Determining Indoor Air Quality in Gymnasium for Indoor Recreation Activity at University Teknologi MARA, Shah Alam

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Abstract. This study is conducted to determine the indoor air quality in the Faculty Sport and Recreation’s gymnasium, UiTM Shah Alam. The objective of the study is to determine possible type and cause of pollutant, determining the health and performance of occupants and assess whether the IAQ parameters comply with the standards set by DOSH. The study consists of questionnaire survey, walkthrough assessment and reading measurement. A total of 350 questionnaires were distributed to the gymnasium users and a walkthrough assessment were conducted at the surrounding area of the gym in order to identify the possible sources of pollutants as well as the reading of selected parameter of IAQ. Several criteria of indoor air quality parameter are identified and measured. Result indicated that concentration of carbon dioxide increases in relation with the number of the occupant. As a conclusion, indoor air quality in the gymnasium is merely complying with DOSH standards. Thus, relevant actions should be taken pertaining to the quality of indoor air in a gymnasium for the betterment of healthy lifestyle.

1. Introduction

In these new millennia, people live in a desirable and comfortable condition and are more conscious about their healthy lifestyle. \cite{1} stated that about 70\% to 90\% of time spent by people is in indoor environment. Some of them prefer to do their recreation and leisure activity in indoor environment due to time constraint and appropriate facilities provided in the gymnasium rather than doing outdoor activities which they feel expose to unhealthy environment \cite{2}. With proper ventilation system and air conditioner in the gymnasium, it resulted to a pleasant place for occupants doing their activity and also improves their health. They perceived exercising in indoor fitness centre is safer compared to outdoor due to deteriorating of air quality. According to \cite{3}, in modern indoor environments, sources of polluted air are identified coming from outdoor particles, emissions produced by pollutants inside the building and also from the ventilation system.

A research on the parameters of indoor air quality at 11 fitness across Lisbon show that indoor air quality of the fitness centres are not really in a good condition, high concentration of carbon dioxide, volatile compound and formaldehyde identified in the fitness centre \cite{4}. According to Parliament of the United Kingdom (2010) indoor air pollutants is a cocktail of pollutants where it is the combination...
of pollutants produced from inside the building, outside the building and natural radon gas that can go inside the buildings from the ground. Indoor air quality (IAQ) in any building can be compromised by microbial contaminants (mold, bacteria), chemicals (such as carbon monoxide, formaldehyde), allergens, or any mass or energy stressor that can induce health effects.

In that case, the equipment and the furnishing inside the fitness centre or gymnasium can possibly becoming the source of contaminants. With humid and dry environment of Malaysia, it is inevitable to acquire a proper ventilation system or air conditioner for a comfortable place for recreation. But this might be a double edge sword. [5] stated that without adequate ventilation and cooling, an excessive increase of efficient use of given spaces may reduce the quality of its indoor climate to the extent that affect the users. It means that poor indoor air quality may risk the health of the occupants while risking the performance. The aim of this study is to identify the indoor air quality in fitness centre. Thus, the objective of this study is to determine the effects of occupant with current condition of indoor air quality and to analyse the current parameter with the standard by Division of Occupational Safety and Health (DOSH).

2. Literature review
Indoor air quality is defined as the concentrations of incoming chemical and biological substances and the comfort-related factors which affect people [3]. Concentration of the indoor air pollutant is crucial to be taken care of, therefore, the level of the indoor air quality at the gym can be controlled.

2.1 Indoor air quality parameter
2.1.1. Carbon dioxide. According to ASHRAE [6], the recommendation level of the carbon dioxide in indoor environment should not be exceeded the outdoor carbon dioxide concentration level by more than 650 ppm. While for the good standard quality, the level of carbon dioxide in indoor air should be about 1030 ppm.

2.1.2. Temperature. The optimum temperature range between 20 to 30ºC but depend on the relative humidity, seasons, clothing and activity done [3].

2.1.3. Relative humidity. The acceptable range of air temperature inside a building is 23-26 degree Celsius while the relative humidity should be at the level of 40-70% [7].

2.1.4. Particulate matter. The standard set by DOSH Malaysia for the particulate matters is 0.15 mg m⁻³.

2.2 Cause of poor indoor air quality
2.2.1 External cause. The cause of the microbial sources is usually the water problem such as stagnant water or the humidity is too high. The polluted air can easily infiltrate indoor area if there are openings such as crack, windows and doors. The polluted air can be as a result of natural based pollution and human induced activity [8]. Biological pollutants are one of the causes of poor indoor quality, these microbial included bacteria, molds, viruses, and mites.

2.2.2 Internal cause. Buildings with the lower amount of outdoor air coming in may have higher pollution levels [9]. The improper cleaning and organizing processes such as storage and disposal of the garbage, the sweeping, dusting and vacuuming during the presence of the occupants will contribute to indoor air quality problem [8]. Materials such as building materials and furnishing such as paint will emit certain chemicals that are harmful to the health.

2.2.3 Heating, ventilation and air-conditioning (HVAC). A HVAC system operation that are poorly design or had an interrupted flow in response to thermal conditioning needs may cause the increase of indoor contaminant levels [10]. A split unit can contribute to the increase concentration level of carbon dioxide compared to centralized air-conditioning system [13]. If HVAC systems are not maintained,
the wheel can severely become dirty or damaged which will cause metal dust to be generated and transmitted to the indoor air [8].

2.3 Impact of poor indoor air quality
2.3.1 Health and well-being. The health impacts due to poor IAQ can be determined as acute or chronic illness for examples asthma, infections in respiratory systems, allergy and even lung cancer. These health problems are referred to as Sick Building Syndrome and Building Related Illnesses [11]. In indoor environment such as inside the fitness centre and gyms, the presence of high concentration of chemicals such as formaldehyde was alarming because it can cause respiratory problems and asthma [4].

2.3.2 Performance and productivity. Health problem will lead to poor performance and productivity among the users inside the gym, making them felt uncomfortable while exercising and felt weak. High level of carbon dioxide and volatile organic compounds would harm the human cognitive function and decision-making skills [12].

3. Methodology
3.1 Study area
The study was conducted at the gyms in Faculty of Sport and Recreation, UiTM Shah Alam. The building had operated for about 57 years and was converted into gym in 1996 which make the gym operated for almost 22 years. The building is generally sealed airtight and covered well. The targeted respondents for this research are among UiTM Shah Alam students and staff that using the gyms for their leisure and recreation purposes.

3.2 Research design and data collection
In order to complete the research, the research approach that has been selected is both qualitative and quantitative method.

3.2.1 Physical measurement. The parameters that have been chosen were the thermal comfort (temperature and the relative humidity); and some IAQ parameters which were carbon dioxide and particulate matters (PM). All measurement was done using a Multi-parameter Environmental Monitoring (EVM-7).

3.2.2 Physical assessment. The forms covered; (1) the symptom of Sick Building Syndrome (SBS), (2) ventilation system, (3) related possible cause and (4) problem of indoor air quality presence, and inside plan/sketch of the gyms and fitness centre.

3.2.3 Questionnaire survey. A set of questions were prepared and given to a total of 350 respondents. The questionnaire was designed in a Likert-scale construction way. This survey is important to determine the possible effect and the opinion of the respondents. The mean of 3-4 shows the respondent is agree, and the mean below 3 indicates the respondent disagree with the statements given in the survey.

3.3 Data analysis
In order to analyse the data, a descriptive analysis and content/inferential analysis were conducted.

3.3.1 Physical measurement. The numbers were compared to the standard for ventilation rate.

3.3.2 Physical assessment. Content analysis was done, and the results were compared to the standard set by DOSH Malaysia and ASHRAE.

3.3.3 Questionnaire survey. A descriptive analysis using SPSS was applied.
4. Result and discussion

4.1 Physical measurement

4.1.1 Carbon dioxide. There are about 12 people inside the gyms and the highest CO₂ recorded was 510 ppm. This level of CO₂ is still within the acceptable standard recommended by DOSH [9].

4.1.2 Relative humidity. The range of relative humidity is 55.2% – 68.9% and it is complied with the standard set by the DOSH which is 40 – 70%. Relative humidity will likely to change when the temperature change, this due to warmer air able to retain more water vapour than cooler air.

4.1.3 Temperature. The range of temperature recorded is between 22.3 – 27.4 ºC. This temperature range values are slightly above the guidelines range set by the DOSH which is 23 – 26 ºC but comply with ASHRAE which is 24 – 27 ºC. The temperature of the gyms decreased significantly when all the six air conditioners inside the gyms were turn on.

4.1.4 Particulate matters. The average reading of particulate matter recorded is 61.5 ug m⁻³. This indicates that the particulate matter level complies with the DOSH standard for indoor environment (0.15 mg m⁻³). The highest reading determined (125 ug m⁻³) when the workers cleaning the floor.

4.2 Physical assessment

4.2.1 General description. Cracks were found inside the building. There are present of mould inside the building. It will lead to allergic reactions towards the building occupants. The flooring has not been changed for quite a long time which about 10 years.

4.2.2 HVAC Systems. By far, the air conditioners work and perform well without any malfunctioning. There are no leakages found such as the leakage of the duct and the supply fan works great.

4.2.3 Facilities and equipment. The condition of the equipment is quite poor in the appearance aspect, the leather of the seat already torn out and cracked as well as the soft leather already worn out, the metal part of the equipment’s are rusty. The equipments are not cleaned properly, there were dust everywhere surrounding the place.

4.2.4 Alteration and activities conducted in the building. The building is altered by flooring covered with rubber like mat used in the exercise centre. The interior of the building also painted. Paint is one of the contributors of volatile organic compound that is one of the causes of poor indoor air quality.

4.2.5 Cleaning and sanitizing process. Cleaning and sanitizing process are a must and the workers done the cleaning and sanitizing process twice a day.

4.3 Questionnaire survey

4.3.1 Demographic profile. The respondents are 58.3% male and 41.7% female. Most of the respondents are in the age of 21-30 years old by the percentage of 78.0%. The total numbers of users that often come to the gym are 79.3% while those who do not often come are 20.7%.

4.3.2 Gym physical condition. For the indoor ventilation system inside the gym, the mean is 3.99 which mean it more towards the likert scale of 4 which is agree (Table 1). During the assessment period, the gyms is properly ventilated, and the air conditioner is at peak and good condition. While for the physical condition of the gym, the mean is also 3.99 which make it more towards the likert scale of 4 which is agree. The furnishing and the equipment are still great in condition because they were maintained about twice a year. The occupants agree with the mean of 4.01 that the interior of the gym is properly design and it is easy to move around inside the gym without being blocked or disturb by the gym’s equipment positioning. The mean for the statement that stated that the occupant is comfortable with temperature and humidity inside the gym is 3.93. The temperature and humidity of
the gym in fact is within an ambient condition and according to the recommended standard set by DOSH Malaysia. The occupants disagree (the mean value of 2.47) that there is an unusual chemical odour presence inside the gym while they were exercising and working out. This may due to the air that has a proper circulation and ventilation inside the building.

**Table 1. Respondent perception on gym physical condition**

| Items                                | Mean | Std. Deviation |
|--------------------------------------|------|----------------|
| Indoor is properly ventilated        | 3.99 | 0.848          |
| Gym physical condition is great      | 3.99 | 0.821          |
| Gym layout is properly design        | 4.01 | 0.878          |
| Comfortable with temperature         | 3.93 | 0.927          |
| Gym atmosphere is fresh              | 3.93 | 0.915          |
| Unusual chemical odour               | 2.47 | 1.255          |
| Presence of strong sweat odour       | 2.42 | 1.234          |
| Equipment and place are dusty        | 2.60 | 1.258          |

4.3.3 *Performance, health and productivity.* Table 2 shows the mean for the question *I perform well* during inside the gym is 4.01. Overall occupants are agreed that they do perform well while doing activities and working out inside the gym. The mean of 2.39 is recorded for the statement that the occupants experiencing the symptom of poor indoor air quality such as dizziness, coughing and difficulty to breathe. Overall, the occupants are disagreed that they are experiencing the symptom of poor IAQ.

**Table 2. Satisfaction of respondent on performance, health and productivity**

| Statements                                      | Mean | Std. Deviation |
|-------------------------------------------------|------|----------------|
| I perform well                                  | 4.01 | 0.759          |
| I have symptom of poor IAQ                      | 2.39 | 1.162          |
| I have sudden allergy                           | 2.12 | 1.089          |
| Easy to concentrate                             | 3.57 | 1.197          |
| I don’t bother spending more time inside the gym| 3.78 | 1.081          |
| My reflexes are good                            | 3.94 | 0.824          |
| I can make good decision making                 | 3.74 | 1.035          |
| My psychomotor performance decrease             | 2.41 | 1.181          |

5. **Conclusion**

Indoor air quality inside the gymnasium of Faculty of Sport and Recreation UiTM Shah Alam can be recognized as good and still on par with the recommendation and standards by DOSH and ASHRAE. Majority of occupants that working out and exercising inside the gymnasium perceived and showing great performance and productivity as well as showing good sign of health. However, not all the occupants do agree with the indoor air quality inside the gym and this may the exceptional cases due to several reasons. Therefore, further details investigation is needed.

6. **Recommendation**

6.1  *Recommendation to gym management*

- Controlling and managing the facilities and the building maintenance inside the gym.
- Enforce proper guidelines and regulation inside the gym that will likely to contribute towards the improvement of the indoor air quality inside the gym.
- Invest more on the consultation involving indoor air so that the indoor air quality inside the gymnasium really comply with the rules and standards.
6.2 Recommendation on parameters of indoor air quality
- The temperature and the relative humidity play important roles for the comfort inside the gymnasium.
- The humidity and temperature are the factors that interrelated with each other.

6.3 Recommendation for the future research
- Continuous monitoring should be done and focus on the dust collection especially from the equipment inside the gym.
- Analysis of dust composition using the appropriate laboratory analysis.
- Study on the bacteria count in the air inside the gymnasium.
- Conduct a health risk assessment based on United States Environmental Protection Agency approach.

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