

## Level of User's Satisfaction Towards Indoor Air Quality at Indoor Sports Hall

Danial Fikri Hishamuddin<sup>1</sup>, Hasniza Abu Bakar<sup>1\*</sup>, Muhamad Hanafi Rahmat<sup>1</sup>

<sup>1</sup>Faculty of Civil Engineering and Built Environment,  
Universiti Tun Hussein Onn Malaysia (UTHM), 86400, Parit Raja, Batu Pahat,  
Johor, MALAYSIA.

\*Corresponding Author Designation

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**Abstract:** Basically, Indoor Air Quality (IAQ) refers to the level of air quality inside the building. People nowadays prefer to do indoor exercises rather than doing outdoor activities as they can exercise anytime without concerning the weather. However, poor indoor air quality can give impact on athletes and their performances. Temperature ( $^{\circ}\text{C}$ ), relative humidity (RH), carbon dioxide ( $\text{CO}_2$ ), total volatile organic compound (TVOC), formaldehyde (HCHO), respirable suspended particulates (RSP), ozone ( $\text{O}_3$ ), airborne bacterial count (ABC) and carbon monoxide (CO) are the examples of parameters that contribute to quality of indoor air. Therefore, a study has been carried out by distribute a questionnaire to the students who use badminton court facility in Universiti Tun Hussein Onn Malaysia (UTHM). The purpose of this study is to identify the awareness level and user's satisfaction towards Indoor Air Quality (IAQ). Data analysis was done using Statistical Package for Social Science (SPSS) and expressed in the form of frequency, percentage and mean. Mean ranking analysis is used to achieve objective one where the highest rank was an air quality plays an important role in ensuring the comfort of users when using the badminton court. Moreover, to achieve objective two mean rank analysis also has been done. As a result, the respondents felt discomfort in using the badminton court facility because of the cumulated water that can be found either at the ceiling or on the floor was the highest rank. In order to achieve objective three, Spearman's correlation analysis has been used to obtain relationship between awareness and satisfaction level towards IAQ. The result shown a positive relationship which is 0.457 based on Spearman rank-order correlation coefficient. It indicates a strong relationship. In conclusion, if the awareness level is high so, the satisfaction level of the user will easily obtain. From the results, badminton court in UTHM can improve level of IAQ by maintaining and upgrading their facility.

**Keywords:** Indoor Air Quality, Awareness, Satisfaction

## 1. Introduction

Air quality inside the building is known as indoor air quality (IAQ). Recently, indoor air quality (IAQ) has becoming a concern because people spend more their time inside the building rather than outside. People nowadays prefer to do indoor activities rather than doing outdoor activities because of the facilities that has been provided and they feel harm to expose with the unhealthy environment [1].

Badminton court, gymnasium and swimming pool are the examples of indoor sports facilities. The quality of indoor air should be in good condition as it can relate to health problem [2]. There are many possible factors that can contribute to indoor air pollutants. For example, tobacco products, building materials and furnishings which is usage of asbestos or newly installed flooring, products for household cleaning and maintenance, excess moisture and outdoor sources such as radon, pesticides and outdoor air pollution [2]. Therefore, the parameters for the IAQ are very important in this case study.

### 1.1 Problem statement

Indoor air pollutants usually related with sick building syndrome (SBS). Irritation of the eyes, sore throat and nose, dizziness, headaches and fatigue are the examples of health effects that may show up. Those are the example of immediate or short term side effect toward health. Moreover, heart and breathing rates will increase abnormal as the user feels anxiety or panic [3].

Poor indoor air quality can give impact on athletes and their performances [4]. Athletes can suffer from indoor air pollutants where they experienced asthma. Asthma is an environmental allergy that can effect athlete's airway such as coughing, wheezing and shortness of breath. Indoor air pollution can also affect the stamina of athletes and their ability to concentrate because of troublesome and distracting breathing symptoms. Although the influence of air pollutants on athletic performance is an issue, a greater problem may be concerning due to the impact of air pollution on both short and long terms on the athletes' health [5]. In order to determine the awareness and satisfaction of the user especially for those who use a sports hall such as badminton court facility a set of questionnaire to examine the satisfaction of the user has been chosen.

### 1.2 Objectives

The objectives of this study are to identify the awareness level of indoor air quality at indoor sports hall which is badminton court in UTHM, to measure the user satisfaction and to establish the correlation between the awareness of the user about Indoor Air Quality (IAQ) and user's satisfaction.

## 2. Materials and Methods

Subjective measurement such as satisfaction of the occupants will be identified by using a questionnaire. The selected method is the most suitable as it can obtain all the results based on the objectives of the research.

### 2.1 Study area

This study was carried out in UTHM indoor sports facilities at badminton court as shown in Figure 1. Badminton court is the best choice for the indoor sports facility as the sampling location since it can relate the relevant issues to overcome the problem. This building is suitable for case study because it can usually be very heterogeneous and badminton court need higher ventilation level.



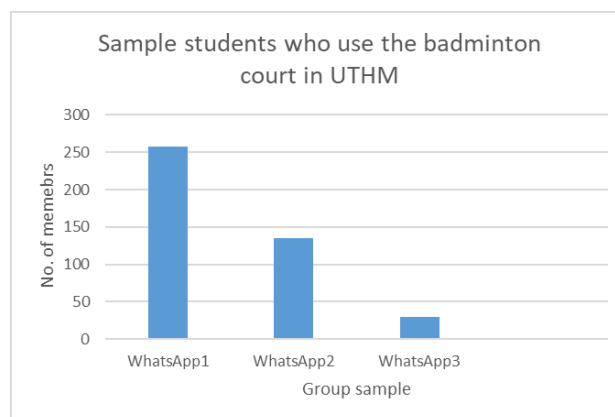
**Figure 1: Location of sampling**

## 2.2 Method

### 2.2.1 Develop questionnaire

For part A, demographic information. For part B, the question is related to general question on indoor air quality. For part C, the question asked about the level of satisfaction of the respondent whether they feel comfortable or not when having an activity inside the indoor sports hall. The last part is part D where the respondent can rate those suggestions and recommendations to improve the indoor air quality in the badminton court based on the current maintenance condition of badminton court.

Determination of the sampling is based on past studies which is from (Krejcie & Morgan, 1970) [6]. Based on Krejcie and Morgan table, a total of 375 samples would be enough for a population size approximately 15000 persons to be able to get result. Therefore, the researcher distributed to three group WhatsApp that consist of student in UTHM. Figure 2 below shows the number of members in each group.



**Figure 2: Sample number of students in each group**

About 421 samples has been taken in this study 36% (150 students) have responded this questionnaire. However, a 30% to 40% response rate are acceptable and good enough [7].

### 2.2.2 Validity test

The questionnaire distributed using an online platform which is google form as it can save cost and time. It is easy to access as the respondent can use mobile phone to answer the questionnaire. Then, a validity test was performed for this study to determine whether the instrument fit the concept as described.

### 2.2.3 Pilot test

For this research, a total number of 20 respondents were involved in pilot test. Pilot test is carried out among the badminton team UTHM members as they use the facility more often about 10 to 30 respondents are sufficient for a pilot test [8]

#### 2.2.4 Data analysis

The research analysis has been assisted by a set of analytical software such as EXCEL and Statistical Package of Social Science (SPSS). Data will be present more organized or structured manner. The most used descriptive analysis is the frequency distribution. The percentage frequency value for the data can be obtained by using the equation 1 below

$$\text{Frequency (\%)} = \left[ \frac{\text{score (each variable)}}{\Sigma \text{score (overall)}} \right] \times 100 \% \quad (1)$$

Mean ranking method is used to analyze data where it is significant to achieve objectives 1 and 2 by using SPSS. It made up of assigning the average of the ranks as the rank for the common frequency. It is used to know the level of awareness and satisfaction when use the badminton court facility. The mean is given by using this formula which is equation 2.

$$\bar{x} = \sum \frac{x}{n} \quad (2)$$

Spearman's correlation is used to inspect the correlation between the level of awareness and the satisfaction of the user in the badminton court facility to achieve objective 3.

### 3. Results and Discussion

The results and discussion section presents data and analysis of the results of level occupant's satisfaction towards indoor air quality at indoor sport halls which is badminton court based on online questionnaire. All data were analyzed using the Statistical Package Social Science (SPSS) Version 20 software. The general demographic of the study was analyzed, followed by reliability test, descriptive test of mean ranking analysis and the Spearman's correlation test. For pilot test, the Cronbach's Alpha value is 0.835 which is good enough while the actual study is 0.847. Hence, it is an acceptable range.

#### 3.1 Analysis of demographic

A total of 150 respondents answer the questionnaire about the level of satisfaction when using badminton court facility in UTHM. Figure 3 shows that majority of the respondents in this study age between 20 to 30 years old (97%). The other 30 to 40 years old represent 2% and the least which is below 20 years old is 1% only. As for the gender, the percentage for male (56%) bigger than female (44%). Hence, age and gender one of the socio demographic factor on behavior that involves with IAQ [9].

In this study, there are 81% respondent who use the badminton court facility in UTHM so the data that has been obtained is reliable enough to measure the awareness and satisfaction of the user. The other 19% is not use the facility. Next, the majority of the respondent use 2 hours and 1 hour of the facility which is represent 51% and 37% respectively. While 12% has been used the badminton court facility about 3 hours. Figure 2 below shows the combination of the demographic information from students UTHM.

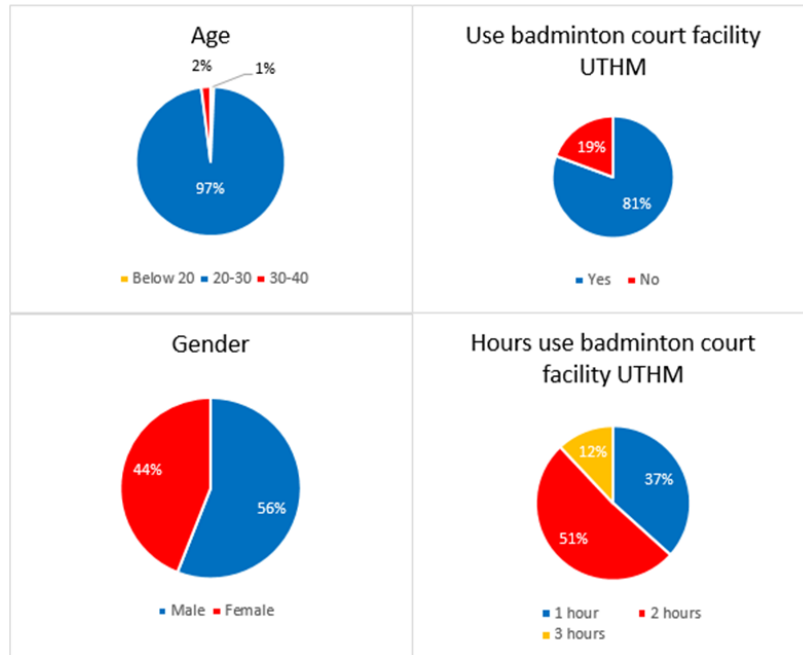


Figure 3: Demographic of respondents

### 3.2 Level of awareness (Objective 1)

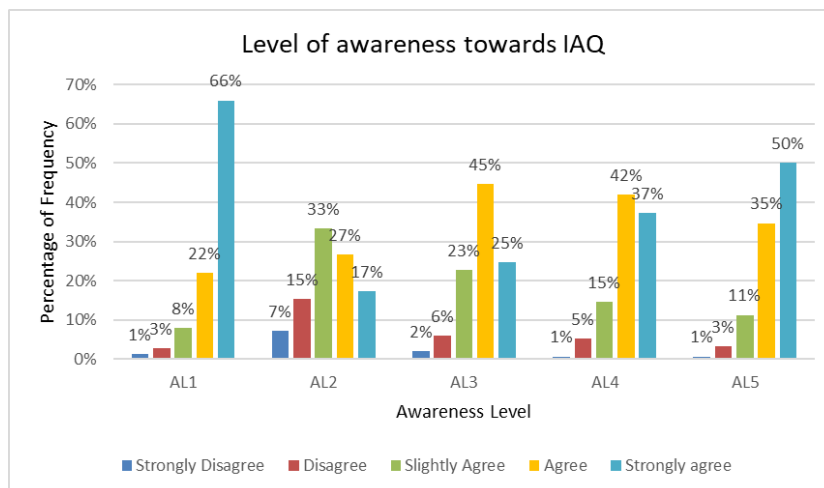


Figure 4: Result of the awareness level towards IAQ

Figure 4 above illustrate the results of awareness of the user towards IAQ in badminton court. The result above it can be conclude that most of the respondents agree with the statement regarding to the awareness level. AL1 shows that 66% of the respondents strongly agree that air quality plays an important role in ensuring the comfort of users when using the badminton court. Only 1% respondents strongly disagree with the important of air quality due to lack of exposure. Based on the previous study, it shows that the important role for indoor air quality in sports is the user’s satisfaction [10].

Next, AL2 shows 33% respondents which is the highest percentage slightly agree that playing badminton can create an indoor air pollution. Only 7% strongly disagree that this activity can gives an impact towards quality of the air. Most of the respondents feels that an activity such as playing badminton can contribute to poor indoor air quality. This is because playing badminton can produce more carbon dioxide and makes the temperature surrounding increases [1].

The next graph which is AL3 indicates 45% respondents agree that badminton court in UTHM comply to the quality standard of indoor air quality (IAQ). Most of the respondents agree that this facility achieve the standard that can gives the user feels comfort and does not affect towards health because they know the important of ambient air inside the building. In Malaysia, DOSH is used as a standard requirement for indoor air quality (IAQ) to achieve a better quality of air [5].

AL4 shows that the highest percentage which is 42% respondents agree and aware that indoor air pollution may cause the health problem. It is known as sick building syndrome (SBS) when the level quality of indoor air is low. Only 1% respondents strongly disagree means that they are not aware that poor indoor air can gives impact towards the user's health especially students among UTHM. There are many type of SBS signs will arise and affect them, such as fever, irritated eyes or nose and blocked nose. Moreover, in the previous study, the researcher found that there's a relationship between the indoor air quality (IAQ) and the occurrence of sick building syndrome (SBS) [11].

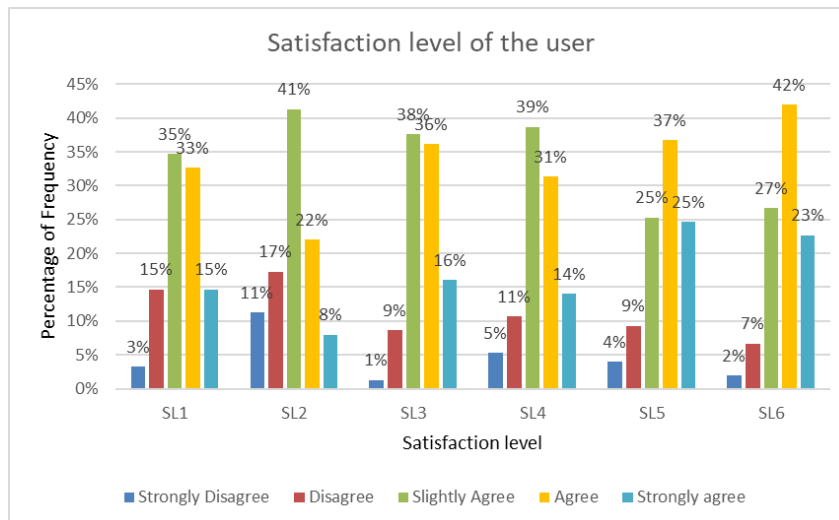
The last graph is AL5 where 50% strongly agree that athletic performance may affect if quality of the air is poor. Half of the respondents agree that level quality of the air may contribute to their performance during play a badminton. Based on previous study, Azuma state that poor productivity such as fatigue is the effect if the air pollutants occurs [12]. Only 3% of the respondents disagree that poor indoor air quality gives a bad performance. In general, most of the respondents agree means they are aware about the indoor air quality (IAQ). Table 1 below shows mean rank for the level of awareness user towards IAQ. Each mean values have different levels of frequency as it is based on the mean values. This mean rank analysis can show more clearly that which parameter about the awareness has the most.

**Table 1: Mean ranking analysis of AL towards IAQ**

No	Item	Mean	Rank
1	I agree that air quality plays an important role in ensuring the comfort of users when using the badminton court (AL1)	4.49	1
2	I agree indoor air pollution may affect athletic performance (AL5)	4.30	2
3	I agree that indoor air pollution in the facilities may cause health problem to the user (AL4)	4.11	3
4	I agree that ambient air in UTHM's badminton court comply to the quality standard to achieve better indoor air quality (IAQ) (AL3)	3.83	4
5	I agree that activities (playing badminton) may create indoor air pollution (AL2)	3.32	5

### 3.3 Satisfaction of the user (Objective 2)

Figure 5 below shows that the result obtained for the satisfaction level of the user. The results indicate whether the respondents feel satisfied or not toward the indoor air quality (IAQ) at the badminton court facility in UTHM.



**Figure 5: Result of the level satisfaction user badminton court in UTHM**

As a result, the respondents slightly agree that they feel fatigue and tired when using the badminton court facility (SL1) at 35%. This indicates that the user feels their performance a bit unsatisfactory. Moreover, 33% also agree that they also feel the same. Based on the past study, it shows that fatigued and tired are the common symptoms when occupants inside the building that has poor level of Indoor Air Quality (IAQ) [13].

Next, (SL2) which is the respondents experienced eye, nose or throat irritation and dizziness when using this badminton court facility obtained a bit high on slightly agree at 41%. There are only 22% and 8% of the total respondents who agree and strongly agree with that statement respectively. This indicates that level quality of indoor air in badminton court is poor. This type of experience is known as Sick Building Syndrome (SBS) as it is categorized under nonspecific subjective health symptoms [13].

The next bar graph (SL3) highlights 38% slightly agree that they not satisfied with the ventilation system of badminton court facility. 36% respondents also agree that they also dissatisfied with the ventilation system. The ventilation system such as exhaust fan has an important role to create a better quality of indoor air. Previous study state that people who participate in sports exchange more energy in surrounding and need a higher requirement on indoor environment such as ventilation [10]. Moreover, a proper ventilation system can create a good air quality circulate inside the badminton court facility in UTHM.

Then, (SL4) shows 39% of the total students slightly agree that they experienced difficulty in concentrating when playing badminton. However, only 5% strongly disagree as they feel easy to concentrate when playing badminton. This results indicate that most of the user feels struggling to focus when doing an activity which is playing badminton. This is because increases of air pollutants lead to to poor performance and productivity by user and making them uncomfortable [1].

(SL5) shows 37% of the total respondents agree that experienced a change in temperature when using the badminton court. Moreover, 25% of the total respondents strongly agree that they also feel a different in temperature. Temperature is directly proportional to the relative humidity so the comfort awareness was related to metabolic heat production, heat transfer to environment, and body temperatures [4]. Body temperature is considered as an indicator of health status. If they feel an increase in body temperatures dramatically, the ventilation system of the building needs to be upgraded.

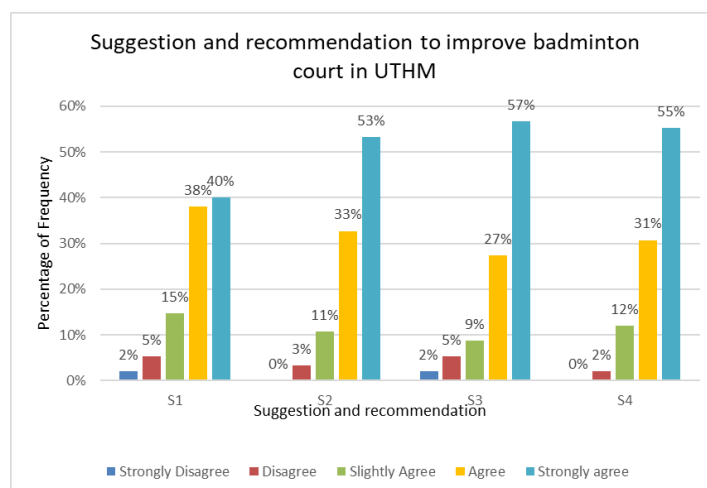
The last graph which is (SL6) 42% of the total respondents agree that they felt discomfort in using the badminton court facility because of the cumulated water that can be found either at the ceiling or on

the floor. The cumulated water might be occurring due to some leakage inside the badminton court. Lack of maintaining the building can cause this problem can happen. Based on the past study, the causes of poor indoor air quality are due to stagnant water or relative humidity is too high [1]. Overall, most of the respondents feels dissatisfied with the Indoor Air Quality (IAQ). Table 2 below shows mean rank for the satisfaction of the user towards IAQ.

**Table 2: Mean ranking analysis of SL towards IAQ**

No	Item	Mean	Rank
1	I felt discomfort in using the badminton court facility because of the cumulated water that can be found either at the ceiling or on the floor (SL6).	3.77	1
2	I experienced a change in temperature when using the badminton court (SL5).	3.69	2
3	I am not satisfied with the ventilation system of badminton court facility (SL3).	3.57	3
4	I feel fatigued and tired when using the badminton court facility (SL1).	3.39	4
5	I experienced difficulty in concentrating when playing badminton (SL4).	3.37	5
6	I experienced eye, nose or throat irritation and dizziness when using this badminton court facility (SL2).	2.98	6

### 3.4 Suggestions and recommendations



**Figure 6: Result of the suggestion and recommendation to improve badminton court in UTHM**

Figure 6 above shows the result obtained from the questionnaire about the suggestion and recommendation. There are 40% from the total respondents strongly agree that the maximum number of users in the badminton court must be limited to ensure a healthy level of indoor air quality (S1). This is because the relationship between the microorganisms and the number of people gives an impact toward the satisfaction of the user [14]. Only 2% respondents strongly disagree that number of users can give an effect towards quality of indoor air as they think it does not give a big impact.

The second bar graph which is (S2) shows that 53% of the total respondents strongly agree that regular maintenance work should be done for ventilation system which is exhaust fan. It is advised to clean all the filters for exhaust fans and schedule the maintenance plans to prevent dust from occurs [3]. However, only 3% respondents disagree that maintenance for ventilation system should be carried out. This indicates that most of the respondents knows the function of ventilation system towards the Indoor Air Quality (IAQ). The next bar graph which is (S3) shows about 57% of the total respondents strongly agree the badminton court should be kept clean and dried to ensure good indoor air quality. If the



badminton court in wet condition, the value of relative humidity would be high. As a result, the tendency for the fungi mold and fungi to grow is high and can cause an effect on health. About 2% of respondents strongly disagree that clean and dry badminton court are the best suggestion.

The last bar graph which is (S4) shows that 55% total of the respondents strongly agree that a reasonable lighting in the court to ensure the comfort of the users. Based on the past research, required lighting level for non-residential building should be obtained by natural lighting because an excessive lighting bulb gives more heat [15]. When heat at the surrounding area increases, user will start to feel uncomfortable. Only 2% of respondents disagree that lighting will gives an effect towards satisfaction of the user badminton court in UTHM. Moreover, there are other practical suggestions from the respondents to improve the indoor quality of the badminton court facility in UTHM.

### 3.5 Correlation between the level of awareness and satisfaction (Objective 3)

Objective 3 in this study is to establish the correlation between the awareness of the user about Indoor Air Quality (IAQ) and user's satisfaction at badminton court in UTHM. As a result, the correlation values are shown in Table 3 below.

**Table 3: Correlation values (Awareness Level vs Satisfaction Level)**

	SL1	SL2	SL3	SL4	SL5	SL6
AL1	-	-	-	-	0.236**	-
AL2	0.291**	0.485**	0.289**	0.389**	0.272**	-
AL3	-	0.364**	-	0.281**	-	0.272**
AL4	0.250**	0.256**	-	0.244**	0.316**	0.303**
AL5	0.346**	-	-	-	0.293**	0.329**

The correlation value of more than 0.3 will be chosen and discuss as it is above moderate relationship. Respondents who feel fatigued and tired when using the badminton court facility in UTHM (SL1) were agree that indoor air pollution may affect athletic performance (AL5). This is because indoor air pollutant may affect towards to the respiratory system and Sick Building Syndrome (SBS) also will occur. In this case, fatigue and tired are one of the symptoms Sick Building Syndrome (SBS). This value of correlation is moderate as it is between 0.30 to 0.39.

Next, respondents who experienced eye, nose or throat irritation and dizziness when using this badminton court facility in UTHM (SL2) were agree that activities such as playing badminton may create indoor air pollution (AL2). When physical activity performed inside the building, the satisfaction of the user also will decrease as they will feel uncomfortable. However, the respondents still agree that ambient air in UTHM's badminton court comply to the quality standard to achieve better indoor air quality (IAQ) (AL3). This is because the respondents know that physical activity are the main factor to the satisfaction level of the user.

Besides, the respondents who experienced difficulty in concentrating when playing badminton (SL4) were agree that activities such as playing badminton may create indoor air pollution (AL2). This physical activity most likely will makes the temperature surrounding increase and so the user will feel difficulty in concentrating when playing badminton.

Respondents who experienced a change in temperature when using the badminton court (SL5) were agree that indoor air pollution in the facilities may cause health problem to the user (AL4). Moreover, temperature is one of the parameter that contribute to indoor air pollution. This statement shows that

the respondents aware with the surrounding since they know indoor air pollution will give effect towards health especially respiratory system.

The last correlation is when the respondents agree that indoor air pollution in the badminton court facility may cause health problem (AL4) and affect athletic performance will felt discomfort in using the badminton court facility (AL5) because of the cumulated water that can be found either at the ceiling or on the floor (SL6). The cumulated water will make the level of relative humidity increases so fungi and mould are easy to appear. Hence, it will effect towards satisfaction of the user.

By using SPSS Software, an overall correlation between the awareness of the user about Indoor Air Quality (IAQ) and user's satisfaction at badminton court in UTHM obtained is 0.457. According to the table of Spearman rank order correlation coefficients, it has a strong relationship since it is between 0.40 and 0.69. In conclusion, objective 3 has achieved in this study and it has a positive relationship where the awareness of the user about Indoor Air Quality (IAQ) is high, they also concern about the satisfaction at badminton court in UTHM.

#### 4. Conclusion

In conclusion, UTHM's management should take action by improving the badminton court facility. Although the respondents which is students from UTHM aware with quality of the indoor air, the management should maintain the building to sustain the satisfaction level of the user. Moreover, there are many parameters for Indoor Air Quality (IAQ) such as temperature ( $^{\circ}\text{C}$ ), relative humidity (RH), carbon dioxide ( $\text{CO}_2$ ), total volatile organic compound (TVOC), formaldehyde (HCHO), respirable suspended particulates (RSP), ozone ( $\text{O}_3$ ), airborne bacterial count (ABC) and carbon monoxide (CO) that needs to be taken into account so the UTHM's badminton court comply to the quality standard. Therefore, to achieve the main purpose of this study a questionnaire has been done.

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#### References

- [1] N. H. Mohd Hashim, W. H. Wan Ismail, F. R. Sulaiman, and M. A. S. Mokhtar, "Determining Indoor Air Quality in Gymnasium for Indoor Recreation Activity at University Teknologi MARA, Shah Alam," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 385, no. 1, 2019, doi: 10.1088/1755-1315/385/1/012034.
- [2] Environmental Protection Agency (EPA), "Introduction to Indoor Air Quality," *Indoor Air Quality (IAQ)*. pp. 1–2, 2018.
- [3] E. M. . Zawawi, A. . Azaiz, S. . Kamaruzzaman, N. M. Ishak, and F. N. . Yussof, "Indoor Air Quality (IAQ) Performance in Refurbished Projects: A Case Study of Two Private Schools in Selangor," *MATEC Web Conf.*, vol. 266, p. 02013, 2019, doi: 10.1051/mateconf/201926602013.
- [4] N. A. Hamzah, K. E. Jun, and S. M. Anua, "Indoor Air Quality and Symptoms of Sick Building Syndrome in Two Selected Building (New Versus Old)," *J. Occup. Saf. Heal.*, vol. 14, no. 2, pp. 7–14, 2017.
- [5] K. J. Syazwan Aizat I., Juliana J. Norhafizalina O., Azman Z. A., "Indoor Air Quality and Sick Building Syndrome in Malaysian Buildings," *Glob. J. Health Sci.*, vol. 1, no. 2, 2009, doi: 10.5539/gjhs.v1n2p126.
- [6] R. V Krejcie and D. Morgan, "Small-Samlpe Techniques," *NEA Res. Bull.*, vol. 30, pp. 607–610, 1970.

- [7] N. L. Sproull, “Sproull, N. L. (1995). Handbook of research methods: A guide for practitioners and students in the social sciences. Metuchen, N.J: Scarecrow Press,” no. 1995, p. 2008, 1995.
- [8] S. Isaac and W. B. Michael, *Handbook in research and evaluation: A collection of principles, methods, and strategies useful in the planning, design, and evaluation of studies in education and the behavioral sciences, 3rd ed.* San Diego, CA, US: EdITS Publishers, 1995.
- [9] M. Nor Faeiza, J. Juliana, and P. H. Chua, “Retrofitting and Purposed-built Buildings: Indoor air quality and Sick Building Syndrome among private higher learning institution students in Kuala Lumpur and Selangor,” *Malaysian J. Public Heal. Med.*, vol. 16, no. 1, pp. 106–112, 2016.
- [10] Y. Ma, S. Lin, L. Liu, Z. Pan, H. Chen, and Q. Peng, “Investigation on Indoor Air Quality in the Badminton Hall of Wuhan Sports University in winter Based on Subjective Questionnaire Survey and Field Test,” *Proceedings*, vol. 49, no. 1, p. 148, 2020, doi: 10.3390/proceedings2020049148.
- [11] N. R. Fadilah, “Indoor Air Quality (IAQ) and Sick Buildings Syndrome (SBS) among Office Workers in New and Old Building in Universiti Putra Malaysia, Serdang,” *Heal. Environ. J.*, vol. 3, no. 2, pp. 98–109, 2012.
- [12] K. Azuma, N. Kagi, U. Yanagi, and H. Osawa, “Effects of low-level inhalation exposure to carbon dioxide in indoor environments: A short review on human health and psychomotor performance,” *Environ. Int.*, vol. 121, no. June, pp. 51–56, 2018, doi: 10.1016/j.envint.2018.08.059.
- [13] A. Norhidayah, C. K. Lee, M. K. Azhar, and S. Nurulwahida, “Indoor air quality and sick building syndrome in three selected buildings,” *Procedia Eng.*, vol. 53, no. 2010, pp. 93–98, 2013, doi: 10.1016/j.proeng.2013.02.014.
- [14] H. Salonen, T. Salthammer, and L. Morawska, “Human exposure to air contaminants in sports environments,” *Indoor Air*, no. April, pp. 1–21, 2020, doi: 10.1111/ina.12718.
- [15] Council of the European Union, “EN 15251 CEN/TC 156 Indoor environmental input parameters for design and assessment of energy performance of buildings- addressing indoor air quality, thermal environment, lighting and acoustics,” pp. 1–52, 2006.