The Effect of Indoor Air Quality (IAQ) Towards Occupants' Psychological Performance in Office Buildings

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ABSTRACT

Indoor air quality (IAQ) in a building is a very important element to ensure the health and comfort level of the building occupants. This is because work productivity may be interrupted due to the polluted environmental condition and bad indoor air quality. Both factors may lead to bad health and physical condition and consequently to bad work performance. The study presents the understanding and knowledge of how indoor air quality (IAQ) affects psychological performance and health impact to the occupants in government high rise office buildings in Malaysia. Four high-rise government office buildings located in Kuala Lumpur and Selangor were selected as the case studies. Questionnaire forms were distributed among the building occupants to get their feedback regarding their satisfaction with the buildings' IAQ performance. All data collected were analysed using SPSS statistical software and based on the data analysed, building occupants' satisfaction level are identified. Finding shows that in the current situation, the majority of respondents are not satisfied with their office current indoor air quality. This condition is believed to be one of the contributing factors affecting occupants' work productivity and stress level. Nevertheless, this research managed to provide better understanding and valuable information on how indoor air quality affect psychological performance and health condition of the occupants in office buildings. Recommendations are made to improve the indoor air quality performance in order to provide a comfortable working environment to the workers.

Keywords: *Indoor Air Quality (IAQ), Stress, Productivity, High-rise, Offices*

INTRODUCTION

Office buildings in Malaysia must provide clean, cosy and comfortable environment with good indoor air quality (IAQ) to ensure the employee health condition either physically or psychologically while carrying their duties inside the building. This is because their health condition will affect their work performance and it will affect the organisation's performance. As reported by Environmental Protection Agency EPA (1997), indoor environments can have pollutant levels higher than outdoor.Quality of outdoor air and emissions from the indoor environment and the buildings' occupants has made the indoor air quality affected by type and performance of heating, air-conditioning, and ventilation technology (Jakola et al., 1994). According to Hodgson (2002), indoor environment in a restricted space is a complex and dynamic combination of physical, biological, and chemical factors that can affect the occupants' health and physical reactions anytime whether we realize it or not. Moreover, evidence shows that volatile organic compounds frequently found in office indoor air may cause symptoms typical of the sick building syndrome symptoms. Cheong and Chong (2001) have mentioned that the only aspect to achieving high IAQ is by providing a comfortable and clean indoor environment for the building occupants.

The majority of office buildings in Malaysia are using mechanical ventilation systems such as ventilation and air-conditioning (VAC) to maintain the building indoor air and environment since the Malaysian climate is hot and humid given the location of Malaysia in the tropical climate region. However, the mechanical ventilation systems will provide fresh air only if in good condition and well-maintained. If not, they will convey unclean air to the indoor environment of the building and that will have a bad effect on the workers as their health will probably be affected since obviously, poor IAQ could cause illnesses such as 'Sick Building Syndrome' (SBS) and 'Building Related Illnesses' (BRI) to building occupants. The consequence of these building illnesses will not only affect the building occupants but it will also affect the company occupying the building. This is because workers who suffer from either SBS or BRI need to take the sick leave. Therefore, if the workers regularly take sick leave, it will affect their productivity and in turnwill lower the company's productivity. Beside, poor IAQ will not only affect the occupants' health physically but also mentally. This is because if the air quality inside the building does not fulfilthe occupants' requirements for instance the air temperature is too hot or too cold, this will make the occupants uncomfortable and it would probably make them use only half of their mind and effort in concentrating on their job while the other half is concentrating on the uncomfortable air quality. Therefore, this research intends to investigate the indoor air quality affecting psychological performance as well as health impact to the occupants in the office buildings in Malaysia. It is expected that a good suggestions can be made to improve the indoor air quality performance in order to create a comfortable working environment for workers.

INDOOR AIR QUALITY PERFORMANCE IN BUILDING

Most countries in the world have acknowledged indoor air as a significant health, environmental, and economic problem. Researchers have found that pollutants in indoor air occur more regularly and at higher concentrations than in outdoor air. Therefore, it is clear that indoor air has created major source for environmental exposure to air pollutants rather than outdoor. Since the majority of populations nowadays usually spend 80 – 90% of their time indoors whether at home, work or elsewhere, it makes the indoor air quality more important to monitorrather than outdoor air. The National Health and Medical Research Centre (NHMRC) (1992) has defined indoor air as air within a building occupied for a period of at least one hour by people of varying states of health. According to the Street, Drainage and Building (SDBA) Act 1974 (act 133), building includes any house, hut, shed, or roofed enclosure, whether used for the purpose of a human habitation or otherwise, and also any wall, fence, platform, staging, gate, post, pillar, pilling, frame, hoarding, slip, dock, wharf, pier, jetty, landing-stage or bridge; or any structure support or foundation connected to the foregoing. However, buildings covered by the definition were homes, schools, restaurants, public holdings, residential institutional, and offices, but no premises otherwise covered by occupational standard. On the other hand, Wesolowski (1987) has given definition of indoor air quality as the entire of attributes of indoor air that affect a person's health and well-being. Therefore, indoor air quality indicators must determine how well indoor air satisfies thermal and respiratory requirements, prevents unhealthy pollutants, and allows for a sense of well-being. The indoor air quality can also be defined as the occurrence of pollutants at concentrations which affect occupant health.

Poor indoor air quality might cause indoor air pollution which has been defined by Woods (1986) as an indication of acceptable limits of air pollutants, how air satisfies the thermal comfort, and standard concentration of gases for respiration. Five factors contribute to indoor air pollution, namely: poor and inappropriate ventilation system; any horrible occupants' activities such as smoking; bad personal habits such as unmanageable clothes, shoes or hair; any product being used in the building such as

powder and fibre; and any processing method done such as heating, grinding, sawing or crushing (Ahmad &Kamaruddin, 2006). Yet, it has been found that a range of subjective symptoms, which are recognised as the 'sick building syndrome' (SBS) by the World Health Organisation (WHO) (1982), occur in a high proportion which is around 30% or more of occupants of specific buildings especially air-conditioned offices without clearly identified causes. Raw (1992) has summarised sick building syndrome into several types as mentioned in Table 1.

Table 1: Symptoms and effects due to sick building syndrome (Raw, 1992)

NO	ORGAN INVOLVED	SYMPTOMS	EFFECTS
1	Eyes	Irritated, dry/watering	Itching, tiredness, smarting, redness, burning, or has difficulty in wearing contact lenses.
2	Nose	Irritated, runny/ blocked	Congestion, nosebleeds, itchy or stuffy nose.
3	Throat	Dry or sore	Irritation, or pharyngeal symptoms, upper airway irritation or difficulty swallowing.
4	Skin	Dryness, itching or irritation	Rash or specific clinical terms such as erythema, rosacea, urticaria, pruritis, xerodermia.
5	Others	Headache, irritability, lethargy, and poor concentration.	

According to Ho et al. (2004), a healthy building is one that has an environment encouragingpositive well-being in its occupants as they referred to the health definition by the World Health Organization (WHO) (1946) which is a state of complete physical, mental and social well-being and not merely the absence of disease. Rousseau and Wasley (1997) have suggested that positive well-being elements such as air, thermal comfort, aural comfort, and spaces should be optimised for building occupants' advantage. Wong et al. (2009) stated that an office and its environment behaviour must match with the workers' satisfaction and requirements as it affected the workers' productivity. On the other hand, Haynes (2008) claimed that the office environmental quality consist of related components to the office workers' skills and ability to physically connect with their office environment, related components on how well the office workers connected among each other, and the possible effects of individual behaviour on the office environment

Dubos (1969) found that poor air quality where the air may contain toxic elements could affect or prohibit human adaption. Besides, the effects of the former are expected to be either direct or more specific, where it resulted in clearly identifiable biological and psychological effects as response to the environmental stressors. Further, according to Selye (1956), the response to the environmental stressor is a common adaption syndrome that produces psychological effect such as a feeling to get out of the building. Two types of psychological effect due to indoor air pollution have been suggested by Colligan (1981) which is involving specific and direct effect of particular pollutants on the behavioural system selected such as on occupants' memory performance and complex psychological reactions involving mood state, motivation, and interpersonal relations. The second way is general arousal of the sympathetic nervous system involved where the occupants will feel tense and anxious whenever they are in any part of the building. This symptom also will make the

occupants feel anxiety, panic or fear and in some situations their heart and breathing rates will increase unexpectedly.

MATERIALS & METHODS

The methods used consist of qualitative and quantitative methodology. Qualitative research is used to obtain preliminary information relating to indoor air quality, high-rise office buildings chosen, and understanding the process of post occupancy evaluation. On the other hand, in getting all the valuable data and information regarding the research, quantitative research method is used. POE method was adopted to get the office building occupants' feedback relating to the IAQ and its performance on psychological effect. Several sets of questionnaires was distributed to four selected case studies. At first, ten buildings were selected as the case studies with five buildings from each state. However, only four management of buildings grantedpermission for the study (two are located in Kuala Lumpur and another two in Selangor). In order to retain the anonymity of the individual buildings, they have been designated as Building 1, Building 2, Building 3 and Building 4. The building occupants were given a maximum of 5 working days to fill up the questionnaires before they were recollected. However, since most of the occupants were busy doing their work and some of the occupants needed to do field work, they could not manage to finish answering the questionsin the limited time given and additional days were given. Table 2 shows the time taken for each building occupants' to complete the questionnaires.

Table 2: Time taken by the occupants to submit the questionnaires

BUILDINGS	DISTRIBUTION DATE	SUBMISSION DATE	TIME TAKEN
Building 1	1st March 2011	7th April 2011	5 days
Building 2	25th February 2011	4th April 2011	6 days
Building 3	4th April 2011	17th April 2011	10 days
Building 4	21st February 2011	24th February 2011	4 days

Questionnaires were aimed at determining the opinion of the building occupants regarding the buildings' IAQ and the internal environment and also to assess the importance of the relevant factors assessed. The survey also assessed personal well-being to identify the occupants' health conditions in the building. This survey should assist in identifying any particular aspects of the environment that require adjustment and improvement, and aimed at providing a better internal environment for the occupants.

RESULTS AND DISCUSSIONS

By referring to the data collected, an analysis has been conducted in getting the result of the evaluation made by the buildings' occupants. However, the analysis cannot be done on 100% respondents as being expected as not all the questionnaires forms were returned. In the first stage, 200 questionnaires forms have been distributed, but the total number returned averaged 50%. Table 3 shows the percentage of the returned forms according to building.

Table 3: Total questionnaire forms distributed and returned

The Office Building		Questionnaires form distributed	Questionnaires form returned	Percentages (%)
KUALA LUMPUR	BUILDING 1	200	78	39
	BUILDING 2	200	138	69
SELANGOR	Building 3	200	89	44.5
	BUILDING 4	200	79	39.5
TOTAL			**394**	**100**

Occupants Age

It is found that majority of the respondents in all four office buildings are in range of 21 to 30 years old. This is because that age range is the most suitable age for work. Besides, in that age range, the undergraduate students are starting to graduate and joining the workforce in their relevant fields. In contrast,only a small number of respondents are below 20 years old and in the range of 51 to 60 years old. This is because, the under 20 group is not the appropriate age to work while at the range of 51 to 60 years old is the age where lots of people have already retirde and being replaced by the new generation.

Even though the number of the senior citizens is small, it is important to take care of the indoor air quality of the building as the resistance level of these citizens is more sensitive than that of the younger citizens.

Current Quality of Indoor Air

It is identified that the current condition of indoor air in all four office buildings are at the concern level since the majority of the occupants mentioned that their office buildings are having dry and stuffy air some of the time. Only few respondents feel the other way round. The opinions could differ because they are from different departments located at different levels and also because they spent less time in the office buildings due to some other field work. On the sick building syndrome (SBS) symptom, the result shows that all four office buildings had the occupants suffered from all the symptoms and most of them are having the syndrome regularly while they are doing their activities in the buildings. Therefore, it is important for the building manager to improve the building IAQ in terms of the air movement or ventilation quality until it satisfies the occupants requirements. The percentage of the occupants that suffered from the SBS can be reduced and the quality achievement of the company that operates inside the buildings can be increased.

The Correlation between Indoor Air Quality and Occupants' Psychology

Having a good work environment is important to the worker as it will affect their psychology in completing their task in the office. One of the major factors that need to be considered in the environment is the indoor air quality. Therefore, to see the correlation between the satisfaction levels of the occupants through the office building

IAQ, the evaluation regarding the topic has been made as can be referred to four tables in Appendix B. where it show that the indoor air quality in the office buildings will affect the satisfaction and comfort level of the occupants. After that, it will affect the productivity of work produced by the occupants and based on their work productivity will affect their psychology or mentally as can be measured by the occupants' stress level. However, to ensure the correlation between the IAQ and the occupants' psychology level, the result are compared between all four office buildings which are Building 1, Building 2, Building 3 and Building 4. The results obtained from the evaluation are illustrated in Figure 1-5.

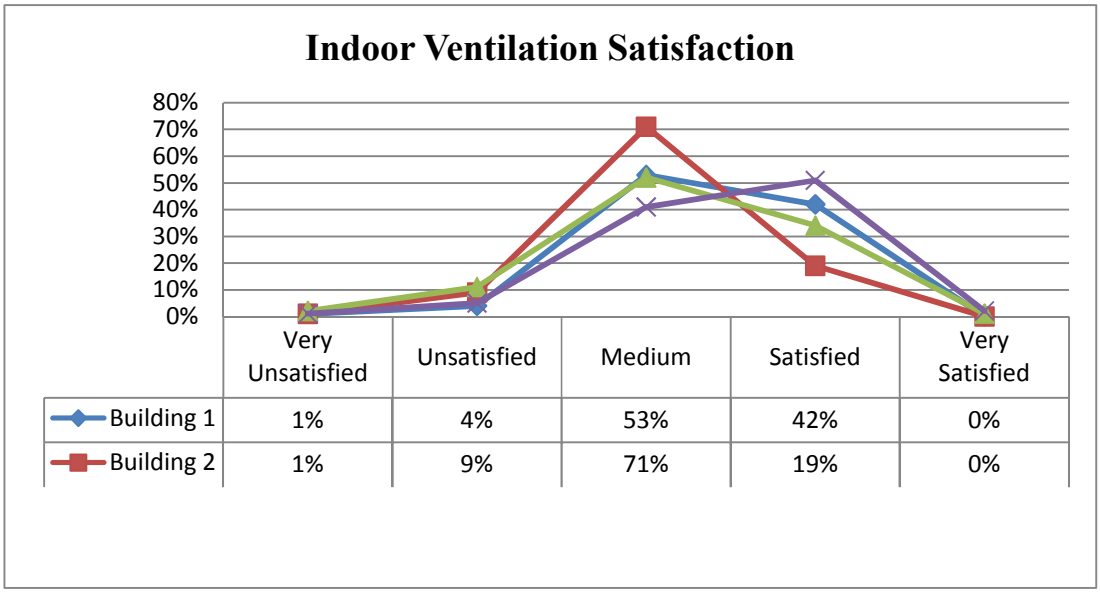


Figure 1: Occupants' indoor ventilation satisfaction in four office buildings

Figure 1 shows that the majority of the respondents' satisfaction levels are only at the medium level. This shows that the ventilation systems in all four office buildings are not good enough, neither the mechanical nor the natural ventilation systems. Building 2 had the highest percentage where 71% of the total respondents rated the ventilation system in middle level. Based on a follow up interview with the building manager, this high percentage is due to the air-conditioning system frequently breaking down and that situation makes the temperature of the office exceed the occupants'preference; hence they need to open the office windows and doors to get natural ventilation to feel more comfortable.

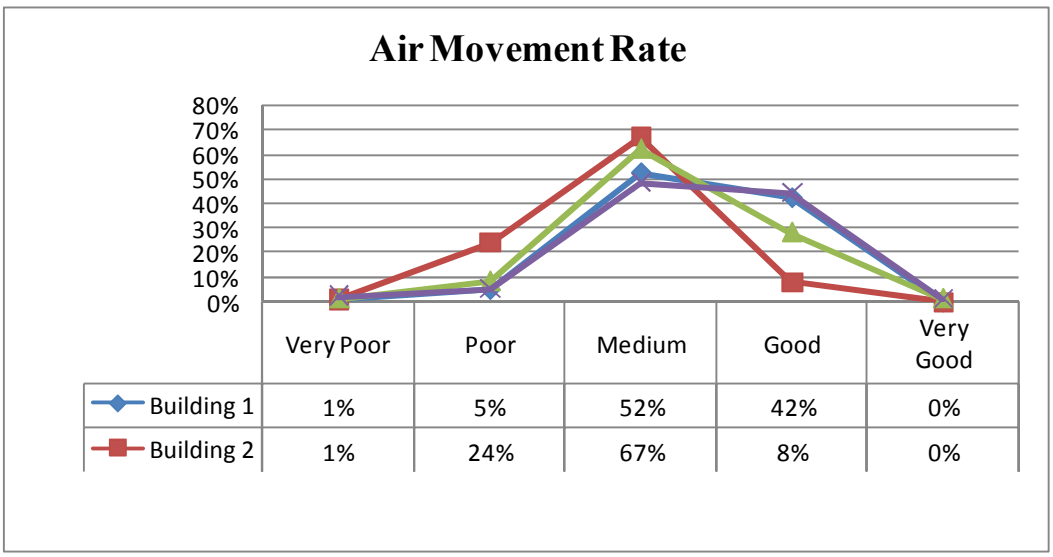
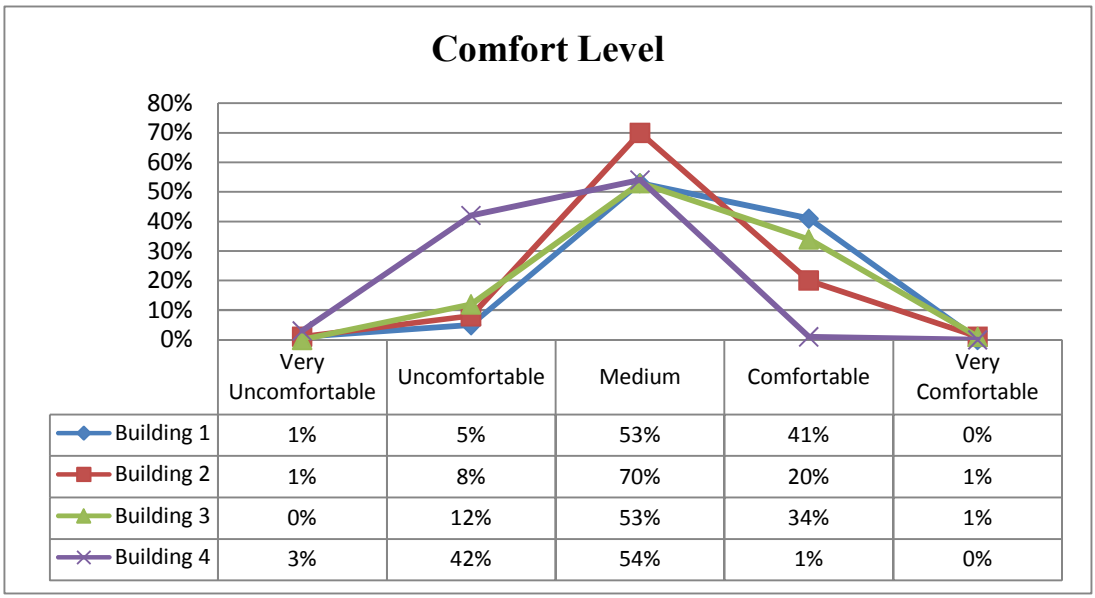


Figure 2: Occupants' indoor air movement rate in four office buildings

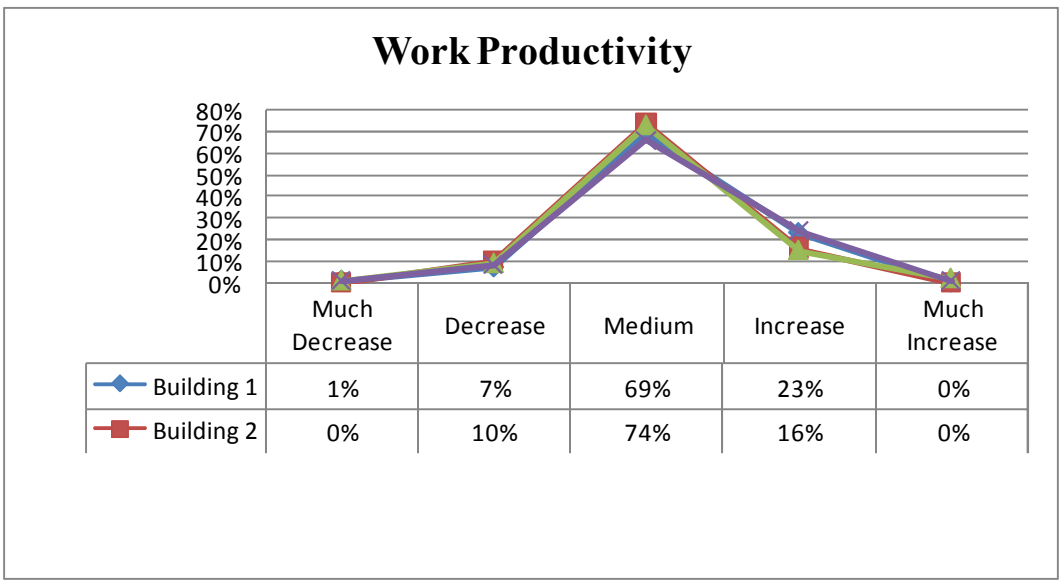
The occupants were also asked to rate the air movements inside their office and based on the air movement rating done, it shows that the majority of respondents from all office buildings indicated middle rating and similarity to Figure 1. Figure 2 shows the respondents 'rating for air movement.



	Very Uncomfortable	Uncomfortable	Medium	Comfortable	Very Comfortable
Building 1	1%	5%	53%	41%	0%
Building 2	1%	8%	70%	20%	1%
Building 3	0%	12%	53%	34%	1%
Building 4	3%	42%	54%	1%	0%

Figure 3: Occupants' comfort level in four office buildings

As shown in the figure 3, the comfort levels of the buildings are also found to be in the medium degree. Nevertheless, there are some difference between the graph curve with the other two graph in Figure 1 and Figure 2. The majority of the respondents feel uncomfortable with the comfort level of the buildings.



	Much Decrease	Decrease	Medium	Increase	Much Increase
Building 1	1%	7%	69%	23%	0%
Building 2	0%	10%	74%	16%	0%

Figure 4: Occupants' work productivity in four office buildings

Based on Figure 1-3, all three elements are having middle rate by the respondents which means they are not really satisfied with the indoor air quality performance in their workplace. Thus, this result is affecting the graph of work productivity produce by the occupants as shown in Figure 4. It is shown that productivity is just in the middle range and increment of productivity due to the effect of indoor air quality is slightly low. This clearly indicates that only a small number of respondents are capable in managing their work efficiently.

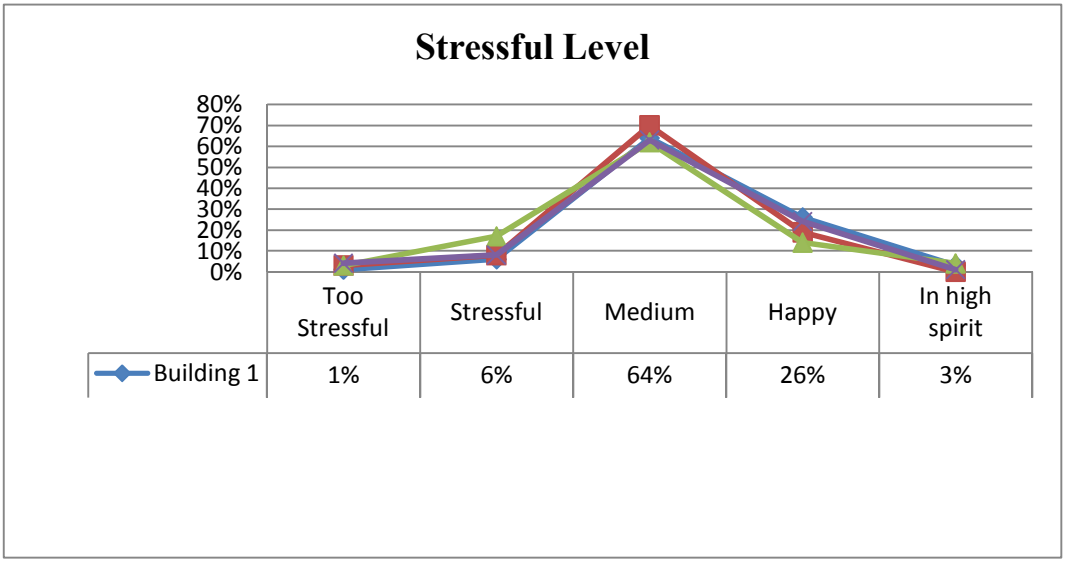


Figure 5: Occupants' stressful level in four office buildings

Based on Figure 5, it is clearly seen that the stress level of the occupants are similar with all four previous figures where the majority of the respondents are rating their stress level in the building as medium. It also shows that the respondents' stress level is affected by their work produced. To get more clear understanding on the topic, let us take an example of two people who are working in Building 2. If they are unsatisfied with the current indoor ventilation because from the observation the quality of the indoor air is poor due to some problems in the office such as technical problem where the HVAC is always down. This situation will make the office environment hotter than usual. Therefore, they will feel uncomfortable while spending time working inside the building and when they are uncomfortable, they will not be able to do their work or might be doing it with force since the ventilation is suffocating. Therefore, with less effort while doing the jobs, they cannot produce better work quality. This eventually would decrease the productivity most of the time. Consequently, as their productivity keeps decreasing, they will start feeling stress while doing their work and this situation would continuously happen and even become permanent if the building management takes no action to resolve the problem.

The Stress Level in Office Buildings

After the correlation between the IAQ and the psychological effect toward the office occupants are identified, the results show that,on average, the satisfaction level of the IAQ is affected by the quality of the IAQ that the building produced. However, by comparing each building's performance each building is having different level of quality performance. Based on the results obtain, the ranking of which building is having better IAQ is identified in Figure 6.

The scale for measuring the stress level among the buildings' occupants are measured based on a five point scale where the smaller the point, the higher the degree of stress faced by the occupants.

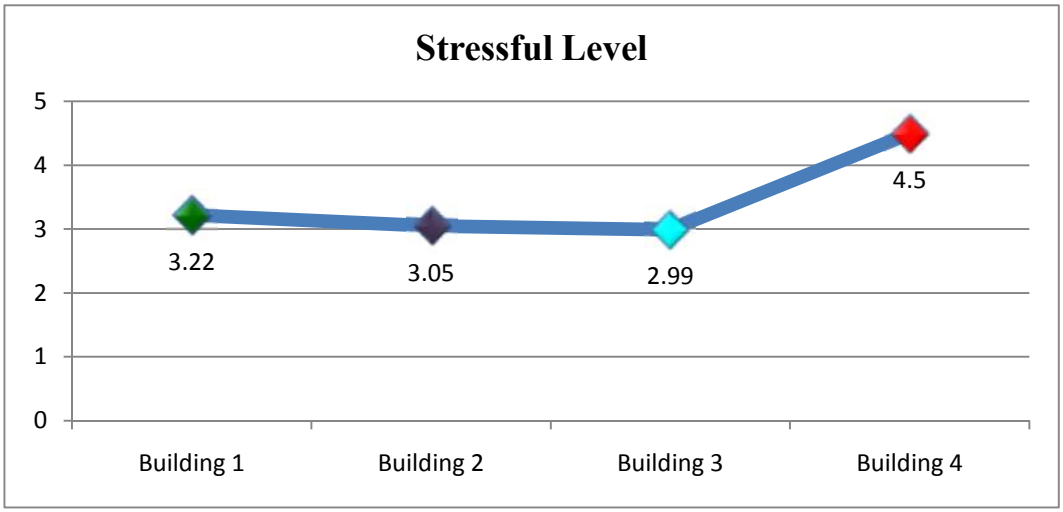


Figure 6: Occupants' stress level in four office buildings

Figure 6 shows the average of stress level faced by occupants in four office government office buildings. It shows that the majority of the occupants are feeling stress while working in their office due to less satisfaction with the IAQ of the building averagely at the middle level. This is justified by the mean score of nearly 3.00 point scale. Building 3 scores 2.99 points, Building 2 scores 3.05 points, and Building 1 scores 3.22 points. For Building 4 occupants' stress level is having quite large point from the other buildings where the mean point of occupants' satisfaction is 4.5. Based on the result, it shows that most of the occupants feeling stress while spending their time in the office are the occupants in Building 3 as the scale point is the lowest among all four buildings. This is followed by occupants in Building 2, Building 1 and Building 4 where the building is having the least occupants who are stressed while working in the building.

In general, IAQ level in a building is undeniably affecting the stress level faced by the occupants. It can be concluded that the IAQ level in Building 4 is more satisfactory than in Building 3. The outcome is basically due to more emphasis and attention given by the management of the building in maintaining the ventilation services in the building. Besides, to ensure the building is providing and delivering satisfied IAQ as required by its occupants, they also must ensure the quality of indoor air is fulfilling the needs of the building occupants. Furthermore, it is capable to make the stress level among the occupants became zero percent if the IAQ of the building is well maintained and all occupants are involved in ensuring the ventilation system provided is maintained. As shown in Figure 6, the building management in Building 3 needs to improve management and maintenance carried out in the building to achieve the satisfaction level demanded by the occupants. Besides, the building occupants also need to participate in increasing the IAQ level such as always being alert to any changes or damage to the ventilation system to ensure the IAQ level and the thermal comfort of the building can be increased and improved.

CONCLUSION

The achievement achieved by any company depends on the achievements and the quality of performance of its workers. That means, if the performance shown by the occupants keeps increasing, than the company performance also will be increased, and vice versa. Therefore, it is important to ensure all workers are performing a great

job every time they are asked to deliver any task. So, to ensure the quality of work done by the workers is achieved to the employer's satisfaction, it is also important to ensure the quality of environmentof the working area satisfies the workers. One of the elements that need to be considered in providing good environmental quality in a building is the indoor air quality including the ventilation and thermal comfort provided in the building such as ensuring the HVAC system provided is functioning well and the temperature is conducive to building occupants. This is because a temperature that is too high or too low will affect the IAQ and in turn affect employee performance.

'Besides, if the IAQ level in a building does not meet the occupants' needs and requirements, several SBS symptom will occur and affect them such as headache, irritated eyes or nose, blocked nose, and so forth; as the syndrome infects the building occupants, they will feel ill and it will reduce their passion to come to work as they know once they enter the building, they will be having the syndrome and it makes them sick. Consequently, as the workers feel unexcited to come to the office, it will affect their productivity where they will not be focused in delivering their work; if they keep completing their task in a half hearted way, it will someday affect their psychology where the condition might cause high stress levels. This situation will also impact the company performance as the higher the stress level faced by the occupants, the lower their work performance and productivity and the lower the performance achieved by the company. Besides, it is identified that the occupants' comfort and health level, SBS symptom, indoor ventilation satisfaction and the comfort level felt by the occupants are the major factors affecting the occupants' psychology.

As shown by the results obtained, it can be concluded that the higher the occupants' satisfaction with the indoor air quality in the building, the higher their work productivity and the lower their stress level. Basically, IAQ is one element or one part of the indoor environmental quality (IEQ). While carrying out the research, the evaluation done among the buildings' occupants covered the IEQ satisfaction of the buildings. However, as the aims of the research is to determine how the IAQ could affect the psychological and health level of occupants in the office building, the analysis made stressed the IAQ in the building where emphasize the IAQ quality, satisfaction level, and some factors that decrease the IAQ satisfaction among the occupants. Therefore, it is hoped that some other researcher will emphasize the other factors of the IEQ in a building either office building or any other type of building to measure the impact on occupants' psychology.

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