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Research Article

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Benefits of Water Quality Monitoring

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Abstract

One of the most significant factors affecting human life is water quality. Water quality tests must typically be performed on-site. There will be a need for multiple test locations if the area to be explored is large. Repeated water quality assessments will be difficult and time-consuming. So, in order to safeguard the water and keep track of its condition in order to prevent contamination, a real-time monitoring system is necessary. The water quality is monitored and shown using environmental sensors, LoRa technology, and the Node-RED application. According to the area in need of analysis, it involves the measurement and gathering of data on variables impacting water quality, such as temperature, electric conductivity, pH, air quality, and turbidity. The sensor data is processed by the microcontroller used in the research before being sent over the wireless network to the database, where it is shown on the Node-RED dashboard. The IoT-based monitoring system can also provide a Node-RED dashboard and monitor water quality in real-time.

Keywords: Water Quality, Internet of Things, LoRa Technology.

1. Introduction

An essential natural resource for human consumption is water. There are about 326 million trillion gallons of water on Earth. Less than 3% of the world's water is freshwater, and more than two-thirds of that percentage is frozen in glaciers and ice caps. Even though it is a plentiful natural resource, only 0.04% of it may be utilized [1-3]. The two main categories of freshwater sources are surface water sources, such as rivers, canals, waterfalls, dams, and reservoirs, and groundwater sources. In addition, due to waste generation and chemical leaks, industrial and agricultural operations are expanding quickly and have a substantial impact on environmental contaminants. Making sure that water resources are safe and usable is essential. The world is experiencing issues with water demand and contamination as a result of growing globalization. To prevent any quality issues brought on by water intake from diverse activities, water quality must be paid close attention. Three categories can be made for water quality parameters. Physical properties such as conductivity, turbidity, chromaticity, temperature, smell, and color are included in the first category. Chemical characteristics such as pH, dissolved oxygen, chemical oxygen demand (COD), biochemical oxygen demand (BOD), total organic carbon, heavy metal ions, and nonmetallic toxins are included in the second group.

All bacteria and coliforms fall within the microbiological category, which is the third category [4]. Water samples must be manually collected from various locations in order to be tested for quality, which is a tedious and time-consuming process. Researchers are therefore interested in evaluating water quality utilizing Internet of Things (IoT) technology, which is a novel strategy nowadays. The term "IoT" describes network-connected devices as well as, more recently, the value chain that results from the connection of things, data, people, and services. Since they are all accumulator-powered, the sensors and other IoT devices need to be connected to the network [5,6]. The IoT currently significantly contributes to data monitoring, recording, storing, and displaying in addition to communication. IoT systems open up new possibilities for finding resources that are economical [7]. Recent years have seen an increase in the application of IoT technology to solve environmental problems such air quality, water pollution, and radiation contamination [8-10]. Recent studies indicate that they have made use of IoT technology to enable real-time monitoring in order to streamline operations and regulate water quality more effectively. In addition, LoRa and Low Power Wide Area Network (LPWAN) technologies are well-liked network protocols in Internet of Things (IoT) systems because of their flexible and reliable technical traits, as well as their capacity to achieve long communication ranges with low power, low cost, and high data rates when implemented in systems [11-14]. However, zoning or national considerations are necessary for the deployment of LoRa technology. This is due to the necessity that LoRa devices be used at the designated frequencies in each nation [15]. Finally, users must comprehend LoRa technology's operation in order to apply roller technology. This is a useful manual for selecting the appropriate equipment. Therefore, the primary goal of this study was to design and evaluate the effectiveness of a water quality monitoring system that was installed on a robot (boat) for community use and used IoT sensors to measure water quality parameters like temperature, electric conductivity, pH, air quality, and turbidity with LoRa wireless communication. Information on water quality was also shown using Node-RED technology.

2. Methodology

Physical elements, technical network setup and configuration, operational protocols, and data formats make up the IoT architecture, which is a framework. IoT architecture implementation may look very diverse. Open protocols must therefore be adaptable enough to handle a wide range of network applications. The three-layer design is the most typical and widely accepted structure. It was utilized in the early stages of this IoT investigation. Perception, network, and application are the three layers that are mentioned [16]. A microcontroller board at the perception layer connects sensors to the network layer. In this study, the scientists created a sensor monitoring system using a microcontroller board that collects data on temperature, conductivity, pH, turbidity, and air quality and sends it using LoRa technology. Communication between devices is possible using LoRa technology. The microcontroller board receives the data and processes it [17]. The Node-RED application, which users can access from their laptops, displays all of the sensor readings. A series of wide-area communication technologies with improved obstacle penetration and greater signal propagation range are together referred to as LoRa (Long Range). It can be used for transmission-related purposes and operates without a license in the radio frequency bands at a frequency below 1 GHz (920–925 MHz in Thailand). When employed in difficult settings, LoRa can enable long-range broadcasts of more than 10 km in open-area testing. Transmission is limited to a radius of less than 1 km. The doppler effect, which impacts signal reception, and comparable speeds were taken into consideration in the study's analysis of LoRa performance [18]. It came to the conclusion that, depending on the hardware configuration selected, the communication might not function. It also carried out coverage of both land and water. Two types of LoRa technology are in use: LoRa and Lora WAN. LoRa will be utilized in a frequency band without a license in this instance. Point-to-point communication will be the main focus between each LoRa active node. The service range is constrained, however with Lora WAN, the LoRa node can interact with the remote end node via the LoRa gateway, allowing the network to provide long-distance communications similar to those of a WAN network [4,19]. Additionally, media access control protocol (MAC), which is the top layer of the physical layer, is used for Lora WAN communication. 433 MHz, 868 MHz in Europe, and 915 MHz in North America are the three most frequently utilized frequency bands. [20-22].

The fundamental idea behind this study is the use of sensors to gauge water quality metrics and the wireless transmission of that data using LoRa technology. There are two components to it: a transmitter and a receiver. The transmitter is made up of sensors that gather information about water quality metrics from water sources and a TTGO LoRa32 development board. The TTGO LoRa32's LoRa communication feature is used to transmit the collected data to the receiver, who then receives the water quality data and presents it on a Node-RED application. A microcontroller called the TTGO T-Beam ESP32 integrates all IoT sensors in a network to track environmental variables. The EPS32 microcontroller enables GPS connectivity and uses LoRa modules to operate in the 868/915 MHz band. Prior to providing the sensor data to the application layer, this component will be in charge of sending, receiving, and processing the data.

With a temperature precision of 0.5 °C, the temperature sensor (DS18B20 Arduino) is used to measure the coldness or heat of the water in degrees Celsius (°C). The operational temperature range (with an accuracy of -10 to 85 °C) is -55 to 125 °C. A thermometer was used to calibrate the temperature sensor at various temperatures. According to the test findings, the temperature sensor's accuracy was 94.05%. When determining whether a given supply of water is suitable for human consumption and use, water temperature is vital. For many aquatic creatures, it also has an impact on oxygen. The World Health Organization (WHO) advises keeping the water between 20 and 30 °C [23]. A tool for determining a liquid's electrical conductivity, or the total dissolved solids (TDS) in water, is a total dissolved solids (TDS) sensor. Micro-Siemens per centimeter of water (S/cm) units are used to measure conductivity, which is the ability of water to conduct electricity due to the presence of dissolved inorganic chemicals. Water conductivity's impact on aquatic animals' ability to survive and reproduce High conductivity values could result in conflict and other unfavorable effects [24]. In order to preserve the quality of water, it is crucial to assess electrical conductivity. The TDS sensor utilized in this investigation has an accuracy of 10% of the entire scale and a measuring range of 0-1000 ppm.

The pH sensor, also known as an analog pH meter, is a device that assesses the acidity and alkalinity of water as well as the pH of any solution. Numerous applications, such as aquaponics, aquaculture, and environmental water testing, make extensive use of it. The pH sensor is typically built to output a value between 0 and 14 based on the negative logarithm of the hydrogen-ion concentration. pH is defined mathematically as pH = -log [H+]. In this situation, the appropriate pH range for intake is between 6.0 and 8.5, which is within the normal pH range of human life [4], [22]. The pH sensor in this investigation was calibrated using a pH meter. (Mettler Toledo S210). The electronic pH measurement probe's accuracy is calibrated using the pH calibration powder. According to the test results, the pH sensor has a 96.95% accuracy rate. The turbidity sensor is utilized to gauge the water's level of turbidity. In order to locate suspended particles in water, it examines the light's transmittance and scattering rate. Depending on the total suspended solids' quality, this rate varies. (TSS). The range of 0.1-1000 Nephelometric Turbidity Units is considered to be the most typical range of water turbidity measurements. (NTU). Turbidity in river water might reach 150 NTU [7,25]. The sensor used in this study measures the light that is refracted in water and converts it to an analog output turbidity value of 0-4.5 volts with a 500 ms measurement accuracy. Volts were used to compare turbidity to 0-1000 NTU. Standard values were used to calibrate the turbidity sensor. The instrument's accuracy was discovered to be 91.03%. Using the principle of resistance change when absorbing gases, the air quality sensor (MQ-135 gas sensor) is one of the MQ Series sensors used to monitor the air quality and detect or measure nitrogen oxides, ammonia, carbon dioxide, benzene, alcohol, smoke, and other gases in the air. Tin oxide sensing layer, heating coil, and ceramic tube made of aluminum oxide, Al2O3, make up the sensor. The analog TTL requires 5 volts to operate, making it compatible with the majority of microcontrollers [26]. Application programming interfaces (APIs), hardware components, and internet services can all be integrated with Node-RED.

It enables more flexible working for developers by allowing them to connect devices to APIs through a configurable web browser. It is advised to install Node-RED on personal PCs to maintain the platform's security and privacy. The graphical user interface of this application makes it very well-liked [27]. Additionally, it is a potent tool for creating visual programming-based IoT applications. The Node-RED dashboard library is used in the current study with the intention of adding gauges, charts, serial ports, functions, and switches and using them to show data from sensor information. To monitor the quality of water resources, a wireless electric boat-based prototype of a mobile water quality collector has been created. The dimensions of the fuel cell employed in this study are 280 mm in width, 175 mm in height, and 880 mm in length. The mobile collector was equipped with every sensor needed to measure the water quality using LoRa technology (TTGO T-Beam ESP32 microcontroller). By using LoRa to transmit meter reading instructions and data, the mobile collector is used to keep an eye on water meters and gauge the condition of equipment. An IoT-based Smart Water Quality Monitoring (SWQM) system that facilitates improved water quality measurement has been created by the authors. on the temperature, conductivity, pH, turbidity, and air quality, which are the five components of water quality.

3. Results and Dialogue

In this work, the author uses IoT technology to track various water quality indicators, including temperature, turbidity, electric conductivity, pH, and air quality. The system uses a TTGO T-Beam as a controller, a temperature sensor (DS18B20), a conductivity sensor (TDS), a turbidity sensor (turbidity), a pH meter (pH), and an air quality sensor (MQ-135 gas sensor) [28]. Using LoRa for data transmission and a computer to display the Node-RED dashboard. To overcome the limitations of conventional water quality monitoring systems, the data of water quality is displayed on the Node-RED dashboard every 1 second for those different parameters and can be automatically uploaded to the Node-RED dashboard as real-time monitoring information [29].

4. The Goal and Benefits of Water Quality Monitoring

1. Finding specific contaminants, a particular chemical, and the source of the pollution is made easier with the aid of water quality monitoring. Agricultural activities (such as the use of pesticides and fertilizer), oil pollution, river and marine dumping, port, shipping, and industrial activity are a few of the numerous sources of water pollution. Other sources include sewage effluent and agricultural practices. Regular water quality assessments and monitoring serve as a source of information for locating current problems and their causes.

2. Recognizing both short- and long-term water quality patterns. Data gathered over time will reveal trends, such as identifying rising nitrogen pollution concentrations in a river or other inland waterway. Key water quality parameters will then be identified using the complete data.

3. Managing and preventing water contamination as part of environmental planning.
For the creation of a sound and successful water quality strategy, data collection, interpretation, and use are crucial. However, the creation of plans will be hampered and the influence on pollution management would be constrained in the lack of real-time data. The answer to this problem is to use digital systems and tools for data collecting and administration.

4. Compliance with international standards.
On land and at sea, monitoring water quality is a problem and a concern on a global scale. The European Green Deal publishes many directives to establish standards of water quality and lays forth objectives for restoring biological variety and lowering water pollution within the European Union. Additionally, distinct legislative frameworks in each nation state, such as France,

mandate effective water quality monitoring. The Environmental Protection Agency (EPA) in the US enforces laws to combat water contamination in every state. Countries all around the world are becoming more aware of the significance of efficient water quality monitoring metrics and techniques.

5. In emergencies, water quality monitoring is a necessity. Examples include significant oil spills from tankers or flooding brought on by too much rainwater runoff. When an emergency arises, quick response is essential, necessitating access to real-time data to determine how pollution levels affect water quality [30].

5. Conclusion

Designing and analyzing the performance of a system for monitoring water quality based on IoT and LoRa technology with the Node-RED application for the design and component architecture, as well as assessing how the system was implemented, were the goals of the research. It is a measurement and data gathering of water quality characteristics like temperature, electric conductivity, pH, air quality, and turbidity, depending on the area that needs analysis to have been done. The TTGO LoRa32 microcontroller processes the sensor data before sending it across the wireless network to the database, where the Node-RED dashboard displays it. The experiment's findings showed that a distance operation of 2.0 km could be used to send and receive data in regions with obstacles to LoRa technology, with a signal transmission efficiency of more than 95.50% of our 600 data sets over a distance of 2.0 km, which will decrease the amount of storage over longer distances. Additionally, the IoT-based monitoring system can provide a Node-RED dashboard and measure water quality in real-time. It was discovered that the usability testing was more practical and time-effective. This method is compatible with cutting-edge strategies like the smart city. As a result, a real-time monitoring system will become more and more in demand. Future efforts will concentrate on integrating the BOD/COD sensor into the system and developing a new LoRa antenna to enhance signal transmission [31,32].

References

1. Shafi, U., Mumtaz, R., Anwar, H., Qamar, A. M., & Khurshid, H. (2018, October). Surface water pollution detection using internet of things. In 2018 15th international conference on smart cities: improving quality of life using ICT & IoT (HONET-ICT) (pp. 92-96). IEEE.
2. Gunther, M. Water as a Natural Resource—The Blue Planet.
3. Baballe, M. A., Muhammad, A. S., Usman, F. A., Mustapha, N. A. K., Naisa, A. H. K., & Shehu, A. K. (2022). A Review of an Automatic Water Level Indicator.
4. AlMetwally, S. A. H., Hassan, M. K., & Mourad, M. H. (2020). Real time internet of things (IoT) based water quality management system. Procedia CIRP, 91, 478-485.
5. Ahmad, M. B., Abdullahi, A. A., Muhammad, A. S., Saleh, Y. B., & Usman, U. B. (2019). The Various Types of sensors used in the Security Alarm system. International Journal of New Computer Architectures and their Applications (IJNCAA), 9(2), 50-59.
6. Çavaş, M., & Ahmad, M. B. (2019). A review advancement of security alarm system using internet of things (IoT). International Journal of New Computer Architectures and their Applications (IJNCAA), 9(2), 38-49.
7. Rukhiran, M., & Netinant, P. (2020). IoT Architecture based on Information Flow Diagram for Vermiculture Smart Farming Kit. TEM Journal, 9(4), 1330.
8. Devalal, S., & Karthikeyan, A. (2018, March). LoRa technology-an overview. In 2018 second international conference on electronics, communication and aerospace technology (ICECA) (pp. 284-290). IEEE.
9. Ullo, S. L., & Sinha, G. R. (2020). Advances in smart environment monitoring systems using IoT and sensors. Sensors, 20(11), 3113.
10. Sabari, M., Aswinth, P., Karthik, T., & Kumar, B. (2020, March). Water quality monitoring system based on IoT. In 2020 5th International Conference on Devices, Circuits and Systems (ICDCS) (pp. 279-282). IEEE.
11. Chowdury, M. S. U., Emran, T. B., Ghosh, S., Pathak, A., Alam, M. M., Absar, N., ... & Hossain, M. S. (2019). IoT based real-time river water quality monitoring system. Procedia Computer Science, 155, 161-168.
12. Mukhamadiev, S., Rogozhnikov, E., & Dmitriyev, E. (2022). Compensation of the Frequency Offset in Communication Systems with LoRa Modulation. Symmetry, 14(4), 747.
13. Gkotsiopoulos, P., Zorbas, D., & Douligeris, C. (2021). Performance determinants in LoRa networks: A literature review. IEEE Communications Surveys & Tutorials, 23(3), 1721-1758.
14. Radhakrishnan, V., & Wu, W. (2018, June). IoT technology for smart water system. In 2018 IEEE 20th International Conference on High Performance Computing and Communications; IEEE 16th International Conference on Smart City; IEEE 4th International Conference on Data Science and Systems (HPCC/SmartCity/DSS) (pp. 1491-1496). IEEE.
15. Gambiroža, J. Č., Mastelić, T., Šolić, P., & Čagalj, M. (2019, June). Capacity in LoRaWAN networks: Challenges and opportunities. In 2019 4th International Conference on Smart and Sustainable Technologies (SpliTech) (pp. 1-6). IEEE.
16. Abdmeziem, M. R., Tandjaoui, D., & Romdhani, I. (2016). Architecting the internet of things: state of the art. Robots and Sensor Clouds, 55-75.
17. Rukhiran, M., Netinant, P., & Elrad, T. (2020). Effecting of environmental conditions to accuracy rates of face recognition based on IoT solution. Journal of Current Science and Technology, 10(1), 21-33.
18. Torres, A. P. A., Da Silva, C. B., & Tertuliano Filho, H. (2021). An experimental study on the use of LoRa technology in vehicle communication. IEEE Access, 9, 26633-26640.
19. Kadhim, K. T., Alsahlany, A. M., Wadi, S. M., & Kadhum, H. T. (2020). An overview of patient's health status monitoring system based on internet of things (IoT). Wireless Personal Communications, 114(3), 2235-2262.
20. Zourmand, A., Hing, A. L. K., Hung, C. W., & AbdulRehman, M. (2019, June). Internet of things (IoT) using LoRa

technology. In 2019 IEEE International Conference on Automatic Control and Intelligent Systems (I2CACIS) (pp. 324-330). IEEE.
21. Khutsoane, O., Isong, B., & Abu-Mahfouz, A. M. (2017, October). IoT devices and applications based on LoRa/ LoRaWAN. In IECON 2017-43rd Annual Conference of the IEEE Industrial Electronics Society (pp. 6107-6112). IEEE.
22. Zhou, Q., Zheng, K., Hou, L., Xing, J., & Xu, R. (2019). Design and implementation of open LoRa for IoT. Ieee Access, 7, 100649-100657.
23. Hasan, M. K., Shahriar, A., & Jim, K. U. (2019). Water pollution in Bangladesh and its impact on public health. Heliyon, 5(8), e02145.
24. Mathur, A. (2014). Conductivity: Water Quality Assesment. International Journal of Engineering Research & Technology (IJERT), 3(3), 1-3.
25. Schwalfenberg, G. K. (2012). The alkaline diet: is there evidence that an alkaline pH diet benefits health?. Journal of environmental and public health, 2012.
26. Abbas, F. N., Saadoon, I. M., Abdalrdha, Z. K., & Abud, E. N. (2020). Capable of gas sensor MQ-135 to monitor the air quality with Arduino Uno. Int. J. Eng. Res. Technol, 13(10), 2955-2959.
27. Lekić, M., & Gardašević, G. (2018, March). IoT sensor integration to Node-RED platform. In 2018 17th International Symposium Infoteh-Jahorina (Infoteh) (pp. 1-5). IEEE.
28. Baballe, M. A., & Bello, M. I. (2022). Gas leakage detection system with alarming system. Review of Computer Engineering Research, 9(1), 30-43.
29. Promput, S., Maithomklang, S., & Panya-isara, C. (2023). Design and Analysis Performance of IoT-Based Water Quality Monitoring System using LoRa Technology. network, 3, 16.
30. https://sinay.ai/en/why-monitoring-water-quality-is-important/#:~:text=Why%20is%20it%20important%20to,to%20not%20harm%20sea%20life.
31. Salika, F., Nasser, A., Mroue, M., Parrein, B., & Mansour, A. (2022). LoRaCog: A Protocol for Cognitive Radio-Based LoRa Network. Sensors, 22(10), 3885.
32. Metzger, M., Konrad, A., Blendinger, F., Modler, A., Meixner, A. J., Bucher, V., & Brecht, M. (2018). Low-cost GRIN-Lens-based nephelometric turbidity sensing in the range of 0.1–1000 NTU. Sensors, 18(4), 1115.