BACKGROUND CONCENTRATION OF AIRBORNE MICROBE IN NEW CONSTRUCTED BUILDING

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ABSTRACT

Exposure to indoor air pollution is now becoming serious public health problem in a wide variety of non-industrial setting such as residences, offices, schools, hospital and vehicles. This study investigate the level of airborne microbe in indoor environment at three different phase of building commissioning for a new constructed building in Bandar Baru Bangi, Selangor, Malaysia. Three phases involved is after building devolves to building owner, during installation of furniture and one month after building occupancies. In particular, the airborne microbes' concentrations were determined by using a single stage impactor (Biosampler) as per requirement of National Institute of Occupational Safety and Health (NIOSH) method, NIOSH Manual Analytical Method NMAM 0800. The total concentration of airborne bacteria were average to 533, 159 and 420 CFU/m^3 in the first, second and third phase. For airborne fungi the results yield a mean concentration of 235, 98 and 101CFU/m^3 respectively across the sampling phases. These findings indicated that although a new constructed building should be having a significant background level of airborne microbe (total bacteria count and total fungi count). The building owner should be aware to their indoor air status to protect the occupant from the safety and health issue in the work place especially for mechanical ventilated building.

ABSTRAK

Pendedahan kepada pencemaran udara dalam bangunan sekarang menjadi masalah kesihatan awam yang serius terutamanya kepada pelbagai jenis persekitaran bukan industri seperti kediaman, pejabat, sekolah, hospital dan kenderaan. Kajian ini menyiasat tahap dedahan mikrob bawaan udara di persekitaran dalaman dalam tiga peringkat pentauliahan bangunan baru yang terletak di Bandar Baru Bangi, Selangor, Malaysia. Tiga fasa terlibat dalam pentauliahan adalah selepas penyerahan kepada pemilik bangunan, semasa pemasangan perabot dan sebulan setelah kemasukan penghuni. Persampelan mikrob bawaan udara telah ditentukan dengan menggunakan *impactor* satu peringkat seperti keperluan kaedah *National Institute of Occupational Safety and Health, NIOSH Manual Analytical Method NMAM 0800.* Jumlah purata kepekatan bakteria bawaan udara adalah 533, 159 dan 420 CFU/m^3 di fasa pertama, kedua dan ketiga. Untuk kulat bawaan udara keputusan menghasilkan satu kepekatan purata 235, 98 dan 101CFU/m^3 masing-masing merentasi fasa-fasa persampelan. Penemuan ini menunjukkan bahawa walaupun di dalam bangunan baru terdapat juga kepekatan latar belakang mikrob bawaan udara (bakteria terampai diudara dan kulat terampai diudara) yang perlu di ambil perhatian. Pemilik bangunan harus sedar kepada status udara dalam bangunan terutamanya pengudaraan bangunan bagi tujuan untuk melindungi penghuni dari masalah keselamatan dan kesihatan di tempat kerja.

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LIST OF SYMBOL AND ABBREVIATION

CFU/m^3	-	Colony Forming Unit per meter squared (concentration)
DOSH	-	Department of Occupational Safety and Health Malaysia
IAQ	-	Indoor Air Quality
ICOP	-	Industrial Code of Practice
MEA	-	Malt Extract Agar
NIOSH	-	National Institute of Occupational Safety and Health
OC	-	Office Carpeted
ONC	-	Office Non-Carpeted
OSHA	-	Occupational Safety and Health Act (Act 514)
SBS	-	Sick Building Syndrome
SOCSO	-	Social Security Organization
TBC	-	Total Bacteria Count
TFC	-	Total Fungi Count
TSA	-	Trypticase Soy Agar
UTHM	-	Universiti Tun Hussein Onn Malaysia
% RH	-	Relative Humidity
^oC	-	Temperature

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter described the fundamental background to this research. This chapter basically discussed problem arising from poor indoor air quality in ventilated building. The significant of the research, scope of study and limitation of the study also been discussed in this chapter.

1.2 Problem Statement

Exposure to indoor air pollution is now becoming serious public health problem in a wide variety of nonindustrial setting such as residences, offices, schools, hospital and vehicles. Convenience indoor environment expressed by safer and healthier condition is one of the most important factors affecting the productivity today. It is noted that people spend almost 80 to 90 percent of their time stay indoors (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 from any pollutant that may harm our health.

Although Malaysia is aggressively promoting green building concept in creating safer and healthier indoor building environment, the Social Security Organization SOCSO data from 2006 till 2012 show that quite significant number of industrial accident have occurred in indoor workplace environment. Indoor accident occurs from varies source such as floor, confine quarters, stairs, other traffic and working surfaces, environment factors such (lighting, ventilation, temperature, noise and others IAQ parameters). The green building concept is a schematic compliances parameter that considers a few factor such as building materials selection, sources of outdoor contaminant and ventilation systems.

In September 2011, one government building located near Cyberjaya was closed up to three month due to fungi growth inside their building. All the worker were instructed to work from home as interim measure to prevent worker directly inhale contaminated air. Overexposure of airborne microbe were also reported in April 2008, where Hospital Sultan Ismail in Johor was closed for seventeen month due to clear growth of microbe inside the building.

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. Contamination of indoor air with microorganisms can occur under many circumstances. Such contamination most often occurs when a fault in the building that utilizing Heating Ventilation Air Conditioning HVAC system, or other system that allows the germination of micro-organisms.

Inhalation of very large concentrations of fungal spores can cause hypersensitivity pneumonitis, but this rarely results from building exposure. Chronic exposure to most fungi can induce allergic or asthmatic reactions in humans, and a very few species can cause diseases directly. Some moulds are toxigenic, producing mycotoxins that often accumulate in the spores. The inhalation of spores containing certain mycotoxins has been shown to induce many of the symptoms normally associated with Sick Building Syndrome SBS. Other products of fungi include certain Volatile Organic Carbon VOCs. Such compounds characterized by mouldy smells occur only when there is active and considerable fungal growth. There is some evidence to suggest that these can contribute to SBS. The potential of health risk caused by the exposure to indoor air contaminant airborne microbe could produce a significant increase of health problem to the worker especially that work in offices.

In 2005, Department of Occupational Safety and Health DOSH published a Code of Practice of Indoor Air Quality (COP IAQ) marked as one of the first attempts to have a legal related implication of indoor air quality in Malaysia. Later in 2010, DOSH announced new improved legal related requirement of The Industrial

Code of Practice Indoor Air Quality ICOP IAQ 2010. Under this ICOP IAQ it stipulated minimum standard for selected parameters that will avoid discomfort and/or adverse health effect among employees and other occupant of an indoor or enclosed environment served by a mechanical ventilation and air conditioning (MVAC) system including air-cooled split unit. This ICOP IAQ has been drawn up to ensure employees and building occupants are protected from poor indoor air quality that could adversely affect their health and wellbeing, and thereby reduce their productivity. It is one of the general duties under the Occupational Safety and Health Act 1994 (*Act 514)* for the employer and an occupier (including building owner and building management) to provide a safe workplace to their employees or other person than his employees (occupant). The role of scientific research in distinguishing a safer indoor environment for public health is to provide the necessary technical basis for assessing; managing and communicating the risks furthermore contribute to increase compliances to the related IAQ regulation.

In the recent year, many studies have been conducted about the healthfulness of indoor air quality, including the amount of time people spend indoors and the associated implications for indoor contributions to total exposures, the sources of indoor air pollutant contributions to problematic indoor air quality and the increasing number of health-related complaints related to indoor air quality.

Building materials exposed to environmental conditions and with poor maintenance can lead to mould growth. Some materials, especially those that are porous, are more likely than others to support microbial growth. As a result, these materials can become potential indoor sources of bio-contaminants including mould. Common materials susceptible to mould growth include porous materials and those with cellulose substrates. These may include gypsum wallboard, ceiling tile, insulation, textiles, wall coverings, floor coverings, and office panels. In some cases, materials may be treated with anti-microbial agents as a preventive step. The ability of these materials to support or to resist mould growth is often not well documented.

Problematic building related to indoor air quality frequently being identified after health-related complaints been addressed or microbe growth in indoor air environment prevailed. Reactive approaches were implemented by conducting a thorough indoor air quality assessment resulting to a non-decisive conclusion due to fail to identify the possible source of indoor air pollutant. Baseline data should be measured to distinguish the possible sources of health-related complaints especially for new constructed building. Commissioning program should take into account issues related to indoor air pollutant baseline measurement in order to recognize the potential health risk inside the building.

From above discussion, it can be seen that in order to investigate the interaction and relationship between airborne microbe concentration and good indoor environment, two aspects of knowledge is required. The first is to quantify the building commissioning phases contributes to concentration of airborne microbe. The second is to distinguish the level of compliance for airborne microbe at each phase of new building commissioning against the ICOP IAQ 2010.

1.3 Objective of the study

The specific objectives of the study are:

i. To measure the concentration of airborne bacteria and airborne fungi in a new constructed building during commissioning processes.
ii. To investigate the concentration of airborne bacteria and fungi in new constructed buildings and compare with recommended acceptable exposure limit at 500 CFU/m3 and 1000 CFU/m3 respectively.
iii. To determine whether there is differences of indoor bacteria and fungi in different phase of new building commissioning (after building devolve to building owner, during installation of furniture and one month after building occupancies).

1.4 Scope of the study

NIOSH new constructed buildings was selected for this research for it nature of typical office, training and research centre. There was a new building selected in the research; which located in Bandar Baru Bangi, Selangor, Malaysia named as Menara NIOSH in this study.

i. Since the buildings located in Malaysia with typical a Mechanical Ventilation Air Conditioning MVAC system, it represents the normal setting of Malaysian building. Now days, the new constructed building in Malaysia is equipped with this MVAC system as an alternative in overcoming the issue of hot and humid condition in this region.

ii. Different phase of building commissioning program in this research normally is similar with others; i.e building devolved to building owner, furniture instalment and one year warranty after occupancy. Data gathered in this research in some way can be generalized with the other Malaysian building, which has similar setting with NIOSH new constructed building.

iii. Even though microbe in indoor environment covers a wide variety of family, such as mites, protozoa, fungi, bacteria, and dander; this research however focus only on total bacteria and total fungi. Bacteria and fungi are studied due to their established available method and data based on previous studies. The concentrations of airborne microbe are represents by total number of bacteria and fungi colonies count in sampling media. The thermal environment parameters that were covered are relative humidity and temperature.

1.5 Significant of the study

The study to determine the background level of airborne microbe in new buildings can be an informative data to enhance the industries and government knowledge regarding indoor air quality and to provide scientific data for future research for education sector as well.

1.5.1 Industry (employer and employees)

Some related industries would benefit from the outcome of the study. The employers' awareness will increase in establishing good practice of IAQ in terms of monitoring the work environment. At the same time the employer would comply with section 15, Occupational Safety and Health Act 1994. Also the outcome of the study would influence on the workers' productivity.

The direct impact to employees is conducive work environment. The guideline that will be developed will be able to monitor the building performance and at the same time will be able to analyse the data to ensure the adequate ventilation provided to the workers and protect the workers from adverse health problems. The traditional technique used in industrial hygiene will be improved and more monitoring process will became easier.

1.5.2 Government

The government will get direct benefit from this study. As the awareness from the industries increases, it will become easier to establish the occupational safety and health policy as required in section 16, OSHA that is the duty to formulate safety and health policy. The government also would be able to reduce the amount of insurance claimed through SOCSO, and this savings can be allocated to the other sectors for economic development. With this allocation, the government can produce and place emphasis on foreign direct investment (FDI) to Malaysia. At the same time, the government can benefit through the available established Malaysian Standard. These standards provide guidelines to the employer to develop their capabilities on ensuring they follow the Malaysian Standard for their competitiveness in borderless world and global market. Malaysia through government agencies like the Department of

Occupational Safety and Health (DOSH) will be able to compile relevant data and it can be a resource in developing the regulation and enforcement activities. This study is needed to provide national data related to airborne microbe in indoor air and may provide general overview of Malaysian offices. Early indication of microbe contamination in new constructed building is essential and in conjunction with the establishment of Malaysian Industrial Code of Practice Indoor Air Quality ICOP IAQ 2010; to promote healthy working lifestyle among Malaysian citizen.

1.5.3 Education sector

Education and training sector can benefit from the study through the guideline developed. The system will become the starting point to the other researches that are related with the working environment. Through the guideline development, the training agency such as National Institute of Occupational Safety and Health (NIOSH) can take advantages from the system to improve the course curricula that have been developed. The training will be conducted internally or externally (abroad). From the outcome of this study, the guidelines on IAQ commissioning and maintenance in new building will be established. The technique on data capture and analysis will become more appropriate due to working environment quality improvement.

1.6 Limitation of the study

The studies are limited to the activities involved in new constructed building. The buildings that involved in this study were owned by National Institute of Occupational Safety and Health (NIOSH), Malaysia. Nevertheless, the implementation proposed solution depends on company's willingness to deploy the solution. Moreover, the research work has no direct access and authority to enforce the proposed solution to the company even though the case study was carried out at the designated buildings. For this study, the building was selected due to availability of new building. The nature of the study is on safety and health enhancements in the working environment, the development process and the related activities like data collection in selected buildings. The stages that were involved in the building occupancy were before, during furniture and fitting install and one month after occupancy. The key point is to monitor the airborne microbe in the working environment that includes total bacteria and total fungi that posed health effects. The predicted result is based on the sampling and testing of air quality parameters within the nominated premises at the specified sampling times. The level of contaminant may be different depend on the weather condition or the level of activity of the occupants in the building.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, the relevant literature is reviewed. As the scope of study is at the new constructed building, building properties are discussed in section 2.3 which mainly touch about the building properties and building commissioning process. Thermal environment factors that become one of the contributors of microbe growth are reviewed in section 2.4.The overview of management of occupant and building itself are discussed in section 2.5. The legal requirement pertaining to acceptable limits for indoor airborne microorganism are reviewed in section 2.6.

2.2 Airborne microbe in indoor environment

Exposure to indoor air pollution is now 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. Among the indoor air pollutant identified, airborne microbe is one of the most contaminant that addressing major issue in defining poor indoor air quality. Bacteria and fungi are most commonly microorganisms associated with indoor air quality complaint and most often implicated as indoor bio contaminants (Wong *et al.,* 2009). Microbial amplification that occurs in the indoor environment can become source of exposure to the occupants especially when the organisms and/ or their by-products are released into the air as bioaerosols (Wong *et al.,* 2009).

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