Design of Air Quality Monitoring System Based On Web Using Wireless Sensor Network

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Abstract. Air pollution (O₃, SO₂, CO, NOₓ, PM, and Pb) can have a severe impact on environmental damage and human health problems. Therefore, monitoring of pollutant levels in the air is essential to find out how much that gas levels can cause air pollution. In general, air quality monitoring is carried out using a conventional system. Inside the system requires large-sized equipment, long time for analysis, expensive, and with limited space resolution. It becomes inefficient, amid the development of technology that can carry out online monitoring, real-time, low cost, small size and a wide range of distance. The technology is known as the wireless sensor network system. The aim of this research is to design an air quality monitoring system using a Wireless Sensor Network (WSN) that can be accessed via the web and smartphone. The developing of WSN systems consist of two steps, are design and implementation device. The first step is done by assembling sensor nodes and hosting a web server. And after the device was finished, the next step is testing and calibrating of the system. The results of experiment show that the system is able to detect various air pollution, such as SO₂, NOₓ, CO, and other environmental factors such as temperature, humidity and wind speed.

Keywords: air quality analysis, monitoring system, wireless sensor network (WSN)

1. Introduction

Law of the Republic of Indonesia No. 32 of 2009 and Government Regulation No. 41 of 1999 defines air pollution as the entry or inclusion of substances, energy, and/or other components into ambient air by human activities, so that the quality of ambient air drops to a certain level which causes ambient air to be unable to fulfil its functions [1]. Naturally, air can contain and decompose substances, energy, and/or components that enter, but at a certain level, the air will experience saturation (saturation), so that the addition of substances or other components will cause pollution. According to [2], The Environment Protection Agency (EPA) has identified 6 (six) air pollutants namely ozone (O₃), particulates (PM), carbon monoxide (CO), nitrogen dioxide (NO₂), sulfur dioxide (SO₂), and lead (Pb). SO₂ pollutants have severe effects on cardiovascular disorders such as asthma, emphysema and others and can cause environmental damage such as the greenhouse effect and acid rain [3]. Therefore, monitoring SO₂ contamination needs to be carried out continuously.
especially in places that have the potential to cause pollution, such as areas around industrial estates and crowded and crowded traffic areas. Monitoring of pollutant levels in the air is essential to find out how much that gas levels can cause air pollution [4],[5].

Generally, air pollution monitoring is performed using conventional methods, namely monitoring methods that are not real time and cannot be accessed online. Conventional air monitoring has several characteristics, including large, permanent tool sizes, in locations that are fixed, expensive, have limited space resolution, and are not efficient concerning speed to get results. Currently, it is available technology that can measure SO\textsubscript{2} contamination directly and deliver the results online and real time. Such detection systems can be realised by using Wireless Sensor Networks (WSN) [6].

WSN has the ability to collect measurement data and communicate with other sensors that are connected in a network [7]. WSN is an electronic device that combines sensors, microcontrollers, memory, operating systems, radio communications and energy sources in an integrated embedded platform [8]. This form of technology has several advantages, such as low cost requirement, relatively small in size, low power consumption, easy to operate, wide coverage area, and the collected data can be made available on website, smartphone and other online media [9]. In the WSN system, data generated by the sensor module can be sent to the gateway through various communication modules, including Mobile Wi-Fi (MiFi), Bluetooth, Zigbee and others. Data from the WSN system can also be displayed in browsers on personal computers or smartphones by utilising an internet connection.

2. Methods

2.1. System Design

This research is aimed at developing a monitoring system for SO\textsubscript{2} levels and any influencing environmental factors such as air temperature, humidity and wind speed, using wireless sensor networks. The design will also enable delivery of near real-time data and information that can be accessed from personal computers and smartphones [10]. The scheme of the system design can be seen in Figure 1.

![Figure 1. Diagram of air quality monitoring system based on web](image)

This monitoring system consists of 3 sensor nodes, where each sensor node is placed on one pole with a different height level. Figure 2. show the scheme for installing the three equipment. One sensor node consists of ADC5669 16 Bit 8 channel, power supply, Mobile Wi-Fi (MiFi) and five sensors, one each for measuring SO\textsubscript{2} (MQ-136), NO\textsubscript{x} sensor, CO sensor, air temperature and humidity (SHT15), and wind speed (anemometer).

The sensors measure data in analog, except for digital data measurement from the SHT15 sensor. Analog data is converted into digital data by 16-bit ADC, then sent wirelessly to Web Server by MiFi. Data from the three sensor nodes will be displayed in the form of graphs and tables.
through a web server. The data can also be accessed by smartphone devices so that it can be seen anywhere in real-time and online.

Before the system is ready to be launched as a reliable measuring device, it must be tested and calibrated. Calibration is the process of comparing measurements made by a tool created with standardized measuring devices. Tool calibration can be done at institutions that have SNI-certified measuring equipment such as BBTPPI (Center for Industrial Prevention and Pollution Technology) Central Java Province Indonesia.

Figure 2 shows that equipment 1 is placed at a level of 1.5 m, equipment 2 is at a level of 4 m and equipment 3 is at a level 8 m. The purpose of dividing the distance between the 3 equipment is to find out whether there are differences in measurement data based on the height of the place.

Figure 2 Scheme of Installation of air quality monitoring system
The data generated by the 3 devices is then sent wirelessly to the web server. Data was stored by the web server, then was processed and displayed on the web with the address www.monispu.id. Data can be displayed in the form of tables and graphs.

2.2. Flow Chart of System Testing

The flow chart of equipment testing until the results obtained can be displayed on the LCD 16x2, shown in Figure 3.

![Flow chart of testing and running system](image)

Figure 3 shows the steps of device settings and it's configuration. Starting from parameter initialization, APN settings, reading of data on the LCD and sending of data using the internet network to web server. If the data transmission fails, the alarm will sound. Users can restart of the device until data can be sent successfully.
2.3. Web Based Interface Design

For the web-based interface, we use the PHP programming language with MySQL database engine. Figure 4 shows the appearance of web hosting for air quality monitoring system consist of 4 stations, one for fix station and 3 for mobile stations.

![Image of web-based interface](image)

**Figure 4. Display of air quality monitoring results**

3. Results and Discussion

The measurement results for several air pollution parameters (SO$_2$, CO, Temperature, and Relative Humidity) can be seen in figures 5 and 6.

![Graphs of SO$_2$ and CO](image)

**Figure 5. SO$_2$ and CO measurement data in graphical display**

*Left side (SO$_2$), right side (CO)*
The equipment testing is carried out for 11 minutes. Figures 5 and 6 shows that the system is able to measure air quality parameters such as SO\textsubscript{2}, CO, temperature and relative humidity. The results of the monitoring shows that concentration of SO\textsubscript{2} increase from 4.351 to 4.548 ppm, while concentration of CO show fluctuating results between 8.90 to 8.95 ppm. And then, the temperature data shows a decrease about 0.06 degrees and then it rises at the 7\textsuperscript{th} minutes, while the relative humidity fluctuates and rises sharply after 7 seconds.

Figures 5 and 6 are not shows a positive correlation or causal relationship among the four parameters. But there is interesting phenomenon between temperature and concentration SO\textsubscript{2}. If the temperature decreases than the concentration SO\textsubscript{2} will increase. It means the opposite relationship.

4. Conclusion

The development of a wireless sensor network-based monitoring system is enabling an affordable tool for delivery of real-time data and information that can be accessed online using personal computers and smartphones. This system is highly relevant as an alternative solution to overcoming various problems that are experienced by air pollution monitoring stations in Indonesia, either due to equipment damage or absence of equipment.

5. References

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