DAFTAR ISI BUKTI KORESPONDENSI JURNAL

Effect of Exhaust Fan to Microorganism Concentration in the Air-Conditioned Room

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ABSTRACT
Certain amounts of bacteria and fungi in the room can cause Sick Building Syndrome (SBS). The main reason for bacteria and fungi accumulation is a lack of air circulation in the air-conditioned room. Therefore, we study exhaust fan usage to microorganism concentration in the air-conditioned room. The experiments were carried out to find the optimum exhaust fan running time for reducing microorganism concentration until below the threshold value. The quasi-experiment was using with repeated experiments and non-random methodology. The samples were consisting of four air-conditioned classrooms with six repeated measurements. The sampling instrument used a petri dish filled with NA (Nutrient Agar) and PDA (Potato Dextrose Agar) placed at five points in each room. The results showed that the variation of exhaust fan running time sig affected the concentration of bacteria (sig ~0) and fungi (sig 0.023) in the classrooms. We found that the bacteria concentration was reduced by using exhaust fan. While we observed that the exhaust fan gives inconsistency effect to reduce the fungi concentration in the classrooms.

Keywords: room air quality; exhaust fan; bacteria; fungi; air-conditioned room

INTRODUCTION

Air is one of the essential needs to maintain life's existence. The atmosphere divided into outdoor air and indoor air. Indoor air quality dramatically affects human health due to ~90% of human activity is in indoor[1].

Healthy indoor air quality is indicating by the absence of pathogenic microorganisms in the air, such as bacteria and fungi (~0 CFU/m^3)[2]. The Indonesian government has set the minimum threshold concentration for bacteria and fungi in the indoor air, which is 0 CFU/m^3 and 1000 CFU/m^3, respectively[3].

A sufficient microorganism concentration in the room possible to cause Sick Building Syndrome (SBS)[4,5]. SBS is a disease caused by substandard indoor air quality. SBS is defined as symptoms that occur based on the user's experience when they are in the building, such as skin allergies, breathing difficulty, irritation of the eyes, nose and dry mucous layer, mental fatigue, headaches, acute respiratory infection, asthma, cough, flu, sneezing, and other hypersensitivity reactions[2,4].

According to the National Institute of Occupational Safety and Health (NIOSH) at 1997, poor indoor air quality is generally caused by several things, such as lack of air ventilation (52%), indoor contaminant (16%), outdoor contaminant (10%), microbes (5%), property materials (4%), and others (13%)[6]. Improving air quality can be made by exchanging air regularly, specifically: (1) houses equipped with ventilation, which has an area of >10% from floor area using the cross-ventilation system. (2) In an air-conditioned room, enhancing the air quality can be done by device maintenance and opening the window once a day. (3) Using an exhaust fan. (4) Room layout management[7].

Herein, we demonstrate the utilization of exhaust fan to improve the air-conditioned indoor air quality. The exhaust fan significantly reduces bacterial and fungal concentration by exchanging the air in the room. We seek to investigate the optimum time needed for running the exhaust fan to achieve sufficient air quality.

MATERIALS AND METHODS

This study used a quasi-experimental method, which uses non-randomized repeated experiments. The population in this study was air-conditioned classrooms in Campus A, Health Polytechnic of Ministry of Health, Pontianak. We used four air-conditioned classrooms equipped with an exhaust fan that has an airflow capacity of ~1728 CMH. Based on the Federer formula, the experiment in each class repeated six times. The exhaust fan running time was varied to be 30 min, 60 min, 90 min, and 120 min. The bacterial and fungal concentration calculations performed before and after the exhaust fan running.

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points on the median of the diagonal line and the center point of oblique intersection[8]. After 30 minutes of placing the petri dish, Laboratory officials collect, breed, and perform the calculation (time and procedure for breeding and prediction under Laboratory standards). This procedure executed at each class before and after the exhaust fan running.

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$$CFU/M3 = a.1000/p.t.0.2$$

With **'a'** is many colonies in Petri dishes, **'p'** is a surface area of a petri dish, and **'t'** is Petri dishes exposing time.

Research also measurements: temperature, humidity, and light intensity. Data analyzed by univariate, i.e., the percentage decreased in bacterial and fungal levels before and after the exhaust fan running for 30, 60, 90, and 120 minutes.
The multivariate-analysis performed by the Manova.
To know the presence of the effect in the variations exhaust fan running time on the numbers of bacterial and fungal colonies.

RESULTS
We observed that there is no significant variation in the bacterial and fungal concentration in the classroom before running the exhaust fan — the class condition controlled to running the experiment. We set the classroom with air conditioner power of 18,000 BTU; the temperature was 26–28 °C, the humidity was 70.16–75.81%, light intensity was 175.10–177.34 Lux, and there were 36–44 persons in that room.

After running the exhaust fan at different times, there is a notable difference in the bacterial and fungal concentration. A sign of the effectiveness of exhaust fan usage to reduce improve air quality by decreasing the bacterial and fungal levels.

Levels of bacteria and fungi in the classroom by turning on the Exhaust Fan seen in the table. The average value of bacterial and fungal colonies for each treatment obtained from 6 experiment repetitions.

Table 1. Bacterial and fungal concentration result

Running time (min)	Average bacterial concentration (CFU/M^3)		Shift	Average fungal concentration (CFU/M^3)		Shift
	PRE	POST		PRE	POST	
30	1.756,53	1.493,01	-261,51	1.009,67	548,35	-461,32
60	2.167,44	1.760,37	-407,07	667,67	802,08	+134,20
90	1.328,41	812,56	-515,84	363,82	382,69	+18,87
120	972,98	712,96	-260,02	456,08	310,35	-145,74

Figure 1. Average bacteria concentration at pre and post exhaust fan running

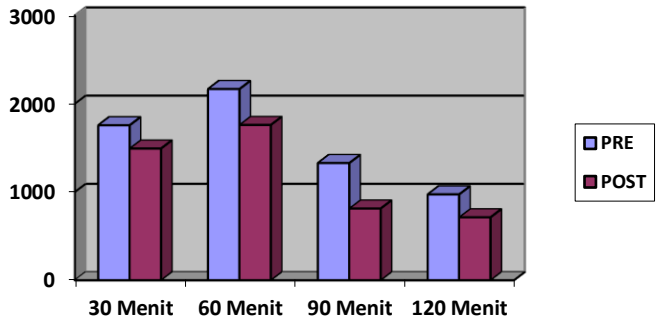
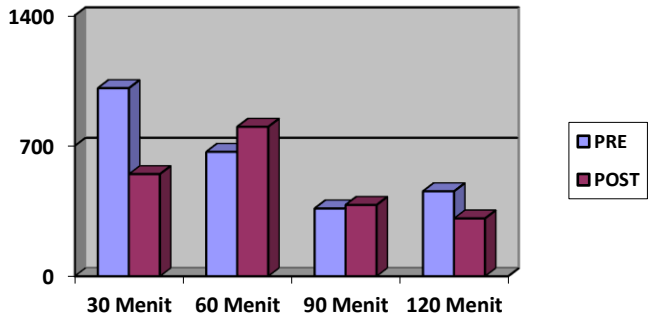


Figure 2. Average fungal concentration at pre and post exhaust fan running



After 30 min of running the exhaust fan, the decrement in bacterial and fungal concentration was 261.51 and 461.32 CFU/m^3. While for 60 min running time of exhaust fan, the bacterial level decreased for 407.07 CFU/m^3, and the fungal concentration increased for 134.20 CFU/m^3.

For 90 min of running exhaust fan, the bacterial concentration was decreased for 515.84 CFU/m^3, while the fungal level increased for 18.87 CFU/m^3. The decrement in bacterial and fungal strength observed after 120 min of running the exhaust fan, with a decrement value of 260.02 and 145.74 CFU/m^3, respectively.

This result shows that the bacterial concentration was still slightly above the threshold level (>700 CFU/m^3), with reach 712.96 CFU/m^3 after solely 120 min running time of exhaust fan. The significant decrement in bacterial concentration observed after exhaust fan running for 90 min while the level of fungi notably decreased after solely 30 min of running time of exhaust fan.

Before the Manova analysis was carried out, a homogeneity test with the Lavene method obtained sig. values of >0.05. Therefore, Benferroni's method used as the Post Hoc test. This method enables to de-convoluted that the exhaust fan was significant or not to reduce the bacterial and fungal concentration in the air.

Table 2. Effect of post-treatment (different from exhaust fan running time) on the bacterial and fungal concentration

.e	lues in bacterial concentration	lues in fungal level
nt exhaust fan running time		

Table 2 shows that the bacterial and fungal concentration was significantly affected by running the exhaust fan, with both sig. value (0.000 and 0.023, respectively) demonstrate the value below 0.05.

DISCUSSION

The different decreasing ratio obtained with modified exhaust running time due to different ventilation condition and people population in the room, according to Hayleeyesus's, Wamedo's, and Graudenz's experiment in 2014, 2012, and 2005, respectively[10,11,12].

There is inconsistency in fungal concentration between 30 and 120 min of exhaust fan running time that the decrement in fungal level after 30 min was higher compare to after 120 min of running the exhaust fan.

Moreover, after 60 and 90 min of running the exhaust fan, the fungal concentration was increased, which may be owing to a person's activity that opens the door several times.

Ponce-Caballero's experiment, 2013, demonstrated that the fungal concentration was significantly affected by fungal levels from outside of the room. The fungi can enter the room from the opened window or door, which leads to the increment in indoor fungal concentration. Therefore, opening the door from person activity can cause the fluctuation the indoor fungal concentration[13].

Additionally, according to Adams experiment in 2015, the people population in the room was an essential factor to the indoor microorganism concentration, especially in poorly circulated room[14].

For bacterial concentration, there is a significant difference in sig. A value between exhaust fan running time of 30 and 90 min, with sig. 0.040; between 30 and 120 min, with sig. 0.015; between 60 and 90 min, with sig. 0.003; between 60 and 120 min, with sig. 0.001. For fungal concentration, notable differences in sig.-value Observed between exhaust fan running time of 60 and 120 min, with sig. 0.030.

The threshold of bacterial concentration was below 700 CFU/m^3. Therefore, although the exhaust fan was running for 30, 60, and 90 min, the bacterial level was still above the threshold value. However, with the exhaust fan running time of 120 min, the bacterial concentration was reduced to slightly above the threshold value. This result indicates that the exhaust fan usage in this experiment still not be able to reduce the bacterial level to below the threshold. We posit that may be originated from human number and activity in the room, as shown in the Fox experiment in 2013, Mahyuddin in 2013, and Meadow in 2014[15,16,17]. They also demonstrate that CO_2 concentration in the place also gives a significant improvement in microorganism concentration in the air. Although the microorganism concentration was affected by outdoor air quality additionally, however, human factor give impact to almost two times higher to microorganism concentration in indoor air[17].

For fungal levels in the air, the threshold was below 1000 CFU/m^3. With running the exhaust fan for 30–120 min, the fungal concentration of below threshold can be achieved. Therefore, the exhaust fan method is an effective way to reduce the fungal level in the air, which solely required 30 min to reach below the threshold.

The Barberan study in 2015 and Adams in 2013 showed that mold in indoor air was lower than in outdoor air[18,19]. Goh's study in 2000 with a sample of libraries in Singapore also stated that the rate of mold in indoor air was about 50 times lower than outdoor air[20].

CONCLUSION

We demonstrate the simple exhaust fan to improve indoor air quality by reducing the bacterial and fungal concentration. Exhaust fan significantly reduces bacterial and fungal concentration with sig. value of 0.000 and 0.023, respectively. The exhaust fan running time to reduce the bacterial concentration to near the threshold was 120 min, while to reduce the fungal concentration to below the threshold solely required 30 min.

ACKNOWLEDGEMENTS

We would like to thank the Director of Health Polytechnic of Ministry of Health, Pontianak, Indonesia that provides laboratories facilities to analysis the sample. We also thanks for the support and advice from our health associates so that make this research well.

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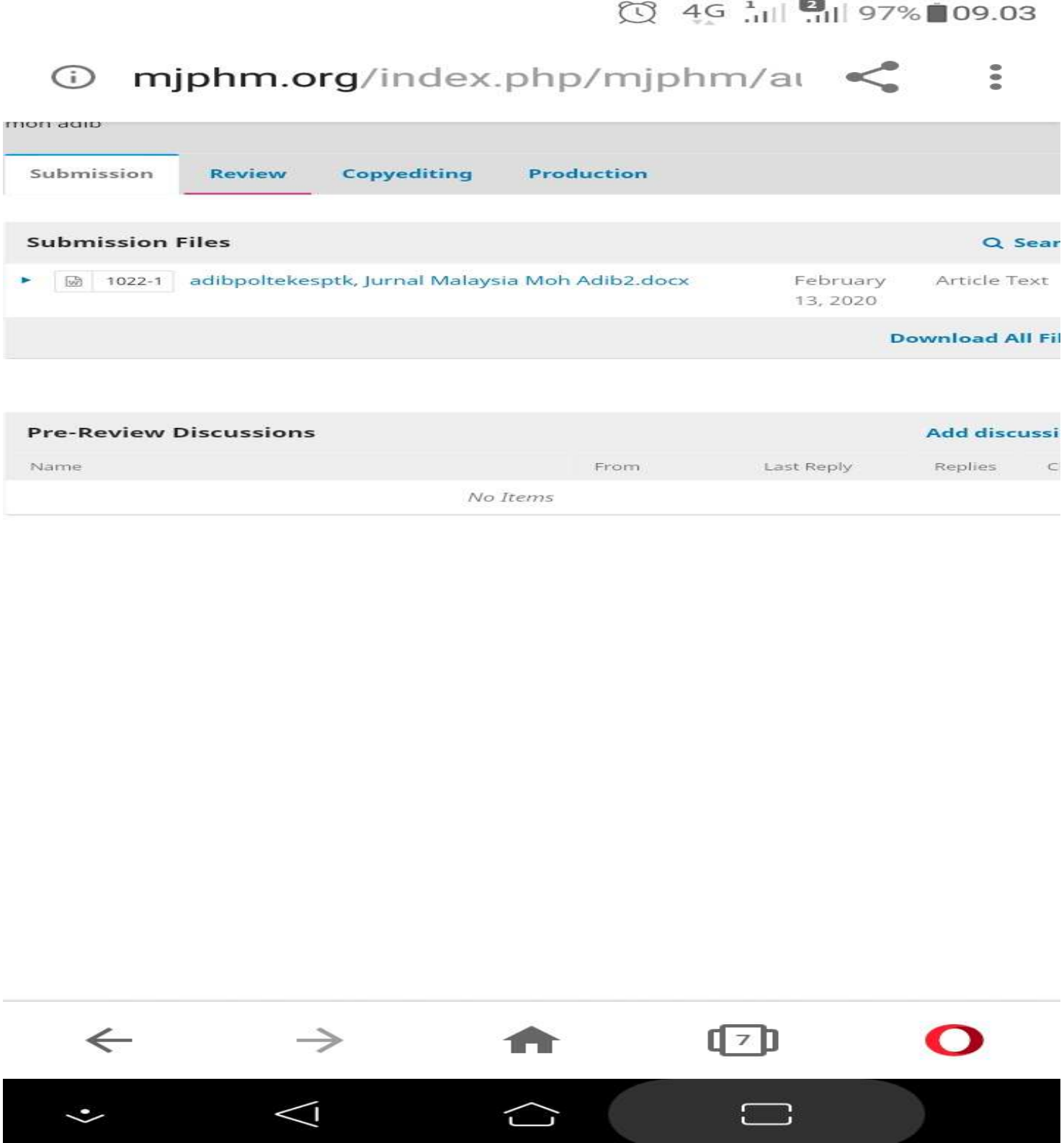
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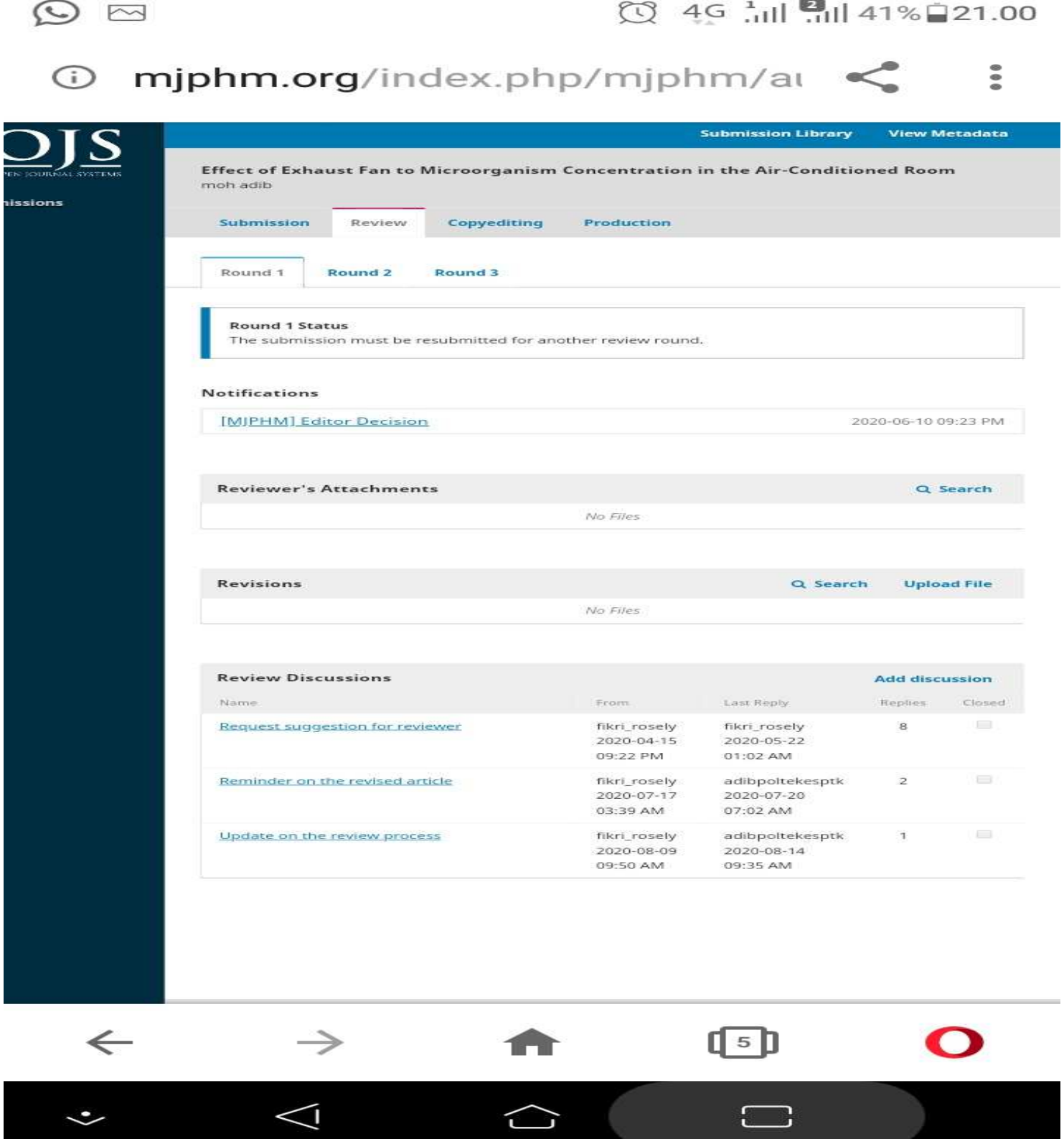
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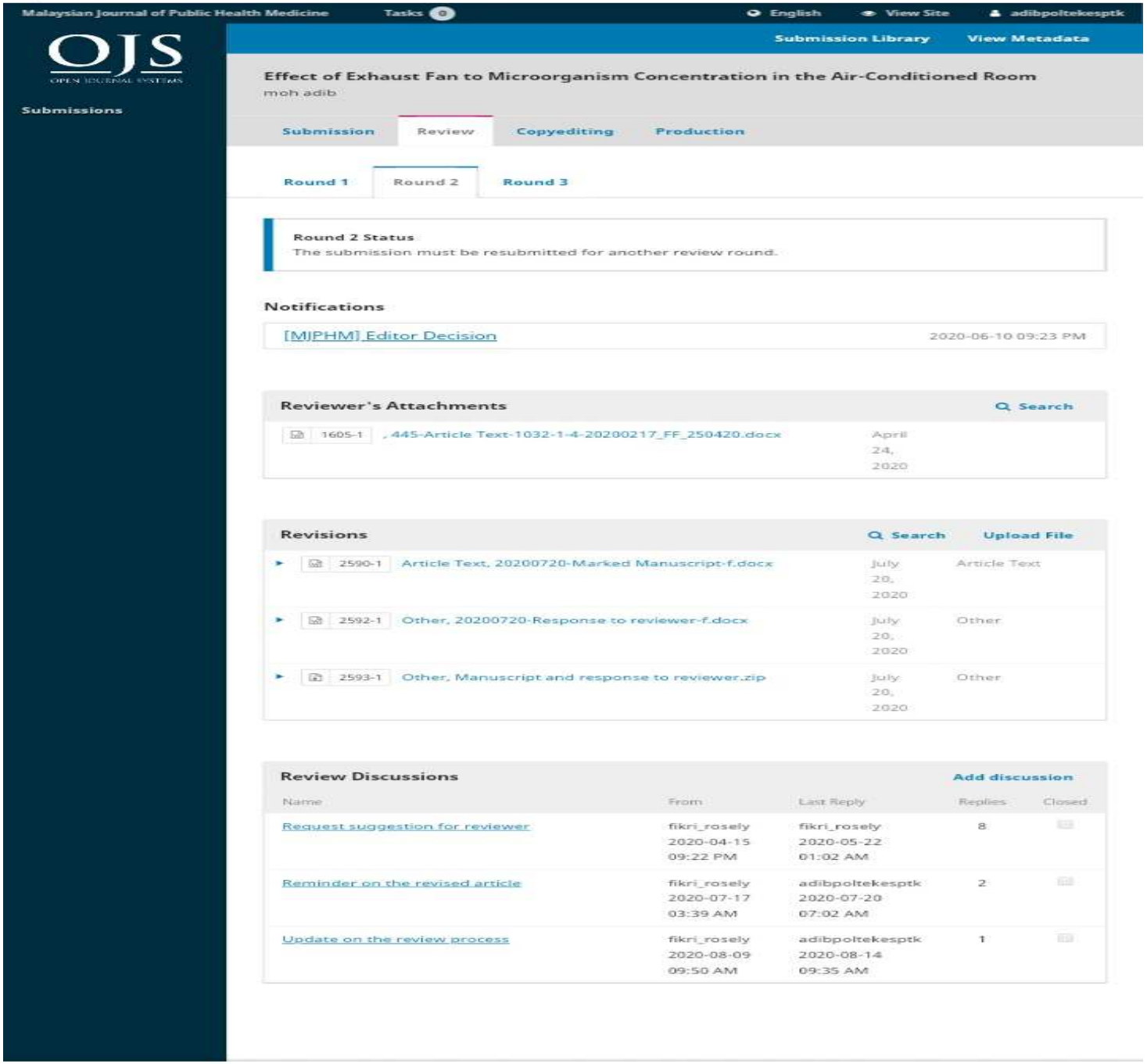
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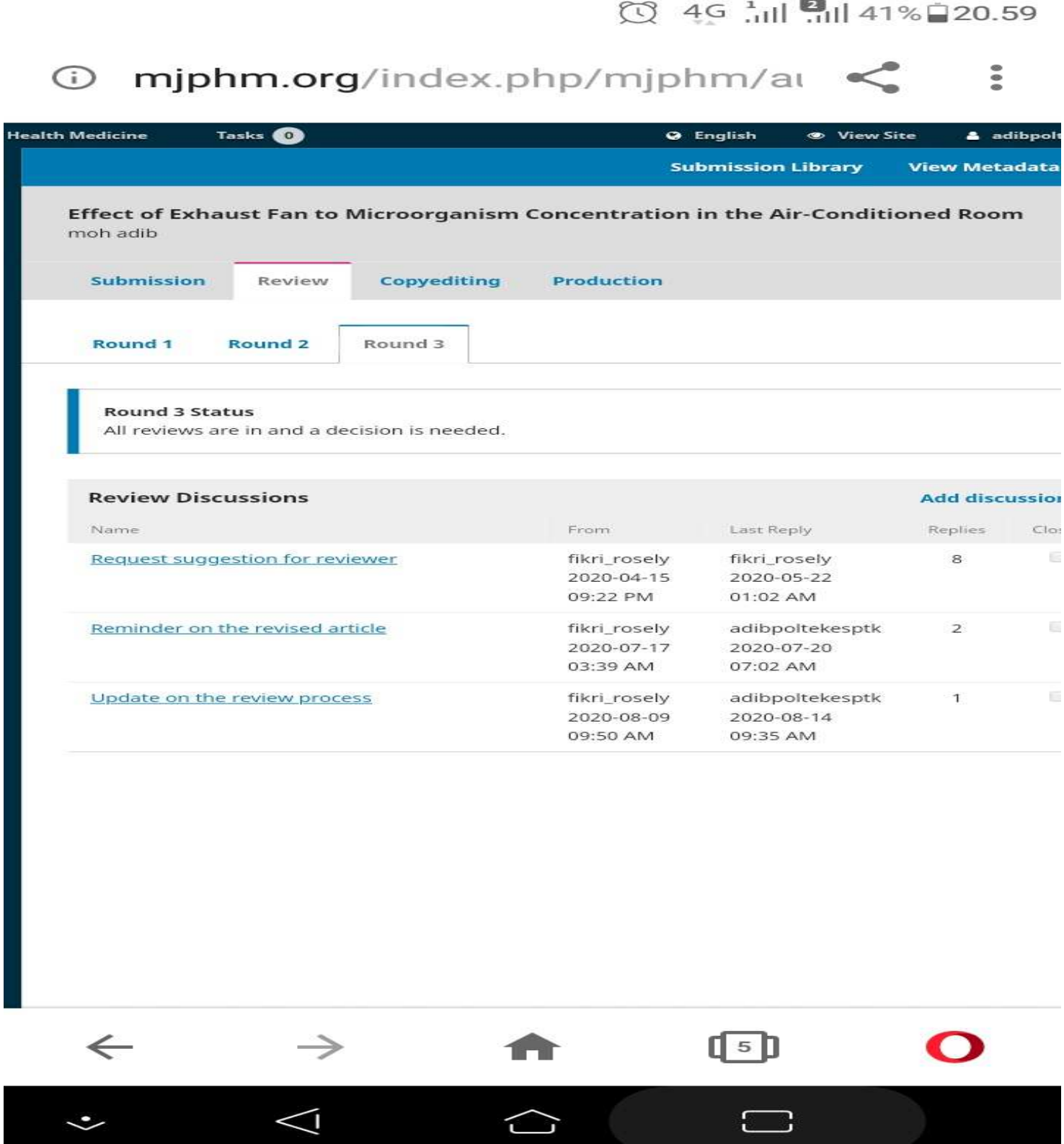
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ARTICLE REVIEW RESULTS-1

Article title	Effect of Exhaust Fan to Microorganism Concentration in the Air-Conditioned Room
Abstrack	Need to be stated clearly objectives in this study.
Introduction	Expansion of diseases transmitted from air-conditioned rooms. The function of the AC and Exhaust Fan are the same as artificial air ventilation methods
Method	explanation: . Why use a time difference that is: 30 minutes, 60 minutes, 90 minutes and 120 minutes. 2. Why this research does not use Control, so that the results obtained from the arrangement can be ascertained.
Materials	It may be necessary to use materials to make measurements and observations during intervention activities.
Procedure	Need to add a brief procedure for implementing interventions in this study
Results And Discussion	The discussion needs to be clarified by comparing previous research on the use of exhaust fans as cleaners in air-conditioned rooms, based on certain time differences eg, 25 minutes and 180 minutes. .
Conclusion	need to be added about the conditions of temperature and humidity, as well as the time of the last air conditioner cleaning
Excellence	- Presentation of images and graphics are very good and clear. - This study provides a discussion of new ways to use the Exhaust Fan for air conditioned room air pollution and can prevent airborne infections in air conditioned rooms.
Deficiency	The design of this study does not use control or comparison of non-air-conditioned rooms, so it can be known with certainty whether the decrease in bacteria is due to the treatment effect.

Thank You
Best Regard

Dr. Malik Saepudin, SKM, M.Kes
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REVIEW RESULTS OF STAGE 2 ARTICLES

Article title	Effect of Exhaust Fan to Microorganism Concentration in the Air-Conditioned Room
Abstrack	The purpose of this study has been added to the abstract
Introduction	The author of the article has clearly threatened and threatened diseases transmitted from the air-conditioned room
Method	The author of the article has explained the difference in treatment time well.
Materials	Has been clearly and given good and adequate reasons
Procedure	Brief procedures have been added in the implementation of this intervention
Results And Discussion	Researchers have clearly provided good and adequate reasons
Conclusion	The research conclusions have been well presented
Excellence	This study provides recommendations for the use of artificial ventilation exhaust fans to prevent water born infection in air-conditioned rooms, which previously had not been imagined.
Deficiency	Disadvantages of this article have been completed in detail, related to control and How to control temperature, humidity in this study with statistical ui did not show a significant difference.
Reviewer Conclusion	This article is eligible for publication in Malaysia Journal of Public Health Medicine

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Thank You
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The researcher officially accepts the calculation results from the laboratory officer. Calculation of microorganism colonies based on Polish Standard PN 89/Z-04008/08, using the formula[9]:

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Levels of bacteria and fungi in the classroom by turning on the Exhaust Fan seen in the table. The average value of bacterial and fungal colonies for each treatment obtained from 6 experiment repetitions.

Table 1. Bacterial and fungal concentration result

Running time (min)	Average bacterial concentration (CFU/M^3)		Shift	Average fungal concentration (CFU/M^3)		Shift
	PRE	POST		PRE	POST	
30	1.756,53	1.493,01	-261,51	1.009,67	548,35	-461,32
60	2.167,44	1.760,37	-407,07	667,67	802,08	+134,20
90	1.328,41	812,56	-515,84	363,82	382,69	+18,87
120	972,98	712,96	-260,02	456,08	310,35	-145,74

Figure 1. Average bacteria concentration at pre and post exhaust fan running

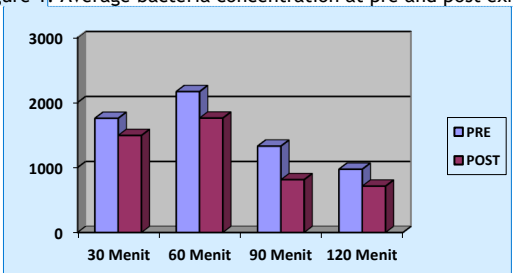

Figure 2. Average fungal concentration at pre and post exhaust fan running

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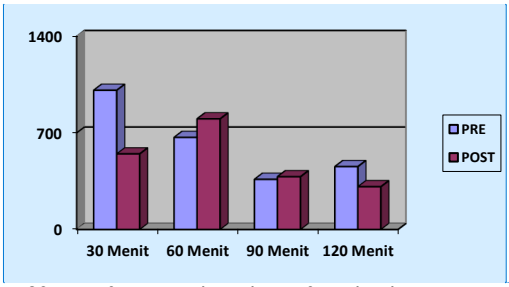

After 30 min of running the exhaust fan, the decrement in bacterial and fungal concentration was 261.51 and 461.32 CFU/m^3. While for 60 min running time of exhaust fan, the bacterial level decreased for 407.07 CFU/m^3, and the fungal concentration increased for 134.20 CFU/m^3.

For 90 min of running exhaust fan, the bacterial concentration was decreased for 515.84 CFU/m^3, while the fungal level increased for 18.87 CFU/m^3. The decrement in bacterial and fungal strength observed after 120 min of running the exhaust fan, with a decrement value of 260.02 and 145.74 CFU/m^3, respectively.

This result shows that the bacterial concentration was still slightly above the threshold level (>700 CFU/m^3), with reach 712.96 CFU/m^3 after solely 120 min running time of exhaust fan. The significant decrement in bacterial concentration observed after exhaust fan running for 90 min while the level of fungi notably decreased after solely 30 min of running time of exhaust fan.

Before the Manova analysis was carried out, a homogeneity test with the Lavene method obtained sig. values of >0.05. Therefore, Benferroni's method used as the Post Hoc test. This method enables to de-convoluted that the exhaust fan was significant or not to reduce the bacterial and fungal concentration in the air.

Table 2. Effect of post-treatment (different from exhaust fan running time) on the bacterial and fungal concentration

Variable	Sig.-Values in bacterial concentration	Sig.-Values in fungal level
Different exhaust fan running time	0,000	0,023

Table 2 shows that the bacterial and fungal concentration was significantly affected by running the exhaust fan, with both sig. value (0.000 and 0.023, respectively) demonstrate the value below 0.05.

DISCUSSION

The different decreasing ratio obtained with modified exhaust running time due to different ventilation condition and people population in the room, according to Hayleeyesus's, Wamedo's, and Graudenz's experiment in 2014, 2012, and 2005, respectively[10,11,12].

There is inconsistency in fungal concentration between 30 and 120 min of exhaust fan running time that the decrement in fungal level after 30 min was higher compare to after 120 min of running the exhaust fan. Moreover, after 60 and 90 min of running the exhaust fan, the fungal concentration was increased, which may be owing to a person's activity that opens the door several times.

Ponce-Caballero's experiment, 2013, demonstrated that the fungal concentration was significantly affected by fungal levels from outside of the room. The fungi can enter the room from the opened window or door, which leads to the increment in indoor fungal concentration. Therefore, opening the door from person activity can cause the fluctuation the indoor fungal concentration[13].

Additionally, according to Adams experiment in 2015, the people population in the room was an essential factor to the indoor microorganism concentration, especially in poorly circulated room[14].

For bacterial concentration, there is a significant difference in sig. A value between exhaust fan running time of 30 and 90 min, with sig. 0.040; between 30 and 120 min, with sig. 0.015; between 60 and 90 min,

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with sig. 0.003; between 60 and 120 min, with sig. 0.001. For fungal concentration, notable differences in sig.-value Observed between exhaust fan running time of 60 and 120 min, with sig. 0.030.

The threshold of bacterial concentration was below 700 CFU/m^3. Therefore, although the exhaust fan was running for 30, 60, and 90 min, the bacterial level was still above the threshold value. However, with the exhaust fan running time of 120 min, the bacterial concentration was reduced to slightly above the threshold value. This result indicates that the exhaust fan usage in this experiment still not be able to reduce the bacterial level to below the threshold. We posit that may be originated from human number and activity in the room, as shown in the Fox experiment in 2013, Mahyuddin in 2013, and Meadow in 2014[15,16,17]. They also demonstrate that CO_2 concentration in the place also gives a significant improvement in microorganism concentration in the air. Although the microorganism concentration was affected by outdoor air quality additionally, however, human factor give impact to almost two times higher to microorganism concentration in indoor air[17].

For fungal levels in the air, the threshold was below 1000 CFU/m^3. With running the exhaust fan for 30–120 min, the fungal concentration of below threshold can be achieved. Therefore, the exhaust fan method is an effective way to reduce the fungal level in the air, which solely required 30 min to reach below the threshold.

The Barberan study in 2015 and Adams in 2013 showed that mold in indoor air was lower than in outdoor air[18,19]. Goh's study in 2000 with a sample of libraries in Singapore also stated that the rate of mold in indoor air was about 50 times lower than outdoor air[20].

CONCLUSION

We demonstrate the simple exhaust fan to improve indoor air quality by reducing the bacterial and fungal concentration. Exhaust fan significantly reduces bacterial and fungal concentration with sig. value of 0.000 and 0.023, respectively. The exhaust fan running time to reduce the bacterial concentration to near the threshold was 120 min, while to reduce the fungal concentration to below the threshold solely required 30 min.

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