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Investigation of Indoor Air Quality of the Mechanical Engineering Department Office Politeknik Kuching Sarawak

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Abstract

The occupants of all buildings have right for a healthy and quality indoor air. However the air property inside buildings may contain a range of pollutants that adversely affect the cardiovascular and respiratory systems of the human body. This paper highlights the investigation of indoor air quality of the Mechanical Engineering Department office, Politeknik Kuching Sarawak and to evaluate the occurrence of SBS among the staff through a survey. The comfort evaluation survey shows that the occupants are not satisfied with the indoor air quality in the office. The indoor air quality assessment is investigated by using IAQ Meter, Velocicalc meter, and Dust Monitor. The specific parameters investigated are carbon dioxide, air temperature, air movement, and dust particle. From all of the parameters evaluated, air movement, air temperature, and dust particle are recorded out of acceptance range. The findings suggested that the main factors are due to the malfunctioning of two out of four quantities of air conditioner in the office and imbalance in the ventilation system.

Key-word: - Air Quality, Velococalc Meter, Dust Monitor

INTRODUCTION

The investigation was carried out at Mechanical Department Office of Polytechnic Kuching Sarawak. The dimensions of the office is 17.1m x 18.3m x 3.67m. This office is occupied by 23 staff and equipped with four air conditioner (5HP) and ten series of glass window on left and right side. The office layout plan is shown in Figure 0.5. The IAQ assessment is examined in one working day where all staff are present in the office.

The Industrial Code of Practise on Indoor Air Quality (ICOP) (2010) published by Department of Occupational Safety and Health Malaysia proposed the selected indoor air quality parameters and their acceptable limits (Department of Occupational Safety and Health (DOSH) Malaysia, 2010). Prior to maintain a good IAQ, the acceptable limit of each IAQ parameter must be complied. The characteristics of good indoor air quality include introduction and distribution of adequate ventilation air, control of airborne contaminants, maintenance of acceptable temperature and relative humidity (Norhidayah, Lee, Azhar, & Nurulwahida, 2013). Previous study conducted by EPA states, indoor air pollution is among the top five environmental health risks. In 2009, the World Organization Health (WHO) prepared a report on Global Health Risks: Mortality and Burden of Disease Attributable to Selected Major Risks. This report proposed that indoor air pollution is responsible for 2.7% of the global burden of disease (WHO, 2009). The International Labour Organization (ILO) defines Sick Building Syndrome (SBS) as a phenomenon that occurs when 20% of the respondents report symptoms associated with their respective place of work with the specific association with air quality ("Encyclopaedia of Occupational Health and Safety", 2000). SBS covers the nonspecific subjective health symptoms such as itchy eyes, skin rashes, and nasal allergy symptoms, to more vague symptoms such as fatigue, aches and pains, sensitivity to odours and difficulty in concentration (Burge, 2004). The circumstances most suggestive of sick building syndrome are presence of common symptoms amongst a group of respondents that are present when they are in the building and absent when they are not in the building.

Understanding the factors of SBS in buildings has been a crucial challenge since the exact causes of SBS are still idiopathic that can be directly linked to SBS (Jerry, 2002). SBS may potentially affect job satisfaction, work stress, and productivity. Pertaining to these obstacles, the interests in the prevalence of SBS are quite low with limited documentation (Norhidayah et al., 2013).

OBJECTIVES

1. To investigate the indoor air quality of the Mechanical Engineering Department office, PKS. The specific parameters investigated are carbon dioxide, air temperature, air movement, and dust particle.
2. To evaluate the occurrence of SBS among the staff through a survey.

ASSESSMENT METHODOLOGY

In order to examine the indoor air quality, the investigation is done in two stages. At the first stage, a survey regarding air quality and ventilation is distributed to occupants of the office. At the second phase, experimental measurements are conducted and the result is analyzed. The experiment methodology is summarized in flow chart of Figure 0.1.

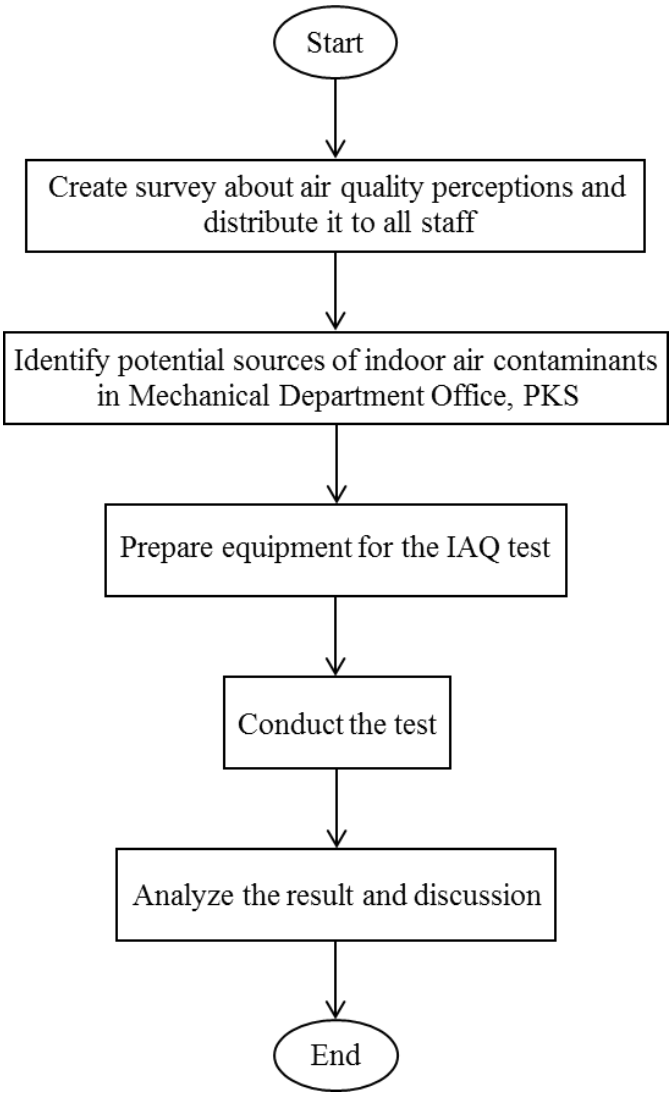

Figure 0.1 Flow chart of the experiment

INSTRUMENT PREPARATION AND SETUP

The equipment used are IAQ meter, Velocicalc meter, and Dust Monitor to assess the air quality. Figure 0.2 until Figure 0.4 show the equipments used in this experiment. The IAQ meter is used for measurement and identification of CO and CO_2, while air temperature, air velocity are measured by Velocicalc meter. Indoor levels of respirable particulates were measured by using Dust Monitor. The data from the devices are used to determine the indoor air quality in the office. All the test instrument were placed at location 1.5m above the floor level.(Ministry of Human Resources, 2005) Every reading of the interest parameter are measured for three times at each point. First reading are collected in the first 60 seconds, second reading is taken for next 60 seconds and third reading are continuously collected for the next 60 seconds as shown in Table 3.1.

Figure 0.2 Dust Monitor

Figure 0.3 Velocicalc

Figure 0.4 IAQ Meter

LOCATION OF SAMPLING POINTS

In general, sampling points should be selected using the following criteria according to ASHRAE standards (Department of Occupational Safety and Health (DOSH) Malaysia, 2010) :

1. Should represent the real individual HVAC zones
2. Include areas under complaints

3. Cover areas with both high and low occupant density.
4. The sampling probe should be located between 75 and 120cm from the floor and the centre of the room or an occupied zone (COP).
5. At least 0.5m from corners or windows.
6. At least 0.5m from walls, partitions and other vertical surfaces (e.g. file carbinet).
7. Not directly in front of air supply diffusers, induction units, floor fans, or heaters, or the exhaled breath of the occupant.

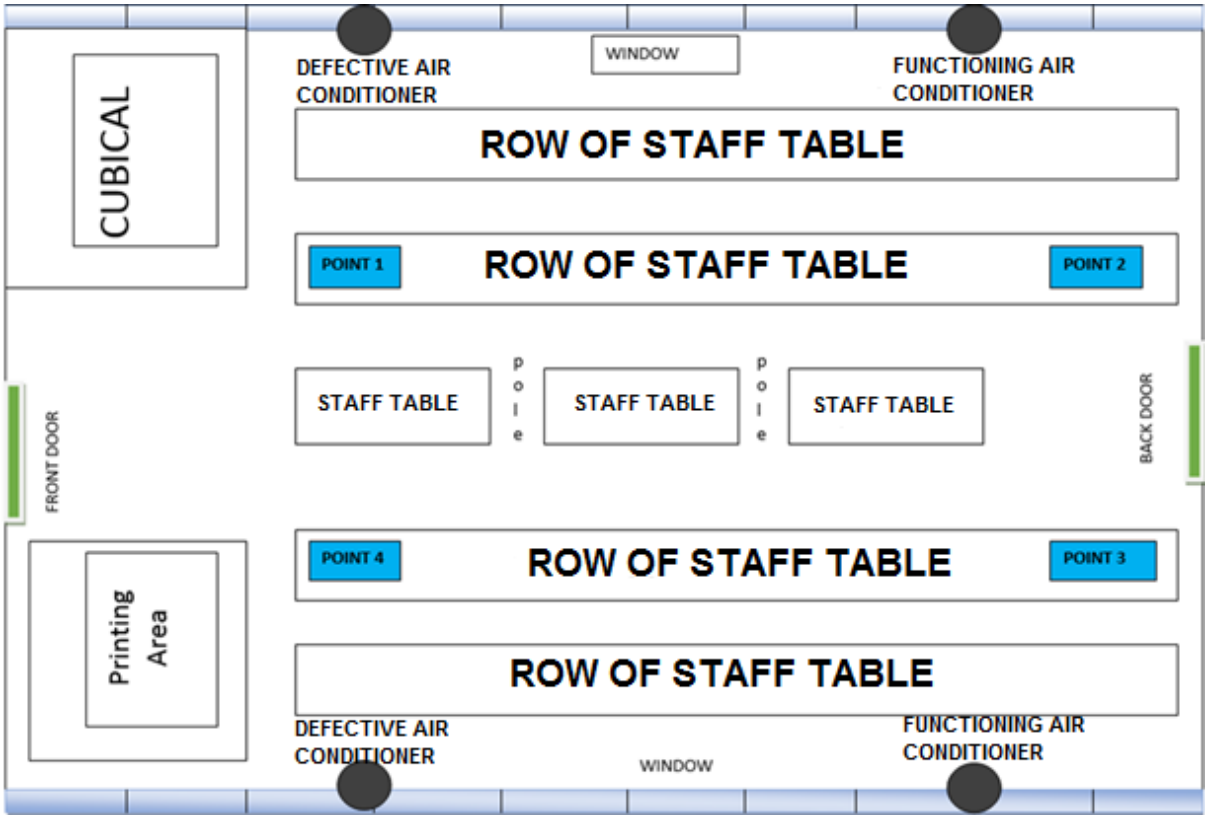

Figure 0.5 Office layout plan

According to the office layout plan in Figure 0.5, there are four sampling point (blue box) as located. Average of each readings is calculated and recorded in Table 0.2.

COMFORT EVALUATION SURVEY METHOD

The questionnaire is based on models by Silva and Roulet (Silva, Maas, Souza, & Gomes, 2017) are created through google form and distribute to the respondents. There are a total 23 respondents comprises of 7 females and 16 males. The focus of the questions are related to the air quality problems, health symptoms and satisfaction of indoor air quality in the working area. The questionnaires include socio-demographic information, respondent's health status and symptoms of SBS, time spent in the building weekly, the job position, the occurrence of SBS and the quality of the air inside buildings. The respondents were defined as having SBS if they had at least one symptom of SBS and the symptoms appeared at least once a week. The respondents also must had reported the occurrence of at least 1-3 days per week during the last four weeks and must had reported that the symptoms showed improvement when they were away from the workplace (Norhidayah et al., 2013). There are 3 chosen questions that are important to be discussed from the survey.

1) THE IAQ PROBLEMS THAT OCCUR IN THE OFFICE ROOM

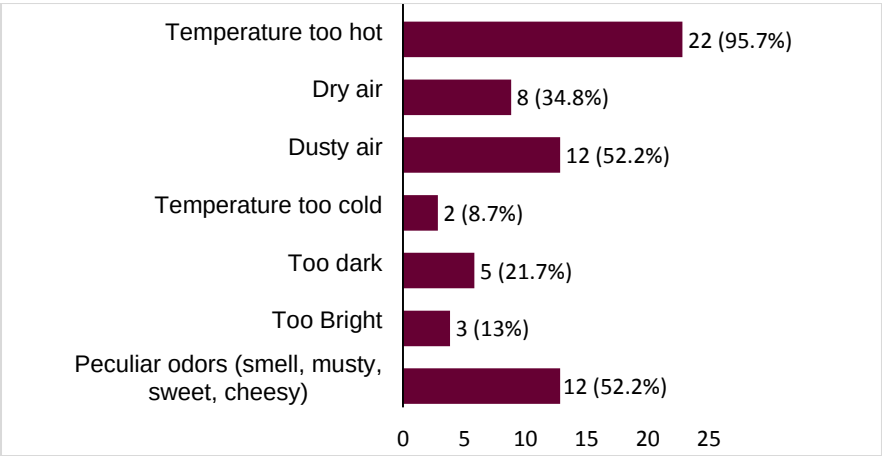

Figure 0.6 The problems that occur in the office room

The bar chart in Figure 0.6 shows the percentage of IAQ problems that occur in the office room. There are 93.7% of respondents said that the temperature of the office is too hot. These problems occur due to the air- conditioner are not functioning well. 52,2% said the office is too air dusty due to the bad ventilation system in this office. There are 52.2% respondents believe that this office has peculiar odors.

2) THE OCCURRENCE OF SBS SYMPTOMS IN THE OFFICE ROOM

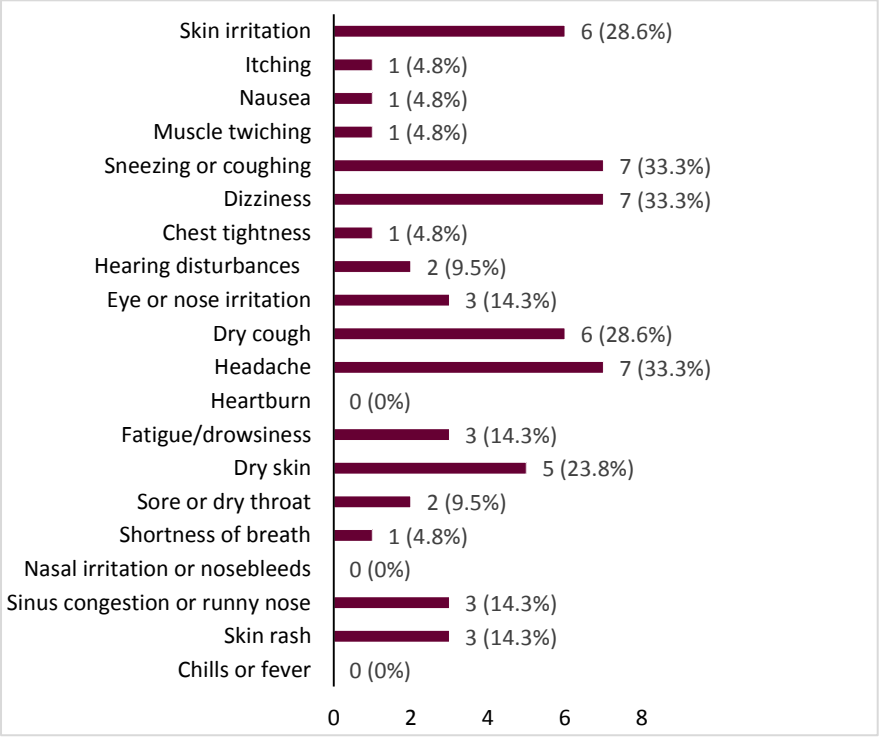

Figure 0.7 The prevalence of SBS symptoms in the office room

By referring to the bar chart in Figure 0.7 above, there are 3 highest problems that occur with the same 33.3% which are sneezing or coughing, dizziness and headache. The responses to questionnaires regarding the frequency of at least 1 to 3 items per week together with reported relief of these symptoms after left the building were used to define and categorize respondents with the SBS symptoms.

3) THE SATISFACTION OF INDOOR AIR QUALITY IN THE WORKING AREA

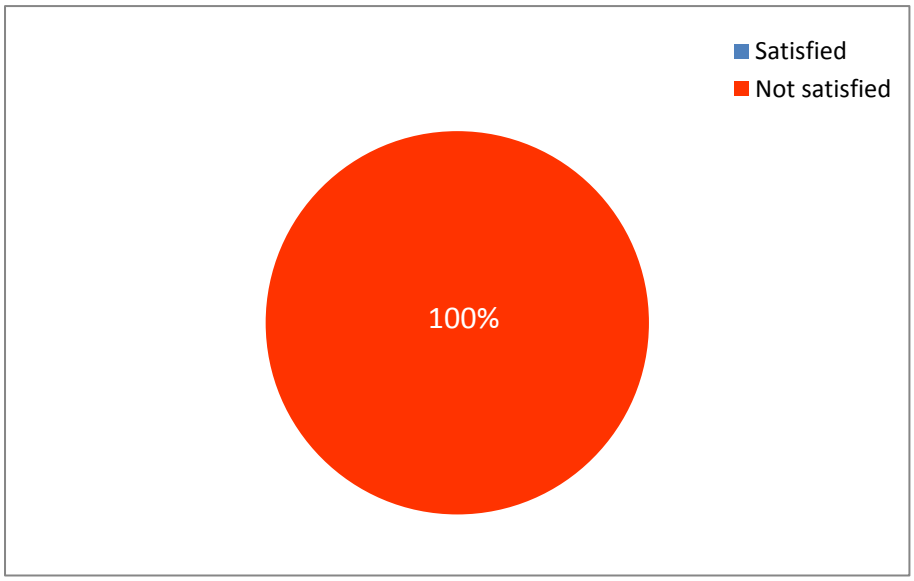

Figure 0.8 The satisfaction of indoor air quality in the working area

By referring to Figure 0.8, 100% of the respondents agreed that they are not satisfied with the indoor air quality in the office, this probably shows that the office has poor IAQ condition.

FINDINGS AND DISCUSSION

EXPERIMENTAL RESULT

The result of the investigation of air quality is summarized in Table 3.1 and Table 3.2.

Table 3.1 Data collection at four sampling point

	Point 1			**Point 2**			**Point 3**			**Point 4**		
IAQ Meter	**Time 1**	**Time 2**	**Time 3**	**Time 1**	**Time 2**	**Time 3**	**Time 1**	**Time 2**	**Time 3**	**Time 1**	**Time 2**	**Time 3**
CO_2 (ppm)	907	907	907	1028	998	991	979	999	1028	945	913	910
Velocicalc												
Air temperature (°c)	28	28	28	26.5	26.5	26.5	26.1	26.1	26.5	26.6	26.7	26.8
Air velocity (m/s)	0.21	0.15	0.04	0.03	0.04	0	0.01	0.05	0.05	0	0.06	0.02
Dust Monitor												
Dust particle (mg/m^3)	0.07	0.09	0.09	0.16	0.17	0.18	0.19	0.18	0.2	1.9	0.19	0.19

Note: *Each time taken 60 seconds consecutively.*

Table 0.2 Comparison between average reading in the office room and acceptable range (Department of Occupational Safety and Health (DOSH) Malaysia, 2010)

Specific parameter	**Acceptance Range**	**Average reading**	**Remark**
Carbon Dioxide	C1000ppm	959.33 ppm	Good
Air temperature	23-26 ^oC	26.85 ^oC	Out of range
Air movement	0.15-0.50 m/s	0.06m/s	Out of range
Dust particle	0.15 mg/m^3	0.30 mg/m^3	Out of range

Note*: C means ceiling limit, not to be exceeded at any time.*

4) CARBON DIOXIDE (CO_2)

The average of CO_2 in the office is 959.3343 ppm. The average result shows that CO_2 is still under acceptance range which is below 1000ppm. Indoor CO_2 concentrations above 1000 ppm are generally regarded as indicative of ventilation rates that are unacceptable with respect to body odors.

5) DUST PARTICLE

Dust particle is very small. The size is less than 10 micron in diameter. In general, among the sources are Environmental Tobacco Smoke (ETS), aerosols from air fresheners are cleaning material. Other sources may include dirt from carpets or dirt carried in from outdoor such as haze. Average of the readings for all points is 0.302175 mg/m^3. This is out of acceptable range which should be below 0.15 mg/m^3 PM10 and 0.065 mg/m^3 PM2.5.

6) AIR TEMPERATURE

The average air temperature in the office is 26.8575^oC. The result shows that the average temperature is over than the acceptance range which is below 26^oC. The malfunctioning air conditioner at point 1 and point 4 cause this high temperature in the office. Imbalance ventilation system also allowed the accumulation of possible contaminants in the indoor environment. A higher number of total fungi can be related to higher temperature and percentage of relative humidity. Both of these parameters provided a suitable condition to increase the growth rate of fungi (Norhidayah et al., 2013).

7) AIR VELOCITY

The graph shows the reading of air velocity of four different point in office room of Mechanical Engineering Department. The highest air movement indicated in the graph is 0.133m m/s at Point 1. This is due to the usage of personal fan by some of the staffs in the office located at the test insturement. At point 2, 3 and 4, the indicated reading are 0.0233 m/s, 0.03667 m/s and 0.02667 m/s respectively. The average air velocity in the office is 0.054993m/s. The result shows that the average air movement in the office is below than acceptance range which is 0.15-0.50 m/s.

The malfunctioning air conditioner at point 1 and point 4 is again cause lower rate of air flow in the office. In addition, there is no other ventilation in the room such exhaust fan and the windows are closed at all time. These are factors that contribute to lower air flow rate.

8) CONDITIONS OF VENTILATION SYSTEM

For conditions of ventilation system, this is a crucial element in maintaining good IAQ. When this system is broken, this can cause rapid accumulation of indoor pollutants that can lead to SBS.

The other half of the ventilation equation is the introduction of outside air flow. As we continue building tighter and tighter buildings for energy efficiency, we must also ensure sufficient outside air delivery. If the carbon dioxide (CO_2) is unventilated, the CO_2 levels rise quicker. CO_2 can be used as an indicator for measuring ventilation effectiveness.

RECOMMENDATION

9) HOUSEKEEPING AND CLEANING

Housekeeping is important in preventing indoor air quality problems as it keeps dust levels down and removes dirt which could otherwise become sources of contamination. The cleaning schedule shall be arranged with reference to occupancy patterns and activity levels. Daily cleaning of surfaces and steam vacuuming of floors is advisable for areas with high traffic or which are in constant use during the day. These include most office areas and public places (Department of Occupational Safety and Health (DOSH) Malaysia, 2010).

10) PREVENTIVE MAINTENANCE

Preventive Maintenance is a key to a good IAQ. To make sure this, the staff should periodically check the air quality equipments(Ministry of Human Resources, 2005).

CONCLUSION

Building environment is a delicate ecosystem. Employer must ensure it is healthy and free from pollutants. Poor indoor air quality can lead to losses in productivity due to comfort problem, sickness, and absenteeism. This study presents the results of research which was based on investigation of the indoor air quality in Mechanical Department Office, PKS. The specific parameters investigated are carbon dioxide, air temperature, air movement, and dust particle. The result shows that air temperature, air movement, and dust particle are not in acceptable range. From the survey of the occupants in the office, there are 3 highest problems that occurred with the same percentages which are sneezing, coughing, dizziness and headache recorded at 33.3%. Therefore, this study suggested that the office can be designated as a sick building. This can affect the working quality of the respondents. The results pointed out that any of the IAQ parameters measured to be the only source of SBS in the office. These results were in a good agreement with a research that carried out by Jerry (2002). This study recommended that further research is required to explore the other multifactorial etiologies of SBS such as psychological, ergonomics of the work, stress level, job satisfaction, position in the hierarchy of the organization and other environmental conditions.

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