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Indoor Air Quality and Sanitary Conditions in Selected Food Vending Premises at the University College Hospital, Ibadan, Nigeria

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Abstract

Poor Indoor Air Quality (IAQ) and non-conformity with acceptable sanitary practices compromise integrity of food and people's health. Studyon nature of indoor air required to institute indoor air quality control regime is lacking in University College Hospital (UCH), Ibadan. This study assessed IAQ and sanitary conditions in selected food vending premises at UCH, Ibadan. A descriptive cross-sectional design involving fourteen consented food premises was adopted. Indoor air (kitchen and dining hall) was monitored for Relative Humidity (RH) and temperature using Multi-Tester N21FR. Particulate matter (PM_{10}), carbon monoxide (CO), carbon dioxide (CO_2), Total Bacterial Counts (TBC) and Total Fungal Counts (TFC) were measured using Single Channel Particle Counter, CO-meter, and CO_2-meter and TE–10–890 Single Stage air sampler respectively. Measurements were taken thrice daily for 8 weeks. Data obtained were compared with WHO guideline limits.Using an observational checklist, building facilities were assessed; while hygiene characteristics were scored on a 50-point scale as unsatisfactory (=25) and satisfactory (>25). Data analysis involved descriptive statistics, ANOVA, and Pearson correlation at p = 0.05. Mean RH, temperature, PM_{10} and CO at kitchen (73.1±7.0%, 28.7±2.2°C, 59.3±30.2µg/m^3 and 10.1±12.9ppm) and dining hall (72.4±7.6%, 29.1±2.3°C, 58.7±29.4µg/m^3 and 0.1±0.7ppm) respectively exceeded guideline limits. Mean CO_2,TBC and TFC at kitchen (472.3±131.4ppm, 198.0±114.5cfu/m^3 and 57.9±17.7cfu/m^3) and dining hall (461.7±127.6ppm, 189.2±84.0cfu/m^3 and 57.6±17.2cfu/m^3) respectively were within acceptable limits. The premises lacked toilet (85.7%); potable water (42.9%); appropriate refuse bin (28.6%) and hand-washing equipment (35.7%). About 29.0% of the premises had unsatisfactory hygiene score. Significant negative correlation existed between hygiene score and CO (r = -0.111), CO_2 (r = -0.064), TBC (r = -0.144) and TFC (r = -0.136). Unsatisfactory sanitary conditions contributed to higher levels of indoor air quality parameters. Routine air monitoring programmes and sanitary inspection of the premises are advocated.

Keywords: Indoor air quality, Sanitary conditions, Food vending premises, University College Hospital

Introduction

Human exposure to indoor air pollutants is inevitable. This is as a result of the fact that people do spend most of their time in enclosed settings – such as an estimated 85% in indoor (including homes and offices) and 3% inside vehicles (Lawrence *et al.,*2004; Lazaridis, 2011). Possible sources of such exposure include infiltration of outdoor air, and emission from indoor materials and activities (such as cooking, cigarette smoking, settling of dust particles, and so on). These means of exposure vary possibly from different compositions and toxic effects. Especially in the developing countries, sanitation has been identified as a neglected area in which significant change could be spurred. Food prepared in large quantities is more liable to contamination. This could give rise to a greater potential for occurrence of foodborne disease outbreaks especially if basic sanitary practices are not maintained (Knife and Abera, 2007). In addition, inadequate facilities for garbage disposal, poor sanitary practices in food storage, handling, and preparation posed further hazards (Mulugeta and Bayeh, 2012).
In the present day, the level of emergence of different kinds of eateries in the country is on the increase. Even in most of such emerging ones, the modes of operation (in terms of sitting and maintenance practices) do not conform to standard/acceptable environmental practices. As a result, the safety of the indoor air and health of occupants (i.e. cafeteria workers, patrons, e.t.c) are liable to being threatened.

Although several studies have been carried out in terms of indoor air quality of various locations that of eateries have not been fully explored, especially in Nigeria. Furthermore, evidence-based study on nature of physico-chemical and biological contaminants of indoor air required to institute indoor air quality control regime is lacking in the University College Hospital (UCH), Ibadan. As a result, it is deemed necessary to conduct a research on the quality of air which affects health of occupants in the settings. Therefore, this study assessed the indoor air quality and sanitary conditions in selected food vending premises at the University College Hospital, Ibadan.

Materials ad Methods

Study Area

The study was carried out in food premises located at the University College Hospital (UCH) in Ibadan, the capital city of Oyo state of Nigeria, Ibadan. The University College Hospital (UCH) was founded in 1952. It was set out to a world-class health institution, established by an act of parliament in West Africa. It was found that many food premises are located within the UCH premises, each of which usually came into being through an established protocol for lease by the UCH Department of General Administration. Subsequently, these food premises were inspected on a regular basis for sanitary/hygiene compliance by the UCH Environmental Health Unit of Total Facility Management Department. In addition, the UCH Infection Control Unit of Medical Microbiology Department carry out personal monitoring of the food handlers to ensure their medical fitness in order to diagnose and checkmate those who are carriers of common food-poisoning agents. Some of the food vending premises served regular meals, while others were involved with only food snacks and drinks.

Methodology

Eighteen food premises were identified within UCH and they were all consented to participate in the study. However, only fourteen of the consented food premises agreed to participate in the study. These were selected for onsite observation of sanitary conditions and air monitoring.

(1) Direct (on-site) observation

Using an observational checklist, a walkthrough was carried out to evaluate sanitary conditions and general building characteristics in each of selected food

vending premises. Each of the selected food vending premises was observed in terms of:

Building structure and available facilities: Variables of assessment were included in the domains such as building materials (floor, wall and roofing/ceiling characteristics) and sanitary facilities.

Overall sanitary condition of the food premises: Certain variables were selected to rate the sanitary conditions based on hygiene characteristics and aesthetic outlook of the food premises. The selected variables were included in such domains as building condition, food preparation and handling, dishwashing area, provision for personal hygiene, site and neighbourhood.

Indoor Air Monitoring

Air monitoring was carried out at the kitchen, dining hall and ambient space (in proximity to fresh air intake by indoor locations) in each of the selected food premises. It involved activities such as measurement of meteorological parameters; measurement of selected physico-chemical parameters; and air m*icrobial load assessment*. In all cases, measurements were taken in the morning (between 8am and 10am), afternoon (between 12pm and 2pm) and evening (between 4pm and 6pm).

(a) Measurement of meteorological parameters: This involved measurements of relative humidity (RH) and temperature using a 4-in-one air quality monitor (Kanomax, USA). The reading were taken at three sampling points (i.e front, middle and back of the food premises) to obtain average readings at each sampling location.

(b) Measurement of selected physico-chemical parameters: This involved measurements of indoor particulate matter (PM_{10}), carbon monoxide and carbon dioxide using Met One GT 321 single channel particle counter, CO and CO_2-digital samplers, respectively.

(c) Microbial Load Assessment: This involved sampling of indoor air for evaluation of microbial loads of bacteria and fungi using a volumetric microbial sampler which uses petri-dish containing agar medium. Each agar plate at about 2 m from the floor was exposed for ten minutes at the central point of each sampling location. Nutrient agar (NA) was used for bacterial sampling while potato dextrose agar (PDA) was used for fungal sampling. After a period of incubation in the laboratory, microbial samples were analysed for identification/ characterization. As described by Fawole and Oso (2004) and Olayemi*et al*., (2008), bacterial isolateswere characterized by colonial morphology and microscopic examination of Gram staining (into Gram positive and Gram negative bacteria). In each case of bacterial and fungal isolates, colonies were counted and calculated as colony-forming units per cubic meter of air (cfu/m^3) by the formula:

$$cfu/m^3 = \frac{colonies\ on\ agar \times 1000}{[air\ flow\ rate \times sampling\ time]}$$

(Zheng, 2009)

All data obtained from the observational checklist and indoor air monitoring were manually coded, sorted, and finally inputed into appropriate file structures on SPSS version 16. The qualitative data were summarised using descriptive statistics (i.e. percentage frequency). Hygiene scores were categorised on a 50-point scale as unsatisfactory (≤ 25) and satisfactory (> 25).The quantitative data were summarised using descriptive statistics (including mean and standard deviation). For each of the food vending premises, the indoor measurements in the morning, afternoon and evening were aggregated to give a single estimate of the indoor concentration of each of the air quality parameters at each of the dining hall and kitchen. This was done in order to obtain a better estimate of the measured air quality parameters. Using Analysis of Variance (ANOVA), mean estimates of each quantitative data were compared appropriately with World Health

Organization (WHO) or American Conference of Governmental Industrial Hygienists (ACGIH) maximum guideline limits across the selected food vending premises. Levels of associations between the air quality parameters were evaluated by determining the correlation coefficients at $p = 0.05$.

Results and Discussion

Sanitary Condition of the Selected Food Vending Premises

It was found difficult to rate the overall sanitary condition of the food premises as good or bad owing to the lack of a standard grading tool and a reference material. As a result, the overall sanitary condition observed in each food vending premises was documented in terms of: (1) the building quality and available facilities; (2) Sanitary and hygiene score obtained by the food vending premises.

As stated in the Food Safety Act (1990) and Nigerian National Environmental Health Practice Regulation (2007), it is necessary for food premises to maintain housing conditions in good repair in order to safeguard occupants' health and food against contamination. However, the findings of this study indicated that while some premises tend to be clean and well repaired, others were unclean and not well repaired especially in terms of the building structures and materials. This is similar to the findings of Knife and Abera (2007); Mulugeta and Bayeh (2012). The discrepancy in the physical status of some of the food vending premises could be explained by the differences in the conformity to housing sanitation requirements. Many of the food premises were initially not intended for food service but were converted later without consideration of adherence to sanitation requirements. Table 1 gives a description of building structures and materials as observed in the selected food premises, while the percentage use of different types of cooking facility in the selected food vending premises is shown in figure 1.

Although the majority of the food vending premises had a kind of refuse storage bin, some (24.6%) did not comply with the appropriate specification for waste collection bin (such that it constitutes less nuisances to occupants or neighbouring premises and being adequate in size to meet the anticipated refuse generation). Some of the waste bins were sacks, polythene bags and cartons which are unhygienic and prone to spillage, thus serving as a breeding site for pests/vectors that can even contaminate foods. Among suggested reasons for the use of inappropriate waste bins was that the owners/cleaners may not be knowledgeable about the importance of appropriate types of refuse bins.

As depicted in Table 2, majority of the food vending premises lacked toilet facility while for those that had a toilet, it was met in good condition (being a flush-type water closet, adequate water available for toilet use, soap for hand washing, and aesthetic outlook). For potable water supply, only about half of the selected food vending premises had privately-owned tap within the premises, sourced from the UCH water treatment plant. Others used to fetch water from a nearby running tap, also sourced from the UCH water treatment plant.

Concerning sanitary and hygiene scores across the selected food vending premises, Table 3 presents the respective scores of each food vending premises in terms of sanitary and hygiene outlook as measured by certain indicators. About 29.0% of the selected food vending premises had unsatisfactory hygiene score. This could be interpreted as a reflection of poor sanitary condition in such food premises.

Table 1: Building Structures and Materials as Observed in the Selected Food Vending Premises

	Concreted floor	11 (78.6%)
Floor Characteristics	Floor cover:	
	Terrazzo	5 (35.7%)
	Tiles	6 (42.9%)
	None	3 (21.4%)
	Plastered concrete:	
	Entire (highly)	5 (35.7%)
	Partly (less)	8 (57.1%)
Wall Characteristics	Wooden:	
	Entire (highly)	2 (14.3%)
	Partly (less)	8 (57.1%)
	Tiled:	
	Partly (less)	3 (21.4%)
	Painted:	
	Entire (highly)	10 (71.4%)
	Partly (less)	1 (7.1%)
Roof/Ceiling Characteristics	Roof covered:	
	Entire (highly)	5 (35.7%)
	Partly (less)	8 (57.1%)
	Ceiling board:	
	PVC rod	6 (42.9%)
	Wooden	1 (7.1%)
	Thick carton	1 (7.1%)
	Decken	5 (35.7%)

Table 2: Sanitary Facilities available in the Selected Food Vending Premises

Running tap for water supply	Functional/in good condition	8 (57.1%)
Drainage ditch	Absent	6 (42.9%)
	Functional/in good condition	8 (57.1%)
Solid waste storage bin	Absent	6 (42.9%)
	Functional/in good condition	10 (71.4%)
Toilet	Absent	4 (28.6%)
	Functional/in good condition	2 (14.3%)
Conventional hand washing basin	Absent	12 (85.7%)
	Functional/in good condition	9 (64.3%)
	Absent	5 (35.7%)

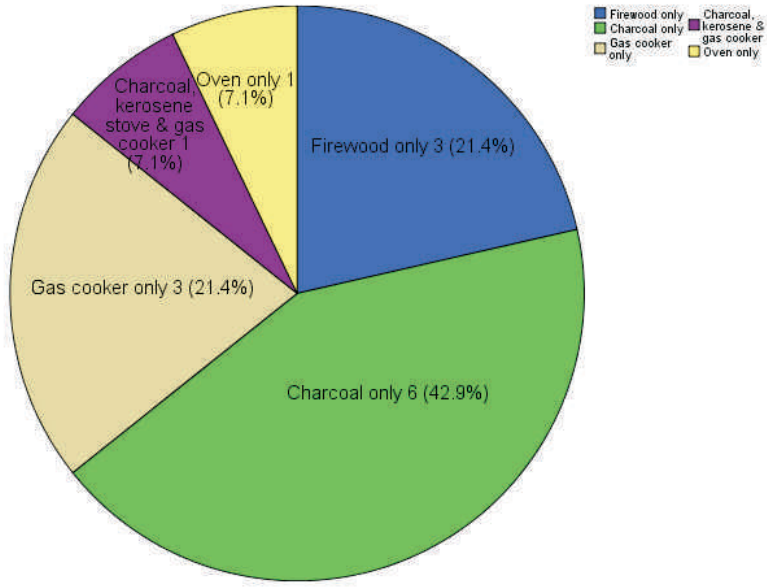

Figure 1: Percentage Use of Different Types of Cooking Facility in the Selected Food Vending Premises

Table 3: Sanitary and Hygiene Scores Across the Selected Food Vending Premises

Food Vending Premises (FVP)	Indicators					Total score
	Building condition	Food preparation & handling	Dishwashing area	Provision for personal hygiene	Site and neighbourhood	
FVP 01	9	3	4	4	20	40
FVP 02	4	2	3	2	8	19
FVP 03	10	5	3	3	18	39
FVP 04	9	4	3	4	13	33
FVP 05	7	3	2	2	9	23
FVP 06	10	6	3	5	17	41
FVP 07	10	3	2	4	13	32
FVP 08	9	2	1	3	9	24
FVP 09	8	2	2	2	10	24
FVP 10	10	4	2	4	18	38
FVP 11	10	5	4	3	20	42
FVP 12	9	4	3	4	17	37
FVP 13	10	5	1	1	13	30
FVP 14	10	5	3	5	22	45
Score obtainable	11	6	4	6	23	50

Variations in Monitored Air Quality Parameters in the Selected Food Vending Premises

Generally, the levels of each measured physico-chemical parameters across the food vending premises vary so much between the locations (i.e. kitchen, dining hall and outdoor) such that patterns are easily discernible.

Temperature and RH together are important determinants of people's perceptions of thermal comfort (WHO, 2007). As shown in Figures 2 and 3 respectively, this study found mean temperature and relative humidity frequently to exceed the WHO guidelines of 25 °C and 60% respectively in all the food premises kitchens, dining halls and outdoors. Ghasemkhani and Naseri (2008) reported that an active humidity system provided better ventilation than systems without active humidity control and led to improved comfort. In addition, relative humidity above 60% may support growth of pathogenic or allergenic microorganisms (WHO, 2007). Similarly, this study revealed a significant positive correlation between RH and total fungal counts, implying that RH accounted for certain percentage of variance in indoor TFC concentrations.

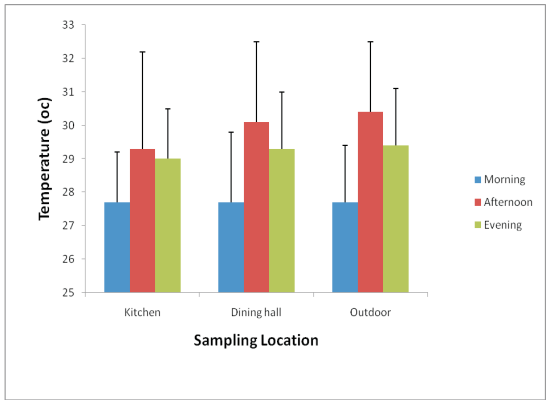

Figure 2: Daily Mean Temperature across the sampling locations

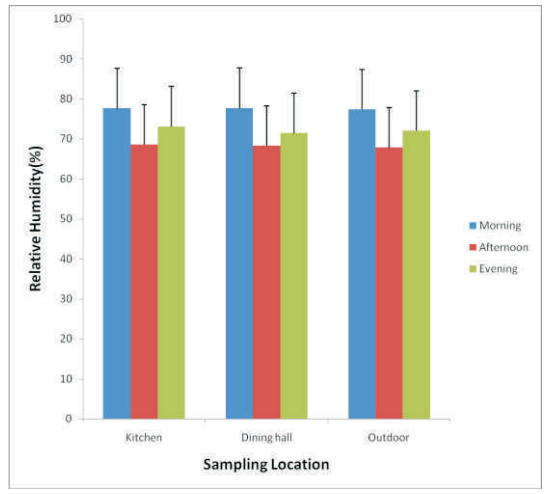

Figure 3: Daily Mean Relative humidity across the sampling locations

As depicted in Figure 4, this study revealed mean daily indoor PM_{10} concentrations higher than the outdoor air levels, though the dining concentration was lower than the kitchen concentration. It is therefore suggested that indoor concentrations are strongly influenced by activities and movement of occupants, which may allow resuspension of previously deposited particles or their delayed deposition or settling. This is consistent with the study findings of *Célia et al.*, 2014; Lee and Chang, 2000; Ekmekcioglu and Keskin, 2007; Fromme *et al.*, 2007; Diapouli *et al.*, 2008, which all reported higher levels of indoor PM_{10} concentration than the outdoor concentrations.

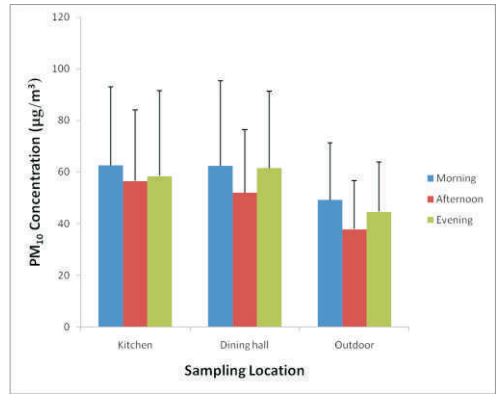

Figure 4: Mean Particulate matter (PM_{10}) Concentrations across the sampling locations

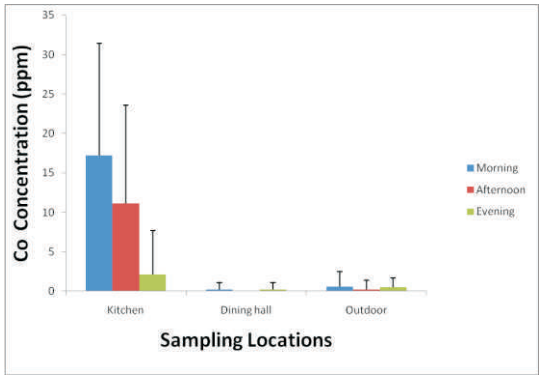

Figure 5: Mean Carbon monoxide (Co) Concentrations across the sampling locations

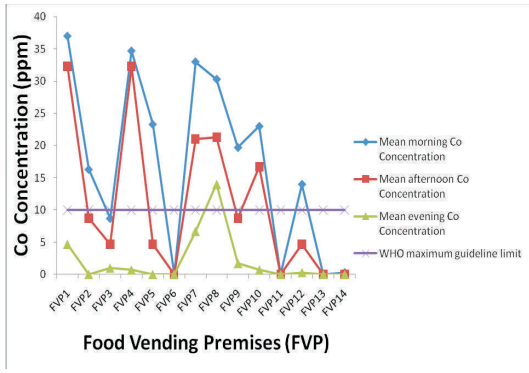

Figure 6: Variation in Kitchen Carbon monoxide (Co) Concentrations across the food vending premises versus the WHO maximum guideline limit

The results presented in Figures 5 and 6 showed that the mean kitchen concentrations of CO in nine (64.3%) of the food vending premises exceeded WHO guideline limit established as 10 ppm whereas the mean concentrations at the dining hall and outdoor were below the standard across all (100%) the food premises. Comparison of average values across the sampled locations revealed that indoor CO concentration (at kitchen) was more than the dining and outdoor concentrations. Similar to studies reported by Lee *et al*., (2001) and Ghasemkhani and Naseri (2008), the higher CO levels at kitchen were probably due to the use of various types of cooking facilities in the kitchens.

The mean indoor concentrations of carbon dioxide differ significantly among food vending premises using different types of cooking facilities (including those with high and less potential for smoke emission). Contrary to the study findings of Milz *et al*., (2007) however, the mean indoor carbon dioxide levels in all cases were within the criterion level of 1000 ppm as set by the World Health Organization (WHO) and the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE). Thus, this study had indicated adequate fresh air supply, which might have diluted the smoke emission from potential cooking facilities in the selected food vending premises. Similar to the findings of Palanivelraja and Manirathinem (2009), this study indicated significant positive correlations between kitchen and dining Co_2 concentration ($R^2 = 0.393$) as depicted in figure 7; kitchen and outdoor Co_2 concentration ($R^2 = 0.040$); dining and outdoor Co_2 concentration ($R^2 = 0.047$), implying a source relationship within the food premises.

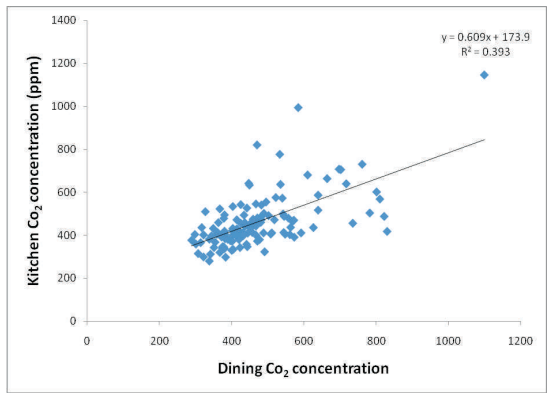

Figure 7: Relationship between Kitchen Co_2 and Dining Co_2concentration

From the perspective of food industry, an increased concentration of microbes in the air may reduce the shelf life of the processed food. In other words, there is an increasing concern over the role of air as a vector of food contamination. As obtained from studies by Osimani *et al*., (2013) and Yusup *et al*., (2014) in restaurants, this study revealed a higher burden of bacteria than fungal load. However, average values of both TBC and TFC were quite low

compared with the American Conference of Governmental Industrial Hygienists (ACGIH) standard value of 500 cfu/m^3. These are shown in Figures 8 and 9. In addition, this study revealed a strong positive correlation between PM_{10} and microbial concentrations. This is consistent with the findings of Abdel Hameed and Habeeballah (2013) and Yusup *et al.*, (2014).

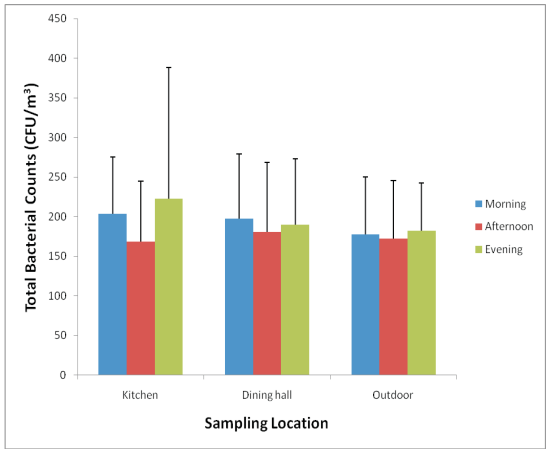

Figure 8: Mean Total Bacterial Counts (TBC) across the sampling locations

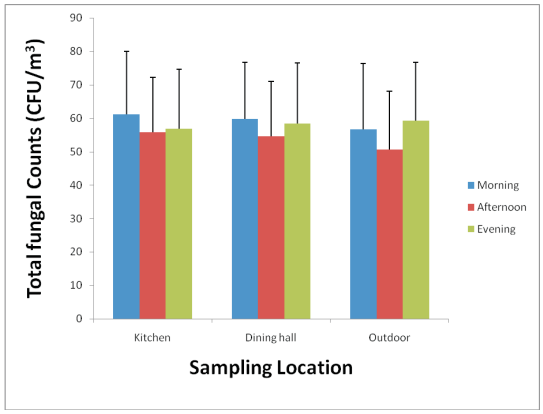

Figure 9: Mean Total Fungal Counts (TFC) across the sampling locations

Conclusion and Recommendations

In general, it can be concluded that not all the food vending premises at University College Hospital were found to be well maintained with good sanitary condition. Specifically, the study identified major deficiencies including poor repair conditions of building structural layout, non-availability of toilet facility, inadequate portable water supply, inappropriate refuse storage bins, inappropriate hand washing equipment, and unsatisfactory hygiene score in a few number of the food vending premises.

On the other hand, indoor air quality assessment of the food vending premises revealed discernible pattern of variations in the levels of each of the measured air quality parameters across the food vending premises such as:

- Higher levels of relative humidity, temperature, PM_{10} and carbon monoxide concentrations than the corresponding guideline limits.
- Lower levels of both total bacterial and total fungal counts than the guideline limits.
- Possible influence of relative humidity and temperature on the variations of other air quality parameters.

Generally, the unsatisfactory hygiene score, indicating poor sanitary condition have potential for contributing to the higher levels of indoor air quality parameters in the food vending premises.

Based on these study findings, the following are suggested to the UCH Environmental Health unit, which is the regulatory body in charge of supervision of established food vending premises:

- Ensuring routine and regular update of the register for available food vending premises, so as to keep them in check.
- Routine educational programmes should be organised to improve awareness of food handlers and other food premises workers on the importance of improved sanitary and hygiene practices which contribute to

air quality.

– Routine air monitoring programmes and sanitary inspection of the premises are advocated in order to maintain indoor air quality and sanitary conditions at safe and acceptable level.

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