



APPLICATION OF ANOVA THEORY TO COFFEE POWDER AS AN IOT-BASED AIR FILTER

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Abstrak

Penelitian ini bertujuan untuk menganalisis efektivitas lima jenis ampas kopi sebagai penyaring udara pada sistem berbasis Internet of Things (IoT) dengan penyimpanan data pada Firebase. Untuk mengetahui kinerja masing-masing jenis ampas kopi dalam menyaring udara digunakan metode Analysis of Variance (ANOVA). ANOVA digunakan untuk mengidentifikasi perbedaan signifikan dalam kemampuan penyaringan di antara lima jenis ampas kopi. Sistem IoT yang dikembangkan pada penelitian ini dilengkapi dengan sensor kualitas udara MQ-135 yang terhubung dengan mikrokontroler untuk memantau parameter seperti partikel debu, kelembapan, dan suhu. Data yang diperoleh dari sensor disimpan di Firebase, sebuah platform penyimpanan berbasis cloud. Hasil penelitian menunjukkan adanya perbedaan signifikan kemampuan penyaringan udara di antara lima jenis ampas kopi yang diuji. Ampas kopi Excelso menunjukkan kinerja terbaik dengan efisiensi penyaringan tertinggi, sedangkan ampas kopi Luwak White Koffie menunjukkan kinerja terendah. Penelitian ini menyoroti potensi penggunaan ampas kopi sebagai bahan penyaring udara yang ramah lingkungan dan efektif. Penerapan sistem berbasis IoT memungkinkan pemantauan kualitas udara secara real-time dan penyimpanan data yang efisien di Firebase. Temuan dari penelitian ini diharapkan dapat berkontribusi pada pengembangan teknologi penyaringan udara yang inovatif di masa depan.

Kata Kunci: Filter Udara, Kopi Bubuk, IOT.

Abstract

This study aims to analyze the effectiveness of five types of coffee grounds as air filters in an Internet of Things (IoT)-based system with data storage on Firebase. To determine the performance of each type of coffee grounds in filtering air, the Analysis of Variance (ANOVA) method is applied. ANOVA is used to identify significant differences in filtering capabilities among the five different types of coffee grounds. The IoT system developed in this study is equipped with an MQ-135 air quality sensor connected to a microcontroller to monitor parameters such as dust particles, humidity, and temperature. The data obtained from the sensor is stored in Firebase, a cloud-based storage platform. The results of the study indicate significant differences in air filtering capabilities among the five types of coffee grounds tested. Excelso coffee grounds showed the best performance with the highest filtering efficiency, while Luwak White Koffie grounds exhibited the lowest performance. This research highlights the potential use of coffee grounds as an environmentally friendly and effective air filtering material. The implementation of the IoT-based system allows for real-time air quality



monitoring and efficient data storage in Firebase. The findings from this study are expected to contribute to the development of innovative air filtration technology in the future.

Keywords: *Air Filter, Coffe Powder, IOT.*

1. INTRODUCTION

Air is a very important natural element for living beings, especially humans. Humans, animals, and plants rely heavily on air for breathing to sustain their lives (Fernando WG., 2012; Hsia CC, Schmitz A, Lambertz M, Perry SF, Maina JN, 2013). However, often, air is polluted by various pollutants, which automatically lower air quality. Pollutants such as dust, gases, and odors come from various sources, such as motor vehicles, factory waste, and industries (IEA, IRENA, UNSD, World Bank, WHO, 2022; Puthumana JS, et.al., 2021). Pollutants that also contribute to lowering air quality are often found around us, such as cigarette smoke, towering piles of garbage, and burning trash smoke.

Cigarette smoke is one of the sources of odor that many people dislike due to its pungent smell and the chest tightness it causes (Blomkvist A, Hofer M., 2021; Akcan E, Polat S, 2016). Cigarettes are one of the biggest health problems in the world. The World Health Organization (WHO) states that cigarettes cause fatal health problems, leading to the death of approximately 6 million people per year (IEA, IRENA, UNSD, World Bank, WHO, 2022). The risk of death due to smoking is higher for active smokers compared to passive smokers (Kim, J., Song, H., Lee, J, 2023; Taucher, E., Mykoliuk, I., Lindenmann, J. & Smolle-Juettner, F.-M., 2022). The level of cigarette consumption in Indonesia is relatively high, according to WHO survey results. Indonesia ranks first in Southeast Asia in terms of daily adult smoker prevalence, and these adults have typically been smoking since their teenage years (Rifqy, et.all, 2022; Fithria F, Adlim M, Jannah SR, Tahlil T, 2021; Bird Y, Staines-Orozco H, Moraros J., 2016).

In this study, the author intends to test 5 different variants of coffee to be used as air filters mixed with activated charcoal in a 2:1 ratio, in order to find the best coffee grounds for air filtration. Subsequently, the author implements the ANOVA theory to determine the significance of differences in each test sample.



2. RESEARCH METHOD

In conducting the research, the author followed several research method stages tailored to the research needs. In the first stage, the author conducted a literature review by searching for various references on clean and healthy air, types of coffee grounds, benefits of activated charcoal and its daily uses, Arduino theory and sensors, as well as ANOVA analysis theory. In the second stage, the author held consultation and guidance sessions with IT experts. Armed with all this, the author then carried out the experimental stage by developing the hardware side, namely an IoT-based air neutralizer prototype, and the software side, namely the use of Telegram and Firebase.

The hardware development involved using Arduino Uno and the MQ-135 Sensor. Arduino UNO is a microcontroller board with the ATmega328 chip, having 14 digital I/O pins (6 of which can be used as PWM outputs), 6 analog input pins, a 16 MHz crystal oscillator, a USB interface, and a reset button. This board is easily connected to a computer via USB or an AC-DC adapter, and is suitable for various electronic projects and microcontroller programming (Priyo Utomo, Kurniawan, & Vidyastari, 2023).

The next development is the MQ-135 sensor, which functions as a smoke detector. The MQ-135 sensor is a type of chemical sensor that is sensitive to compounds such as NH₃, NO_x, alcohol, benzol, smoke (CO), CO₂, and others. This sensor works by receiving changes in resistance (analog) when exposed to gases. This sensor has good durability for use as a pollution hazard marker because it is practical and does not consume much power. The sensitivity adjustment of the sensor is determined by the resistance value of the MQ-135, which varies for different gas concentrations.

Next, on the software development side, the platforms Telegram and Firebase were used. Telegram is used to read the air monitoring results in the form of air PPM (parts per million) readings taken by the sensor. The collected data is analyzed using ANOVA analysis theory. Meanwhile, Firebase is used to track changes in sensor readings during testing by detecting the presence or absence of smoke in the testing process

3. RESULTS AND DISCUSSION

The author uses the latest air measurement standards, Regulation No. 14 of 2020 issued by the Ministry of Environment and Forestry (KLHK), which replaces the Decree of the



Minister of Environment No. 45 of 1997 on the Calculation, Reporting, and Information of the Air Pollutant Standard Index (ISPU). This latest regulation includes 7 parameters: PM10, PM2.5, NO2, SO2, CO, O3, and HC, with two additional parameters, HC and PM2.5. It showed in table 3.1.

Table 3. 1 Concentration Value Conversion Table

ISPU	24 Hour PM 10 (µg/m ³)	24 Hour PM 2.5 (µg/m ³)	24 Hour SO2 (µg/m ³)	24 Hour CO (µg/m ³)	24 Hour O3 (µg/m ³)	24 Hour NO2 (µg/m ³)	24 Hour HC (µg/m ³)
0-50	50	15.5	52	4000	120	80	45
50-100	150	55.4	80	8000	235	200	90
101-200	350	150.4	365	15000	400	1130	180
201-300	420	250.4	800	30000	800	1130	432
>300	500	500	1200	45000	1000	3000	648

The calculation of the Air Pollutant Standard Index (ISPU) is based on the upper ISPU limit, lower ISPU limit, upper ambient limit, lower ambient limit, and measured ambient concentration. The mathematical equation for calculating ISPU is as follows:

$$I = \frac{I_a - I_b}{X_a - X_b} (X_a - X_b) + I_b$$

Which,

I = ISPU Calculated

Ia = ISPU Upper Limit

Ib = ISPU Lower Limit

Xa = Upper limit Ambient Concentration (µg/m³)

Xb = Lower Limit Ambient Concentration (µg/m³)

Xx = Actual Ambient concentration Measurement (µg/m³)

Table 3. 1 Table of Air Pollutant Index Categories

Range	Category	Explanation
1-50	Good	Air quality is very good. It does not have negative effects on humans, animals, or plants.



51-100	Moderate	Air quality is still acceptable for human, animal, and plant health.
101-200	Unhealthy	Air quality is harmful to humans, animals, and plants.
201-300	Very Unhealthy	Air quality can increase health risks for certain segments of the exposed population.
301+	Hazardous	Air quality can cause serious health effects in the population and requires immediate action.

At this stage, the author conducted a series of tests using 5 coffee powder samples and activated charcoal in a 2:1 ratio. The coffee powders used are commonly found around us, such as Kapal Api, Nescafe, Torbika, Luwak White Koffie, and Excelso coffee. The tests were conducted in a designated room with dimensions 3x4 meters, using cigarette smoke for the testing. The author used the MQ-135 Sensor Sensitivity Characteristics graph to convert the sensor's analog signal into air PPM.

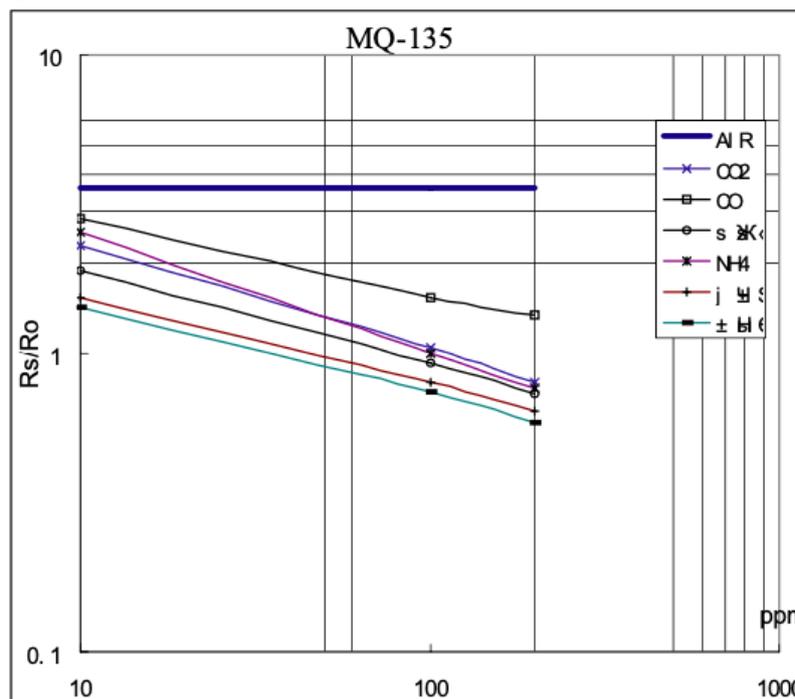


Figure 3.1 MQ-135 Sensor Sensitivity Characteristics

The results of the tests conducted by the author on the 5 coffee powder samples and the activated charcoal mixture show a significant difference in air filtration performance.



Table 3.3 Table of Air PPM Measurement Results

No	Coffe Powder Sample	Initial PPM	Final PPM	Time
1	Kapal Api	465	45	18 Minutes
2	Nescafe	441	32	23 Minutes
3	Torabika	473	185	+ 20 Minutes
4	Luwak White Koffie	471	253	+ 20 Minutes
5	Excelso	483	44	15 Minutes

The test results show a variation in performance among the different samples. Kapal Api coffee was the first sample tested. It was observed that Kapal Api coffee powder was able to reduce the air PPM to 45 PPM within 18 minutes. The second test used Nescafe coffee powder, which achieved a final PPM of 32 after 23 minutes, effectively reducing the air PPM to a safe level. The third test used Torabika coffee powder, which produced somewhat different results compared to the previous tests. The final result for Torabika coffee powder showed an air PPM still above 185 PPM after 20 minutes of testing. The author concludes that Torabika coffee powder is not effective enough in reducing PPM levels.

The next test involved Luwak White Koffie coffee powder using the same method. The results showed that Luwak White Koffie coffee powder was not very effective in reducing air PPM, with a final PPM of 253 after 20 minutes. It may require a significantly longer time to reach a safe level. The final test used Excelso coffee powder with a similar method. The results indicated that Excelso coffee powder was the most effective in reducing air PPM, reaching a safe level in 15 minutes. This demonstrates that Excelso coffee powder is the most effective among all the tested samples.



Figure 3.2 PPM Reading in Telegram



The data from the subsequent tests were further developed and analyzed using ANOVA theory to assess the significance of each sample. A box plot was generated as the final result using SPSS. In this study, ANOVA was used to evaluate the significance of each sample's performance in terms of air filtration efficiency. By analyzing multiple samples, it was possible to identify which configurations of coffee powder and other variables (such as particle size and packing density) yielded statistically significant improvements in air quality. Visualization with Box Plots. Box plots, also known as box-and-whisker plots, are a graphical representation of data distribution and variability. They provide a concise summary of the data, highlighting key statistics such as the median, quartiles, and potential outliers.

The theoretical benefits of using box plots include: Data Summary: Box plots offer a clear summary of the central tendency, spread, and skewness of the data (Cooksey RW., 2020). The median line within the box represents the central value, while the edges of the box indicate the first and third quartiles. Comparison Across Groups: Box plots are particularly useful for comparing distributions across different groups (Regina L. Nuzzo, 2016). In this study, box plots were generated for each sample to visually compare their air filtration performance. Detection of Outliers: Box plots also help in identifying outliers, which are data points that deviate significantly from the rest of the data (M. Papatsimouli., et.al., 2022; R. Fauzi Siregar, R. Syahputra, and M. Yusvin Mustar, 2017). Outliers can provide insights into unusual or extreme behaviors in the system. Visual Appeal: Box plots are an effective way to communicate complex statistical information in a simple and visually appealing manner (A. Aneesh, A. Cyriac, and S. Basheer., 2019; P. Borkar., et.al., 2021; Rohana and Suwarno, 2017). They make it easier for stakeholders to grasp the results of the ANOVA analysis. By generating box plots using SPSS, the study was able to visually represent the distribution and variability of the air filtration performance across different samples. This visualization complemented the ANOVA analysis, providing a comprehensive understanding of the data and supporting the conclusions drawn from the statistical tests.

Source	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	320640.41	4	80160.10	5.726	0.000
Within Groups	1302001.59	93	14000.02		
Total	1622642.00	97			

Figure 3.3 SPSS Output Anova Theory



- **Calculated F-Statistic:** 5.725714670547589
- **p-value:** 0.0003649160673588886

Since the p-value is much smaller than the common significance level (e.g., 0.05), we reject the null hypothesis. This indicates that there is a significant difference between the average air PPM results from the filtration using different coffee variants.

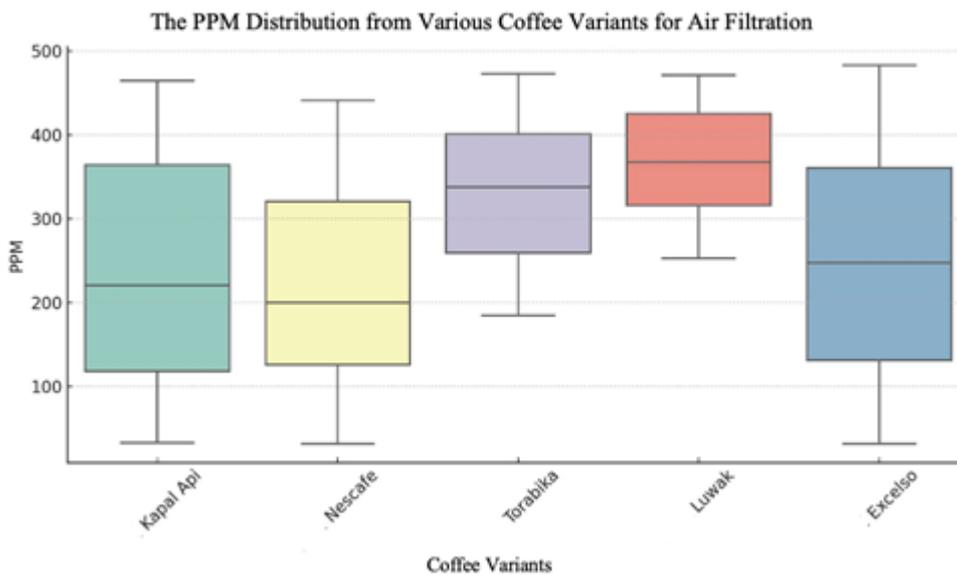


Figure 3.4 Boxplot Graphic

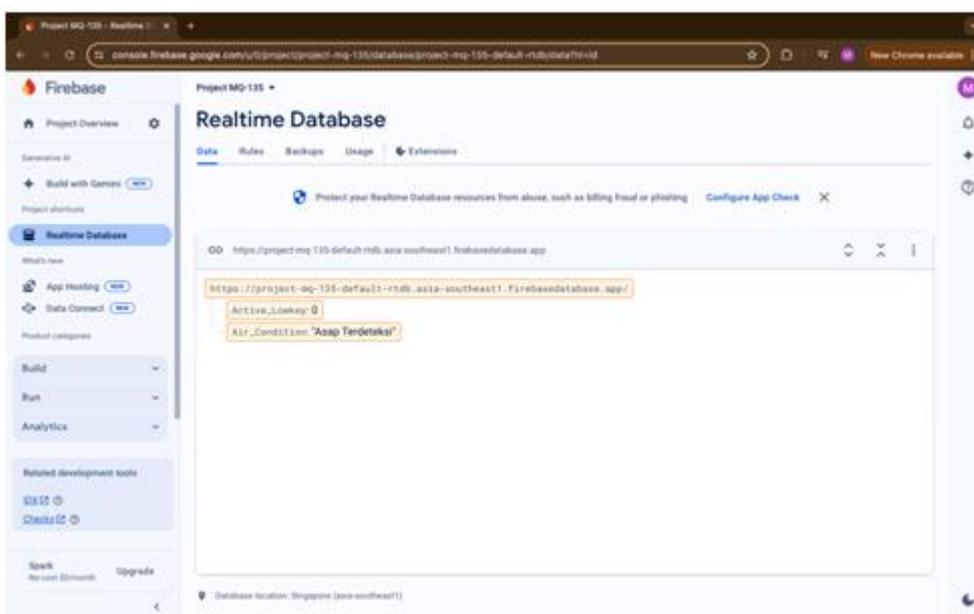


Figure 3.5 Firebase Notification When Smoke is Detected

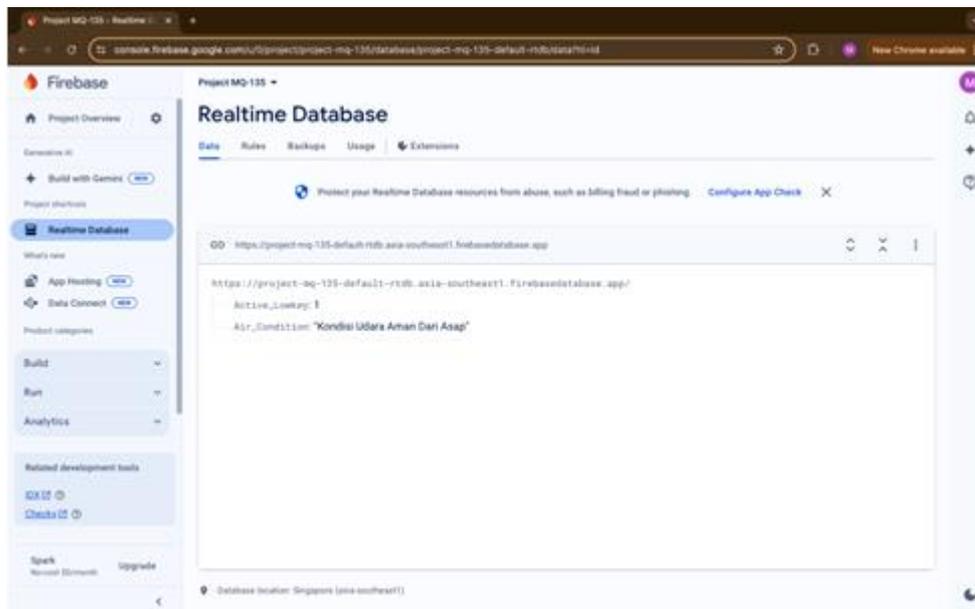


Figure 3. 6 Firebase Notification When Smoke is Not Detected

The Firebase Realtime Database is used to check notifications for the presence or absence of detected smoke during testing or device usage. The integration of the Firebase Realtime Database for monitoring smoke detection via notifications proved to be a pivotal component in the functionality and reliability of the IoT-based air filter system using coffee powder (Lee, Chung-Hyun, Woo-Hyuk Lee, and Sung-Min Kim, 2023)³. This discussion delves into the implications, performance, and potential improvements of utilizing Firebase in this context. The use of Firebase Realtime Database in the IoT-based air filter system for smoke detection proved to be highly effective, offering real-time monitoring, reliability, and ease of use. The platform's capabilities significantly contributed to the system's overall performance and user experience. Future enhancements and additional security measures can further improve the system, making it an even more robust solution for air quality monitoring and smoke detection.

4. CONCLUSION

The application of Analysis of Variance (ANOVA) theory to evaluate the effectiveness of coffee powder as an IoT-based air filter has yielded significant insights. Through rigorous experimentation and statistical analysis, it was determined that coffee powder exhibits promising potential as a viable air filtration medium. The study focused on comparing the air filtration efficiency of coffee powder against traditional filters, measuring variables such as



particulate matter reduction, odor absorption, and overall air quality improvement. The use of IoT sensors provided real-time data collection, enabling precise monitoring and control of the experimental conditions. From the test results, the author concludes that utilizing coffee powder as an air filter is a highly feasible approach. In addition to being an organic material, coffee powder is environmentally friendly and unlikely to harm nature. Moreover, using coffee powder as an air filter is a positive step towards supporting the economy of coffee farmers and improving the welfare of small and medium enterprises (SMEs) in Indonesia.

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