Design and implementation of the quality of mineral water test equipment using fuzzy logic method based on Internet of Things

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Abstract. Water is a chemical compound that is very important for living things on this earth. The function of mineral water for human life cannot be replaced by other compounds. To ensure that it can be used for needs, quality monitoring must be carried out continuously. This study aims at designing mineral water quality test equipment using the fuzzy logic algorithm method that is equipped with a pH sensor, TDS sensor, temperature sensor, LDR sensor, LCD, Wi-Fi module. The simulation results show that an average value of pH sensor of 8.5 - 12, TDS sensor of 300 - 350 ppm, sensor temperature of 22-25°C, and the resistance of the LDR of 110 - 170 Ohm sensor for daytime while the evenings of 920 - 970 Ohm. The several types of water tested was 5 areas around Bandung and Telkom University Dormitories. The accuracy of this tool reaches of 80%, it can be seen from the calibration results.

1. Introduction
Water is a very important thing in human life. Our body needs mineral water. Along with the development of population and mobility, the need of mineral water is increasing. Companies that provide mineral water must always test the quality of the water so that it is fit for public consumption as a daily necessity. Awareness of mineral water quality testing from mineral water companies is still lacking, this can reduce the quality of mineral water and weakening public confidence. Therefore, every mineral water company needs to carry out water quality testing continuously, following the standards in Indonesia [1].

Testing of mineral water content must not exceed the standards set by the government. Mineral water standards used in Indonesia based on Regulation No.492/MENKES/PES/IV/2010. Physical requirements include i.e. colorless, odorless, temperature values between 10-25°C (±3). Chemical requirements include Total Dissolved Solid (TDS) in water is smaller than 500 mg/L (TDS <500 ppm). TDS value can indicate the presence of mineral elements in it [2].

A good pH or acidity level of water is between 6.5 to 8.5. This mineral water equipment test must be carried out continuously or in real-time to provide good water quality and has been set to the applicable standards in Indonesia. Quality of water is a quantitative condition of the water that is measured and tested based on certain parameters and certain methods based on applicable laws and regulations (Article
1 of the decision of the Minister of Environment No. 115 of 2003). Quality of water can be stated with water quality parameters. These parameters include physical, chemical, and microbiological parameters [3].

Potable water according to the Regulation of the Minister of Health of the Republic of Indonesia Number 492 / MENKES / PER / IV / 2010 Concerning Drinking Water Quality Requirements, Article 1 states that: can be drunk immediately ". Drinking water is water used for human consumption. According to the Ministry of Health, drinking water requirements are tasteless, odorless, colorless, do not contain harmful microorganisms, and do not contain heavy metals [4]. Various mineral water quality requirements according to the Indonesian National Standardization Agency can be seen in Table 1.

| Criteria           | Unit   | Requirements          |
|--------------------|--------|-----------------------|
| Odor               | -      | Odorless              |
| Taste              | -      | Tasteless             |
| Color              | TCU    | Max. 15               |
| pH                 | -      | 6.0 – 8.5 (min, 4.0)  |
| Turbidity          | NTU    | Max. 1.5              |
| Dissolved Substances | Mg/L  | Max. 500             |
| Temperature        | °C     | Air temp. ±3          |

| TCUs (True Color Unit), NTUs (Nephelometric Turbidity Unit).

2. Research methodology
Based on the description above this tool was made aiming at designing, implementing, and analyzing mineral water quality systems using the fuzzy logic algorithm method by designing hardware and software, as well as testing the performance of mineral water quality systems in real-time. Checking mineral water is done to maintain stability in the quality of mineral water where the daily needs of the community are very dependent on the quality of mineral water. If the quality of mineral water is not maintained, the impact for the community is very high, starting from health, economy.

The software used to design a fuzzy logic controller system before converted into C in Arduino Uno programming. In the pictures below are the testing steps for simulating mineral water quality testing tools with the fuzzy logic controller method using the MATLAB application. Figure 1 shows the flowchart of fuzzy logic for the mineral water quality testing system. Starting from sensors set point. Namely the pH sensor, the TDS sensor, the temperature sensor, and the LDR sensor.

By taking a sample of drinking water that has been carried out the screening process before and then carried out a calibration process in which in the process produced more than 1 possibility that will occur, if the measurement results with a pH of 6.5 - 8.5, the temperature of 10 to 25 °C (, conductivity 0 -999 ppm, and using an LDR sensor to measure the level of water clarity, the water quality can be said to be close to the drinking water quality standards that have been set., read the sensors if the results meet the set point then continue to process of fuzzification, fuzzy inference, and defuzzification.
Figure 1. Flowchart of fuzzy logic for mineral water quality testing system.

Figure 2. Diagram block of IoT based mineral water quality testing system.

The overall scheme of the IoT-based mineral water quality testing system can be seen in Figure 2. This system consists of a microcontroller with a built-in analog to digital converter (ADC), a pH meter, a liquid crystal display (LCD) screen, a PC. The power supply circuit can be made using a voltage regulator-rectifier from the AC-PLN power source through an adapter. The pH sensor is the instrument used to measure the acidity of a liquid or the concentration of hydrogen ions in water with the value range of 0-14. For the purpose potable of mineral water quality, the pH range is 6.5 - 8.5. Temperature sensor to determine the physical state of water whether hot or cold.

Temperature measurements can be compensated for by measuring pH, either manually or automatically. The conductivity sensor is used to determine the conductivity of water; the sensor can be used to find out the TDS or measure the number of particles in water that are not visible. And the LDR sensor is used to measure the level of water clarity. The hardware design for the IoT-based mineral water quality test tool can be seen in Figure 3. In designing mineral water quality test equipment using IoT-
based fuzzy logic methods hardware is needed to facilitate the system to carry out its tasks such as pH sensors, conductivity sensors, as well as temperature sensors, LDR sensors, controllers, power, Wi-Fi modules, and the results displayed. Fritzing application used as tool for hardware design. The hardware design explains the device construction which is realized in this final project research. The equipment used in this study is a pH sensor, temperature sensor conductivity sensor, LDR sensor, pre-amp, amplifier, solar cell power supply, regulator, microcontroller, LCD, and Wi-Fi module.

3. Results and discussion
Results and analysis of the simulation system for mineral water quality testing tools using IoT-based fuzzy logic methods performed using the MATLAB in the form of figures. From Figure 4 we can see the results of the rules in the defuzzification process. The results of mineral water are indicated by number 1 and non-mineral water is indicated by number 0. Checking can be done after testing by entering the value obtained. After that, the results appear as in the figure. The results and analysis of the testing system for mineral water quality testing tools using the IoT-based fuzzy logic method are shown in Table 2.

![Figure 3. Hardware design.](image)

![Figure 4. Defuzzification process for mineral water and non-mineral water.](image)
The results and analysis of the testing system for mineral water quality testing tools using the IoT-based fuzzy logic method are shown in Table 2.

Table 2. Mineral water testing results in the area around Bandung.

| Place                  | pH Sensor (±) | TDS Sensor (±) | Temp Sensor (±) | LDR Sensor (Ohm) | Information         |
|------------------------|---------------|----------------|-----------------|-------------------|---------------------|
| Kosan Cicaheum         | 11.9 ± 0.94   | 321.3 ± 24.33  | 24.6 ± 0.09     | 128.4 ± 6.0       | 963.7 ± 7.36       | Non-Mineral Water   |
| Orange, Buah Batu      | 9.74 ± 0.34   | 344.8 ± 4.62   | 22.04 ± 0.3     | 134.6 ± 2.9       | 936.7 ± 2.64       | Non-Mineral Water   |
| SPBU Ters. Buah Batu   | 11.16 ± 0.49  | 335.4 ± 0.489  | 26.08 ± 0.04    | 162.6 ± 1.56      | 971.9 ± 11.7       | Non-Mineral Water   |
| Masjid PGA             | 11.27 ± 0.47  | 345.5 ± 1.627  | 24.94 ± 0.05    | 156.9 ± 0.53      | 965.7 ± 3.06       | Non-Mineral Water   |
| Kosan Den Avi PGA      | 10.91 ± 0.56  | 320.2 ± 0.4    | 25.97 ± 0.09    | 158.2 ± 0.74      | 962.5 ± 1.20       | Non-Mineral Water   |
| Masjid SU Tel-U        | 11.07 ± 0.47  | 350.1 ± 0.83   | 26.06 ± 0.04    | 153.8 ± 1.24      | 957.6 ± 1.11       | Non-Mineral Water   |
| Asrama 4 Tel-U         | 8.45 ± 0.03   | 315.4 ± 0.48   | 24.94 ± 0.05    | 116.4 ± 0.91      | 934.1 ± 1.13       | Mineral Water       |
| Asrama 5 Tel-U         | 8.41 ± 0.01   | 312 ± 1        | 21.98 ± 0.34    | 112.2 ± 1.32      | 938.1 ± 0.83       | Mineral Water       |
| Asrama 6 Tel-U         | 9.41 ± 0.02   | 322 ± 1        | 22.08 ± 0.10    | 133.8 ± 1.24      | 945.6 ± 0.8        | Mineral Water       |
| Asrama 8 Tel-U         | 8.48 ± 0.007  | 318.5 ± 0.671  | 23.65 ± 0.16    | 126.4 ± 0.91      | 940.1 ± 0.7        | Mineral Water       |
| Asrama 9 Tel-U         | 8.41 ± 0.006  | 308 ± 0.894    | 22.32 ± 0.25    | 124 ± 1.264       | 941.1 ± 0.53       | Mineral Water       |
| Asrama F Tel-U         | 8.42 ± 0.006  | 318.3 ± 0.64   | 23.93 ± 0.04    | 127.9 ± 0.83      | 942.5 ± 0.67       | Mineral Water       |

The values generated for each sensor in this mineral water quality test tool. The value obtained is the average value in each trial equipped with a standard deviation value. This value is compared with the mineral water quality requirements specified in Table 1. Requirements that must be met include the value of pH 6.5 - 8.5, TDS value of 0-999 ppm, temperature value of 10- 25 °C, resistance value for water clarity from 0 - 500 ohms. When the value produced qualifies as mineral water, it can be said to be mineral water that is suitable for meeting daily needs.

Figure 5 shows the graphics of the image for IoT in this mineral water quality test tool. The graphs can be viewed through the website www.thingspeak.com, where the results of testing the quality of mineral water can be accessed in real-time. When the mineral water quality test equipment is turned on and used, the data generated is immediately updated on this website www.thingspeak.com and can immediately see the changes at any time. At the time of testing; it had been carried out for 30 minutes with a signal that access to the internet must be stable.

Whenever the signal is unstable, the graphs listed in the monitoring will stop and will upload again at a much different time. Temperature sensor monitoring graph, it can be seen that the temperature sensor monitoring from the mineral water quality test tool directly sends data and is displayed on the web page www.thingspeak.com. Values are shown between 20 to 30 °C. But the weakness of this system is that when the internet signal is slow or down, the results of the test equipment cannot be sent directly to the webpage www.thingspeak.com
Figure 5. Monitoring results of pH, TDS and temperature sensors.

4. Conclusion
The conclusion of this research is the design, implementation, and analysis of mineral water quality systems have been carried out using the fuzzy logic algorithm method to produce an average value of a pH sensor around 8.5-12, TDS sensor around 300-350 ppm, temperature sensor around 22-25 °C, and the resistance of the LDR sensor is around 110 - 170 Ohms for daytime while at night around 920 - 970 Ohms and this mineral water quality testing has used MATLAB software where this simulation produces binary value 1 for mineral water and binary 0 for non-mineral water. The design and implementation of hardware and software have been carried out by producing a device equipped with a Wi-Fi module to view the IoT process which can be accessed via the web www.thingspeak.com and the performance test of the mineral water quality system has been carried out in real-time and equipped with an LCD to see the value directly.

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