RESEARCH ARTICLE

Correlational Analysis on Physical and Chemical Contaminants of Indoor Air Quality

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Abstract:

The acceptable or good indoor air quality is important in minimizing the risk of getting any building-related illness especially for those staying indoors and working in the health center. This study assessed the IAQ in the health center of a university, involving physical and chemical parameters. The sampling points are at the entrance door, counter, four treatment rooms, dentist section, and waiting rooms. Sampling was conducted with 15-minutes intervals for each point starting from 0800 hours to 1700 hours for three days. Results show that the respirable suspended particulate (PM_{10}) concentrations (0.015-0.020 mg/m^3), carbon monoxide (CO) (0.40 – 0.43 ppm), and relative humidity (62.7 -66.9%) comply with standard while temperature (21.9-23.6°C), CO_2 (969-1026 ppm), and air movement (0.01-0.18m/s) did not comply with the standard. Spearmen correlation showed that there was high negative correlation between relative humidity and temperature ($r=-0.685$, $p<0.05$), CO ($r=-0.776$, $p<0.01$) and CO_2 ($r=-0.776$, $p<0.05$). Human respiration, diversity of indoor activities, and ventilation system issue are among the important factors in the reduction of IAQ.

Keywords: Carbon dioxide, Health center, Indoor air quality

1. INTRODUCTION

Nowadays, people spent 70-90% of their time indoors especially in indoor area such as office rooms, classrooms, residential and others indoor areas (Abdullah et al., 2019; Pekey et al., 2008). The indoor air quality (IAQ) can be caused by outdoors sources, internal sources and building characteristics especially in the aspects of ventilation and physical parameters such as air temperature, relative humidity and air movement (Abdullah et al., 2018; Delgado-Saborit et al., 2011). Healthcare centre is one of the most complex constructions and should be generator of health and well-being. IAQ in health care centres is important because it effect patient health (Liu et al., 2018). This considered as one of the most important issues to be evaluated and monitored in healing spaces besides to control the infection and to speed physical healing (Balaras et al., 2007). Several studies revealed that the indoor air is complex and dynamic issue in physical and chemical parameters which generated both by outdoor and indoor environments, affecting the health status of occupants (Gola et al., 2019; Liu et al., 2018). The negative impact of poor IAQ would reduce the comfort level of occupants in hospital and also related with a symptom including annoyance, mood changes, sick building syndrome (SBS), stress, headache, sore throat, muscle pain, physical fatigue, anxiety and muscle tension (Shrubsole et al., 2019; Bari et al. 2015). Thus, this study was conducted to assess the IAQ status for physical and chemical parameters in Health Centre in public university (PKU-UMT).

2. MATERIALS AND METHODS

This study is conducted at the Health Care Centre of University Malaysia Terengganu (PKU-UMT) (5° 24' 23.0112" N, 103° 5' 22.128" E) as shown in Figure 1. There are several partitions in PKU-UMT for sampling campaign such as dentist area, waiting room, four treatment rooms, and pharmacy counter.

The data is collected for 3 days during working days at PKU. The reading is taken every 15 minutes. The equipment used are TSI Climomaster Model 9545 for physical parameters measurement such as relative humidity (%), air temperature (°C) and air movement (m/s). Dust TraxTM DRX Aerosol Monitor 8534 was used to measure the RSP (µg/m3), and Kanomax IAQ Model 2211 was used to measure CO (ppm) and CO2 (ppm) (Mansor et al., 2020; Abdullah et al.,

2019). The monitoring was conducted based on Industrial Code of Practice on Indoor Air Quality 2010 (ICOP-IAQ 2010). The devices placed at a height between 75 and 120 cm from the floor (Abdullah et al., 2019).

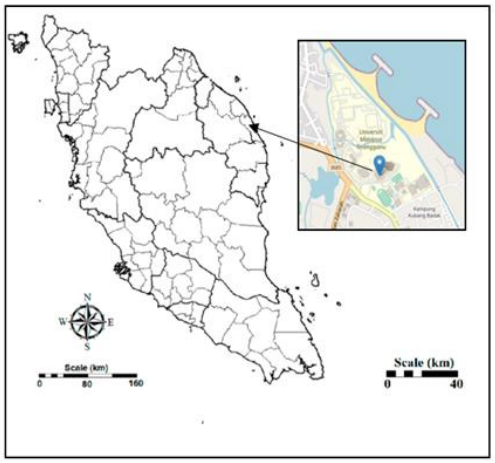

Figure 1. Study Area

Correlation analysis is used to determined degree of agreement between chemical and physical parameters in study area. This correlation analysis is used to establish relationship between parameters that been monitored in public health centre. Correlation coefficient (r) is used to measure the relationship and the equation (1) used to define it.

$$r = \frac{n\sum x_i y_i - \sum x_i y_i}{\sqrt{n\sum x_i^2 - (x_i)^2}\sqrt{n\sum y_i^2 - (\sum y_i)^2}} \quad (1)$$

Where *n* was the total number of samples taken, $\boldsymbol{x_i}$ ***and*** $\boldsymbol{y_i}$ was the individual sample point indeed with *i*.

3. RESULTS AND DISCUSSION

IAQ parameters showed in Table 1 which consists of physical and chemical parameters. The results showed that AM median is 0.15m/s and the standard stated by ICOP-IAQ 2010 are 0.15-0.50m/s. Relative humidity showed that the median for this study is 64.05% and comply with ranged ICOP-IAQ 2010 standard which are 40-70% and temperature also showed that the median is 23°C which comply with ICOP-IAQ 2010. This result comply with ICOP due to the types of ventilation is mechanical ventilation which can control the air movement and temperature at the study area (Hasnusz et al., 2015). This is important to give comfort towards the patients. All chemical parameters also showed comply with the ICOP 2010. The result from minimum and maximum value in this study showed slightly increase or decrease at certain times due to presence of patients and also indoors activities such as sweeping and also cleaning. IAQ is an important component to the design of any building, and it's dynamic when designing a hospital or health care facility (Ye et al., 2014). Proper consideration must be taken to ensure that clean and fresh air is brought into the building. The air is maintained within specific parameters for temperature and humidity besides that the air is not allowed to other spaces as it is routed back through the system (Liu et al., 2018). Chemical parameter also showed compliance with ICOP-IAQ except for CO_2 at certain time. This situation important to avoid adverse impact on the patient comfort and health.

Relationships involving two parameters was analyse using Spearman correlation. Spearman correlation was conducted due to the data was non-parametric and the result violated normality test. Mansor et al., (2020) and Abdullah et al., (2018) agreed range more than 0.50 known as strong correlation, 0.40-0.49 is moderate and less than 0.30 is considered weak relation. Table 2 showed that there was high negative correlation between relative humidity (RH) and temperature (Temp) ($r=-0.685$, $p<0.05$), carbon monoxide (CO) ($r=-0.776$, $p<0.01$) and carbon dioxide (CO2) ($r=-0.776$, $p<0.05$). This is due to natural product from human respiration, dependent from occupant's age and activity level, it is used to evaluate the IAQ (Mansor & Ting., 2020). On the other hand, CO_2 is a substitute for other occupant-generated pollutants also known as particularly bio-effluents which proved that increasing amount of patient can increased temperature, chemical parameter such as CO and CO_2 and decrease the relative humidity (Shrubsole et al., 2019). In addition, CO_2 and Temp also has high positively correlation ($r=0.664$, $p<0.05$). As air temperature increases, air can hold more water molecules, and its relative humidity decreases (Leung & Chan., 2006). Humidity can change a person comfort because temperature related to the water vapour content in the atmosphere. When the air has a high moisture, content caused the sweat cannot evaporate, leaving our bodies feeling hot and sticky (Liu et al., 2018). In addition, increase of CO_2 and decrease relative humidity can be caused by increase of temperature and also patient attendance (Argunhan & Avci., 2018). Low RH were detrimental to the immediately perceived IAQ (a snapshot of perception) by "sniffing" the emission from building materials and increase suspended other gaseous pollutants (Wolkoff., 2018)

Table 1. Summary of descriptive statistics

	AM (m/s)	RH (%)	Temp (°c)	PM_{10} (µg/m_3)	CO (ppm)	CO_2 (ppm)
Min	0.11	62.72	21.88	0.015	0.40	969.50
Max	0.18	66.88	23.58	0.02	0.43	1026.21
Mean	0.15	64.38	22.88	0.02	0.41	999.22
Std. Deviation	0.02	1.347	0.59	0.00	0.01	15.96
Med	0.15	64.05	23.00	0.02	0.41	999.96

Table 2. Spearman correlation

	WS	RH	TEMP	PM_{10}	CO	CO_2
WS	1	0.448	-0.441	-0.189	-0.308	-0.231
RH		1	-0.685*	0.235	-0.776**	-0.776**
TEMP			1	-0.403	0.329	0.664*
PM_{10}				1	-0.266	-0.287
CO					1	0.510
CO_2						1

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

4. CONCLUSION

Primary objective of this study is to determine relationship of the indoor air quality of the Health Centre in UMT with the aim asses IAQ in PKU. The results showed that the physical parameters especially relative humidity has highly negative correlation with temperature ($r=-0.685$, $p<0.05$), carbon monoxide ($r=-0.776$, $p<0.01$) and carbon dioxide ($r=-0.776$) which caused by the indoor activities such as cleaning activities and attendances of patience. The resulted showed that chemical and physical parameter important to comply with the guidelines to protect occupant's health effect due to poor IAQ.

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