**Original Research Article**

**Indoor Quality Assessment of Public Toilets**

**in Port Harcourt Metropolis, Rivers State, Nigeria.**

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**ABSTRACT (ARIAL, BOLD, 11 FONT, LEFT ALIGNED, CAPS)**

**Aims:** assessing the quality of indoor air in some public toilets of major motor parks in Port Harcourt metropolis

**Study design:** indoor air of public toilets in three major parks in Port Harcourt was sampled using the sedimentation technique. This was done in two periods (morning and evening).

**Place and Duration of Study:** The Mile 3, Waterlines and RTC motor park public toilets. This was a three months study (March-May).

**Methodology:** the sedimentation technique was used in collection of air samples. Freshly prepared Nutrient agar, MacConkey agar and Sabouraud Dextrose agar plates in duplicates were left open above one meter in the various study sites for 15 minutes. samples were later transferred to the Microbiological Laboratory and incubated at 22°C for 3-7 days for fungi and at 37°C for 24 hours for bacteria and coliform. After incubation, bacterial and fungal populations were enumerated and distinct isolates were purified by subculturing onto fresh NA and SDA plates. The purified isolates were used for characterization.

**Results:** bacterial isolates belonging to *Staphylococcus, Bacillus, Providencia, Pseudomonas, Escherichia, Enterobacter* and *Klebsiella* were isolated and fungal isolates belonging to the genera *Aspergillus, Penicillium, Rhizopus, Candida*, and *Mucor* species were identified in this study.

**Conclusion:** the high microbial loads in this study indicates that the indoor air is not safe in regards to the suggested WHO standard of 1000CFU/m³. Thus, this could pose serious health challenges to people who use these public toilets. Also, the bacterial and fungal genera could harbour pathogenic strains which may cause diseases or other allergic reactions.

**Keywords:** motor park public toilets, bacteria and fungi contamination, indoor air, plate exposure.

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**1. INTRODUCTION (ARIAL, BOLD, 11 FONT, LEFT ALIGNED, CAPS)**

**INTRODUCTION**

Indoor air is the air within an enclosed space or a building. Thus, indoor air quality of toilets refers to the quality of air within the toilet. In respect to the growing concern about possible biological effects of deposition of various pollutants in the atmospheric environment, air pollution and the health of the populace has become one of the most important environmental and public health issues [1]. Reason being that atmospheric pollution poses
significant impact both to human health and the environment. Evidences from various
governmental organizations and international bodies have proven that air pollution is a major
risk to the environment, quality of life, and health of the population [3, 13, 14, 15, 16]. This is
because the biological agents which are found in the air as a result of the pollution
contaminates the air and could cause serious health challenges to people who inhale them
or touch surfaces contaminated with these biological agents. Previous studies listed
diseases such as carcinogenicity, pulmonary tuberculosis, cerebrospinal meningitis,
pneumonia, whooping cough and measles as the health effects that could result due to air
pollutants [8, 11]. In a recent study by Wemedo and Robinson [12], it was reported that the
presence of biological aerosol in the air which are pathogenic could cause serious health
challenges and that these biological aerosols are discharged via talking, sweeping,
sneezing, as well as flushing toilets. Furthermore, Douglas and Robinson [4] in the study of
indoor air reported hypersensitivity reactions, pneumonia, and toxic reactions could arise
when bye products of this biological aerosols are in contact with man.

Toilets are sanitation facilities at the user interface that allow the safe and convenient
urination and defecation [10]. Thus, maintaining the indoor quality of toilets is important so
as to keep it hygienic and sanitarily conducive for usage [7]. According to Mirbahar and
Memon [6], maintaining good indoor air quality of toilets is one of the first step to create a
healthier and safer indoor environment. Air is the easiest means by which agents of
pathogenic microbes are disseminated, which can cause significant problems in the
environment; especially, in public rooms such as toilets [6]. Insufficient ventilation, high influx
of people and improper management of public toilets, are main sources of indoor air
contamination in public toilets [4, 9, 12].

A motor park is an area of land where cars or vehicles of different sizes are parked.
Travelers as well as those returning from journey get into the vehicle or alight from the
vehicles. The park which houses vehicles also is inhabited by traders and other activities
such as areas for relaxation and facilities for convenience are made available. Thus,
travelers as well as those returning from journey and others who partake in different
activities within this area utilize the toilet facilities. The influx of persons as well as the
unhygienic habits of toilet users no doubt leaves the place dirty thereby making it a
comfortable environment of airborne pathogens [9]. Understanding the quality of the indoor
air of the toilet is important so as to check the hygienic conditions. Thus, this study is aimed
at assessing the quality of indoor air in some public toilets of major motor parks in Port
Harcourt metropolis.

2. MATERIALS AND METHODS

2.1 Study Area/ Study Duration

The Mile III, Waterlines and Rivers Transport Company (RTC) motor park toilets were the
area of study. The three motor parks are in Port Harcourt, Rivers State, Nigeria. This is an
urban setting. The control was a private toilet. This was a three months study (March - May,
2018). These motor parks are highly populated because of the different activities taking
place. There are shops, hawkers, passengers boarding and alighting from buses and taxi.
The Mile 3 and RTC public toilets are water cistern which supports squatting while the
control toilet and Waterlines are standard water cistern that supports sitting. All toilets use
water for flushing urine and faeces. The images of the toilets are presented below. All toilets
use water for flushing.
2.2 Sample Collection

Air samples of the various public toilets were collected using the direct sampling method (plate exposure technique) which has been described by previous studies [4, 5, 12]. In this technique, Petri dishes containing specific medium were exposed to the ambient air in the study sites for fifteen minutes. After which plates were aseptically covered and transferred to the Microbiological laboratory and were incubated for 37 °C and 22 °C for bacteria and fungi respectively. Duration of incubation for bacteria was 24 hours while fungal plates were kept for 3-5 days. The samples were collected between two periods of the day (i.e. Morning (8 A.M) and Evening period (7 PM)).

2.3 Enumeration of Bacterial and Fungal Populations
Nutrient agar, McConkey agar and Sabouraud dextrose agar plates were exposed in the respective studied sites to enumerate the total heterotrophic bacteria, Total coliform and fungal populations. Resulting bacterial and fungal colonies after incubation were enumerated using the sedimentation formulae as described by previous studies [4, 5, 12], and were represented as CFU/M³ and SFU/M³ for bacterial and fungal isolates. The formula is described below.

\[ A = \frac{a \times 10^4}{0.2 \times \pi r^2 \times t} \]

\( a \) = number of colonies on plates
\( r \) = radius of the Petri dish
\( t \) = time of exposure of plate

2.4 Isolation and Identification of Bacterial Isolates
The distinct bacterial isolates were sub-cultured on freshly prepared nutrient agar plates until it was certain that colonies were pure (having no contaminants) and were identified as described by Cheesbrough [2]. Isolates were identified based on macroscopy (colour, shape, size, elevation and texture), microscopically and response to some biochemical tests (catalase, citrate, oxidase, motility, MR, VP, indole, and fermentation of glucose, mannitol, maltose and lactose).

2.5 Isolation and Identification of fungal isolates
After incubation, distinct fungal colonies were isolated and sub-cultured on freshly prepared SDA plates to obtain pure fungal isolates. Macroscopy and microscopic examination were used in identifying the fungal isolates before they were compared with fungal texts to aid proper identification [4].

2.6 Statistical Analysis
Two-AOVA was adopted to check for significant differences in the microbial loads of the two study sites.

3. RESULTS AND DISCUSSION
In this study, the mean microbial population of the various study sites is presented in Log₁₀Cfu/m³. The mean microbial population of the various study sites for the morning sampling period is illustrated in Table 1. The total heterotrophic bacteria ranged from 3.08±0.15 to 3.83±0.17 Log₁₀Cfu/m³, while the total coliform ranged from 2.82±0.00 to 3.73±0.27 Log₁₀Cfu/m³. The mean fungal load ranged from 2.21±0.23 to 3.01±0.48 Log₁₀Sfu/m³. The RTC and the Mile 3 motor park public toilet has the highest microbial load while the control had the least microbial loads. The Two-way analysis of variance revealed a significant difference between the control private toilet and the public toilets at \( P \geq 0.05 \). There was no significant difference in the microbial loads of the public toilets \( P \geq 0.05 \) even though the microbial loads in this study sites were very high. Also, there were no recorded significant difference in the total coliform bacteria and fungal loads of the various study sites (Table 1).

The mean microbial loads of the study sites in the evening sampling period is presented in Table 2. The mean total heterotrophic bacteria load ranged from 3.03±0.16 to 3.83±0.14 Log₁₀Cfu/m³ while the mean total coliform ranged from 2.82±0.00 to 3.81±0.19 Log₁₀Cfu/M³. The mean total fungal load ranged from 2.28±0.28 to 2.69±0.08 Log₁₀Sfu/M³. The result revealed higher bacterial load in the Mile 3 public toilets while lower bacterial loads was recorded in the control (private toilet). Apart from the significant difference observed in the control of the total heterotrophic bacterial loads, all other studied sites despite the variations in bacteria load shew no significant difference at \( P=0.05 \). Also, the coliform and fungal load had no significant differences across the studied sites (Table 2). Furthermore, there were increase in the total heterotrophic bacteria loads of the evening sampling as compared to the morning sampling of the Mile 3 and Waterlines public toilets, while a slight decrease was
recorded in the evening sampling of the control. Also, apart from the Mile 3 public toilet whose coliform loads increased in the evening period, other studied sites had higher coliform counts in the morning period. Despite the variations of microbial loads observed in the different sampling period, there were no significant difference between the microbial load of the morning and evening sampling period. In a recent study, it was reported that the microbial load increased in the evening sampling period and that increased microbial population is related to the influx of persons [9, 12]. Thus, the high microbial load observed in the evening sampling period of the Mile 3 and Waterlines motor park public toilet could be that the public toilet is frequently used more in the evening period than in the morning. In the RTC motor park public toilet, the heterotrophic bacteria load was almost the same for both sample periods. It could be asserted that the number of persons who utilize the toilet in the morning could be equal to the number of persons who uses it in the evening, or it could also be attributed to the regular cleaning of the toilets. Cleaning of toilets could cause unfavourable conditions of microbes thereby cause a reduction in the microbial load [9]. Furthermore, the microbial load in the public toilets are very high and exceeds the 1000Cfu/m^3 suggested standard of microbial loads in indoor air [12]. The result in this study revealed that the private toilet has the least microbial populations (both the total heterotrophic bacteria, coliform bacteria and fungal load). This could be related to the continuous use by lots of persons in the motor park as well as other activities taking place in these motor parks. Also, the attitude of the users such as indiscriminate disposal of wastes in the toilets, urinating on toilet floors instead of the sink, and littering the toilet environment with water or tissues or inappropriate flushing of the toilets. This statement agreed with [9].

Table 1. Mean count of the microbial population of the morning sampling session of the various study locations in Log_{10}Cfu/M^3

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>THB</th>
<th>TCC</th>
<th>TFC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>3.08±0.15a</td>
<td>2.82±0.00c</td>
<td>2.21±0.23d</td>
</tr>
<tr>
<td>Mile 3</td>
<td>3.83±0.03b</td>
<td>3.70±0.26c</td>
<td>2.88±0.53d</td>
</tr>
<tr>
<td>RTC</td>
<td>3.83±0.17b</td>
<td>3.73±0.27c</td>
<td>3.01±0.48d</td>
</tr>
<tr>
<td>Waterlines</td>
<td>3.54±0.21b</td>
<td>3.37±0.43c</td>
<td>2.91±0.57d</td>
</tr>
</tbody>
</table>

 Means with the same alphabet across columns shows no significant difference (P≥0.05)

Table 2. Mean count of the microbial population of the evening sampling session of the various study locations in Log_{10}Cfu/M^3

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>THB</th>
<th>TCC</th>
<th>TFC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>3.03±0.16a</td>
<td>2.82±0.00c</td>
<td>2.28±0.28ab</td>
</tr>
<tr>
<td>Mile 3</td>
<td>3.87±0.05b</td>
<td>3.81±0.19c</td>
<td>2.69±0.08ab</td>
</tr>
<tr>
<td>RTC</td>
<td>3.83±0.12b</td>
<td>3.60±0.38c</td>
<td>2.36±0.17ab</td>
</tr>
<tr>
<td>Waterlines</td>
<td>3.83±0.14b</td>
<td>3.6±0.24c</td>
<td>2.47±0.09ab</td>
</tr>
</tbody>
</table>

 Means with the same alphabet across columns shows no significant difference (P≥0.05)
In this study, seven bacteria belonging to *Bacillus*, *Escherichia*, *Staphylococcus*, *Providencia*, *Enterobacter*, *Pseudomonas* and *Klebsiella* species were isolated. The frequency of occurrence of the bacterial isolates are presented in Table 3. The result revealed that *Escherichia*, *Staphylococcus*, *Klebsiella*, and *Bacillus* species were isolated from all the public toilets including the control (private toilet). *Providencia* species were only isolated in the Mile 3 and Waterlines public toilets, while *Enterobacter* and *Pseudomonas* species were isolated in all the public toilets but were not isolated in the control. In the result, *Staphylococcus* species was highest in the Mile 3 public toilet (33.3%) followed by the 25% in the Waterlines and RTC public toilets while 16.7% was recorded in the private toilets. The frequency of occurrence revealed that *Bacillus*, *Providencia*, *Enterobacter*, *Escherichia* and *Klebsiella* were very high in the Waterlines public toilets as compared to other locations and frequency was observed as 34.8%, 55.6%, 54.6%, 40% and 40% respectively. *Bacillus* and *Staphylococcus* species which are present in the indoor air of this study have been isolated in the indoor air of some motor park public toilet in Imo state, Nigeria [9]. Similar bacteria genera have been isolated from indoor air in previous study [5, 12]. The presence of *Staphylococcus* and *Bacillus* species could be attributed to their ubiquitous nature. Previous studies have reported infections from the bacteria in this study [12, 17]. The presence of endospores in *Bacillus* confers them the ability to survive even in unfavourable environments [12]. *Escherichia coli* could cause urinary tract infections under favourable conditions.

Five fungal genera belonging to *Aspergillus*, *Candida*, *Rhizopus*, *Mucor* and *Penicillium* were isolated in this study (Table 4). The frequency of occurrence of fungal isolates as presented in Table 4 revealed that *Aspergillus* species were the most predominant fungi and was present in all study sites. *Candida* species were isolated from all the studied sites except from the RTC motor park public toilet. The RTC motor park public toilet recorded the highest frequency of *Aspergillus* species (33.3%) followed by the 25.9% recorded in the Mile 3 and Waterlines motor park public toilets. *Mucor* species was isolated in only the Mile 3 and Waterlines motor park public toilets, while *Rhizopus* species were only isolated from the Waterlines and RTC public toilets. The fungal isolates in this study have been isolated from public toilets in of some motor parks in Imo state, Nigeria. In a recent study, the fungal isolates in the indoor air of this study have been reported in the indoor air of some government health facilities [4]. The presence of these fungal spores in the indoor air could impact the health of individuals especially those with low immune response who may come in close contact with the spores [4, 5].

<table>
<thead>
<tr>
<th>S/N</th>
<th>Bacterial Isolate</th>
<th>Control</th>
<th>Mile 3</th>
<th>Waterline</th>
<th>RTC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>Staphylococcus</em> sp</td>
<td>16.7</td>
<td>33.3</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>2</td>
<td><em>Bacillus</em> sp</td>
<td>13</td>
<td>21.7</td>
<td>34.8</td>
<td>30.4</td>
</tr>
<tr>
<td>3</td>
<td><em>Providencia</em> sp</td>
<td>0</td>
<td>44.4</td>
<td>55.6</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td><em>Pseudomonas</em> sp</td>
<td>0</td>
<td>41.2</td>
<td>35.3</td>
<td>23.5</td>
</tr>
<tr>
<td>5</td>
<td><em>Escherichia</em> sp</td>
<td>20</td>
<td>15</td>
<td>40</td>
<td>25</td>
</tr>
<tr>
<td>6</td>
<td><em>Enterobacter</em> sp</td>
<td>0</td>
<td>36.4</td>
<td>54.6</td>
<td>9.1</td>
</tr>
<tr>
<td>7</td>
<td><em>Klebsiella</em> sp</td>
<td>10</td>
<td>30</td>
<td>40</td>
<td>20</td>
</tr>
</tbody>
</table>
Table 4. Frequency of occurrence of fungi in the Different Location (%)

<table>
<thead>
<tr>
<th>S/N</th>
<th>Bacterial Isolate</th>
<th>Control</th>
<th>Mile 3</th>
<th>Waterline</th>
<th>RTC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>Aspergillus</em> sp</td>
<td>14.8</td>
<td>25.9</td>
<td>25.9</td>
<td>33.3</td>
</tr>
<tr>
<td>2</td>
<td><em>Candida</em> sp</td>
<td>23.1</td>
<td>46.2</td>
<td>30.8</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td><em>Rhizopus</em> sp</td>
<td>0</td>
<td>0</td>
<td>62.5</td>
<td>37.5</td>
</tr>
<tr>
<td>4</td>
<td><em>Penicillium</em> sp</td>
<td>14.3</td>
<td>42.9</td>
<td>0</td>
<td>42.9</td>
</tr>
<tr>
<td>5</td>
<td><em>Mucor</em> sp</td>
<td>0</td>
<td>66.7</td>
<td>33.3</td>
<td>0</td>
</tr>
</tbody>
</table>

4. CONCLUSION

This study has revealed that the microbial load in these public toilets are high and indicates that the indoor air is not safe in regards to the suggested WHO standard of 1000CFU/m³. Thus, this could pose serious health challenges to people who use these public toilets. Also, the bacterial and fungal genera in this study could cause diseases or allergic reactions to users as studies have associated these microbes to cause related infections such as urinary tract infections to respiratory infections. It is therefore recommended that sanitary measures be put in place to enhance the cleanliness. Also, water should be made available both for flushing of toilets and hand washing. Waste bins should be provided and people should be put in charge to ensure that users utilize the facilities effectively without littering the place.

REFERENCES


Abbreviations
SFU: Spore forming unit
THB: Total Heterotrophic Bacteria
TCC: Total Coliform Count
TFC: Total Fungal Count