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Water Turbidity Alert System for IoT-Based Water Tank

Hasanah Putri, Atik Novianti, Dadan Nur Ramadan

School of Applied Science, Telkom University, Bandung, Indonesia

Abstract: Water has enormous benefits in daily life; quality and quantity maintained are required to be always ensured. In Indonesia, Bandung, many people keep clean water supplies in water tanks. The habit appeared as the result of their dependency on groundwater. However, some people also have already been connected to the government's water pipeline network, but they still need to have clean water tanks for prevention. The tanks need regular maintenances to ensure the stored water remains clean. When the tanks are rarely cleaned, moss appears, clogging the water pipe. The manual process of monitoring water conditions has several weaknesses, such as needing expert staff, taking more extended time, having a greater possibility of errors, and not presenting and neatly storing documentation. This paper aims to implement a water turbidity warning system in tanks and an IoT-based scheduling system for cleaning water tanks. The system will be implemented at several points of the house or water tank and can transmit data in real-time either alternately or simultaneously. The sensor detects water turbidity, and the microprocessor control unit node is in charge of processing the sensor reading data to calibrate and classify the turbidity level. Water turbidity values and levels are sent to Firebase, which resides in the cloud. The information from Firebase is passed and displayed on the application. The turbidity level of water was categorized into three: clean, turbid, and dirty. Managers, as the service providers, and consumers can monitor the tank's condition with a warning in the form of an indicator when the tank must be cleaned.

Keywords: water, turbidity, alert, Internet of Things, application.

基於物聯網的水箱水濁度警報系統

摘要：水在日常生活中有著巨大的好處；需要始終確保質量和數量。在印度尼西亞的萬隆，許多人在水箱中保存乾淨的水源。這種習慣是由於他們對地下水的依賴而出現的。不過，有些人也已經接入了政府的自來水管網，但仍需要有乾淨的水箱以防萬一。水箱需要定期維護，以確保儲存的水保持清潔。當水箱很少清洗時，會出現苔蘚，堵塞水管。人工監測水情的過程有幾個弱點，例如需要專家人員、花費更多的時間、出錯的可能性更大，以及不能提供和整齊地存儲文檔。本文旨在實現水箱水濁度預警系統和基於物聯網的水箱清洗調度系統。該系統將在房屋或水箱的多個點實施，可以交替或同時實時傳輸數據。傳感器檢測水濁度，微處理器控制單元節點負責處理傳感器讀取數據以校準和分類濁度級別。水的濁度值和水位被發送到位於雲端的消防基地。來自消防基地的信息被傳遞並顯示在應用程序上。水的濁度等級分為三級：乾淨、混濁和臟。管理者，作為服務提供者，消費者可以監控罐的狀況，並在必須清洗罐時以指示器的形式發出警告

关键词：水、濁度、警報、物联网、應用。

1. Introduction

As one of the basic needs for humans, water has enormous benefits in daily life, is required to be always ensured that its quality and quantity are maintained. In Indonesia, Bandung, many people keep clean water supplies in water tanks. The habit appeared as the result

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About the authors: Hasanah Putri, Atik Novianti, Dadan Nur Ramadan, School of Applied Science, Telkom University, Bandung, Indonesia

of their dependency on groundwater. However, some people also have already been connected to the government's water pipeline network, but they still need to have clean water tanks for prevention. The tanks need regular maintenances to ensure the stored water remains clean. When the tanks are rarely cleaned, moss appears that the water pipe can clog. The manual process of monitoring water conditions has several weaknesses, such as needing expert staff, taking more extended time, having a greater possibility of errors, and not presenting and neatly storing documentation.

In the past few years, many small and medium businesses have engaged in the services sector, especially cleaning water tanks and bathrooms; some even have thousands of consumers consisting of houses, boarding houses, mosques, schools, and many more. The businesses have professional workforces in their field, but they do not yet have a warning system for cleaning the tanks periodically. Therefore, there are no notifications when the water is turbid or needs to be cleaned. It makes the business owners (the managers) and consumers do not know the actual tank water condition. Thus, it brings the demand to clean the tanks simultaneously and irregularly. The managers find it challenging to serve all the consumer requests; moreover, water is usually very turbid and mossy. Therefore, a notification system is needed to display the water turbidity level in the tank and a schedule for cleaning the tank.

Several previous studies have discussed the efforts in maintaining water quality. The water quality, whether contaminated with pollutants or not, can be represented through the water quality index, Horton index, and Dinius index [1]. The Water Quality Index (WQI) determines the minimum, maximum, and annual average biological, chemical, and physical water parameters [2]. Parameters of temperature, pH, turbidity, salinity, nitrate, and phosphate obtained from the sensor become the indicators of the water quality test [3]. In addition, a modified Fuzzy Sugeno model was applied to classify the water quality into three classes: feasible, safe, and unsafe. The three classes of water described can be consumed; other than is dangerous. The experiments have been carried out using a robot equipped with three sensors to identify the water quality [4]. The related research to monitor and control water quality using wireless devices has also been carried out, including LoRa technology, wireless sensor networks, Internet of Things (IoT), and others [5-10].

This paper discusses implementing a water turbidity warning system in tanks and an IoT-based scheduling system for cleaning water tanks. The system will be implemented at several points of the house or water tank and can transmit data in real-time either alternately or simultaneously. The sensor detects water turbidity, and the microprocessor control unit (MCU) Node processes the sensor reading data to be calibrated and classified the turbidity level. Water turbidity values and levels are sent to Firebase, which resides in the cloud. The information from Firebase is passed and displayed on the application, where the turbidity levels include: clean, turbid, and dirty. There are several features in the application section: a list of consumer locations, a confirmation chat feature from admin to consumers, and information on water turbidity levels. The paper is written in several parts: introduction, water turbidity warning system, results and discussions, and conclusions.

2. Water Turbidity Warning System

The water turbidity warning system was implemented to determine the water level in the tank and send the water condition to the application via the internet network. In this paper, two scenarios were proposed, the first is a single water tank scenario, and the second is a multiple water tank scenario. Fig. 1 illustrates the single tank and multiple tanks scenarios. The primary difference from these scenarios is the number of water tanks being monitored for their condition. In the single tank scenario, only one tank is monitored, the sensor reading results are sent to the cloud and then be displayed via the application. At the same time, the second scenario monitors several water tanks where the data from sensor reading in each tank can be sent simultaneously or alternately in real-time. The two scenarios aim to see the level of effectiveness of the number of tanks that the system can monitor.

The first step is conducted when implementing the system was overall designing. The design includes determining the system block diagram, workflow, and realization.

2.1. System Block Diagram

The system consists of several parts, as shown in Fig. 2. The sensor is placed on the side of the water tank according to how the sensor works. In the designed warning system, water quality is seen from the turbidity level. The data from the sensor readings are forwarded to the microcontroller to be calibrated, and then the turbidity level is determined. The information is then sent to the cloud. The water turbidity warning system utilizes the database in the cloud to store data from the sensor readings. Then the data is sent to the application and displays the water quality level, whether it is clean, turbid, or dirty. The application will display the information of water quality level and several other supporting features. The specifications for each component of the water turbidity warning system are described in Table 1. The sensors used are turbidity sensors, the microcontroller uses the MCU Node, the database used is Firebase, and the application can be accessed through the Android operating system.

Fig. 1 Implementation Scenario of water turbidity warning system: (a) Single water tank scenario; (b) Multiple water tanks scenarios

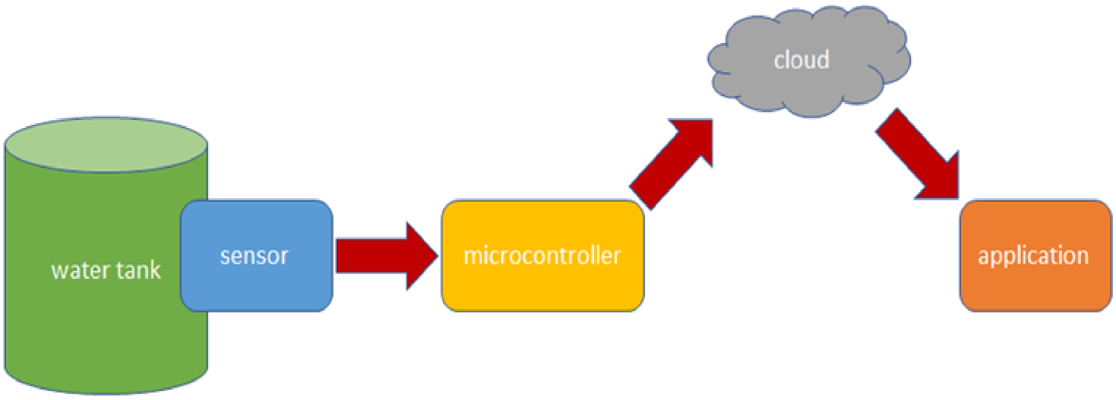


Fig. 2 Block diagram of water turbidity warning system

Table 1 Specification of water turbidity warning system

No	Tool and material	Specification
1	DFRobot Analog Turbidity Sensor	Operating Voltage: 3-5V DC Operating Current: 40 mA (MAX) Response Time: <500 ms Insulation Resistance: 100 MOhm (Min) Output Method: Analog Analog output: 0-4.5V Digital Output: High/Low-level signal Operating Temperature: 5℃~90 ℃ Storage Temperature: -10℃~90℃ Weight: 30g Adapter Dimensions: 38×28×10 mm/1.5×1.1×0.4 inch.
2	Node MCU ESP 8266	Microcontroller / Chip: ESP8266-12E Input Voltage: 3.3 ~ 5V GPIO: 13 Pin Kanal PWM: 10 Kanal 10-bit ADC Pin: 1 Pin Flash Memory: 4 MB Clock Speed: 40/26/24 MHz Wi-Fi: IEEE 802.11 b/g/n Frequency: 2.4 GHz – 22.5 GHz USB Port: Micro USB USB Chip: CH340G
3	Database	Real-Time Database Firebase
4	Battery	Voltage: 5V
5	Android	Android Minimum Specification OS Nougat
6	Case	Length: 12 cm Width: 12 cm Height: 15 cm

2.2. Workflow System

The system consisting of several parts has a workflow, as shown in Fig. 3. It shows that the input from the system is in the form of data from the turbidity sensor readings in the tank filled with water. The data is forwarded to the MCU Node to calibrate the turbidity level. The water turbidity level is also determined to identify the water, whether clean, turbid, or dirty. Meanwhile, the determination of turbidity level is based on Equation 1.

$$x = \begin{cases} x \leq 5 & clean \\ 5 < x \leq 9 & murky \\ x > 9 & dirty \end{cases} \tag{1}$$

The calibration results and the water turbidity level are sent to the cloud to be stored in Firebase. The data stored in Firebase comes from several different water tank locations. Therefore, in Firebase, data mapping is carried out based on the predetermined MCU Node ID. Each tank location has a different MCU Node ID. Data mapping is conducted so that the information displayed in the application is matched, for example, the time for house X to be cleaned. The application displays information related to the condition of the X house water tank and its location. Thus, it will be more accessible for the consumers to know the condition of their water tanks and for managers to find out the location of consumers' homes. The turbidity level information will be displayed in the application in real-time.

2.3. System Realization

The system realization consists of two parts, namely hardware and applications. The hardware section discusses the process from the circuit building to the configuration of sensor reading result data sent to Firebase. In contrast, the application section outlines making the interface so that it functions properly.

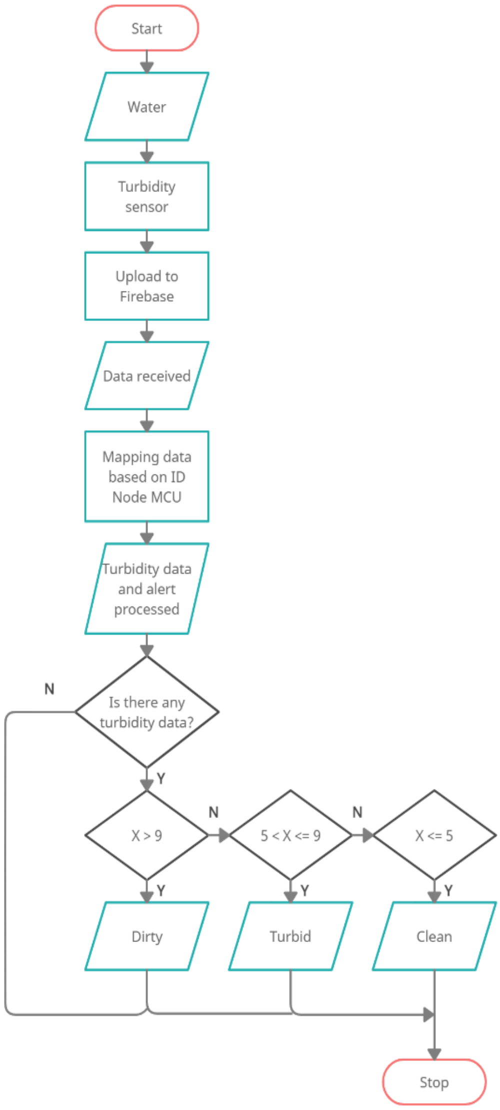


Fig. 3 Flowchart of the workflow system

2.3.1. Hardware

As previously explained, the water turbidity warning system consists of a turbidity sensor and MCU Node. The connecting wiring is described in Table 2, and the schematic circuit between the two devices is shown in Fig. 4.

Table 2 The wiring between turbidity sensor and MCU node

Node MCU ESP 8266	Turbidity snsor
Vcc 3.3 V	Vcc
Gnd	Gnd
A0	Pin Out

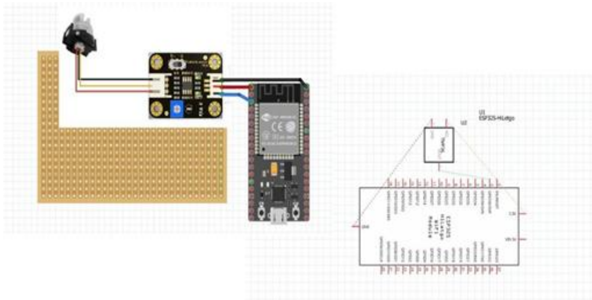


Fig. 4 The schematic circuit of water turbidity warning system

Furthermore, several configurations are carried out using the Arduino IDE, as presented in Fig. 5.

```
FirebaseData firebaseData;
void
printJsonObjectContent(FirebaseD
&data);
unsigned long
sendDataPrevMillis = 0;
String path = "/dataTandon/sd";
```

(a) Identifying the Firebase destination

```
void setup()
{
  Serial.begin(115200);
  WiFi.begin(WIFI_SSID,
WIFI_PASSWORD);
  Serial.print("Connecting to
Wi-Fi");
  while (WiFi.status() !=
WL_CONNECTED)
  {
    Serial.print(".");
    delay(300);
  }
```

(b) Opening the port and starting connecting to WIFI

```
Serial.println();
Serial.print("Connected with IP:
");
Serial.println(WiFi.localIP());
Serial.println();
```

(c) Checking the connected IP address to the WIFI

```
int sensorValue =
analogRead(A0);
float voltage =
(sensorValue/1024.0) * 5.0;
Serial.println(voltage);
delay(500);
```

(d) Sensor reading

```
Serial.println("--------------------
---------------");
    Serial.println("Set string...");

(Firebase.setString(firebaseData
, path + "/kekeruhan", "" +
String(sensorValue)));
```

(e) Sending data to Firebase according to the path

```
if(voltage<0.02){

(Firebase.setString(firebaseData
, path + "/peringatan", "0" ));
    }else if(voltage<0.05)
    {

(Firebase.setString(firebaseData
, path + "/peringatan", "1" ));
      }else{

(Firebase.setString(firebaseData
, path + "/peringatan", "2" ));
        }
      }
```

(f) Determining the condition of water turbidity

Fig. 5 Hardware configuration

2.3.2. Application

The application design includes several programs built to display the features based on the plan. Some programs built are described in Table 3.

Table 3 Programs built on application

Program	Description
Login	A program calls the database from Firebase to authenticate the email and password. A

	matched user will enter the dashboard; the error notification will appear if it does not
Dashboard	A program calls the database from Firebase to generate data of dirty and clean tanks. The dashboard can also log out account
Water tank form	A program to fill in a new water tank in which data will be entered into the database and monitor the tank using the application
Water tank location	A program in which the application retrieves data from Firebase to display the registered locations on the database and monitor the entire location of water tanks
Water tank monitoring	A program to monitor water tanks and check the water turbidity; the admin can view the calendar for tank cleaning
Calendar	A program to generate a calendar based on the admin request, enter January and March on the calendar for tank cleaning, and display the intended month in real-time
Firebase DB configuration	A program allows the application to access the database from Firebase

3. Results and Discussion

After carrying out the process from the design to the realization of the water turbidity warning system, the results are shown in the following pictures. Fig. 6 shows the realization of multiple water tanks scenario, where there were two containers filled with water which were supposed as tanks. The two containers contained water with different turbidity, the first was water from Local Government Owned Water Utilities or called PDAM, and the second was tea. These containers were set to be in different locations, namely Perum Pesbal and Kampung Sumur. The turbidity sensor read the turbidity value in each of these containers then was calibrated to determine the NTU value and turbidity level. The two values were sent to Firebase and stored on the MCU Node ID. The turbidity level sent was number variations 0, 1, or 2, where 0 represented clean condition, 1 represented turbid condition, and 2 represented dirty condition.

Fig. 6 Multiple tanks scenario test

The test results using two sensors showed that the sensor readings for PDAM's water had an average of 209,321 NTU; meanwhile, tea indicated as turbid water had an average of 649,633 NTU. On the second sensor, the reading showed that PDAM water had an average of 1223,714 NTU, and tea, as a comparison, had an average of 2301.7 NTU. The test data for each sensor is shown on the graph in Fig. 7.

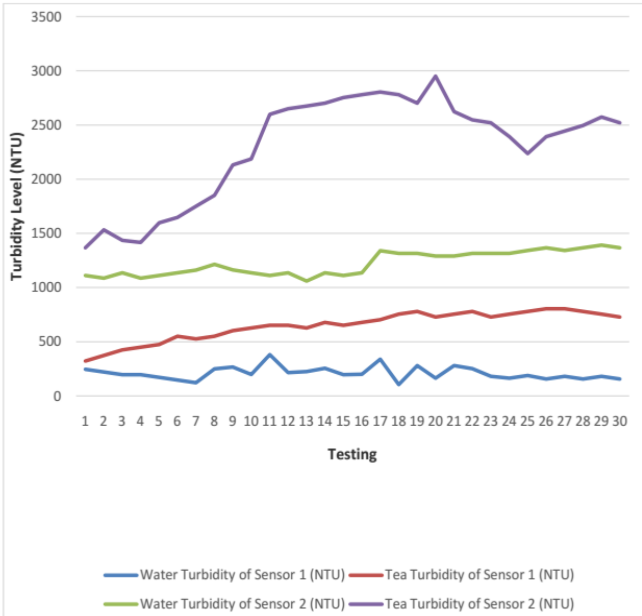


Fig. 7 The comparison graph of two sensors reading

In Firebase, several variables were automatically filled based on the input. These variables include addresses, first and second cleaning schedules, turbidity values, telephone numbers which also become MCU Node IDs, warnings representing water turbidity levels, and user names. The Firebase display for testing the multiple reservoir scenario described previously is presented in Fig. 8. It shows that the tank with ID 082210149271, located in Kampung Sumur, was in a dirty state, which the warning shows number 2. On the other hand, the tank with ID 082210152589 is located in Perum Pesbal as in a clean state where the warning shows number 0. The turbidity value stored in Firebase is a calibrated value in NTU units. The value and level of water turbidity displayed on the application are information to be known by consumers and managers, at the same time as warnings.

Fig. 8 Firebase display of water turbidity warning system

The test display for the multiple tanks scenario in the application is shown in Fig. 9. A monitoring report showed the number of clean or cleaned and dirty tanks in this display. Based on the case previously described, it is known that the tank located in Perum Pesbal was in the clean status; meanwhile, located in Kampung Sumur was in the dirty status. Following the application display, it found one tank clean and another dirty. The dirty tank location was also displayed to facilitate the manager monitor and head to the location for cleaning. In addition to the dashboard display to show the number of tanks with clean and dirty status and location, the application also has other supporting features.

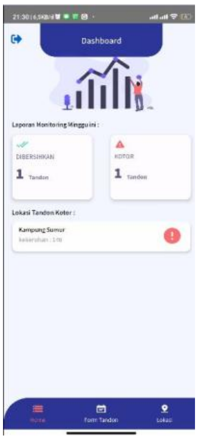
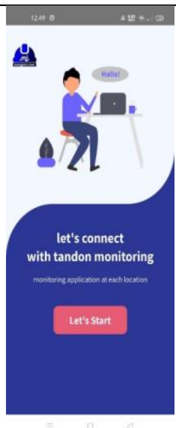
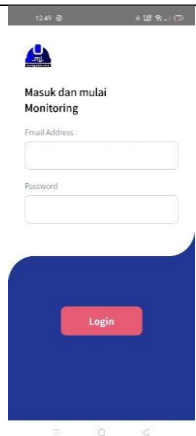
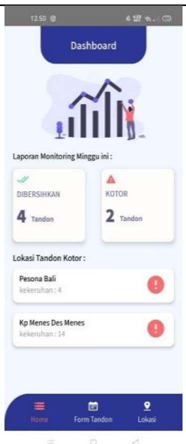


Fig. 9 Application display of water turbidity warning system

The features provided in the water turbidity warning application are summarized in Table 4.

Table 4 Features of water turbidity warning application

Display and Description		
 The initial display of the application displays the logo and website address that can be accessed	 The boot display before logging in provides a Start button to start	 Login display
 The dashboard display shows the number of tanks with clean and dirty status, including the dirty tank location	 The tank confirmation displays the tank that has been cleaned	 It is a display for adding a new tank to the water turbidity warning system

4. Conclusion

In this research, the design and implementation of a water turbidity warning system with multiple tank scenarios have been carried out in which several tanks can be monitored simultaneously in real-time. The system was built by utilizing the turbidity sensor, the MCU Node as a microcontroller, using Firebase, and the application can be accessed through the Android operating system. The turbidity level of water was categorized into three: clean, turbid, and dirty. Managers, as the service providers, and consumers can monitor the tank's condition with a warning in the form of an indicator when the tank must be cleaned. In addition, there are other features in the application, which include: application login, adding tanks, tanks' location that must be monitored, and cleaning schedule. These features can work as expected.

The next research focuses on measuring hardware reliability when realized by carrying out proper calibration and testing on a larger scale.

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