Data Analysis of Indoor Air Quality with and without HEPA Filter in Air Purifier (Study Case: East Jakarta Residential Area)

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Abstract. Humans in good health breathe air containing 21% oxygen ($O_2$) (1). At rest, humans typically inhale and exhale approximately 12 times per minute (2). When people engage in activities, the number of breaths increases; for example, when runners do a marathon run outdoors, it dramatically accelerates the rate of airborne particulate matter (PM$_1$, PM$_{2.5}$, PM$_{10}$) deposition in runners' respiratory tracts (3). Good air quality is essential for humans to breathe, and measuring the air quality both indoors and outdoors is also necessary (4) to have healthier daily life.

In fine particulate matter PM$_{2.5}$, some factors and situations may impact the value, such as weather (4,5), indoor-outdoor (6,7), and others. This value may be different in one place and another. Jakarta has two seasons (dry and rainy seasons), and its located near the equator.

1 Introduction

Healthy humans breathe air containing 21% of oxygen ($O_2$) (1). At rest, humans typically inhale and exhale approximately 12 times per minute (2). When people engage in activities, the number of breaths increases; for example, when runners do a marathon run outdoors, it dramatically accelerates the rate of airborne particulate matter (PM$_1$, PM$_{2.5}$, PM$_{10}$) deposition in runners' respiratory tracts (3). Good air quality is essential for humans to breathe, and measuring the air quality both indoors and outdoors is also necessary (4) to have healthier daily life.

In fine particulate matter PM$_{2.5}$, some factors and situations may impact the value, such as weather (4,5), indoor-outdoor (6,7), and others. This value may be different in one place and another. Jakarta has two seasons (dry and rainy seasons), and its located near the equator.
(8,9), which has temperature relatively high (9). Jakarta's air quality requires particular attention (10). Air purifier/filtration helps improve indoor air quality (11,12), which needs to be tested in East Jakarta – Indonesia.

Various types of air purifiers can be found on e-marketplaces in Jakarta. Air purifiers are divided into different filters: high-efficiency particulate air (HEPA) and electrical filters (13). HEPA filters have been developed and improved as part of ongoing efforts to maintain clean, breathable air (14). Air purifiers with HEPA filters effectively reduce particulate matter (15).

This research aimed to investigate how installing a HEPA in an air purifier affects air quality in a residential area in East Jakarta, Indonesia. The findings of this research contribute to providing a solution on whether to use or not to use air purifiers indoors to achieve better air quality.

2 Research Methodology

This research employed a quantitative, primary, and descriptive approach to gather data similar to the previous research approach (4,7). Additionally, statistical analysis was conducted in this study.

2.1 Research Preparations

There are steps in this research, Figure 1 shows each step that has been taken:

![Diagram of research flows]

**Fig. 1. Research Flows.**

A literature study has been performed with the support of articles from journals, proceeding, and some official websites related to air quality. A small portable air purifier with a HEPA filter was procured in late 2022, and an air quality sensor was procured earlier through an e-marketplace in Indonesia. The HEPA filter dimension used in this research was 34 x 27 x 2.5 cm.

The air purifier and the sensor were positioned on top of the 1-meter table in the living room with a volume of approximately 45m³ living room. The house was located in a residential area in Ciracas, East Jakarta, Indonesia. They were placed in the centre of the room to accommodate the movement of people and allow proper airflow from outdoors. Figure 2 shows the sensor position during the research period.
Fig. 2. Sensor Position During Data Acquisition

The sensor was directly powered to electricity and connected via Wireless LAN to the Internet, so the sensor could synchronize the date/time and gather outdoor data from the sensor. The sensor captured data for 14 days with two scenarios. Sensor stored locally the captured data similarly to other research (16) as a text file in CSV format, then data standardization was processed with the support of a spreadsheet desktop application.

The sensor can capture some parameters of the air, and only six were used in this research, they were PM$_1$, PM$_{2.5}$, PM$_{10}$, CO$_2$, Temperature (in Celsius), and Humidity. Unnecessary columns were eliminated during data cleansing for more accessible analysis, and decimal conversion was made from the text-generated data as standardization for statistical calculation. Data visualizations were also made and put on this document for analysis purposes. Analysis was made in the Result and Discussion section, and the conclusion for this research can be found in the last part.

2.2 Data Acquisitions

The sensor used in this research was AirVisual Pro, a low-cost sensor with high accuracy (17). Data was captured from January 1$^{st}$ to January 14$^{th}$, 2023, with a sensor set up to capture data every 3 minutes in 24 hours and two weeks. Phase 1 was day-1 to day-7 when the sensor captured data with the activated air purifier, and phase 2 was day-8 to day-14 when the sensor captured data with the air purifier deactivated.

Data was then accessible to be downloaded from the sensor after day-14 as guided (18). The data format was in text CSV file was then copied to local computer storage for further steps. The ideal amount of data captured every 3 minutes in 14 days was 6,720 rows of data, and the actual data captured was 8,018 rows, which was 119.32% from the ideal seen from the data that there were times when the sensor captured data in intervals of 10 seconds. This interval is in range with that defined by the Government (19).

Population means were calculated from the data collected both with and without air purifiers. The population standard deviation was determined using Equation 1:

\[
\sigma = \sqrt{\frac{\sum_{i=1}^{N} (x_i - \mu)^2}{N}} \tag{1}
\]

The result was then analyzed and discussed in more detail in the following section.
3 Result and Discussions

Based on data acquisition processes in this research, it was found that PM$_1$, PM$_{2.5}$, and PM$_{10}$ fluctuated. This variability was attributed to certain periods when the value decreased during less busy times while increasing due to the hectic schedules of people's activities in Jakarta. Figure 3 shows the result from Day-1 to Day-7 with an installed air purifier and HEPA filter:

![Figure 3. PM$_1$, PM$_{2.5}$, and PM$_{10}$ with HEPA Filter Result Analysis](image)

**Fig. 3.** PM$_1$, PM$_{2.5}$, and PM$_{10}$ with HEPA Filter Result Analysis

From Figure 3 can be seen that all Particulate Matters increased during office days and office hours. There were instances when spikes were noticed, indicating increments in Particulate Matter value. These spikes coincided with the start of office hours in Jakarta, which aligns with the finding of this research paper (20). A linear trend line was then defined to understand the situation for this air quality, and it was found that the trends were inclining gradually in the seven days of data acquisition with the air purifier activated. There were times when the particulate matter had the lowest value, especially during the new year public holiday and in the early morning.

Like in Figure 3, Figure 4 demonstrates that the particulate matter spiked more when the air purifier was deactivated. It further illustrates that the value of PM$_1$, PM$_{2.5}$, and PM$_{10}$ higher in $\mu$g/m$^3$, and it was found that this graph had a higher value compared to the situation in which the air purifier was activated.

![Figure 4. PM$_1$, PM$_{2.5}$, and PM$_{10}$ Without HEPA Filter Result Analysis](image)

**Fig. 4.** PM$_1$, PM$_{2.5}$, and PM$_{10}$ Without HEPA Filter Result Analysis
From Figure 4, it was also found that the linear trend in seven days also gradually inclined with different values of inclination compared with before. From all rows of data, mean, and standard deviation have been calculated for the six parameters captured by the sensor. The summary of the result is presented in Table 1.

<table>
<thead>
<tr>
<th></th>
<th>Without HEPA</th>
<th>With HEPA</th>
<th>Diff</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM₁ (µg/m³)</td>
<td>27.46 ± 13.21</td>
<td>18.58 ± 9.01</td>
<td>↓ 8.88</td>
</tr>
<tr>
<td>PM₂.₅ (µg/m³)</td>
<td>29.8 ± 15.16</td>
<td>19.68 ± 9.94</td>
<td>↓ 10.12</td>
</tr>
<tr>
<td>PM₁₀ (µg/m³)</td>
<td>30.4 ± 15.96</td>
<td>19.91 ± 10.18</td>
<td>↓ 10.49</td>
</tr>
<tr>
<td>CO₂ (ppm)</td>
<td>578.58 ± 117.99</td>
<td>571.1 ± 112.67</td>
<td>↓ 7.48</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>29.51 ± 0.59</td>
<td>27.7 ± 0.79</td>
<td>↓ 1.81</td>
</tr>
<tr>
<td>Humidity (%RH)</td>
<td>69.42 ± 2.74</td>
<td>77.11 ± 4.15</td>
<td>↑ 7.69</td>
</tr>
</tbody>
</table>

All six parameters selected to be captured in this research show that all the values went down after the air purifier with the HEPA filter was activated except for the humidity. PM₂.₅ values show in the range of average category (21), while PM₁₀ values show in the range of good category (22) based on Indonesia's air pollutant standard index. This means that the data captured were in an appropriate value. Similar research (15,23) shows that air purifiers reduce the particulate matter in the air.

### 4 Conclusions

It has been found that activating an indoor air purifier with a HEPA filter for 24 hours in 7 days reduced all three types of particulate matter, directly improving the air quality during the research period in the East Jakarta residential area from 8.88 to 10.49 µg/m³ with standard deviations of 9.01 to 10.18 µg/m³. Additionally, carbon dioxide was also found to be decreased when the air purifier was activated.

### References


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