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Design and Construction of a Mini Laminar Airflow Cabinet to Support Laboratory Activities in Aseptic Condition

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ABSTRACT

Laboratories have made considerable use of laminar airflow cabinets to create a microorganism-free environment with excellent and consistent results. Providing a laminar airflow cabinet at a high price is one of the factors involved. Consequently, a similar-functioning alternative to the standard laminar airflow tool is required. The objective of this research was to create a miniature laminar airflow cabinet. Interview and observational data were collected via questionnaires for the experiments. Examination of the data utilized by the Likert scale mini laminar airflow (MLAF) was able to create a sterile workplace with the high efficacy of laminar airflow, HEPA filtration, and a high air-change rate, as demonstrated by the results. 82.50% of respondents indicated that the effectiveness of MLAF supported any laboratory work requiring a sterile environment, as indicated by the mean questionnaire answer.

Keywords: aseptic, laboratory, mini laminar airflow.

INTRODUCTION

Aseptic or sterile conditions are uncontaminated by bacteria or particles that float freely in the air. For laboratory activities to support practicum and research, hygienic conditions are required. Aseptic is a system for preserving sterility and preventing contamination from a technical standpoint. A laminar airflow cabinet or laminar is the common name for a work room that can provide aseptic conditions. Laminar will prevent contamination of the object or product being worked on during practice or research operations. Laminar airflow can reduce the risk of product failure due to contamination and assure worker safety (Harjanto & Raharjo, 2017). Numerous research and clinical procedures necessitate the use of laminar airflow cabinets, including the preparation of microorganism culture media, the injection of bacteria, the provision of sterile materials, the practice and preparation of gene extraction, and a multitude of other procedures that necessitate air-free environments.

The laminar working principle is to circulate air into the workspace through two filters, namely the pre-filter, which functions to filter incoming air with particles larger than 0.5 mm, and the HEPA (High-Efficiency Particulate Air Filter), which prevents the entry of particles larger than 0.3 mm to produce sterile air in the workspace. (Labnusantara, 2019). The following tests must be performed to determine that MLAF is fit for use and can offer aseptic conditions: (a) airflow test, (b) contamination test, (c) UV radiation test, and (d) MLAF trial use. Due to the high cost of laboratory laminar airflow cabinets, aseptic or sterile practicum or research cannot be performed optimally. This research was conducted to develop a mini laminar airflow cabinet (MLAF) as an alternative to conventional laminar airflow cabinets for practicum and research activities requiring a relatively small, contamination-free workspace that can be made quickly, efficiently, and cheaply.

MATERIALS AND METHODS

The approach contains explanations and descriptions: This study employs an experimental production and testing approach. Design, manufacturing, testing, and analysis are the phases of the research procedure. The findings of questionnaire completion by respondents were subjected to descriptive and quantitative analysis. A descriptive study was conducted to analyze the data obtained from the airflow, contamination, and UV radiation tests. Quantitative analysis with a Likert scale test was used to look at the results of a questionnaire (Pranatawijaya et al., 2019), but MLAF analysis was used to look at the effects of trials.

Manufacture of mini laminar airflow cabinet

The parts of MLAF can be seen in Figure 1 and several stages in the manufacture of a mini laminar airflow design, which is as follows:

- Transparent acrylic with a thickness of 4 mm is cut into pieces according to the size of the MLAF to be formed, which is 700×572×350 mm.
- The shape of the front side of the MLAF is curved, and there are two 150×100 mm utility holes for inserting small hands or tools with a magnetic-adhesive cover.
- The side of the MLAF is equipped with a utility hole measuring 200×150 mm for inserting materials or equipment that has a larger size.
- Aluminum 0.4 mm measuring 700×572 mm is glued to the acrylic bottom as an MLAF work base.
- On the back side of the MLAF, there are pores/gaps before HEPA to protect HEPA (High-Efficiency Particulate Air) from splashes of liquid material that can damage or reduce the effectiveness of HEPA.
- The air filter system is placed at the back of the MLAF, which consists of 2 filters/slits, HEPA with 0.3 m pore size 345×295×40 mm, 10 DC 12V 12 cm fans, and 50 l prefilter measuring 300×300 mm as much as two pieces.
- The upper part of the MLAF is installed with a 9 watt 60 cm TL lamp, which serves to provide lighting while working, and a 20 watt 60 cm UV lamp serves to sterilize before and after MLAF is used and is equipped with an anti-UV cloth cover to prevent the release of UV radiation. from within the MLAF to the environment during sterilization.

Mini laminar airflow test

MLAF testing is carried out to ensure that the MLAF can provide an aseptic room during the activity. The following four tests were carried out, namely the airflow test, contamination test, UV radiation test, and testing the use of MLAF. (a) an airflow test is carried out by introducing smoke inside and outside the MLAF, (b) contamination test using 10 Petri dishes that already contain media to be spread in the MLAF workspace both in the MLAF state off and on and the MLAF doors open or closed. Furthermore, (c) UV radiation test using a UV light meter, the last trial, namely (d) testing the use of MLAF by involving students as respondents to provide an assessment of MLAF, which includes several parameters on the questionnaire that has been prepared.

RESULTS AND DISCUSSION

Mini laminar airflow design is an alternative tool for solving problems in providing laminar airflow in an agency or institution. According to

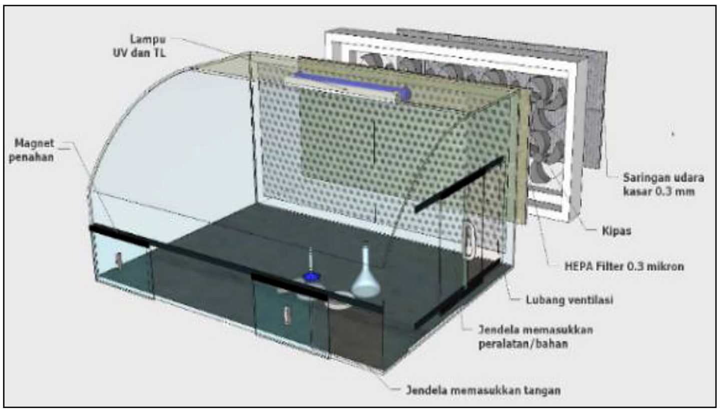

Figure 1. Mini laminar airflow cabinet components

Harjanto and Raharjo (2019), laminar airflow can support success in inoculation activities carried out by students to complete their research. This statement is in line with this research regarding the use of laminar airflow in microbiology practicum, which requires aseptic conditions in the workspace, tools, and media to inoculate microorganisms. After going through the assembly of tools and testing on the MLAF, a device that can produce aseptic conditions is produced, as evidenced by the test results as follows:

a) Airflow test.

The airflow in the MLAF moves in one direction out of the utility hole, and air from outside cannot enter the workspace. To be more precise, it can be seen in Figure 2. This shows that the air produced from the fan does not cause turbulence, so the air produced comes out. through the utility hole.

b) Contamination test.

The results of the contamination test can be seen in Table 1. There were three open Petri dishes in MLAF dead condition with the door open, six available Petri dishes in MLAF off the situation with the door closed, contamination occurred, and ten open Petri dishes in MLAF live situation with the door open and not closed. Contamination occurs. As for the positive control, 100% Petri dish was contaminated, and 0% Petri dish was not contaminated in the negative control.

Figure 2. Airflow test on MLAF

c) UV radiation test.

The UV index is a number without a unit that describes the level of exposure to UV rays on human health (BMKG, 2017). UV radiation testing in this study resulted in a value of 78 W/cm^2 or each UV index scale equivalent to 0.0025 W/m^2 UV radiation

d) Trial using MLAF.

The MLAF feasibility test involved 32 students in the microbiology practicum. This activity was carried out by preparing agar media, isolation, and injecting bacteria. All students involved were briefed on how to use the MLAF aseptically and provided a prepared questionnaire. The Table 2 shows the results of the MLAF feasibility test. These results show the effectiveness of the HEPA filter which functions to filter dust particles and microorganisms in the air before entering the MLAF workspace. The results of contaminated and uncontaminated tests can be seen in Figure 3.

Based on the Table 1 and related to Figure 5, the noise level on the MLAF obtained 88.96% strongly agree that the fan noise and vibration from the air filter box do not disturb MLAF users while working. This indicates that the distance and arrangement of the MLAF air filter are appropriate

Table 1. Trial using MLAF

No.	Criteria	Test results (%)	Category
1	MLAF noise level	88.96	Totally Agree (TA)
2	The level freedom of hand movement	82.50	Totally Agree (TA)
3.	Parts of MLAF	88.54	Totally Agree (TA)
4.	MLAF eligibility level	88.75	Totally Agree (TA)

Table 2. Contamination test on MLAF

Description	Contamination (%)	Information
Petridish open outside MLAF (positive control)	100	Contaminated
Petridish close outside MLAF (negative control)	0	Not contaminated
Petridish opens in MLAF off state with door open	30	There are 3 contaminated petridish
Petridish opens in MLAF off state with door close	60	There are 6 contaminated petridish
Petridish open in MLAF lit state with door open	0	Not contaminated
Petridish open in MLAF lit state with door close	0	Not contaminated

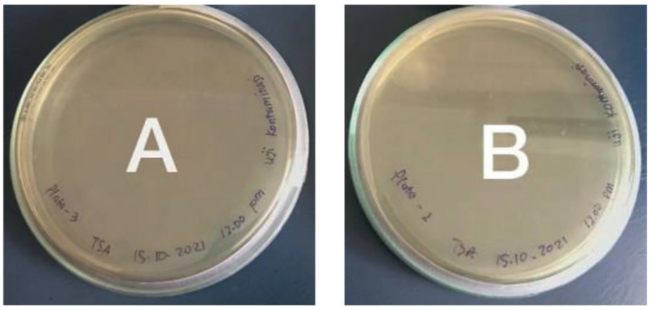

Figure 3. Results of contaminated and uncontaminated tests

so that it does not cause sound or vibration. MLAF noise measurements are also measured using a sound meter which produces an average value of 56.1 dB, which can be seen in Figure 4.

According to Ministerial Regulation No.13/ Men/X/Year 2011 concerning threshold values (NAV) for physical and chemical factors in the workplace, the noise NAV of 85 dB is a value that can still be tolerated and does not cause health problems for workers. For the level of flexibility of hands, respondents assessed that 82.50% strongly agreed that the size of the utility hole and the size of the MLAF did not prevent users from an injection, inserting, and removing tools in the MLAF. This was proven by the absence of user problems at work. Trial using parts from MLAF got the results 88.54% (Fig. 5) strongly agree that the user can easily open and close the utility door, the TL lamp can provide maximum illumination, and the front arch does not block the user's vision. The parts of the MLAF are assembled as simply as possible to provide comfort and convenience at work. While the feasibility level of MLAF obtained results of 88.75% strongly agree that MLAF is easy to operate and can support laboratory activities, it is proven that the movement of inoculating microorganisms in MLAF runs smoothly.

CONCLUSIONS

Mini Laminar Airflow Cabinet can provide a sterile workspace with a relatively small size, easy to manufacture at a low price. This is evidenced from several test results that the airflow inside the MLAF moves one way out through the utility hole. For the contamination test there is 0% uncontaminated Petri dish when the MLAF is on, which is better than MLAF in the off condition by a 60% contaminated Petri dish. The value of UV radiation obtained is 78 W/cm^2. While in the trial using MLAF, as many as 32 respondents assessed > 82.50% strongly agree that MLAF is suitable for use in laboratory activities.

Figure 4. Noise level measurement using a sound meter

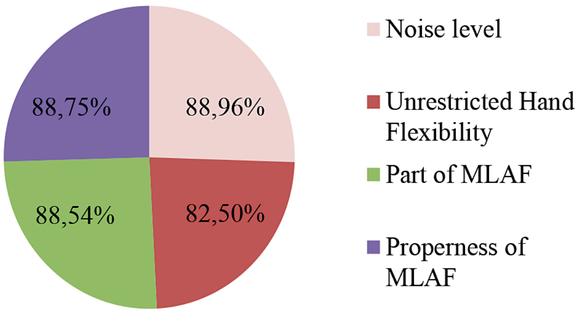

Figure 5. Variance and percentage distribution of the electric power demand in dairy barns

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