Water Quality Monitoring System Based on Microcontroller and LoRa

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ABSTRACT
Water is essential for human and other lives such as marine and plants. However, water pollutions are a serious issue that needs to be solved. One of the actions that needs to be taken is to monitor the water quality regularly. However, many areas still used manual monitoring due to high cost of automatic monitoring system. Hence, this study aims to develop a low-cost and low-power water pollution monitoring system using a microcontroller and long-range wireless system (LoRa). The system monitors the water pollutions through pH and temperature sensor. Next, the data transmitted to a host PC wirelessly through LoRa communication. The data received will be stored in a cloud with GUI. Moreover, the system equipped with a PV panel and Lithium-ion battery storage. This will allow the system to be deployed in remote areas with no power sources. The system performance on pollution detection and transmission distance were tested via several experiments. Several substances with different pH values were used simulate polluted water. Meanwhile, the data transmission was evaluated through several distance parameters. The results show the system successfully able to monitor polluted water with high accuracy and capable to transmit long-range data wireless. Hence, the system has efficient power usage through few numbers of sensors alongside LoRa that uses low power for communication.

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1. INTRODUCTION

Water is crucial for life on earth. Unfortunately, the number of constructions, ch These pollutions occurs when chemicals are put into bodies of water, either inadvertently or intentionally, without proper treatment to remove hazardous sediments. As a result, it will have an impact on the environment and human lives.

Nowadays, the methodology used to test. The water standard is to have operators perform the task of extracting a sample of water supplies a few times a day and conducting the test in a laboratory environment. However, this method is time-consuming and repetitive that requires an additional workforce for manual reading. Furthermore, the data were also unable to be monitored in real-time from different locations. Therefore, many researchers have developed a microcontroller system to monitor water quality in real-time to solve these issues. For example, Shwetal et al. developed a wireless sensor network to monitor water pollution for several locations in a metropolitan area [1].

Moreover, Brinda et al. develop a water quality monitoring system with Internet of Things (IoT) [2]. This system able to monitors the data and store in a cloud-based environment. Additionally, Nowshin et al. develop a smart water quality measurement system with several sensors and a controller [3]. There are also many other researchers who are working in the the development of water quality monitoring system as in [4]–[9]. Furthermore, Not limited to urban areas only. Kadir et al. developed a system to monitors the river water pollutions [10]. There were also researcher developed a system for the aquaponic water system [11].

Recently, LoRa technology has been used for long distance and low-power communication [12]. Therefore, many studies were conducted that includes LoRA for data transmission. For instance, Bhawiyuga et al. uses LoRA for data transmission to a host PC for a smart aquaculture [13]. Meanwhile, Lin et al. developed a water meter reading system based on LoRa communication [14].

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Similarly, this study aims to develop low-cost and low-power systems to monitor water quality for urban areas. The system uses several sensors such as pH and temperature to monitoring water quality alongside LoRa for data transmission.

This paper is structured as follows: Section 2 presents the methodology conducted for this study. Then, section 3 discusses the results. Finally, section 4 summarizes the finding of this study.

2. METHODOLOGY

This section discusses the method used to develop this that includes the block diagram, flow chart, schematic diagram, plan layout, and list of components. Figure 1 showed the block diagram of water quality monitoring using a sensor that measures the necessary parameters and transmits them to a host PC. The following block diagram is divided into five parts: input, process, transmitter, receiver, and output. This study utilizes an Arduino to process data from information to output as the central controller. There are three types of input sensors used: the pH sensor and the temperature sensor of water quality. The temperature sensor measures the water temperature, and it can detect the atmospheric temperature. For example, the PH sensor would measure the river's water pH value to check the acidity of the water. A biosensor is an analytical instrument that combines a biological component with a physicochemical detector to detect a chemical material. The sensor attached to the water transmits information to Arduino to analyze the information. LoRa nodes can receive the data and send it to the network server using the LoRa gateway. Data is stored in the cloud and can be accessed from the user interface devices such as PC and laptops for monitoring purposes. The user will collect the data regarding pH sensor, surrounding temperature sensor, biosensor, and the current activity when water pollution happens with high data recorded.

![Fig. 1. Block Diagram for water quality monitoring.](image1)

The process of the system is shown in the flowchart in Figure 2. Firstly, the sensors measure the data of pH and temperature. Once the data is read, the value will be passed to the controller. Finally, the user can access data and information using a PC and laptop, and the process ends.

The complete schematic drawing of the development and monitoring of water pollution using a long-range wireless system is shown in Figure 3. The components are pH sensor, temperature sensor (DS18B20), solar panel, solar charge controller, Arduino UNO, Dragino LoRa shield 915MHz, lithium battery, on/off push button Dc-Dc step down voltage regulator.

![Fig. 2. Flowchart Water Quality Monitoring System](image2)

![Fig. 3. Block diagram](image3)

3. RESULTS AND DISCUSSION

Several experiments were conducted to evaluate the developed prototype. There were two experiments conducted.
Experiment 1 focuses on the evaluation of the data transmission distance between LoRa transmitter and LoRa receiver. Several distances were selected such as 3 km, 7 km and 10 km for the Dragino LoRa shield 915 MHz. This will provide a clear picture on the actual distance of data transmission that can be achieved by the prototype.

Table 1. Data Monitoring Distance Test Between LoRa Transmitter and LoRa Receiver

<table>
<thead>
<tr>
<th>No.</th>
<th>Item</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3 Kilometers</td>
<td>RSSI -29</td>
</tr>
<tr>
<td>2</td>
<td>7 Kilometers</td>
<td>RSSI -77</td>
</tr>
<tr>
<td>3</td>
<td>10 Kilometers</td>
<td>RSSI -116</td>
</tr>
</tbody>
</table>

Figure 8 and Figure 9 show the Mixed phosphate (pH 6.86) used in the experiment to test the pH value. After testing, the data recorded using Serial Monitor IDE is 2.53V, the exact value given is based on the 2.535V datasheet. Figure 10 and Figure 11 show the Sodium tetraborate (pH 9.18) used in the experiment to test the pH value. After testing, the data recorded using Serial Monitor IDE is 2.06V which is the exact value given based on the 2.066V datasheet. Based on the value of the output voltage that has been tested shows very close and accurate.

3.1 Experiment 1: Distance Evaluation Between LoRa Transmitter and Receiver

Table 1 shows the experiment setup for distance evaluation of the LoRa module. Based on the experiments conducted above with three different lengths from where the LoRa Transmitter is placed for testing, the main checkpoint used is UniKL British Malaysian Institute which is the place of data transmission for this study. At the same time, the LoRa Receiver is brought along in the vehicle for data recording and evidence to strengthen this testing further. Google map was used to decide on the actual distances. This experiment contains three different lengths, namely 3 km, 7 km, and 10 km. For the first 3 km, the distance that can be recorded via Google Map is 3.1Km with RSSI LoRa -29 reading. For the 7 km, the RSSI reading of LoRa -77. For the second 10 km, the RSSI reading of LoRa -116. Finally, the lower the RSSI reading, the higher the strength of the received signal.

3.2 Experiment 2: Water Pollution Evaluation based on pH values

The experiment was conducted by using pH substances, namely Mixed phosphate, Potassium Hydrogen Phthalate, and Sodium tetraborate. Figure 6 and Figure 7 show the Potassium Hydrogen Phthalate (pH 4.00) used in the experiment to test the pH value. The data recorded using Serial Monitor IDE. The data obtained is 3.07V which is the exact value given based on the 3.071V datasheet. Hence, the value obtained is validated and accurate.
4. CONCLUSION

This study has successfully developed a water quality monitoring system using pH and temperature sensors. Furthermore, the data was able to be transmitted wirelessly using LoRa. Moreover, the system performance was successfully tested based on several experiments. In conclusion, this system can be used as a low-cost and low-power solution for water quality monitoring. The system also uses PV solar panels and battery storage for power input.

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REFERENCES