Advances in Social Science, Education and Humanities Research, volume 651
Proceedings of the 4th International Conference on Innovation in Engineering and Vocational Education (ICIEVE 2021)

Development of Portable IoT Data Logger for Water Quality Monitoring

Eka Ratri Noor Wulandari*, Harnan Malik Abdullah, Salnan Ratih Asriningtias
Vocational Education
Universitas Brawijaya
Malang, Indonesia
*ekaratri@ub.ac.id, harnan_malik@ub.ac.id, salnan@ub.ac.id

Abstract—**Water is a limited natural resource and essential thing for the human being. Clean water is needed for various needs, especially for drinking water. In recent years, a lot of human activities cause a decrease in water quality. So, if these activities take place further, it will damage the water sources. With the requirements for water quality for community consumption, it is necessary to analyze and monitor the quality of water. Water quality is described as the general composition of water concerning its chemical, physical, and biological properties. Generally, the water quality analysis and monitoring are carried out in a laboratory so it requires time and certain expertise. The physical properties of water can become an indication of whether the water is safe to consume. Therefore, with the rapid development of technology, this research will develop a portable device for monitoring the physical quality of water based on the internet of things (IoT). This development an ESP32 microcontroller as the main processor. The sensors used are temperature sensors, turbidity, pH, and also TDS (total dissolved solid). The RTC module is used to provide information of time. While the GPS module functions to provide information about the location coordinates. The data generated from sensor readings will be displayed on a website so that users can monitor the results in real-time anywhere and anytime. It is experimentally observed the physical properties of water less than a minute to update its values. This system is very beneficial for the resident to analyze and monitor the water quality for consumption.**

Keywords—data logger, internet of things, water quality

I. INTRODUCTION

Water is a natural resource which is very essential for human life. Nowadays, water resources in many regions are being overexploited. Such as the groundwater depletion give a huge impact into freshwater availability [1]. In the earth surface, 71% consists of water while 29% consists of continents and islands. From water resources, it consists of 97% sea water and 3% freshwater. Out of the freshwater content, only 0.4% usable and drinkable water is available [2]. Nowadays, great pollution of water resources is occurred. Based on Dwivedi [3], around 1500 substances have been listed as pollutants in freshwater ecosystems. Around the world, it is known that probably 250 million cases of disease caused by polluted water annually. The contaminants of water are due to two major factors, namely natural processes and man-made (anthropogenic) activities [4].

According to the regulation of the Minister of Health, Republic of Indonesia number 492/Menkes/PER/IV/2010, drinking water is water that has been processed or without processing that meets health requirements and can be drunk directly. Drinking water is categorized safe for health if appropriate the physical, microbiological, chemical and radioactive requirements. Physical parameters consist of odor, color, total dissolved solids (TDS), turbidity, taste [5]. The terms of the physical quality of drinking water are shown in Table 1 below according to the regulation of the Minister of Health, Republic of Indonesia number 492/Menkes/PER/IV/2010.

TABLE I. PHYSICAL PROPERTIES OF WATER

No.	Parameter	Unit	Safe Range
1	Odor	-	odorless
2	Color	TCU	15
3	Total Dissolve Solid (TDS)	mg/L	500
4	Turbidity	NTU	0-5
5	Flavor	-	flavorless
6	Temperature	°C	Air temperature ± 3
7	pH	-	6.5-8.5

Generally, water quality analysis, especially for drinking purposes, is carried out by laboratory tests so that it takes a long time, qualified human resources, and costs. In addition, the measurement results cannot be seen in real time. Water quality monitoring is important to identify changes in parameters of quality to ensure its safety to be consumed. Water quality monitoring helps in evaluating the nature and extent of pollution control required, and effectiveness of pollution control measures [6].

Currently, the technology is growing fast. Internet of things (IoT) is an open and comprehensive network of intelligent objects that have the capacity to auto-organize, share information, data and resources, reacting and acting in face of situations and changes in the environment [7]. The IoT is used cloud environment to store data, communicate, and connected into different devices. It connected through networks using the wireless communication [8]. IoT system is used for water quality monitoring, it give the possibility of real time-monitoring, automation for smart solutions, adaptive and responsive systems and in a reduction of water quality monitoring costs [9]. Beside of those advantages, the application of IoT in water monitoring system is about empowering human with automation technologies that escalate their knowledge to know the water quality which is consumed in their daily life [10]. There are several studies about IoT for water quality monitoring with different parameters measured. Rahman et al. [11], built an IoT water quality measurement using several sensor relate to Arduino for monitoring water parameter.

In this experiment, we propose an Internet of Things (IoT) based system for water quality monitoring that is capable to analyze the physical properties of water with competitive accuracy. It will simplify the laboratory analysis which is usualy used to analyze the water quality. So, the purpose of society empowerment will be achieved.

II. Materials and Methods

A. *Materials*

In this experiment, the components used to build a Water Monitoring System (WMS) instrument are an ESP32 microcontroller as the main processor, RTC module to provide time information, GPS module functions to provide information about the location coordinates, LCD for configuration and information during measurements and temperature, turbidity, pH, and also Total Dissolve Solid (TDS) sensors. Moreover, GSM module is acquired to perform internet connection through General Packet Radio Service (GPRS).

Website application is built using Xampp and Visual Studio code software. This website is constructed using HTML, bootstrap, PHP, JavaScript Dan MySQL.

B. *Network Topology Design*

The block diagram (Figure 1) shows the network topology that built in this experiment. The topology has two main parts, namely Water Monitoring System (WMS) instrument and online servers. These perform an internet of things (IoT) system. Water quality measurement can be done anywhere. The sensor reads the physical quality parameters of the water, then the reading data will be stored in the ESP32. Each time the data is read, the coordinates of the location and the time of reading will also be stored. These reading data can be sent to the online server if there is a Wi-Fi internet network, if there is no internet connection, the data will be stored in ESP32. On the server side, there is an API (application programming interface) that will capture the data sent by the measuring instrument and then saved to the database server. Furthermore, the data can be displayed using a web-based application. Hence, the live reading data can be performed when the measurement location has Wi-fi infrastructure or cellular internet network is available.

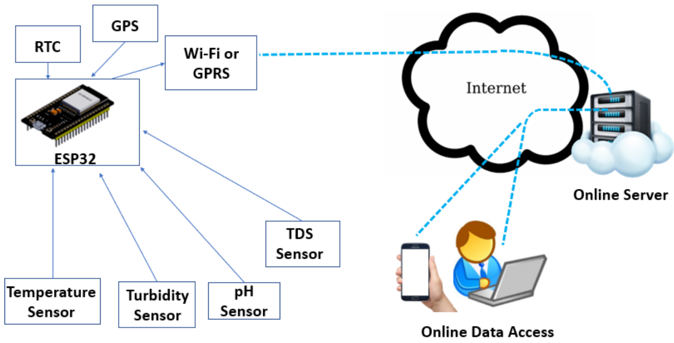

Fig. 1. Network topology block diagram.

C. *Website Application Design*

This application consists of one user level as admin. Admin can perform several actions, including viewing dashboard, managing location, managing sensors, managing WMS Instruments, viewing temperature data, viewing TDS data, viewing turbidity data, viewing pH data, viewing data logger graphs, managing users, and changing passwords. All actions can be done by the admin if the admin has logged in to the application. The use case diagram for this application is shown in Figure 2.

Data flow diagram (Figure 3) shows that the application consists of nine modules including the location module connected to the location table in the database, the sensor module connected to the sensor table in the database, the instrument module connected to the instrument table in the database, the user module connected to the user table in the database and the viewing module for temperature, TDS, turbidity and pH data. Also, the module to view the data logger graph which is connected to the data logger table in the database.

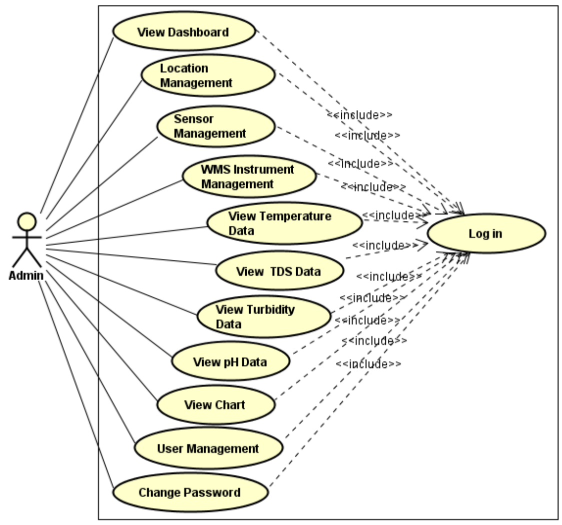

Fig. 2. Use case diagram.

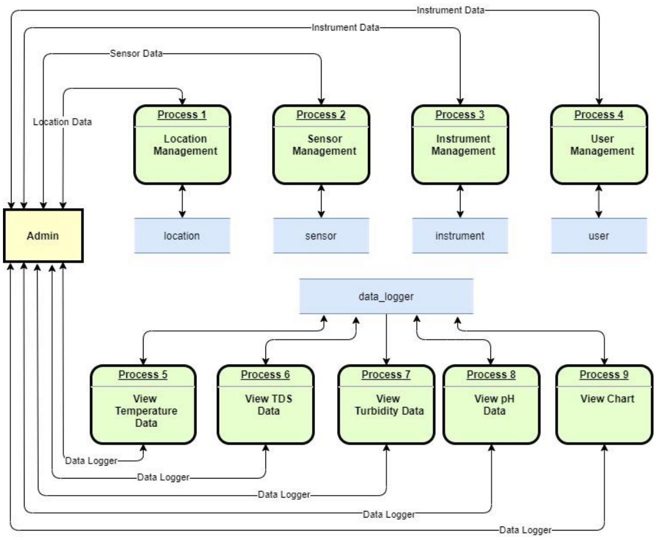

Fig. 3. Data flow diagram.

Database relations in this application design is shown in Figure 4. This application has five tables consisting of user table, location table, sensor table, an instrument table and data logger table. Logger table related to location table, sensor table and instrument table.

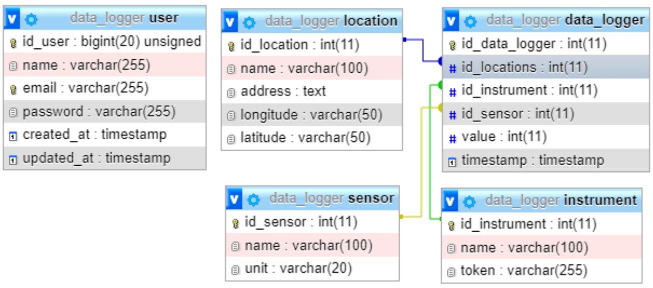

Fig. 4. Database relation.

D. *System Testing Method*

To confirm the functionality and reliability of the water monitoring system created, there are several stages carried out, namely sensor testing, testing data transfer to online servers and testing the functionality of the data viewer website. Sensor testing is done by comparing sensor readings with commercial measuring instruments, if there is a difference, calibration is carried out on the reading algorithm in the ESP32. The data transmission test is carried out by sending sensor reading data to an online database via the internet network, both GPRS and Wi-Fi. While testing the appearance of the website is mainly carried out to display sensor data readings that have been stored in the database.

III. Result and Discussion

A. *Water Monitoring System (WMS) Instrument*

WMS instrument built in this study is shown in Figure 5. This instrument consists of four sensors. The sensors are shown sequentially i.e.:

- Temperature sensor
- TDS sensor
- pH sensor
- Turbidity sensor

Temperature sensor is used to measure the amount of heat in the system. The sensor measures the heat of an external object. TDS sensor is used to detect the number of dissolved solids in the form of organic ions, compounds, and colloids in the water. pH sensor is used to measure the presence of hydrogen ions in water. Turbidity sensor is used to measure of the level of turbidity of water. This WMS instrument can be used for direct water measurement. Physical properties data can be read in real time and recorded on online server.

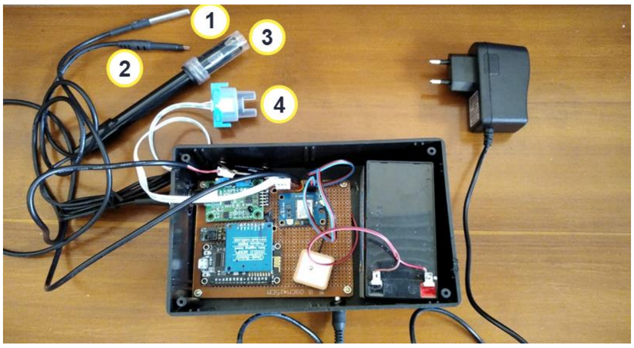

Fig. 5. WMS instrument.

B. *Website Application*

Website application is used to display the readings of WMS instrument. This website application dashboard is shown in Figure 6. This page displays the temperature, TDS, turbidity and pH data which is collected from working sensor. This page also displays a map of the city where this WMS instrument is used.

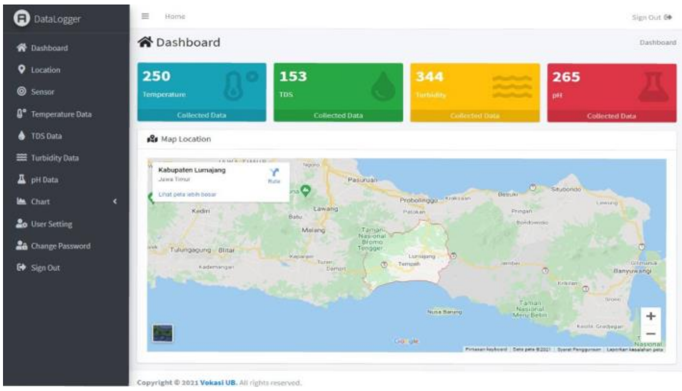

Fig. 6. Dashboard page.

Sensor page is used to set each sensor for data collection. On this page user can view, add, edit, delete and search data. The sensor page is shown in Figure 7.

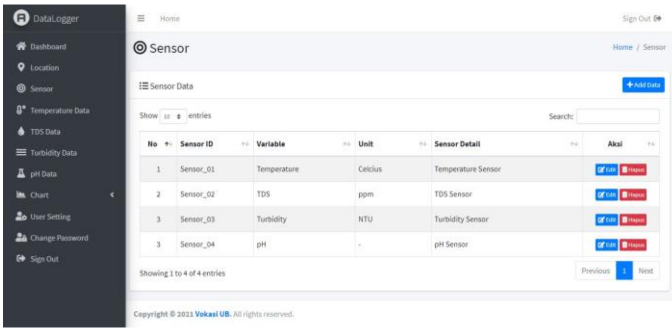

Fig. 7. Sensor page.

Also, there are four sensors page consist of temperature, TDS, pH and turbidity data page. This page is used to display each sensing data which is collected in every 30 minutes in several different locations. Based on the result, WMS can work properly to measure water quality parameters, such as temperature, TDS, pH and turbidity in real time. Sensor measurement results can be monitored online through the web application, so that can be viewed anywhere in the world.

In the previous research, the water quality monitoring is important for several different location because with different environment and ecosystem gives different result [12]. Such a condition needs a separate device for monitoring the water quality. WMS installation is very easy because it is portable and low cost, so in our proposed system we can monitor the water quality parameters in different location in the same time using web application with install WMS in several multiple point of measurement location. The results values of each parameter can display on the web application from different location. For example, the result of pH value is shown in Figure 8.

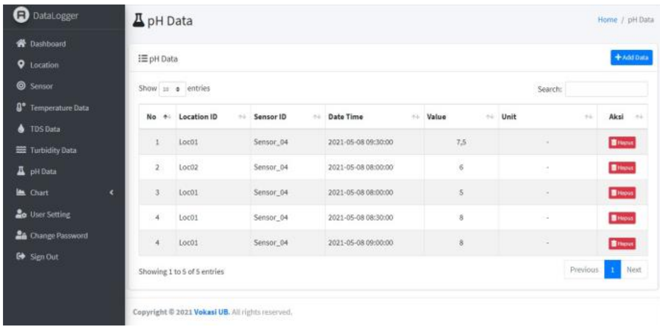

Fig. 8. pH data page.

It shows that WMS more efficient reading, sending and viewing the data on web application. Otherwise, in Figure 9 the web application can display chart with all water quality parameter values in a specific location, so this can make it easier to compare water quality between one location to each other. For future development, the web application can prediction that the water is drinkable or not.

Fig. 9. TDS chart page.

IV. Conclusion

This research develops a device for monitoring the physical quality of water based on the internet of things (IoT) called Water Monitoring System (WMS) instrument. This development an ESP32 microcontroller as the main processor. The sensors used are temperature sensors, turbidity, pH, and also TDS (total dissolved solid). The RTC module is used to provide information of time. While the GPS module functions to provide information about the location coordinates. The data generated from sensor readings will be displayed on a website so that users can monitor the results in real-time anywhere and anytime.

Acknowledgment

This was fully supported by Vocational Education, Universitas Brawijaya. We thank you for the financial support in this research.

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