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ASSESSMENT OF INDOOR ENVIRONMENTAL QUALITY AND OCCURRENCE OF SICK BUILDING SYNDROME IN SMALL OFFICES IN PENANG, MALAYSIA

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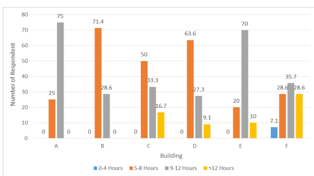
Graphical abstract



Abstract

This study was done to investigate the relationship between indoor environmental quality and prevalence of Sick Building Syndrome in six small offices in Penang Island. Indoor environmental quality measurement was conducted according to relevant standards. There are totally Sixty workers were selected to participate in an electronic questionnaire survey. Questionnaire was used to record the comfort level of respondents in the case studies and level of sick building syndrome faced by respondents. Through indoor environmental quality measurement, it is found that most of the offices facing the lighting and noise problem. The result from the questionnaire shows that in overall, the occupants satisfy with their working environment in term of indoor environmental quality although the result also shows the opinions of occupants on dissatisfaction on certain indoor environmental parameter according to case study. The study also found that most of the occupants feel drowsy and fatigue when they work within the offices. Besides, due to the difference of the indoor environmental quality of the buildings, the occupants are suffered from different symptoms of the sick building syndrome.

Keywords: Indoor environmental quality; sick building syndrome; offices

Abstrak

Penyelidikan ini bertujuan untuk mengkaji hubungan antara kualiti persekitaran tertutup dalam pejabat dengan kelaziman Sindrom Sakit Bangunan dalam enam pejabat-pejabat kecil di Pulau Pinang. Kualiti persekitaran tertutup pejabat-pejabat tersebut telah dikaji mengikut piawaian yang berkaitan. Enam puluh orang pekerja-pekerja telah dipilih untuk mengambil bahagian dalam soal selidik elektronik bagi penyelidikan ini. Soal selidik elektronik digunakan untuk merekod tahap keselesaan responden dalam kajian kes dan tahap sindrom sakit bangunan yang dihadapi oleh responden. Melalui pengukuran kualiti persekitaran tertutup dalam kajian kes, didapati bahawa kebanyakan pejabat menghadapi masalah tentang lampu dan bunyi. Manakala melalui soal selidik, didapati bahawa responden berpuas hati dengan persekitaran kerja mereka dalam keseluruhan, walaupun terdapat juga responden yang menunjukkan ketidakpuasan terhadap parameter persekitaran tertutup tertentu mengikut kajian kes. Penyelidkan ini juga menunjukkan bahawa kebanyakan respondent mudah mengantuk dan berasa letih apabila mereka bekerja di dalam pejabat. Selain itu, disebabkan kualiti persekitaran tertutup yang berbeza mengikut kajian kes, penghuni mengalami dengan gejala sindrom sakit bangunan yang berbeza.

Kata kunci: kualiti persekitaran tertutup; Sindrom Sakit Bangunan; pejabat

1.0 INTRODUCTION

People in Malaysia tends to spend more than 80% of their time in the working place, provided the heating, ventilation and air-conditional (HVAC) system is equipped. [1] As people work indoor for such long period, they will then be exposed to various effect of indoor environmental problem such as indoor temperature, humidity. Thus, various health problems have been faced by occupants in office. [2] Among the health problems that trouble the office occupants, the sick building syndrome (SBS) is one of the primary and serious problems [3].

The sick building syndrome (SBS), which is widely used to describe symptoms where occupants inside a building will experience. For example, the allergic of eyes, nose, throat and skin and lassitude. These symptoms will exist when a person stays inside a building, but they tend to disappear when he or she goes out. It is the non-specific and untraceable nature of these symptoms from which the name SBS originated [4], [5].

The real cause of SBS is nowhere to found yet. [6] There are tonnes of possible causes such as psychological factors, poor indoor environmental quality, external source of pollution, noise and others were suggested by researchers, nonetheless no single cause has been identified and certified. However, with the high percentage of time spending in office, workers who face the symptoms of SBS have biased that the SBS is always caused by the poor indoor environmental quality (IEQ) [7].

In previous researches conducted for buildings of Kuala Lumpur and Selangor, both suggested that the content percentage of carbon dioxide, carbon monoxide and other air pollutants in office might affect the prevalence of sick building syndrome, while noise level and illuminance which might cause sick building syndrome are not measured. Besides, both researches are comparing an old building to a new building. The conclusion which is made out from two building to represent the overall condition is less persuasive. In addition, the researcher outline that temperature and humidity are important factor that will affect the prevalence of sick building syndrome in buildings in Kuala Lumpur but not in Selangor. Therefore, this study intend to investigate the indoor environmental quality (temperature, humidity, air velocity, air flow rate, noise and illuminance) which has not been measured by previous Malaysian researchers and its prevalence of sick building syndrome (SBS) among workers in 6 offices in Penang Island.

2.0 LITERATURE REVIEW

2.1 Indoor Environmental Quality

There are many researches considered indoor environmental quality or indoor air quality as a factor that cause the sick building syndrome, although it is not ascertained yet. The high level of carbon dioxide, low ventilation rate and various other indoor air pollutants always been criticized as the main factors in indoor air quality to lead to serious health effect on human beings. [8] There are 6 factors that will affect the productivity of human beings in work. [9] These including temperature, lighting, sound, vibration, indoor air quality and personal control. Imbalance or deficiency on above factors will cause the diseases such as sick building syndrome or even infectious diseases that thus decrease the human performance. [10] In recent years, many philosophers are encouraged to study about workplace comfort level by using field studies. By this, they can study on various parameters within the workplace. [11] However, in many studies that the researcher hands on, the existing condition of indoor environment is obviously not good for humans to work in term of either physical work or mental work. To change the condition, standards recommending the various building indoor environmental quality optimum

2.2 Sick Building Syndrome

The definition and condition of SBS is actually quite clear from opinions given by several scholars. However, as the Malaysians were not aware about the sick building syndrome, they do not realize that they might have faced the symptoms. There are several definitions regarding SBS is given by various researchers and health bodies. However, all of the definition given by them are more or less including similar keywords, these include:

- SBS is a set of non-specific symptoms, an environmental related condition or situation.
- SBS affects the occupants in certain building.
- SBS appears when the occupants stay in certain building, but is recovered after leaving the building.
- The symptoms of SBS have no specific illnesses or cause can be identified [12], [13], [14], [15].

3.0 METHODOLOGY

3.1 Selecting of Case Studies

Six small offices are chosen as case studies for this research. The research aimed to study the above elements in small offices of Penang Island. The small office in this research is defined by mean of number of employees. In this research, the population of employees within each case study is ranged from 5-15 people. The occupants included the senior managers, managers, senior and junior executives, secretaries, fresh entries, intern/training staffs and other, with a population size of 60 in total. The intention was to target all of the occupants in hope to get a good spread of gender, age group and positions in the offices.

3.2 Questionnaire Survey

The questionnaire is used to correlate to two of the objectives of the research. It is derived from an extensive and complete literature review and scanning of the data, with major part adapted from questionnaire of previous researches [30] [31], and then regenerated. The questions were set in order to collect relevant data to achieve the aim and objectives of the study. All of the questions in this research questionnaire are open-ended questions which including multiple choices. The questionnaire is divided into three parts: demography data, evaluation about comfort level of occupants regarding indoor air quality in offices and evaluation about level of sick building syndrome faced by occupants in offices. The demographic data will include the personal information of respondents such as gender, age, number of years working within the case studies, number of hours working within the case studies during working day and position in the office. The comfort level of occupants regarding indoor environmental quality and the SBS symptoms questions in the case studies were referred to previous research. The questionnaires include the sick building syndrome symptoms which including flu, cough, breathing problem and so on. The respondent is said to face sick building syndrome if he or she has the symptoms given in the questionnaire at least 1-3 days per week when work in office but the symptoms disappear when he or she leaves the office [32].

3.3 Indoor Environmental Quality Measurements

Assessment of indoor environmental quality in case studies were conducted according to various approved standard and previous research [23] [33] [34] [35] [36]. The indoor environmental quality was measured using the Hygro-Thermometer Clock which measure temperature and relative humidity (%RH). Hot Wire CFM Therm-Anemometer Extech was used to assess the air velocity and air flow in the case studies. Light Meter Extech was used to measure the lighting level of the case studies. Lastly the Sound Level Meter Extech was used to assess the noise level in the case studies.

4.0 RESULTS AND DISCUSSION

4.1 Indoor Environmental Quality Measurement

Table 1 The various parameters of Indoor Environmental Quality Measurement result

Case Study	Temperature	Humidity	Air Velocity	Air Flow	Noise	Lighting
	℃	%	m/s	cfm	dBA	Lux
Normal Case	23.0-28.0	30-60	0.1-2.0	>5.0	49-58	200-500
Building A	25.7	47	0.056	6.638	49.35	457
Building B	28.0	57	0.196	9.11	51.4	130
Building C	27.0	55	0.29	3.602	89.7	370
Building D	26.0	53	0.523	4.237	65	187
Building E	29.2	64	0.236	5.508	49.7	86
Building F	29.0	60	0.807	17.16	78	177

Building A has the least problem in term of indoor air quality according to the test results. In fact, it can be considered as optimum office to work within. All of the results shown are within the optimum level except for that it has too slow indoor air velocity, which only reach 0.056 m/s. Building B also show quite optimum results on various parameters. The only problem is the lighting of the office, which reach only at 130 lux, way lesser than optimum lighting for an office.

The noise level present within the Building C is highest among all of the case studies, which reach 89.7 dBA. However, according to the manager from Building C, the maintenance works are undergoing at the neighbor unit for a month before till the day of indoor environmental quality measurement. Thus, the building is disturbed by the high noise level and vibration for the whole month. The air flow rate of the office is also behind the optimum value, which only achieve 3.602 cfm.

The noise level that can be tested in Building D reach 65 dBA, which is higher than optimum. However, the office has lower air flow rate which only reach 4.237 cfm. The lighting within office is also lower than optimum, which has only 187 lux. Building E has high temperature and high humidity, which are 29.2℃ and 64% respectively. The most serious problem in this office is the lighting. The lighting within the office only reaches 86 lux, which is way too far behind from the optimum lighting.

4.2 Questionnaire Data

4.2.1 Demography Data

In Building A, the sample group is 12, female respondent covers 66.7%, while male only cover 33.3%. In Building B, the sample group is 7 with 57.1% of male and 42.9% of female. In Building C, the number of respondent is 6 with 33.3% of male respondent and 66.7% of female respondent. In Building D, 36.4% of respondent is male while the rest are female, with total of 11 respondents. In Building E, in total of 10 respondents, 40% of them are male and 60% of them are female. Lastly in Building F, with total of 14 respondents, 35.7% of them are male while 64.3% of them are female.

As can be seen in Figure 1, in Building A and Building E, more than half of their respondents spent 9-12 hours in office during working day, which cover 75% and 70% from all respectively. While in Building B, Building C and Building D, they tend to spent 5-8 hours in office during working day, which cover 71.4%, 50% and 63.6% of all respectively. In Building F, quite equal percentage covers the different group of selection. 7.1% of them spent 0-4 hours in office, 28.6% of them spent 5-8 hours, 35.7% of them spent 9-12 hours while 29.6% of them spent more than 12 hours in office during working day. As the chart showed, most of the respondents from all case studies tend to spent 5-8 hours or 9-12 hours in the office during working day. This coincide to Malaysian Employment Act 1955 which states that an employee shall not be required to work more than 8 hours a day without rest time. Besides, the law also states that if any employees work in excess of the normal hours of work, the employee shall be paid with reasonable overtime (Clause 60A). [37]

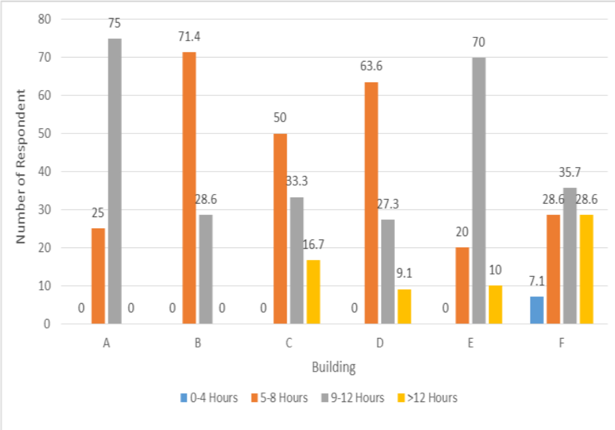


Figure 1 Duration spent by respondents within office during working day

4.2.2 Comfort Level of Respondents In Case Studies

Table 2 shows the summary of all the mean value and standard deviation of comfort level of respondents regarding indoor environmental quality in case study for each case study according to different variables. According to Table 2, respondents from Building E and Building F have high agreement that they feel warm or even hot when they work in the office, with high mean value of 4.00 and 3.93 respectively. In contrast, respondents from Building A, Building B, Building C and Building D have cool or cold feeling when they work in the case studies. Among of them, all respondents from Building C strongly agree that they have such feeling, with mean value of 5.00. Both result is totally contrast, which the result is expected. The respondents from the Building E and Building F are actually expected to have warm feeling in their workplace as the indoor environmental quality measurement shows that the temperature within the place is higher than the optimum, which is 29.2̊C and 29.0̊C respectively. While referring to the design part, all of the case studies have centralized air-conditioning system and all are sealed open space design. Thus there is no possibility that the respondents from Building E and Building F to feel warm as related to the design of the case studies.

The respondents from Building E and Building F neither agree nor disagree that they have felt that the office is in high humidity condition, with mean value of 3.40 and 3.43 respectively. Respondents from the rest of the case studies did not feel the high humidity of the building. Humidity in office is usually kept between 40-70% because of computers even though the optimum is 30-60%. [25] Table 1 shows that the humidity of the case studies are coincide as the condition stated above, which maintain a bit higher than normal. The humidity of Building E already pass the normal level, while humidity of Building F was at the border line. High humidity environments (which the humidity is more than 80%) will prevent the evaporation of sweat from skin as the condition have a lot of vapour in the air. which will later result the sticky and uncomfortable feeling of human beings. The result proves the fact as the occupants from Building E and Building F have high sensitivity on humidity and highly uncomfortable regarding humidity within the building.

Respondents from Building E and Building F feel that the air velocity within the case studies is low as the results give the mean value of 3.70 and 3.79 respectively. The respondents from the rest of the case studies did not agree that their office building have low air velocity. According to Evans, the optimum indoor air velocity must be kept between 0.10-2.0 m/s. [26] Table 1 shows that the only case study that have problem with indoor air velocity after the indoor environmental quality measurement is Building A, which has low indoor air velocity than usual. However, the respondents from Building A disagree that they have such movement even though the indoor air velocity is slower than usual.

In case of air flow rate, surprisingly it is again the respondents from Building E and Building F feel that the air flow rate within the case studies is low as the results give the mean value of 4.10 and 3.43 respectively. While respondents from Building A, Building B, Building C and Building D did not agree that they need to open the window to banish the moldy smell which indicate they do not agree that the air flow rate within the building is low. All four of the case studies give mean value less than 3.00.

In questionnaire, the respondents are asked whether they think that outside environment is better than indoor office environment. In overall, respondents from Building A, Building B and Building D disagree that outside environment is better than environment inside their office, with mean value of 1.83, 2.00 and 2.27 respectively. Respondents from Building C, Building E and Building F show neutral opinion on this part, with mean value of 3.00, 3.20 and 2.79 respectively.

Table 2 Comfort level of respondents regarding indoor environmental quality in case study

Components	Building A		Building B		Building C		Building D		Building E		Building F	
	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Warm Feeling	1.92	0.515	1.57	0.535	2.00	0.000	1.82	0.603	4.00	0.943	3.93	0.616
Cold Feeling	3.58	1.505	4.00	1.528	5.00	0.000	4.18	1.401	1.90	1.287	1.64	1.151
High Humidity	1.50	0.905	1.86	1.069	1.33	0.516	1.73	0.647	3.40	1.506	3.43	1.089
Low Air Velocity	1.25	0.452	2.00	1.000	2.17	1.472	1.55	0.522	3.70	1.252	3.79	1.051
Low Air Flow Rate	1.92	0.996	2.71	1.604	2.17	1.472	2.55	1.214	4.10	0.876	3.43	1.284
Optimum Noise Level	4.17	0.577	3.57	1.512	1.67	0.516	3.45	1.293	2.80	1.033	2.93	1.207
Optimum Illuminance	4.33	0.888	2.29	1.254	3.33	1.211	3.00	1.095	2.60	1.265	3.00	1.301
Overall Dissatisfaction	1.83	1.115	2.00	1.155	3.00	0.894	2.27	1.272	3.20	1.033	2.79	1.477

4.2.3 Prevalence of Sick Building Syndrome

Table 3 shows the summary of all the mean value and standard deviation of various levels of sick building syndrome symptoms faced by respondents in case study. The analysis of the research question is done by using SPSS. The respondent is said to face the sick building syndrome if he or she has the symptoms given in the questionnaire at least 1-3 days per week when they are working in office but the symptoms will disappear when he or she leaves the office.

Respondents from Building B, Building C and Building D have high agreement that they often face to flu when they work in the case studies, with mean value of 3.57, 4.17 and 3.73 respectively. The flu event as sick building syndrome symptoms is believed to be related to the low temperature within office. [27] Thus, it is expected that none of the case studies should be affected by flu as sick building syndrome as none of the case studies has temperature lower than optimum. However, the result from questionnaire show those respondents from Building C and Building D are suffering from flu as sick building syndrome. The room temperatures of the case studies are within the optimum value. It is suggested that the case might be caused by inadequate indoor air flow as mentioned in previous researches [1], [28]. Inadequate air flow would bring to continuous exposure to indoor air pollutants or dangerous gases (which including flu viruses that cannot be transferred away) that might elevate risk of getting health problems.

Respondents from Building E and Building F agree that they often have headache when work within the office, with mean values of 4.20 and 3.57. According to various researches, the reasons of people facing to headache are either high indoor temperature, low noise level than optimum or low lighting condition [27], [19], [29]. Thus, Building B (low lighting), Building D (low lighting), Building E (high temperature and low lighting) and Building F (high temperature and low lighting) are risky case studies that the respondents would face to the illness. While referring to above, only respondents from Building E and Building F suffered from headache. The analysis indicated that the headache level of occupants is much more affected by the high temperature condition in the building. However, the low lighting is not seemed to affect headache level of occupants according to the result.

Respondents from most of the case studies agree that they feel drowsy when work within the office. These including respondents from Building A, Building B and Building C, which gives mean values of 3.58, 4.14 and 4.67 respectively. Low room temperature will increase the rate of drowsiness within a workplace in various researches. [14] Thus, similar to the flu symptom, it is expected that none of the case studies should be affected by drowsiness as sick building syndrome as none of the case studies has temperature lower than optimum. However, the result from the questionnaire obviously does not correspond to the expected effect. Apart from that, the respondents from Building A agree that they only have drowsy as symptom when they work in the case study, even though they are within normal range of room temperature (25.7°C). The finding coincide with a research which found that most of the occupants who work in air-conditioned space with temperature less than 24°C suggested that temperature at 27°C would be more comfortable compare to current condition. [31] The respondents from Building B also face to high prevalence of drowsiness although the room temperature is also not low. For Building B case, it is suggested that the drowsiness might be caused by the low artificial lighting although there is no literature mentioned that it would be the cause drowsiness. However, a research states that intensity of indoor artificial lighting is much less than the natural light, while the colour emitted also differs, which later affect the amount of hormone melatonin released by the body. [32] The melatonin control human biological clock and the melatonin is controlled by lighting, lack of the intensity of light at the right time might cause the body reduce the production of melatonin, thus make people feel drowsy. More to the point, the release of melatonin will be delayed by turning lights on at night and thus shift the timing of human internal clock, making a possibility of the respondents to feel drowsy in this research. [33]

Respondents from most of the case studies agree that they are fatigue when they work in the offices. Respondents from Building B, Building C, Building D, Building E and Building F admit the case with mean values of 4.14, 3.67, 3.73, 4.10 and 3.71 respectively. According to previous researches, fatigue can be caused by either high temperature, low noise level or low lighting [19], [29], [34], which are the same as headache. Thus the research result is obviously correlate to the expected outcome as respondents from Building B (low lighting), Building D (low lighting), Building E (high temperature and low lighting), and Building F (high temperature and low lighting) agree that they are suffering from fatigue when they work within the building. Regarding Building C which equipped with optimum temperature, high noise level due to maintenance work of neighbour unit and optimum lighting level, but occupants of this building still admit that they feel fatigue when they are working, which is the only unexpected from this research.

Table 3 Level of sick building syndrome faced by respondents in case study

Elements	Building A		Building B		Building C		Building D		Building E		Building F	
	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Flu	3.33	1.557	3.57	1.813	4.17	1.602	3.73	1.272	2.10	1.595	2.21	1.311
Cough	2.08	0.996	2.86	1.464	2.50	1.643	2.36	1.206	3.40	1.506	3.64	1.151
Fever	1.92	1.165	1.43	0.535	2.17	1.169	1.64	0.674	1.50	0.527	1.64	1.082
Skin Rash	2.25	1.215	3.14	1.464	1.67	0.816	2.27	1.421	3.80	1.317	3.79	1.122
Headache	2.42	1.084	2.29	1.604	2.83	2.041	3.00	1.612	4.20	1.229	3.57	0.938
Drowsy	3.58	1.505	4.14	1.464	4.67	0.516	3.36	1.433	2.50	1.354	2.50	1.225
Hard to Breath	1.92	0.793	1.29	0.488	2.50	1.225	1.64	0.924	2.40	1.430	2.71	1.069
Nausea	1.58	0.515	2.29	1.254	1.50	0.548	1.64	1.027	1.40	0.516	1.86	0.864
Irritated Eyes	2.00	0.853	2.71	1.604	2.83	1.472	3.64	0.809	2.60	1.506	3.00	1.414
Fatigue	2.92	1.505	4.14	1.464	3.67	1.033	3.73	0.905	4.10	0.568	3.71	0.994

5.0 CONCLUSION

The purposes of this study were to study the effect of various indoor environmental quality parameters on sick building syndrome symptoms and to understand the requirements of occupants on the quality of indoor environment for the offices. Firstly, it was found that the occupants are quite satisfy in overall on the current indoor environmental quality within the case studies, which acts as their offices. However, respondents also express various dissatisfactions on certain indoor environmental parameter according to case study. Besides, it was also found that most of the occupants feel drowsy and fatigue when they work within the case studies. Apart of that, due to the differences between the indoor environmental quality of the buildings, the occupants are suffered from different symptoms of the sick building syndrome. The interesting part that is found in this study is that the sick building syndrome symptoms that are faced by the occupants in high temperature differ much from the previous research. The occupants suffer from the symptoms that are stated to be faced when the temperature is lower in previous research. Thus it is quite a point for future researchers to work on.

Serving as a fundamental research, there was some recommendations are to be proposed for future research in this related field of study. A few add-points are to be noted to enhance the findings:

- Focus on only one type of indoor environmental parameter, especially thermal comfort, and study its effect on various symptoms of sick building syndrome.
- Focus on only one symptoms of sick building syndrome, and study the risk factor in term of indoor environmental quality of it.

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