Jurnal E-Komtek
Vol. 6, No. 2 (2022) pp. 337-349
https://jurnal.politeknik-kebumen.ac.id/index.php/E-KOMTEK
p-ISSN : 2580-3719 e-ISSN : 2622-3066

Smart Control Monitors the Active Period of Using Biofilters on Motor Vehicle Exhausts

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https://doi.org/10.37339/e-komtek.v6i2.1064

Published by Politeknik Piksi Ganesha Indonesia

Artikel Info
Submitted:
21-11-2022
Revised:
19-12-2022
Accepted:
19-12-2022
Online first :
31-12-2022

Abstract

Many natural ingredients can be used as biofilters, but the use of biofilters is constrained by the difficulty of knowing when the saturation period is so that the active ingredients can be replaced immediately. The research aims to make a smart control of the active period of a motor vehicle exhaust biofilter that effectively provides information about the active period of the biofilter used. The tools and materials used are motorbikes, exhaust biofilters, MQ-135 sensors, exhaust filter housings, ESP8266 Node MCUs, 16 x 2 LCDs, switches, jumper cables and smartphones. The data collection method uses measuring CO_2 levels using the MQ-135 sensor, which is read on the LCD screen and sends notifications to smartphones via the Telegram application. Data analysis used descriptive statistical analysis presented in tables and graphs. The results showed that the smart control filter is a blend of leaf biofilter Simplicia, filter housing, MQ-135 sensor, power bank, IoT, LCD screen and cellphone installed with the Telegram application. To turn on the sensor so it can send notifications to the LCD screen mounted on the speedometer, you need to turn on the ON button. CO_2 levels and filter status will be read on the LCD screen. Notifications are also sent to cellphones via the telegram application so owners can find CO_2 levels and control the active period of using leaf biofilter simplicial.

Keywords: Biofilters, Exhaust, Active period, Smart controls, Telegram

Abstrak

Banyak bahan alami yang dapat dimanfaatkan menjadi biofilter, namun penggunaan biofilter terkendala oleh kesulitan mengetahui kapan masa jenuhnya. Tujuan penelitian adalah membuat smart control biofilter knalpot kendaraan bermotor yang efektif memberikan informasi tentang masa aktif dari biofilter yang digunakan. Alat dan bahan yang digunakan adalah seperda motor, biofiter knalpot, sensor MQ-135, rumah filter, Node MCU ESP8266, LCD 16x2, saklar, kabel jumper dan smartphone. Metode pengumpulan data dengan menggunakan melakukan pengukuran kadar CO_2 menggunakan sensor MQ-135 yang terbaca pada layar LCD dan terkirim notifikasinya pada smartphone melalui aplikasi Telegram. Analisis data menggunakan analisis deskriptif statistik yang disajikan dalam bentuk tabel dan grafik. Hasil penelitian menunjukkan smart control filter yang merupakan perpaduan antara simplisia biofilter daun, rumah filter, sensor MQ-135, power bank, IoT, layar LCD dan ponsel yang terinstal aplikasi Telegram. Kadar CO_2 dan status filter akan terbaca dilayar LCD. Notifikasi terkirim ke ponsel pemilik dapat mengetahui kadar CO_2 dan mengontrol masa aktif penggunaan simplisia biofilter daun.

***Kata-kata kunci**: Biofilter, Knalpot, Masa aktif, Smart control, Telegram*

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1. Introduction

The smoke emitted by the exhaust of motor vehicles hurts human health and even causes various diseases such as asthma, pneumonia, tuberculosis, and other lung disorders. Children and the elderly exposed to motor vehicle fumes are more susceptible to disease, with symptoms often seen, including easy coughing, runny nose, or difficulty breathing. The International Agency for Research on Cancer (IARC) revealed that air pollution has carcinogenic properties that can cause lung cancer and increase the risk of bladder cancer **[1].**

Among the pollutants produced by motor vehicle exhaust emissions is CO_2 gas which can cause serious health problems, such as acidosis. This condition can cause the body to lack oxygen because it is difficult for oxygen to enter the blood to be released into the cells. CO_2 gas poisoning can cause nausea, vomiting, dizziness, headaches, and increased heart rate. Even if the case is severe enough, it can cause seizures, coma, to death **[2].**

An increase in population in Indonesia will lead to the use of many transportations, especially motorized vehicles, which cause traffic jams and air pollution. The gases released from the exhaust of motor vehicles are one of the causes of environmental pollution. Motor vehicle has exhausted gas pollution increases each year rapidly **[3].** CO_2 gas is a pollutant that is proven to cause health problems in the lungs **[4].** The most significant contributor to CO_2 emissions is motor vehicle exhaust. So that the greening program carried out on each road has the aim of reducing CO_2 gas. One tree can absorb CO_2 gas of around 45 kg/hour, so it effectively reduces CO_2 gas emissions **[5].**

The air pollution problem in the era of the industrial revolution 4.0 is increasingly worrying. Many sources of air pollution have been made, such as factories, power plants that are not environmentally friendly, and motor vehicles with fossil fuels. Air pollution's impact on humans triggers various dangerous diseases, such as respiratory disorders. Pollutants that pollute the air are visible, but many are not visible because some smell and some do not **[6].** Motor vehicle exhaust contains several hazardous chemical elements such as water, carbon monoxide, carbon dioxide, nitrogen oxides, and hydrocarbons **[7].**

Absorbency technology is one of the technologies to control exhaust emissions. The most widely used material is activated carbon. Absorption of exhaust emissions is carried out in motorized vehicles by placing activated carbon in the exhaust gas channel with two variations: pellets and hollow briquettes **[8].** Several natural ingredients are effectively used as adsorbents

for vehicle exhaust gases, such as trembesi leaves, which are effective in absorbing exhaust emissions **[9].**

Manufacture of air filters can use materials around them that are considered less valuable, such as charcoal, cotton and ice blocks **[10].** The use of materials that have natural coagulation and adsorption activities is also the right choice to reduce emission levels effectively, quickly and cheaply, such as Jatropha Multifida L. or Chinese distance. Jatropha Multifida L. is a shrub that effectively absorbs CO, CO_2 and HC because it has a coagulation effect and is effectively used as a biofilter **[11].**

Many natural ingredients can be used as biofilters, such as Jatropha Multifida L. leaves and Gliricidia septum leaves, reducing carbon dioxide (CO_2) pollution by up to 56.72 percent **[11].** However, the use of biofilters is constrained by the difficulty of knowing when the saturation period for its use is so that the active ingredients can be replaced immediately. For this reason, it is necessary to design a practical tool that can monitor the active period of using biofilters on motor vehicle exhausts using Arduino-based sensors.

In **[12],** research the design of a tool to detect exhaust gas levels of motorized vehicles for CO measurements uses the MQ-9 gas sensor and for HC measurements uses the MQ-2 sensor. The processing device used is the Arduino microcontroller with the output device using Bluetooth to send data to a smartphone. However, according to **[13]** there are problems with the use of metal oxide-based gas sensors, namely the low sensitivity, selectivity, and stability of the sensor for long-term use.

2. Method

The research was conducted in July – September 2022 at SMA Negeri 1 Maos, Cilacap Regency, assembling sensors connected to IoT technology was carried out at the Cilacap State Polytechnic (PNC) and tool calibration was carried out at the Cilacap Regency Transportation Service.

The primary data source was obtained directly from the research object by conducting experiments on measuring the active life of the biofilter and interviewing respondents who conducted a smart control exhaust biofilter trial. Meanwhile, secondary data sources were obtained by conducting literature studies.

The tools used for the research were 125 ccs 4 stroke motorcycles, exhaust biofitters, MQ-135 sensors, and automotive diagnostic solutions. The materials used in this study were Jatropha multifida (Jatropha cina) leaf simplicia, Gliricidia sepium (gamal) leaf simplicia, and white cloth.

The devices used in the manufacture of IoT-based smart control biofilters are exhaust filter housings, ESP8266 Node MCU, 16 x 2 LCD, switches, jumper cables, MQ-135 sensors, laptops/computers, and smartphones.

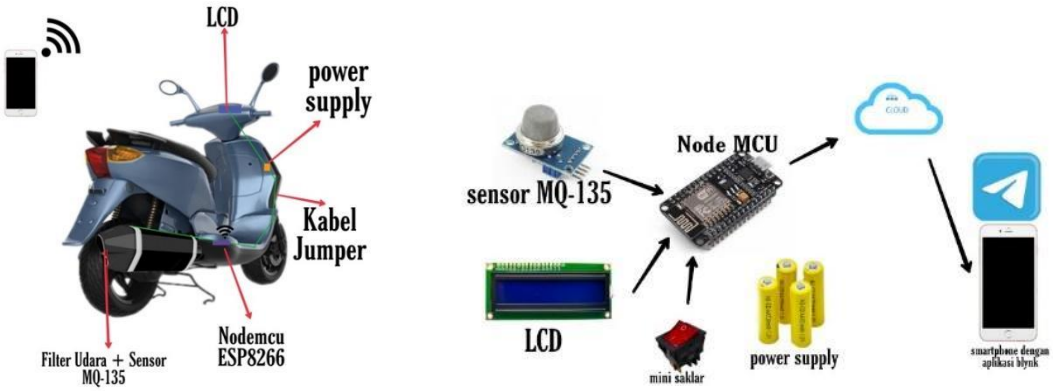

Figure 1. Smart Control Filter Prototype Design

Data collection was carried out by measuring CO_2 levels using the MQ-135 sensor which was installed in the filter housing and connected to IoT and then calibrated using the Cilacap District Transportation Office's automotive diagnostic solutions. The biofilter saturation standard uses the level of CO_2that comes out of the exhaust intake before the biofilter is installed. If the CO_2 level after installing the biofilter is the same as the standard saturation limit, the sensor will send a notification on the LCD screen that the biofilter must be replaced. Then a similar notification will be sent via IoT technology to the vehicle owner's smartphone. If the CO_2 level has exceeded the threshold specified by the Minister of Transportation Regulations, the sensor will send a warning notification that exhaust fumes have polluted the air.

Data analysis used descriptive statistical analysis by displaying data from sensor readings on the LCD screen and on smartphones via the Telegram application. The smart Control biofilter readings have already been calibrated with automotive diagnostic solutions owned by the Cilacap Regency Transportation Service. Presentation of data using tables and graphs.

3. Results and Discussion

a. Presenting Result

A smart control filter, is a tool to reduce exhaust gas pollution in the exhaust using a leaf biofilter simplicia placed on the exhaust intake. It uses an Arduino-based MQ-135 sensor to control the filter with a leaf biofilter simplicia adsorbent so that it does not exceed the usage threshold. So that the sensor is always connected to the vehicle owner's cellphone, it needs to be integrated with IoT technology. The steps for setting up the application are as follows:

1) Installing the ESP board on the Arduino IDE.
2) Enter the Telegram library on the Arduino IDE.
3) Install the Telegram application on the smartphone's Google Playstore.
4) Login by creating a new account required for Arduino programming
5) Create a new project, then give it a name.
6) Select the device used with the type of WiFi connection.
7) Enter the token into the Arduino program until a blank Telegram page appears.
8) Make an on-off button with logic “0” and “1”.
9) Make a measure of pollution levels using a gauge.
10) Create a slider to set the target.
11) Make a notification for Telegram as a sign that the biofilter simplicia must be replaced.

Programming in the Arduino IDE includes the Automatic Operation Arduino Program, which includes defining the components used in calling the NodeMCU and Telegram libraries. It defines the component pins used on Arduino, programs the serial monitor, displaying data sent from sensors. It is moreover, popping up notifications on smartphones when simplicia has to be replaced.

After all, the programming is complete, and the sensor is mounted on the filter housing. The working mechanism is as follows:

1) The filter is filled with a cloth package containing leaf biofilter simplicia.
2) Then, the filter is installed on the exhaust intake using a screwdriver.
3) The switch is pressed on the state to activate the sensor.
4) Then, when the motor is turned on, the sensor will automatically read the pollution levels monitored on the LCD screen. The data is also sent to the cloud via the NodeMCU microcontroller to the Telegram application.

5) When the leaf biofilter simplicia is less effective, the tool will notify that the leaf biofilter simplicia needs to be replaced with a new simplicia.

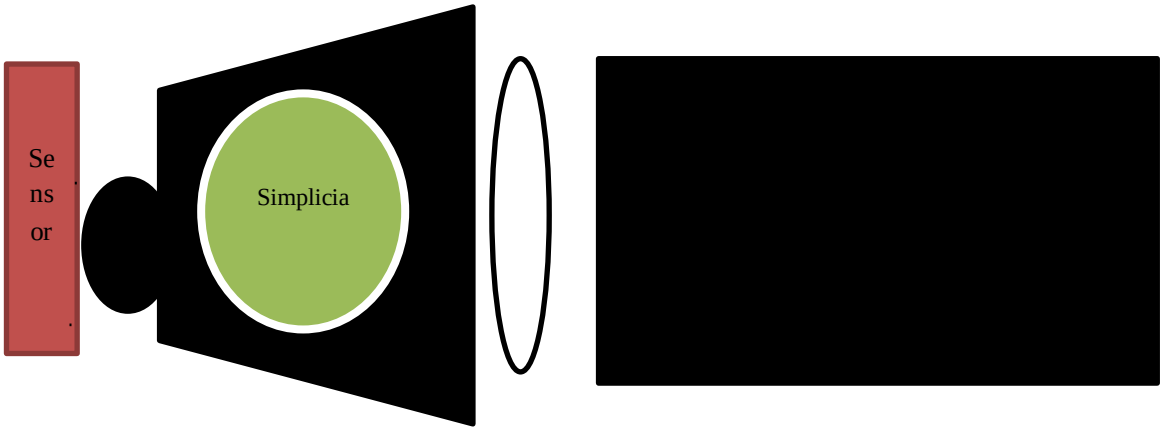

Figure 2. Technical installation of the Smart Control Filter

The working mechanism of the tools and sensors is as follows:

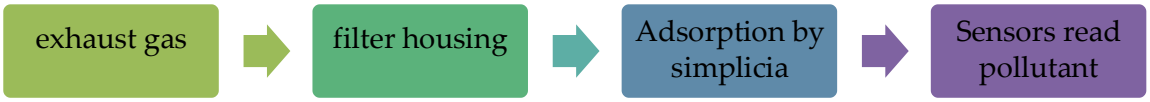

Figure 3. Mechanism of Smart Control Filter

b. Activity Diagram of Office Stationery Requests Each Unit

Measurement of smoke and CO using the Arduino Uno-based MQ-135 sensor was carried out using a 125 cc 4-stroke motorcycle with variations in the speed of 0 km/hour, 35 km/hour, and 60 km/hour. The independent variables in this study are:

1) Exhaust filter with simple *Jatropha multifida* leaves wrapped in cloth
2) Exhaust filter with *Gliricidia sepium* leaves wrapped in cloth
3) Exhaust filter with cotton wrapped in cloth.
4) Cloth-coated exhaust filter.
5) Does not use any filter as a standard level for exhaust emissions.

Figure 4. Smoke and CO test using the MQ-135 sensor

The motorbike was run for each treatment for 30 seconds with 10 repetitions of measurements with the results as shown in the table below:

Table 1. Average Smoke Content Test Results (Smoke)

FILTERS	0 KM/JAM	35 KM/JAM	60 KM/JAM
No Filters	16.899,9 ppm	20.024,2 ppm	22.069,6 ppm
Cloth filters	177,6 ppm	219,2 ppm	126,0 ppm
Cotton Filters	685,3 ppm	245,3 ppm	180,1 ppm
Gliricidia filter	210,7 ppm	55,4 ppm	44,8 ppm
Jatropha filters	21,8 ppm	39,1 ppm	15.9 ppm

Based on the table above, it is known that the ability of the Jatropha multifida L. leaf filter is far more effective in reducing smoke levels from motorcycle exhaust than other filters. Then it is followed by Gliricidia sepium leaves, cloth and cotton. In this study, filters covered with cloth were better at absorbing smoke than filters filled with cotton. The results of the Anova test obtained the value of F = 166.14 and F crit = 3.48 which means F > F crit means that there is a significant difference with the results of the test of variance <0.05. The addition of a biofilter affects reducing the level of smoke (smoke) in motorcycle exhaust. The results of the BNT/LSD analysis are as follows:

Table 2. Analysis of BNT/LSD Smoke Test

FILTERS	AVERAGE	NOTATION
No Filters	19587,70	a
Cloth filters	1816,33	b
Cotton Filters	668,60	c
Gliricidia filter	349,13	c
Jatropha filters	59,00	c

Note: The BNT value is 2131.72.

Based on the results of the BNT/LSD test analysis, data was obtained that all filters had a significant impact on reducing smoke (smoke) in motorcycle exhaust. However, the filter added with Jatropha multifida L. leaf simplicia was the best at suppressing the amount of smoke, followed by the Gliricidia sepium leaf simplicia filter, cloth filter and cotton filter.

Table 3. Average CO Test Results

FILTERS	0 KM/JAM	35 KM/JAM	60 KM/JAM
No Filters	18.374,1 ppm	19.978,5 ppm	20.410,5 ppm
Cloth filters	621,9 ppm	960,6 ppm	423,3 ppm
Cotton Filters	3.680,2 ppm	1.132,2 ppm	636,6 ppm
Gliricidia filter	757,7 ppm	167,4 ppm	122,3 ppm
Jatropha filters	39,8 ppm	105,6 ppm	31,6 ppm

Based on the table above, it is known that the filtering ability of Jatropha multifida L. leaves is effective in reducing CO (carbon monoxide) levels from exhaust gases from motorbike exhausts. The simplicia filter from Gliricidia sepium leaves, cloth filters and cotton filters follow it.

The results of the ANOVA test obtained the value of F = 267.28 and F crit = 3.48, which means that F > F crit. It means that there is a significant difference in the results of the test of variance <0.05. So, the addition of a biofilter affects reducing CO levels in motorbike exhaust. The results of the BNT/LSD analysis are as follows:

Table 4. Analysis of the BNT/LSD CO Test

FILTERS	**AVERAGE**	**NOTATION**
No Filters	19587.70	a
Cloth filters	1816.33	b
Cotton Filters	668.60	c
Gliricidia filter	349.13	c
Jatropha filters	59.00	c

Note: BNT value is 1631.13.

Based on the results of the BNT/LSD test analysis, data was obtained that almost all filters had a significant impact on reducing CO levels in motorcycle exhaust. However, the filter added with Jatropha multifida leaf simplicia was the best at suppressing the amount of smoke, followed by the Gliricidia sepium leaf filter and the cloth filter. The filter that is added to the cotton can go below the other filters.

c. Emission Test with Automotive Diagnostic Solutions

In order to calibrate the smart control, emissions were measured using Automotive Diagnostic Solutions at the Cilacap Regency Transportation Service on September 16 2022. The emission test results at the Cilacap Regency Transportation Service are as follows:

Table 5. Emission Test Results with Automotive Diagnostic Solutions

FILTERS	PARAMETER		
	CO	CO2	HC
No Filters	0,61 % vol	6,7 % vol	1005 ppm vol
Cloth filters	0,32 % vol	3,6 % vol	477 ppm vol
Cotton Filters	0,27 % vol	3,5 % vol	508 ppm vol
Gliricidia filter	0,23 % vol	2,9 % vol	389 ppm vol
Jatropha filters	0,20 % vol	2,9 % vol	330 ppm vol.

Source: emission test receipt from the Cilacap Regency Department of Transportation

The test was carried out at a speed of 0 km/hour. Based on emission tests, the best filter data to reduce CO, CO_2 and HC levels were Jatropha multifida and Gliricidia sepium leaf simplicia.

Figure 5. Emission Test at the Cilacap District Transportation Office

d. Smart Control Exhaust Filter Mechanism

The prototype of the exhaust smart control filter, with the addition of Arduino sensors and IoT-based technology, can be used effectively to control the effectiveness and saturation of the biofilter. Furthermore, when the biofilter has reached saturation, the sensor will send a notification via the Telegram application on the vehicle owner's cellphone to immediately replace it with the new biofilter.

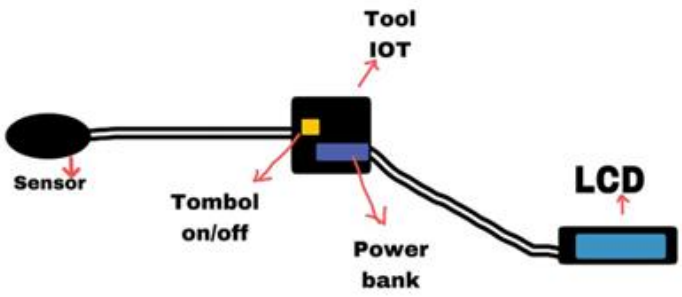

Figure 6. Smart Control Filter Circuit

The parameter used by smart control to determine the active period of leaf biofilter simplicia is CO_2, which is most dominantly found in exhaust smoke.

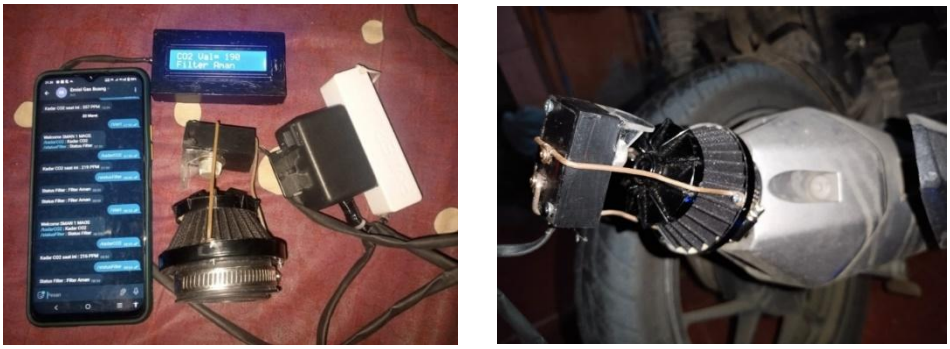

Figure 7. Prototype of Smart Control

The sensor uses power from the power bank, so when the sensor is activated, it needs to turn on the switch so that the electric current from the power bank turns on the sensor circuit. Notifying CO_2 levels will automatically be sent to the LCD screen attached to the speedometer. IoT devices will also send notifications to the user's cellphone using the Telegram application. The mechanism of action on the cell phone is as follows:

1) Start booting by typing “start”
2) It will be answered automatically with operator messages, namely the option to choose what data you want to know.
3) If you want to know the level of CO_2, just type "kadar CO_2", and the CO_2 level will appear in units of ppm.
4) If you want to know the status of the active period of the leaf biofilter, just type "statusFilter", and then a "Safe Filter" will appear if it is still functioning correctly. When it reaches saturation, the filter will display the "Filter Needs to be Replaced" role. However, suppose CO_2 levels have been detected to exceed the ambient air threshold based on the Air Pollutant Standard Index (ISPU). In that case, the sensor will warn that exhaust fumes have polluted the environment.

IoT technology is motivated by not all motorized vehicle owners are users, such as motorbike renters and cars that rent out their vehicles. An IoT technology is needed to send notifications about CO_2 levels and whether it is safe for the environment or not to cell phones via the Telegram application. The owner only needs to open Telegram and turn on the real-time tool based on his needs, namely " CO_2 levels" to find out the level of CO_2 pollution and "Filter status" to find out the active period of the filter. If the filter is saturated, the vehicle owner or user must replace the leaf biofilter simplicia.

e. Discussion

Air pollution due to exhaust gases from motor vehicles is increasing along with the increase in motorcycle ownership which is directly proportional to the increase in population each year. Based on the results of smoke and carbon monoxide emission tests using the MQ135 sensor, data was obtained that leaf biofilter simplicia such as Jatropha multifida and Gliricidia sepium were effective in reducing smoke and CO levels.

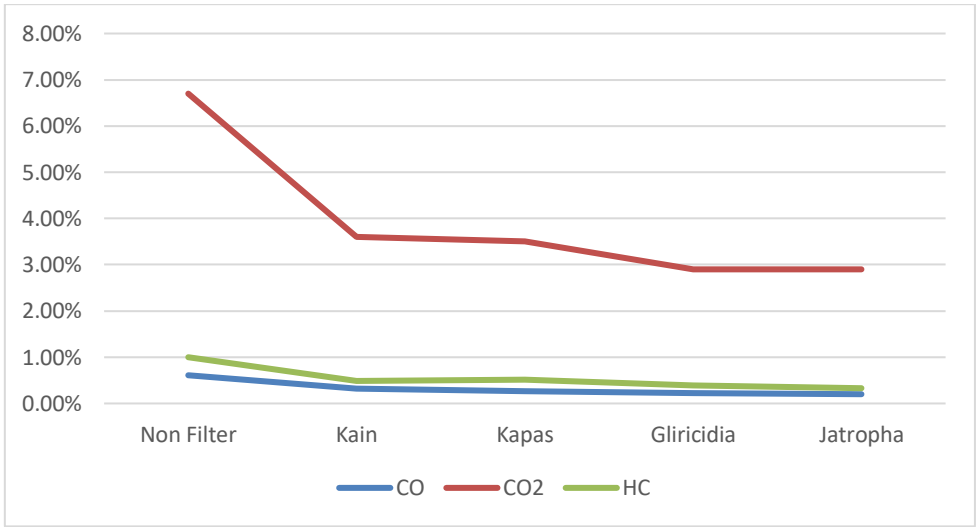

Figure 8. Emission Test Results at the Cilacap District Transportation Office

The ability to reduce CO_2 levels based on the results of emission tests conducted at the Cilacap Regency Transportation Office obtained data that the Jatropha multifida leaf biofilter and Gliricidia sepium leaf biofilter were the most effective in reducing CO_2 levels by up to 56.72%. Likewise, the ability to reduce levels of HC and CO. The innovation of pollution-reducing filters for exhaust gases is the solution needed to reduce air pollution, which can harm human health.

Figure 9. Output from Smart Control

The placement of the LCD on the speedometer makes it easy for users to control the active period of the leaf biofilter they use. Likewise, vehicle owners can control it remotely using a cellphone via the Telegram application.

4. Conclusion

Making a smart control filter is done by adding an Arduino-based MQ-135 sensor to the exhaust filter device. Based on comparing CO, CO_2 and HC measurements have been using Arduino-based sensors and Automotive Diagnostic Solutions. It is known that the accuracy of the prototype of the exhaust smart control filter with the addition of the Arduino sensor. Moreover, IoT technology can effectively control the effectiveness and saturation period of leaf biofilter simplicia. Another advantage is that when the biofilter reaches saturation, the sensor will notify via the Telegram application installed on the vehicle owner's cellphone to replace it with a new biofilter immediately.

Considering that air pollution due to exhaust fumes is increasing daily, it is necessary to make more serious efforts to reduce air pollution levels so that the environment is sustainable and the community is healthier than the previous one. Among the genuine efforts is to create safe, cheap, easy-to-make and effective biofilter innovations.

References

[1] Gerardus Septian Kalis, "Dampak Asap Knalpot Kendaraan Bermotor bagi Kesehatan," https://www.klikdokter.com/info-sehat/read/3224074/dampak-asap-knalpot-kendaraan-bermotor-bagi-kesehatan, 2018.

[2] Diyah Eka Andayani, "Peran dan Dampak Karbon Dioksida terhadap Tubuh Manusia," https://www.alodokter.com/mari-telusuri-seluk-beluk-karbon-dioksida-di-dalam-tubuh-kita#:~:text=Terlalu%20tingginya%20kadar%20karbon%20dioksida,tubuh%2C%20sehingga%20tubuh%20kekurangan%20oksigen, Jun. 28, 2019.

[3] S. Gunawan, H. Hasan, and R. D. W. Lubis, "Pemanfaatan Adsorben dari Tongkol Jagung Karbon Aktif untuk Mengurangi Emisi Gas Buang Kendaraan Bermotor," J. Rekayasa Mater. Manufaktur dan Energi, vol. 3, no. 1, pp. 38–47, Mar. 2020, doi: 10.30596/rmme.v3i1.4527.

[4] N. Syamiyah and S. Wahyuni, "Pencemaran Udara Dalam Ruangan (Karbon Dioksida dan Total Senyawa Organik Volatile) Serta Gangguan Paru Pada Siswa SD di Depok," J. Joubahs, vol. 1, no. 2, pp. 126–140, 2021, doi: https://doi.org/10.47080/joubahs.v1i02.1485.

[5] A. Kurnia and Sudarti, "Efek Rumah Kaca Oleh Kendaraan Bermotor," J. Pendidik. Fis. dan Sains, vol. 4, no. 2, pp. 1–9, 2021, doi: https://doi.org/10.33059/gravitasi.jpfs.v4i02.4518.

[6] J. Abidin, F. Artauli Hasibuan, K. kunci, P. Udara, and D. Gauss, Pengaruh Dampak Pencemaran Udara Terhadap Kesehatan Untuk Menambah Pemahaman Masyarakat Awam Tentang Bahaya dari Polusi Udara. 2019.

[7] H. W. Sudarwanto, I. W. Utami, R. Asmoro, and A. A. Wulandari, "Bahaya Emisi Gas Buang Kendaraan Berbahan BakarBensin dan Menumbuhkan Lingkungan Hijaudi Perkotaan," in Seminar Nasional & Call For Paper Hubisintek 2020, 2020, pp. 101–105.
[8] F. Redha, R. Junaidy, and I. Hasmita, "CO and NOx Emissions Adsorption in Gas Vehicles using Activated Carbon fromCoffee Bean Shell," Biopropal Ind., vol. 9, no. 1, pp. 37–47, 2018, doi: http://dx.doi.org/10.36974/jbi.v9i1.3458.
[9] Sentiyaki et al., "Alat Penyaring Karbon Monoksida Pada Knalpot Kendaraan Bermotor Dengan Menggunakan Adsorben Alami Ekstrak Daun Trembesi," J. Chem. Process Eng., vol. 03, no. 01, pp. 38–42, 2018.
[10] M. Nur Hasani, N. Halimah, and Ernawati, "Alat Penyaring Asap Sederhana," Spektra J. Kaji. Pendidik. Sains, vol. 3, no. 2, pp. 149–159, 2017, doi: http://dx.doi.org/10.32699/spektra.v3i2.33.
[11] Edi Mustofa Yulianto, "Pemanfaatan Simplisia Jatropha multifida L. Sebagai Adsorden pada Filter Knalpot," Cilacap, 2021.
[12] Ikhsan and Irwanto, "Implementasi Arduino Dalam Rancang Bangun AlatUji Emisi Kendaraan Bermotor Berbasis Android," J. Ilmu Komput., vol. 6, no. 2, pp. 1–7, 2017, doi: https://doi.org/10.33060/JIK/2017/Vol6.Iss1.38.
[13] S. Widodo, "Kajian Perkembangan Teknologi Sensor Gas Untuk Emisi Gas Buang Kendaraan Bermotor," J. Techno-Socio Ekon., vol. 13, no. 1, pp. 71–80, 2020.