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Potential Health Risk of Exposure to Microbial Contaminants in Settled Indoor Dusts (SIDs) from a Polytechnic Environment

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Abstract
Dust particulates are solid, settle on the surface of objects and harbor a range of largely benign microbes, some of which are beneficial or pathogenic. Indoor dust exposure is a growing public health concern and needs a wide range of attention. The study aims to examine the microbial contaminants in indoor dust from a polytechnic environment. A total of ten (10) composite settled dust samples were collected from selected sampling sites in Moshood Abiola Polytechnic (MAPOLY), Abeokuta, Ogun State, Nigeria. Samples were collected, labeled and transported to the laboratory for microbial analysis using standard microbiological techniques. The findings revealed that the dust contained six (6) bacterial species (*Escherichia coli, Enterococcus sp., Staphylococcus aureus*, *Staphylococcus epidermidis, Bacillus subtilis* and *Pseudomonas aeruginosa)* which can be grouped into gut-associated bacteria (*Enterococcus sp*. and *E. coli)* suggesting potential fecal contamination, skin-associated bacteria (*S. aureus* and *S. epidermidis),* and soil-associated bacteria (*B. subtilis* and *P. aeruginosa*), suggesting contamination from outdoor dust particulate. Also, isolated are nine (9) fungal species (*Aspergillus niger, A. nidulans, A. terrus, Rhizopus sp., Candida sp., Mucor sp., Penicillium sp., Conidiobolus sp.,* and *A. flavus).* The fungal isolates were primarily soil and dust dwellers, which must have evolved from the outside environments. Although they are considered non-pathogenic, they can be harmful to occupants with compromised immune systems. In conclusion, the presence of the isolates indicates dust contamination and, therefore, is a public health concern.
Keywords: indoor dust; Health Risk; Microbial; Contaminants; Polytechnic Environment

Introduction

Environmental contamination is a serious global health issue that has generated a lot of scientific investigations worldwide. One of the most serious issues for human health, according to researchers, is the condition of the indoor environment [1,2]. Dusts are solid particles ranging from 1 to 100 microns in diameter [3]. According to Eneji et al. [4], they can be seen on floors, as fine powder, lying on the ground, on the surface of objects, or being blown by the wind. Dust particulates come from various origins, including asbestos, soil, wood, waste collection, sorting and transportation [5]. The composition of dust is complex and contains organic and inorganic as well as microbial entities [6-8]. Additionally, dust contaminants in an indoor environment, most especially microbes may emanate from the interaction of the outdoor environment, indoor furniture, building materials or the occupants' activities [9,10].

Microbes can survive or even grow on any surface, acting as a reservoir for environmental exposure. They can be found everywhere and within each of us, either as commensals or pathogens [11]. Dust-borne microbes can endanger the health of those living nearby by getting into food, drinks, and the surfaces of indoor appliances [8]. Though most of these microbes are harmless, and beneficial some exhibit pathogenicity [11], which can lead

to the death of infected individuals, especially immunocompromised individuals.

The quality of the indoor environment is an environmental health concern because people spend up to 90% of their time indoors in places, such as workplaces, homes, offices, schools etc. [11,12] and they may be exposed to microbes in dust through inhalation, ingestion or skin contact [10,13]. According to Ediagbonya et al. [14], atmospheric particulates are Nigeria's main air pollution source. Over the past decades, there has been increasing concern about the exposure of people to indoor contaminants in order to assess the health impacts and reduce human health risks [15].

The study of chemical pollution especially metals and metalloids in urban air, residential home dust, roadside dust, and soils in Nigeria has received much attention (e.g. [2,4,10]). Although little research on microbial contaminants in dust has also been investigated, for example, in workplaces, schools, hospitals etc. (e.g. [8,16-18]), there is still a paucity of information. Therefore, it is pivotal to fill such a gap and to meet up with sustainable developmental goal number 3 (SDGs3). The study examined the potential health risk of exposure to microbial contaminants in settled indoor dust from a polytechnic environment.

Materials and Methods

Study Area

The study was carried out at Moshood Abiola Polytechnic (MAPOLY), Ojere, Abeokuta, Ogun state, Nigeria in February 2023. MAPOLY is a tertiary learning institution in Abeokuta, Ogun State, Nigeria. The Ojere campus is in the Southeastern part of Abeokuta, covering about 960 hectares of rolling land bounded by the Ogun River to the south. The Polytechnic was formally established in 1980 as Ogun State Polytechnic during the military administration of Harris Eghagha. The Polytechnic started on two temporary campuses, Oke-Egunya and Onikolobo, before moving to the Ojere campus between April 1985 and March 1988 [19]. The description of the sampling sites is shown in Table 1.

Table 1: Geographical description of the sampling site

Samples	Sampling sites	Coordinates
RM01	Marketing Department (MD)	7.102200,3.330738
RM02	Communication Department (CD)	7.101682,3.329595
RM03	Mass Communication Mini Department (MCMD)	7.101545,3.330786
RM04	Accounting Lecture Theater 1 (ALT1)	7.099750,3.329917
RM05	Computer Science Department (CSD)	7.098613,3.329964
RM06	Chemistry Laboratory (CL)	7.097154,3.328815
RM07	Physics Laboratory (PL)	7.096602,3.329326
RM08	Tetfund Building (TB)	7.080199,3.327397
RM09	ETF Project Building (EPB)	7.096356,3.327716
RM10	Accounting Lecture Theater 2 (ALT2)	7.099597,3.330255

Sample Collection and Preparation

Ten (10) composite settled dust samples, made from 7- 8 sub-samples were collected using a sterile brush, dustpan, and brooms from various corners, windows, chairs etc. of ten (10) strategically selected buildings in the study area (MAPOLY). The collected samples were kept in a transparent sample bag and then transported to the laboratory of the biological science unit of Pure Sciences, Abeokuta, Ogun state, Nigeria for further processing. At the laboratory, the samples were carefully passed through a 500 µm sieve to separate them from dirt and unwanted substances, and then further subjected to microbial analysis.

Quality Control

All glassware and kits used were sterilized using autoclaving and aseptic methods. The workbench and the used areas were sterilized with a freshly prepared 90% ethanol solution. A spirit lamp was lit up to ensure that the air in the vicinity of the workbench was free of contaminants.

Media Preparation and Microbial Analysis

The culture media used were Nutrient and Mac Conkey agar for bacteria isolation [20], while potato dextrose agar (PDA) was used for fungal isolation respectively. All media used were prepared as described by the manufacturers. One (1) g of the dust sample was aseptically transferred into a sterile beaker containing 9 ml of physiological saline under complete aseptic conditions. The mixture was allowed to stand for 2 minutes at room temperature. Then, 1 mL of the mixture was transferred to a sterile test tube containing 9 ml of physiological saline using a sterile pipette, from which further decimal tenfold dilutions were prepared up to 10^{-5}. 1 mL of each of these dilutions was subsequently inoculated into sterile plates after which the sterilized prepared media were poured into the plates. Bacterial plates were incubated at 37°C for 18 to 48 hours while the fungal plates were incubated at 25°C for five days. The bacterial count was determined by visual counting [22], while the distinct colonies were sub cultured into other selective mediums to get a pure culture.

Characterization and Identification of the microbial isolates

The bacterial isolates were characterized using the following features (size, form or shape, edge, texture,

degree of opacity and colour) of each colony [22]. They were also characterized based on their shapes and appearance using differential Gram's staining technique [20, 22]. The biochemical tests done on the isolates included catalase, coagulase, urease, indole, citrate, hydrogen sulphide, methyl red, oxidase, Voges-Proskauer, and carbohydrate fermentation test [21, 22].

Statistical Analysis

Data collected was subjected to statistical analyses using the Statistical Package for Social Sciences (SPSS) Version 21.

Results and Discussion

Bacteriological Contaminants

The morphological and biochemical characteristics of bacterial isolates are presented in Tables 2 and 3. It showed that the bacteria isolates are circular, the margin ranges from entire to undulates, and the surface of the colony is mucoid, dry and glossy, the colony colours ranges from cream, yellow, green and golden yellow, the texture of the isolate is smooth and rough while the degree of opacity is translucent and opaque. The bacterial colony counts and the number of species in the examined indoor dust are presented in Table 4. The highest mean colony count was recorded in RM01 (134×10^4 cfu) followed by sample RM07 (220×10^3 cfu), and the lowest in RM04 (47×10^2 cfu). The mean colony count was significantly ($p<0.05$) higher in RMO1 than at other sampling sites. However, this appears in the following order: RM1>RM7>RM10>RM6>RM9>RM8>RM2>RM3>RM5>RM4. An equally high number of bacterial species was detected in RM01, RM02, RM04, RM05 & RM10. The bacterial count from the study is lower than the report from science laboratories (254.5 - 1530.0 cfu/m^3) in Olabisi Onabanjo University, Nigeria [18] but higher than that of the University Campus (1.06 x 101 -1.04 x 10^2 cfu/5mins) in Port Harcourt, Nigeria [7]. The variation in microbial count at the study sites can be due to the different levels of occupancy in the area. Gram-positive bacteria formed 66.7% of the organisms isolated while 24.3% were gram-negative which conformed to the work of Ilusanya et al. [18], who reported 83% gram-positive from science laboratories in Olabisi Onabanjo University, Nigeria. Six (06) bacterial species (*Escherichia coli, Staphylococcus epidermidis, Enterococcus sp., Pseudomonas aeruginosa, Staphylococcus aureus* and *Bacillus subtilis)* were isolated from the dust. The bacterial distribution of dust across the rooms is presented in Table 5. The results showed that the most distributed was *Staphylococcus aureus* (50%), while the least was *Enterococcus sp.* (10%). These are some of the bacteria that are most frequently isolated from indoor air settings [23-25]. They are normal flora which could also be opportunistic pathogens. Staphylococcus aureus was the most widely distributed bacterial species in the study, although saprophytic by nature and typically connected to human skin, Staphylococcus aureus can, in the right circumstances, be an opportunistic pathogen that causes disease in humans. Skin infections, septicemia, and some gastrointestinal illnesses can all be brought on by *Staphylococcus aureus*. These organisms' presence in indoor air further indicates that human activity and presence have contaminated the environment [17,18]. *Pseudomonas aeruginosa* is most likely from feces while *Escherichia coli* is the most predominant aerobic bacteria in the guts of humans and warm-blooded animals; their presence in the dust suggests fecal contamination arising from poor personal hygiene. It may also be associated with the low level of sanitation in the environment [25]. The Presence of bacteria such as *E. coli* in the sample could be a transfer of these bacteria between the sampling site within the environment. Ilusanya et al. [18] showed that *S. aureus* and *E. coli* are common types of bacteria that exist in nature, hence their predominance.

Table 2: Morphological and Cultural Characteristics of Bacterial Isolates

S/N	Shape	Margin	Colour	Surface	Texture	Opacity	Probable Organism
01	Circular	Entire	Cream	Mucoid	Smooth	Translucent	*Escherichia coli*
02	Circular	Entire	Yellow	Dry	Smooth	Opaque	*Staphylococcus epidermidis*
03	Circular	Entire	Cream	Dry	Smooth	Opaque	*Enterococcus sp.*
04	Circular	Entire	Green	Glossy	Smooth	Translucent	*Pseudomonas aeruginosa*
05	Circular	Entire	Golden Yellow	Glossy	Smooth	Opaque	*Staphylococcus aureus*
06	Circular	Undulate	Cream	Dry	Rough	Opaque	*Bacillus subtilis*

Table 3: Biochemical Characterization of Bacterial Isolates

S/N	Gram	Cit	Oxi	Cat	Ind	Mot	Suc	Glu	Lac	H_2S	Gas	Coa	Probable Organism
01	-rod	-	-	+	+	+	+	+	+	-	+	-	*Escherichia coli*
02	+cocci	-	-	+	+	-	+	+	+	-	-	-	*Staphylococcus epidermidis*
03	+cocci	-	-	-	-	-	+	+	+	-	-	-	*Enterococcus sp.*
04	-rod	+	+	+	-	+	-	+	-	-	-	-	*Pseudomonas aeruginosa*
05	+cocci	-	-	+	+	-	+	+	+	-	-	+	*Staphylococcus aureus*
06	+rod	+	+	+	+	+	+	+	+	+	+	-	*Bacillus subtilis*

Key: Gram- Gram stain reaction; Cat- Catalase test; Oxi- Oxidase test; H2S- Hydrogen Sulphide Production; Gas- Gas production; Lac- Lactose fermentation; Suc- Sucrose utilization; Glu-Glucose utilization; Cit- Citrate utilization; Ure- Urease test; Coa- Coagulase test; Mot- Motility test; Ind-Indole Production Test; += Positive reaction; -= Negative reaction.

Table 4: Bacterial Colony Count (cfu/ml) and Number of Species

Sample	Descriptive Statistics				
	Mean (n=3)	Std. Dev.	Minimum	Maximum	No. of species
RM01	134×10^4	56.7	93	199	02
RM02	156×10^2	11.7	143	166	02
RM03	153×10^2	41.1	127	200	01
RM04	47×10^2	10.1	36	56	02
RM05	102×10^2	60.1	56	170	02
RM06	159×10^3	89.9	55	215	01
RM07	220×10^3	22.0	195	235	01
RM08	109×10^3	15.9	98	127	01
RM09	143×10^3	18.2	127	163	01
RM10	160×10^3	16.6	142	175	02

Table 5: Distribution of bacterial isolates

Fungal Isolates	Dust Samples										Percentage (%)
	RM1	RM2	RM3	RM4	RM5	RM6	RM7	RM8	RM9	RM10	
Escherichia coli	+						+				20
Staphylococcus epidermidis			+								10
Enterococcus sp.					+						10
Pseudomonas aeruginosa	+	+	+								30
Staphylococcus aureus				+	+	+			+	+	50
Bacillus subtilis				+				+		+	30

Note: + =Present

Mycological Contaminants

The morphology of the fungal colony in the indoor dust is presented in Table 6, it shows that the colonies appear dark brown, creamy, greyish white, tan, olive green, greenish and creamy yellow, the sporulation ranges from heavy to poor, hyphae types range from septate to aseptate, the vesicles are biserate and uniseriate and the shapes are globose, spherical and oval. The metula covering is entirely, half and quarter. The mean fungal colony counts and number of species from the examined indoor dust are presented in Table 7, The highest mean colony count was recorded in RM1 (62.00±9.85 cfu) followed by RM3 (42.00±7.00 cfu) while the lowest was in RM09 (17.33±12.66 cfu). The mean colony count was significantly ($p<0.05$) higher in RM01 than at other sampling sites. The fungal load appears in the order of sample RM1> RM3> RM4> RM2> RM08> RM07> RM05> RM10> RM06> RM09. The highest number of fungal species was recorded in RM02 (08) followed by RM06 and RM10 (07) respectively while the lowest was recorded in RM08 (02). The level of fungal colony count observed in the dust from the sampled site indicates the viability of the fungi [26], this is lower than the fungal load reported in indoor dust (2500 to 3100 Cfu/m^3) in Port Harcourt, Nigeria [16] and Malaysia (292 CFU/m^3) by Hussin et al. [27]. The mean fungal load in indoor environments can vary depending on several environmental conditions, including the state of the building, the construction status, the window safety condition, the room ventilation system, temperature, humidity, and particulate matter level [26]. Nine (09) fungal species (*Aspergillus niger, A. nidulans, A. terrus, Rhizopus sp., Candida sp., Mucor sp., Penicillium sp., Conidiobolus sp.,* and *A. flavus)* were isolated from the dust. This is similar to the work of Enitan et al. [16], Hussin et al. [27] & Naruka & Gaur [28]. The bacterial distribution of dust across the rooms is presented in Table 8. The results showed that the most widely distributed was *A. niger* (100%), followed by *Candida sp (90%) and Conidiobolus sp.* (10%). *A. niger, A. flavus, A. nidulans* and *A. terrus* belong to the genus Aspergillus, which is composed of fungi found mostly in soil, dust and compost [29]. The distribution of these organisms in the indoor dust appears normal and must have resulted from the infiltration of dust particulates from the outdoor environment. Additionally, *A. niger* and *A. terrus* are potential causal agents for *otomycosis* (an infection of the ear) leading to hearing loss and sometimes permanent damage to the tympanum membrane [22, 30]. *Candida* species had the second highest frequency in the dust. According to Prescott et al. [30], Candida species are a typical part of the female vaginal flora. Their dominance may also indicate the presence of a yeast infection because a weaker immune system may facilitate the growth of Candida. This conforms the work of Zewudu et al. [26]. Candida species are known as dermal and gut commensals but can cause oral (mouth) candidiasis (thrush) when ingested by an immunocompromised individual [23, 30].

Mucor sp. and *Rhizopus sp.* belonging to the genus Mucorale are known for their angio-invasive manifestations. Human exposure to their spores can result in neurological and gastrointestinal mucormycosis through inhalation and ingestion [29]. Penicillium species are among the most common fungi in the environment (soil and dust) and are usually considered non-pathogenic to humans. However, in immunocompromised hosts, they can be virulent pathogens and can cause death [31]. Therefore, an exposure to this fungus in dust can result in illness to the occupants.

Table 6: Morphological characteristics of the fungal colony in settled dust

Colony Colour	Stipes Colour	Type of hyphae	Sporulation	Vesicle Serration	Vesicle Shape	Metula covering	Probable Organism
Dark brown	Slightly Brown	Septate	Heavy	Biseriate	Globose	Entirely	*A. niger*
Greenish	Brown	Septate	Moderate	Biseriate	Spherical	Half	*A. nidulans*
Tan	Colorless	Septate	Poor	Biseriate	Globose	Half	*A. terrus*
Greyish White	Light brown	Aseptate	Heavy	Uniseriate	Spherical	Half	*Rhizopus sp.*
Creamy-White	-	-	Moderate	-	-	-	*Candida sp.*
Whitish	Colorless	Aseptate	Heavy	Uniseriate	Spherical	Half	*Mucor sp.*
Olive green	Colorless	Septate	Moderate	Biseriate	Oval	Entire	*Penicillium sp.*
Whitish	-	-	Moderate	-	-	-	*Conidiobolus sp.*
Creamy- Yellow	Pale brown	Septate	Moderate	Biseriate	Globose	Quarter	*A. flavus*

Table 7: Fungal colony load (cfu ×10²) and number of isolated species

Sample	Descriptive Statistics				No. of species
	Mean (n=3)	Std. Dev	Minimum	Maximum	
RM01	62.00	9.85	54	73	04
RM02	37.00	11.36	24	45	08
RM03	42.00	7.00	37	50	06
RM04	39.00	2.00	37	41	06
RM05	26.67	10.69	15	36	05
RM06	22.00	16.7	07	40	07
RM07	25.67	6.51	19	32	05
RM08	27.33	6.11	22	34	02
RM09	17.33	12.66	03	27	06
RM10	23.67	16.26	11	42	07

Table 8: Distribution of fungi isolates

Fungal Isolates	Dust Samples										Percentage (%)
	RM1	RM2	RM3	RM4	RM5	RM6	RM7	RM8	RM9	RM10	
A. niger	+	+	+	+	+	+	+	+	+	+	100
A. nidulans	+	+	+	+		+	+	+	+		80
A. terrus		+	+			+				+	40
Rhizopus sp.	+	+			+		+		+	+	60
Candida sp.	+	+	+	+	+	+	+		+	+	90
Mucor sp.		+	+	+	+	+					50
Penicillium sp.		+	+	+			+			+	50
Conidiobolus sp.										+	10
A. flavus				+		+			+	+	40

Note: + =Present

Conclusion

The study investigated the potential health risks of being exposed to microbial contaminants found in settled indoor dust from the MAPOLY environment. The detected bacteria were mainly gut and soil-associated bacteria, linked to fecal and outdoor dust particulate contamination. The fungal isolates detected were soil and dust dwellers, associated with contamination from outdoor dust. However, the majority of the microbes is opportunistic and has the potential to cause disease in people with weakened immune systems.

Additionally, some of the likely infections range from respiratory, oral, gastrointestinal, brain, ear, and skin-associated infections, which are a matter of public health concern. Frequent room and environmental fumigation can aid in lowering the level of bio-contaminants and the hazards they pose.

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