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Relationship Between Indoor Air Quality and Sick Building Syndrome in Post Office Building in Bandung

[a]Yudi Prana Hikmat, [b]Ismail Wellid, [b]Kasni Sumeru*, [b]Salma Dzakiyah AZ-zahro, [c,d]Mohamad Firdaus bin Sukri

[a]Department of Electrical Engineering, Politeknik Negeri Bandung, West Java 40559, Indonesia
[b]Department of Refrigeration & Air Conditioning Engineering, Politeknik Negeri Bandung, West Java 40559, Indonesia
[c]Green and Efficient Energy Technology (GrEET) Research Group, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia
[d]Faculty of Mechanical Engineering, Universiti Teknikal Malaysia, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia

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ABSTRACT

Sick building syndrome (SBS) is a collection of symptoms experienced by buildings occupants such as headaches, mucous, membrane irritation, respiratory problems, and fatigue. A building has SBS if more than 20% of building occupants experience symptoms. Poor indoor air quality contributes to SBS in the building. This study investigates the correlation between indoor air quality and SBS symptoms in Post office building in Bandung. The study used quantitative methods with a cross-sectional study design. Data collection was carried out using particle counter, thermometer, lux meter, anemometer, and questionnaire. Primary data results compared with the air quality standard from Minister of Health No. 1077, 2021. Statically Compare Means and Independent T-test results that the p-values for the 1st floor and 2nd floors, temperature were 0.437 and 0.000, respectively, PM10 and PM2.5 were 0.005 and 0.290 and 0.004 and 0.364, respectively, and lighting were 0.002 and 0.015. It indicates a significant relationship between concentrations of PM10 and PM2.5 on the 1st floor with SBS symptoms and the temperature and humidity on the 2nd with SBS symptoms. Since 29 people (24% of the building's occupants) experienced SBS, the building was considered the significant potential to cause SBS to its occupant.

KEYWORDS

Sick building syndrome
Random sampling
Indoor air quality
Air quality standard

INTRODUCTION

Bandung is one of the largest cities in Indonesia after Jakarta and Surabaya. As a big city, Bandung has many high-rise buildings; as a result, the potential for sick building syndrome

*Corresponding Author: sumeru@polban.ac.id

(SBS) symptoms in its occupants is most likely to occurred. The post office is one of the buildings located in the urban area of Bandung. The post office employees are working indoors around 8 hours per day. Workers in other fields generally also spend approximately 90% of their time indoor (Gupta et al., 2007; Hoang Quoc et al., 2020; Nguyen et al., 2018).

Sick building syndrome is a collection of symptoms experienced by buildings occupants with several symptoms such as headaches, mucous, membrane irritation, repertory problems and fatigue (M, 2002; Schweickert et al., 2009; Vafaeenasab et al., 2015). When a person is in a building with poor indoor air quality, various symptoms and complaints can arise (Cincinelli & Martellini, 2017; Leung, 2015). Several researches show a correlation between indoor air quality and the incidence of SBS in building (Arikan et al., 2018; Chang et al., 2015; Jafakesh et al., 2019). In order to avoid SBS in the buildings, the HVAC system plays the most important role (Gupta et al., 2007; Lu et al., 2018). A building is considered to have the potential to cause SBS if more than 20% of building occupants experience symptoms (Fanger, 1988; Israeli & Pardo, 2011).

The cause of SBS is not caused by a single factor, but it is always associated with several factors, such as poor ventilation, outdoor and indoor air quality, biological contaminants, allergy, gender, smoking, workload, as reported in China, United Kingdom, Iran, Sweden and Turkey (Arikan et al., 2018; Belachew et al., 2018; Jafakesh et al., 2019). A study conducted by Occupational Safety and Health Administration (OSHA) reported that SBS can be caused by several factors in a building, for example due to inadequate ventilation (52%), indoor contaminants (16%), outdoor contaminants (10%), presence of microbes (5%), pollution from building materials (4%) and others (13%) (OSHA, 2011). Chang et al. (2015) [11] reported that hospital in employees showed at least one SBS symptoms in China. Therefore, Vafaeenasab et al. (Vafaeenasab et al., 2015) found that hospital workers in Iran suffered SBS symptoms 86.4%, while 20.9% in Turkey (Arikan et al., 2018).

The effect of indoor humidity and temperature on the SBS has been reported by Zuo et al. (Zuo et al., 2021). They reported that increasing the humidity to 70% at 300C had a negative effect on the occupants. The negative effects will trigger SBS symptoms on the occupants. The aim of the study is to investigate the correlation among indoor quality, which is indicated by humidity, temperature, lighting, PM10 and PM2.5 concentrations, to the emergence of SBS symptoms on the 1st and 2nd floors of the Bandung post office.

METHOD

Location Description

The research was conducted on the Central Post office in Bandung. Fig. 1 shows the front view of the building. The post office building is an old building, a former Dutch heritage. The building consists of two floors and located in urban area of Bandung. The layouts of the 1st floor and 2nd floor are shown in Fig. 2 and Fig. 3, respectively. It can be seen that there are six rooms for each floor and 9 measurement points were selected for each floor.

Figure 1. Front view of the post office

Figure 2. Layout of the 1st floor

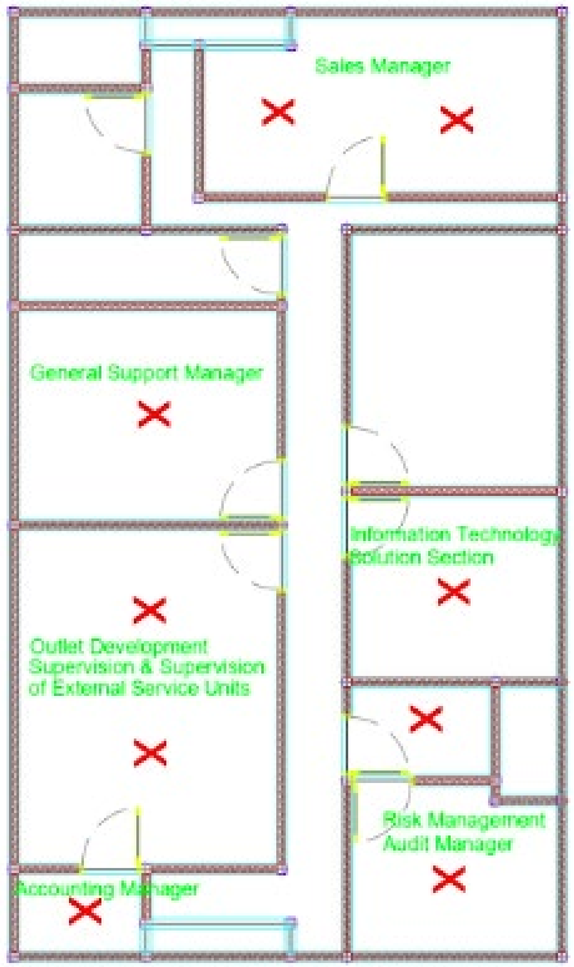

Figure 2. Layout of the 2nd floor

Sampling Method

In order to investigate the correlation between indoor air quality and SBS symptoms in the post office building, quantitative approach to cross-sectional method was utilized. Data was measured directly using a sling thermometer, an anemometer, a particle counter and lux meter. The humidity in the rooms was measured using sling thermometer, while particle counter was utilized to measure the PM10 and PM2.5 concentrations. The anemometer and lux meter were used to measure the air velocity and lighting in the rooms. The data was taken simultaneously for six days in three different conditions of morning, midday and afternoon. Then, the results were compared with the National Standard of Minister of Health No. 1077, 2021.

A total number of 119 respondents were selected to answer a questionnaire, with 80% of the employees in the post office were chosen as respondents. Number of employees in the post office is 148. There are two variables in this study, i.e., dependent and independent variables. The dependent and independent variables are SBS symptoms and air quality, respectively.

Data analysis was performed using Ms. Excel and IBM SPSS Statistics Statistical data processing software program. There are two type analyses used to analyze the samples, namely univariate and bivariate. The univariate characteristics of respondents are gender, age, nutritional status, year of service, length of work, and history of smoking. Meanwhile bivariate is the correlation between indoor air quality and SBS symptoms using the Compare Means test and the T-Independent Sample test.

RESULT AND DISCUSSION

Indoor Air Quality

There are five parameters being measured, namely temperature, humidity, PM10, PM2.5 and lighting illuminance. The data obtained in six rooms on each floor were analyzed and the maximum data was taken to be compared with the air quality standard (National). The data of five parameters in the six rooms for 1st and 2nd floors is shown in Table 1. It can be seen that the highest temperature on both floors occurred in room F. It is because the rooms are located close to the window and exposed to direct sunlight. Table 1 also clearly shows that the temperature distributions on the two floors are significant in different. In general, the temperature distribution on the 2nd floor tends to be higher than the 1st floor. It is caused by the low ventilation rate on the 1st floor, as compared to the 2nd floor.

In terms of humidity, the highest humidity occurred in room A for the 1st floor, and room C for the 2nd floor. Unlike the temperature, the humidity in the 1st floor is higher than the 2nd floor. This is because the temperature on the 1st floor is relatively low, causing the humidity on the 1st floor tends to be higher.

In the other aspect, the highest of PM10 and PM2.5 concentrations occurred in room A for the 1st floor, and room D for the 2nd floor. It is because the two rooms have a higher employee density, as compared to other rooms.

From the lighting point of view, the illumination of the two floors is relatively the same and has exceeded the recommended value of 60 lux. It can be seen that the highest level of illumination in both floors occurred in room C and D for 1st and 2nd floors, respectively.

Table 1. Indoor air quality

No	Indoor Air Quality	Rooms						Mean Value	Standard Value
		A	B	C	D	E	F		
	1st floor								
1	Temperature (°C)	28,40	29,04	29,60	30,57	30,41	30,67	29,78	30
2	Relative humidity (%)	75,6	73,1	69,6	67,4	66,8	66,4	69,81	60
3	PM10 (μg/m^3)	116	84	81	84	83	81	88,03	70
4	PM2,5 (μg/m^3)	104	75	72	75	74	72	78,81	35
5	Lighting (lux)	95	173	141	124	170	139	140,31	60
	2nd floor								
1	Temperature (°C)	29,28	30,57	30,25	30,88	31,04	31,79	30,63	30
2	Relative humidity (%)	66,9	66,1	70,4	65,0	65,1	62,8	66,07	60

No	Indoor Air Quality	Rooms						Mean Value	Standard Value
		A	B	C	D	E	F		
3	PM10 (µg/m³)	30	27	34	49	33	32	34,11	70
4	PM2,5 (µg/m³)	26	24	31	44	31	28	30,58	35
5	Lighting (lux)	99	88	20	140	89	182	102,86	60

Respondent Characteristics

The characteristics of respondents are depicted in Table 2. It can be seen that there are 54 respondents on 1st floor, consists of 31 males and 23 females. Meanwhile, there are 65 respondents on 2nd floor, with 34 males and 31 females. As a result, the total number of respondents is 119 peoples. The highest age distribution is between 26-35 years, that is 22%. In terms of nutritional status, 61.3% of respondents were in normal condition (average on 1st and 2nd floors), of which 64.6% and 58.4% were on 1st and 2nd floors.

Furthermore, the average data for the 1st and 2nd floors were: 89.9% respondents have working period of less than 6 years, and 4.2% respondents have working period of more than 10 years. In addition, the most respondents' working hours are 8 hours per day, equivalent to 88.2%. A total of 98.3% respondents have no history of disease and 69.6% respondents have no history of smoking. Furthermore, most of the respondents do not smoke while work (97.5%).

Table 2. Distribution of respondent characteristics

No	Characteristic	Location				Total	
		1	%	2	%	n	%
1	**Gender**						
	Males	31	57,4	34	52,3	65	54,6
	Females	23	42,6	31	47,7	54	45,4
	Total	54	100	65	100	119	100
2	**Age**						
	17-25 years	6	11,1	3	4,6	9	7,6
	26-35 years	22	40,7	23	35,5	45	37,8
	36-45 years	18	33,3	16	24,6	34	28,6
	46-55 years	7	13	22	33,8	29	24,4
	56-65 years	1	1,9	1	1,5	2	1,7
	Total	54	100	65	100	119	100
3	**Nutritional Status**						
	Thin	2	3,7	0	0	2	1,7
	Normal	35	64,8	38	58,4	73	61,3
	Over weight	10	18,5	12	18,5	22	18,5
	Obesity	7	13	15	23,1	22	18,5
	Total	54	100	65	100	119	100
4	**Years of Service**						
	<6 years	49	90,7	58	89,2	107	89,9
	6-10 years	2	3,7	5	7,7	7	5,9
	>10 years	3	5,6	2	3,1	5	4,2
	Total	54	100	65	100	119	100
5	**Length of Working**						

No	Characteristic	Location				Total	
		1	%	2	%	n	%
	5 hours	1	1,9	0	0	1	0,8
	7 hours	3	5,5	4	6,2	7	5,9
	8 hours	45	83,3	60	92,3	105	88,2
	9 hours	1	1,9	1	1,5	2	1,7
	10 hours	1	1,9	0	0	1	0,8
	12 hours	3	5,5	0	0	3	2,5
	Total	54	100	65	100	119	100
6	**Disease History**						
	Yes	1	1,9	1	1,5	2	1,7
	No	53	98,1	64	98,5	117	98,3
	Total	54	100	65	100	119	100
7	**Smoking History**						
	Yes	20	37	16	24,6	36	30,3
	No	34	63	49	75,4	83	69,7
	Total	54	100	65	100	119	100
8	**History of Smoking in the Workspace**						
	Yes	0	0	3	4,6	3	2,5
	No	54	100	62	95,4	116	97,5
	Total	54	100	65	100	119	100

Indoor Air Quality Correlation to Sick Building Syndrome

The respondents are considered to be exposed to SBS if they experience two symptoms. The incidence of SBS symptoms by respondents based on the results from the questionnaire is shown in Table 3. The table shows that 29 respondents or about 24% have SBS in the building while working. Since the building has caused 24% of its employees to experience symptoms of SBS, the building is considered to have significant potential to cause SBS for its employees (Israeli & Pardo, 2011).

Table 3. Distribution of respondent characteristics

SBS symptoms	Frequency	Percentage
Experience	29	24%
Not Experience	90	76%
Total	**119**	**100%**

Table 4 shows the results of Compare Means analysis on each floor where average respondent experienced SBS at a temperature of 29.880C and respondents who did not experience SBS were at a temperature of 30.080C (1st floor). Meanwhile, the results on the 2nd floor showed that the average respondent experienced SBS at a temperature of 31.220C and did not experience SBS at a temperature of 30.470C. It means that respondents tend to obtain symptoms of SBS in the condition of the workplace where the temperature is higher than 1.020C from the respondent's room that does not experience SBS.

Table 4. The statistic of the relationship of indoor air quality to SBS symptoms

No	Variable	***Sick Building Syndrome symptoms***				***p-value***	
		1		**2**			
		No (N=12)	**No (N=42)**	**Yes (N=17)**	**No (N=48)**	**1st floor**	**2nd floor**
1	Temperature (°C)	29.88	30.08	31.22	30.47	0.437	0.000
2	Relative humidity (%)	69.67	68.45	64.5	66.1	0.250	0.001
3	PM10 (μg/m^3)	93	83	32	33	0.005	0.290
4	PM2,5 (μg/m^3)	83	74	29	30	0.004	0.364
5	Lighting (lux)	124	145	122	96	0.002	0.015

The results from Independent Sample T-test on the 1st floor from Table 4 also show that there is no significant relationship between the temperature of the workplace and the symptoms of SBS (the p-value of 0.437 is greater than 0.05). Meanwhile, the 2nd floor showed that there was a significant relationship between workplace temperature and SBS symptoms (the p-value of 0.000 is less than 0.05). As mentioned in several references above, the temperature condition of too high or too low will cause the body to feel tired faster than normal, and experience various symptoms including SBS symptoms. The SBS symptoms will have a great impact on decreasing the immunity for the occupants inside of the building. This decrement in immunity will potentially expose the employee to Covid-19.

Furthermore, the results from the Independent Sample T-test on the 1st floors show that there is significant relationship between the concentrations of PM10 and PM2.5 in the workplace and the symptoms of SBS (the p-value of 0.004 is less than 0.05). Exposure to particulates has an effect on increasing the risk of cardiovascular and respiratory diseases, and even contributes to an increased risk of lung cancer. Unlike on the 1st floor, the 2nd floor depicted no significant correlation between the concentrations of PM10 and PM2.5 in the workplace and the symptoms SBS (the p-values of 0.290 (PM10) and 0.364 (PM2.5) are higher than 0.05).

In terms of lighting, the Independent Sample T-test showed that there is a significant correlation between workspace lighting and SBS symptoms on the 1st and 2nd floors (the p-values of 0.002 (1st floor) and 0.015 (2nd floor) are less than 0.05). Lighting with illuminance out of standard value can results in eye fatigue and reducing work efficiency, as well as triggers other SBS.

CONCLUSION

Based on the data and statistical analysis in the discussion, the conclusions of the study are:

- The PM10 and PM2.5 concentrations on the 1st floor are above the standard for all rooms, and lower than the standard for all rooms, except for room D in 2nd floor.
- There are 29 (24%) and 90 (76%) respondents felt and did not felt the symptoms of SBS, respectively.
- Significant relationship between PM10, PM2.5 and light on SBS symptoms were detected on the 1st floor.
- Significant correlation between temperature, humidity and light on the SBS symptoms were detected on the 2nd floor.

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