Visualization of Air Quality Conditions in Medan City

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Abstract: Visualization of urban air pollution requires massive data processing because it has to create a map of air pollution in either two dimensions or three dimensions and we have to deal with geographical data, that is, GIS data. Weather data are multivariate and contain plane vectors formed by wind speed and direction. Several tools are used to detect air quality. Data points are marked with location and time using on-board GPS. Periodically, measurements are uploaded to the server, processed and then published on the Sensor Map portal. With a sufficient number of nodes and diverse mobility patterns, a detailed picture of air quality over a large area will be obtained at low temperatures. The purpose of this study is to determine the visualization of air quality conditions in the city of Medan using pollutant sensors based on regional mapping of Medan. With this research, it is expected that a tool that can read the data of pollutant conditions in Medan will be obtained. This research method begins with hardware design using CO gas sensors namely TGS 822, SHT31 temperature and humidity, GPS sensor, and SPS 30 sensor as particulate sensors. The device is then connected to Bluetooth so that it is connected to a PC and can be read in realtime.The tool can be used on cars with 9V power source. The tool is then used to detect pollution at several sample points that represent the city of Medan as a whole. The results of the reading of pollutant values are then processed and used to visualize the condition of air quality in the city of Medan. Based on the results of calibration testing and measurement of ambient air quality in the city of Medan, obtained air quality data in the field city during the test time has an AQI value ranging from 30 to 90 which shows that the air quality in Medan is still relatively moderate.

1 INTRODUCTION

In 2012 WHO reported that around 7 million deaths or 1/8 global deaths were caused by air pollution. The highest fatalities are in low to middle income countries namely in the Southeast Asian region with a total of 1.69 million deaths due to air pollution (WHO, 2014). Several countries and big cities have implemented various policies to reduce the impact of this air pollution (Smedley Team. 2017). Some of the studies that have been conducted include the first research that has designed a gas emission test device in real time and was monitored via the web (Smedley Team, 2017; Fikri, 2013; Rochmana et al., 2016).

Based on the Decree of the Minister of Health of the Republic of Indonesia number 1407 of 2002 concerning Guidelines for Controlling the Impact of Air Pollution, air pollution can be defined by the entry or inclusion of substances, energy, and/or other components into the air by human activities, so that air quality drops to a certain level causing or affect human health (Kadir, 2013). Increased industrial development and increasing population will produce a quantity of types of transportation that have an influence on air quality in an urban setting (Mukono, 2011).

The air quality index is generally calculated based on five main pollutants, namely surface oxidants/ozone, particulate matter, carbon monoxide (CO), sulfur dioxide (SO) and nitrogen dioxide (NO). However, at present the calculation of the air quality index uses two parameters namely NO and SO The NO parameter represents emissions from motor vehicles that use gasoline, and SO represents emissions from industry and diesel vehicles that use diesel fuel and other sulfur-containing fuels (Ministry of Environment and Forestry, 2018). Carbon monoxide (CO) is a pollutant. Based on estimates, the amount of CO in Indonesia is estimated at close to 60 million tons/year. One-eighth of this amount comes from motorized vehicles that use gasoline and a third come from stationary sources. Even though

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carbon monoxide is a flammable gas and very poisonous to humans. In the World Health Organization report, WHO is estimated that at least one type of air pollution in large cities has exceeded the tolerance limit of air pollution (The World Bank, 1994).

There is a very strong need we have to make urban air pollution maps that can be efficiently and easily used to help city officials to provide citizens with a pleasant and safe urban environment: The World Health Organization (WHO) states that 2.4 million people die every year from causes that are directly linked to air pollution and we still remember terrible memories of the Great Smog of 1952 in London, England (Qu et al., 2007; Völgyesi et al., 2008). Atmospheric particulate matter is a criterion commonly used to evaluate air quality (Park et al., 2011; Janssen et al., 2013). The level of adverse health effects depends on the size and composition of the particles (Zirui et al., 2015). PM2.5 and PM10 are defined as particles with a diameter of 2.5 µm or less and 10 µm or less, respectively; this parameter is usually measured using the air quality index (AQI). AQI is calculated from particle concentrations at the monitoring station expressed as micrograms per cubic meter (Popeet al., 2002). According to technical regulations on the ambient air quality index (on trial) (Air Quality Index, 2019), the air pollution index for PM2.5 is divided into six levels, namely, 0-50, 51-100, 101-150, 101-150, 151-200, 201-300, and greater than 300. With this level, we can identify the severity of air pollution.

2 RESEARCH METHOD

2.1 Tool Design and Manufacturing

2.1.1 Block Diagram

The hardware design of the air quality monitoring system consists of Arduino Uno microcontroller, TGS 822 sensor, MQ-135 sensor, SHT-31, GPS, Ozone Sensor, and Arduino Uno. In general, system hardware design is as follows:

1. The MQ-135 sensor is a sensor that will detect carbon dioxide gas which is represented as a CO_2 gas sensor. This sensor output in the form of analog voltage.
2. The TGS 822 sensor is a sensor that will detect carbon monoxide gas which is represented as a CO gas sensor. This sensor output in the form of analog voltage.
3. The SHT-31 sensor is a sensor that will detect temperature and humidity.
4. GPS sensor is a sensor that will detect the location/position of the sensor against latitude and longitude.
5. Ozone Sensor is a sensor that will detect ozone gas. This sensor output in the form of analog voltage.
6. Arduino Uno Microcontroller which functions as a control center for all sensors.

Arduino microcontroller is the main component that functions as a data processing center that will be processed before sending to the viewer (PC) via bluetooth. PC functions as a viewer of data obtained from the sensor so that it can be directly seen visually.

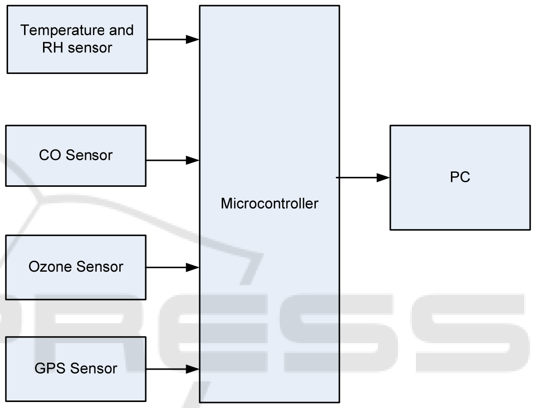

Figure 1. System work block diagram

2.1.2 Arduino Uno Microcontroller Circuit

Arduino is an electronic kit or open source electronic circuit board in which there are main components, namely a microcontroller chip with AVR type from Atmel company. The Arduino programming language is C language. But this language has made it easier to use simple functions so that beginners can learn it quite easily.

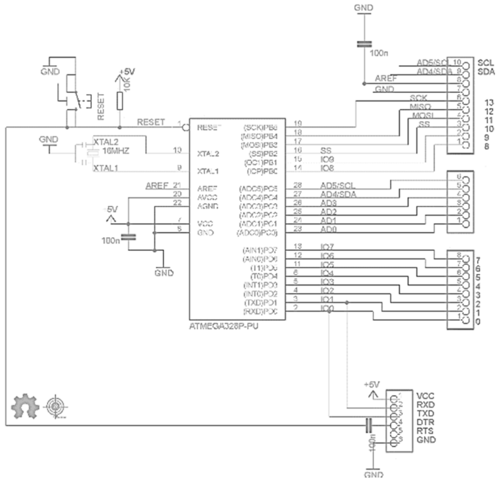

Figure 2. Arduino Uno Microcontroller Schematic (*Source: www.electroschematics.com*)

The vehicle exhaust emission measurement tool uses Arduino Uno which uses the ATmega 328 microcontroller as the central working controller of all design tools, including reading sensor measurement results and changing sensor measurement results to digital because the sensor output is analog. From figure 2, Arduino Uno microcontroller is programmed using the Arduino IDE software which is sent through a computer USB port. The power supply used is 9V connected at 30 (VIN) and 29 (GND).

2.1.3 TGS Sensor Circuit 822

The sensing element of Figaro gas sensors is a tin dioxide (SnO_2) semiconductor which has low conductivity in clean air. In the presence of a detectable gas, the sensor's conductivity increases depending on the gas concentration in the air. A simple electrical circuit can convert the change in conductivity to an output signal which corresponds to the gas concentration. TGS 822 has high sensitivity to the vapors of organic solvents as well as other volatile vapors. It also has sensitivity to a variety of combustible gases such as carbon monoxide, making it a good general purpose sensor.

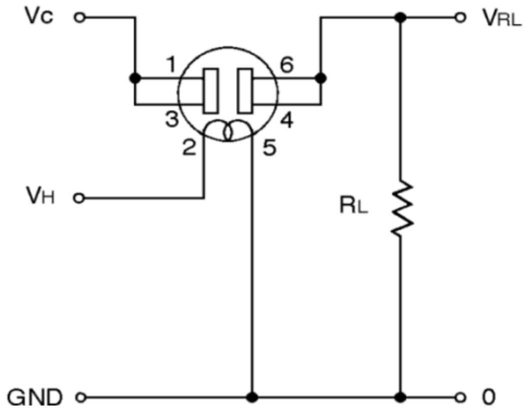

Figure 3. TGS Sensor Circuit 822 *(Source: www.researchgate.net/figure)*

The structure of the sensor is shown in Figure 3. TGS 822 is the main transducer used in this circuit, which is a gas sensor. This sensor has a resistance value of Rs that will change when exposed to gas and also has a *heater* that is used to clean the sensor room from outside air contamination.

2.2 Design and Manufacture of Software

Software design is needed because in order to run the Arduino Uno system the ATMega328P microcontroller chip will be filled with the desired command program.

3 RESULT AND DISCUSSION

a. Ambien CO Test Equipment Calibration Results

Tool calibration is done using the CO meter shown as shown in the following test:

Figure 4. Tool calibration process

The test is carried out in a closed container for 10 minutes. After that given the smoke coming from burning paper then a fan will make the smoke spread evenly in the container so that it triggers the sensor to detect the smoke content in the air inside the container. Standard tools and tools for CO sensor design are Sensor TGS 822. After processing the data, the graph is obtained as figure 5.

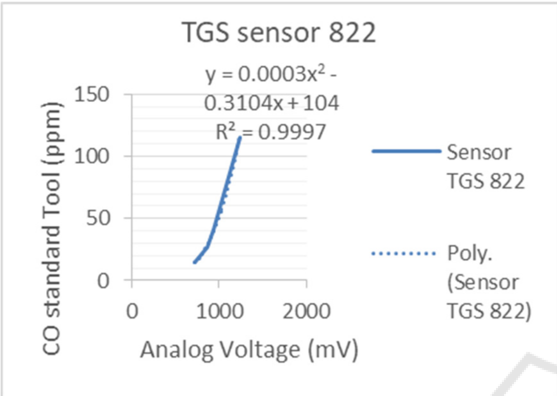

Figure 5. CO calibration regression graph with the TGS 822 sensor

In Figure 5 the test results using the TGS 822 sensor compared with the CO meter tool obtained a regression equation y = $0{,}0003x^2$ - 0.3104 + 104 with a value of R^2 = 0.9997. A large R^2 value indicates a strong correlation between the data from the CO meter with the TGS 822 sensor.

Tool testing is done by attaching the tool to the hood and connected to the 9V power source in the car. Tests carried out in the afternoon during rush hour (between 16:00 to 18:00) and carried out observations along the road. The reading results can be seen in realtime via a PC by connecting via a Bluetooth network. The sensor voltage source is 9V power that is owned by the car. The data collected included temperature and humidity, latitude and longitude, and CO content in ambient air. This can be seen in Figure 6.

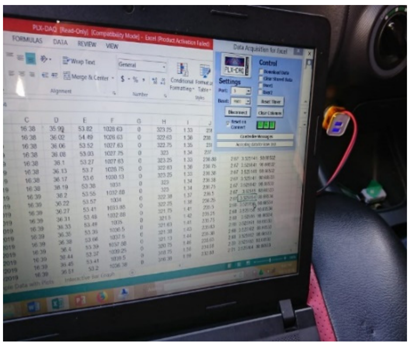

Figure 6. Reading of the ambient CO value via a PC

One of the sampling locations is the Medan Johor area, Jl. Eka Rasmi and Jl. Karya Jaya. The results of the reading can be seen in Figure 7.

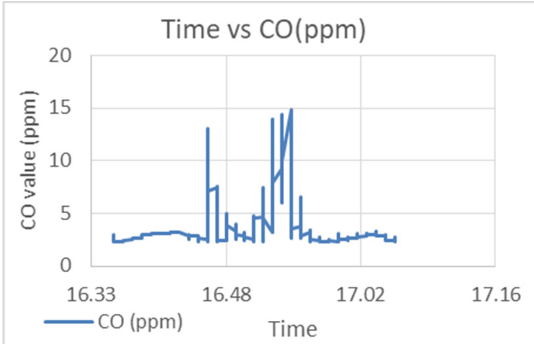

Figure 7. Graph of CO Ambient

From the graph shown in Figure 7 it can be seen that the air on Jl. Eka rasmi has a lower ambient CO value compared to the CO value from Jl. Karya Jaya. This is because Jl. Karya Jaya has a larger vehicle volume because it connects several roads including works of love, devoted work, eka rasmi, iridescent and eka surya. While Jl. Eka Rasmi has a smaller volume of vehicles because it is a branch road from the victorious works and tourist works. Next is to do an Air Quality Index (AQI) calculation which can be determined using the following formula:

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

Real ambient concentration (ppm). Real AQI figures

I = Air Pollution Standards Index calculated
Ia = Air Pollution Standards Index upper limit
Ib = Air Pollution Standards Index lower limit
Xa = Ambient upper limit
Xb = Ambien lower limit
Xx = Real ambient level measurement results.

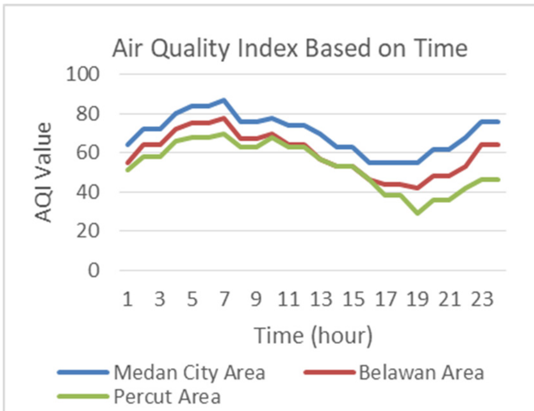

Figure 8. Graph of ambient air in some area in Medan

Measurement of the air quality index in the city of Medan and surrounding areas in October or during testing showed values between 30 to 90 shown in the graph in Figure 8. From the graph it can be seen that the Medan city area, Medan Sunggal, and Delitua have almost the same value in various points and is an area that has the highest AQI value (the lowest air quality) compared to the other three. While Labuhandeli is the area with the lowest AQI value so that the air quality is still better compared to other places. But overall these values indicate that air quality in the city of Medan and its surroundings is still classified in the medium category.

4 CONCLUSIONS

After testing and analyzing the data obtained, conclusions can be drawn including:

a. The tool can measure ambient air quality with sensor.
b. Based on the results of sensor testing and testing of measuring devices, the measurement of ambient quality air in Medan works well.
c. The Air Quality Index in the city of Medan and its surroundings shows a value between 30 to 90.

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