Groundwater feasibility test system by using wireless sensor network

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Abstract. Water is one of the most important natural resources for human life. Water is used by the community for bathing, drinking, cooking and for other consumptive needs. Therefore, the water quality must be maintained cleanly. It is not uncommon to find water that is not suitable for use because it is turbid and smelly from its source. Things that must be considered to assess good water quality are pH, oxygen levels dissolved in water, conductivity, water temperature, water turbidity, salinity (salt content), zinc content and so on. The testing of groundwater quality is a better alternative than the testing that has been done manually and requires expensive costs. The measuring devices are made by using sensor circuit that is controlled by Arduino. Monitoring is done by using a web application that is stored on a server where the server also communicates with Arduino with the help of the SIM800L module. The results showed that the system ran well. The sensors succeed in detecting water quality and data communication between sensors, servers and clients ran well.

1. Introduction

Water is one of the most important natural resources for human life. There are several sources of water that are used for daily needs, such as from rivers, ground water (wells), mountain water, etc. Water from the water source is used by the society for bathing, drinking, cooking and for other consumptive needs. Therefore, the water quality must be maintained cleanly. It is not uncommon to find water that is not suitable for use because it is turbid and smelly from its source. The water source itself has a standardized quality level.

Nowadays, the community prefers to use water that is managed by a Regional Water Company (PDAM), but some also use groundwater sourced from well water directly or through the pumping process. However, it should be noted that the well water can also contain chemicals with levels that are not in accordance with the standard level of quality that has been set, so it is not suitable for use. The inappropriate well water can give a negative impact on human health.

Things that must be considered to assess good water quality are pH, oxygen levels dissolved in water, conductivity, water temperature, water turbidity, salinity (salt content), iron, zinc content, and so on. In addition, the environmental conditions around water sources also affect water quality. Groundwater testing is still done manually and the expensive laboratory test costs become obstacles in monitoring groundwater quality.

One of the ways to overcome these problems is by testing groundwater quality. With the existence of groundwater quality testing system, so the society can filter the water based on the quality of water in their groundwater sources, in this case it is usually sourced from wells or natural wells.

Several studies related to the feasibility of water and wireless sensor network technology have been done before. [2] concerning the detection system of wastewater quality standards by using Wireless Sensor Network technology using sensors for pH, conductivity, dissolved oxygen levels and water temperature. The output produced in the form of the monitoring results of the wastewater quality based on the detected parameters and web notification if any of the water parameters are below the quality standard.
Regarding to monitoring of water quality with Wireless Sensor Network technology has been done by several researchers before. Research that discusses about the real-time monitoring of water quality in the Internet of Things (IoT) environment by using raspberry PI B + as its core processing and using temperature sensor, pH, turbidity, conductivity and dissolve oxygen sensors as a water quality determination [3].

The monitoring water quality in real-time by using PH, turbidity and conductivity when the is known to be very dangerous, so the system will send a message to users who have access to the system [4].

2. Data and Method Used

2.1. Data Used

The data used in this study is in the form of water quality standards which are a measure of the limits or levels of living things, substances, energy or components that exist or must be present. Water quality is a condition of water quality measured based on certain parameters. By comparing the conditions of water quality with water quality standards, it can be seen the status of water quality. Water quality standards are intended to control the level of water pollution which is caused by the entry or inclusion of living things, substances, energy or other components so that the water quality decreases until it is not suitable for use at certain levels. The quality standard used is based on PP Number 82 of 2001.

| Parameter      | Unit   | Level of Feasibility to Use | Information                                                                 |
|----------------|--------|------------------------------|------------------------------------------------------------------------------|
| *Ph*           | -      | 5 – 9                        | If it is outside the range, then it is determined based on natural conditions.|
| Conductivity   | µmhos/cm| 0 - 2000                     | If it is > 2000, so it is categorized as not feasible.                       |
| Temperature    | °C     | 23 – 33                      | If it is outside the range, then it is determined based on natural conditions.|
| Turbidity      | NTU    | 0 – 25                       | If it is outside the range, then it is categorized as not feasible           |

The sample data used is groundwater which sourced from well water in paddy fields and collected by using pH sensor, conductivity, temperature and turbidity sensors based on the parameters specified above.

2.2. Method Used

This study is used the following hardware:

2.2.1. Sensor Acidity (*pH*)

The electrochemical potential that occurs between the solution in the glass electrode and the glass electrode becomes the basis of *pH* measurement. The thin layer of glass bubbles will interact with hydrogen ions which are relatively small and active. The electrochemical potential of the hydrogen ion that occurs will be measured by a glass electrode and will be compared with a reference electrode.
Measurement of sensor voltage to the pH solution level has a positive voltage value for pH above 7, for pH values below 7 has a negative voltage value and for a pH value of 7 or neutral has a voltage value close to 0.

The term pH comes from "p" which is a mathematical symbol of negative logarithms and "H" is a chemical symbol for chemical elements. For the form of the pH equation can be stated as follows "pH = - log [H +]", the pH value is obtained from quantitative information expressed by the acidity or base level related to the activity of Hydrogen ions.

The specifications of the pH sensor used:

- Measurement range: 0 - 14 pH
- Temperature during use: 0 - 80 °C
- Response time: <1 minute
- Accuracy of readings: up to 0.01 (with calibration)
- Interference: <0.5 mV

2.2.2. Conductivity Sensor

Conductivity or also known as electrical conductivity (DHL) is the ability of a solution to conduct electric current. The size of the solution’s ability to conduct electrical current is determined by the presence of ions, the total ion concentration, the valence of the relative concentrations of ions and the solution temperature when tested.

A good conductivity value if a solution or water is smaller than 500 µmhos/cm, while a bad conductivity value if a solution or water is greater than 2000 µmhos/cm. Conductivity can be expressed in units of µS/cm or mS/cm where 1 mS/cm = 1000 µS/cm or 1000 mmhos/cm.

2.2.3. Temperature Sensor

The DS18B20 sensor is a digital temperature sensor that is able to read temperatures with a precision of 9 to 12-bits, a range of -55 °C to 125 °C with accuracy (+/- 0.5 °C). This sensor has a unique code of 64-Bit embedded in the chip, so it allows the sensor use in large numbers only through one cable (single wire data bus / 1-wire protocol).
Specifications of temperature sensors used:
• Measurement range : -55 - 125 °C
• Accuracy : +/- 0.5 °C
• Diameter : 6 mm
• Length : 100 mm

2.2.4. Turbidity Sensor
Turbidimeter is a tool used as a standard test tool to determine the level of water turbidity. The basis for reading the water turbidity, there is a kind of light source sensor and light catcher in the sensor which is then passed to the water that will be measured or checked for turbidity. This sensor can be connected to the measurement instrument processing devices such as to the microcontroller or to Arduino. To be able to be used for reading sensor data through the ADC, this turbidity sensor requires two resistors that connected at pin 2 and pin 3. And we also need a connecting cable from the sensor to the processing unit / microcontroller / arduino.

2.2.5. Arduino Uno
Arduino Uno is a microcontroller board based on ATMEGA 328 (datasheet). It has 14 input pins from digital outputs where the 6 input pins can be used as PWM outputs and 6 analog input pins, 16 MHz crystal oscillator, USB connection, jack power, ICSP header and reset button. To support the microcontroller to be used, it is enough to simply connect the Arduino Uno Board to the computer by using a USB cable or AC power-to-DC adapter or battery to run it: Uno is different from all the previous boards that it does not use FTDI USB driver chips -to-serial. In contrast, the Atmega16U2 feature (Atmega8U2 through R2) is programmed as a USB-to serial converter. Revision 2 of the Uno board has a resistor that pull to the 8U2 HWB line to ground, making it easier to put into DFU mode.
2.2.6. GSM SIM 800L Module
SIM800L is the SIM module used in this study. SIM800L GSM / GPRS module is a part that functions to communicate between the main monitor and the computer. AT Command is a command that can be given by a GSM / CDMA modem such as to send and receive GSM / GPRS-based data or send and receive SMS. SIM800L GSM / GPRS is controlled via AT commands. AT + Command is a collection of commands that are combined with other characters after the "AT" character that is usually used in serial communication. In this study AT command is used to manage or give commands for GSM / CDMA modules. The AT Command instruction starts with the character "AT" or "at" and ends with the code (0x0d).

2.2.7. Wireless Sensor Network
Wireless Sensor Network is a communication network that connects a sensor node with a data node that aims to monitor the state of a particular environment at different locations between the sensor and the end node. Wireless Sensor Network has a network hardware which in this case uses a network hardware in the form of SIM800L Module which is connected to Arduino Uno that functions to send data from the sensor to the internet network. Wireless Sensor Network is built based on several interconnected sensor devices. Sensor devices that able to be connected can amount to hundreds or even thousands of sensors that can operate in remote areas.

This module functions to send information that has been processed in Arduino to servers and computers that access the application of groundwater feasibility test system.

- Internet
- The internet is a media that connects computers, servers and tools of the groundwater feasibility test system.
- Server
- The server functions as a database that is a storage media for information of quality standards, results of measurements and results of groundwater feasibility tests. Web server that was used, namely Apache and database management using MySQL.
• User Client
• Users are components that receive and run applications with Personal Computer as a platform used through a web browser media.

3. Research Results and Discussion
3.1. Water Testing
Water testing is carried out to determine the water quality, so that its eligibility can be determined. The test plan can be seen in Table below.

| No | Component System | Test Items                                      |
|----|------------------|------------------------------------------------|
| 1  | Well water       | 1. pH measurement  
                     | 2. Temperature measurement 
                     | 3. Conductivity measurements 
                     | 4. Turbidity measurement 
                     | 1. SIM800L Testing |
| 2  | Data Communication | 2. Query Testing 
                        | 3. Data Display Testing |

3.1.1. Sensor Circuit Test Results

| No | Testing Parameter | Feasibility Standard | Well Water 1 | Well Water 2 | Result |
|----|-------------------|----------------------|--------------|--------------|--------|
| 1  | pH                | 5 – 9                | 7            | 7            | Feasible to Use |
| 2  | Temperature (°C)  | 25 – 32              | 27           | 26           |          |
| 3  | Conductivity (µmhos/cm) | 0 – 2000 | 443         | 227         |          |
| 4  | Turbidity (NTU)   | 0 – 25               | 0            | 999          | Not Feasible to Use |

3.1.2. Data Communication Test Results

| No | Testing Target | Expected Result | Test Result | Status |
|----|----------------|-----------------|-------------|--------|
| 1  | Test Module of SIM800L | Modules can send queries to the server to be executed. 
|    | Query Test     | Query sent successfully to the server. 
|    | Test Data Display | A query that is run can enter data into the database. 
|    |                | Data is added after the query is excited. 
|    |                | Data that has entered to the database are able to be seen in the web application. |

4. Conclusion and Suggestions
4.1. Conclusion
After conducting a literature study, analysis, design and testing of groundwater feasibility testing tools, it can be concluded as follows:
1. This tool can measure the pH, conductivity, temperature and level of turbidity of groundwater as well as knowing the water condition that is feasible or not for use.
2. This system can be attached to both smartphones and computers by using a browser to display the test results more easily.
3. Sensor data can be sent to the server via the SIM800L module where the data transmission is affected by the cellular service provider network used on the SIM800L module.
4. The calibration process carried out in accordance with the procedures and works well which is marked by a sensor that can detect the value of the quality standard of wastewater samples. This also indicates that the sensors performance and detection systems are running well.

4.2. Suggestions
The suggestions that can be offered by the writer for the further development and researches are as follows:
1. In the future studies, it is expected to be able to test the dissolved oxygen sensor value in ppm by using a sensor that can study the salinity value and the atmospheric pressure which aims to provide a more accurate value.
2. This study only uses the parameters of pH, conductivity, temperature and turbidity in determining groundwater quality standards, henceforth it is expected to be able to add other parameters such as TDS, dissolved oxygen and so on.
3. For the further development, it is expected that the system can be made into an Android application, so that it is easier to use on a smartphone device.

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