

STUDY ON INDOOR AIR QUALITY AND SICK
BUILDING SYNDROME AMONG LIBRARY STAFFS IN
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA
2015



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**STUDY ON INDOOR AIR QUALITY AND SICK BUILDING
SYNDROME AMONG STAFFS IN LIBRARY AT
UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Engineering Technology (Refrigeration and Air-Conditioning System) (Hons.)

by

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920214-14-5152

FACULTY OF ENGINEERING TECHNOLOGY

2015

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: Study on Indoor Air Quality and Sick Building Syndrome among Staff in Library at Universiti Teknikal Malaysia Melaka

SESI PENGAJIAN: 2014/15 Semester 2

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Engineering Technology (Refrigeration and Air Conditioning) (Hons.). The member of the supervisory is as follow:

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ABSTRAK

Sindrom bangunan sakit (SBS) adalah penyakit yang berlaku dikalangan pekerja dimana ia mempunyai perkaitan dengan masa yang diluahkan di dalam sesebuah bangunan. Terdapat pelbagai punca yang menyebabkan berlakunya SBS tetapi tahap kualiti udara dalaman (IAQ) mempunyai perkaitan yang sangat tinggi. Kajian ini dilakukan untuk mengatasi masalah kesihatan yang dialami oleh pekerja disebabkan oleh sistem penyaman udara bangunan tersebut. Justeru, kajian ini dijalankan untuk mengenalpasti perkaitan IAQ dengan SBS dikalangan pekerja perpustakaan di Perpustakaan Kampus Induk, Universiti Teknikal Malaysia Melaka (UTeM). Sebanyak 54 staf perpustakaan telah menjadi responden bagi soal selidik untuk mengetahui simptom yang biasa dilaporkan mengenai SBS seperti gatal-gatal mata dan hidung, batuk, lesu, mual, pening kepala dan sakit tekak. Pengukuran secara objektif untuk mendapatkan tahap IAQ seperti suhu udara, halaju udara, karbon dioksida (CO_2), tahap habuk ($\text{PM}_{2.5}$) dan kelembapan relatif (% RH) telah dilakukan di setiap unit kerja di dalam perpustakaan. Pengukuran-pengukuran ini dijalankan pada bulan Oktober sehingga bulan November 2014. Parameter-parameter IAQ telah dibandingkan bacaannya dengan kod amalan industri 2010 dan telah didapati bahawa CO_2 dan $\text{PM}_{2.5}$ masih lagi di dalam piawaian yang ditetapkan manakala bacaan parameter yang lain terkeluar daripada piawaian tersebut. Terdapat juga kewujudan simptom SBS di dalam bangunan tersebut (72.2%) dan daripada semua simptom yang dilaporkan, sakit kepala, pening dan kepala terasa berat adalah gejala yang paling banyak dilaporkan dalam kajian ini (59.2). Terdapat juga perkaitan diantara setiap parameter IAQ dengan SBS. Kajian ini telah menyedarkan kepentingan menjaga sistem penghawa dingin untuk mengelakkan masalah kesihatan pekerja.

ABSTRACT

Sick building syndrome (SBS) is an illness that occurs among occupants that appear to be linked to time spent in a building. The causes of SBS can be various but it has a significant relations to indoor air quality (IAQ) of the building itself. This study was focused to overcome the health problems among occupants in a workplace that was affected by air conditioning system of the building. Hence, this study was carried out to identify the relationship between IAQ and SBS among occupants in main campus library of Universiti Teknikal Malaysia Melaka (UTeM). Fifty-four staffs of the library had responded to self-administered questionnaire of commonly reported symptoms of SBS such as eye and nose irritation, cough, fatigue, nausea, headache and sore throat. Objective measurement for the IAQ level such as air temperature, air velocity, carbon dioxide (CO₂), particulate matter (PM_{2.5}) and relative humidity (%RH) were conducted at the working unit of the library. These were conducted on October to November 2014. The IAQ parameters were compared to industry code of practice (ICOP) and it was found that CO₂ and PM_{2.5} were within the standard whilst the rest of the parameters were slightly out of the range. There was prevalence of SBS in the building (72.2%) and of all the reported symptoms, headache, dizzy and heavy headache was the most reported symptoms in this study (59.2%). There were correlations between each IAQ parameters and SBS symptoms. This study was able to increase awareness on the importance of maintaining the air conditioning system in order to avoid further health problems to the occupants.

DEDICATION

In the name of Allah, the Most Beneficial, the Most Merciful. Nothing can ever be achieved without His will for letting it to happen.

This thesis work is dedicated to my dear parents, Nor Azmi Bin Mohamad and Nor Azia Binti Ibrahim, who have always loved me unconditionally and whose good examples have taught me to work hard for the thing that I aspire to achieve. This work is also dedicated to my Indoor Air Quality mates who have been through this journey together with me and provide constant source of support and encouragement during the challenges of graduate school and life. Thank you for making it far more interesting to endure and may we find success in things that we love. I am grateful for everything.

ACKNOWLEDGEMENT

I am very fortunate to have performed my bachelor degree project at a university as collaborative as the Universiti Teknikal Malaysia Melaka; therefore, there are many people to thank for their part in my success. First, and most importantly, I would like to thank my supervisor, En. Azwan Bin Aziz, for his incredible patience and guidance as well as knowledge which were immensely helpful in moving my project forward.

I would also like to thank the administrative staffs of Main Campus Library at Universiti Teknikal Malaysia Melaka for allowing me to do my field measurement there and provide amazing cooperation. This also goes out to the staffs who have contributed their time and energy in completing the questionnaires that without it, my project would not have been completed.

Not to forget, my gratitude goes out to En. Nur Rashid bin Mat Nuri @ Md Din, the head of Mechanical Engineering Technology Department for allowing me to use faculty's laboratory equipments and to En. Khairul Fitri Bin Zainal, the assistant engineer for constantly provides and assists me with all of the equipments that were used without hesitations.

Lastly, my appreciation goes out to my closest people whom I love whole-heartedly. They have been patiently dealt with me and celebrated me when even the littlest things go right. I am thankful.

TABLE OF CONTENT

Abstrak	i
Abstract	ii
Dedication	iii
Acknowledgement	iv
Table of Content	v
List of Tables	viii
List of Figures	ix
List Abbreviations, Symbols and Nomenclatures	x
CHAPTER 1: INTRODUCTION	1
1.1 Background study	1
1.2 Problem statement	2
1.3 Objectives	3
1.3.1 Main objective	3
1.3.2 Specific objectives	3
1.4 Scope	4
CHAPTER 2: LITERATURE REVIEW	6
2.1 Introduction	6
2.2 Air conditioning system	7
2.3 Concerns of indoor air quality	8
2.3.1. Indoor air quality parameters	8
2.4. Sick building syndrome among office workers	12
2.4.1. Diagnosis of sick building syndrome	13
2.4.2 Contributor towards severity of sick building syndrome	16
2.5. Ways to improve the condition of air in a building	18
2.5.1 Air conditioning system	19
2.5.2. Condition of the building	20
2.5.3. Building authorities	20

2.5.4. Occupants	21
2.6. Improvement in IAQ and SBS study	21
CHAPTER 3: METHODOLOGY	23
3.1. The target area	23
3.2. Study population	24
3.3. Data collection	25
3.3.1. Walkthrough survey	25
3.3.2. Measurement of the level of indoor air quality	25
3.3.3. Questionnaire study	26
3.3.4. SBS score	27
3.3.5. Correlation between mean SBS symptoms per person and different parameters	28
3.4. Conceptual framework	28
3.5. Flow of the study	29
CHAPTER 4: RESULT AND DISCUSSION	32
4.1. The indoor air quality parameters results	32
4.1.1. Air movement	32
4.1.2. Air temperature	34
4.1.3. Relative humidity	35
4.1.4. Particulate matter 2.5	36
4.1.5. Carbon dioxide concentration	37
4.2. Questionnaire results	38
4.2.1. Social demographic	39
4.2.2. Respondents' health status	40
4.2.3. Perceived indoor air quality	41
4.2.4. Symptoms of SBS	42
4.3. Relationship between indoor air quality parameters and sick building syndrome	43
4.3.1. Air velocity around working area and SBS symptoms	44
4.3.2. Air temperature and SBS symptoms	45

4.3.3.	Relative humidity around working area and SBS symptoms	45
4.3.4.	Concentration of carbon dioxide in the working area and SBS symptoms	46
4.3.5.	Respirable dust level around working area and SBS symptoms	47
4.4.	Discussions	48
4.4.1.	Physical parameters and indoor air contaminants of indoor air quality	48
4.4.2.	Social demographic of the occupants	50
4.4.3.	The prevalence of SBS and its correlation with IAQ	51
CHAPTER 5: CONCLUSION		53
5.1.	Conclusion	53
5.2.	Recommendations	54
5.3.	Limitation of study	54
REFERENCES		56
APPENDICES		58
A	Location of field measurement	58
B	Checklist for walkthrough inspection	64
C	Photos of researcher using the equipment	69
D	Table of physical parameters data for every level	70
E	Table of indoor air contaminants data for every level	71
F	Questionnaire	72
G	Photos of equipments used	80

LIST OF TABLES

3.1	List of instruments used	25
3.2	Components of the SBS questionnaire	26
4.1	Comparisons of physical parameters with the level of floor in the library	31
4.2	Comparison of specific physical parameters results with ICOP 2010	32
4.3	Profile of the occupants	38
4.4	Respondents' health status	39
4.5	Comparisons of the perceived of indoor air quality between the level of the library	40
4.6	Prevalence of SBS	41
4.7	Comparison of prevalence of sick building syndrome among library staffs between each floor	41
4.8	Correlation between SBS symptoms and IAQ parameters	42

LIST OF FIGURES

3.1	Conceptual framework	29
3.2	Flowchart of research methodology	30
4.1	Graph of Air Movement against Time for eight hours in every level	32
4.2	Graph of Air Temperature against Time for eight hours in every level	34
4.3	Graph of Relative Humidity against Time for eight hours in every level	34
4.4	Graph of Dust Level against Time for eight hours in every level	35
4.5	Figure 4.5 : Graph of Carbon Dioxide Level against Time for eight hours in every level	36
4.6	SBS symptoms against air velocity	43
4.7	SBS symptoms against air temperature	44
4.8	SBS symptoms against relative humidity	45
4.9	SBS symptoms against concentration of carbon dioxide	46
4.10	SBS symptoms against respirable dust level	47

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

AHU	-	Air handling unit
ANOVA	-	Analysis of Variance
CO ₂	-	Carbon dioxide
DOSH	-	Department of Occupational Safety and Health
HVAC	-	Heating, ventilation and air conditioning
IAC	-	Indoor air contaminants
IAQ	-	Indoor air quality
ICOP	-	Industry Code of Practice
M	-	Mean
m/s	-	meter per second
mg/m ³	-	milligram per meter cube
N	-	population size
n	-	sample size
<i>P</i>	-	Significance value
PM _{2.5}	-	Particulate matter up to 2.5 micrometers in size
SBS	-	Sick building syndrome
SD	-	Standard deviation
TVOC	-	Total volatile organic compound
R	-	Pearson's R correlation
UTeM	-	Universiti Teknikal Malaysia Melaka
<	-	Less than
%RH	-	Percentage of relative humidity
°C	-	Degree celcius
χ^2	-	Chi square

CHAPTER 1

INTRODUCTION

This section is basically on the introduction of this study where the contents are background study, problem statement, objectives of the study as well as the scope.

1.1 Background study

First noticed in the 1960s, sick building syndrome was formally recognized as a medical condition by the World Health Organization (1983) and there have been progressively more reported cases since then by several countries. According to Industry Code of Practice on Indoor Air Quality (2010), sick building syndrome (SBS) is defined as an illness that occurs among occupants that appear to be linked to time spent in a building. The causes of this sickness cannot be identified and it is not specific. Due to that, there have been vigorous debates over the causes of SBS and it is prudent to say that SBS has various factorial causes.

Despite being said that most of Malaysia buildings were designed to be energy-efficient with air conditioning systems, SBS has become common in our country (Berardi *et al.* 1991). This consequence happens to appear due to poor maintenance and services of Heating, Ventilation and Air Conditioning (HVAC) system which resulting to the decrement of indoor air quality and escalation of indoor air pollutants (IAP).

Indoor air quality (IAQ) has significant relations with SBS. Poor IAQ can lead to more complaints of ill health than expected (Finnegan *et al.* 1984) and because of that, the public has become more concerned about IAQ since they are aware of the fact that exposure to insufficient supplied air and the exposure to indoor air pollutants may risk their health (Syazwan Aizat *et al.* 2009). Issue of IAQ is often related to relatively poor distribution of fresh air over the conditioned space or the ventilation rate of the room (Siti Hamimah *et al.* 2010).

Building with air conditioning system was focused on this research given that the majority of reported cases of SBS came from buildings that were equipped with air conditioning systems (Burge, 2004; Mendell and Smith 1990). Although there were numerous number of possible causes for SBS, air conditioning systems happen to be the most prevalent one (Finnegan *et al.* 1984). Furthermore, according to Cooper (1998) and Bholah *et al.* (2000) cited in (Redman *et al.* 2011), subtropical climate such as Malaysia has an extensive growth of air conditioned buildings, which will help increase awareness on the vitality of maintaining good IAQ and provide guidance towards a healthy working environment.

Therefore, this research was designed to identify the IAQ status of the library contributed by the air conditioning system and its relationship with SBS. This research will hopefully increase awareness on the importance of maintaining good IAQ and provide guidance towards a healthy environment of working space.

1.2 Problem statement

Occupants of non-industrial workplace tend to spend most of their time indoors. Attributing to this, the air quality of the indoors need to be maintained or else the IAQ can drop and cause health problems toward tenants in it. According to ICOP by DOSH (2010), IAQ predicaments can arise due to indoor air contaminants or inadequate pollution controls despite otherwise normal or baseline rates of ventilation. This poor IAQ can lead to severe health problems, in this case, SBS. Although SBS does not generally have a permanent impact towards those who

experience it, its symptoms have a tendency to increase in severity with time spent in sick buildings causing inclination of absenteeism from work and low productivity due to poor health (Burge, 2004). According to Simon Muhič and Vincenc Butala (2004), the frequency of absenteeism from work due to illness is significantly higher in air conditioned buildings. Hence, this research emphasis on space that is equipped with air conditioning system.

Good IAQ needs to be achieved as it will reduce the SBS complaints by occupants. In order to accomplish that, air conditioning system must work efficiently so that the library receives an adequate amount of fresh air supply and reasonable air return (Sulaiman and Mohamed, 2011). Without proper assessment of air conditioning system in the library according to Industry Code of Practice (ICOP) 2010 by Department of Occupational Safety and Health (DOSH), indoor air quality of the conditioned space will lessen from day to day, thus, occupants are the people who have to face the consequences of it such as affected by SBS symptoms.

Therefore, this study was focused to overcome the health problems among occupants in a workplace that was affected by air conditioning system of the building. If this issue is ignored and no effort is being made, SBS among occupants will escalate and more airborne microbes can easily spread. Due to this matter, this study is designed to identify the IAQ and SBS status among the occupants in the UTeM Library and its relationship with air conditioning system using selected parameters. This study can help increase awareness among UTeM's staffs on the importance of having good IAQ and the vitality of maintaining air conditioning system.

1.3 Objectives

1.3.1. Main objective

To identify the relationship of IAQ and SBS status among the occupants in the UTeM Main Library.

1.3.2. Specific objectives

- a. To measure the library's IAQ parameters (percentage of relative humidity (%RH), particulate matter up to 2.5 micrometers in size (PM_{2.5}), carbon dioxide (CO₂), air temperature and air velocity) and compare it with ICOP 2010 standard.
- b. To identify the symptoms of SBS (eye and nose irritation, cough, fatigue, nausea, rhinitis, headache, sore throat or a combination of these) among library staffs.
- c. To identify the relationship of IAQ and SBS status among the occupants in the UTeM Main Library

1.4 Scope

Primarily, this study involved the measurement of IAQ parameters in the library around staffs' working unit. The findings were compared with inputs from Industry Code of Practice on Indoor Air Quality (ICOP) 2010 by the Department of Occupational Safety and Health, Malaysia (DOSH) in order to identify whether or not the values are in compliance with the standards.

A cross-sectional study was carried out among UTeM's Main Library staffs from October 2014 until November 2014 in order to get their most commonly reported symptoms of sick building syndrome. Sixty-two staffs (28 male and 26 female) were selected as respondents. The selection of respondents is by using universal sampling. Eight sections of the working unit in the library were involved in obtaining data. Office workers happen to be the easiest candidates to be studied for this kind of research as there are other few confounding factors. This research can also be conducted in school, hospital or care homes as they retain the similar problem (Burge, 2004).

Both inputs from objective measurement and subjective assessment mentioned above were analyzed and relate it with air conditioning system of the library.

Other locations besides the working unit in the main library were not encompassed as this research will mainly stress on occupants perspectives and IAQ contributed by the air conditioning system at the working unit in the library.

CHAPTER 2

LITERATURE REVIEW

This section will be on the literature review that the researcher's has made throughout the study. There are introduction, brief on air conditioning system, concerns of indoor air quality (IAQ), IAQ parameters, sick building syndrome (SBS) among office workers, diagnosis of SBS, contributor towards severity of SBS, ways to improve the condition of air in a building and improvement of IAQ and SBS study.

2.1 Introduction

The environment of indoors needs to be maintained its quality for the sake of occupants and tenants' health. The poor level of indoor air quality (IAQ) due to the impurities and pollutions in the air can let several occurrences to happen within the professional milieu. Initially, people with affected health related to their working environment will be the source of increment in official reported cases. This will lead to reduce productivity of each individual (Kamaruzzaman and Sabrani 2011) and in the end, increasing in absenteeism (Muhič and Butala 2004).

In Virgin Island, United States, Virgin Island Territorial Emergency Management Agency (VITEMA)'s headquarters experienced difficulty when their air conditioning system failed to work. Employees faced arduous predicament in working within the office while waiting for the air conditioning system to be fixed because the building

was too hot that it became unbearable. Employers acknowledged that this issue were affecting occupants' productivity and causing further loss to the government. VITEMA director, Elton Lewis, provided alternatives for the occupants by letting them to work and leave the office building periodically to spend time outside. Administrative leave was also granted to people who apply it in order to provide options for the workforces (Blackburn, 2014).

2.2 Air conditioning system

Air conditioning system issues are often brought up by researchers with a mission to identify the major cause of poor IAQ. The system and its efficiency on performing tasks are questioned. Before we make judgement on the ability of air conditioning system in maintaining the quality of air, the system itself provides benefits for the workers in the building. Air conditioning system happens to save lives. Air conditioning system with mechanical ventilated system is functioning as filtering, mixing and distributing both outdoor and indoor air to the needed space. It also provides temperature and humidity control for the benefits of human.

Altogether, air conditioning system is a provider of clean and conditioned air with suitable quality and quantity (Siti Hamimah *et al.*, 2010). There are evidences that display its ability in reducing number of mortality by avoiding people from die due to direct effect on heatstroke and also from such causes as heart and respiratory disease. Excessive heat towards human being can cause harmful effect that lead to death. In addition, air conditioning system also proliferations human's productivity level as well as endowing comfort. It could also help in reducing employees' well-being by keeping the air clean. These benefits can only be attained if the system is well-maintained and it is chosen correctly according to the space requirements (Redman *et al.*, 2011).

2.3 Concerns of indoor air quality

If a particular building management takes IAQ matters lightly, it could escalate more problems and tenants will start to report symptoms of sick building syndrome (SBS). A building in which complaints of ill health are more common than might reasonably be expected is termed as SBS and it is often being related to poor IAQ within the working environment (Finnegan *et al.*, 1984). Sick building syndrome is seen harmless for some buildings managers as occupants can easily get better once they step outside of the building that is considered 'sick' (May, 2006). Therefore, this matter has not been looked upon thoroughly and sometimes is ignored totally. Impact of SBS, nevertheless, can be severe depending on time spent in the affected building (Burge, 2004). In the United States alone, between 800,000 and 1.2 million buildings have a characteristic that could lead to SBS and that 30 to 70 million workers may be affected by it. Such figures are immensely high that proves SBS should be given it deserving attention. As has been noticed, air conditioning offices correlate with SBS and sick employees.

2.3.1 Indoor air quality parameters

a. Carbon dioxide

In most cases, carbon dioxide is one of the parameters that is frequently being measured in relation to the quality of air around any space (Au Yeung *et al.*, 1991; Ponsoni and Raddi 2010; Sulaiman and Mohamed 2011). Carbon dioxide is measured as it is the main indicator to detect the efficiency of supply air ventilation (Syazwan Aizat *et al.*, 2009). If the reading of carbon dioxide exceeds 1000ppm, the space is considered to have inadequate ventilation (ICOP, 2010). This also points out that the indoor air pollutants have not successfully been reduced by the air conditioning system of the building. The high amount of carbon dioxide in a building should not only be blamed generally by the effectiveness of ventilation system used in a building since the low amount of carbon dioxide does not give assurance that ventilation rate is sufficient. Therefore, it is better to look upon other aspects. There

are several possibilities that lead to the escalation of the level of carbon dioxide in a building.

First, the number of occupants against the air supply per area is not compliance with standards that could lead to more emission of carbon dioxide per space. Second, the faulty design of workplace for private office, which does not consider the location of the supply and return diffuser (Siti Hamimah *et al.*, 2010). Although the health authorities do not consider carbon dioxide at typical indoor concentrations as harmful towards human health (Ponsoni and Raddi 2010), reading of carbon dioxide beyond the standard apparently appear to create stuffiness inside of the building (Au Yeung *et al.* 1991; Sulaiman and Mohamed 2011). This is due to low air change per person which led to the stagnation of air and correspondingly indicates that there's low amount of fresh air.

Not only that, this quality of air can result in drowsiness which automatically dwindling productivity of occupants. Attributing to this, carbon dioxide has significantly correlation with sick building syndrome (Sulaiman and Mohamed 2011).

b. Carbon monoxide

Besides that, carbon monoxide is also one of the parameters measured to know its level in an office environment. This is to estimate the percentage of outdoor air in the supply air stream using the direct reading meter (Siti Hamimah *et al.*, 2010). Value of carbon monoxide is usually high in a building if the working space is near to the traffic, parking area and cafeteria. Different value in diverse locations can be obtained due to the location of intake point. Reading of carbon monoxide can be taken at supply outlets or air handlers. One company has less value than the other studied building since the latter one has an intake point facing the heavy traffic whereas the first building point is located on top of the building.

In this study, value of carbon monoxide was not affected by environmental tobacco smoke (ETS) since both buildings implemented non-smoking policy and application of local exhaust were installed in both car park and cafeteria. Carbon monoxide is a