
MICROCONTROLLER-BASED WATER QUALITY MONITORING SYSTEM IMPLEMENTATION

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Article History:

Submitted: 02-06-2022

Accepted: 06-06-2022

Published: 07-06-2022

Keywords:

Internet of things;

Microcontroller; Turbidity

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ABSTRACT

So far, Regional Drinking Water Companies (PDAMs) have used conventional methods by taking water samples, measuring all water quality parameters, and analyzing them one by one. In addition, the process of making conclusions on water quality has not been integrated so that it can cause misclassification of water quality and prolong the work. In this study, an expert system was designed to monitor water quality that works in real time so that it can be accessed anytime and anywhere. The water quality analysis process is carried out with a fuzzy classifier realized using Arduino Mega 2560. The fuzzy input variables include the pH value, total dissolved solids (TDS), and turbidity or turbidity. A fuzzy inference system is used to classify water quality into three classes, namely good (meets quality standards), ordinary, and bad (polluted). The expert system of success provides inference results with a 100% success percentage. The results of monitoring and water quality classification can be accessed online using the Internet of Things (IoT) ThingSpeak platform

INTRODUCTION

Water is the main need needed for human daily needs. The water used must meet the requirements stipulated in the Regulation of the Minister of Health of the Republic of Indonesia No. 32 of 2017 concerning Environmental Health Quality Standards and Water Health Requirements for Sanitary Hygiene Needs,[1]. Water has many uses for sanitary hygiene needs including bathing, washing groceries, washing dishes, washing clothes, as well as for drinking water. Polluted water causes many bad impacts, such as environmental damage, environmental discomfort, to reduce the level of human health and safety. Determination of water quality is still mostly done by conventional methods, namely by measuring and analyzing one by one the test results data. Of course, this will take a long time, also the budget is not small. Various ways have been done to monitor water quality which includes pH, turbidity level, temperature, TDS. The parameter sensor is used with the microcontroller to get the water quality value displayed on the computer using a [2] - [4] cable. Previous studies that have applied internet of things technology have also included a lot of validation of amplitude range data on Internet Sensor Objects (IoT) [5]. Rain monitoring system for drying nutmeg based on internet of things [6]. Prototype of IoT-Based Fruit Alcohol Level Measurement Tool [7].

LITERATURE REVIEW

In this study, an expert system based on fuzzy logic was built for water quality classification. The variables measured were the value of acidity (pH), total dissolved solids (TDS), and turbidity. These three variables were chosen because they are the physical and chemical parameters that most influence water quality. These parameters become input for the fuzzy-based expert system to classify water quality into three classes, namely: good (meets quality standards), ordinary, and bad (polluted). The classification results that have been generated are then displayed on the ThingSpeak IoT platform so that they can be accessed by users anytime and anywhere.

METHOD

PH stands for power of hydrogen, which is a measurement of the concentration of hydrogen ions in the body. The total pH scale ranges from 1 to 14, with 7 being considered neutral. A pH less than 7 is said to be acidic and a solution with a pH greater than 7 is basic or alkaline. This tool can measure water quality and other affordable parameters. It is also Arduino compatible, - especially designed for Arduino controllers to easily interface sensors with practical connectors. This will allow to expand your project to bio-robotics. It has an LED that works as a Power Indicator, a BNC connector and a PH2.0 interface on the sensor. To use it, just connect the pH sensor with a BND connector, and plug the PH2.0 interface into the port. analog input of any Arduino controller. If it is pre-programmed, you will get the pH value easily.



Figure 1. pH sensor

The working principle of this tool is that the more electrons in the sample, the more acidic it will be and vice versa, because the bar on the pH meter contains a weak electrolyte solution. There are digital and analog tools. pH meters are widely used in quantitative chemical analysis. The pH probe measures the pH as well as the activity of the hydrogen ions surrounding a thin-walled glass bulb at the end. (approximately 0.06 volts per pH unit) which is measured and displayed as a reading of the pH value. Acids have a pH between 0 and 7 and alkaline properties have a pH value of 7 to 14.

Turbidity sensor that can detect the turbidity of water by reading the optical properties of water due to light and as a comparison of the light to be reflected with the incoming light. Turbidity is a condition of water that is not clear and is caused by individual particles (suspended solids) which are generally invisible to the naked eye, similar to smoke in air. The more particles in the water, the higher the turbidity of the water. On the turbidity sensor, that the higher the level of turbidity of the water will be followed by a change in the sensor output voltage (Wadu, 2017) as shown in Figure 2 below.



Figure 2. Turbidity Sensor

This system consists of three designs, namely hardware design, electronic design, and software design, as shown in Figure 3. The hardware used in designing this system consists of an Arduino Mega 2560, sensor for each parameter, an ESP8266 WiFi module, and an adapter. AC to DC 9V 2A. Electronic design is done by doing the wiring process or connecting all sensors and WiFi modules with Arduino Mega 2560 according to the pins used. The software used is a program coded on the Arduino Integrated Development Environment (IDE) to process data from sensors, send data using the ESP8266 WiFi module and design a fuzzy classifier as part of the expert system designed.

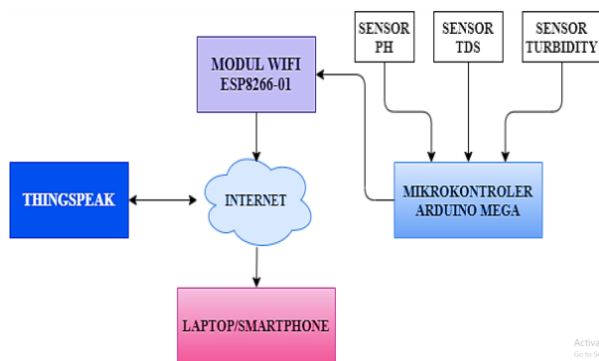


Figure 3. System Block Diagram

RESULT

The entire series of commands on this system are executed by Arduino Mega 2560. The workflow from the software side is explained through the flow diagram shown in Figure 4.

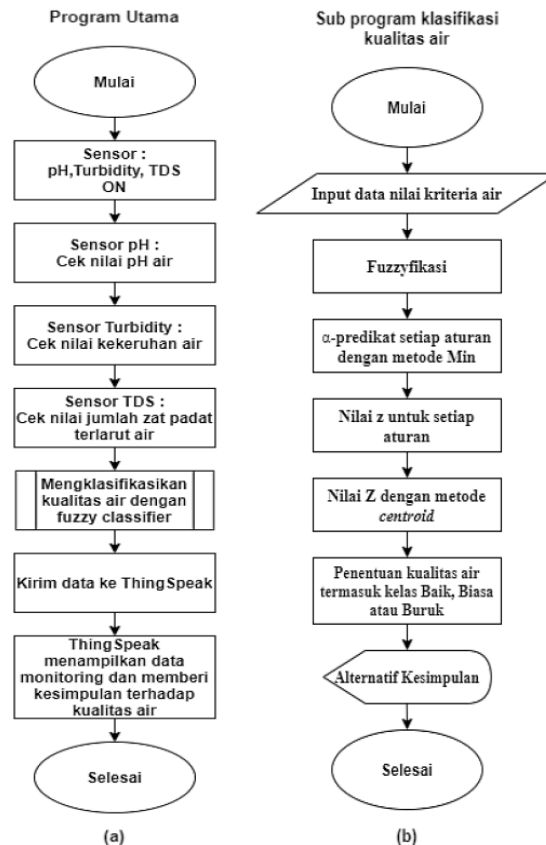


Figure 4. Flowchart of (a) main program and (b) sub-program of water quality classification

DISCUSSION

Sensor testing is done by testing the three sensors using six types of water samples, namely PDAM water, river water, salt water, sugar water, orange juice, and soapy water. The pH sensor test was carried out using the DFRobot V.1 analog pH sensor. This sensor has an accuracy of ± 0.1 pH at 25°C and has a response time of 1 minute. To test the TDS sensor, it is done using the DFRobot analog TDS sensor. This sensor has an accuracy of $\pm 10\%$ FS at 25°C and has a measurement value range of 0 – 1000 ppm. While the turbidity sensor testing was carried out using the DFRobot analog Turbidity sensor. This sensor has a response time of < 500 ms and can work optimally in a temperature range of 5°C – 90°C. Experimental testing of the three sensors was carried out by measuring the value of pH, TDS.

Table 1. Test Results for pH, TDS and Turbidity

No	Water Type	pH value	TDS Value (PPM)	Turbidity Value (NTU)
1	PDAM water	7.48	209	0
2	River water	7.45	361	6.89
3	Water with Salt Mix	7.47	1207	0
4	Water with Sugar Mix	7.54	198	3.56
5	Water with Orange Mix	3.18	1058	10
6	Water with Soap Mix	6.88	1113	3.56

The test is carried out by comparing the output of the fuzzy classifier on the Arduino with the results of manual calculations using the data generated by the sensor, as shown in Table VI. The expert system successfully provides inference results with a success percentage of 100%, both in testing water quality classifications and displaying data on the ThingSpeak website. The full test tabulation can be seen in Table 2. This test was carried out by testing the graphic display, the display of the water quality classification results, and the results of data downloads on the ThingSpeak website. The data displayed is derived from the sensor output processed by Arduino, which is then sent to the ThingSpeak API using the ESP8266-01 WiFi module.

Table 2. System Test Results

No	Test Variable	Test Specification	Test to-							%
			1	2	3	4	5	6	7	
1	PDAM water	Classifying Water Quality	☐	☐	☐	☐	☐	☐	☐	100
		Showing to thingspeak	+	+	+	+	+	+	+	100
2	River water	Classifying Water Quality	☐	☐	☐	☐	☐	☐	☐	100
		Showing to thingspeak	+	+	+	+	+	+	+	100
3	Salt water	Classifying Water Quality	☐	☐	☐	☐	☐	☐	☐	100
		Showing to thingspeak	+	+	+	+	+	+	+	100
4	Sugar Water	Classifying Water Quality	☐	☐	☐	☐	☐	☐	☐	100
		Showing to thingspeak	+	+	+	+	+	+	+	100
5	Orange water	Classifying Water Quality	☐	☐	☐	☐	☐	☐	☐	100
		Showing to thingspeak	+	+	+	+	+	+	+	100
6	Soap water	Classifying Water Quality	☐	☐	☐	☐	☐	☐	☐	100
		Showing to thingspeak	+	+	+	+	+	+	+	100

Information :

☐: The expert system has successfully classified

+: Measurement and classification values successfully displayed on ThingSpeak

Meanwhile, to test the required transmission time from receiving sensor input to displaying the results on ThingSpeak, it is done by recording the time every time there is a new entry on the ThingSpeak website. Meanwhile on the Arduino program, it has been determined that the main program repeats every 20 seconds. So the results of the transmission time test can be seen in Table 3.

Table 3. Transmission Time Test Results

No	Delay (seconds)	Time	ThingsSpeak Interval (seconds)	Logging	Transmission (seconds)	Time
1	20		27		7	
2	20		22		2	
3	20		22		2	
4	20		22		2	
5	20		22		2	
6	20		22		2	
7	20		22		2	
8	20		22		2	

CONCLUSION

Based on the results of the design that has been carried out on a solar cell-based garden watering device, it can be concluded that: Fuzzy classifier is able to classify water quality based on pH, TDS, and water turbidity values according to the designed fuzzy rules. The whole system is implemented using Arduino Mega 2560 and ESP8266 WiFi module. To make monitoring easier, the ThingSpeak website displays graphically all sensor values and also the results of water quality classification. The expert system has succeeded in classifying water quality with a 100% success rate and also displays it on the ThingSpeak website with a 100% success rate. With this tool, the process of monitoring water quality can be done anytime and anywhere.

REFERENCES

- [1] Mohhammad H.H., Zaini, & Haditya.F., “Sistem Monitoring Kunci Pintu Ruangan Menggunakan Modul Wifi”, Jurnal Universitas Muhammadiyah Jakarta, 2017.
- [2] Agistian.N, Arif.S.,& Herfia.R, “Aplikasi Pendeteksi Kualitas Air Menggunakan Turbidity Sensor dan Arduino Berbasis Web Mobile”, Jurnal Core IT, 5(1), hlm. 13-18 , 2019.
- [3] Wadu,R.A, Ada,Y.S.B., & Panggalo.I.U, “Rancang Bangun Sistem Sirkulasi Air Pada Akuarium/Bak Ikan Air Tawar Berdasarkan Kekerusuhan Air Secara Otomatis”, Jurnal Ilmiah Flash, 3(1), hlm.1-10, 2017.
- [4] Muammarul.I., Esa.Apriaskar, Djuaniadi, “Pengendalian Suhu Air Menggunakan Sensor Suhu DS18B20”, Journal of Engineering and Sustainable Technology, 6(1), hlm.347-352, 2019.
- [5] Candra, R. A., Suherman, & Ilham, D. N. (2021). Amplitude range data validation in Internet of Things (IoT) sensor. *IOP Conference Series: Earth and Environmental Science*, 644(1). <https://doi.org/10.1088/1755-1315/644/1/012063>
- [6] Ilham, D. N., Satria, E., Anugreni, F., Candra, R. A., & Kusumo, H. N. R. A. (2021). Rain Monitoring System for Nutmeg Drying Based on Internet of Things. *Journal of Computer Networks, Architecture, and High-Performance Computing*, 3(1), 52–57. <https://doi.org/10.47709/cnahpc.v3i1.933>
- [7] Nursila, N., Ilham, D. N., Yunan, A., Harahap, M. K., & Candra, R. A. (2021). Prototype of IoT-Based Fruit Alcohol Level Measurement Tool. *Brilliance: Research of Artificial Intelligence*, 1(1), 8–13. <https://doi.org/10.47709/brilliance.v1i1.1078>
- [8] Purba, Dina Stefani., Pangaribuan, Porman., & Wibowo, Agung Surya.”Pengendalian Suhu Air Berdasarkan Durasi Pemanasan Menggunakan Fuzzy Logic Dan Pi Kontroler”. eProceedings of Engineering 5.3, pp. 4011-4017, 2018.
- [9] Iqbal, Muhamad., Pangaribuan, Porman., & Wibowo, Agung Surya. “Perancangan dan Implementasi Alat Pengendali Suhu Air Berbasis Mikrokontroler”. eProceedings of Engineering 4.1, hlm. 53-59, 2017.
- [10] R. Pramana, “Perancangan Sistem Kontrol dan Monitoring Kualitas Air dan Suhu Air Pada Kolam Budidaya Ikan,” J. Sustain. J. Has. Penelit. dan Ind. Terap., vol. 7, no. 1, pp. 13–23, 2018, doi: 10.31629/sustainable.v7i1.435.
- [11] L. Parra, J. Rocher, J. Escrivá, and J. Lloret, “Design and development of low cost smart turbidity sensor for water quality monitoring in fish farms,” *Aquac. Eng.*, vol. 81, pp. 10–18, 2018.
- [12] M. J. Villaseñor-Aguilar et al., “Fuzzy Classification of the Maturity of the Tomato Using a Vision System,” *J. Sensors*, vol. 2019, pp. 1-12, 2019, doi: 10.1155/2019/3175848.