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Microbial Air Quality in Port Harcourt, Nigeria

Kome Otokunefor* and Hillary Mabel Victor

Department of Microbiology, Faculty of Science, University of Port Harcourt,
P.M.B. 5323, Port Harcourt, Nigeria
**Corresponding author:*

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A B S T R A C T

Healthy indoor air is a fundamental human right, and in unventilated rooms is affected by outdoor air quality. Studies are on-going on the effect of the presence of the current 'strange black soot' in Port Harcourt, Nigeria on microbial air quality, but it is of essence to have baseline data for comparison. This study presents such data from two sources; work carried out in our laboratory and a snapshot of all published literature on microbial air quality in Port Harcourt, prior to date. Bacterial load was determined using the passive natural sedimentation method and results presented as CFU/m^3. A comprehensive review of the literature was then carried out using the search terms "(air) AND (quality) AND (Nigeria)". Inclusion criteria included determination of bacterial load and a study site of Port Harcourt. Bacterial counts ranged from 200 to 11850 CFU/m^3. The assessment of the literature revealed that these results were similar to previously reported studies carried out in the Port Harcourt area with a range of 1230 – 12540 CFU/m^3. This study presents information on microbial air quality in Port Harcourt, Nigeria, which could serve as baseline data particularly with respect to the current environmental situation in Port Harcourt.

Introduction

Numerous studies have been carried out worldwide assessing indoor microbiological air quality, pointing at the important role air quality plays in impacting the general health and well being of humans as a whole. A World Health document outlining the WHO guidelines for indoor air quality, describes healthy indoor air as a fundamental human right. This is particularly important considering that a significant number of people have been reported to spend the majority of their time (between 80% and 90%) indoors (Hospodsky *et al.*, 2012; Hayleeyesus and Manaye, 2014). Currently, though no single international standard exists as a guide for bacterial contamination of indoor air, several recommendations have been made. A WHO publication asserts that environments with a greater than 1000CFU/m^3 microbial load should be considered contaminated (WHO, 2009). Most other reports have set thresholds ranging from 500 to 1000 CFU/m^3 as acceptable (Nevalainen and Morawska, 2009; Borrego *et al.*, 2012; Naruka and Gaur, 2013; Kabir *et al.*, 2016).

The quality of indoor air may be affected by several factors. One of such factors is the influence of the external environment, with reports that in a well-ventilated room, the indoor air quality is similar to that of the outdoor air quality (Meadow *et al.,* 2014). Since November 2016, Port Harcourt has been affected by a 'strange black soot' of relatively unknown source (The Guardian, 2017). Port Harcourt, the capital city of Rivers State, Nigeria, is part of the oil producing Niger Delta region of the country. Several speculations on the source of the soot have pointed at illegal refineries and asphalt burning by asphalt firms. The presence of the black soot has been suspected of being linked with respiratory tract infections. There have however been no documented confirmatory reports so far. One important facet of air quality is the level and composition of airborne bacterial load. And no reports, speculative or otherwise, have so far made mention of the effect of the current event in Port Harcourt on bacteriological air quality.

Prior to this time, several studies have been carried out to ascertain both microbial load and composition to provide a picture of air quality in different locations in Port Harcourt. One such study was carried out in our lab. This article therefore sets out to present the results of the effect of human activity on microbial load in a University classroom environment prior to the current 2017 environmental problems, as well as provide a summary of all the published work done to date on microbial air quality in Port Harcourt, in a bid to provide a benchmark for subsequent comparisons.

Materials and Methods

Determination of bacterial load 'pre-black soot'

Determination of bacterial load was carried out between October and November 2015. Air sampling was carried out using the passive natural sedimentation method as previously described (Napoli *et al.,* 2012). Sampling was carried out in duplicates, at two different time points, before the beginning of the days' activities ("at rest") and after the days' activities, on seven lecture halls at the University of Port Harcourt, Faculty of Science complex. Total bacterial count was determined using nutrient agar (NA). Following this, CFU/m^3 determined using the Omeliansky equation (Borrego *et al.,* 2012) $N = 5a \times 10^4(bt)^{-1}$.

Where: N = colony forming unit per cubic meter of air (CFU/m^3) a = number of colonies per Petri dish, b = dish square centimeter, t = exposure time (min).

Review Protocol/Search Criteria

To obtain a comprehensive review of published literature, a direct PUBMED search was carried out using the following search terms "(air) AND (quality) AND (Nigeria)". Subsequent search of Google Scholar was then carried out using 'the same or similar" search terms. Papers were deemed eligible for inclusion only if the study involved determining at least the bacterial load and were carried out in Port Harcourt, Rivers State.

Results and Discussion

Air Sampling

Bacterial counts varied between sampling sites (Fig. 1), with counts ranging from 200 to 8250 CFU/m^3 in the morning and 2650 – 11850 CFU/m^3 in the evening (average of 4019 and 7907 CFU/m^{3}respectively).All sites had higher levels of bacterial load in the evening, than in the morning. The levels of variation however differed (Table 1). Three sites had a less than 15% increase in total bacterial load, while for two sites, the increase in bacterial load was greater than 1000%.

Literature review/summary of literature

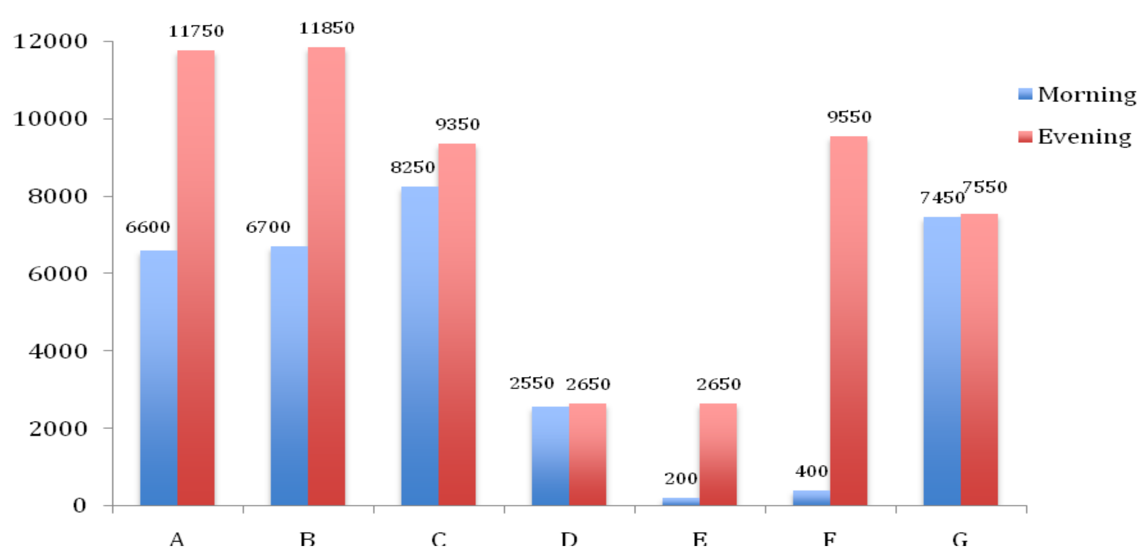
A PUBMED and Google Scholar search for articles on microbial air quality in Port Harcourt found five articles published between 2012 and 2016. Majority (4/5) of these studies assayed indoor air quality. These studies all used a similar sampling method, the settle plate or passive natural sedimentation method. They however differed in their mode of result presentation. Of the 5 studies, only 2 represented the results of their study as CFU/m^3 (Udochukwu *et al.*, 2015; Emuren and Ordinioha, 2016).These studies did not however describe how these values were obtained, and reported values ranging from 5.33 – 227.33 CFU/m^3. Two other studies (Wemedo *et al.*, 2012; Agbagwa and Onyeamachi, 2014) presented their results as CFU/30min and simply as 'no of colonies'. Conversion of these values to CFU/m^3 based on the Omeliansky formula (Borrego *et al.*, 2012) showed a wide variation in microbial load present, with a rangeof 1230 – 12540 CFU/m^3. The final study (Mbakwem-Aniebo *et al.*, 2016) presented results as CFU/m2/h, with values ranging from 75 – 4710.

With each human being inhaling 14 m^3 of air per day on the average (Kabir *et al.*, 2016), the potential impact air quality has on the quality of human life cannot be over-emphasized. The microbial analysis of indoor air quality carried out in this study revealed a count range of 200 – 11850 CFU/m^3 and these were generally (12/14) above the recommended acceptable standards. This range was however similar to two previously published reports on air quality in Port Harcourt (Wemedo *et al.*, 2012; Agbagwa and Onyeamachi, 2014), which reported ranges of 1230 - 6660 and 1500 – 12540 respectively.

Table.1 Level of variation in bacterial load

Site ID	A	B	C	D	E	F	G
% Level of Variation	78	76.9	13.3	3.9	1225	2288	1.3

Fig.1 Total bacterial count on nutrient agar (CFU/m3)



Also, these ranges were similar to those of several studies carried out in Ethiopia, which noted microbial loads with ranges of 117 – 7284, 397 – 2595, 511 – 9960 and 3106 – 9733 (Kabir *et al*., 2016; Hayleeyesus and Manaye, 2014; Hayleeyesus *et al*., 2015; Fekadu and Getachewu, 2015).

These studies noted a variation in microbial load based on sampling location (i.e. indoor or outdoor), function of the indoor environments and month of the year. A similar study carried out in Poland (Fraczek and Gorny, 2011), also noted a range of 21 – 6223. All these reports however differed from some reports from the rest of Nigeria, which noted low microbial loads with ranges such as 42 – 100, 422 – 1386 and 45 – 1125 CFU/m^3 (Makut *et al*., 2014; Ambrose *et al*., 2015; Awosika *et al*., 2012). One common observation of the various studies, was the effect of human activity on microbial load. This trend was also observed in our study with higher microbial loads observed at the end of the day (Figure 1), possibly due to human activity.

The analysis of current literature on microbial air quality in Port Harcourt yielded data that could serve as a baseline for further comparison. This data was comparable with previously published literature as noted in the preceding paragraph. Additionally though, this assessment of the literature revealed an immediate need for standardization and clear representation of methodology, despite the fact that 5 different articles reported on microbial air quality in Port Harcourt, Rivers State, Nigeria, data comparison could only be clearly made from two papers due to a lack of standardized methodology. While all 5 studies made use of the passive sampling methodology, variations existed in the representation of the results obtained following the passive sampling. Various methods are widely employed, with results presented as CFU/m^3, CFU/m2/h, CFU/30min and 'number of colonies'. To aid widespread comparison therefore, it is expedient for the scientific community to come up with standard data reporting with regards to microbial air quality reporting, and lay out guidelines advising on specific methodology to be employed under specific conditions.

In conclusion, though our study presents baseline data, which is of essence for future comparisons especially with the current environmental situation in Port Harcourt, Nigeria, it also highlights several limitations that could be addressed by future studies.

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