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Smart Water Quality IoT-Based System for Healthy Living

[1]A.N. Amir, [2]H. Alhussian, [3]G. Hayder, [4]S. Basri, [5]S. Jadid

[1,2,4,5]Department of Computer and Information Sciences, Universiti Teknologi PETRONAS,Bandar Seri-Iskandar, Perak, Malaysia.
[3]Institute of Energy Infrastructure (IEI), Universiti Tenaga Nasional (UNITEN), Kajang, Selangor Darul Ehsan, Malaysia.
[3]Department of Civil Engineering, College of Engineering, Universiti Tenaga Nasional (UNITEN), Kajang, Selangor Darul Ehsan, Malaysia.

Abstract

In order to avoid the risk of drinking contaminated water, the information of drinking water quality must be available in real time. This paper presents the design and development of a real time monitoring system of drinking water quality using Internet of Thing (IoT). Several sensors IoT water sensors are used to measure and validate the water quality parameter values. These parameters include pH, turbidity and oxidation-reduction potential (ORP). The sensors are connected through an Arduino UNO controller. The Arduino UNO controller reads and sends sensor parameter values to an android mobile application which displays the measurements and concludes whether the quality of the water is safe to be drinkable or not.

Keywords: Arduino UNO, real time water quality, Internet of Thing, water quality assessment, monitoring

1 Introduction

Water may be polluted due to bad management of disposal of solid waste and over usage of fertilizers as well as from living environment, aquatic life and water supply that have great impact on water quality that

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might be greater than the self-purification capacity [1] and [2]. There is national concern about river water quality that is essential to ensure a sustainable development [3]. Globally, 26% of all deaths are because of disease caused by intake of poor quality of drinking-water. Drinking water with low-mineral lead to various health risk including dental caries. Other than mineral, the lack of calcium and fluoride may also contribute to the incidence of dental caries. Comprehensive testing by the Environmental Working Group (EWG) reveals a surprising array of chemical contaminants in every bottled water brand analysed. The bottled water company takes advantage towards the public as public is not expose with the method on how to measure the water quality. Therefore, current study suggests performing regular monitoring of water quality. IoT solution can be incorporated with water quality assessment by applying it with measuring of PH value, turbidity and ORP.

High iron concentration of drinking water was found in industrial area due to industrial and chemical waste discharge [4]. Poor water quality may also cause cholera and typhoid as these diseases were being occurred in the contaminated area. Bottled drinking waters that have gone through the reverse-osmosis technique are also considered as a harmful substance because the minerals substance contained in the water have been completely removed [5]. Drinking water with low-mineral lead to various health risk including dental caries.

The problem of drinking such low quality water arises when there are many water borne disease cases were reported around the world. In the region of South Asia, more than 0.5 million deaths of infants happened per year due to poor water quality and bad sanitation [6],[7]. The quality of drinking waters from water resources like tap water, bottled mineral water and home water filtration system are commonly unknown. With this situation, it may cause the consumers to expose with the risk of drinking contaminated water. Consumer of drinking water may perform the water quality assessment to avoid the risk of drinking contaminated water but the conventional method of performing water quality assessment have several drawbacks.

The main concern of using the conventional method is the method is lack of real time information. The main objective of this paper is to perform a real time monitoring of water quality.

Therefore, below are the sub-objectives to achieve the main objective:

- To measure the quality of drinking water using IoT sensors.
- To develop a mobile as well as a web application that will display water quality information from the IoT sensors.
- To perform water-quality data analysis using water parameters value.

2 Literature Review

The process of determining the quality of drinking water is usually evaluated based on the Drinking Water Quality Index (DWQI) [8]. DWQI is a mathematical tool that converts water quality data into a single value of overall quality status. For drinking water quality assessment, several parameters which are important to health will be selected. The selected parameter will be pH, turbidity and Oxidation Reduction Potential (ORP).

The traditional method of doing assessment of water quality involves collecting the sample of water manually. This water sample will then be sent to laboratory to do analytical techniques for water-quality results. This methodology has several drawbacks especially in terms of time management. It took longer time as it needs to go through a long physical procedure. Therefore, this method is a time-consuming method as well as less efficient because it is labor intensive as well as high cost [9],[10]. The main problem of using traditional method is the lack of real time information.The real time water quality information is crucial in helping the decision- making processes for public health protection. In order to solve this problem, a continuous online water quality monitoring is needed.

Internet of Thing (IoT) application in water quality monitoring may improve the management of water quality, thus reduce the risk of water borne disease in order to improve the public health [11]. The system may increase the speed of delivering information as well as providing all day access to information. IoT connect the embedded devices and sensors with each other and allow exchange of information over the Internet. Sensors will collect and send information in real time. The water quality parameters can be monitored on the Internet by using cloud computing. The related values for water quality parameters are stored in a web server on the cloud. Cloud computing is suitable to be implemented in environment monitoring as the data are available word widely [9],[12]. These environmental and sustainable practices are considered as practical initiatives that should be explored and conducted to increase awareness sustainability practices [13][14][15]. Table 1 shows Drinking Water Quality Index.

Table 1: Drinking Water Quality Index [8]

Substance or characteristics	BIS (2003)		WHO (2006b)	
	Desirable	Max. acceptable	Permissible	Max. acceptable
pH	6.5 – 8.5	No relax.	6.5 – 8.5	6.5 – 9.2
EC (dS/m)	1	3	–	–
Total Alkalinity (as $CaCO_3$), mg/l	200	600	500	–
Total hardness (as $CaCO_3$), mg/l	300	600	200	500
Calcium (as Ca), mg/l	75	200	–	–
Magnesium (as Mg), mg/l	30	100	–	–
Sodium (as Na), mg/l	–	–	–	200
Chloride (as Cl), mg/l	250	1000	250	600
Fluoride (as F), mg/l	1.0	1.5	–	1.5
Sulphate (as SO_4), mg/l	200	400	250	500
Nitrate (as NO_3), mg/l	45	No relax.	–	50
Copper (as Cu), mg/l	0.05	1.5	–	2.0
Zinc (as Zn), mg/l	5	15	3.0	5.0
Lead (as Pb), mg/l	0.05	No relax.	–	0.01
Iron (as Fe), mg/l	0.3	1.0	0.3	1.0 – 3.0
Manganese (as Mn), mg/l	0.1	0.3	0.4 [a]	0.5
Chromium (as Cr), mg/l	0.05	No relax.	–	0.05

3 Methodology

Fig. 1 shows the system architecture of this paper. The first component consists of a cup attached with IoT sensors. The sensors are responsible to detect the water parameter value and send the data. According to Drinking Water Quality Index, there are about 20 parameter value that are considered important to determine the degree of water quality. In this work, only three important parameters to be measured which are pH, turbidity and Oxidation Reduction Potential (ORP).

In the block diagram (Fig. 2), the prototype will be using three sensors, which are pH sensor, turbidity sensor and Oxidation Reduction Potential (ORP) sensor. All of these three sensors are connected to the Arduino UNO board. A power supply will be connected to the Arduino board. Arduino act as a middle controller that retrieve the parameter values from the three sensors and transfer these values through the Internet. The data will be stored in a form of database in the cloud system. The application will retrieve all the data from the cloud system and display it to the user. The application will also perform data analyzation to generate the degree of drinking water quality.

Figure 1 System Architecture

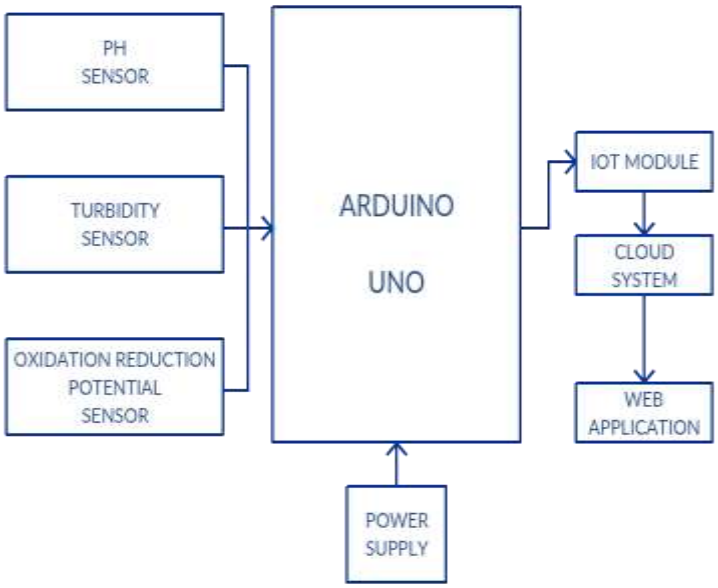

Figure 2 Block Diagram

Fig. 3 presents the schematic diagram of the proposed system iot system architecture. Arduino UNO is used as a core controller. It supports portability as it runs on Windows, Macintosh OSX, and Linux operating systems. However, it is not built-in with WiFi module. Therefore, the WiFi shield ESP8266 is attached to the Arduino UNO board to support the WiFi module. Arduino IDE is used to write an upload programs to the Arduino board.

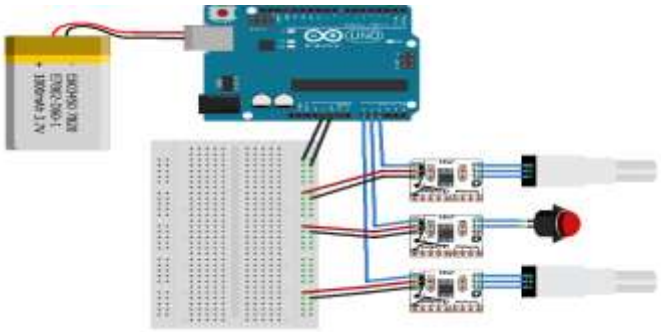

Figure 3 Schematic Diagram

pH sensor has been selected to be one of the three sensors because this sensor can determine the acidity or alkalinity of water. The acidity or alkalinity can be measured by measuring the hydrogen-ion activity of the solution. The normal range for pH of water is 6.5 to 8.5. Water with pH low than 6.5 is acidic to corrosive. The possible cause of this maybe due to leach metal and damage to metal piping.Turbidity sensor will measure the amount of light scattered inside the drinking water. Therefore, it can calculate the amount of suspended solid inside the water including sediment and algae. The normal range of turbidity is less than 4.0 NTU.Another sensor that will be used is the Oxidation Reduction Potential (ORP) sensor. ORP sensor will measure the degree whether the water is capable of oxidizing or reducing another substance. ORP is measured in millivolts (mV). ORP measures the cleanliness of the water and the ability to break down contaminants.Table 2, presents the normal range values for selected IoT sensors.

Table 2: Normal Range from Selected Sensor [8]

Sensors	Unit	DWQI Standards
Turbidity pH Oxidation Reduction Potential	*NTU* *U* *pH* *mV*	0 - 4 6.5 – 8.5 200-400

The values retrieved from Turbidity sensor and PH sensor are in analogue value. Therefore, a computation is needed for calculating the NTU of the Turbidity sensor and mV of the PH sensor using the following equations:

$$Turbidity\ NTU = (analogSensorValue/1023) \times 5 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$PhValue = analogSensorValue \times 5.0/1024/6 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

To do drinking water quality analysis, the quality of each water parameter value has to be defined. Each water parameter value is a good quality if its value falls under the normal range. The drinking water is in a good quality if all of the water parameter value from the three sensor is in a good condition.

4 Results and Discussion

The designed application is able to connect the Arduino board to the wireless connection. Once it is successfully connected to a wireless connection, it will display the IP Address. Then, the program will retrieve the water parameter value measured by the sensors. These values will be used to do water quality analysis to determine the level of water quality. Finally, the application will upload the results to the cloud system (Fig. 4).

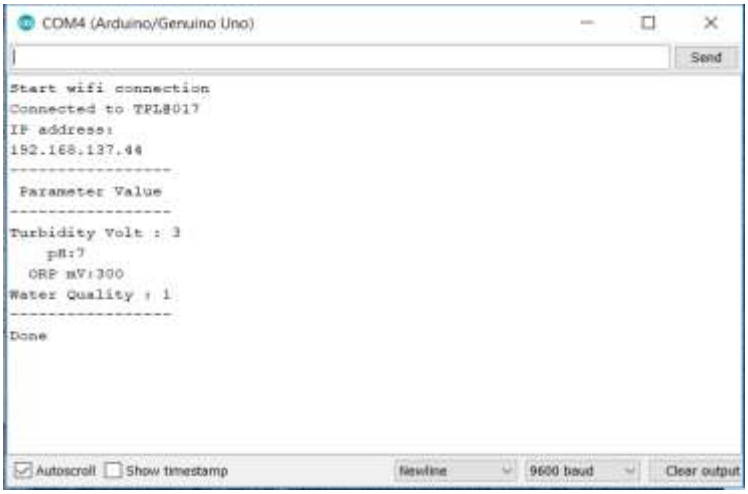

Figure 4 Output of Adruino IDE Serial Monitor

The list of water parameter value and the drinking water quality results are uploaded to the web server. Fig. 5 shows the output results from the web server. The mobile application will retrieve the value from the web server and display it to the user. The mobile application shows the list of water parameter value and a message that indicates whether the drinking water is drinkable or not (Fig. 6).

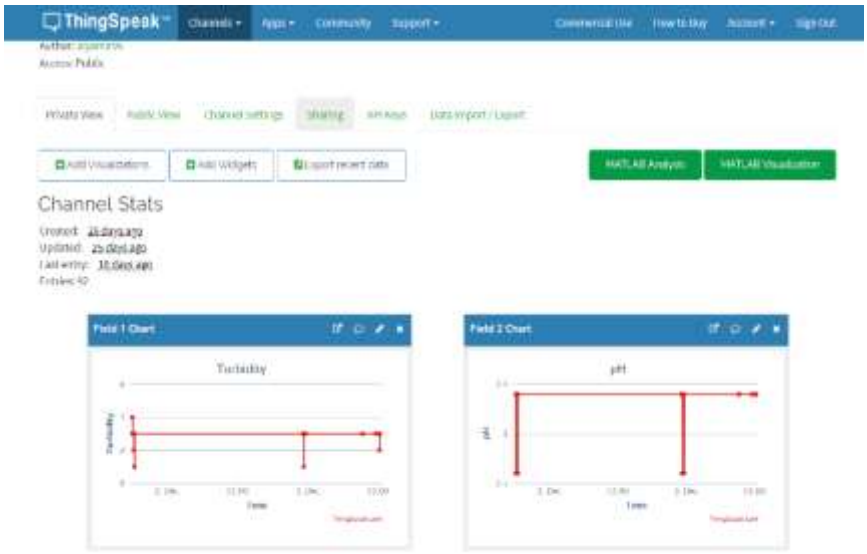

Figure 5 Web Server Interface

Figure 6 Mobile Application Interface

5 Conclusion

The design and development of drinking water quality monitoring in real-time is presented. The proposed systems were consisting of 3 different sensors, Arduino UNO and IoT module (ESP8266). The quality of drinking water will be evaluated based on the Drinking Water Quality Index (DWQI). A mobile or web application is used to analyse and display the water quality information to the user.

It is crucial to get the information of water content to avoid the consumption of low-quality drinking-water. Therefore, implementing IoT application in monitoring water quality may help people in getting water quality information in real time. The proposed system can replace the conventional method of performing water quality assessment. Internet of Thing (IoT) application in water quality monitoring may improve the management of water quality, thus reduce the risk of water borne disease.

For future development of this paper, more sensors will be implemented, and the paper scope will be widened. The end product will be distributed in a selected area to collect data of water quality. With this collection of data, data analytics can be done to find the quality of water supply in different area. Other parameter will be added and used to do more detailed water quality data analysis including the prediction of water quality.

When all this information is gathered, people can avoid the consumption of low drinking water quality. In other words, this future paper may help to prevent the problems before the problems happen. The result of water parameter analysis in the future paper will give a broader impact to the society.

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Biographies

A.N. Amir , Department of Computer and Information Sciences, Universiti Teknologi PETRONAS,Bandar Seri-Iskandar, Perak, Malaysia.

,H. Alhussian, Department of Computer and Information Sciences, Universiti Teknologi PETRONAS,Bandar Seri-Iskandar, Perak, Malaysia.

G. Hayder Institute of Energy Infrastructure (IEI), Universiti Tenaga Nasional (UNITEN), Kajang, Selangor Darul Ehsan, Malaysia.He I sworking in Department of Civil Engineering, College of Engineering, Universiti Tenaga Nasional (UNITEN), Kajang, Selangor Darul Ehsan, Malaysia.

S. Basri, Department of Computer and Information Sciences, Universiti Teknologi PETRONAS,Bandar Seri-Iskandar, Perak, Malaysia.

S. Jadid, Department of Computer and Information Sciences, Universiti Teknologi PETRONAS,Bandar Seri-Iskandar, Perak, Malaysia.