Air Quality Monitoring System in Urban Areas

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Abstract. This study aims to investigate the use of technology to monitor air quality in urban areas. The method used is descriptive research using the data obtained from the application provided to monitor the air quality of urban areas. The results of this study indicate that there are many applications to monitor air quality in major cities in the world. Air quality monitoring systems can produce information on which cities have the best, sufficient, and worst air quality. Also, the applications show air quality information in real-time. The disadvantages are that complete and accessible information is only from big cities.

1. Introduction

Internet of things is a smart device system that can connect with the environment and interact with users or other devices. The Internet of Things includes objects "things" that have network availability, make it possible to send data, and get information. That "things" here include people, information, software agents,[1-3] In this modern era, there has been a very rapid growth of development in various fields, ranging from the fields of economy, agriculture, technology, health, and other fields. This growth certainly has risks to environmental quality if there is no balance. The problem faced if there is no balance between technology and the environment are air, water, and soil pollutions. High growth in urban and suburban areas has great potential in increasing the use of energy consumption, such as fuel requirements for electricity generation, industrial furnaces, and transportation [4-6].

Combustion of these fuels is the primary source of pollutants released into the air, such as CO₂, NO₂, SO₂, SPM (suspended particulate matter), and various other heavy metals [7,8]. With too much concentration of this substance and exceeding the threshold released will harm the environment, both for humans, plants, animals, and damage to objects (materials) [9]. To overcome the effects of air pollution, the use of "internet of things" as an air monitoring tool is needed, where air data is used for further decision making. Previously several studies discussed air monitoring, including research conducted by Dhingra, where the results of the study were displayed with graphs of levels of substance concentration in the air and mapping displayed in a line [10,11]. Internet of things is to measure and monitor the surrounding air where the difference is the result of a detection tool, not displayed directly but displayed on an android with a dot shape when clicked on a point there is displayed info about the ambient air content [3]. The detection tools they used formed a mapping line and points that were installed on Android, where the lines contained information about the level of air content in the area [4]. The difference some research use bicycles to be able to retrieve data in an area.

The purpose of this study is to improve the use of technology on air conditions in cities to minimize respiratory diseases, with the technology it is expected to increase the level of public trust to live in an area by feeling safe and lifting the economic sector to develop rapidly. This research method uses descriptive research methods where data is obtained from certain areas.

2. Method
The research used is a descriptive method, wherein this method in solving the problem by describing the state of the subject or object based on facts and the required data obtained from events that have occurred in an area [5]

3. Results and Discussion

The growth and development of technology in an area cannot be prevented. The development of technology requires large energy consumption as well. Large energy consumption such as the use of fuel for industry and transportation, if not regulated, air pollution will occur, which will affect human health. The following is the number of sulfur emissions produced by the world per region from 1850-2010 (Figure 1).

![Figure 1. Global Sulphur Dioxide Emissions by Word Region](image)

Ourworldindata data throughout the world, the level of emissions released by each region is substantial, for example, Asia in 2010 issued SO\(_2\) gas emissions of 51.73 million tons [12]. Sulfur dioxide appears as a colorless gas with choking odor and can irritate the eyes and mucous membranes [13]

Sulfur dioxide in the air comes mainly from human activities such as industrial activities used the burning of coal and oil at power plants or from copper smelting. In nature, sulfur dioxide can be released to the air from volcanic eruptions.[13] The effects of disease from air pollution are a severe problem. WHO mentions one-third of deaths due to stroke, lung cancer, and heart attack [14]. If it continues to be exposed to harmful substances from bad air, it will result in the death of not only humans but also living creatures in the vicinity who will die, for example, animals and plants. The following is a map of mortality rates due to air pollution in the world (Figure 2).
Based on data from ourworldindata in Indonesia 2016, the death rate due to outside air pollution is 80,650 persons, this is very worrying and efforts are needed to minimize deaths due to this [6]. The impact of air pollution is not only a health problem but also causes acid rain. Acid rain can damage forests, lakes, rivers, and buildings, especially objects made of iron [15]. As a result of damage to objects affected by acid rain will undoubtedly endanger the economy because of the many tools of the production process or the delivery of goods that use iron must go through expensive maintenance. The following are losses caused by air pollution (Figure 3).
Based on the data above, the total cost of damage caused by air pollution in 2012 in Europe reached 59 billion euros and could even reach 189 billion euros; this is very detrimental to the country [16]. From the data obtained, it is proven that air pollution is very influential for the health, environment, and economy of people who live in an area. Therefore, we need a system that can monitor air quality and give warnings to people suffering from respiratory diseases to wear masks or stay away from areas that have inferior air quality. So the result of this research is the creation of an "internet of things" based system to monitor air condition by sending data obtained by the device, where the device is installed on public vehicles that have passed emission test standards. The data obtained is sent to the server for processing so that it can provide information about air quality and give warnings to people who have respiratory problems. The following is a system work architecture (Figure 4).
Figure 4. System Work Architecture

The system works as follows:
1. Sensor Unit
Detecting the concentration of substances in the air in an area and the data that has been obtained will be sent to the server for processing.
2. Server Unit
Receive data, process data, save and display to the website for further purposes.
3. Mobile Application and Website
Display air quality information in real-time with the heat map display and give cell phone users a warning in the form of a warning when entering an area where the air is terrible. Heat maps are used to display data that has been processed into color maps that refer to AQI (Air Quality Index)[17]. Heat map example view (Figure 5).

Figure 5. Heat Map Display
The following is information about colors (Figure 6).

| Air Quality Index | Who Needs to be Concerned? | What Should I Do? |
|-------------------|----------------------------|-------------------|
| Good 0-50         | It’s a great day to be active outside. |                      |
| Moderate 51-100   | Some people who may be unusually sensitive to particle pollution. | Unusually sensitive people: Consider reducing prolonged or heavy exertion. Watch for symptoms such as coughing or shortness of breath. These are signs to take it easier. Everyone else: It’s a good day to be active outside. |
| Unhealthy for Sensitive Groups 401-500 | Sensitive groups include people with heart or lung disease, older adults, children and teenagers. | Sensitive groups: Reduce prolonged or heavy exertion. It’s OK to be active outside, but take more breaks and do less intense activities. Watch for symptoms such as coughing or shortness of breath. People with asthma should follow their asthma action plans and keep quick relief medicine handy. If you have heart disease: Symptoms such as palpitations, shortness of breath, or unusual fatigue may indicate a serious problem. If you have any of these, contact your health care provider. Everyone else: Reduce prolonged or heavy exertion. Take more breaks during all outdoor activities. |
| Unhealthy 151-200 | Everyone | Sensitive groups: Avoid prolonged or heavy exertion. Move activities indoors or reschedule to a time when air quality is better. Everyone else: Reduce prolonged or heavy exertion. Take more breaks during all outdoor activities. |
| Very Unhealthy 201-300 | Everyone | Sensitive groups: Avoid all physical activity outdoors. Move activities indoors or reschedule to a time when air quality is better. Everyone else: Avoid prolonged or heavy exertion. Consider moving activities indoors or rescheduling to a time when air quality is better. |
| Hazardous 301-500 | Everyone | Everyone: Avoid all physical activity outdoors. Sensitive groups: Remain indoors and keep activity levels low. Follow tips for keeping particle levels low indoors. |

**Figure 6. Air Quality Index Table**

4. Support Unit
Public transportation is used as a means of placing tools to obtain air quality data from strategically targeted areas. The use of public transportation is used because it can reduce the cost of making excess device. However, public transportation must pass the standard emission test.

The following devices are used:

**A. Hardware**
- MQ 135 Sensor is suitable for detecting of Nox alcohol, NH3, benzene, CO2, smoke, huge.
- DHT 22 Sensor is used to detect humidity and temperature.
- GPS module is used to detect the location of the device.
- SIM900 module GSM/GPRS is used for communication between devices and mobile phones.
- Arduino is a microcontroller to regulate the work of the primary control devices used in air monitoring systems.
- Solar panels convert solar energy into electricity to support the power of air monitoring systems.

**B. Software**
- Arduino IDE is software for entering commands that have been made and put into the microcontroller.
- Android Studio is software for developing android-based cellular applications.
- Laravel is a framework used to create web applications.
- Firebase is a database that is hosted in the cloud. Data is synchronized in realtime in the form of JSON.
4. Conclusion

Technology is developing rapidly. With technology, we are much helped especially to provide information about the quality of the surrounding air and to give a warning to sufferers of respiratory disease to protect themselves from things that are not desirable. With advances this technology, it certainly makes people who want to live in the area believe, comfortable to live, can improve the economic sector, and can reduce losses due to air pollution in the economic sector.

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