4] Exposure to such bioaerosols containing airborne microorganisms and their by-products, may result in respiratory disorders and other adverse conditions which include hypersensitivity, pneumonitis and toxic responses.[5] Spores of moulds and bacteria can enter indoor areas either by means of passive ventilation or by the ventilation system. Depending on the exposure time and concentration of pollutants, indoor air pollutants have been reported to hinder human health, wellbeing and productivity of workers. [6, 7] The quality of air inhaled indoors is of utmost importance compared to outdoor air quality due to the concentration of contaminants (mostly biological- molds, bacteria and viruses) indoors.[8] Thus, this study aimed at assessing indoor air quality and microbial burden of key office buildings within Covenant University.

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Citation: Oranusi SU, Akinkunmi O, Onibokun EA, Olopade BK, Oshamika OO and Obafemi YD. The Microbial Burden of Interior Surfaces and Spaces in Main Administrative Buildings of Covenant University. Trop J Nat Prod Res. 2020; 4(11):985-989. doi.org/10.26538/tjnpr/v4i11.24

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Materials and Methods

Sample collection

Sterile swab sticks were used to collect swabs from seats and shelves of offices within the main administrative buildings of Covenant University, Ogun State, Nigeria (7°00'0.00" N 3°34'59.99" E). The various offices sampled include the Centre for Learning Resources (CLR) which is the University Library, the University Chapel (UC), University Senate Building (USB), Covenant University Center for Research, Innovation and Discovery (CUCRID) building, the African Leadership Development Centre (ALDC), the Dean's Office, College of Science and Technology (DCST). Air sampling was carried out by exposing already-solidified Nutrient agar (NA), Plate count agar (PCA) and Potato dextrose agar (PDA) plates in respective offices for one hour. Samples were collected in triplicates and each plate carried a unique label depending on the sample collection site.

Isolation of microorganisms

All swab samples were inoculated in NA plates, PDA plates and Eosin Methylene Blue Agar (EMB) plates using the spread plate method. All plates (including air sampling plates) were incubated at appropriate temperatures and time. Series of sub-culturing were carried out to obtain pure cultures.

Morphological characterization of isolates

Bacteria isolates were observed for colonial features and Gram's reaction. Fungal isolates were subjected to microscopy using the Lactophenol cotton blue staining method.

ISSN 2616-0684 (Print)
ISSN 2616-0692 (Electronic)

Biochemical characterization of isolates

Biochemical tests carried out on bacterial isolates included catalase, coagulase, Methyl Red Voges Prokauer (MRVP), sugar fermentation, citrate utilization, urease, hydrogen sulfide (H_2S) production and motility. All results were compared with the Bergey's Manual of Systematic Bacteriology for confirmation of bacterial species while a reference fungal compendium and atlas was used to confirm fungal species.[9]

Antibiotic susceptibility test

All bacteria isolates were subjected to antibiotic susceptibility test according to the disk diffusion method.[10] Bacterial isolates were standardized using 0.5 McFarland standard and inoculated onto freshly-prepared and cooled Mueller Hinton agar plates. The plates were incubated at 37^{o}C for 18 h and zones of inhibition were measured using a millimetre rule. The results were interpreted using Clinical Laboratory Standards Institute Guidelines.[11]

Results and Discussion

In this study, both bacterial and fungal species were isolated from furniture in offices and air samples from six different buildings in Covenant University. The total aerobic plate count (TAPC) and fungal count for surface samples ranged from 4.5 x 10^1 - 1.2 x 10^2 and 2.3 x 10^1 – 1.0 x 10^2 CFU/mL respectively (Table 1). For the air samples, TAPC and fungal count ranged from 5.4 x 10^1 - 1.1 x 10^2 CFU/mL and 4.9 x 10^1 – 1.3 x 10^2 CFU/mL respectively (Table 2).

In both instances, the result indicated that the CLR, which is the University library had the highest TAPC and fungal count while the office of the DCST had the least count. According to the European Community Commission (ECC) guidelines for non-industrial environments, only the Office of the Dean which had 45 CFU falls within the very low class of indoor air contamination while the sample sites have low to intermediate (100-500 CFU) indoor air contamination.[12]

The higher microbial load was consistently observed in the building, which was most frequently accessed by a large population of individuals. Previous studies have shown that the number of persons in indoor environments is directly proportional to the level of microbial build-up.[13,14] The high microbial count could also be due to the closed ventilation design of these spaces, enhancing the proliferation of fungi. Some indoor contaminants that contribute to microbial air pollution include ~~like~~ dust, hair spray, perfumes, paints, photocopiers, printers, computers etc.[15] Microscopic examination of fungi revealed the presence of *Aspergillus, Penicillium, Alternaria, Neurospora* and Yeast (Table 3). Majority of the fungal species isolated were members of the genera *Aspergillus*. *Aspergillus* species are mostly reported to be found in warm climates with temperatures between 25 – 40^{o}C supporting optimal growth.[16] Although mostly found in soil and air, *Aspergillus* species could have been introduced from the outdoors into these office spaces from dust and sand on shoe~~s~~ surfaces. *Cladosporium* spp was also isolated in this study and it has been identified as the most abundant fungi in indoor air.[16,17] Similarly, *Alternaria* spp have also been isolated from indoor environments.[18] It is important to note that these fungi are known opportunistic pathogens and are associated with allergic and hypersensitivity conditions such as rhinitis, asthma and conjunctivitis.[19] These organisms have been reported as triggers of respiratory diseases, hence ~~there~~their ~~present~~presence in the office environment is of public health importance.[18]

Morphological and Biochemical characterization showed the presence of members of the genera *Staphylococcus, Bacillus, Pseudomonas Streptococcus and Cronobacter* (Table 4), with *Staphylococcus* species being the most predominant bacteria isolates (n = 18; 60%) (Table 5). ~~This~~These genera, particularly *Staphylococcus aureus*, are normal flora of the human skin.[20] Therefore, their presence on the chairs/tables of the indoor environments is expected. Other species isolated were *Bacillus, Streptococcus. Bacillus* is a remarkably diverse bacteria that can be isolated from myriad environments, terrestrial and aquatic, making it ubiquitous. *Bacillus* species are spore formers, [21] therefore it is easy for their spores to be dispersed by wind. From the antibiotic sensitivity test, of the total thirty isolates, nineteen (63.3%) were sensitive to Ofloxacin and Gentamycin, which was the highest observed for sensitivity. The least effective antibiotic was Ceftazidime, as most of the isolates were resistant (n= 23) (76.7%) while only a few were intermediately sensitive to the antibiotic (n = 7) (23.3%) (Table 5).

Table 1: Mean Total Aerobic Plate Count and Fungal Count of Microorganisms Isolated from Chairs/shelves of Main Administrative Buildings within Covenant University

Sample Location	Total Aerobic Plate Count (CFU/cm^2)	Fungal Count (CFU/cm^2)
CLR	1.2 x 10^2	1.0 x 10^2
UC	1.0 x 10^2	9.5 x 10^1
USB	9.0 x 10^1	8.0 x 10^1
CUCRID	8.0 x 10^1	8.0 x 10^1
ALDC	7.0 x 10^1	5.0 x 10^1
DSCT	4.5 x 10^1	2.3 x 10^1

Table 2: Mean Total Aerobic Plate Count and Fungal Count of Microorganisms Isolated from Air Spaces of Main Administrative Buildings within Covenant University

Sample Location	Total Aerobic Plate Count (CFU/cm^2)	Fungal Count (CFU/cm^2)
CLR	1.5 x 10^2	1.3 x 10^2
UC	1.2 x 10^2	1.2 x 10^2
USB	1.1 x 10^2	1.1 x 10^2
CUCRID	1.1 x 10^2	1.0 x 10^2
ALDC	8.6 x 10^1	6.5 x 10^1
DCST	5.4 x 10^1	4.9 x 10^1

CLR = Centre for Learning Resources, UC= University Chapel, USB= University Senate Building, CUCRID = Covenant University Centre for Research, Innovation and Discovery, ALDC = African Leadership Development Centre, DCST = Dean's Office, College of Science and Technology.

ISSN 2616-0684 (Print)
ISSN 2616-0692 (Electronic)

Table 3: Characteristics of Fungi Species Isolated from chairs/shelves and Air spaces of Main Administrative Buildings within Covenant University

Class of fungi	Description of isolate
Aspergillus niger	Black dense growth on entire plate.
Aspergillus flavus	Lemon green, powdery moldy growth on plate. Non-septate hyphae with spores arranged in chains on vesicle
Penicillium	Smooth, powdery compact, greenish-blue growth on entire plate. Septate, spores arranged in brush-like arrangement on the conidiophores
Mucor	White/grey long cottony hyphae growth covering entire plate. Spores are arranged inside the vesicle and the hyphae lack rhizoid
Neurospora spp	Orange colony on margin and entire plate with spherical shapes, conidia present
Yeast	Flat, creamy, smooth, shiny, widespread colony on entire plate
Cladosporium spp	Blackish-brown, powdery widespread on plate, with pigmented conidia.
Alternaria spp	Greyish-white flat colony, cottony hyphae. Septate brown hyphae producing a zig-zag appearance.
Aspergillus fumigatus	Greyish small smooth colony on entire plate

Table 4: Morphological and Biochemical Characteristics of Bacterial Species Isolated from chairs/shelves and Air spaces of Main Administrative Buildings within Covenant University

Suspected Isolates	Morphology	Gram stain	Catalase	Coagulase	Methyl red	Voges proskeur	Glucose	Fructose	Lactose	Citrate	Urease	H_2S	Indole	Motility
Bacillus spp	Cream colonies colonies with a transparent appearance	Gram positive rods	+	-	-	+	+	+	-	+	-	-	-	+
Pseudomonas spp	Greenish transluscent appearance	Gram negative rods	+	-	-	-	-	-	-	+	-	-	-	+
Staphylococcus spp	Cream, Opaque, buff, smooth colonies	Gram positive cocci	+	+	-	-	+	+	+	-	+	+	-	-
Cronobacter spp	Yellow pigmented colonies	Gram negative rods	+	-	+	+	+	+	+	+	-	-	-	+
Streptococcus spp	Cream, opaque smooth colonies	Gram positive cocci in chains	-	-	+	-	+	+	+	-	-	-	-	-

+ = Positive, - = Negative

ISSN 2616-0684 (Print)
ISSN 2616-0692 (Electronic)

Table 5: Distribution of antibiotic sensitivity of bacterial species isolated from chairs, shelves and indoor air of main administrative buildings within Covenant University

Bacterial Species	Number of Isolates	Sensitivity/ Resistance (%)	Antibiotics							
			AUG	CZD	CXM	GN	ERT	CLOX	CZN	OFL
Bacillus spp	6	Resistant	5	4	3	2	2	5	5	5
		Sensitive	1	2	3	4	4	1	1	1
Staphylococcus spp	18	Resistant	11	16	10	5	8	14	9	2
		Sensitive	7	2	8	13	10	4	9	16
Streptococcus spp	4	Resistant	3	3	2	2	4	3	2	2
		Sensitive	1	1	2	2	0	1	2	2
Penicillium spp	2	-	-	-	-	-	-	-	-	-

AUG = Augmentin, CZD = Ceftazidime, CXM= Cefuroxime, GN = Gentamycin, ERT = Erythromycin, CLOX= Cloxacillin, CZN = Ceftriazone, OFL= Ofloxacin. - = Penicillium species not considered as Gram positive disk was employed Zones of inhibition less than 15mm was considered as resistant

Conclusion

The microbial population within indoor spaces of key administrative buildings of Covenant University have been reported. Higher microbial population was observed in the library compared to other areas sampled. This confirms that areas with more human activity were prone to greater microbial contamination. Hence, there is a need to ensure that such areas are well-ventilated and cleaned regularly to prevent the accumulation of contaminating microbes. Further research may be carried out to investigate the effects of these contaminants on the health and work efficiency of inhabitants of such office environments.

Conflict of interest

The authors declare no conflict of interest.

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

Acknowledgements

The authors acknowledge all the Technologists in the Microbiology Laboratory of Covenant University and also Covenant University Centre for Research Innovation and Discovery for bearing publication costs.

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