IMPLEMENTATION OF INTERNET OF THINGS (IoT) BASED ON GOOGLE SHEETS FOR WATER QUALITY MONITORING SYSTEM

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Abstract

[Implementation of Internet ff Things (IoT) Based on Google Sheets for Water Quality Monitoring System] Temperature, pH, and TDS are important indicators of water quality that affect various aspects. This research aims to develop a water quality monitoring system by implementing Internet of Things (IoT) technology based on Google Sheets. Based on the tests for each sensor - temperature, pH, and TDS - the results show that the system has an excellent level of measurement precision, with an average precision value of above 95%. The findings also indicate that Google Sheets can be utilized in IoT technology and can operate on more than one distinct computer device at the same time. The use of Google Sheets in IoT technology is highly effective, flexible, and user-friendly. The measured data can be automatically stored and can be visualized effectively.".

Keywords: Google sheet, Internet of Things (IoT), pH, TDS, temperature

INTRODUCTION

Water quality is a critical aspect that influences human well-being, aquatic ecosystems, and industries that rely on clean water supplies. Parameters such as temperature, pH, and Total Dissolved Solids (TDS) are vital indicators of water quality that affect various aspects, ranging from the health of aquatic organisms to the reliability of industrial processes (Ustaoğlu et al., 2020; Sharma et al., 2020; Chebet et al., 2020).

Currently, technology has provided us with the capability to monitor water quality more efficiently. One way to achieve this is by utilizing the Internet of Things (IoT) technology. IoT enables devices to connect to the internet and transmit data in real-time, facilitating decision-making based on accurate and timely data (Ayvaz & Alpay, 2021; Nurelmedina et al., 2021).

The implementation of the Internet of Things (IoT) technology in various aspects of life has experienced significant growth over the past few decades. Research utilizing IoT has been conducted by several researchers. Wilani et al., in 2023, conducted a study on noise level monitoring in laboratories based on IoT using the Blynk application. The results of their research indicated that IoT technology can effectively monitor sound intensity levels. Another study on monitoring patients infected with Covid-19 based on IoT using the Blynk application also demonstrated that IoT technology can display measurement parameters accurately (Amri and Pebralia, 2022). Furthermore, a study by Pebralia et al., in 2022, showed that IoT technology can be used to monitor forest fires with good performance.

However, one of the challenges in implementing IoT is how to store, process, and analyze data effectively (Yadav et al., 2018; Banafa, 2016). Google Sheet, as an easily accessible and user-friendly cloud platform, offers a solution to this problem (Kusuma et al., 2022; Kulkarni et al., 2016). By integrating IoT devices with Google Sheet, water quality data can be recorded, analyzed, and presented easily, quickly, and cost-effectively.

Utilizing Google Sheet in an IoT-based water quality monitoring system offers various advantages, such as easy data access across different devices, the convenience of sharing data with others, and integration with various other analytical tools available on the Google platform.

Given the importance of monitoring water quality and the potential integration between IoT and Google Sheet, this study aims to delve deeper into the implementation and practical applications of combining these two technologies in monitoring the parameters of water temperature, pH, and TDS.

RESEARCH METHODOLOGY

This research aims to create an affordable and efficient water quality monitoring system. The

system is developed using low-cost instrumentation components and open-source (free) software. The hardware block diagram is displayed in Figure 1.
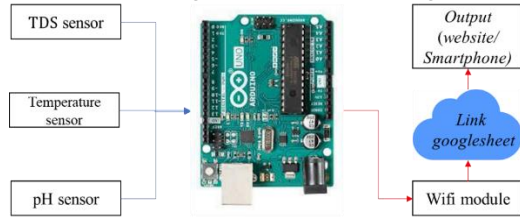

Figure 1. IoT-based water quality monitoring system block diagram.

The hardware system of the smart water quality monitoring consists of two main parts: the input system and the output system. The input system is composed of electronic components, namely the Arduino Uno microcontroller, TDS sensor, temperature sensor, and pH sensor. The output system consists of electronic components like the WiFi module, smartphone, and computer. Furthermore, the software system for smart water quality monitoring is designed and executed using the Arduino Uno IDE program.

Data Analysis

There are two stages of data analysis conducted in this study. The first stage involves analyzing the measurement values from each of the temperature, pH, and TDS sensors. The aim is to determine the precision value of each sensor's measurements. To obtain the precision value, the following equation is used:

$$Precision = (100 - \sigma)\% \qquad (1)$$

where σ represents the standard deviation of the experiment. The standard deviation value is obtained through the following equation:

$$\sigma = \sqrt{\frac{\sum(x_i - \mu)^2}{N}} \qquad (2)$$

where x_i is the i-th data, μ represents the mean value, and N is the total number of data points. If the precision value exceeds 90%, the water quality measuring device can be considered to have good performance.

Subsequently, data analysis was conducted on the performance of the IoT-based monitoring system using Google Sheets. The monitoring system's analysis was carried out by remotely monitoring for 1 hour through the prepared Google Sheets link. The monitoring system's performance was evaluated based on the system's ability to display data on different computer devices. During the monitoring process, the research team added powdered salt to the water solution being tested to observe fluctuations in TDS and pH values. Additionally, the team varied the water's temperature by mixing in hot water with the room-temperature test water, aiming to observe temperature fluctuations being monitored.

RESULT AND DISCUSSION

The Hardware System of Water Quality Monitoring

The developed water quality measurement system aims to measure the temperature, pH, and TDS levels of water in real-time and from a distance. The water quality measurement system was developed by connecting the temperature sensor, pH sensor, and TDS sensor to the Arduino Uno microcontroller. The schematic of the measurement system is displayed in Figure 2.
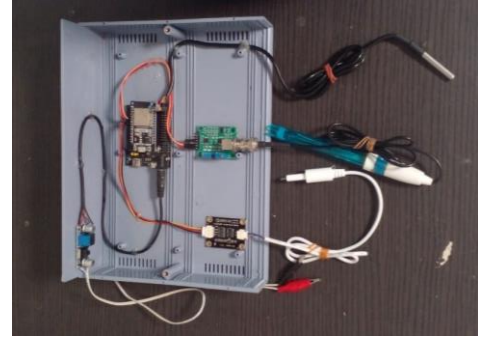

Figure 2. The hardware of IoT-based water quality measurement

The power source used in this measurement system comes from a lead-acid battery. The utilized voltage is 5.5 V. In the hardware circuit, a step-down transformer is integrated. The step-down transformer functions to reduce the incoming voltage in the circuit to the desired level. This is because the original voltage from the battery has a relatively high value, reaching 12 V. Therefore, this voltage needs to be reduced first to 5.5 V.

Testing of Water Qualities by The Sensors

This stage aims to measure the precision level of the water quality parameters, namely temperature, pH, and TDS, from the system that has been developed. The test was conducted by taking measurements to obtain 100 continuous data points. Figure 3 displays the graph of the water quality parameter measurement results.
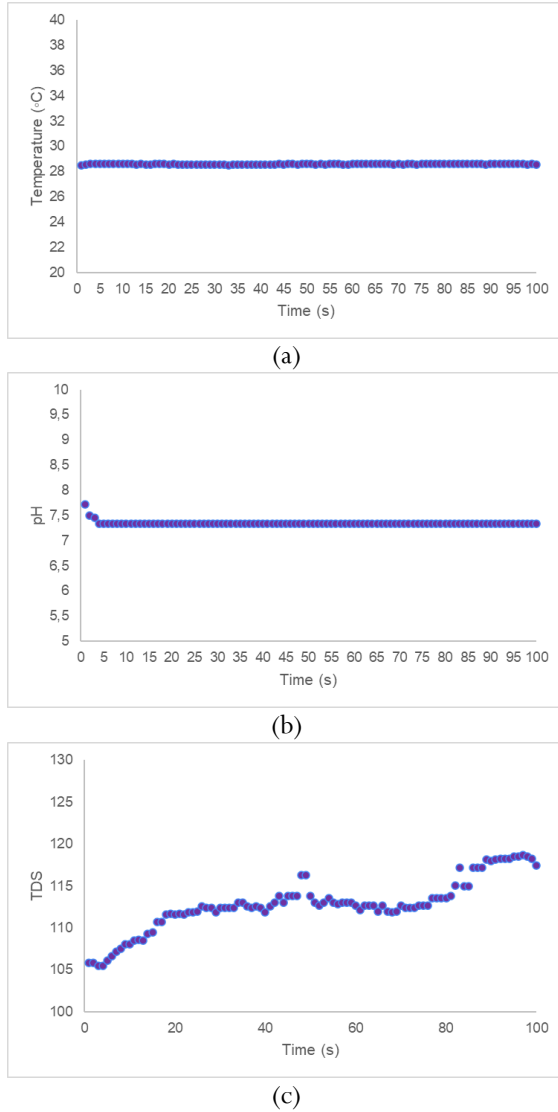
(a)

(b)

(c)

Figure 3. Sensors test results: (a) temperature sensor test, (b) pH sensor test, (c) TDS sensor test.

The precision level of each sensor was then calculated using equations (1) and (2). Table 1 displays the standard deviation values for measurements with a total of 100 data points and the respective precision values for each sensor.

Table 1. The precesion values of each sensors

Parameters	The Number of Datas	Deviation Standard	Precision
Temperature	100	0,03	99,97%
pH	100	0,04	99,96%
TDS	100	3,13	96,87%

Based on the tests conducted, it can be observed that each sensor has a very high precision level, exceeding 95%. This indicates that the system can be effectively used for measuring water parameters, specifically temperature, pH, and TDS.

**IoT-Based Water Quality Monitoring System**

Based on the test results of each sensor, as shown in Figure 3, it is evident that the measurement system has a very high level of precision. The research then proceeded to develop an IoT-based monitoring system using the Google Sheets application. Figure 4 displays a screenshot of the coding used in creating the monitoring system.

```
//   Serial.print("HTTP Status Code: ");
//   Serial.println(httpCode);
  //-----------------------------------------------------------
  //getting response from google sheet
  String payload;
  if (httpCode > 0) {
      payload = http.getString();
//      Serial.println("Payload: "+payload);
  }
  //-----------------------------------------------------------
  http.end();
  }
  count++;
  delay(1000);
}
```

Figure 4. Screenshot of the IoT-based water quality monitoring code

In this study, Google Sheets was used as the water quality monitoring application. This choice was made because Google Sheets can display measured parameters in real-time and is very user-friendly. Additionally, the Google Sheets application is open-source, allowing users more flexibility in developing the monitoring display interface.

After calculating the precision value of each sensor used and integrating the Google Sheets software into the device through the developed code, the test for the IoT-based water quality monitoring system was conducted. This test aimed to observe the performance of the developed monitoring system. Figure 5 displays the monitoring graph of temperature, pH, and TDS over a 1-hour period using Google Sheets.
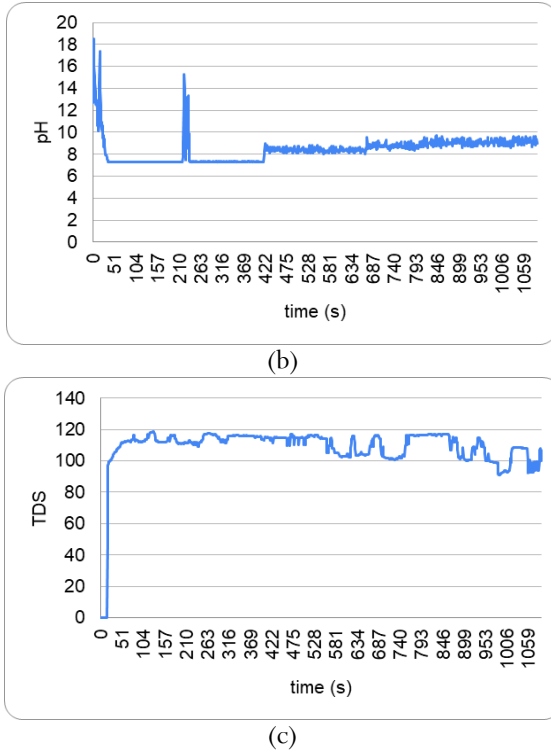

(a)

(b)

(c)
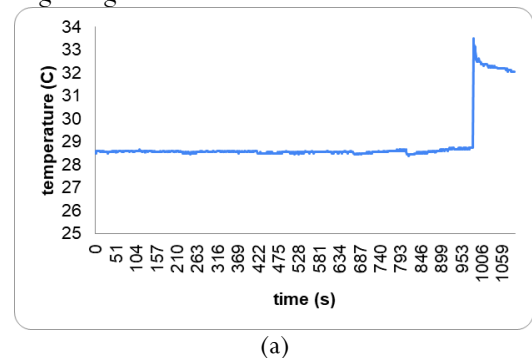
Figure 5. Graph of temperature, pH, and TDS monitoring results over a 1-hour period displayed on Google Sheets.

Temperature fluctuations occur at data point 938, as shown in Figure 5(a). The initial test water temperature, which was stable at 28.75°C, experienced a significant fluctuation, reaching 33.13°C. This fluctuation resulted from the addition of hot water to the test sample. Fluctuations were also observed in the measured pH value. As seen in Figure 5(b), there are at least three significant fluctuation peaks. These fluctuations were due to the addition of powdered salt to the test water. In contrast to the temperature and pH parameters, the monitored TDS value of the water in the monitoring system experienced unstable fluctuations. This instability was due to the non-homogeneous addition of powdered salt to the test water.

Overall, the graph for each water quality parameter can be displayed on various computer devices. Table 2 presents the readability indicators of the monitoring system on two different computer devices.

Table 2. Monitoring system on two different computer devices.

| | Water Qualities Parameter | | |
	Temperature	pH	TDS
Computer A	On	On	On
Computer B	On	On	On

One of the advantages of using Google Sheets in remote monitoring is its ease of use. This research produced a Google Sheets link that can be accessed by any computer or smartphone from a distance. Based on tests on two different computers, each computer was able to display the monitoring graph in real-time. The graph displayed on computer A was identical to the graph on computer B. Besides being able to display graphs as shown in Figure 5, Google Sheets can also present attractive visuals similar to those on websites, as illustrated in Figure 6.
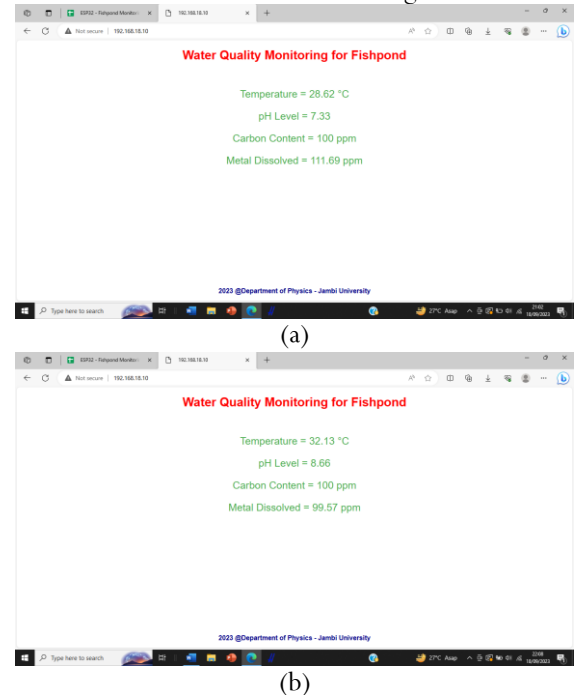

(a)

(b)

Figure 6. Water quality monitoring display: (a) monitoring results at t = 15 minutes, (b) monitoring results at t = 65 minutes.

CONCLUSION

In conclusion, through this research, an IoT-based water quality monitoring system using Google Sheets has been successfully developed. Based on tests conducted with 100 data points, each sensor integrated into the measurement system demonstrated a very high precision level, with an average exceeding 95%. Furthermore, the Google Sheets application was successfully integrated into the monitoring system and could display water quality parameters in real-time. Testing on two different computers simultaneously showed that the monitoring system functions well and accurately displays monitoring data.

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