Iris Journal of Astronomy and Satellite Communications

Iris Publishers

Research Article

Review of the Goals and Benefits of Monitoring Water Quality

Auwal Rabiu Dansharif[1], Zainab Abdulkadir[2], Suleiman Bashir Abubakar[3], Amina Ibrahim[4], Ibrahim Umar[5] and Muhammad Ahmad Baballe[6*]

[1]*Lecturer, Department of Electrical and Electronics Technology, Kano State Polytechnic, School of Technology, Kano, Nigeria*

[2]*Lecturer, Department of Computer Science, School of Technology, Kano State Polytechnic, Nigeria*

[3]*Lecturer, Jigawa State Institute of Information Technology, Informatics Kazaure, Nigeria*

[4]*Lecturer, Department of Computer Science, School of Technology, Kano State Polytechnic, Nigeria*

[5]*Lecturer, Department of Building Technology, School of Enviromental Studies Gwarzo, Kano State Polytechnic, Kano, Nigeria*

[6]*Lecturer, Department of Computer Engineering Technology, School of Technology, Kano State Polytechnic, Kano, Nigeria*

***Corresponding author:** Muhammad Ahmad Baballe, Department of Computer Engineering Technology, School of Technology, Kano State Polytechnic, Kano, Nigeria.

Received Date: June 19, 2023

Published Date: June 29, 2023

Abstract

Water quality is one of the most important variables affecting human life. Tests of the water's purity must normally be done on the spot. If the area to be explored is large, it will be necessary to conduct tests at various sites. Repeated evaluations of the water quality will be challenging and time-consuming. Therefore, a real-time monitoring system is required to protect the water and monitor its state in order to prevent contamination. The water quality is monitored and shown using environmental sensors, LoRa technology (Long Range) refers to a group of wide-area communication technologies that have better obstacle occlusion and longer signal propagation distances, and the Node-RED application. It entails the monitoring and collection of information on elements that have an impact on water quality, including climate, conductivity of electricity, pH, air pollution, and turbidity. The microcontroller utilized in the study processes the sensor data before sending it wirelessly to the database structure, where it can be seen on the Node-RED display the Node-RED dashboard and real-time water quality monitoring are both features of the IoT-based monitoring system.

Keywords: Water quality; Internet of things; LoRa technology

Introduction

An essential natural resource for human consumption is water. The amount of water on Earth is roughly 326 million trillion gallons. Less than 3% of the world's water supply is freshwater, and more than two-thirds of that amount is frozen in icebergs and glacier crowns. Even though it is a plentiful natural resource, only 0.04% of it may be utilized [1, 2]. 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. The first group includes physical characteristics like electrical conductivity, turbidity, chromaticity, warmth, smell, and color. The second group of chemical properties includes elements like pH, oxygen that is dissolved, chemical demand oxygen (COD), biochemical oxygen demand (BOD), complete carbon inorganic, ions of heavy metals, and nonmetallic toxins. All bacteria and coliforms fall within the microbiological category, which is the third category [3]. 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. The sensors on these along with other IoT gadgets have to be linked to the network because they are all accumulator-powered.

The IoT currently significantly contributes to data monitoring, recording, storing, and displaying in addition to communication. IoT systems open up new possibilities for finding economical resources [4]. Recent years have seen an increase in the application of IoT technology to solve environmental problems such as air quality, water pollution, and radiation contamination [5-7]. 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. LoRa and LPWAN technologies are frequently utilized in IoT systems because of their flexible and reliable technical attributes, along with their capacity to attain extended communication distances with minimal power consumption, cost-effectiveness, and high data transfer speeds in system deployment [8-11]. 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 [12]. Finally, users must comprehend LoRa technology's operation in order to apply roller technology. This is a useful manual for selecting the appropriate equipment. Consequently, the main objective of this study was to develop and assess the performance of a water quality monitoring system that was mounted on a robot (boat) for community usage and used IoT detectors to determine parameters related to water quality like temperatures, the conductivity of electricity, pH, air purity, as well as turbidity with LoRa wireless communication. Information on water quality was also shown using Node-RED technology.

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 [13]. A microcontroller board at the perception layer connects sensors to the network layer. In this investigation, the researchers built a sensor monitoring system utilizing a microcontroller board that gathers information on the temperature, conductivity, pH, turbidity, and the quality of the air before transmitting it using LoRa technology. The LoRa technology enables device-to-device communication. The microcontroller board receives the data and processes it [14].

The Node-RED application, which users can access from their laptops, displays all of the sensor readings. The term LoRa (Long Range) refers to a group of wide-area communication technologies that have better obstacle occlusion and longer signal propagation distances. It can be used for transmission-related purposes and operates without a license in the radio frequency bands at a frequency below 1GHz (920-925 MHz in Thailand). When employed in difficult settings, LoRa can enable long-range broadcasts of more than 10km in open-area testing. Transmission is limited to a radius of less than 1km. The Doppler effect, which impacts signal reception, and comparable speeds were taken into consideration in the study's analysis of LoRa performance [15]. It concluded 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. In this instance, Lora will be utilized unauthorized in a frequency range. Point-to-point communication will be the main focus between each LoRa active node. The service area is limited, but Lora WAN enables interaction between LoRa nodes and remote end nodes through LoRa gateways, enabling the network to offer long-distance communications comparable to those of a WAN network [3, 16].

Media access control protocol (MAC), the top layer of the physical layer, is used by the Lora WAN for communication. The three most frequently used frequency bands are 433MHz in North America, 868MHz in Europe, and 915MHz in North America [17-19]. 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. To track environmental variables, an IoT sensor network is integrated by a microcontroller called the TTGO T-Beam ESP32. The EPS32 microcontroller enables GPS connectivity and uses LoRa modules to operate in the 868/915 MHz band. Before providing the sensor data to the application layer, this component will be in charge of sending, receiving, and processing the data. With a temperature accuracy of 0.5°C, the temperature detector (DS18B20 Arduino) measures the water's temperature in degrees Celsius (°C). With an accuracy of -10 to 85°C, the operative temperature range is -55 to 125°C [20].

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 [21]. 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 express how well water conducts electricity when there are dissolved inorganic substances. Effects of water conductivity on aquatic species' capacity for survival and reproduction Conflict and other negative outcomes may emerge from high conductivity values [22]. Maintaining the quality of the water requires regular analysis of electrical conductivity. The TDS sensor utilized in this study has a measuring range of 0-1000ppm and an accuracy of 10% of the overall scale, making it suitable for experimenting. 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. According to the negative logarithm of the hydrogen-ion concentration, the pH sensor is often built to produce a value between 0 and 14 as needed. pH is defined as pH = -log [H+]. The pH range for intake in this case should be between 6.0 and 8.5, which is within the typical pH range for human existence [4, 23].

The pH sensor in this investigation was calibrated using a pH meter. Mettler Toledo S210 is what it is. The pH calibration powder is used to calibrate the accuracy of the electronic pH measurement probe. 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. It looks at the transmittance and scattering rate of the light to locate suspended particles in water. 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 [24, 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 500ms 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%. An air quality sensor from the MQ series, the MQ-135 gas sensor can measure and detect a wide range of gases, including smoke, nitrogen oxides, ammonia, carbon dioxide, benzene, and alcohol. When it absorbs these gases, the sensor's resistance changes, which is how it works. Its primary job is to track the air quality by looking for these gases. 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 [27-30]. Additionally, it is a potent tool for creating visual programming-based IoT applications. The current study makes use of the Node-RED dashboard library to implement gauges, charts, serial connections, functions, and switches and use them to display 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 280mm in width, 175mm in height, and 880mm in length. With the aid of LoRa technology and a TTGO T-Beam ESP32 microcontroller, the mobile collector has every sensor required to measure the water quality. 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 the equipment. The authors have developed an SWQM system that is based on the IoT and allows for better water quality measurement. The temperature, conductivity, pH, turbidity, and air quality are the five components of water quality.

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 apparatus includes a TTGO T-Beam controller, the DS18B20 temperature sensor, the TDS conductivity sensor, the turbidity sensor, the pH meter, and the MQ-135 gas sensor as an air quality sensor [31-33]. transferring data through LoRa and displaying the Node-RED dashboard on a computer to get beyond the limitations of conventional water quality monitoring systems, data on water quality is shown on the Node-RED dashboard once every second for each of those several parameters. For real-time monitoring, this data may also be automatically sent to the Node-RED dashboard [30].

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.

Among the many causes of water pollution are industrial activity, dumping in rivers and on the ocean floor, the application of pesticides and fertilizers in agriculture, oil pollution, port activity, shipping, and oil spills. Additionally, agricultural operations and sewage effluent are sources. 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.

Trends can be seen in data obtained over time, such as rising nitrogen pollution levels in a river or other inland waterways. After that, utilizing the whole data, key water quality parameters will be found.

3. Managing and preventing water contamination as part of environmental planning.

Data gathering, interpretation, and utilization are essential for developing a good and effective water quality strategy. Lack of real-time data, however, will make it difficult to create plans and would limit your ability to impact pollution control. The answer to this problem is to use digital systems and tools for data collecting and administration.

4. Compliance with international standards.

Water quality monitoring is a global issue that affects both land and marine. The European Green Deal outlines goals for restoring biological diversity and reducing water pollution inside the European Union (EU) and publishes numerous regulations to set standards for water quality. Furthermore, each nation state, like France, has its own legal systems that need accurate water quality monitoring. In the US, the Environmental Protection Agency (EPA) is responsible for enforcing state-by-state water contamination laws. The importance of effective water quality monitoring measures and methods is being recognized by nations all over the world.

5. In emergencies, water quality monitoring is a necessity.

Instances consist of notable occurrences of oil spills caused by tanker accidents or instances of flooding due to excessive runoff of rainwater. When an emergency arises, quick response is essential, necessitating access to real-time data to determine how pollution levels affect water quality [27].

Conclusion

Using the Node-RED program for design and component architecture, the study's goals were to create, assess the effectiveness of, and assess the implementation of an IoT and LoRa-based device for monitoring water quality. It entails measuring and collecting information on water quality characteristics like temperatures, electrical conductivity, pH level, the condition of the air, and sediment, depending on the location that needs to be examined. 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 study's findings showed how a signal transmission that transferred more than 95.50% of our 600 data sets across this shorter distance might be used to send and receive data over a distance operation of 2.0km in places where LoRa technology is impracticable. As a result, less storage will be needed for farther distances. Additionally, the IoT-based monitoring system can provide a Node-RED dashboard and measure water quality in real-time. It was discovered that 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.

Acknowledgment

None.

Conflicts of Interest

No conflict of interest.

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