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Drawbacks of Traditional Environmental Monitoring Systems

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Abstract

Traditional methods for evaluating water quality have a number of drawbacks. They need expensive, specialized equipment as well as knowledgeable employees first. Second, data loss may result from human error. Thirdly, because people rather than algorithms will be analyzing the obtained data, these schemes cannot foresee future patterns. Additionally, changes in the characteristics of water may result from the sample transit process. Therefore, it is challenging to consistently check water quality using outdated monitoring techniques. The disadvantages of traditional environmental monitoring techniques have been covered in this study.

Keywords: Arduino Uno, old measuring methods, monitoring water quality, Internet of things (IoT), drawbacks

1. Introduction

A natural resource that is essential for human usage is water. On Earth, there are about 326 million trillion gallons of water. 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 tops. Only 0.04% of this naturally plentiful resource may be utilized (Shafi, U., Mumtaz, R., Anwar, H, Qama,r A. M., & Khurshid, H., 2018); (World Wide Fund For Nature (WFF), 2020). The two primary categories of freshwater sources are surface water sources, such as rivers, canals, waterfalls, dams, and reservoirs, and groundwater sources. Additionally, due to waste generation and chemical leaks, industrial and agricultural operations are expanding quickly and have a substantial impact on environmental toxins. It is crucial to guarantee the safety and usability of water resources. Due to increasing globalization, there are problems with water contamination and demand around the world. Water quality must be closely monitored to avoid any problems caused by water consumption from various activities. Water quality parameters can be divided into three groups. Physical traits like electrical conductivity, turbidity, chromaticity, warmth, smell, and color are included in the first group. Chemical elements such as pH, dissolved oxygen, chemical oxygen demand (COD), biochemical oxygen demand (BOD), complete inorganic carbon, heavy metal ions, and nonmetallic poisons are included in the second category of chemical attributes. The third category, known as microbiological, includes all bacteria and coliforms (AlMetwally, S. A. H., Hassan, M. K., & Mourad, M. H., 2020). It is a laborious and time-consuming process to hand collect water samples from various areas in order to analyze them for quality. Therefore, Internet of Things (IoT) technology, a modern approach, is of interest to researchers for use in assessing water quality. Network-connected devices and, more recently, the value chain that comes from the connecting of things, data, people, and services are both referred to as "IoT" in the same sentence. These and other IoT devices all run on accumulators; thus, their sensors need to be connected to the network. In addition to communication, the IoT currently makes a substantial contribution to data monitoring, recording, storing, and displaying. IoT systems create new opportunities for locating affordable resources (Netinant, P., & Rukhiran, M., 2020). IoT technology has been used more frequently in recent years to address environmental issues like poor air quality, water pollution, and radiation exposure (S Devalal, & A Karthikeyan, 2018); (Ullo, S. L., & Sinha, G. R., 2020); (Daigavane, V. V., & Gaikwad, D. M. A., 2017).

According to recent studies, they have used IoT (Zainab, A., Amina, I., Abdulmuhaimin, M., M. A. Baballe, & Sadiku, A. S., 2023). technology to provide real-time monitoring in order to streamline operations and more effectively regulate water quality. Because of their adaptable and dependable technical characteristics, as well as their ability to achieve long communication distances with little power consumption, cost-effectiveness, and fast data transfer speeds during system deployment, LoRa and LPWAN technologies are frequently used in IoT systems (Chowdury, M. S. U., Emran, T. B., Ghosh, S., Pathak, A., Alam, M. M. et al., 2019); (Mukhamadiev, S., Rogozhnikov, E., & Dmitriyev, E., 2022); (Gkotsiopoulos, P., Zorbas, D., & Douligeris, C., 2021); (Radhakrishnan, V., & Wu, W., 2018). For the adoption of LoRa technology, however, zoning regulations or national considerations are required. This is because LoRa devices must be utilized in each country at the assigned frequencies (Gambiroža, J. Č., Mastelić, T., Šolić, P., & Čagalj, M., 2019). Finally, in order to use roller technology, users must know how LoRa technology works. This guide will help you choose the right equipment. Consequently, the main objective of this study was to develop and assess the performance of a water quality monitoring system for public use that was mounted on a robot (boat) and used Internet of Things detectors to measure parameters related to water quality like temperatures, electrical conductivity, pH, air purity, and turbidity with LoRa wireless communication. Data on water quality were also shown using Node-RED technology.

2. Related Works

In this paper, the author uses IoT technology to monitor a range of water quality indicators, including temperature, turbidity, electric conductivity, pH, and air quality. The equipment consists of a TTGO T-Beam controller, a MQ-135 gas sensor acting as an air quality sensor, a DS18B20 temperature sensor, a TDS conductivity sensor, a turbidity sensor, a pH meter, and several more sensors (Muhammad, A. B., Mukhtar, I. B., 2022); (Mehmet, Ç., & Muhammad, B. A., 2019); (Muhammad, B. A., Abdullahi, A. A., Abubakar, S. M., Yusuf, B. S., & Usman, B. U., 2019). Data is exchanged through LoRa and displayed on a computer with the help of the Node-RED dashboard to get around the limitations of conventional water quality monitoring sensors. Data on water quality is shown on the Node-RED dashboard once every second for each of those several metrics. This information may also be immediately delivered to the Node-RED dashboard for real-time monitoring (Sommart, P., Somkiat, M., & Chawalit, P., 2023). The IoT architecture is a framework made up of physical components, technical network setup and configuration, operational protocols, and data formats. The implementation of IoT architecture may appear extremely different. Therefore, open protocols need to be flexible enough to handle a variety of network applications. The most conventional and widely used structure is three layers. In the beginning of this IoT inquiry, it was used. The three layers stated are perception, network, and application (Abdmeziem, M. R., Tandjaoui, D., & Romdhani, I., 2016). At the perception layer, sensors are connected to the network layer by a microcontroller board. Using a microcontroller board, the researchers created a sensor monitoring system for this study that measures the temperature, conductivity, pH, turbidity, and quality of the air before transmitting the data using LoRa technology. Devices can talk to other devices thanks to LoRa technology. The data is delivered to the microcontroller board, which then processes it (Rukhiran, M., Netinant, P., & Elrad, T., 2020). All of the sensor readings are displayed in the Node-RED application, which users may access from their computers. A collection of wide-area communication technologies known as LoRa (Long Range) provide improved obstacle occlusion and longer signal propagation distances. It runs without a license in the radio frequency bands at a frequency below 1GHz (920-925 MHz in Thailand) and can be used for transmission-related applications. LoRa can provide long-range transmissions of more than 10 km in open-area testing when used in challenging environments. A radius of less than 1 km is the maximum for transmission. The study's research of LoRa performance took the Doppler effect, which affects signal reception, and comparable speeds into account (Torres, A. P. A., Silva, C. B. D., & Filho, H. T., 2021). It was determined that the communication might not work depending on the hardware configuration chosen. Additionally, it completed coverage of both land and ocean. Lora and Lora WAN are the two versions of LoRa technology now in use. This will involve unlawful use of Lora in a certain frequency range. The primary method of communication between each LoRa active node will be point-to-point. Although the service area is constrained, Lora WAN facilitates connection between LoRa nodes and distant end nodes via LoRa gateways, allowing the network to provide long-distance communications on par with those of a WAN network (AlMetwally, et al., 2020); (Kadhim, K. T., Alsahlany, A. M., Wadi, S. M., & Kadhum, H. T., 2020). The Lora WAN communicates via Media Access Control Protocol (MAC), the top layer of the physical layer. In North America, 868 MHz is the most often utilized frequency range, followed by 915 MHz and 433 MHz in Europe (A Zourmand, AL Kun Hing, C Wai Hung, M AbdulRehman, 2019); (O Khutsoane, B Isong, AM Abu-Mahfouz, 2017); (Zhou, Q., Zheng, K., Hou, L., Xing, J., & Xu, R., 2019). The utilization of sensors to measure metrics related to water quality and wireless transmission of that data utilizing LoRa technology are the core concepts driving this project. It has a transmitter and a receiver as its two halves. A TTGO LoRa32 development board and sensors that collect data on water quality indicators from water sources make up the transmitter. The data is transmitted to the receiver using the TTGO LoRa32's LoRa communication function, who subsequently receives the water quality data and displays it on a Node-RED application. An IoT sensor network is integrated with a microcontroller known as the TTGO T-Beam ESP32 to track environmental factors. In addition to enabling GPS connectivity, the EPS32 microcontroller also uses LoRa modules to operate in the 868/915 MHz range. This component will be in charge of sending, receiving, and processing the sensor data prior to presenting it to the application layer. The temperature detector (DS18B20 Arduino) measures the water's temperature in degrees Celsius (℃) with a temperature precision of 0.5℃. The operative temperature range is -55 to 125℃, with an accuracy of -10 to 85℃ (Muhammad, A. B., 2022). The temperature sensor was calibrated at various temperatures using a thermometer. The test results showed that the temperature sensor's accuracy was 94.05%. The temperature of the water is a key factor in deciding if a particular supply is fit for human use and consumption. It also affects oxygen levels for a variety of aquatic animals. The water should be kept between 20 and 30℃, according to the World Health Organization (WHO) (Hasan, M. K., Shahriar, A., & Jim, K. U., 2019). A total dissolved solids (TDS) sensor is a device for measuring a liquid's electrical conductivity or the amount of TDS in water. In order to measure how well water conducts electricity when there are dissolved inorganic materials, micro-Siemens per centimeter of water (S/cm) units are utilized. Effects of water conductivity on the ability of aquatic animals to survive and reproduce High conductivity values have the potential to cause conflict and other undesirable effects (Abha, M., 2014). Analyzing electrical conductivity on a frequent basis is necessary to maintain the water's purity. The TDS sensor used in this study is suited for experimentation because it has a measuring range of 0-1000ppm and an accuracy of 10% of the total scale. The pH sensor, commonly referred to as an analog pH meter, is a tool that measures both the pH and the acidity and alkalinity of any solution. It is widely used in many applications, including aquaponics, aquaculture, and environmental water testing. The pH sensor is frequently designed to produce a value between 0 and 14 as needed, according to the negative logarithm of the hydrogen-ion concentration. The formula for pH is pH = -log [H+]. Within the usual pH range for human existence, the pH range for ingestion in this instance should be between 6.0 and 8.5 (Netinant, et al., 2020); (Schwalfenberg, G. K., 2012). In this study, a pH meter was used to calibrate the pH sensor. What is Mettler Toledo S210. The electronic pH measurement probe's accuracy is calibrated using the pH calibration powder. The pH sensor has a 96.95% accuracy rate, per the test findings. The turbidity sensor is used to determine the turbidity of the water. To find suspended particles in water, it examines the light's transmittance and scattering rate. This rate changes depending on the quality of the total suspended solids. (TSS). The most frequent range for measuring water turbidity is thought to be between 0.1 and 1000 Nephelometric Turbidity Units. (NTU). River water turbidity can exceed 150 NTU (Salika, F., Nasser, A., Mroue, M., Parrein, B., & Mansour, A., 2022); (Metzger, M., Konrad, A., Blendinger, F., Modler, A., Meixner, A. J. et al., 2018). The sensor employed in this study captures the light that is bent by water and converts it to an analog output turbidity value of 0-4.5 volts with a measuring precision of 500ms. Turbidity was compared to 0-1000 NTU using volts. The turbidity sensor was calibrated using standard values. The accuracy of the instrument was found to be 91.03%. The MQ-135 gas sensor is an air quality sensor from the MQ series that can measure and detect a variety of gases, such as smoke, nitrogen oxides, ammonia, carbon dioxide, benzene, and alcohol. The sensor functions by altering its resistance as a result of absorbing these gases. Its main duty is to monitor the air quality by keeping an eye out for these gases. The sensor is made up of an aluminum oxide (Al_2O_3) ceramic tube, a heating coil, and a tin oxide detecting layer. The analog TTL is compatible with the majority of microcontrollers because it runs on 5 volts (Neamah, F., Intisar, M., Khyioon, Z., & Abud, E., 2020). Node-RED allows for the integration of hardware parts, internet services, and application programming interfaces (APIs). By enabling developers to connect devices to APIs using a customizable web browser, it promotes more flexible working practices. Installing Node-RED on personal computers is recommended to ensure the platform's security and privacy. This application is highly well-liked because of its graphical user interface (Lekić, M., & Gardašević, G., 2018); (Muhammad, A. B., Abubakar, S. M., Fatima, A. U., Najaatu, K. M., & Abdulkadir, H. K. N. et al., 2022); (Sommart, P., Somkiat, M., & Chawalit, P., 2023). It is also a powerful tool for developing IoT apps with visual programming. The current study implements gauges, charts, serial connections, functions, and switches and uses them to show data from sensor information using the Node-RED dashboard module. To monitor the quality of water resources, a wireless electric boat-based prototype of a mobile water quality collector has been created. The fuel cell used in this investigation has the following measurements: 280 mm wide, 175 mm high, and 880 mm long. The mobile collector is equipped with all the sensors required to measure the water quality thanks to the TTGO T-Beam ESP32 microprocessor and LoRa technology. By using LoRa to broadcast meter reading instructions and data, the mobile collector is used to monitor water meters and evaluate the equipment's condition. The IoT-based SWQM system developed by the authors enables more accurate measurements of water quality. Temperature, conductivity, pH, turbidity, and air quality make up the five components of water quality (Auwal, R. D., Zainab, A., Suleiman, B. A., Amina, I., Ibrahim, U., & Muhammad, A. B., 2023); (Zainab, A., Amina, I., Abdulmuhaimin, M., Sadiku, A. S., & M. A. Baballe., 2023).

3. Traditional Environmental Monitoring Systems' Drawsbacks

Traditional methods for evaluating water quality have a number of drawbacks. They need expensive, specialized equipment as well as knowledgeable employees first. Second, data loss may result from human error. Thirdly, because people rather than algorithms will be analyzing the obtained data, these schemes cannot foresee future patterns. Additionally, changes in the characteristics of water may result from the sample transit process. Therefore, it is challenging to consistently check water quality using outdated monitoring techniques.

1. NON-PROVISION OF REAL-TIME DATA

A major problem with a typical quality monitoring system that relies on human data input and output is the absence of real-time data provisioning. Automated methods can help in this situation. Without relying on manual procedures or analysis, these technologies can process data. This offers perceptions that cannot be obtained manually. Additionally, they can be made accessible at various levels of detail. For instance, while some consumers might just need the final results, others could need the raw data as well. And it might be made practical by an inexpensive sensor network. Since conventional water monitoring uses sensor data, the raw data may not be of high quality, making it challenging to interpret the water quality. The data may also be subject to access limitations, which makes it more challenging to interpret. For this reason, constant, trustworthy, and useful information regarding water quality must be delivered through real-time water quality monitoring solutions.

2. EQUIPMENT VALUE

The equipment needed to operate traditional water quality monitoring systems is expensive. Traditional water monitoring systems, in contrast to wireless communication technologies, are either wired or not connected at all, making it challenging to set up continuous monitoring. Methods used to measure the quality of water traditionally have many drawbacks. For instance, they demand expensive and highly specialized employees and equipment. Therefore, inadequate water control and associated issues emerge from not all cities or utility corporations being able to afford these efforts. Future trend forecasting is especially challenging due to human mistake, which can be expensive. Finding practical insights from poor data takes time. Because of this, contamination detection may be postponed and slowed down for an unforeseen amount of time.

3. USING WATER QUALITY INDEXING AS A BASIS

The statistics required to evaluate the cost-effectiveness of water quality improvements are generated by the water quality index. The index technique eliminates some of the issues that other cost-effectiveness assessments have by allowing for the comparison of the costs and benefits of various pollutants. The fundamental tool for disseminating information about water quality in this strategy is the water quality index. However, other factors also affect water quality, so relying just on this one can have unpredictable outcomes.

4. Conclusion

Numerous studies on water quality monitoring are reviewed in this study. In all the studies I've seen, none of them mention the shortcomings of conventional environmental monitoring methods, despite the fact that we have seen technological advancements in water purification and water quality monitoring.

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