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Analysis $PM_{2.5}$ Removal Efficiency and Electrical Energy Consumption in The Use of Air Purifier and Air Conditioner in a Room

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Abstract
Indoor air quality is important for an individual's quality of life because humans often spend 90% of their time indoors. Indoor air quality impacts human comfort, health, and performance. This research aims to identify the effect of variations in AC temperature control systems and air purifier fan speed on PM2.5 concentrations, as well as indoor thermal comfort and recommendations for AC and AP settings to remove PM2.5 with high efficiency and lower electrical energy with statistical tests. The highest percentage of PM2.5 removal when the AC was set to a temperature of 22°C with the AP turned on automatically, namely 89.7% in removing PM2.5. The lowest percentage of removal of PM2.5 concentrations when the AC temperature was set to be turned on at 25°C with the AP set turned off, namely 40.57%. The first recommendation is to set the AC to be turned on at 25°C and the AP to be turned on automatically, which has a percentage of 84.72% with a monthly price of 17,400 IDR. The second condition that can be recommended is setting the AP to be turned on automatically, but the AC set turned off, which has a percentage of 88.34% for 1,800 IDR.
Keywords: *air conditioner, air purifier, electrical energy, indoor air quality, particulate matter 2.5*

Abstrak
Kualitas udara di dalam ruangan atau *indoor air quality* (IAQ) penting untuk kualitas hidup suatu individu karena pada dasarnya manusia sering menghabiskan waktunya 90% di dalam ruangan. Kualitas udara dalam ruangan memiliki efek penting pada kenyamanan, kesehatan, dan kinerja manusia. Penelitian ini bertujuan untuk mengidentifikasi pengaruh dari variasi sistem pengaturan suhu AC dan air purifier (AP*) fan speed* terhadap konsentrasi PM2.5 serta kenyamanan termal di dalam ruang dan rekomendasi pengaturan AC dan AP untuk menyisihkan aerosol dengan tingkat efisiensi yang tinggi dengan energi listrik yang lebih rendah dengan uji statistika. Persentase penyisihan PM2.5 tertinggi adalah kondisi pengaturan AC dengan suhu 22°C dengan AP yang dinyalakan secara otomatis yaitu 89,7% dalam menyisihkan PM2.5. Persentase penyisihan konsentrasi PM2.5 yang paling rendah adalah kondisi pengaturan suhu AC yang dinyalakan pada suhu 25°C dengan AP yang dikondisikan tidak menyala yaitu 40,57%. Rekomendasi pertama yaitu pengaturan AC yang dinyalakan pada suhu 25°C dan AP dinyalakan secara otomatis mempunyai persentase 84.72% dengan harga perbulan Rp 17.400. Kondisi kedua yang dapat direkomendasikan yaitu pengaturan AP yang dinyalakan secara otomatis tetapi AC tidak menyala mempunyai persentase 88.34% dengan biaya Rp 1.800.
Kata Kunci: *pendingin udara, air purifier, energi listrik, kualitas udara dalam ruang, particulate matter 2.5*

1. Introduction

Indoor air quality (IAQ) is important for an individual's quality of life because basically humans often spend 90% of their time indoors. Indoor air quality has important effects on human comfort, health, and performance [1]. Polluted air quality can cause health problems, namely acute respiratory disease, chronic obstructive pulmonary disease and lung cancer [2]. Poor indoor air quality is caused by occupant-related pollutants for example carbon dioxide (CO_2), aerosols, bio-effluent, particulate matter (PM), and building-related pollutants such as volatile organic compounds (VOC). These pollutants can be produced from human activities, for example smoking, cooking, cosmetics and the use of air freshener [3]. A good indoor air quality standard is to optimize the use of ventilation as an indoor air exchange system [4]. Indoor air quality can be said to be adequate according to standards if the concentration of contaminants does not chronically endanger the health of occupants and avoids contaminants that are carcinogenic [5].

The problem of indoor air pollution generally arises from a lack of optimization of ventilation for gas exchange which has the largest percentage, namely 52%, sources of contaminants in the air are smoking, cooking, use of cosmetics and air fresheners [6], with a percentage of 16%, sources of contaminants from outside room 10%, volatile building materials 4%, and others come from pollutant sources caused by respiration of small animals indoors with a percentage of 13% [7]. According to the study, it is also stated that there are five sources of indoor pollution, namely the first, pollution comes from office buildings which produce room cleaning materials, equipment and building materials from buildings that easily evaporate, for example asbestos and cigarette smoke. The second pollutant comes from outside of the building, namely motor vehicle emissions. The third pollutant comes from building materials, for example asbestos, formaldehyde, glue and fiber glass. The fourth source of pollution is due to the growth of microbes in the form of protozoa, bacteria and fungi. The fifth source of pollution is dust, gas, smoke and steam [8]. This research aims to identify the effect of variations in AC temperature control systems and air purifier fan speed on PM2.5 concentrations as well as indoor thermal comfort and recommendations for AC and AP settings to remove aerosols with a high level of efficiency with lower electrical energy with statistical tests.

2. Material and Methods

The location of the research at Department of Environmental Engineering, Faculty of Civil, Planning and Geo Engineering. The specific location of the research was carried out in the Environmental Engineering Department classroom**. Fig. 1** a picture of a classroom. Classroom R.104 as a research object is located on the first floor of the ITS Environmental Engineering Department building. The dimensions of the classroom are 1080 cm × 827.5 cm × 380 cm. Classroom R.104 has two air conditioners located near the windows and one air purifier. The use of AC in this study was one located in the upper left corner of the classroom. The windows in the classrooms in this study will be completely closed so that there is no ventilation through the windows and the door.

Fig. 2 is the classroom layout. Dust Particle Counters (DPC) are placed on the right and left sides of the classroom while spraying air freshener (PM2.5) is carried out in the middle of the classroom. **Fig**. 3 is the configuration of inlet and outlet placement on the air purifier that is most effective in removing aerosols in the room. The configuration for placing the inlet and outlet on the air purifier is a recommendation from previous research, namely that it is more effective if the inlet position is blocked while the outlet position is unblocked.

Fig. 1: Classroom R.104 Department of Environmental Engineering

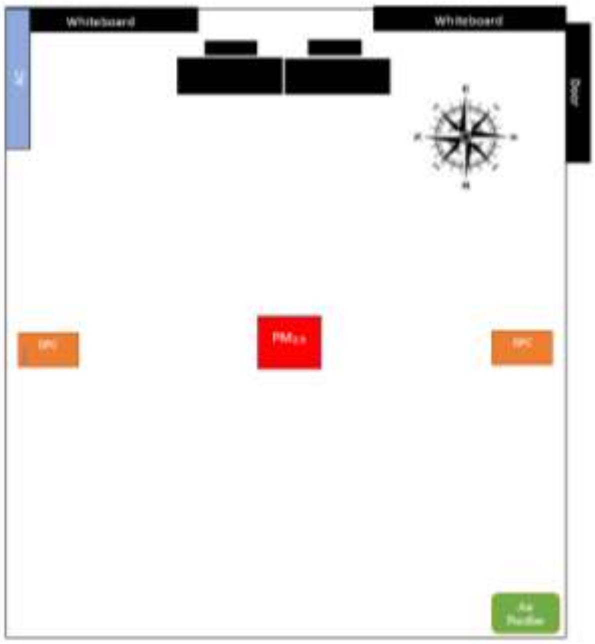

Fig. 2: R.104 Classroom Layout for Experimental Activities

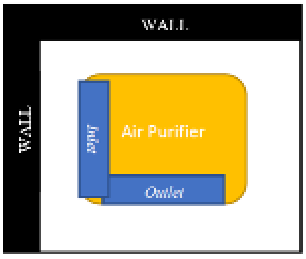

Fig. 3: Configuration of the Inlet and Outlet Placement of the Air Purifier

Preparation of research equipment are an AC and air purifier (AP), HEPA-13 filter, anemometer, dust particle counter (DPC), and barometer. The anemometer is intended to collect data on wind speed in the room, air flow speed in the AC, flow speed of spray fragrance from the injector, and air flow speed in the air purifier, the units used are m/s. The DPC tool is intended to collect temperature and PM concentration data, in °C units for temperature and $\mu g/m^3$ unit for PM concentration. The barometer is intended to collect air pressure data in the classroom environment in hPa unit.

The data collection stage is collecting primary and secondary data. Primary data collection is carried out by measuring using tools, while secondary data collection is obtained through journals, books and other relevant literature. Primary and secondary data collection serves to analyze the efficiency of PM removal in classrooms experimentally. Primary data collected included indoor wind speed, indoor temperature, PM concentration, indoor environmental air pressure, air flow speed in the AC, spray fragrance flow speed from the injector, and air flow speed in the air purifier. Secondary data that needs to be collected includes air density, spray fragrance density, and the temperature of the spray fragrance coming out of the tube. The aerosol that will be analyzed is spray room freshener. The air density in the study was 1,225 kg/m^3, the aerosol density from the spray was 1,200 kg/m^3, and the temperature of the aerosol coming out of the spray tube was 308.15 K or 35°C [9].

Experimental activities were carried out with control variables in the form of AC temperature settings and air purifier fan speed. The pollutant injection (PM2.5) stage uses room freshener in the form of a spray tube which is sprayed for 20 minutes. The pollutant dilution stage in the room is carried out for 60 minutes. The control variables for the condition of the air purifier and air conditioner are on and off. The optimal air conditioner temperature determined in experimental activities is 25°C because according to the (SNI 03-6572-2001, 2001), the optimal thermal comfort for indoor tropical areas it ranges between 22.8°C – 25.8°C and cool comfortable thermal comfort 20.5°C – 22.8°C so that in this study the middle value of this temperature determination was taken, namely 25°C [10]. The lowest AC temperature is set at 22°C. The air purifier (AP) fan speed is set to low, medium and automatic. This automatic state is where the air purifier setting has an automatic state, namely the fan speed will automatically be at high speed because the aerosol concentration in the room is high and vice versa. **Table** 1 is a test of variables in experimental activities.

Table 1. The Variables in Experimental Analysis

Number	Variables		Code
1.	AC OFF	AP OFF	A1
2.	AC OFF	AP ON LOW	A2
3.	AC OFF	AP ON MEDIUM	A3
4.	AC OFF	AP ON AUTO	A4
5.	AC ON LOW	AP OFF	B1
6.	AC ON LOW	AP ON LOW	B2
7.	AC ON LOW	AP ON MEDIUM	B3
8.	AC ON LOW	AP ON AUTO	B4
9.	AC ON OPTIMAL	AP OFF	C1
10.	AC ON OPTIMAL	AP ON LOW	C2
11.	AC ON OPTIMAL	AP ON MEDIUM	C3
12.	AC ON OPTIMAL	AP ON AUTO	C4

The next step is to calculate the price of the electrical energy consumption of the AC and AP used. The usage time is assumed to be 80 minutes or 1.3 hours because it refers to the injection and dilution stages of PM2.5 in the classroom. The electricity tariff category for using AC and AP is R-2, namely for medium households (3,500-5,500 VA) it is 1,467.28 per kWh rounded up to 1,500 per kWh [11]. Details of prices for AC and AP electrical energy consumption can be seen in **Table 2.** Details of Prices and Electrical Energy Consumption for AC and AP**.**

Table 2. Details of Prices and Electrical Energy Consumption for AC and AP

Tool	Condition	Usage time		Electrical power		One month usage (kWh)	Price per kWh (IDR)	Price per month (IDR)
		minute	hour	Watt	kWh			
Air Conditioner	22°C	80	1.33	310	0.41	12.4	1,500	18,600
	25°C	80	1.33	260	0.35	10.4	1,500	15,600
Air Purifiers	Low	80	1.33	15	0.02	0.6	1,500	900
	Medium	80	1.33	25	0.03	1	1,500	1,500
	Automatic	80	1.33	30	0.04	1.2	1,500	1,800

The correlation test is a test used to analysis the direction of the relationship between two variables. These two variables are declared to have a significant relationship if the p-value obtained is lower than 5%. Statistical tests in this study determined the relationship between PM2.5 removal efficiency and the most effective energy from controlling AC temperature and air purifier fan speed.

3. Results and Discussion

The Effect of Variations in AC Temperature Control Systems and Air Purifier Fan Speed on PM2.5 Removal and Thermal Comfort

Setting the temperature of the air conditioner (AC) is useful for thermal comfort, while setting the air purifier (AP) is useful for reducing the concentration of PM2.5. If AC and AP are used simultaneously, a high level of aerosol removal efficiency can be achieved. **Table 3** is the PM2.5 removal efficiency based on peak and low concentrations in DPC 1 and DPC 2. **Table 4** is the result of PM2.5 removal efficiency by varying AC and AP settings in the classroom. The results show that the highest PM2.5 concentration removal efficiency results are in the condition of setting the AC temperature and air purifier fan speed when the AC is turned on at a low temperature (22°C) with the AP set automatically with code B4, namely 89.7 %. The lowest PM2.5 concentration removal efficiency results were in the AC temperature setting condition which was turned on at the optimal temperature in the room (25°C) with the AP conditioned as not turning on with code C1, namely 40.57%. The percentage of PM2.5 removal under these conditions is lower than for AC and AP which are turned off with a percentage of 70.08%.

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This is caused by the influence of gravitational forces on aerosols. Heavier aerosol particles will tend to fall to the floor or other surfaces under the influence of gravity, thereby reducing the concentration of aerosols in the air. Meanwhile, if the AC is turned on but the air purifier is turned off, aerosols will continue to fly in the air and cause the aerosol to fall slowly. The nature of sedimentation or deposition of aerosols also influences the reduction of aerosol concentrations in the air.

Table 3. Peak and Low PM2.5 Concentrations at DPC 1 and DPC 2

No.	Information		Code	PM2.5 concentration (µg/m^3)				Efficiency (%)	
				DPC 1		DPC 2		DPC 1	DPC 2
				Peak	Low	Peak	Low		
1.	AC OFF	AP OFF	A1	243	86	458	112	64.61	75.55
2.	AC OFF	AP ON LOW	A2	284	88	575	125	69.01	78.26
3.	AC OFF	AP ON MEDIUM	A3	270	58	197	41	78.52	79.19
4.	AC OFF	AP ON AUTO	A4	531	68	999	105	87.19	89.49
5.	AC ON LOW	AP OFF	B1	177	95	323	106	46.33	67.18
6.	AC ON LOW	AP ON LOW	B2	282	57	155	48	79.79	69.03
7.	AC ON LOW	AP ON MEDIUM	B3	239	45	382	50	81.17	86.91
8.	AC ON LOW	AP ON AUTO	B4	592	68	999	91	88.51	90.89
9.	AC ON OPTIMAL	AP OFF	C1	61	39	71	39	36.07	45.07
10.	AC ON OPTIMAL	AP ON LOW	C2	65	20	107	20	69.23	81.31
11.	AC ON OPTIMAL	AP ON MEDIUM	C3	162	41	215	45	74.69	79.07
12.	AC ON OPTIMAL	AP ON AUTO	C4	207	39	384	45	81.16	88.28

Table 4. PM2.5 Removal Efficiency Results by AC and AP Arrangements in a Classroom

Information		Code	PM2.5 removal efficiency (%)		Average (%)
			DPC 1	DPC 2	
AC OFF	AP OFF	A1	64.61	75.55	70.08
AC OFF	AP ON LOW	A2	69.01	78.26	73.64
AC OFF	AP ON MEDIUM	A3	78.52	79.19	78.86
AC OFF	AP ON AUTO	A4	87.19	89.49	88.34
AC ON LOW	AP OFF	B1	46.33	67.18	56.76
AC ON LOW	AP ON LOW	B2	79.79	69.03	74.41
AC ON LOW	AP ON MEDIUM	B3	81.17	86.91	84.04
AC ON LOW	AP ON AUTO	B4	88.51	90.89	89.70
AC ON OPTIMAL	AP OFF	C1	36.07	45.07	40.57
AC ON OPTIMAL	AP ON LOW	C2	69.23	81.31	75.27
AC ON OPTIMAL	AP ON MEDIUM	C3	74.69	79.07	76.88
AC ON OPTIMAL	AP ON AUTO	C4	81.16	88.28	84.72

Table 4 shows that the highest PM2.5 removal efficiency recorded by the DPC was the AC setting condition with a low temperature of 22°C with the AP turned on automatically (B4) with a removal percentage of 89.7% in removing PM2.5. The results are a significantly large percentage in removing PM2.5 by involving the air purifier in an automatic condition. The condition of an air purifier is set to turn on automatically is better at removing aerosols due to various reasons, namely an air purification system that operates automatically can detect the level of air pollution and speed up or slow of the fan speed necessary, if the aerosol concentration increases, the air purifier can automatically increase its aerosol filtering capacity is more effectively [12]. Changing the air filling rate in automatic mode can regulate the air circulation and filtering process according to the detected air quality so that aerosols enter the room more quickly and efficiently. The use of automatic mode on the air purifier works flexibly and responds better to fluctuations in air quality. This can result in higher aerosol reduction because the air purifier can work adaptively and optimally according to the needs of the surrounding environment [13].

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DPC 1 is placed near the AC while DPC 2 is placed near the AP. Based on the results of the primary data, it was then substituted into a comparison graph between the concentrations of PM2.5 with an exposure time of 80 minutes. The results showed that the placement of DPC 1 and DPC 2 had different conditions. DPC 1 which is located near the AC has a longer reduction time for aerosol removal concentrations compared to DPC 2 which is located close to the air purifier. This is because aerosols will be absorbed and filtered by the HEPA-13 filter which has small filter pores, namely 0.2 µm in size with an efficiency level of 99.95%. The AC in a class R.104 have filters ranging in size from 10-20 µm. This causes the aerosol that can be filtered by the AC to be of the PM10 type, while PM2.5 still escapes and cannot be filtered.

According to Taib et al., 2022, AC is specifically designed to reach a room temperature that can provide comfort to the occupants in the room, so the benefits of using AC are focused on providing thermal comfort rather than removing aerosols in the room. Air purifiers are able to filter particles in the air, including aerosols that come from air fresheners. Some air conditioners are not specifically designed to filter fine particles such as aerosols. AC usually focuses more on cooling and air circulation. So even if the AC is turned on its effectiveness in removing aerosols is limited [14].

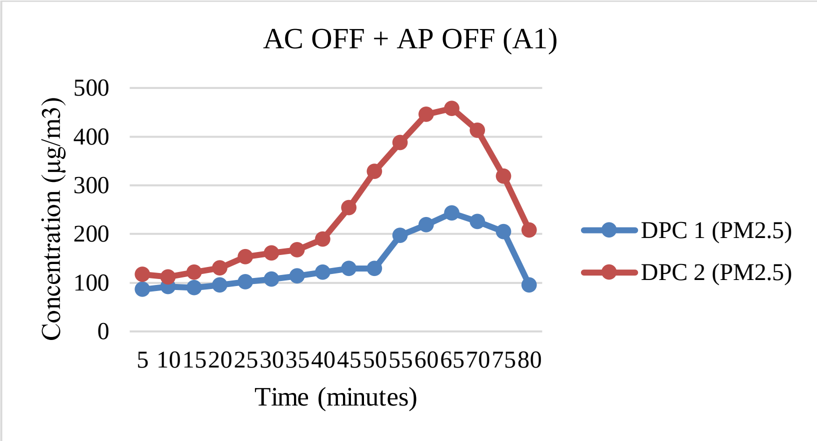

Fig. 4: Graph of Decreased PM2.5 Concentrations with AC and AP Conditions are Turned Off

Fig. 4 is a condition where the AC and AP are turned off. The decrease in PM2.5 concentrations still occurs under these conditions but the percentage of removal efficiency is low, namely 70%. The decrease in aerosol concentration from air fresheners without AP or AC may involve a number of factors and natural mechanisms. For example, these factors include sedimentation and deposition processes. This process makes aerosols in the air tend to have sedimentation properties, namely the process of particles falling on the surface of objects in the room. Aerosol accumulation on the surface of objects such as walls can reduce the concentration of aerosols in the air. Although the condition of the AC and AP not being on can reduce aerosol concentrations, additional devices such as APs or HEPA filtered air purifiers can be a more effective solution for cleaning indoor air.

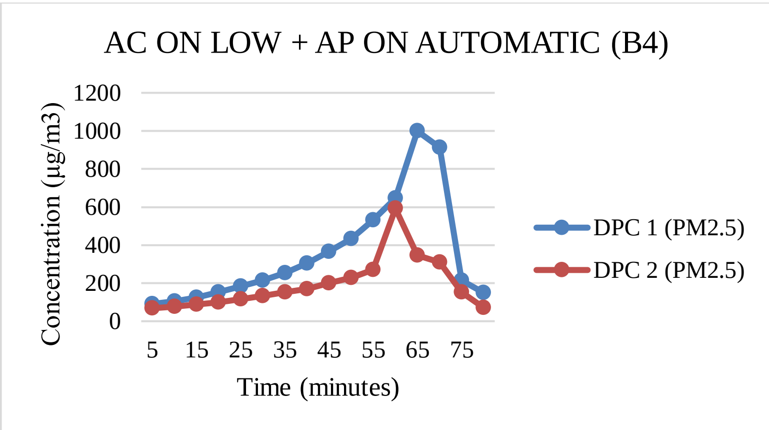

Fig. 5: Graph of Decreased PM2.5 Concentrations with the AC Condition at Low Temperature and the Air Purifier Fan Speed Adjusted Automatically

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Fig. 5 is a graph of the decrease in PM2.5 concentrations with the AP fan speed set automatically and the AC turned on at 22°C. The peak time for PM2.5 concentrations recorded in DPC 1 occurred at 65 minutes, namely the aerosol dilution time (dilution) in the classroom, while the decrease in PM2.5 concentrations occurred at 70 minutes of dilution, while the results recorded in DPC 2 were faster on reducing PM2.5, namely at 65 minutes of dilution.

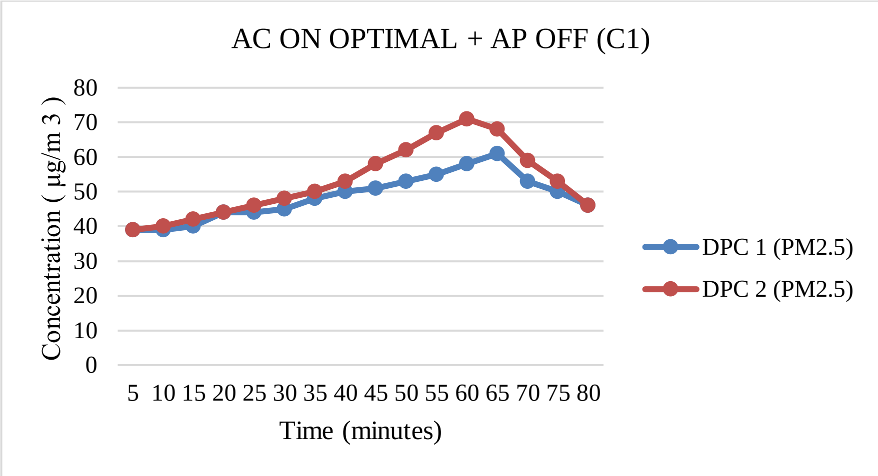

Fig. 6: Graph of Decreased Concentrations of PM2.5 with the AC Condition at Optimal Temperature and the Air Purifier is Turned Off

Fig. 6 is a graph of the decrease in PM2.5 concentrations when the AP is turned off. The peak time for PM2.5 concentrations recorded in DPC 1 occurred at 65 minutes, namely the dilution time in the classroom and the decrease in PM2.5 occurred at 70 minutes of dilution, while the results recorded in DPC 2 were faster reduction in PM2.5, namely at 65 minutes of dilution. It causes of the long decline in PM2.5 concentrations occurs due to a number of factors that can be related to the nature and size of aerosol particles, indoor environmental conditions, and the capacity of the air purifier. Aerosols can consist of particles of different sizes. Larger particles may be more easily filtered by an air purifier while fine particles may take longer to completely remove. Air purifiers have a certain capacity to handle air volume. If the initial aerosol concentration is very high, the air purifier may take longer to reduce the concentration significantly. Environmental factors such as humidity, temperature and air composition can influence aerosol behavior [15].

The physical and chemical properties of aerosols from spray fresheners consist of liquid particles or a mixture of solid and liquid particles. The general characteristics of room spray freshener aerosols are physical characteristics which include particle size and persistence. Chemical characteristics include fragrances and solvents. Fragrances used in aerosols can vary and often consist of volatile organic compounds (VOCs) that can cause odors. Aerosols contain solvents in the form of water or volatile organic compounds such as ethanol. The ability of an air purifier equipped with a HEPA (High-Efficiency Particulate Air) filter to filter aerosols can effectively filter most particles from the air, including most aerosol particles from air fresheners. HEPA filters are very effective at capturing fine particles as 0.2 microns [16]. Environmental factors such as humidity and temperature can influence aerosol behavior in different ways and their influence depends on the specific properties of the aerosol. Air humidity causes evaporation effects, particle coagulation, and aerosol stability. The temperature in the room causes changes in the phase of the aerosol particles and changes in size [15].

High humidity can influence aerosol behavior because liquid particles can absorb water vapor and increase in size. This can make the particles heavier and tend to settle more quickly, whereas low air humidity can make the particles tend to float in the air. Air humidity can affect particle coagulation, which means particles clump together into larger particles [17]. High humidity can increase the possibility of coagulation which can accelerate particle deposition. The temperature in the room causes changes in the phase of the aerosol particles and changes in size. Increasing temperature can cause liquid particles to evaporate and become smaller particles which more difficult to settle [15].

Recommendations for AC Temperature Control Systems and Air Purifier Fan Speeds to Obtain High Levels of PM2.5 Removal Efficiency with Lower Electrical Energy Consumption

The AC temperature control system and AP fan speed in a classroom that is turned on for 80 minutes will be compared with the cost of electrical energy. This comparison is assumed to be low cost if the monthly price for 80 minutes of use is below 18,000 IDR, while the cost is expensive if the price is more than or equal to 18,000 IDR. **Table 5** is the cost of electrical energy consumption when using AC and AP indoors. Table 6 is the result of a correlation test.

Table 5. Electrical Energy Consumption Costs for AC and AP

Information		Code	Average removal efficiency (%)	Price per month for 80 minutes of use (IDR)	Cheap < 18000 IDR	Expensive ≥ 18000 IDR
AC OFF	AP OFF	A1	70.08	0	✓	
AC OFF	AP ON LOW	A2	73.64	900	✓	
AC OFF	AP ON MEDIUM	A3	78.86	1500	✓	
AC OFF	AP ON AUTO	A4	88.34	1800	✓	
AC ON LOW	AP OFF	B1	56.76	18600		✓
AC ON LOW	AP ON LOW	B2	74.41	19500		✓
AC ON LOW	AP ON MEDIUM	B3	84.04	20100		✓
AC ON LOW	AP ON AUTO	B4	89.70	20400		✓
AC ON OPTIMAL	AP OFF	C1	40.57	15600	✓	
AC ON OPTIMAL	AP ON LOW	C2	75.27	16500	✓	
AC ON OPTIMAL	AP ON MEDIUM	C3	76.88	17100	✓	
AC ON OPTIMAL	AP ON AUTO	C4	84.72	17400	✓	

Table 6. Correlation Test Results Between Efficiency and Cost Variables

Variable	Information	Cost
Efficiency	Pearson Correlation	0.740
	Sig. (2-tailed)	0.006

Table 6 shows that the p-value of the efficiency and cost variables is 0.006. This value is smaller than the 5% significance level. Thus, it can be concluded that these two variables have a significant relationship or are correlated. The Pearson correlation coefficient obtained from the cost variable is 0.740, so it can be concluded that this variable has a strong unidirectional (positive) relationship with the efficiency variable. Cheaper costs with high efficiency in removing PM2.5 concentrations can be used as a recommendation in choosing AC and AP settings.

The results of the efficiency of removing PM2.5 in the first condition, which can be used as a recommendation, setting the AC to be turned on at 25°C and the AP to be turned on automatically has a percentage of 84.72% with a monthly price of 17,400 IDR for using the AC and AP for 80 minutes. The second condition, namely at a cheaper cost with a large efficiency allowance, is another setting where the AP is turned on automatically but the AC is turned off, which has a percentage of 88.34% at a cost of 1,800 IDR. Even though the second condition has high PM2.5 removal efficiency at a lower cost than the first condition, the use of AC is important for indoor thermal comfort. If the AC is turned off, occupant must consider the comfortable temperature in the room. This can be influenced by the number of occupants in the room, the more occupants, the higher the temperature in the room.

4. Conclusion

The highest PM2.5 removal efficiency results recorded by the DPC were conditions of setting the AC with a low temperature of 22°C with the AP being turned on automatically (B4) with a removal percentage of 89.7% in removing PM2.5. The lowest efficiency results for removing PM2.5 concentrations were the conditions for setting the temperature of the AC which was turned on at the optimal temperature in the room (25°C) with the AP conditioned as turning off with a code C1, namely 40.57%. The percentage of PM2.5 removal under these conditions is smaller than for AC and AP which is turned off with a percentage of 70.08%. DPC 1 which is located near the AC has a longer reduction time for aerosol removal concentrations compared to DPC 2 which is located close to the air purifier. This is because aerosols will be absorbed and filtered by the HEPA-13 filter which has very small filter pores, namely 0.2 µm.

Cheaper costs with high efficiency in removing PM2.5 concentrations can be used as a recommendation in choosing AC and AP settings. The results of the efficiency of removing PM2.5 in the first condition, namely setting the AC to be turned on at 25°C and the AP being turned on automatically, has a percentage of 84.72% with a monthly price of 17,400 IDR. The second condition, namely at a cheaper cost with a large efficiency allowance, is another setting where the AP is turned on automatically but the AC is turned off, which has a percentage of 88.34% at a cost of 1,800 IDR. If the AC is turned off, occupant must consider the comfortable temperature in the room. This can be influenced by the number of occupants in the room, the more occupants, the higher the temperature in the room.

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