

IoT-Based Household Clean Water Quality Monitoring System Using Rule-Based Method

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Abstract : *The availability of clean water requires a quality monitoring system that can operate quickly and continuously. This study aims to develop an Internet of Things (IoT)-based household clean water quality monitoring system using a Rule-Based method to measure Total Dissolved Solids (TDS), pH, and turbidity and determine water quality conditions. The study employed a system design approach and experimental method using an ESP8266, TDS, pH, and turbidity sensors, ADS1115, LCD, buzzer, and web-based dashboard. Sensor data were processed using threshold-based rules to classify water conditions. Testing was conducted on individual sensors, three-sensor integration, system communication, and monitoring display. The results show that the system can measure the three parameters in real time, classify water conditions, display information through an LCD and web dashboard, and provide warnings through a buzzer when water conditions exceed the specified limits. Therefore, the developed system can support automatic and continuous monitoring of household water quality.*

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Introduction

The availability of clean water is essential for supporting human, animal, and plant life, both for metabolic needs and for maintaining ecosystems. However, urban areas face the challenge of decreasing clean water availability due to the increasing number of users. This condition is not only related to water quantity but also to water quality, which can be affected by pollution from household and industrial waste, as well as poor water resource management. Visually clear water is not necessarily chemically and biologically safe, therefore, monitoring various water quality parameters, such as acidity (pH), temperature, turbidity, Total Dissolved Solids (TDS), and Dissolved Oxygen (DO), is necessary to ensure the water remains suitable and safe for use (Yusri et al., 2024; Pembangunan & Budi, 2020). Water quality conditions that do not meet criteria can increase risks to public health and ecosystem balance, making regular water quality monitoring a crucial need.

Water quality is also a concern in households because people may use water from different sources. For example, in Paya Pasir Village in Medan Marelan District, residents use PDAM water, drilled wells, and dug wells to meet their daily needs. These differences in water sources can vary the quality of the water received by the community, necessitating monitoring that can provide direct information on water conditions. Water quality in Indonesia is assessed based on physical, chemical, and biological parameters according to its intended use (Kakas & Minahasa, 2025). Based on Regulation of the Minister of Health of the Republic of Indonesia Number 2 of 2023 concerning Drinking Water Quality Requirements, one of the parameters used is pH with a range of 6.5–8.5 and a turbidity level not exceeding 3 NTU. TDS is also an important indicator in assessing water quality, with safe values for drinking water generally below 300–500 mg/L (Ministry of Health of the Republic of Indonesia, 2023; Lembaran et al., 2023). Thus, measuring these parameters is necessary to help determine the suitability of water used for household needs.

Problems encountered in household water quality monitoring relate to the monitoring process, which is still not optimal and sustainable. Household water consumption monitoring still uses an analog system that requires direct meter readings (Rosyady & Anugerah, 2023). In the context of water quality, visual observation also cannot provide information on parameters such as pH, TDS, and turbidity. While people can detect changes in water color or clarity, they cannot directly determine the chemical and physical parameters that form the basis for assessing water quality. This situation makes it difficult to detect changes in water quality quickly and accurately, while manual testing is time-consuming and expensive. Therefore, a system that can automatically and continuously measure water quality parameters is needed.

The next problem is the need for a system capable of presenting measurement results directly so users can determine water conditions without having to perform manual inspections. The development of the Internet of Things (IoT) provides the opportunity to connect physical devices via the internet so that data can be sent and accessed in real time (Syahra & Tanjung, 2026). IoT devices allow users to monitor remotely without direct human intervention (Utara, 2025). Previous research shows that the application of IoT-based technology has been used in monitoring household water usage. Rosyady and Anugerah (2023) developed a website-based household water consumption monitoring system capable of digital and real-time monitoring. Alkahfie et al. (2025) also developed an IoT-based PDAM water usage monitoring system and an Android application that can present information via smartphone in real time. These findings indicate that the use of digital technology can support the water monitoring process, but the research that underpins this development is focused on water quality monitoring through measuring TDS, pH, and turbidity parameters, as well as water quality classification.

In addition to the need for real-time data measurement and presentation, a decision-making mechanism is needed that can determine the water's suitability based on the measurement results. Water quality monitoring not only produces parameter values, but also needs to provide information on whether the water is in a suitable, fairly suitable, or unsuitable condition. The Rule-Based method is used because it applies clear logical rules and can be used to determine conditions based on predetermined parameter threshold values. In this study, this method is used to classify water quality based on TDS, pH, and turbidity parameters. This problem is then directed at the development of a system capable of measuring water quality parameters, processing data using the Rule-Based method, displaying monitoring results in real time, and providing warnings when the water quality is in an unsuitable condition. Thus, the system not only functions as a measurement tool, but also as a means to provide information on water quality conditions to users.

Based on these problems, this study aims to design and develop an Internet of Things (IoT)-based household clean water quality monitoring system that is capable of measuring TDS, pH, and turbidity parameters and determining water suitability using the Rule-Based method. This study also aims to develop web monitoring that can display water quality data directly and provide information when the water is in a safe or unsafe condition, as well as evaluate the accuracy and effectiveness of the Rule-Based method in classifying water quality based on the parameters used. The urgency of this research lies in the need for household water quality monitoring that can be carried out automatically and in real-time, considering that manual monitoring can cause changes in water quality to be difficult to detect quickly. The novelty of this research lies in the development of a household water quality monitoring system that integrates ESP8266, pH, TDS, and turbidity sensors with the Rule-Based method to produce

a water suitability classification and display this information through a web-based monitoring system in real-time. This research is expected to provide convenience for the community in monitoring water quality independently as well as being a reference in the development of an IoT-based water quality monitoring system with the application of the Rule-Based method.

Method

This research is a system design study with an experimental approach to develop a household clean water quality monitoring system based on the Internet of Things (IoT) using the Rule-Based method. The research began with a literature study on water quality parameters, quality standards, IoT, and the Rule-Based method as a basis for determining system requirements, sensors, architecture, and decision-making mechanisms (Syahra & Tanjung).

The experimental method was carried out through the stages of system design, assembly, implementation, and testing. The system uses an ESP8266 integrated with pH, Total Dissolved Solids (TDS), and turbidity sensors. Sensor data is processed using a rule-based method to classify water quality into suitable, moderately suitable, and unsuitable. The system then sends the data via an IoT network to a server and displays it via a web dashboard in real time (Supratman et al., 2024).

The research instruments consisted of an ESP8266, pH, TDS, turbidity sensors, ADS1115, 16×2 I2C LCD, buzzer, NodeMCU, breadboard, and other supporting devices. The software used included Arduino IDE, Node.js, and Visual Studio Code. Sensor data was processed by the ESP8266, sent via WiFi using HTTP (POST) to the Node.js server, then displayed via the dashboard using API (GET). The use of a website-based monitoring system also refers to the research of Rosyady and Anugerah (2023).

Data analysis was performed on sensor readings and water quality classification using the Rule-Based method. Testing included testing each sensor individually, testing all three sensors simultaneously, testing the website, and implementing the program to ensure the system ran as designed. Data collection was conducted through observation and experimentation (Darmawan et al., 2021).

The research object was water in household tanks, measured based on TDS, pH, and turbidity parameters. The system was developed for the household scale using the ESP8266 and a rule-based method. Testing focused on the results of water parameter measurements and the system's performance in determining the water's suitability.

The research procedure included problem identification, literature review, problem formulation, objectives and limitations, system design, implementation, and testing. Problem identification was performed on water quality monitoring, which is still performed manually. Next, a literature review was conducted and system requirements were formulated using the ESP8266, pH, TDS, and turbidity sensors, with real-time water quality information as the output.

The design was carried out by integrating pH, TDS, and turbidity sensors with the ESP8266 and the ADS1115 module. Sensor data is processed using a Rule-Based method, then sent via WiFi to a Node.js server and displayed on a web dashboard. An LCD is used to display data directly, while a buzzer provides warnings when water quality is unsuitable.

The implementation phase involves transforming the design into a prototype and integrating hardware, software, and rule-based methods. Testing is conducted to ensure that sensor readings, inter-device communication, the classification process, and real-time data presentation are running as planned.

Results and Discussion

System design results

This research developed a household clean water quality monitoring system that utilizes Internet of Things (IoT) technology with a rule-based approach as a decision-making mechanism. The system is designed to integrate the measurement, processing, and presentation of water quality data in real time, based on key parameters: Total Dissolved Solids (TDS), acidity (pH), and turbidity.

Results of tool testing and system analysis

1. TDS Sensor Test Results

Testing of the Total Dissolved Solids (TDS) sensor was conducted by observing the sensor's response to several water samples with varying levels of dissolved substances. This testing process aimed to assess the sensor's ability to detect changes in TDS values in real time and to evaluate the stability of the resulting data.



Figure 1. Results of testing dissolved substances in the very suitable category



Figure 2. Results of testing dissolved substances in water in an unsuitable condition



Figure 3. Test results for dissolved substances in water in a suitable condition

Based on the test results, the TDS sensor demonstrated a fairly good ability to read dissolved substance values, where changes in detected values are in line with the conditions of the water sample being tested. The sensor is able to provide relatively stable output with fluctuations that are still within reasonable limits, so it can be used as a parameter in a water quality monitoring system. In addition, data obtained from the sensor is then processed by a microcontroller to be compared with predetermined threshold standards. The results of this comparison are used as the basis for determining the category of water quality, whether it is suitable, quite suitable, or unsuitable. In general, the performance of the TDS

sensor in this system can be said to be quite good to support the decision-making process based on the rule-based method.

2. Turbidity Sensor Test Results

Turbidity sensor testing was conducted to determine the sensor's ability to detect water turbidity levels based on changes in clarity in the tested water samples. This testing process aimed to assess the sensor's sensitivity in reading changes in turbidity levels in real time and ensure the stability of the data generated during system operation. Based on the test results, the turbidity sensor was able to provide a fairly good response to changes in water conditions, where the sensor readings changed according to the turbidity level of the sample used.



Figure 4. Testing if the water is in very suitable condition



Figure 5. Test results if the water is too cloudy



Figure 6. Test results if it is not too cloudy

The more turbid the water, the higher the turbidity readings from the sensor. The ESP8266 microcontroller then processes the readings using a rule-based method to determine the water quality category.

3. pH Sensor Test Results

pH sensor testing was conducted to determine the sensor's ability to measure the acidity and alkalinity of water in several samples with varying pH values. This testing process aimed to evaluate the sensor's accuracy, sensitivity, and stability in detecting changes in pH in real time during system operation.



Figure 7. Test results if the water is not acidic and basic



Figure 8. Test results if the water is not too acidic and its validity



Figure 9. Test results if the water is too acidic and too basic

Based on the test results that have been carried out, the pH sensor is able to provide readings that correspond to the conditions of the water samples being tested, where changes in the acidity and alkalinity of the water can be detected well by the sensor. The reading data is then processed by the ESP8266 microcontroller using a rule-based method to determine the water quality category based on the predetermined pH value limits. In addition, the sensor shows quite stable performance even though

there are slight changes in reading values influenced by environmental conditions and the sensor calibration process, but this is still within the tolerance limit and does not affect the overall system performance. Thus, the pH sensor is considered capable of working well as one of the main components in the household clean water quality monitoring system based on the Internet of Things (IoT), so that it can help the process of monitoring water quality automatically, continuously, and more efficiently.

4. Testing 3 Tools Simultaneously

Simultaneous testing of the three sensors was conducted to determine the system's ability to read and process data from the TDS, turbidity, and pH sensors simultaneously. This testing aimed to ensure that all sensors could operate in an integrated manner without experiencing communication disruptions or data reading errors when the system was running in real time. Based on the test results, all three sensors performed well and produced measurement data consistent with the conditions of the water samples being tested.



Figure 10. Test results of 3 sensors showing unsuitable water conditions



Figure 11. Test results with 3 water condition sensors

The TDS value indicates the amount of dissolved substances in water, the turbidity sensor detects the level of water turbidity, while the pH sensor reads the level of acidity or alkalinity of the water. All data from the sensor readings are then processed by the ESP8266 microcontroller using a rule-based method to determine the water quality category into suitable, fairly suitable, or unsuitable conditions. In addition, the test results show that the system is able to display data simultaneously on the LCD and send monitoring information to a web-based application in real-time via the internet network. The buzzer can also function well as a warning indicator when one of the water parameters is outside the specified limits. Thus, this test proves that the developed Internet of Things (IoT)-based household water quality monitoring system is able to work in an integrated, stable, and effective manner in monitoring water quality automatically and continuously.

5. Website Monitoring View

The water quality monitoring website is designed to display real-time sensor readings, allowing users to monitor water quality more easily and efficiently. The website displays information such as TDS values, turbidity levels, and pH values, all obtained from the system's sensor readings.

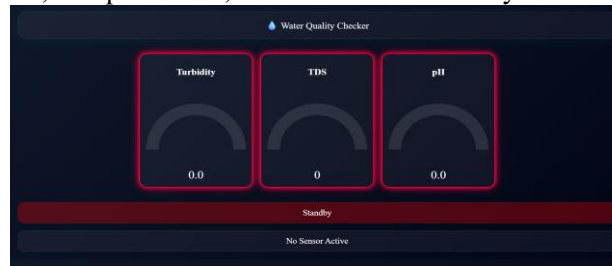


Figure 12. Display of the Water Quality Monitoring Website in standby mode

The data is sent by the ESP8266 microcontroller over the internet and displayed automatically on the website without the need for manual updates. In addition to displaying monitoring data, the website also serves as a means of providing information on water quality conditions based on the results of the rule-based analysis method implemented in the system. With this website, water quality monitoring can be conducted remotely in a more practical, fast, and integrated manner, making it easier for users to monitor water conditions directly and continuously.

6. Results of Arduino IDE Coding Implementation

The results of the program implementation on the system show that all the designed code can run according to its intended function. The program embedded in the ESP8266 microcontroller is capable of integrating TDS sensors, turbidity sensors, and pH sensors to automatically and real-timely read water quality data. The data obtained from each sensor is then processed using a rule-based method to determine water quality conditions based on predetermined parameters.

```

1 // no
2 float getTds(float v) {
3   if (v < 0.0) return 0;
4
5   float tds = (0.142 * v * v - 25.46 * v + 851.28 * v) * 0.5;
6
7   if (tds < 0) tds = 0;
8   return tds;
9 }
10
11 // no
12 float getpH(float v) {
13   return 7 + ((0.5 - v) / 0.10);
14 }
15
16 // return string based on
17 String stTds(float v) {
18   if (v <= 4) return "Sangat Layak";
19   else if (v <= 6) return "Cukup Layak";
20   else return "Tidak Layak";
21 }
22
23 String stTbd(float v) {
24   if (v <= 100) return "Sangat Layak";
25   else if (v <= 500) return "Layak";
26   else return "Tidak Layak";
27 }
28
29 String stpH(float v) {
30   if (v >= 8.5 && v <= 8.0) return "Sangat Layak";
31   else if ((v >= 8.0 && v < 6.5) || (v > 8.0 && v <= 8.5)) return "Layak";
32   else return "Tidak Layak";
33 }

```

Figure 13. Results of Arduino IDE Coding Implementation

The system also successfully displays monitoring results on an LCD and sends data to a web-based platform via the internet, allowing remote monitoring. The program's implementation also supports a buzzer as a warning indicator when water quality values exceed normal limits. Based on implementation testing results, the developed program operates stably and is integrated, effectively and sustainably supporting Internet of Things (IoT)-based household water quality monitoring.

Table 1. Rule Based Description

no	Information	Script
1	Determining the level of water suitability is based on the water turbidity level (NTU). If the turbidity value is ≤ 4 , it is considered "Very Suitable," if ≤ 6 , it is considered "Quite Suitable," and if > 6 , it is considered "Not Suitable."	<pre>String stTbd(float v) if (v <= 4) return "Very Worthy"; else if (v <= 6) return "Quite Decent";</pre>

		else return "Not Eligible";
2	Determining water quality is based on the amount of dissolved substances in the water. If the TDS value is ≤ 300 , it is considered "Very Suitable," if it is ≤ 500 , it is considered "Suitable," and if it is > 500 , it is considered "Unsuitable."	String stTds(float v) if (v $\leq$ 300) return "Very Worthy"; else if (v $\leq$ 500) return "Eligible"; else return "Not Eligible";
3	Determining the level of water suitability based on the level of acidity or alkalinity. If the pH is 6.5–8.0 then it is "Very Suitable", pH 6.0–6.4 or 8.1–8.9 then it is "Suitable", otherwise it is "Not Suitable".	String stPH(float v) if (v $\geq$ 6.5 && v $\leq$ 8.0) return "Very Worthy"; else if ((v $\geq$ 6.0 && v < 6.5) (v > 8.0 && v $\leq$ 8.9)) return "Eligible"; else return "Not Eligible";
4	Produces a final decision on overall water quality. Water is declared "SUITABLE" if all parameters meet safe limits.	Conclusion string(float tbd, float tds, float ph) bool tbd_ok = tbd $\leq$ 20; bool tds_ok = tds $\leq$ 500; bool ph_ok = (ph $\geq$ 6.0 && ph $\leq$ 8.9); if (tbd_ok && tds_ok && ph_ok) { return "WORTHY";} else { return "NO";}
5	Determines whether the sensor is considered installed / active. Detects whether the turbidity, TDS, and pH sensors are in use or not. The turbidity sensor is considered active if the voltage is in the range of 0.50V–4.5V. The TDS sensor is considered active if the voltage is more than 0.15V. The pH sensor is active if the voltage change from the baseline is more than 0.15V.	bool useTbd = (vTbd > 0.50 && vTbd < 4.5); bool useTds = (vTds > 0.15); bool usePh = (abs(vPh - basePh) > 0.15); vTbd > 0.50 && vTbd < 4.5 vTds > 0.15 abs(vPh - basePh) > 0.15
6	Adjust the LCD display according to the sensor used. The mode is determined based on the active sensor combination. Mode 1 is for Turbidity, Mode 2 is for TDS, Mode 3 is for pH, Mode 4 is for more than one active sensor, and Mode 0 is for Standby.	if (useTbd && !useTds && !usePh) mode = 1; else if (useTds && !useTbd && !usePh) mode = 2; else if (usePh && !useTbd && !useTds) mode = 3; else if (useTbd useTds usePh) mode = 4; else mode = 0;
7	Provides an audible warning when the water quality is unsuitable. The buzzer activates if the result shows "Unsuitable" or "NO."	if (result == "Not Eligible" result == "NO")
8	Converts analog sensor data into turbidity values. Sensor voltage is converted to NTU values using a specific mapping.	if (mv > 1810) else if (mv $\geq$ 1000)
9	Converts sensor voltage to TDS value (ppm/mg/L). Voltage is converted using a polynomial equation.	(133.42 * v * v * v - 255.86 * v * v + 857.39 * v)
10	Converts sensor readings into the pH value of the water. The pH value is calculated from the difference between the voltage and a reference voltage.	return 7 + ((2.5 - v) / 0.18);

Table 2. Script Description

1	The program uses several supporting libraries such as Wire.h for I2C communication, LiquidCrystal_I2C.h to control the 16x2 LCD,	#include <Wire.h> #include <LiquidCrystal_I2C.h> #include <Adafruit_ADS1X15.h>
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	Adafruit_ADS1X15.h to read analog data via ADS1115, ESP8266WiFi.h to connect the ESP8266 to a WiFi network, and ESP8266HTTPClient.h to send data to the server using the HTTP POST method.	#include <ESP8266WiFi.h> #include <ESP8266HTTPClient.h>
2	LiquidCrystal_I2C lcd(0x27, 16, 2); Adafruit_ADS1115 ads;	In this section, an I2C LCD object is created with address 0x27 and a screen size of 16x2, as well as an ADS1115 object which is used as an external Analog to Digital Converter to read sensor data with a more stable resolution than the ESP8266's internal ADC.
3	const char* ssid = "wifi_name"; const char* password = "pass_wifi";	This section is used to store the WiFi network name (SSID) and password which will later be used by the ESP8266 to connect to the internet or local network so that sensor data can be sent to the monitoring server.
4	const char* serverUrl = "http://(Laptop IP:3000/data";	The serverUrl variable is used to store the server address to which the sensor data is sent. Water quality data will then be sent in JSON format to that address using the HTTP protocol.
	#define TURBIDITY_CH 0 #define TDS_CH 1 #define PH_CH 2	This section defines the ADS1115 channel used by each sensor. Channel A0 is used for the turbidity sensor, A1 for the TDS sensor, and A2 for the pH sensor. This channel assignment simplifies the process of reading each sensor.
	#define BUZZER_PIN D5	Pin D5 on the ESP8266 is used as a buzzer output. The buzzer serves as a warning alarm when water quality is unsuitable based on sensor analysis.
	unsigned long buzzerTimer = 0; int buzzerState = 0; int buzzerCount = 0; bool buzzerActive = false; String lastResult = "";	Variables such as buzzerTimer, buzzerState, buzzerCount, and buzzerActive are used to automatically set the buzzer sound pattern, including the duration and number of alarm sounds.
	float baseTbd = 0; float baseTds = 0; float basePh = 0;	The baseTbd, baseTds, and basePh variables are used to store the sensor's initial reference values during the calibration process. These baseline values are used to compare changes in sensor readings during the instrument's operation.
	void printClean(int col, int row, String text)	This function is used to display text on the LCD while clearing the remaining previous characters so that the LCD display remains neat and no characters are left behind when the data changes.
	float readVoltage(int ch)	This function reads the sensor voltage from the ADS1115 10 times, then sorts the data and finds the median. This technique aims to reduce noise and produce more stable and accurate sensor readings.
	float getTurbidity(float v)	This function converts the turbidity sensor voltage value into a water turbidity (NTU) value. The program uses several voltage mapping conditions to adjust the output value based on the water clarity level.
	float getTDS(float v)	This function converts sensor voltage into a TDS value using a polynomial equation. The TDS value indicates the amount of dissolved substances in water that affect water quality.
	float getPH(float v)	This function is used to calculate the pH value based on the pH sensor's output voltage. The calculation is performed using a simple calibration formula to obtain the water's acidity level.
	String stTbd(float v)	This function contains a rule base for determining water quality categories based on turbidity values.

	Classification results are categorized as "Very Suitable," "Fairly Suitable," and "Unsuitable."
String stTds(float v)	This function is used to determine water quality status based on TDS values. Water quality categories are determined based on the TDS value limits specified in the program.
String stPH(float v)	This function is used to determine water quality based on pH values. The system will classify the water condition as "Very Suitable," "Suitable," or "Unsuitable" based on a specific pH range.
Conclusion string(float tbd, float tds, float ph)	This function is used to generate a final decision on overall water quality by combining turbidity, TDS, and pH readings. If all parameters meet the requirements, the water is declared "SUITABLE." If any of the parameters fail, the result is "NO."
void startBuzzer(int repeat)	This function is used to start the buzzer sounding with a specified number of repetitions. The function will set the number of sound cycles the buzzer must execute.
void updateBuzzer()	This function is used to regulate the process of turning the buzzer on and off periodically using a millis() based timer so that the buzzer sound is more regular and does not hinder the main process of the program.
void sendData(float tbd, float tds, float ph, String status)	This function is used to send sensor data to the server using the HTTP POST method. The data is sent in JSON format, containing turbidity, TDS, pH, and water quality values.
void setup()	The setup() function is executed once when the device is powered on. This section initializes the serial monitor, connects to the WiFi network, initializes the LCD, configures the buzzer, checks the ADS1115, and performs the initial sensor calibration.
void loop()	The loop() function is the main program that runs continuously while the device is active. This function reads the sensor, processes data, determines water quality status, controls the LCD, activates the buzzer, and sends data to the server.
float vTbd = readVoltage(TURBIDITY_CH); float vTds = readVoltage(TDS_CH); float vPh = readVoltage(PH_CH);	The program reads voltage values from the turbidity, TDS, and pH sensors using the readVoltage() function. The resulting data is then processed to obtain water quality values.
float dTbd = abs(vTbd - baseTbd); float dTds = abs(vTds - baseTds); float dPh = abs(vPh - basePh);	The program calculates the difference between the current sensor value and the baseline to determine changes in sensor readings. This difference is also used to detect whether the sensor is active or not.
if (dTbd < 0.02) baseTbd = vTbd;	If the sensor changes are very small, the baseline will be updated automatically. This ensures the sensor remains stable and can adapt to environmental changes slowly.
if (dTds < 0.02) baseTds = vTds;	
if (dPh < 0.02) basePh = vPh;	
bool useTbd = (vTbd > 0.50 && vTbd < 4.5); bool useTds = (vTds > 0.15); bool usePh = (abs(vPh - basePh) > 0.15);	The system determines whether a sensor is active based on a specific voltage value. If the voltage falls within a range considered valid, the sensor is considered active.
float tbd = getTurbidity(vTbd); float tds = getTDS(vTds); float ph = getPH(vPh);	The voltage values from each sensor are converted into actual data such as NTU for turbidity, ppm for

	TDS, and pH values using previously created conversion functions.
<pre> int mode = 0; if (useTbd && !useTds && !usePh) mode = 1; else if (useTds && !useTbd && !usePh) mode = 2; else if (usePh && !useTbd && !useTds) mode = 3; else if (useTbd useTds usePh) mode = 4; else mode = 0; </pre>	The program determines the LCD display mode based on the active sensor. The system can display data from a single sensor or all sensors simultaneously.
<pre> if (mode == 1) printClean(0, 0,"Turb:") printClean(6, 0,String((int)tbd)); result = stTbd(tbd); printClean(0, 1, result); printClean(9, 0,"NTU");} else if (mode == 2) { printClean(0, 0, "TDS:"); printClean(5, 0,String((int)tds)); result = stTds(tds); printClean(0, 1, result); printClean(9, 0,"mg/L");} else if (mode == 3) { printClean(0, 0,"pH:"); printClean(4, 0,String(ph, 1)); result =stPH(ph); printClean(0, 1, result);} else if (mode == 4) {printClean(0, 0,"Tbd:"); printClean(4, 0,String((int)tbd)); printClean(9, 0, "pH:"); printClean(12, 0,String(ph, 1)); printClean(0, 1,"Tds:"); printClean(4, 1,String((int)tds)); result = conclusion(tbd,tds,ph); printClean(9, 1,result);} else { printClean(0, 0,"Standby Device"); printClean(0, 1,"Insert Sensor");} </pre>	The LCD is used to display sensor readings and water quality status in real time so that users can directly monitor water conditions without opening the monitoring server.
<pre> if (result == "Not Eligible" result == "NO") </pre>	The program will activate a buzzer if the analysis results indicate the water is "Unsuitable." This alarm serves as an automatic warning to the user.
<pre> if (millis() - lastSend > 1000) </pre>	The system sends sensor data to the server every 1 second using the millis() function so that data monitoring can be done in real time via a database or monitoring website.

delay(200);

Delay is used to provide a short pause in the looping process so that sensor readings are more stable and the system does not work too quickly.

Conclusion

This research produces a household clean water quality monitoring system based on the Internet of Things (IoT) using ESP8266, Total Dissolved Solids (TDS), turbidity, and pH sensors integrated with the Rule-Based method. The test results show that the three sensors are able to read water quality parameters in real-time and work in an integrated manner. The measurement data can be processed to determine the water condition to be suitable, quite suitable, or unsuitable, then displayed via LCD and web dashboard. The system is also able to send data via the internet network and activate a buzzer as a warning when the water condition does not meet the specified limits. These findings indicate that the developed system can support the process of monitoring household water quality automatically and continuously.

The limitations of this study lie in the focus of the test object on water in household tanks and the use of TDS, pH, and turbidity parameters, so the results do not yet describe the condition of water quality from various sources and broader environmental characteristics. Further development is recommended to use more samples and water sources, add other water quality parameters, and conduct sensor accuracy tests and classification methods with more measurable comparators. Practically, this system can help users monitor water conditions directly without manual inspection and provide warnings when water quality is in an unsuitable condition. The system can also be the basis for the development of household water quality monitoring that is more integrated, easy to use, and able to provide real-time information.

Bibliography

- Alkahfie, R., Fujiyanti, L., Josi, A., Manufaktur, P., & Bangka, N. (2025). Perakitan sistem monitoring penggunaan air PDAM pada rumah tangga secara *real-time* berbasis aplikasi Android. *03*(1).
- Darmawan, D., Sudrajat, I., Maulana, M. K. Z., & Febriyanto, B. (2021). Perencanaan pengumpulan data sebagai identifikasi kebutuhan pelatihan lembaga pelatihan. *5*(1), 71–88. <https://doi.org/10.15294/pls.v5i1.30883>
- Kakas, K. E. C., & Minahasa, K. (2025). Tinjauan *water quality* berbasis *Internet of Things* (IoT) dengan parameter TDS, pH, dan temperatur dari tiga sumber berbeda di Kecamatan Kakas, Kabupaten Minahasa. *1*(2).
- Kementerian Kesehatan Republik Indonesia. (2023). *Peraturan Menteri Kesehatan Republik Indonesia Nomor 2 Tahun 2023 tentang peraturan pelaksanaan Peraturan Pemerintah Nomor 66 Tahun 2014 tentang kesehatan lingkungan*.
- Lembaran, T., Lembaran, T., Lembaran, T., & Lembaran, T. (2023). *Berita Negara*. 55.
- Pembangunan, U., & Budi, P. (2020). Sistem monitoring kualitas air Danau Siombak. *5*(2), 171–177.
- Rosyady, P. A., & Anugerah, P. A. (2023). Sistem monitoring konsumsi air rumah tangga berbasis website. *14*(2), 62–66. <https://doi.org/10.22441/jte.2023.v14i2.001>
- Supratman, A., Nugroho, B. I., & Kurniawan, R. D. (2024). Penerapan metode *rule-based system* untuk menentukan jenis tanaman pertanian berdasarkan ketinggian dan curah hujan. *INNOVATIVE: Journal of Social Science Research*, *4*, 7879–7890.
- Syahra, Y., & Tanjung, J. (2026). Sistem pengelolaan sampah cerdas: Inovasi tempat sampah IoT dengan otomatisasi dan mekanisme keamanan modern. *2025*.
- Utara, U. S. (2025). Pengembangan teknologi IoT sebagai pemantau kualitas air budidaya ikan di Desa Lubuk Kasih, Berandan Barat, Kabupaten Langkat, Sumatera. *TALENTA Conference Series*, *8*(2), 0–5. <https://doi.org/10.32734/lwsa.v8i2.2453>
- Yusri, M., Maulita, Y., & Sembiring, H. (2024). Penerapan IoT dalam monitoring dan pengendalian kualitas air. *Repeater: Publikasi Teknik Informatika dan Jaringan*, *2*(4), 231–242.