IoT- Based Design and Development Remote Drinking Water Quality Monitoring and Analysis System

Tarek S. Elhabian
High Institute for Computer & I.T, El- Shorouk Academy, Cairo, Egypt

tarekrdsc@hotmail.co.uk

ABSTRACT

Today, smart solutions are gaining more importance with the communication technology in all areas of life by governments. Especially if the issue is concerned with the health of citizens, and since drinking water is the most important requirement of life, so the great care of governments is to confirm the validity of drinking water, usually by using specific equipment where the water quality is tested on all characteristics such as minerals, temperature, etc. This process takes more time to complete for the selected sample. In this paper, the design implementation and development of a system for monitoring the quality of drinking water using Internet of Things (IoT) technology is presented and explained. The proposed system consists of several sensors to measure different variables such as pH value, turbidity in water, dissolved oxygen and, temperature and humidity. Also, a microcontroller unit (MCU) is connected with these sensors and further processing is done on the personal computer (PC). The data obtained is sent to the cloud using to the point of interest by Wi-Fi Module, can be viewed online using the Internet of Thing (IoT) technology and ThinkSpeak IoT-based application for water quality monitoring. The uniqueness of our proposed paper are obtain high frequency water control system, high mobility, was implemented, manufactured and tested in one of the localities and low power.

Keywords: *temperature, pH, turbidity, and dissolved oxygen, Arduino, Internet of Thing, ThingSpeak API*

1. INTRODUCTION

Water is one of the basic needs for human survival, and good quality water is critical in preventing the spread of water-borne diseases, as well as improving the quality of life. But due to the increase of environmental pollutants along with the lack of water resources, and the lack of law enforcement, the pollution rate of drinking water has increased, resulting in less availability of potable water. To ensure a safe supply of drinking water, quality control must be conducted in real time to enable rapid detection (and response) of cases with potentially serious consequences for human health. This made water utilities in most developed countries maximize online monitoring tools and early warning systems during all phases of the urban water cycle.

IoT is a revolutionary concept that has the potential to turn almost anything into intelligent. The expression "Internet of Things" was formally presented in 1998–1999 by Kevin Ashton of Automatic Identification center (Auto-Id) at Massachusetts Institute of Technology (MIT). Kevin recommended widely Web-associated RFID advancements can be utilized in supply chains to monitor things without human contribution [20]. Internet of Things (IoT) is the concept of connecting different devices to each other and to the internet to transmit thousands of bits of data and information. IoT is changing a great part of the world significantly; from the manner in which we drive to how we make buys, what is more, even how we get vitality to our homes. Complex sensors and chips are implanted around us.

How these devices share data and information and how we make use of them. The common platform of IoT is personal health. Different devices contact the IoT stage which arranges the data from various devices and offers assessment to give the most significant data to applications that address explicit industry needs. Creating applications for the IoT could be a difficult undertaking because of a few reasons; (I) the high multifaceted nature of circulated registering, (ii) the absence of general rules or systems that handle low level correspondence and improve high level execution, (iii) different programming languages, and (iv) different communication protocols.

It includes designers to deal with the framework and handle both programming and equipment layers alongside protecting all practical and non-useful programming prerequisites. This multifaceted nature has prompted a bad-tempered development regarding presenting IoT programming structures that handle the previously mentioned difficulties [21].

After some time, the IoT is depended upon to have huge home and business applications, to add to the individual fulfillment and to build up the world's economy. For example, smart homes will enable their occupants to normally open their garage while arriving at home, set up their espresso, control environment control systems, televisions and various machines. So as to comprehend this potential improvement, rising advances and progressions, and organization applications need to grow moderately to facilitate showcase solicitations and customer needs. Besides, devices ought to be made to fit customer essentials regarding openness wherever and at whatever point. Moreover, new shows are required for correspondence likeness between heterogeneous things (vehicles, living things, products, telephones, apparatuses, and so forth [2].

As the complexity of Internet of Things (IoT) systems increases, a large variety of tools and technologies for IoT management are making their way into both research setups and the market. IoT management arrangements must consider the asset confinements of implanted gadgets, as well as their heterogeneity and network dynamics. With these in mind, the Internet Engineering Task Force developed several standards targeting the joining and inter-operation of heterogeneous gadgets, for example, the Representational State Transfer Configuration Protocol (RESTCONF) or the Constrained Application Protocol (CoAP) Management Interface. Concurrently, the Open Mobile Alliance developed the Lightweight Machine-to-Machine protocol, for IoT device management.

The rest of the sections in this paper is organized as follows: section 2 details related work and literature review; section 3 explains the proposed system design and description; section 4 working scenario and results, section 5 conclusions; and finally, list of the references.

2. LITERATURE REVIEW

Many applications based on Wireless Sensor Networks (WSN) and IoT are for environmental monitoring of applications such as water quality monitoring [1, 2, 3, 4], and chemical water monitoring [5]. This WSN is suitable for environmental parameters in remote areas with lower cost and reduced manpower requirements [6]. It can be used to monitor water quality [1] which offers many advantages such as portability [7], near real-time data acquisition and the possibility of data recording [8]. It has gained popularity among the research community ranging from the environment [9] to the community of embedded systems [5].

An automated system and intelligent sensor introduced to monitor water quality and monitor water tank level and water pipe leakage based on an ultrasonic sensor, flow sensor, pH sensor, temperature sensor and IoT is represented by using the Labview software. This automation system is controlled using cell phones / laptops [10]. A ZigBee wireless network suggested to monitors the water level periodically and that has less power and behavior in real time along with Raspberry pi microcontroller and water level sensor are used to design the system [11, 12].

A system provided for continuous monitoring of water quality in remote locations using wireless sensor networks where parameter readings are sent to the remote monitoring station and displayed on a server computer with the help of MATLAB for comparison with standard values and send an SMS alert to the agent if it exceeds the threshold value [13]. A real-time IOT-based water quality monitoring system has been proposed. To transfer data to IOT, a gateway is created on Raspberry Pi using FTP [14].

A reconfigurable smart sensor interface introduced for the water quality monitoring system in the IoT environment. The intelligent monitoring system consists of a Field Programmable Gate Array design panel, sensors, Zigbee-based wireless communication module, and PC. The monitoring system is based on water pH, water level, turbidity, and carbon dioxide (CO2) on water surface and water temperature [15].

A model for detecting pipeline leakage by a computerized electronic system using pressure analysis, as a determinant of leakage in the pipe proposed. Compression data is obtained from simulation results using EPANET 2.0. To train the system detects the size and location of the leakage data with the pressure analysis obtained from EPANET using the neural network method [16]. A simpler energy efficiency solution provided for monitoring water quality inside pipes based on Internet of Things technology and analyzing the data uploaded online and gives an alert to the remote user, when water quality standards deviate from the predefined set of standard values [17].

In accordance with water quality standards of the Central Council for Pollution and Control (CPCB), New Delhi, India. Raspberry Pi microcontroller was used as a control platform for drinking water quality monitoring and GUI implementation to provide an interactive user interface for the end user for ease of operation using Python programming language to develop a GUI, data acquisition, and data analysis to make decisions to classify water quality in different categories [18].

Arduino microcontroller was used as a central processing system, SIM900A as the communication unit to send SMS service to the authenticated user to monitor water in remote location areas based on IoT technology and all sensors connected to the central processing system [19].

3. SYSTEM DESIGN and DESCRIPTION

The block diagram of proposed system is shown in Figure 1. The Arduino microcontroller will acquire the data from different sensors and then processes the data. The sensor data can be viewed by the proposed website and Android applications after it sanded to the corresponding authority via Wi-Fi module ESP8266 on the cloud using ThingSpeak App.

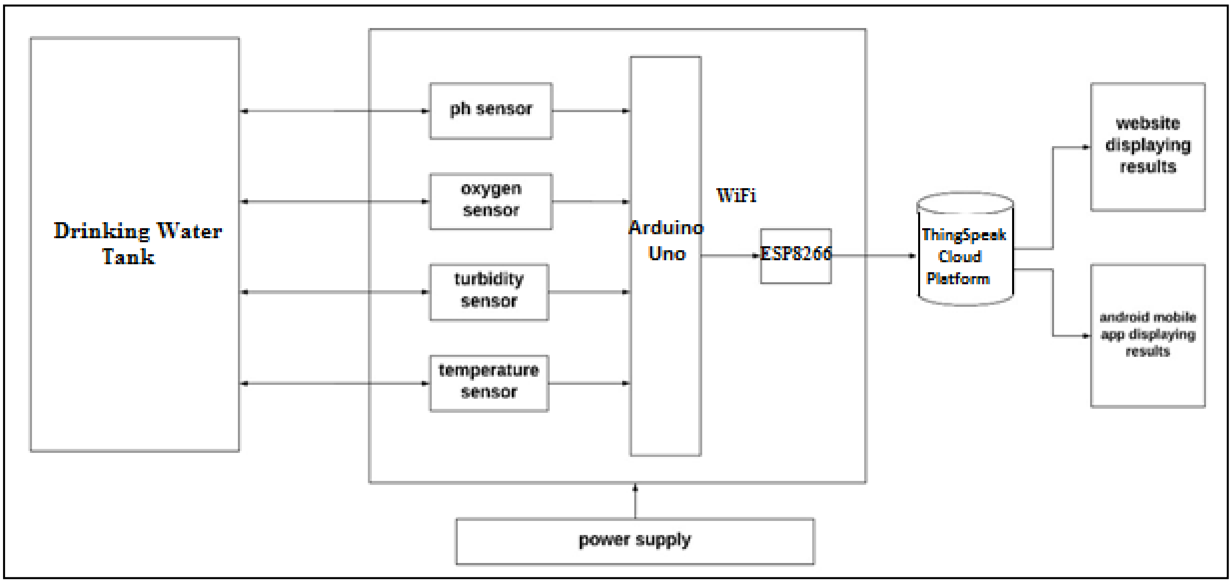


Figure 1: Proposed System Block Digram

NodeMCU Arduino Module: NodeMCU is Single-board microcontroller and an open source IoT platform. It includes firmware which runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module. The term "NodeMCU" by default refers to the firmware rather than the development kits. The firmware uses the Lua scripting language.

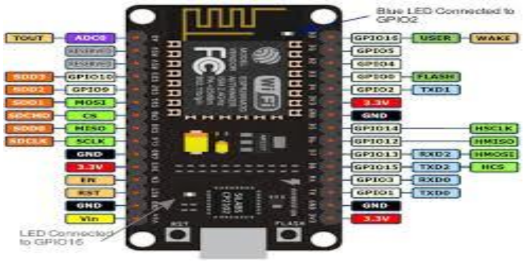


Figure 2: NodeMCU Arduino Module

ESP8266 WiFi module: The ESP8266 a micro-controller chip from Chinese manufacturer Espressif. Built around a Tensilica Xtensa LX3 processor, it includes on-board Wi-Fi. Originally intended as a UART to WiFi adaptor, allowing other micro-controllers to connect to a Wi-Fi network and make simple TCP/IP connections using Hayes-style commands, the ESP8266 quickly became popular as a stand-alone micro-controller because of its low price point.

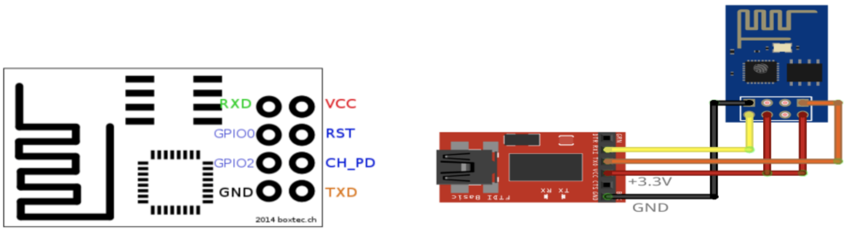


Figure 3: WiFi Module integration with Arduino

3.1 How did water quality are measured?

Water quality is assessed by measuring the physical and chemical parameters: Temperature, Turbidity, Dissolved Oxygen, and PH.

Analog pH sensor SEN0161: The pH is a measure of acidity or alkalinity of water and is measured on a scale from 1 to 14. If the water is not acid or alkaline, it is neutral and is expressed as a pH of 7. The water we drink from the tap is usually neutral. If the water in a stream is too acidic or too alkaline, it can kill all aquatic organisms.

Substance	pH approximate
Lemon juice	2,4 – 2,6
Cola drink	2,5
Vinegar	2,5 – 2,9
Orange or apple juice	3,5
Beer	4,5
Coffee	5,0
Tea	5,5
Milk	6,5
Water	7,0
Saliva	6,5 – 7,4
Blood	7,38 – 7,42
Seawater	8,0

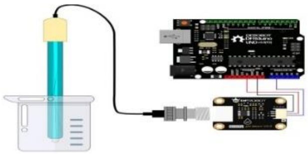


Figure 4: Ph sensor integration with Arduino

Temperature sensor DS18B20 Waterproof Digital: Water temperature is important for water quality because it is able to influence oxygen levels. Hot water cannot contain a large amount of oxygen but cold water can contain large amounts of oxygen. If the water is warm, it will promote plant growth. If conditions such as light, nutrients and flow are suitable for warm water, an alga is likely to bloom. All aquatic life depends on temperature.

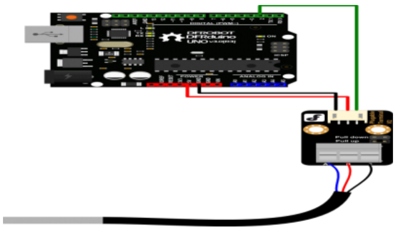


Figure 5: Tempreture sensor integration with Arduino

Turbidity sensor SEN0189: Turbidity measures how clear the water is, the greater the turbidity the dirtier the water. Turbid water looks cloudy or muddy and is caused by clay silt or organic particles being washed into the waterways. The sediment travels downstream and is deposited on the seabed, especially in times of flood. Sources of turbidity include eroding river banks, waste discharge or land disturbance such as grazing, road construction or housing developments.

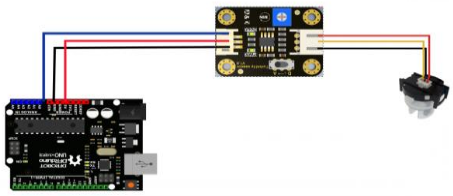


Figure 6: Turbidity sensor integration with Arduino

Dissolved Oxygen sensor SEN0237-A: Dissolved oxygen is the amount of dissolved oxygen gas in water and is necessary for all aquatic organisms, which is measured in milligrams per liter (mg/ l) and as a percentage of saturation (% sat). This percentage indicates the amount of oxygen saturation of water that can be retained by water at a given temperature. Many aquatic organisms will suffocate if there is not enough oxygen in the water.

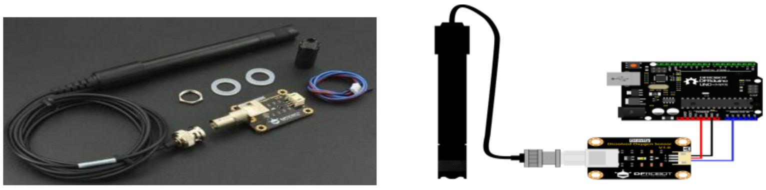


Figure 7: Dissolved Oxygen sensor integration with Arduino

3.2 Internet of Things and cloud

Internet of Things is ecology system of linked physical substance which is available through the internet. The “things‟ in IoT might be a human being with a heart monitor or a vehicle with built-in-sensors, i.e. substance that have been allotted with an Internet Protocol address and it has the skill to gather and move the data over a system without physical help or involvement. The embedded technology used in the substance makes them to work together with internal or external surroundings, which influence the results taken.

ThingSpeak Cloud Platform: ThingSpeak server is an open data platform and API for the Internet of Things that enables you to collect, store, analyze, visualize, and act on data from sensors. More about ThingSpeak can be read here. This article describes how to make standalone ThingSpeak server.

4. WORKING SCENARIO and RESULTS

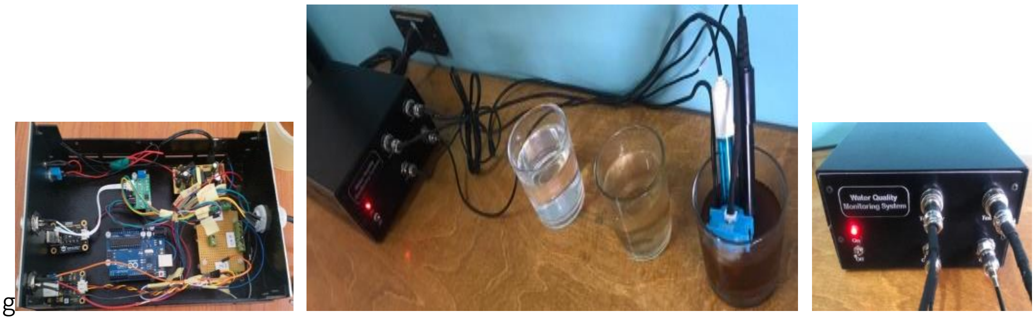
g 

Figure 8: Integration all components with casing and testing

Figure 8 shows the integration all components and casing and testing. Thus, the system's work sequence begins with the transmission of representative data captured by the four sensors to a microcontroller through the analog-to-digital converter. After processing, the digital information in the small control unit, where the water quality is determined without analyzing these parameters and sending it to the person who works with the device via cloud server.

The central monitoring system reads the measured value from cloud server on time. After performing the data retrieval process to know the sensor characteristics and sensors capability to detect the pH, Dissolved Oxygen and turbidity levels, obtained large data of sensor output voltage to change of turbidity level of water obtained by adding sediment to a number of water.

A quantity of raw water is simulated using 1- liter potable water mixed with sediment as a suspended substance in the water. The range of measuring instruments is from 0 until ±1000 NTU and examined from the water level of turbidity that can be drunk up to standard raw water source of 600 NTU. This is done so that this tool can monitor the turbidity of water in raw water treatment process. The study was conducted at the author's residence on Thursday, April 4, 2020 at the time of the study, the room thermometer showed a temperature of 26.4° C. by using drinking water as much as 1-liter and the mass of sediment which weighed using the mg scale will be obtained data of sediment concentration that exist in that water. And the data obtained in the study are as follows:

Based on the data received, the Company's authorities will take action to make further decisions. Through it, water quality will be controlled. Figure 9 shows samples of Website and android applications and the values presented for the various water quality standards.

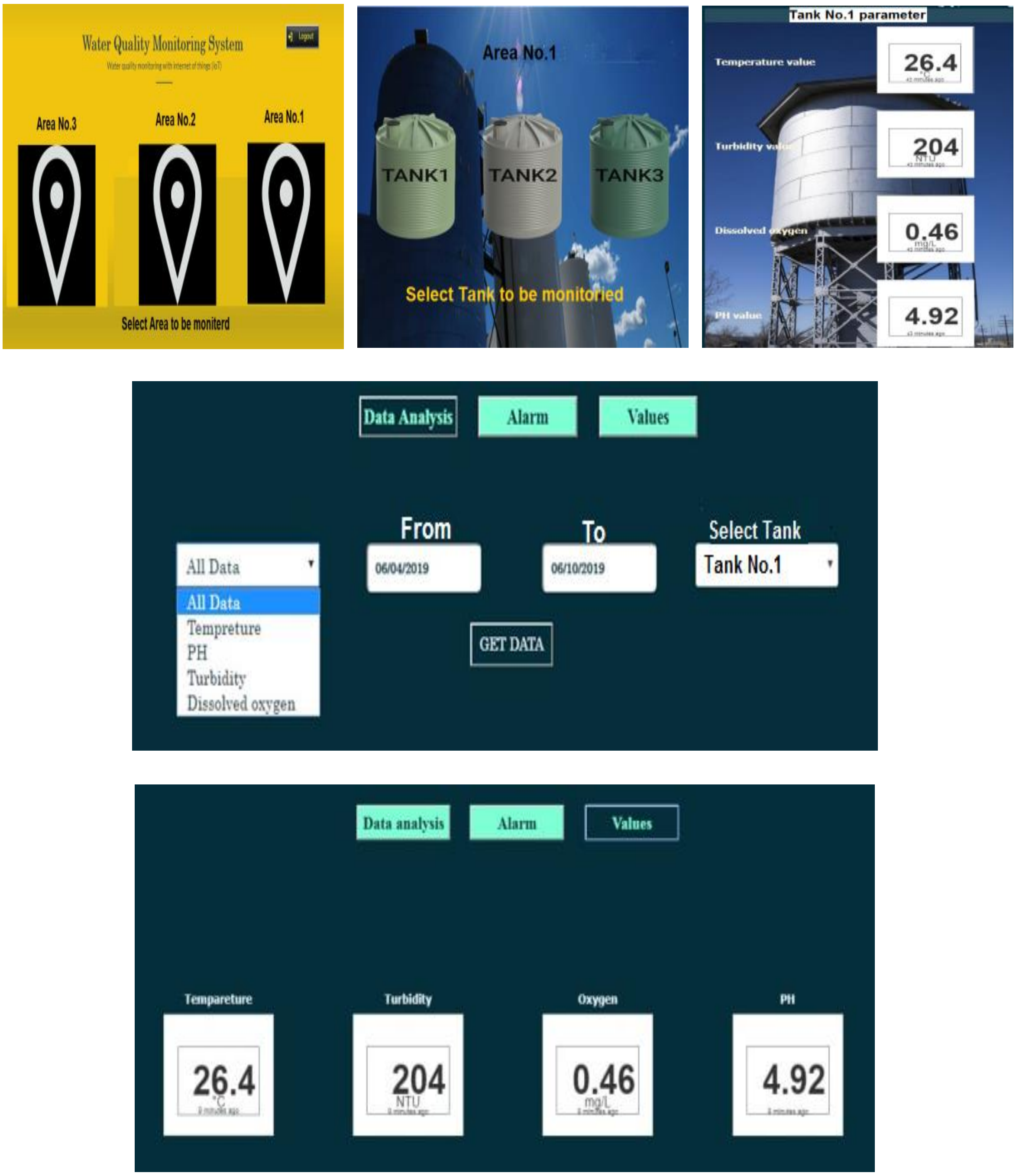


Figure 9: Measurement and analysis Website and Android Apps.

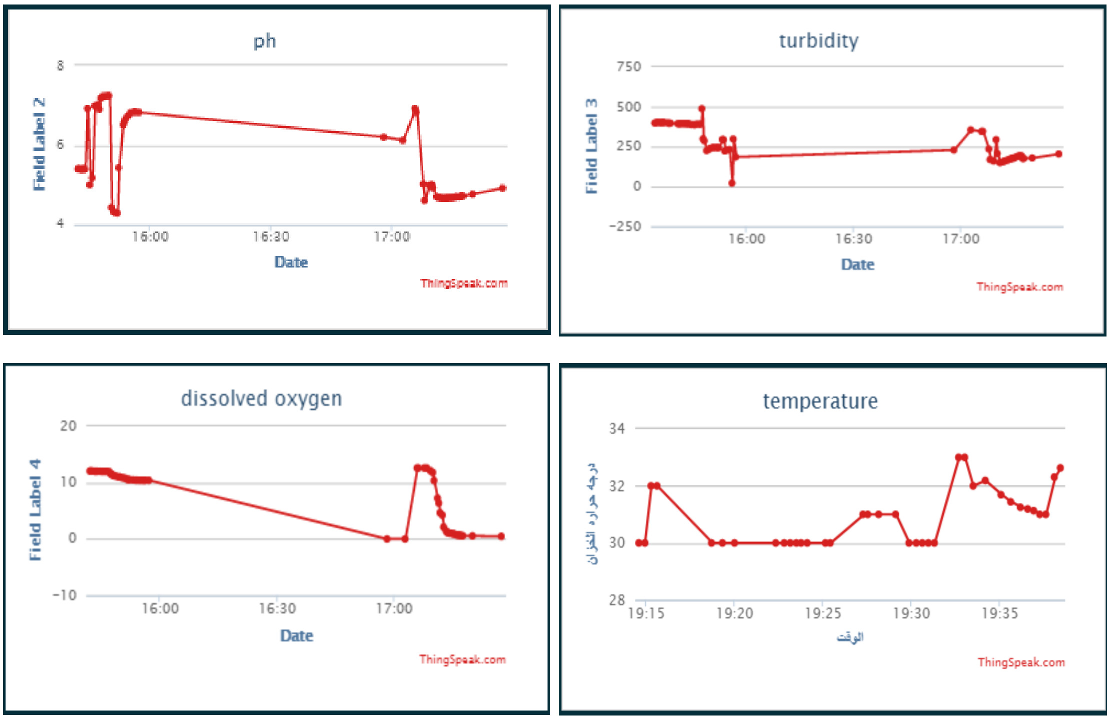


Figure 10: Measurement and Analysis of Ph, Turbidity, D.Oxygen and Tempreture

5. CONCLUTIONS

This study provides an automated water quality monitoring system that is low cost and does not require people on duty based on measured parameters such as pH, turbidity and dissolved oxygen temperature being monitored and tested in real time. It uses commercially available electrochemical sensors, the use of a lithium-ion battery for the power source and displays the result in the web using WSN and Internet of Things technology. It can display real-time results over the Internet, providing sufficient information on the true water quality scenario in the areas it covers. The main feature of the proposed system is the ease of installation and the possibility of placing it near the target area. So water quality testing is likely to be more economical, convenient and quick. This water system can be applied and used to homes, offices, schools, localities and anywhere water tanks are used. Its applicability is attributed to its long operation, flexibility and repeatability.

REFERENCES

[1] Chung WY, Yoo JH. Remote water quality monitoring in wide area. Sensor Actuat B Chem. 2015;217:51–7.

[2] Alippi C, Camplani R, Galperti C, Roveri M. A robust, adaptive, solar-powered WSN framework for aquatic environmental monitoring. IEEE Sensors J. 2011;11:45–55.

[3] Kumar RK, Mohan M, Vengateshapandiyan S, Kumar MM, Eswaran R. Solar based advanced water quality monitoring system using wireless sensor network. Int J Sci Eng Technol Res. 2014;3:385–9.

[4] Faustine A, Mvuma AN, Mongi HJ, Gabriel MC, Tenge AJ, Kucel SB. Wireless sensor networks for water quality monitoring and control within Lake Victoria Basin: prototype development. Wirel Sens Netw. 2014;6:281–90.

[5] Hayes J, Beirne S, Lau KT, Diamond D. Evaluation of a low cost wireless chemical sensor network for environmental monitoring. In: IEEE SENSORS 2008. Lecce; 2008 Oct 26-29.

[6] De Marziani C, Alcoleas R, Colombo F, Costa N, Pujana F, Colombo A, et al. A low cost reconfigurable sensor network for coastal monitoring. In: OCEANS 2011 IEEE. Santander; 2011 Jun 6-9.
[7] Rashid B, Rehmani MH. Applications of wireless sensor networks for urban areas: a survey. J Netw Comput Appl. 2016;60:192–219.
[8] Can Z, Demirbas M. Smartphone-based data collection from wireless sensor networks in an urban environment. J Netw Comput Appl. 2015;58:208–16.
[9] Bromage M, Obraczka K, Potts D. SEA-LABS: a wireless sensor network for sustained monitoring of coral reefs. In: Akyildiz IF, Sivakumar R, Ekici E, Oliveira JC, McNair J, editors. Networking 2007. Ad hoc and sensor networks, wireless networks, next generation internet. Berlin and Heidelberg: Springer; 2007. p. 1132–5.
[10] M.B.Kawarkhe1,Sanjay Agrawal, "Smart Water Monitoring System Using IOT at Home", OSR Journal of Computer Engineering (IOSR-JCE) e-ISSN: 2278-0661,p-ISSN: 2278-8727, Volume 21, Issue 1, Ser. II (Jan -Feb 2019), PP 14-19www.iosrjournals.org
[11] J. Navarajan, B. Aswin kumar, S. venkatesh , T. jayachandran,"Detection of Water Pollution and Water Management Using Smart Sensors with IOT", International Research Journal of Engineering and Technology (IRJET)Volume: 04 Issue: 04 | Apr -2017.
[12] Bhad Vidya, Kale Poonam, Gavhale Priyanka, Darekar Gaurav, Prof A.S Chandgude,"Water Level Monitoring SystemIn Real Time Mode Using WSN",International Journal of Emerging Technology and Advanced Engineering(ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 6, Issue 9, September 2016
[13] Mithila Barabde, Shruti Danve,"Real Time Water Quality Monitoring System",International Journal of Innovative Research in Computer and Communication EngineeringVol. 3, Issue 6, June 2015
[14] jayti bhatt, jignesh patoliya ,"IoTbased water quality monitoring system",International Journal Of Industrial Electronics And Electrical EngineeringVolume-4, Issue-4, Apr.-2016
[15] Cho Zin Myint*, Lenin Gopal*, and Yan Lin Aung,"Reconfigurable Smart Water Quality Monitoring System in IoT Environmet",ACIS 16th International Conference on Computer and Information Science (ICIS), IEEE xplore, ISBN:978-1-5090-5507-4.
[16] A Ejah Umraeni Salam, Muh.Tola1, Mary Selintung and Farouk Maricar,"On-Line Monitoring System Of Water Leakage Detection In Pipe Networks With Artificial Intelligence",ARPN Journal of Engineering and Applied SciencesVOL. 9, NO. 10, OCTOBER 2014.
[17] S. Geetha and S. Gouthami ,"Internet of things enabled real time water quality monitoring system",Department ofElectrical and Electronics Engineering",(2016) 2: 1. https://doi.org/10.1186/s40713-017-0005-y.
[18] Punit Khatri1, Karunesh Kumar Gupta1, and Raj Kumar Gupta2, "Raspberry Pi-based smart sensing platform for drinking-water quality monitoring system: a Python framework approach ", Drink. Water Eng. Sci., 12, 31–37, 2019.
[19] P. Gopi krishna, Panchumarthi Harish, K. Krishna Veni, Gangisetti Sai Kumar, J Raja Sekhar, "Design and Development of Remote Location Water Quality Monitoring System using IoT " , International Journal of Recent Technology and Engineering (IJRTE)ISSN: 2277-3878, Volume-7, Issue-6, March 2019.
[20] Dasgupta, A. Q. Gill and F. Hussain, "Privacy of IoT-Enabled Smart Home Systems", Open access peer-reviewed chapter, February 20th 2019, DOI: 10.5772/intechopen.84338.
[21] M. Ammar, G. Russello, B. Crispo, "Interent of Things: A Survey on the Security of IoT framework", Journal of Information Security and Applications 38 (2018) 8–27.