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**DETECTION AND IDENTIFY CARBON CONCENTRATION EMITTED
FROM FOREST FIRE IN TROPICAL REGION****热带地区森林火灾排放的碳浓度的检测和识别**Evizal Abdul Kadir^{a*}, Sri Listia Rosa^a, Muhammad Ramlee Kamarudin^b^aDepartment of Informatics Engineering, Faculty of Engineering

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*Received: June 18, 2020 ▪ Review: September 14, 2020 ▪ Accepted: October 3, 2020**This article is an open-access article distributed under the terms and conditions of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>)***Abstract**

Global warming impacted the rise of temperature globally, some of the places a high risk of fire such as land and forest fire. Many efforts to prevent the occurrence of land and forest fire, but some methods are not achieved in optimum results. One of the issues is carbon emitted to the sky is in general concentration. The current sensor only detected carbon status and without the detail of the carbon concentration either from the forest fire or any other source that contribute carbon. This research identifies and detects the fog of haze emitted from a forest fire by identifying the carbon concentration. The carbon sensor detects particles flying in the skies and calculates based on number and size to identify if the fog comes from a forest fire or other fire sources. There are many other sources of haze in the skies. It can be from the pollution emitted from vehicles, fire from the garbage or rubbish, or fog emitted from the factory. The size and number of particles detected by the sensor were analyzed to identify the quantity and the size to match the type of particles emitted from the forest fire. Results show that particles from the forest fire are higher and bigger compare to other sources of fires. The fog's intensity less than from other fire sources because of forest fire the material mostly from the trees and leaves getting burn then gives less in quantity.

Keywords: Forest Fire, Carbon Dioxide, Detection, Concentration, Tropical Region

摘要 全球變暖影響了全球氣溫的上升，其中一些地方有發生火災的高風險，例如土地和森林火災。為防止土地和森林火災的發生做出了許多努力，但某些方法並未達到最佳效果。問題之一是排放到天空的碳普遍集中。當前傳感器僅檢測碳狀態，而沒有森林火災或其他任何產生碳源的碳濃度細節。這項研究通過識別碳濃度來識別和檢測森林大火散發出的霧霾。碳傳感器檢測天空中飛揚的顆粒，並根據數量和大小進行計算，以識別霧是否來自森林大火或其他火源。天空中還有許

多其他霾源。這可能是由於車輛排放的污染，垃圾或垃圾引起的火災或工廠排放的霧氣。分析傳感器檢測到的顆粒的大小和數量，以識別數量和大小，以匹配森林大火排放的顆粒類型。結果表明，與其他火源相比，森林大火產生的顆粒更高，更大。由於森林大火，霧的強度低於其他火源，主要來自樹木和樹葉的物質被燃燒後產生的霧量較少。

关键词: 森林火災，二氧化碳，檢測，濃度，熱帶地區

I. INTRODUCTION

The forest fire happened in many countries and contributed to global warming emitted from the fire to the skies. Accumulation of the gases and haze into the atmosphere (Co₂) can damage the ozone layer. Initially, forest fire occurs because of thought the nature of hot environmental and dryland, but in some cases, most likely because humans have a role to play in starting the fire to open the land for farming or other purposes. Although the fires are a feature of the forest worldwide for many years, suppose occurred lesser in terms of frequency, then the global impact should be in minimum. One of the disasters is a forest fire in Indonesia, especially in the summer season, which dries land. This is because of some area type of land, which is easy to get dry and fire. In most of the significant fire cases, which is the El Nino effect in climate change phenomenon and combination of improper way to manage the forest by the authority, the results destroyed millions of hectares of tropical forest. Data from the National

Development Planning Agency (BAPPENAS) and joint with the Asian Development Bank (ADB) estimated 9.75 million hectares of the forest fire. Furthermore, the forest fire in Indonesia continues every year. Though area burned and losses, it is relatively small and generally not well documented. According to the Directorate General of Forest Protection and Nature Conservation shows the forest fires that occur every year from 2000 to 2002 recorded ranging from 42 thousand to 2.6 million hectares. One of the significant impacts that occurred due to forest fires the presence of fog. The haze caused by forest fires in Indonesia has been troubling and bring disease to residents. Many hospitals, especially clinics in the suburban and urban areas, are flooded with patients with Acute Respiratory Tract Infection (ARI). Children and older people's physical endurance is fragile, and they have to breathe the air that is not already healthy due to smoke and haze from forest fires.

Table 1.
Forest Fire Data in Indonesia Year 2014-2019

No	Province	2014	2015	2016	2017	2018	2019	Total (ha)
1	Aceh	155.66	913.27	9,158.45	3,865.16	1,284.70	141.78	15519.02
2	Bali	30	373.46	-	370.8	206.54	-	980.8
3	Bangka Belitung	-	19,770.81	-	-	2,055.67	-	21826.48
4	Banten	2	250.02	-	-	-	-	252.02
5	Bengkulu	5.25	931.76	1,000.39	131.04	8.82	1.47	2078.73
6	DKI Jakarta	-	-	-	-	-	-	0
7	Gorontalo	-	5,225.89	737.91	-	158.65	27.7	6150.15
8	Jambi	3,470.61	115,634.34	8,281.25	109.17	1,390.90	4.18	128890.45
9	Jawa Barat	552.69	2,886.03	-	648.11	4,104.51	-	8191.34
10	Jawa Tengah	159.76	2,471.70	-	6,028.48	331.67	-	8991.61
11	Jawa Timur	4,975.32	7,966.79	-	5,116.43	7,279.76	-	4975.32
12	Kalimantan Barat	3,556.10	93,515.80	9,174.19	7,467.33	68,311.06	2,273.97	180742.35
13	Kalimantan Selatan	341	196,516.77	2,331.96	8,290.34	98,637.99	52.53	306170.59
14	Kalimantan Tengah	4,022.85	583,833.44	6,148.42	1,743.82	41,521.31	27.00	0
15	Kalimantan Timur	325.19	69,352.96	43,136.78	676.38	26,605.57	5,153.07	145249.95
16	Kalimantan Utara	-	14,506.20	2,107.21	82.22	625.82	792.11	18113.56
17	Kepulauan Riau	-	-	67.36	19.61	320.96	4,969.85	5377.78
18	Lampung	22.8	71,326.49	3,201.24	6,177.79	14,963.87	-	95692.19
19	Maluku	179.83	43,281.45	7,834.54	3,918.12	14,131.33	180.03	69345.47
20	Maluku Utara	6.5	13,261.10	103.1	31.1	69.54	56.79	13528.13
21	Nusa Tenggara Barat	3,977.55	2,565.71	706.07	33,120.81	14,352.26	29.10	0
22	Nusa Tenggara Timur	980.87	85,430.86	8,968.09	38,326.09	55,207.64	99.13	189012.68
23	Papua	300	350,005.30	186,571.60	28,767.38	87,676.88	-	653321.16
24	Papua Barat	-	7,964.41	542.09	1,156.03	120.63	58.36	9841.52
25	Riau	6,301.10	183,808.59	85,219.51	6,866.09	37,220.74	27,683.47	347099.5
26	Sulawesi Barat	-	4,989.38	4,133.98	188.13	978.38	56.77	10346.64
27	Sulawesi Selatan	483.1	10,074.32	438.4	1,035.51	1,741.27	441.07	14213.67
28	Sulawesi Tengah	70.73	31,679.88	11,744.40	1,310.19	3,890.95	215.92	48912.07
29	Sulawesi Tenggara	2,410.86	31,763.54	72.42	3,313.68	8,121.35	16.42	45698.27
30	Sulawesi Utara	236.06	4,861.31	2,240.47	103.04	125.07	9.98	0
31	Sumatera Barat	120.5	3,940.40	2,629.82	2,227.43	2,421.90	60.68	11400.47
32	Sumatera Selatan	8,504.86	646,298.80	8,784.91	3,625.66	13,019.68	236.49	680470.4
33	Sumatera Utara	3,219.90	6,010.92	33,028.62	767.98	3,678.79	152.55	46858.76
34	Yogyakarta	0.27	-	-	-	-	-	0.27
TOTAL (ha)		32,438.97	2,012,184.19	429,268.22	125,399.82	447,285.81	42,674.34	3,089,251.35

The forest fire disaster impacted the human and economic losses because many activities are limited to the haze and fog spreading to the air. Students in the school highly risk to their health and respiratory. Other disadvantages are ecological losses that include a reduction in the forest area's size, reduction of clear air produced by vegetable and forest, and the loss of forest as the function of water disruption and regulator and to prevent erosion for the land. The direct impact of forest fires is as follows. First, it is the emergence of acute respiratory infections for the community. Secondly, socially and economically, the community is disadvantaged because of the reduced efficiency of work, offices, and schools are closed, and transportation is disrupted. Third, immaterial and material losses to the local community even cause transboundary haze pollution (cross-boundary smoke pollution) to the region of neighboring countries such as Singapore, Malaysia, and Brunei Darussalam. Table 1 shows forest fire data in Indonesia from 2014 to 2019 based on Province and area of fire hectares.

The motivation for this research is to identify the exact carbon concentration on the sky with a complex particle. The current sensing system only detects the carbon status without detail particular concentration, then the authority or representative department has difficulties finding the correct solution and preventive action. By identifying the exact cause and source of the haze, the correct countermeasure can be done correctly. There are many sources of the smoke and haze polluting the air, such as pollution by the vehicle in the heavy traffic in land transportation, the carbon emitted from the industry, smoke from the burning of rubbish or waste in the community villages, and fog or haze spreading by land or forest fire that one of the main issue currently in the global. The results are expected to identify and differentiate types of smoke and haze caused by which sources mention early, then proper action in the correct way to overcome the fire issues.

II. LITERATURE REVIEW

Some studies have been conducted in the previous for forest fire detection. However, most of them identify the size and detection of how the smoke potentially becomes the fire and spreading estimation. Mathematical modeling is used for the investigation of the size of smoke emitted from fire and prediction of the smoke spreading vertically and horizontally with the remote observation [1],[2],[3]. The antenna sends the signal using a microwave noise-adding

radiometer to detect fire in the forest and environmental pollution. Then, with a low-noise block received, the signal reflected from the presence of fire, the bigger size of the smoke or fire. Then, a more significant signal will be received [4],[5],[6]. The study of forest burnt and assessment using geospatial technology to detect forest fire, especially during the summer season as reported in [7],[8] the mapping and monitoring used satellite imaginary to get the data and analyze where the place got the hotspot and get the fire. Geographic Information System (GIS) identifies the area with a high probability of getting fire based on images analysis and models the area using a mapping plan to monitor any changes to prevent forest fire.

Detection of forest fire using Artificial Neural Network (ANN) based on imaginary satellite technique from remote sensing to identify the smoke spreading as discussed in [9] imaginaries captured by NOAA satellite with the Advanced Very High-Resolution Radiometer (AVHRR) analysis with a multi-threshold algorithm to get accurate results of the smoke spreading. A Convolutional Neural Network (CNN) is reported in [10] to achieve excellent and accurate results for the forest fire smoke spreading based on the CNN model. The model required an additional backbone network to identify fire smoke and extracted it precisely. Artificial Neural Network (ANN) is applied for smoke spreading detection in wildfire [11]. Computer vision technology detects smoke, heat, flame, and smoke spread. Then, the data analysis determines the potential of fire getting worst. Study on the changing of the soil conditions and direct altering used Arbuscular Mycorrhizal (AM) is a method to determine the potential of fire in a land. The viability of the function AM in the burnt area of soil then compare to the previous normal condition to determine the root of the most frequent burnt area [12], [13]. A new method to approach and detect a smoke event in forest fire used a Variational Autoencoder and Neural Decision, as discussed in [14]. This method gives good advantages to detect smoke by combining a Variational Autoencoder with a random forest to classify the collected data into smoking and nonsmoking after data preprocessing.

The forest fire modeling used a sensor network for mapping the smoke spreading based on ground sensor installed [15], the mapping and modeling applications in one location or area with high potential to become forest fire and smoke or haze spreading to the city and community villages. Analysis of potential fire risk used of sink data reported in [16] is how to

do a prediction of fire will happen. El Nino season effect related to the unpredicted season and risk of forest fire in the tropical area is a solution to forecast the forest fire [17], based on NASA satellite imaginaries, then analyze the season's changing Indonesia territory for the potential of the forest fire. The investigation of statistical relation between dynamics in fire events then compare to the landscape, climate change variable, and socioeconomic in Portugal to predict the potential of fire in the summer season as reported in [18],[19]. The use of machine learning to predict wildfire is one of the methods used [20]. The approach is from a video recorded in the event of a forest fire. Then analysis uses Deep Belief Network and Boltzman machine technique to determine and extract and classify the smoke simultaneously.

Spatial distribution analysis to determine forest fire, as discussed in [21], gives a good response in the analysis of a significant number of data. The data analyzed is in the long for the year 1969 to 2013 with the four-season area. Relationship between Moderate Resolution Imaging Spectroradiometer (MODIS) data and effect of climate change and global warming, as discussed in [22], the data analyzed during the year 2001 to 2017, where the increasing number of fire hotspot based on increasing of temperature because of global warming. The effect of vegetation on the surface temperature and global warming, as reported in [23],[24], as the vegetable's growth cycle can lower the temperature and clean the air pollution because vegetables absorbed the carbon. Study and simulation on the time and quantity vegetable to be absorption the air pollution and haze reported. The influence of forest fire particles on the air and how many quantities per square meter, as studied by the [25],[26],[27], development model and theoretical analysis of the particle characteristic spread to the air based on the types of the fires was studied. The use of the Internet of Things (IoT) for the detection of forest fire then analyzed the data according to the sensor detected the hotspot, as discussed in [28],[29]. Modeling of the Wireless Sensor Network (WSN) for detection of number fire hotspot on the area of forest calculates to get forecasting data the impact of the hot sun in the summer [30], the use of technology including Long Range Sensor (LoRa) to get large coverage area detection. Simulating and forecasting the discharge of number particles discharge from the satellite data, especially for the remote area to get the data [31], the study of the correlation data to the measurement and number of discharges using

a combination of data classification and outlier detection procedures. All those methods discussed above mostly mention and elaborate on how to detect and analyze the carbon and data to determine how much the impact. Thus, this research aims to elaborate in detail that assists in determining the carbon concentration source from the forest fire.

III. CARBON DIOXIDE SENSING SYSTEM

Carbon dioxide (CO₂) is one of the standard materials or gas on the earth's atmosphere. A significant concentration in the air then contributes to pollution and change in the climate. CO₂ can make the climate become warming and change the ecological system. The source of the CO₂ comes from various sources such as transportation, fire (forest fire), human population, etc. CO₂ is one of the essential factors to determine air quality, with the high concentration of the carbon in the air then gives a harmful effect to the human because difficult to breathe. Information on the CO₂ in the air is essential to know how clean the air in the area. There are several techniques to measure CO₂ concentration or air quality, and one of them is installing a sensor to detect the number of CO₂ particles in time. A nondispersive infrared (NDIR) sensor is one of the most commonly used sensors for detecting CO₂ particles. Using an infrared system, a small particle can detect and determine the concentration. To calculate the concentration of CO₂ in an area (room) can be calculated by the formula (1) as below [32].

$$C(t) = \frac{G}{aV}(1 - e^{-at}) + C_t \quad (1)$$

Where:

- $C(t)$ concentration (ppm) at time t (h)
- G_{Co2} generation rate (mL/h) introduced at $t=0$
- a an air exchange rate (h^{-1})
- V area (room) volume (m^3)
- C_t concentration in the replacement air (ppm(v))

The analysis is based on the time interval during measurement by the sensor to determine the CO₂ concentration, typically starting to steady measurement according to the tick of the carbon in the air. The carbon NDIR sensor's relative performance can be calculated as formula (2), Relative Standard Error (RSE) in % computed from all the sensors.

$$RSE = \frac{SE}{Mean} \times 100 \quad (2)$$

Where:

$$SE = \frac{SD}{\sqrt{N}}$$

In the real environment, air pollution caused by CO₂ comes from many sources; thus, the differentiation of source CO₂ is important to classify come from which sources either transportation or fire as well the fire need to specify from the forest or other fires. This research discusses source CO₂ by using NDIR sensors to measure carbon concentration and identify other parameters related to CO₂.

A. Sensor System

Measurement and sensing of the air's carbon concentration can be applied by installing sensors to detect the particles' quantity. In this research, several sensors are used to achieve better results. The sensors are temperature, humidity, carbon, and haze, or fog. Signal received from the sensors forwarded to the processing controller to do signal condition and cut off the noise. The microcontroller unit received signal analyzed using the algorithm to achieve the final results of the carbon concentration and other support parameters related to the CO₂. A wireless system is used to transfer and send data to the computer as the back-end system to display the final data. Figure 1 shows a block diagram of a carbon detection system using an NDIR sensor to detect carbon concentration in the air. The system's design added with additional sensors, temperature, and humidity, to get related parameters affected the carbon concentration based on the fire sources. The microcontroller unit in this system used Arduino as the controller to analyze the data received from all the sensors, with the mini processor inside the Arduino be able to run an algorithm programmed in the chip. A radio unit in the Radio Frequency part uses to transfer the data wirelessly. This technique expected no restriction in the distance to place the sensor at the strategic location to detect carbon concentration. A display system is set up in the back-end system to visualize the sensors' results or data. With this data, it is possible to compare all the fire source to the carbon or CO₂ concentration.

The system designed can be standalone and working in a remote area, provided self-power supply from the solar system, then the sensor system not depending on the fixed power utility. Furthermore, the system designed compact that

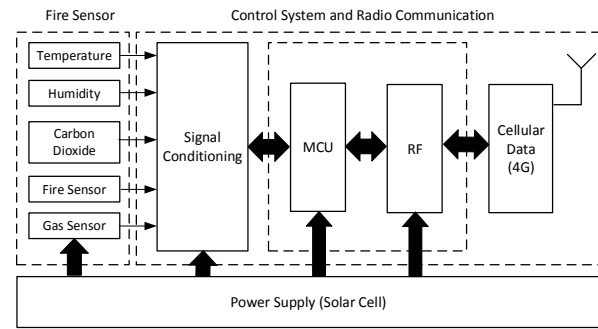


Figure 1. Block diagram of carbon detection using NDIR sensor

suitable for a mobile application, and data transfer can be used with cellular data communication such as 4G network or point-to-point radio communication for rural or remote areas.

B. NDIR Sensor

Nondispersive Infrared (NDIR) is a sensor system that is mostly used to do a measurement of the carbon concentration. The detection concept is based on the InfraRed (IR) signal sent to a medium, a tube. Then the light goes through inside the tube, filled with an optical sensor as a detector of carbon particles. The IR sensor can detect the small size of carbon particles in micron based on infrared light wavelength. Figure 2 shows a model of how a sensor detects carbon particles. The tube completes with an inlet and outlet of the gas to let carbon particles pass through the medium. Then, the sensor detects the number of particles inside the medium, as shown in figure 2(a). The optical detector at the end of the tube with a gap of optical filter can absorb light wavelength size in 4.26 micron, as shown in the graph in figure 2(b). The detection up to 70% of the light transmission to detect the carbon particles, while the infrared wavelength range was effectively covered from 2 to 8 microns, as shown in the graph in figure 2(b).

The NDIR sensor's principle to measure the carbon particle is by calculating the difference of the source light from IR to the light received by the detector. The difference results of the light absorbed by the detector compared to the source proportional to the sample tube's carbon concentration. The sensor then detected the number of carbon particles inside the tube flowing from the inlet to the outlet through light flowing in the tube. The output signal from a sensor, an analog voltage range from 4-20 mA, is connected to the Arduino microcontroller equipped with Analogue to Digital Converter (ADC) to convert the data into digital. The digital

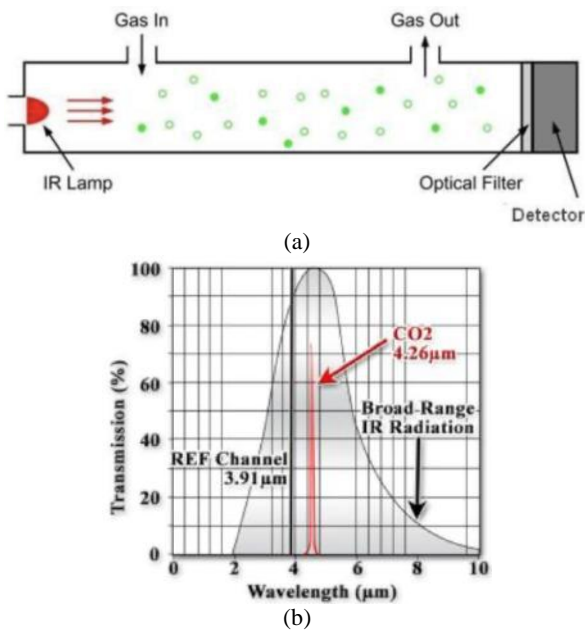


Figure 2. NDIR sensor for Co2 detection (a) sensor tube with detector (b) graph of the detection at 4.26 micron [33]

data received by the processor analyzing to achieve the actual quantity of the carbon detected by the sensor.

C. Various Sources of Carbon

The carbon in the air, as mention in early, is the most common material of particles, especially in the polluted air. The carbon comes from various sources such as vehicle exhaust, factory emission, fire from the rubbish, or fire from the land or forest. One of the most common lands in the tropical region is with forest. In the summer or dry season, it is easy to get fire. Forest fire in Indonesia, especially in Riau Province, is one of the main issues that happens almost every year in the summer season. There is preventive action to reduce or overcome the disaster, but sometimes fire gets by itself because of the typical land and soil. Figure 3(a) shows how the forest fire emitting the carbon into the air and get polluted. Air pollution from vehicle emission is another issue in Indonesia because some vehicles emitted with dirty carbon and get polluted, and traffic jams contribute more carbon. Every year the increasing number of vehicles very significant, then traffic in the city gets jams, and more pollution is caused by transportation. Figure 3(b) shows vehicles emitting the carbon from the exhaust. Then, the air gets polluted. Some of the countries and region dispose of the housing garbage by firing. This method impacts air pollution and contributes carbon to the air. Figure 3 (c) shows that garbage gets firing to do clearance and contribute carbon to the air. The factory is one of the sources that make air

pollution from the processing. Conventional processing emits dirty smoke containing carbon. Figure 3 (d) shows a factory emitting black smoke with a high carbon concentration then polluting the fresh air.



(a)



(b)



(c)



(d)

Figure 3. Carbon polluting air sources (a) forest fire contribute carbon (b) air pollution from the vehicle (c) smoke and carbon from the fire of the rubbish (d) dark smoke with carbon emit from factory

D. Measurement Setup

The experiment and measurement of the air's carbon concentration based on the various sources have been set up to get the results. Carbon sensor used as the primary sensor to detect carbon concentration, while additional sensors related to the fire installed to achieve high accuracy of detected data. The additional sensors used, such as temperature and humidity of the air that high related to the fire, besides that gas sensor representative of smoke and haze in the air, and fire sensor to detect and indicate the fire's occurrence. Figure 4 shows a complete setup system with a computer to display the results; several sensors installed and connected to the microcontroller and get the sensing data to analyze how much carbon concentration in the air refers to the fire scenarios, as mention in the previous section.

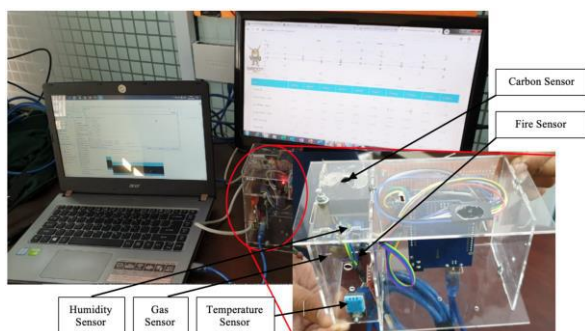


Figure 4. Sensors setup with the Arduino microcontroller and connected to the computer to display the results

In the actual measurement, the sensing system is placed near or around the fire area sources to detect a representative, actual polluted environment better. In this case, the carbon concentration measurement has been done for as long as 60 minutes to get representative values in several fire scenarios. Data detected from all the sensors analyzed and compared the relationship used an algorithm, then high accuracy results achieved. Final results logged into computer memory for the record, then a graph is drawn for better display and easy to see the fluctuate.

IV. RESULTS AND DISCUSSION

Measurement of carbon concentration has been done for various scenarios, as mention in early. The results were achieved based on testing according to the case scenario. Figure 5 shows how the graph for every scenario drawn that the first scenarios, in which forest fire contributes the highest carbon concentration for a case of fire. While the other scenarios in which vehicle

pollution, a garbage fire, and factory emission contribute similar carbon concentration, for the garbage fire, the graph keeping increase since start measurement. The fire scenarios are measured for the case on a small scale for the testing with fire coverage about 100 square meters, and the distance to the sensor is about 20 meters. A sensor installed and set up around the fire simulated then measure the carbon concentration in the air by record the reading. NDIR sensor senses the number of particles going into the infrared tube and calculated epy estimation number of particles going through the hole then record the results. Besides that, carbon particles from the forest fire bigger in size than the others fire, followed by the second large is garbage particle when getting firing. While factory carbon and vehicle emit from the exhausts small is the size of the particles. The testing and measurement were done quickly, which is only 60 minutes to compare and find the typical carbon concentration from a fire, especially for the forest fire, which almost happens in a tropical region. The data give a good idea to identify and carbon concentration and the typical size of the carbon (particles flying in the air) for analysis and determine the fire's cause.

The second setup and measurement are to compare the fire effect to the temperature and analysis of how much impact of temperature to a fire. Every case of fire will contribute heat to the environment or air. On average normal heat increasing in these testing scenarios is 2-3 degrees. Figure 6 shows a graph plotted by measurement results for the temperature in every case of fires. In the first case, forest fire contributes to high temperature and heat to the environment, which is up to 41 degrees Celsius. Other scenarios are average, and the temperature is mostly in maintaining value, which is 30 to 35 degrees Celsius. Similar to the carbon contribution, the garbage fire temperature graph keeps increase from the stated measurement to the end of the graph. The time is the same as carbon measurement, which is 60 minutes to compare carbon and temperature. The actual environmental temperature during the testing actual at 30 to 32 degrees Celsius, and fire contributes to increasing the environmental temperature. The temperature measurement used a particular sensor installed together with the carbon sensor in the system then recorded simultaneously for both parameters.

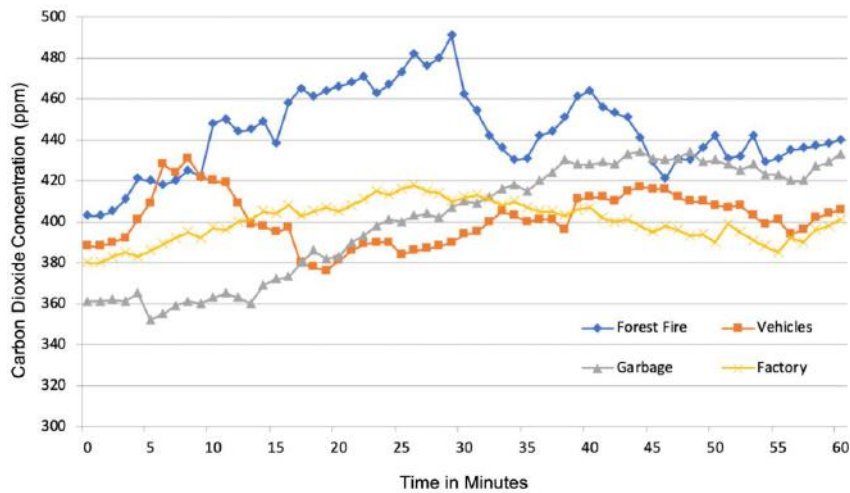


Figure 5. Results of carbon concentration measurement for four scenarios

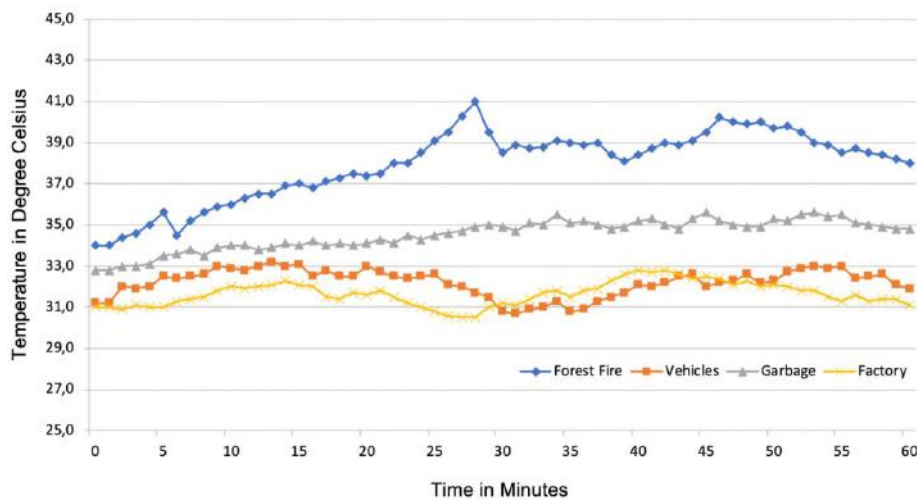


Figure 6. Results of temperature measurement for testing in 4 scenarios

The results were achieved for both parameters, carbon concentration and environmental temperature, based on measurement with a similar procedure for all the scenarios of fires. A sensing system setup for detecting the environmental effect emits from the fire, the sensors such as carbon dioxide (particle), air temperature, humidity, and gas (smoke or haze). All the parameter data from the sensors logged to the system with timing every 5 seconds, but the display shows that the data timing is minute (60 seconds). The final value shows are based on average data within the current minute logged. According to the four environmental parameters detected, the two most significant parameters impact the change while fire happens. The other two parameters are not significantly changing. In contrast, fire or sensors detect the fire in all scenarios. Anyhow the value is changing but not impactful. Thus, in the report, only two parameters are shown and discussed, carbon dioxide concentration and environmental

temperature. Carbon particles emitted from forest fires are more in number and big because the forest's material with fast fire contributes more carbon, and the environment temperature changes while fire happens. This is because fire emits the heat according to the size and how big the firing area or material getting firing.

V. CONCLUSION

Detection and identification of the carbon emitted from a fire depend on the fire's material or region (forest fire) in the tropical region with a specific type of forest (trees). The soil gives more carbon and particles emits into the air. The sensing system is designed to detect how much carbon and particles emitted from fire and differentiate based on the type of fire and source of carbon emitted to air. In this research, measurement results show that carbon from forest fire gives more in quantity and particles bigger than other scenarios. Besides, the quantity

of the carbon emitted from the forest fire fluctuates according to the area's size getting fire and quantities of the trees. The fluctuation of the carbon detected depends on the wind blow and direction. It is usual with the normal wind blowing to the fire, then carbon is detected in the average number. While wind blowing in fast, then the detection of carbon suddenly with a significant number followed by the significant reducing number of carbons detected. The other scenarios, which are carbon from vehicles (transportation), garbage, and factory are detected the carbon but in average number. Garbage fire emits more carbon when starting the firing than when the material reduces and getting the finish, and the carbon emission reduces until the fire is stopped. All the scenarios tested and measured in the different areas according to the best location to do a measurement, but the procedure is the same to meet accurate data.

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