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IOT BASED WATER QUALITY MONITORING SYSTEM

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Abstract - Water is one of the most vital resources for life, and protecting its quality is crucial for both the environment's health and the well-being of people. Monitoring and preserving the quality of the water is now essential given the mounting problems caused by pollution, climate change, and expanding populations. In this environment, the Internet of Things (IoT) has emerged as a ground-breaking innovation that has the potential to revolutionize the way we manage and monitor water quality. An IoT-based water quality monitoring system's relevance, components, advantages, and prospective applications are highlighted. It offers a chance to proactively address problems with water quality, protecting both the environment and the general people. Sensors used in IoT-based water quality monitoring systems can measure a wide range of factors, including temperature, dissolved oxygen, turbidity, pH levels, and chemical concentrations. These sensors are interfaced with the microcontroller unit. The sensors are positioned in pipelines, treatment facilities, or water bodies. Through wireless communication protocols like Wi-Fi or cellular networks, the data gathered by sensors is sent to a central server or cloud platform. This makes it possible to access and analyses data in real time. Users can use online or mobile applications to get the data on the quality of the water. These intuitive user interfaces offer up-to-the-minute data, historical trends, and alarms if water quality measurements differ from predetermined criteria. Urban populations can have access to safe drinking water by using IoT systems at water treatment facilities to monitor and manage water quality indicators. Aquaculture farms' production is increased by IoT-based systems' assistance in maintaining ideal water conditions for fish and other aquatic species. Monitoring soil and water quality helps farmers improve irrigation operations, which increases agricultural yields and decreases water waste. IoT is an excellent instrument for preserving water resources, defending the environment, and delivering real-time data, affordable solutions, and data-driven decision-making.

***Key Words*:** Microcontroller, Pumping station, Sensor, IoT, data, aquaculture.

1. INTRODUCTION

Water is a necessary resource that supports life and is essential to many human endeavors, including agriculture, industry, and use in the home. However, water quality is continually changing. Pollution, contamination, and human activity pose threats, that have a negative impact on both human health and the surroundings. Ensuring one's safety and cleanliness of water sources is of paramount importance, and this has driven the need for advanced monitoring systems. The Internet of Things (IoT) has completely changed how we collect, evaluate, and manage data. The Internet of Things (IoT) is a network of interconnected gadgets and sensors that can talk to one another and share data online. This technology has found widespread applications across diverse domains, and one area where it proves monitoring water quality has particular advantages. The Internet of Things (IoT)-based water quality monitoring system is a cutting-edge strategy that makes use of the IoT power to monitor, evaluate, and control the quality of water sources in real-time. Regularly checking the quality of the water systems were often labor-intensive, time-consuming, and lacked the ability to provide instant data insights. With IoT, these limitations are overcome, and a more efficient and effective solution is realized. A cutting-edge and creative a technique for monitoring and controlling water quality in a variety of situations, including natural bodies of water, aquaculture facilities, water treatment plants, and more is an IoT-based solution for monitoring water quality. The Internet of Things (IoT) is utilized to collect, transmit, and analyses real-time data from a network of sensors and devices installed in and around water sources continually and remotely. Such a system's main objective is to deliver precise and fast data regarding significant water quality indicators including conductivity, temperature, pH, turbidity, and dissolved oxygen, and others. Decision-makers can use this information to control the quality of the water, environmental protection, and public health, including environmental agencies, aqua-culturists, water treatment operators, and researchers. Systems for monitoring water quality that are IoT-based have many benefits, such as increased productivity, lower operating costs, better environmental stewardship, and improved data-driven decision-making abilities. They are essential in protecting water resources, promoting sustainable aquaculture methods, and guaranteeing adherence to laws and norms governing water quality. The Internet of Things, in which common things are given sensors, connection, and computing capabilities, is at the core of this groundbreaking technology. This entails placing specialized sensors in the aquatic environment, such as rivers, lakes, treatment facilities, and distribution networks in order to continuously gather important data on different water quality indices. This is carried out as part of the monitoring of water quality. There are several different kinds of sensors in this system, including pH sensors, turbidity sensors, temperature sensors, and others stationed at various areas of the water bodies. These sensors provide data to a central server or cloud platform while continually measuring important water quality indicators. The data is then processed and analysed to generate valuable insights and alerts. The measurement of crucial elements such as pH, turbidity, dissolved oxygen, temperature, and various contaminants with the use of sophisticated sensors that are meticulously calibrated and placed in key locations. These sensors can give real-time information on water quality by spotting variations and abnormalities that can indicate pollution incidents or alterations in the environment.

2. LITERATURE REVIEW

Gupta et al (2021) proposed a model which automatically assesses water quality factors including turbidity, pH, and temperature was proposed by Gupta et al. in 2021. ESP32 was utilized for underwater communication because of its built-in Wi-Fi and low power consumption. To create the IoT-based model, communication modules, a turbidity meter, and a pH sensor were incorporated. Additionally, a machine learning technique based on K Means was utilized to examine the water quality using previously thought-out parameters. The created model is a locomotive that continually checks the water quality in both large and small water bodies. A robot may be used to monitor water quality from any location. This project is self-sufficient and effective since the designed model is affordable and the robot can communicate from underwater using high-speed Wi-Fi. [7]

Chowdury et al. (2019) suggested a thorough and creative method for real-time Internet of Things river water quality monitoring technology. (Iodine). This study responds to growing concern about river water quality management, highlighting the need for continuous monitoring and data-driven decision-making to protect freshwater ecosystems and public health. The major goal of this study is to design, build, and implement a sophisticated Internet of Things-based system that can gather, transmit, and analyze real-time data on important water quality metrics that are different in river environments. The system combines a network of strategically placed sensors and advanced IoT technologies to ensure the precision, dependability, and timeliness of data on water quality. The necessity of river water quality monitoring is emphasized by the writers in the first paragraph, along with its crucial function in supporting aquatic ecosystems and human activity. They highlight the challenges posed by traditional periodic sampling methods that often fail to capture dynamic changes in water quality. The document describes the IoT-based architecture in detail, describing the components and functions of the system. This includes selecting the right sensors to measure characteristics including conductivity, temperature, dissolved oxygen, turbidity, and pH. The sensors are placed strategically at various points along the river, ensuring comprehensive coverage [2].

M. Diallo, B. Gueye, N. Marilleau, and B. Ngom investigated the development of the Internet of Things in 2019. Things (IoT), which has aided in the development of various applications. Remote observation or sensing has been facilitated by IoT. Numerous sensor nodes with network capabilities might be used to produce sporadic or ongoing monitoring. UCAD Faculty of Science, nevertheless Physicists continue to gather information about water quality at the department's swimming pools, Botanical Garden utilizing measurements taken on-site. is employed in aquaculture and the investigation of a few aquatic species. We describe the LoRa transmission water quality monitoring system in this article. A remote station for real-time data collecting and a web platform for viewing and processing make up this low-cost infrastructure. We do performance tests on the system, and the results are also supplied, in order to assess its dependability and effectiveness. [1]

3. METHODOLOGY

The proposed system monitor conductivity, turbidity, water level, and pH of the water. The hardware and software architecture are used to create the proposed system's block diagram. The heart of the IoT-enabled water quality monitoring system is a controller. Most IoT-based systems, it has been noted, employ a controller with external Wi-Fi. Such designs produce complicated circuitry and are neither cost- or power-efficient. The ESP32 single-chip microcontroller used in this project includes an inbuilt Bluetooth and Wi-Fi module that is used to connect to the nearby Wi-Fi hotspot and access the internet. Sensors are directly connected to the controller because the recommended system is designed to check water quality. It is possible to keep track of the sensor's characteristics, such as conductivity, turbidity, water level, and pH, by keeping the sensor into various locations of water reservoirs. The measured parameters may be shown on an LCD. The controller is used to transport the sensor data to the cloud. The WHO criteria are used to configure Threshold on the cloud. A message is sent from the cloud to the user's mobile device if the value exceeds the threshold. A mobile application has been developed that allows users to access the information gathered by each sensor in the cloud. This may be used by both customers and the organizations in charge of keeping an eye on the water's quality. Turbidity is a measurement of water cloudiness.

Utilizing opto-electronic tools like LDR and LED, turbidity is measured. The sensors detect the light that is reflected and transmitted by the floating particles. An LDR is a high resistance semiconductor. The bound electrons in the gadget receive the energy they require to enter the conduction band from photons that are absorbed by the semiconductor when high-frequency light strikes it. The recommended method separates the LED and LDR by 9 cm. More free electrons are produced as a result, which carries electricity and lowers resistance. The water level is sensed to determine the depth of the water in the tank. For this, the probing method is utilized. Three indicators display the water level such as low, medium, and high. The cloud continuously updates sensor readings. The LCD that is linked also shows the sensor readings. The device is programmed using the Arduino IDE. Data that is maintained in the cloud is sent by the controller. For programmers to gather data and turn it into relevant data, the cloud offers a platform. A real-time dashboard for data analysis, device control, and public link sharing is one of the features. The data stored in the cloud might be thoroughly examined. The cloud is built to send alert SMS texts when a monitored parameter exceeds the threshold limit.

4. COMPONENTS OF THE PROPOSED SYSTEM

- **pH sensor:**
  The pH sensor is a tool that gauges a liquid's pH level. An indication of a liquid's acidity or alkalinity is its pH value. A pH of 7 is neutral, whereas a pH of 7 or lower is acidic and a pH of 7 or higher is alkaline. The pH sensor functions by determining the liquid's electrical conductivity. The conductivity of a liquid increases with its acidity.

- **Turbidity Sensor:**
  A tool that gauges a liquid's turbidity is a turbidity sensor. Turbidity is a measure of how cloudy or clear a liquid is. The more turbid the liquid, the more suspended particles it contains. The amount of light scattered by the suspended particles in the liquid is measured by the turbidity sensor.

- **Dissolved oxygen sensor:**
  The dissolved oxygen sensor is a tool that calculates the amount of dissolved oxygen in a liquid. The volume of oxygen that has been dissolved in the liquid is known as dissolved oxygen. The healthier a liquid is for fish and other aquatic life depends on how much dissolved oxygen it contains. The dissolved oxygen sensor measures the liquid's electrical conductivity in order to function.
  ESP32:

  A microcontroller called the ESP32 may be used to gather data from sensors and transmit it to a computer or the internet. Due to the ESP32's integrated Wi-Fi module, connecting to the internet is simple.

- **Node-RED:**
  A visual programming tool called Node-RED may be used to make IoT apps. Node-RED uses a graphical interface to create flows, which are sequences of actions that are triggered by events. Node-RED can be used to visualize data, send alerts, and take other actions based on the data.

- **LCD display:**
  An LCD display, like the 16x2 Liquid Crystal Display, will be used to show real-time sensor readings and system status.

- **Power Supply:**
  Ensure a stable power supply for the ESP32 and all sensors. Refer to the datasheets of the individual components since their voltage needs might vary.

- **Wires and Connectors:**
  The ESP32, sensors, and LCD should all be connected using the proper cables and connectors.

5. CONNECTING SENSORS TO ESP32

- **pH Sensor Connection:**
  Connect the pH sensor's BNC connector to the pH sensor board. Connect the pH sensor board to the ESP32's analog pin (e.g., A0) for analog pH measurements. Ensure the sensor has a stable power supply and proper ground connection.

- **Turbidity Sensor Connection:**
  Connect the Turbidity sensor's output to one of the ESP32's analog pins (e.g., A1) for analog turbidity readings. Connect the sensor's power and ground pins to the appropriate ESP32 pins and provide stable power.

- **Dissolved Oxygen Sensor Connection:**
  The Atlas Scientific DO Sensor typically uses an I2C interface. Connect its SDA and SCL pins to the equivalent ESP32 pins. (e.g., GPIO 21 and GPIO 22). Ensure the sensor has a stable power supply and proper ground connection.

- **LCD Display Connection:**
  Connect the GPIO pins on the ESP32 to the data pins on the LCD, which are commonly RS, EN, D4, D5, D6, and D7. Connect the ESP32's ground and the VCC and GND pins of the LCD, respectively. Additionally, connect a potentiometer to adjust the LCD's contrast and connect it to the LCD module.

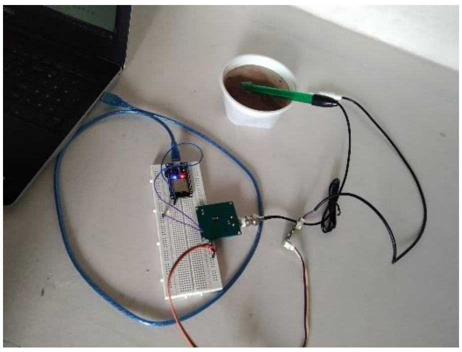

Fig 1. Sensor connections to ESP32

6. SOFTWARE SETUP

1) ESP32

The ESP32 will need to be programmed with the necessary code to gather sensor data and transmit it to Node-RED. Python or C/C++ can be used to program the ESP32.

The code will need to include the following steps: Initialize the sensors. Gather data from the sensors. Transfer the data to Node-RED which is a graphical interface.

Fig 2. ESP32 Board

2) Node-RED

Node-RED will need to be configured to visualize the data and take actions based on the data. The configuration for Node-RED can be done using the graphical interface.

The following nodes will need to be added to the flow: A sensor node to receive data from the ESP32. A visualization node to visualize the data. An action node to take actions based on the data. The following are some of the actions that can be taken based on the data: Send an alert if the pH value, turbidity, or dissolved oxygen concentration falls outside of an acceptable range. Automatically turn on a water filter if the water quality is poor. Automatically notify a water treatment plant if the water quality is poor.

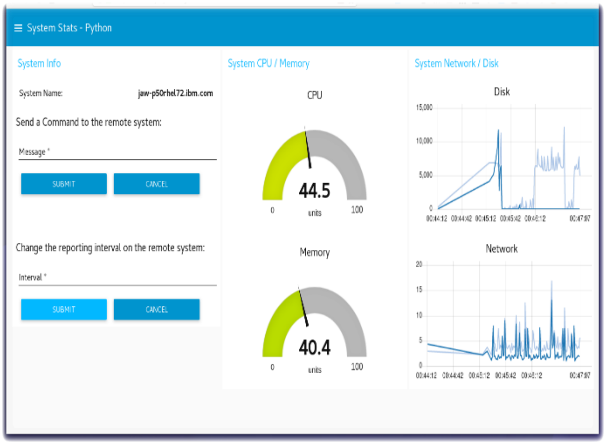

Fig 3. Node-Red Dashboard View using ESP32

Some examples of the visuals that may be made are as follows: a graph that displays the pH value's historical trend. a graph demonstrating the connection between the turbidity and the amount of dissolved oxygen. a table displaying the pH, turbidity, and dissolved oxygen levels as of the present time. The software setup of the proposed system can be done by following these steps. The specific steps may vary depending on the sensors and the software that is used.

7. DATA COLLECTION

A cloud-based IoT water quality monitoring system that uses cloud computing has several benefits, from data storage and analysis to remote accessibility and scalability. Cloud computing systems offer almost infinite storage space. This is crucial for managing the enormous amounts of data generated over time by IoT devices. Historical data on water quality may be safely kept in the cloud for protracted times, enabling trend analysis, ongoing monitoring, and compliance reporting. To guarantee the integrity and confidentiality of private information about water quality, cloud service providers include strong security features such as data encryption, access restriction, and disaster recovery. Real-time water quality data may be sent to the cloud via IoT sensors, allowing authorized users to view and analyses it right away. Because cloud services are built for low latency data processing, users and stakeholders may get real-time information without experiencing substantial delays. Machine learning skills and strong data analytics tools are provided by cloud platforms. These may be used to examine trends, anomalies, and predictive modelling in data on water quality. Cloud systems can combine data from many sensors, providing a thorough understanding of water quality across various metrics and areas. As the system expands, cloud platforms can readily support the addition of new sensors or monitoring sites. It is essential for the monitoring network to be scalable. Since cloud services employ a pay-as-you-go business model, you only pay for the resources you really use. Cloud-based water quality data may be shared with interested parties, environmental organizations, researchers, or the general public, encouraging openness and cooperation. Cloud systems frequently provide collaboration tools, such as shared dashboards or access restrictions, to support user collaboration and data sharing.

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Energy-efficient server farms and data centers Cloud providers might be able to reduce the environmental impact of operating the water quality monitoring system by prioritizing energy-efficient data centers and server farms. The possibilities of a cloud-based IoT-based water quality monitoring system in terms of data storage, analysis, accessibility, scalability, and cost efficiency are significantly enhanced. It enables enterprises to take data-driven choices, act quickly in the face of changing circumstances, and guarantee the security and sustainability of water supplies. Additionally, cloud-based technologies are ideal for teamwork and offer the adaptability required to develop and expand the monitoring network over time. In terms of environmental management and public health, the Internet of Things-based system for monitoring water quality is a prime example of innovation. The pay-as-you-go cloud computing concept reduces up-front capital expenditures and makes it possible for businesses to operate on a limited budget. Additionally, a lot of cloud service providers put an emphasis on using energy efficient data centers, which helps the environment. Additionally, the addition of cloud computing to this system greatly expands its potential. Platforms built on the cloud make it possible to store, analyses, and share data at a scale that was previously unimaginable. This enhances stakeholder participation and transparency while also enabling advanced data analytics that result in predictive modelling and better resource management. Because of its scalability, versatility, and cost efficiency, IoT-based water quality monitoring systems are a crucial tool for addressing current and prospective challenges in water management. These solutions provide promise for a better, more resilient future in a world where access to clean, plentiful water is becoming increasingly rare. With the IoT at its core, the water quality monitoring system transforms into a representation of development, a crucial instrument for safeguarding water resources, and a demonstration of how technology can address the most urgent problems confronting our world.

8. CONCLUSIONS

The IoT-based water quality monitoring system has significantly increased our ability to ensure the safety, sustainability, and responsible management of our irreplaceable water resources. This revolutionary technology totally transforms how we monitor and protect water quality by combining the Internet of Things (IoT), cutting-edge sensors, real-time data processing, and cloud computing. This method offers benefits at its core. In real-time surveillance, we can quickly identify changes and abnormalities because to the capacity to gather and send water quality data in real-time. The protection of aquatic ecosystems, the provision of clean drinking water, and effective response to pollution incidents all depend on this fast reaction capabilities. IoT sensors provide accurate and reliable readings, lowering the margin of error brought on by human sampling.

Making educated judgments about the management of water quality requires this degree of precision. Predictive modelling and comprehensive data analysis are made possible by cloud computing integration. This enables proactive resource management, the optimization of water treatment processes, and not only aids in the identification of trends and patterns. IoT technology enables remote access to data on water quality, allowing stakeholders to keep track on conditions and make wise choices from almost anywhere. This accessibility encourages effectiveness, teamwork, and convenience. IoT-based devices aid in more environmentally friendly water management procedures by offering insightful information on trends in water quality and pollution incidents. It may be possible to prevent pollution episodes and limit harm to aquatic ecosystems by managing water quality more proactively, which would encourage environmental preservation. The safety of drinking water is ensured through prompt diagnosis of water quality problems, which also lowers the risk of waterborne illnesses and related medical expenses. Labor savings for manual sampling, transportation, and analysis. Using real-time data to optimize water treatment and distribution resources. Rapid detection and reaction to water quality problems can save expenses associated with damage and recovery.

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