Measurement and analysis of air quality impacts caused by CO and NO\textsubscript{2} on Margonda Raya street Depok

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\textbf{Abstract.} Based on data from the Central Statistics Agency (BPS) in 2019, the population of the City of Depok has now jumped to 2,254,513 people. Analysis of air quality is important for the people of Depok. The biggest ambient air parameters are Nitrogen Dioxide (NO\textsubscript{2}) and Carbon Monoxide (CO). Land transportation activities are among the biggest causes of decreasing air quality in the city of Depok. One type of land transportation is motor vehicles. A high growth rate of motor vehicles can cause a serious impact on the environment. Traffic jams and noise can cause air pollution. This research was conducted around Margonda Raya Street. In this research, the components used are Arduino Mega 2560 Microcontroller, SHT11 Temperature and Humidity Sensor, MQ-7 CO Sensor, MQ-135 NO\textsubscript{2} Sensor, Wi-Fi Module ESP8266, Wind Direction and Wind Speed JL-FS2 Sensor. Data from the designed tool will then be sent to the cloud server which will then be collected in a web-based application. The results will be analyzed to determine for fluctuations in CO and NO\textsubscript{2} gas concentrations and the impact of CO and NO\textsubscript{2} on air quality around Margonda Raya Street Depok. The MQ-7 and MQ-135 Sensor test results show a very strong correlation value with the value $R^2 = 0.9906$ for MQ-7 and $R^2 = 0.9988$ for MQ-135. The results of the test show that in the Region has the highest CO value of 202.67 around 3:00 to 4:00 p.m. and the highest NO\textsubscript{2} value of 227.34 around 2:00 p.m., the data values of CO and NO\textsubscript{2} are still in the medium category, this is related to the decline in community activities on weekends.

1. Introduction

Based on data from the Central Statistics Agency (BPS) in 2019, the population of the City of Depok is 2,254,513 people, and transportation modes are needed to support the increasing community activities. Analysis of air quality is important for knowledge of the people of Depok. The current constraint of the published information given to the people of Depok in general is still based on data that are not yet real-time. To determine whether the level of air quality is good or not, we need a tool that can be used to connect with a better level of mobility.

Land transportation activity is one of the biggest causes of the reduction of ambient air quality in a city. A high rate of growth of motor vehicles can cause a serious increase in environmental impact. Environmental impacts caused by traffic jams, noise, and causing air pollution. The biggest ambient air parameters generated from these transport activities are Nitrogen Dioxide (NO\textsubscript{2}) and Carbon Monoxide (CO) levels in urban air are usually 10-100 times higher than in rural air. NO\textsubscript{2} emissions are affected by
population density because the main source of NO\textsubscript{2} from combustion is mostly caused by motor vehicles, energy production, and waste disposal.

2. Methodology

2.1 Conceptual Framework
Measurement and analysis of air quality impacts caused by CO and NO\textsubscript{2} along Margonda Raya Street near University of Indonesia have a conceptual framework on this study which can be seen in the following figure.

![Conceptual Framework](image)

Figure 1. Conceptual Framework

Figure 1 it is known that the levels of CO and NO\textsubscript{2} will affect the air quality. If the air quality is bad, it will harmful for the health and therefore information is needed to the public. Air quality information system has been owned by Indonesian Agency for Meteorological, Climatological and Geophysics (BMKG) and The Ministry of Environment and Forestry (KLHK), while our air quality monitoring system specifically addresses the influence of CO and NO\textsubscript{2} in Depok.

2.2 Needs Analysis
The government needs real-time data about CO and NO\textsubscript{2} concentration around Margonda Raya Street Depok as basic information for further policy making. The community also needs information about CO and NO\textsubscript{2}. This system will consist of hardware (sensors) and web-based software.

2.3 Air Quality Monitoring Techniques
According to Attachment VI Minister of the Environment Regulation No. 12 of 2010, the air quality monitoring method consists of two methods, manual and automatic. The manual method is done by first taking air samples and then analyzed them in the laboratory. The automatic method (which we used in this research) is carried out using a tool that can measure air quality directly.

2.4 Data collection technique
The data collected is primary data because the data is directly taken from the source without going through an intermediary. The data taken is the number generated by the two nodes which are installed in units of micrograms / m\textsuperscript{3}. The data needed to support air quality is the direction and speed of the wind, humidity, and temperature. Wind direction and speed are measured using the JL-FS2 Sensor, while humidity and temperature are measured using the SHT11 sensor. This data is then sent to the server to be stored in a database so that it can be used as material for air quality information on Margonda Raya Street Depok.

2.5 Data Analysis Techniques
The data collected will determine the air quality in Depok based on the Air Pollution Standard Index because the parameters used are only CO and NO$_2$ concentration. Data analysis was carried out by comparing the data obtained by the results of sampling and laboratory analysis with the Ambient Air Quality Standards which refer to the Minister of Environment Regulation No. 41 of 1999 concerning Pollution Control. The data obtained will be analyzed descriptively.

**Table 1. Air Quality Criteria Index**

| CATEGORY       | RANGE  | INFORMATION                                                                                                                                 |
|----------------|-------|---------------------------------------------------------------------------------------------------------------------------------------------|
| Well           | 0 - 50| An air quality level that has no effect on human or animal health and has no effect on plants, buildings or aesthetic value.                    |
| Moderate       | 51 – 100 | The level of air quality does not affect human or animal health but affects sensitive plants and aesthetic value.                           |
| Not healthy    | 101 – 199| The level of air quality that is detrimental to humans or groups of animals that are sensitive or can cause damage to plants or aesthetic value.|
| Very unhealthy | 200 – 299| The level of air quality that can be detrimental to health in a number of exposed population segments.                                      |
| Dangerous      | 300 – 3000| Dangerous air quality levels that generally can seriously harm health in the population.                                                  |

Source: Keputusan Menteri Negara Lingkungan Hidup Nomor: KEP-45/MENLH/10/1997 Tentang Indeks Standar Pencemar Udara.

2.6 Monitoring System Block Diagram

In the block diagram, the tool will display a general picture of the entire hardware. The following is the block diagram of the tools in this study:

![Monitoring System Block Diagram](image)

Figure 2 shows that there are several components used. At the input, there are SHT11 temperature and humidity sensors, JL-FS2 direction, and wind speed sensors, CO MQ-7 sensors, NO$_2$ MQ-135 sensors, and Wifi Module ESP8266. Data from the sensor will be processed on the microcontroller as well as appearing on the LCD and stored in memory, then real-time data will appear on the web.
2.7 Hardware

Arduino Mega 2560 Microcontroller is a type of Arduino that is quite popular to use. In addition to having a lot of input and output pins, this type of Arduino has a larger memory capacity compared to several other types of Arduino. Arduino functions as the control center of the entire system. Microcontrollers can control the input and output provided.

The SHT11 sensor is a sensor module for temperature and relative humidity. This sensor can be used as a temperature and humidity sensing device in temperature and humidity control applications as well as temperature and relative humidity monitoring applications.

The MQ-135 sensor is a sensor that monitors air quality to detect NO₂ gas. This sensor reports the results of air quality detection in the form of changes in the analog resistance value at the output pin.

MQ-7 is a sensor to detect CO gas with a detection concentration range ranging from 10 to 10,000 ppm (Parts per Million). This sensor has high sensitivity and fast response time. The sensor output is analog resistance.

The ESP8266 module is an integrated chip component for Wi-Fi networking and as an application provider or for separating all Wi-Fi networking functions into other application processors. ESP8266 has on-board processing and storage capabilities that allow the chip to be integrated with sensors or with certain device applications via input-output pins with only short programming.

Wind is air that moves from areas with high air pressure to areas with low air pressure. Wind speed is influenced by the surface characteristics in its path. In this study, wind speed was measured using a JL-FS2 type wind speed sensor.

The direction of the wind is a sign of wind movement. The direction of the wind is expressed in the direction from which the wind comes. In this study wind direction was measured using a JL-FS2 type wind direction sensor.

2.8 Monitoring System Design Flow Chart

The flow chart in the design of the tool states the flow of the algorithm or describes the operational processes of the tool that have been made so that it is easily understood and easily seen based on the sequence of steps from one process to another. Here is a picture of the flow diagram in the design of the tool:

![Flow Diagram](image)

**Figure 3.** Monitoring System Design Flow Chart

Figure 3 explains the flow chart above starts by initializing the program, then measuring CO, NO₂, temperature, humidity, wind direction, and wind speed data performed by sensors MQ7, MQ135, SHT11, and JL-FS2 and monitoring data on air quality conditions appearing in the web.

2.9 Sensor Testing

Sensor testing is the most important stage in making the device because with the test, the performance of the sensors used can be known whether it can operate in accordance with its function and in
accordance with what is targeted, and from the results we can know the advantages and disadvantages of these sensors. Sensor testing is also carried out with the aim to find out how much the value issued by the sensor. The MQ-7 and MQ-135 Sensor testing was conducted at the ITB Physics Engineering Laboratory. The sensor is put in a closed container and fired CO and NO$_2$ gas using the Ecotech Environment comparator engine. Below is a graph of the results of tests conducted on the MQ-7 sensor and the MQ-135 sensor:

![Graph of MQ-7 and MQ-135 Sensor Testing Results]

**Figure 4. Correlation between Standard and Design of CO and NO$_2$ Sensor**

From Figure 4 above it can be seen that the testing of the equipment carried out has an output. The MQ-7 and MQ-135 Sensor test results show a very strong correlation value with the value $R^2 = 0.9906$ for MQ-7 and $R^2 = 0.9988$ for MQ-135. It can be concluded that from the results of testing the sensor is feasible to operate.

**2.10 Calibration Sensor**

Sensor calibration is the most important stage in making a device because calibration is carried out to determine the correctness of the sensor designation. Calibration is carried out at the Engineering Instrumentation and calibration center at BMKG. Calibration testing aims to ensure that the sensor can function properly following the purpose of manufacture. Calibration of SHT11 Sensor uses Temperature and humidity parameters, where the temperature sensor will be compared with Fluke Hart Scientific, Humidity sensor compared to the HTM333 Standard sensor, Wind speed sensor is calibrated with a wind tunnel calibrator and Wind direction sensor compared to the actual wind direction comparison.

![Graph of Calibration Sensor Results]

**Figure 5. Calibration Sensor of Humidity and Temperature**
Figure 5 shows the SHT11 sensor calibration graph for temperature parameters showing a linear measurement between the design tool and the standard device. The biggest correction value at the set point of 40°C with a correction value of -0.333°C and the smallest correction value at the set point of 30°C with a correction value of -0.0045°C the biggest correction is at 80% setpoint with a correction value as large as 5.770% and the smallest correction value is 1.330% at the 40% set point. The SHT11 Temperature Sensor is declared suitable for use because the sensor's correction value is still within the correction tolerance range specified in WMO NO.8 Guide of the Meteorological Instruments and Methods of Observation which is ± 0.2°C for temperature parameters and ± 5% for humidity parameters.

Figure 6 shows a JL-FS2 sensor calibration graph for wind speed parameters showing linear measurements between the design tool and the standard device. The largest correction value at the setpoint is 20 m/s with a correction value of -0.785 m/s and the smallest correction value at the set point of 10 m / s with a correction value of -0.148 m/s. The JL-FS2 Wind Direction Sensor calibration graph has no irregularities. The calibration data is very good and feasible to use based on WMO and BMKG rules, which is equal to ± 0.5 m/s for wind speed.

3. Results and Discussion of CO and NO₂ Measurements and Analysis
University of Indonesia on Margonda Raya street is located in a dense zone. It is surrounded by colleges, business buildings, and residence areas. A fairly high level of traffic can have an impact on rising Carbon Monoxide and Nitrogen Dioxide gas.
The results of CO and NO$_2$ gas sensor data testing was carried out at FMIPA UI for several days on November 2019. The data above shows that the highest CO gas value around 3:00 to 4:00 p.m is 202.67 ppm and the highest NO$_2$ value of 227.34 ppm around 2:00 p.m. Based on the above analysis, the CO and NO$_2$ gas values are in moderate category. The high level of community activities along with the modes of transportation result in an increase of CO and NO$_2$ gas pollutants in the Margonda area, University of Indonesia.

Figure 7 shows hourly measurement results of CO and NO$_2$ parameter in ppm. For the SHT11 sensor with temperature parameters has an average correction value of 1.689°C and the air humidity parameter has an average correction value of 0.157%. The JL-FS2 sensor has an average correction value of 0.367 knots for wind speed and an average correction of 0 degrees for wind direction. The concentration of CO and NO$_2$ increase significantly on rush hour because of human activities around FMIPA UI which is carrying high amount of pollutants. Human activities using motor vehicles cause the increase of pollutant concentrations. Decrease in CO and NO$_2$ concentrations due to the increase of humidity. The increase in temperature between 8 a.m. until 5 p.m. causes an expansion in air volume so that the air quality decrease. Pollutant concentrations will decrease with increasing wind speed unless there is a higher source of pollutants coming from the direction of the wind. Pollutant concentrations will decrease with increasing wind speed unless there is a higher source of pollutants coming from the direction of the wind.

Figure 8. Display monitoring observation data

Figure 8 shows the real-time data display from the system where the data is displayed every 1 hour, this data display can be in the form of tables and graphs, so it makes it easy to analyze and observe air quality data. In the future, this system can be utilized for the benefit of the community.
Figure 9 shows web display of CO and NO\textsubscript{2} measurement index. It is consist of instrument location on map and realtime information graphics of NO\textsubscript{2} and CO measurement results. It can be accessed by IP address http://66.42.52.76/Gas/.

4. Conclusions

a) Based on the results of this study it was found that the system has been successfully designed and has carried out sensor testing activities, the SHT11 sensor with temperature parameters has an average correction value of 1.689\textdegree C and the air humidity parameter has an average correction value of 0.157%. The JL-FS2 sensor has an average correction value of 0.367 knots for wind speed and an average correction of 0 degrees for wind direction. At CO gas concentration, the MQ-7 sensor has an average correction value of 2.270 ppm and NO\textsubscript{2} gas concentration, the MQ-135 sensor has an average correction value of 2.455 ppm. So the calibration results show that the sensor is fit to be used according to WMO and BMKG regulations relating to the sensor correction value.

b) The MQ-7 and MQ-135 Sensor test results show a very strong correlation value with the value $R^2 = 0.9906$ for MQ-7 and $R^2 = 0.9988$ for MQ-135.

c) The testing of this system has been carried out in at FMIPA UI by taking weather data and air quality data for several days on November 2019, the results of the test show that in the Region has the highest CO value of 202.67 around 3:00 to 4:00 p.m. and the highest NO\textsubscript{2} value of 227.34 around 2:00 p.m., the data values of CO and NO\textsubscript{2} are still in the medium category, this is related to the decline in community activities and vehicles on weekends.

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