VOL. 3, NO. 6, June 2013 ISSN 2225-7217
ARPN Journal of Science and Technology

http://www.ejournalofscience.org

Comparative Study on Airborne Microbe in Different Phases of Building Commissioning for Indoor Air Quality Improvement

[1] Ahmad Sayuti Zainal Abidin, [2] A.M. Leman, [3] Nor MohdRazif Noraini, [4] M.D Amir Abdullah
[1] Laboratory Division, National Institute of Occupational Safety and Health (NIOSH), Malaysia
[2, 4] Faculty of Engineering Technology, University Tun Hussein Onn Malaysia,
86400 Parit Raja, BatuPahat, Johor, Malaysia
[3] Industrial Hygiene Divisions, National Institute of Occupational Safety and Health (NIOSH), Malaysia

ABSTRACT

Exposure to indoor air pollution is becoming serious public health problem in a wide variety of non-industrial setting such as residences, offices, schools, hospital and vehicles. This study intended to investigate the level of airborne microbe in indoor environment at three different phases of building commissioning for a new constructed building in Bandar Baru Bangi, Selangor, Malaysia. The airborne microbes' concentrations were determined by using a single stage impact or (Biosampler) as per requirement of National Institute of Occupational Safety and Health (NIOSH) method, NIOSH Manual Analytical Method NMAM 0800 were used in this study. The total concentration of airborne bacteria and fungi were average 641 and 338 CFU/m^3 in the first phase, 133 and 117 CFU/m^3 in the second phase, and 389 and 52 CFU/m^3 in the third phase. These findings indicate that although a new constructed building should be having a significant background level of airborne microbe (total bacteria and total fungi). The building owner should be aware to their building maintenance status to protect the occupant from the safety and health problem (risk). The study also can be the basics baseline study of new constructed ventilated building

Keywords: *Airborne Microbe, Total Bacteria, Total Fungi, Indoor Air Quality and Safety and Health*

1. INTRODUCTION

In the recent years, exposure to indoor air pollution is becoming serious public health problem in a wide variety of nonindustrial setting such as residences, offices, schools, hospital and vehicles. Increasing concern regarding this issue is due to most people spending their working time in indoor environment (Siti Hamimah et al 2010). Among the indoor air pollutant identified, airborne microbe is one of the most contaminant that addressing major issue in defining poor indoor air quality. A wide variety of microorganism such as fungi (moulds, yeasts), bacteria, viruses, and amoebae can be found in the indoor environment. It is noted that people spend almost 80 to 90 percent of their time stay indoors (Hai-Qiao Wang et al 2001). With the range of 10 000 to 30 000 litre of air breath by normal person, it is essential to ensure that the air we breathe is clean for any pollutant that may harmful to human health. This study was performed to investigate the level of airborne bacteria and fungi in new constructed building and will be compared it with the maximum exposure limit as stipulated by the Department of Occupational Safety and Health (DOSH), Industrial Code of Practices for Indoor Air Quality (ICOP-IAQ 2010).

2. RELATED WORKS

Common pollutants found in buildings are volatile organic compounds (VOC), airborne microorganism, formaldehyde (CH_2HO), particulates matter (PM), radon, asbestos, and combustion gases and by-products. These pollutants come from a variety of sources such as household cleaning products, wood or fuels burning, building materials and products, furnishings, paint strippers, pesticides, the soil surrounding, and human activities (Ronald E. Gots, 2003). In Malaysia, comprehensive guidelines were produce in order to provide guidance on improving the indoor air quality (IAQ) and to set minimum standard for selected parameter that will avoid discomfort and adverse health effect among employees and other occupants of indoor or enclosed environment served by mechanical ventilating and air conditioning (MVAC) system including cooled split unit.

However, this guideline was produce as reactive limits for the place of works such as office building in dealing with the indoor pollutant exposure in indoor environment. The selected parameter include three thermal comfort parameter; air temperature, relative humidity and air movement; and eight common indoor environmental parameters which been divided into two type of air contaminant which is Carbon Monoxide, Formaldehyde, Ozone, reparable particulate and Total Volatile Organic Compounds (TVOC) is classified as chemical contaminant, total bacteria counts and total fungi count is categorized as biological contaminant (Department of Occupational Safety and Health (DOSH), Industrial Code of Practices for Indoor Air Quality (ICOP-IAQ 2010). One of the best parameter to evaluate poor indoor environment quality is airborne microorganism (L.T Wong et al. 2006 and Ki Youn Kim and Chi Nyon Kim 2007). A wide variety of microorganism such as fungi (moulds, yeasts), bacteria, viruses, and amoebae can be found in the indoor environment. Studies have demonstrated that even at the clean room there were a significant number of airborne microorganisms found (Martin S. Favero et al, 1966). Existence of moldy partition or decomposed wall frequently becomes first choice indicator of problematic indoor environment related to biological exposure especially in the office (L.T. Wong et al, 2008 and Kwok Wai Mui et al 2010).

3. METHODOLOGY

3.1 Sampling Location

A new constructed building was selected for this study. Sampling location was selected in each level according to the procedure specified in the Industrial Code of Practices for Indoor Air Quality (ICOP-IAQ) 2010, recommended minimum number of sampling points for indoor air quality assessment. It was divided by three different phases of building commissioning in Bandar Baru Bangi, Selangor, Malaysia. The first phases of the sampling were carried out after the building fully handed over from the main contractor to the building owner. Second phase of the sampling took place after the building is equipped with furniture. Third phase sampling is conducted after one month of building occupancy. Table 1 below show the total number of sample collected from each phase.

Table 1: Information on indoor environment sampling point

Location	No of Sampling Point	Phase 1	Phase 2	Phase 3
Office Non Carpeted	8	/	/	/
Office Carpeted	8	/	/	/
Classroom	12	/	/	/
Classroom Corridor	6	/	/	/
Total Sampling Point	34 x 3 phases = 102			

3.2 Sampling

Airborne microbes' concentrations were determined by using a Anderson single stage impact or and operated at a flow rate of 28.3 L/min as per requirement of National Institute of Occupational Safety and Health (NIOSH) method NIOSH Manual Analytical Method NMAM 0800. The impact or was located at the centre of the sampling location and 1.0 to 1.5 meter above the floor for the sampling point. The sample was obtained over 2 minute periods to prevent overloading of the substrate. Airborne microbe was collected on specific nutrient media in Petri-dishes placed on the impact on. Trypcase soy agar (TSA) was used to sample airborne bacteria and Malt extract agar (MEA) for airborne fungi. After sampling completed, the agar plate was immediately seal and kept in the disinfected cool box filled with ice pack to inhibit microbe growth. The entire sample collected was delivered immediately to an accredited laboratory which was Industrial Hygiene Analytical Laboratory (IHAL), NIOSH Malaysia within 18 hour. The bacteria sample was incubated at 37^{o}C and counting was done after 2 days. Counted microbe was calculated as colonies forming units per cubic meter of air (CFU/m^3). The sample was analyzed for total fungi count by incubating them at 25 ^{o}C for 5 days. Figure 1 below show flow chart for the sampling of airborne microbe.

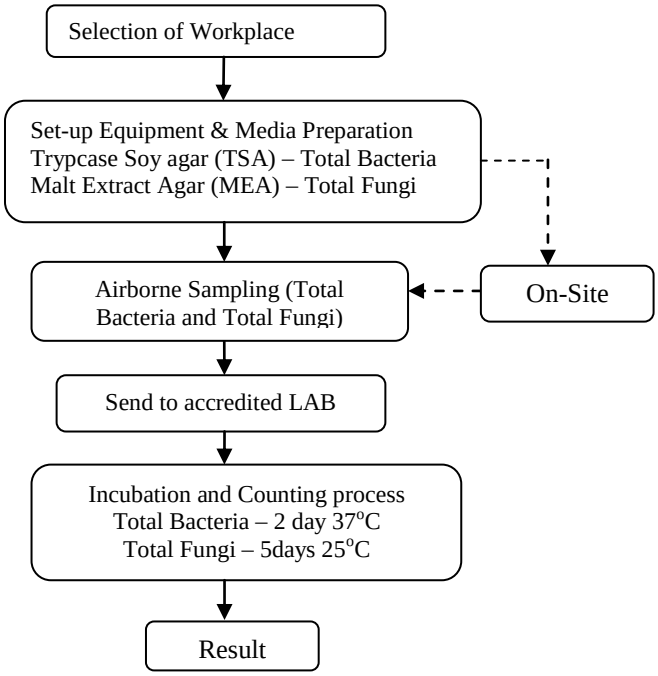

Fig 1: Airborne microbe sampling flow chart

4. RESULT AND DISCUSSION

From the measurement data (colonies) of airborne bacteria and airborne fungi in non carpeted office data were tabulated based on mean (SD), minimum and maximum. Table 2 show the average of total bacteria and total fungi in non-carpeted office collected at different phases of building commissioning. The total bacteria concentration in non-carpeted office for all the phases fell within the range of 0 to 777 CFU/m^3. The concentration of total fungi fell within the range of 0 till 760 CFU/m^3. Total sample collected is 23 samples at all three phases. It was observed that the average concentration of airborne bacteria detected at all three phases was significantly lower than maximum exposure limit 500 CFU/m^3. The average concentrations of airborne fungi were found far below the maximum exposure limit 1000CFU/m^3. This indicate that the office setting without carpet yield low result of airborne microorganism furthermore reduce the risk of unwanted exposure that can lead to poor health condition. The measurement data (colonies) of airborne bacteria and airborne fungi in carpeted office at different phases shows in table 3. Total sample collected is 24 at all three phases.

Table 2: Airborne Bacteria and Fungi detected in Non Carpeted Office at Different Phases

Sampling Location	N	Airborne Bacteria (CFU/$m^{3)}$			Airborne Fungi(CFU/$m^{3)}$		
		Mean(SD)	Min	Max	Mean(SD)	Min	Max
OC Phase 1	8	1530 (2284)	0	6360	433 (410)	0	1140
OC Phase 2	8	73(52)	0	141	53(69)	0	212
OC Phase 3	8	99(84)	0	242	12(13)	0	35

Table 3: Airborne Bacteria and Fungi detected in Carpeted Office at Different Phases

Sampling Location	N	Airborne Bacteria (CFU/$m^{3)}$			Airborne Fungi(CFU/$m^{3)}$		
		Mean(SD)	Min	Max	Mean(SD)	Min	Max
ONC Phase 1	7	346 (285)	35	777	270 (185)	0	565
ONC Phase 2	8	157 (113)	0	318	221 (272)	18	760
ONC Phase 3	8	320 (154)	141	583	62 (49)	0	141

Table 4: Airborne Bacteria and Fungi detected in Classroom at Different Phases

Sampling Location	N	Airborne Bacteria (CFU/$m^{3)}$			Airborne Fungi(CFU/$m^{3)}$		
		Mean(SD)	Min	Max	Mean(SD)	Min	Max
Class Phase 1	12	197 (201)	0	777	159 (90)	35	389
Class Phase 2	12	158(166)	18	583	91(99)	0	336
Class Phase 3	12	627(548)	106	1837	71(64)	0	230

Table 5: Airborne Bacteria and Fungi detected in Classroom Corridor at Different Phases

Sampling Location	N	Airborne Bacteria (CFU/$m^{3)}$			Airborne Fungi(CFU/$m^{3)}$		
		Mean(SD)	Min	Max	Mean(SD)	Min	Max
CorPhase 1	6	274 (113)	71	406	185 (76)	53	247
CorPhase 2	6	377(602)	18	1590	53(56)	0	159
CorPhase 3	6	591(537)	18	1590	133(127)	0	371

Table 6: Compliance result on total bacteria and total fungi concentration

Airborne Microbe		Frequency	Per cent (%)	Standard
Airborne Bacteria (CFU/$m^{3)}$	Comply	96	94.1	500 (CFU/$m^{3)}$
	Not Comply	6	5.9	
	Total	102	100.0	
Airborne Fungi(CFU/$m^{3)}$	Comply	100	98.0	1000 (CFU/$m^{3)}$
	Not Comply	2	2.0	
	Total	102	100	

The mean value for total bacteria and total fungi at the first phase of the sampling project is 1530 CFU/$m^3$and 433 CFU/m^3 respectively. It was found that the concentration of total bacteria was significantly higher compare to maximum exposure limit 500 CFU/m^3 as stipulated under ICOP IAQ 2010. The airborne microbes were tremendously reduced during the second and third phase of sampling. High concentration of airborne microorganism in the early phase of the sampling might be hazardous to the building occupant thus might result building complaint related to health issues increased.

For classroom data measurement (colonies) for data were tabulated in table 4. Table 4 shows the average concentration of total bacteria and total fungi in classroom sampled at different phases of building commissioning. It was found that the average concentration of airborne bacteria at the third phase was slightly higher compare to maximum exposure limit 500 CFU/m^3. The concentration of total fungi at each phase was found not much different with a concentration of 159, 91 and 71 CFU/m^3 at each sampling phases. In general it was demonstrated that the indoor levels of airborne bacteria showed an increasing trend in the classroom setting. This appears to be due to the active behavioral pattern of classroom participant in relatively small spaces. Such a assumption is supported by the fact that one of the main causes of indoor bioaerosols is the residents' activities (Jozef S. Pastuszka et al 2000).

On the other part, the total bacteria and total fungi in the classroom corridor was tabulated in table 5. Table 5 shows the average concentration of total bacteria and total fungi in classroom corridor sampled at different phases of building commissioning. Total sample collected from the classroom corridor is 18 at all three phases. It was found that the average concentration of airborne bacteria at the third phase of sampling was slightly higher compare to maximum exposure limit 500 CFU/. The concentration of total fungi at each phase yielded a fluctuation trend with a concentration of 185, 53 and 133 CFU/m^3 at each sampling phases. Since the sampling location is a new constructed building, thus no abnormality of airborne fungi detected due to no moisture damage found inside the building that can be a catalyze in the growing of fungal in indoor environment (TeijaMeklin et al 2003).

From the data observation, the compliance on standards of ICOP was tabulated in table 6. The compliances result on total bacteria and total fungi concentration compared to maximum exposure limit stipulated in Malaysian ICOP IAQ 2010.Total bacteria detected in all sampling phases yielded 5.9% of noncompliance result which was above the maximum exposure limit. The maximum bacteria concentration detected during the sampling was 6360 CFU/m^3. The result was obtained during the first phase of sampling in the office equipped with carpet. For total fungi concentration, only 2.0% of fungi concentration was above the maximum exposure limit.

The maximum fungi concentration detected during the sampling was 1140CFU/m^3. The result was also obtained during the first phase of sampling in the office equipped with carpet. The microbe detected at all sampling phase's yielded significant number of colony forming unit of bacteria and fungi in the airborne, thus might lead to unhealthy indoor environment. The risk become more severe especially to those how involve in early stage of building commissioning. Building owners should consider the entire factor that might potentially introduce high exposure of airborne microorganism in a new building starting from the building design and the construction processes. Furthermore the maintenance of the building is crucial in order to avoid building damage or water intrusion (F.Fung and W.G. Hughson 2003). Support from the building occupant is also an important to ensure maximum protection against any unwanted pathogenic or hazardous contaminants (Leung M et al 2006).

5. CONCLUSION

In general, findings from sampling conducted at new constructed buildings that consist of office without carpet, office with carpet and classroom setting indicate that although a new constructed building should be having a significant background level of airborne microbe (total bacteria and total fungi). The reported microbe count vary within the building levels area depending on the cleanliness from the dust residual on that level, the outdoor and indoor air movement either mechanical or natural and type of flouring used whether carpet or not. Therefore, it is necessary to consider the establishment of recommended value for acceptable indoor microbe levels in a new constructed building.

ACKNOWLEDGEMENT

This study was funded by National Institute of Occupational Safety and Health (NIOSH) Malaysia (NIOSH/RnD/2010/005). It was conducted by Consultation, Research and Development Department of NIOSH Malaysia starting from August 2011 to October 2012.

REFERENCES

[1] L.T. Wong, K.W Mui, P.S. Hui, W.Y. Chan and A.K.Y. Law (2008); Thermal Environmental Interference with Airborne bacteria and Fungi Level in Air-Conditioning Offices, Indoor and Built Environment, 17;2:2:122-127.

[2] Ronald E.Gots, Nancy J. Layton and Suellen W. Pirages (2003): Indoor Health: Background Level of Fungi, AIHA Journal, 64:4, 427-438.

[3] Jozef S. Pastuszka, U. KyawTha Paw, Danuta o. Lis, AgnieszkaWlazlo, Krzysztof Ulfig (2000): Bacterial and Fungal aerosolin indoor environment in Upper Silesia, Poland, Atmospheric Environment 34 3833-3842.

[4] TeijaMeklin, Anne Hyvaarinen, Mika Toivola, Tina Reponen, VirpiKoponen, TuulaHusman, TainaTaskinen, MattiKorppi and AinoNevalainen (2003): Effect of Building Frame and Moisture Damage on Microbiological Indoor Air Quality in School Building, AIHA Jurnal, 64:1, 108-116.

[5] Department of Occupational Safety and Health, Industrial Code of Practices for Indoor Air Quality 2010.

[6] National Institute of Occupational Safety and Health (NIOSH) method NIOSH Manual Analytical Method NMAM 0800.

[7] Miller, D.P. Haisley and H. Reinhardy (2000); Air sampling results in relation to extent of fungal colonization of building materials in some water damaged building, Indoor Air 10:146-151.

[8] Siti Hamimah Ismail, Bab Md Deros &Abd Mutalib Leman (2010); Indoor Air Quality Issues for Non-Industrial Workplace, IJRRAS 5 (3).

[9] Hai-Qiao Wang, Jin-Duan Chen and Hao Zhang (2001): Ventilation, Air Conditioning and the Indoor Air Environment, Indoor and Built Environment 10:52-57.

[10] J. Karbowska-Berent, Rafal L.Gorny, Alicja B. Strzelczyk, Agnieszka Wlazlo (2011): Airborne and Dust Borne Microorganism in Sleceted Polish Libraries and Archives, Indoor and Built Environment 46: 1872-1879.

[11] Kwok WaiMui, Wai Yee Chan, Ling Tim Wong and Pui Shan Hui (2010): Scoping indoor airborne fungi in an excellent indoor air quality office building in Hong Kong, Building Services Engineering Research and Technology 31,2 191-199.

[12] Frederick Fung and William G. Hughson (2003): Health Effects of Indoor Fungal Bioaerosol Exposure, Applied Occupational and Environment Hygiene, 18:1, 535-544.

[13] Micheal Leung and Alan H.S. Chan (2006): Control and Management of Hospital indoor Air Quality, Med Sci Monit 12(3):SR17-23.

[14] Ki Youn Kim and Chi Nyon Kim (2007): Airborne microbiological characteristic in public buildings of Korea, Building and Environment 42:2188—2196

[15] L.T Wong, K.W. Mui and P.S. Hui (2006): A statistical model for characterizing common air pollutants in air-conditioned offices, Atmospheric Environment 40: 4246-4257.