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An Assessment of the Microbiological Quality and Physical Properties of Indoor Atmosphere in Port Harcourt

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ABSTRACT: The assessment of microbiological quality and some properties of indoor atmosphere in Port Harcourt were carried out at seven different sites. Air samples were collected from these sites during the rainy and dry seasons as well as day and night periods. Microbiological identification tests were performed on isolated organisms while the environmental factors measured were air temperature, relative humidity and wind speed. Results obtained indicated that all seven sites yielded microorganisms at different degrees with site 5 having the highest microbial load and site 4 the lowest. The most conducive atmosphere for the growth and increase of airborne indoor microorganism were temperature between 31^0C and 32^0C, dry, dusty atmosphere and an overcrowded enclosure. The species of organisms isolated were *Staphylococcus* species, *Bacillus* species, *Enterobacter* species, *Penicillium* species, *Rhizopus* species, *Mucor* species and *Cladosporium* species. The study revealed that no indoor atmosphere is completely free from microorganisms; rooms that carry above their original design capacity for occupancy are prone to have a high load of microorganism and indoor microorganism survive and multiply faster during the dry season compared to their growth in the rainy season. @JASEM

In an environment of high industrial activities which includes manufacturing processes, mineral exploration activities and increase in technological advancement, it is understandable and even expected that there would be great awareness of outdoor air pollution that would occur as a result of these activities. Pollution in itself is defined as the contamination of the environment as a result of human activities. It primarily refers to the fouling of the air, water and land by wastes but in recent years, it has come to signify a wide range of disruptions to the environmental quality (Encyclopedia, 2000). Indoor air quality is the acceptable quality of air indoors that would not be harmful or detrimental to the health of man. Indoor air quality can be "poor" or "good" (AIHA, 2003), and depends on factors such as temperature, humidity, air movement and ventilation, bioaerosols and volatile organic hydrocarbons (Healthy Environment, 2003).

Indoor air pollution is a wide spread problem in both old and new homes, whether located in cites or in rural areas, developed or developing countries. A survey carried out by the US Environmental Protection Agency (2003a) discovered that most people spend as much as 90 percent of their time indoors. Studies performed by Kreiss, (1989) and Home Inspection Article, (2001) agree with this percentage. Measurement carried out by De Nevers (2000) indicates that pollution concentrations inside houses and indoor air pollution can be higher than those outside. In some sealed buildings with mechanical ventilation, there is a range of complaints such as symptoms of eye and nose irritation, nasal congestion, sore throat, fatigue, malaise and headache that are referred to as "Sick Building Syndrome"(Burge and Hoyer, 1990).

Typical sources of indoor air pollutants and conditions that can have an impact on indoor air quality in buildings include mould, moisture, temperature and humidity control, humidity and microbial growth, particulates, environmental tobacco smoke, combustion products including carbon monoxide, pesticides, asbestos, lead-based paint, heating, ventilating and air conditioning systems etc (IAQ, 2004). An in-depth study by Morey *et al* (1990) suggest that the greatest air pollutants are the biological pollutants which include bacteria, moulds, mildew, viruses, animal dander and cat saliva, house dust, mites, cockroaches and pollen.

There has been an accumulation of data concerning outdoor air quality and its effect on man and the components of his environment such as trees, fishes, water, land, etc. Due to the great emphasis and importance placed on the quality of outdoor air, very little attention has been given to indoor air quality. This oversight in itself has resulted in untold and most times undocumented hazard or risk to man and its resultant effect has also affected man's environment and its development. It is on these bases that this study was designed to determine the microbiological quality and physical properties of indoor atmosphere in Port Harcourt and the factors that determine the quality of these indoor atmospheres were identified.

MATERIALS AND METHOD

Sampling for this study was carried out during the rainy season (April-October) and the dry season

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(November-March), while the sample collection area was within the Port Harcourt metropolis of Rivers State. Seven (7) sample sites were used and their full description is in Table 1 below. Samples collected were air samples from the different indoor atmosphere, temperature, relative humidity and wind speed.

Sample collection and processing: For the purpose of analysis of air for the isolation of microorganisms, petric dishes of freshly prepared and sterile appropriate media were left to stand open for 30mins. The plates were then covered, labeled and taken to the laboratory for incubation at 37^0C for 24hours. The resulting colonies were identified based on their cultural, morphological and physiological characteristics (Buchanan and Gibbons, 1974; Cowan, 1974). Further characterization and identification of microbial isolates were done on discrete colonies using gram stain, catalase test, coagulase test, oxidase test, methyl red, indole test, voges-proskauer test, citrate test and sugar fermentation. The Psychrometer was used for air temperature measurement; the Beaufort scale was used for wind speed while the relative humidity was determined using the hygrometric tables.

Table 1 Sample sites and their description

Sampling sites	Description of site
Site 1; Reading Hall of the main library in the RSUST Campus	This is a large room with headroom of 2.8m, made of hallow pot floor slabs. It is German-floored with rows of windows at two parallel sides of the walls crammed with wooden chairs, tables, book shelves and cubicles for reading. There are no fans or air conditioners in this reading hall. An average of 100 persons stays in the library for an average of 2hrs at a time
Site 2 Reading room of the Science Faculty in RSUST	This is a large room with headroom of 6.2m, made up of suspended gypsum board. It has no windows, no ceiling or standing fans, two outlets at opposite ends and a provision for central air-conditioning that is not functioning. It has cemented floor and is equipped with rows of writing seats and tables built in a stepwise plan. An average of 80persons occupies this room for a minimum of 2hours at a time.
Site 3; A classroom at the Dept of Applied and Environmental Biology RSUST	This is a 7.0m by 7.0m room with Formica covered working slabs fitted with sinks and taps. It has cemented floor with rows of widows on one wall of the classroom, ceiling fans and a single door. It has stools for sitting. An average of 30persons occupies this classroom for a minimum of 2hours at a time
Site 4; A room in the post graduate hostel of the RSUST.	This is a 3.0m by 3.0m room with headroom of 2.8m. It has a single entrance door with windows on opposite sides of the room, where the front windows are higher elevated than the back. It has a cemented floor and a ceiling fan. This room is occupied by two persons for the duration of a full academic year.
Site 5; A room at the block."C"female hostel(undergraduate hall) of the RSUST	This is a 4.0m by 5.0m room with headroom of 3.1m. It has a single entrance door with windows on opposite sides of the room, where the front windows are higher elevated than the back. It has a cemented floor that is carpeted and a ceiling fan. An average of eight persons occupies this room originally designed for two people, for a full academic year.
Site 6; A room at the creek road waterside area of Port Harcourt	This is a room made from zinc sheet with plywood as its skeletal support. It has a thick cemented floor with headroom of 3.0m. It has one entrance door and two windows, one at the back and the other at the front of the room. It has rooms attached to it at both sides. An average of six persons lives in this room for a minimum of one year at a time.
Site 7; A two-bed room flat located at the Orazi area of Port Harcourt.	This is a building made of mainly concrete. The two bedrooms and sitting room were used in the study. Bedroom (1) has two windows in adjacent position while bedroom (2) has one. The sitting room is adjoined with the dinning and as such has four windows; one each on opposite walls while the third section of the wall has two windows. It has headroom of 3.0m. They each bear a ceiling fan. It is fully carpeted with an average of four persons living in this flat.

RESULTS AND DISCUSSION

The result of the physical properties of the sampling sites during the rainy season in Table 2 showed that air temperature was lower during the night period with a mean of 28^0C than in the day which had 30^0C, while the relative humidity and wind speed showed very little or no change between the night and day periods. Table 3 shows that air temperature during the dry season was generally higher with the day temperatures as high as 32^0C in several sites with a mean of 31^0C while the night temperatures were lower with a mean of 29^0C.

It showed that the relative humidity during the dry season were very low with means of 42% during the day and 39% during the night while the wind speed remained the same. The microorganisms isolated from the sites during the study period are illustrated in Table 4. It shows that *Staphylococcus* sp, *Bacillus* sp, *Mucor* sp, and *Cladosporium* sp were isolated from all the sample sites, while *Penicillium* sp and *Rhizopus* sp were isolated from only five of the sites and *Enterobacter* sp from four of the sites. Table 5 shows the total microbial count of the sampling sites during the day and night of rainy and dry seasons. It shows that the dry season had more microbial count (2,004cfu) than the rainy season (257cfu), while the day periods recorded higher counts than the night periods in both seasons and sampling site 5 had the highest microbial count in all the seasons and in all periods of the study.

Table 2 Physical Properties of the Sampling Sites in the Rainy Season

Site	PERIOD OF SAMPLING					
	DAY			NIGHT		
	Air Temperature (^{0}C)	Rel. Humidity (%)	Wind Speed Beaufort Scale(m/s)	Air Temperature (^{0}C)	Rel. Humidity (%)	Wind Speed Beaufort Scale(m/s)
1	30	85	2(1.6-3.3)	28	85	2(1.6-3.3)
2	30	93	3(3.4-5.4)	29	85	2(1.6-3.3)
3	29	85	3(3.4-5.4)	27	84	3(3.4-5.4)
4	30	72	4(5.5-7.9)	29	71	3(3.4-5.4)
5	30	85	3(3.4-5.4)	29	85	2(1.6-3.3)
6	30	78	2(1.6-3.3)	27	84	3(3.4-5.4)
7	31	72	3(3.4-5.4)	29	64	3(3.4-5.4)
Mean	30	81	3(3.4-5.4)	28	80	3(3.4-5.4)

Table 3 Physical Properties of the Sampling Sites in the Dry Season

Site	PERIOD OF SAMPLING					
	DAY			NIGHT		
	Air Temperature (^{0}C)	Rel. Humidity (%)	Wind Speed Beaufort Scale(m/s)	Air Temperature (^{0}C)	Rel. Humidity (%)	Wind Speed Beaufort Scale(m/s)
1	32	44	2(1.6-3.3)	29	39	3(3.4-5.4)
2	32	49	2(1.6-3.3)	30	42	3(3.4-5.4)
3	30	47	3(3.4-5.4)	28	33	3(3.4-5.4)
4	32	39	4(5.5-7.9)	30	36	3(3.4-5.4)
5	30	47	3(3.4-5.4)	28	45	3(3.4-5.4)
6	32	49	3(3.4-5.4)	28	39	4(5.5-7.9)
7	30	42	4(5.5-7.9)	29	40	3(3.4-5.4)
Mean	31	42	3(3.4-5.4)	29	39	3(3.4-5.4)

Table 4 Microorganisms Isolated from the Sites during the Period of Study

Sites	**Organisms Isolated**
1	*Staphylococcus* sp, *Bacillus* sp, *Penicillium* sp, *Mucor* sp, *Cladosporium* sp
2	*Staphylococcus* sp, *Bacillus* sp, *Penicillium* sp, *Mucor* sp, *Cladosporium* sp, *Rhizopus* sp
3	*Staphylococcus* sp, *Bacillus* sp, *Penicillium* sp, *Mucor* sp, *Cladosporium* sp, *Rhizopus* sp
4	*Staphylococcus* sp, *Bacillus* sp, *Enterobacter* sp, *Mucor* sp, *Cladosporium* sp,
5	*Staphylococcus* sp, *Bacillus* sp, *Enterobacter* sp, *Penicillium* sp, *Mucor* sp, *Cladosporium* sp, *Rhizopus* sp
6	*Staphylococcus* sp, *Bacillus* sp, *Enterobacter* sp *Penicillium* sp, *Mucor* sp, *Cladosporium* sp, *Rhizopus* sp
7	*Staphylococcus* sp, *Bacillus* sp, *Enterobacter* sp, *Mucor* sp, *Cladosporium* sp, *Rhizopus* sp

Table 5 Total Microbial Count of the Sampling Sites during the Day and Night of Rainy and Dry Seasons

	Microbial Count (cfu)			
	Rainy Season		Dry Season	
Sites	Day	Night	Day	Night
1	162	142	1,250	1,180
2	178	129	1,410	1,220
3	121	105	763	719
4	62	58	438	426
5	222	175	1,486	1,444
6	176	155	1,400	1,393
7	62	52	590	413
Mean1	140	116	1,048	970
Mean2	257		2,004	

Every organism that is capable of causing air pollution must be air-borne. This means that the environmental conditions of the site must be first conducive for the organism to be airborne and cause pollution. The environmental conditions most favorable for airborne microorganism are dry, hot and airy. These criteria were fully met in the dry season with its high temperature, windy atmosphere and low humidity, which resulted in a higher microbial load in the study sites compared to the rainy season.

Site 5 which had the highest microbial load had environmental conditions that were hot and humid with very poor ventilation. This was due to overcrowding caused by eight people occupying a room originally designed to accommodate two people and their respective luggage in the same room. This condition will trap dust and due to the movement of too many people in and out of the room for various reasons, more opportunity is created for microorganisms to be introduced into the room through clothing, shoes etc. This condition is made unbearable in the rainy season when it becomes very stuffy, damp and practically airless inside the room. This resulted in high humidity in the room and thus led to the isolation of more fungal species in this site than in all other sampling sites. This finding gives credit to the recommendation of the US Environmental Protection Agency (2003b), which recommends that relative humidity in homes should be at 30% -50% in order to prevent the growth of moulds.

The study also observed that the sites whose building design did not include vents, proper situation of windows and doors and low headroom which inadvertently trapped moisture inside all gave high microbial conditions (Mayo Clinic, 2002; Hult, 1998). The conclusion could then be drawn that the building design of a room could determine the microbial quality of that indoor atmosphere.

The diurnal fluctuations in microbial loads showed that the day period which is characterized by a high degree of activities in and out of the rooms is capable of stirring up more microorganisms into the air. This is unlike the night hours when most people go to sleep and some of the airborne microorganisms are given opportunity to settle down. Another reason for the fluctuations could be that during the night hours, most people close their doors and windows and as such reduce the chances of microorganisms getting into the rooms via these routes, hence a lower microbial load at night periods. The higher temperature recorded during the day compared to the lower temperature of the night is also a factor in the high microbial load of the day period.

The clear evidence of seasonal changes in microbial load could be attributed to increase in the air temperature which positively affects the growth of microorganisms. The dust particles in the air which characterizes the dry season will also allow more airborne microorganisms to be introduced into indoor environments. In contrast to this, lower microbial loads recorded during the rainy season could be a result of rain washing down the microorganism in the outdoor air into runoffs or other surfaces thereby not only reducing the level of microorganisms in the outdoor air, but also causing the ones indoors to drop from the atmosphere unto surfaces as a result of reduced temperature and the possible dampness of the indoor atmosphere.

In conclusion, every indoor atmosphere has a certain level of microbial load in it and every room that carries above its original design capacity for occupancy is prone to having a very high number of microorganisms. Rooms that are built to be air tight without proper vents and adequate windows properly situated, tend to be more susceptible to high microbial load. Carpets and furnishings could become habituating places for microorganism while badly planned building structures (without consideration of free air flow in and around the house) provide conducive environment for microorganisms to grow. Rooms and houses where a lot of activities and movement occur are more predisposed to high microbial load. The study also showed that microorganisms survive and multiply faster during the dry season compared to their growth in the rainy season. While areas that are susceptible to frequent flooding, making them damp are good places for fungi to grow, i.e. the higher the humidity, the higher the increase in the growth of fungi. The findings of the American Industrial Hygiene Association (2003) agree with the findings of this study.

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