IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁙ Peer-reviewed / Refereed journal ⁙ Vol. 11, Issue 12, December 2024

DOI: 10.17148/IARJSET.2024.111211

ADVANCED WATER QUALITY MONITORING SYSTEM FOR ENVIRONMENT CONSERVATION

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Abstract: Water pollution is a global issue, endangering health, ecosystems, and sustainability. Traditional methods of water quality assessment are slow and labor-intensive, delaying contamination detection and increasing the risk of waterborne diseases. This paper presents a low-cost, efficient system for real-time monitoring of key water quality parameters, such as pH, turbidity, temperature, TDS, and flow rate. The system uses sensors integrated with an Arduino microcontroller for continuous data collection, displaying real-time results on a TFT screen. Alerts are triggered when parameters exceed set thresholds, enabling timely intervention. Advanced calibration algorithms ensure accurate readings, while low power consumption supports long-term deployment in remote areas. The system is designed for easy use by both technical and non-technical users, providing reliable, cost-effective monitoring for improved decision-making in various environments.

Keywords: Water monitoring, Microcontroller, Turbidity sensor, PH sensor, Cloud

I. INTRODUCTION

Water pollution is a global issue, endangering health, ecosystems, and sustainability. Traditional methods of water quality assessment are slow and labor-intensive, delaying contamination detection and increasing the risk of waterborne diseases. This paper presents a low-cost, efficient system for real-time monitoring of key water quality parameters, such as pH, turbidity, temperature, TDS, and flow rate. The system uses sensors integrated with an Arduino microcontroller for continuous data collection, displaying real-time results on a TFT screen. Alerts are triggered when parameters exceed set thresholds, enabling timely intervention. Advanced calibration algorithms ensure accurate readings, while low power consumption supports long-term deployment in remote areas. The system is designed for easy use by both technical and non-technical users, providing reliable, cost-effective monitoring for improved decision-making in various environments.

Key parameters such as pH, turbidity, temperature, total dissolved solids (TDS), and flow rate are essential indicators of water quality. pH levels reflect the acidity or alkalinity of water, which can affect both human health and aquatic ecosystems. Turbidity measures the cloudiness of water caused by suspended particles, often signaling contamination by sediments, microorganisms, or pollutants. Temperature is crucial for assessing the thermal conditions of water, which directly influences the metabolic rates of aquatic organisms and the solubility of oxygen and other chemicals. A real-time monitoring system addresses the limitations of traditional approaches by providing continuous, accurate, and up-to-date information on water quality. Such a system enables immediate detection of contamination, allowing for timely interventions and mitigating potential hazards. Moreover, it reduces the reliance on manual labor and laboratory infrastructure, making it more cost-effective and scalable for widespread deployment. The system transmits data for further analysis, visualization, and alerts when water quality parameters deviate from safe thresholds, providing real-time feedback for quick decision-making. In summary, the increasing threats posed by water pollution necessitate the development of innovative solutions for real-time water quality monitoring. The implementation of automated systems not only ensures the continuous surveillance of water resources but also enhances decision-making processes for water management authorities. These systems play a crucial role in safeguarding public health, protecting ecosystems, and promoting sustainable water resource management in the face of growing environmental challenges.

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II. LITERATURE SURVEY

KELECHI, A. H., ALSHARIF, M. H., ET AL. (2021). "DESIGN AND IMPLEMENTATION OF A LOW-COST PORTABLE WATER QUALITY MONITORING SYSTEM," COMPUTERS, MATERIALS AND CONTINUA, VOL.69, NO. 2, PP. 2405-2424.

In this research paper, a system is being proposed, the design of a portable water quality monitoring system that utilizes a low-cost microcontroller (Arduino) to measure parameters such as pH, turbidity, and temperature. The authors focus on achieving affordability without compromising measurement accuracy. The system is equipped with a mobile interface to provide real-time feedback and alerts. This paper highlights the effectiveness of using inexpensive sensors for accurate water quality monitoring in low-resource settings, which is highly relevant to our project as it also aims to offer a low-cost solution.

DEMETILLO, A. T., JAPITANA, M. V., & TABOADA, E. B. (2019). "A SYSTEM FOR MONITORING WATER QUALITY IN A LARGE AQUATIC AREA USING WIRELESS SENSOR NETWORK TECHNOLOGY," SUSTAINABLE ENVIRONMENT RESEARCH, 29:12.

This research focuses on a water quality monitoring system for large-scale aquatic environments using wireless sensor networks (WSNs). It discusses the integration of multiple sensors and wireless communication for remote monitoring of parameters like pH, turbidity, and temperature. The study emphasizes the system's ability to provide real-time data from dispersed locations, which is crucial for managing large water bodies. Although the focus is on wireless networks, the concept of remote data collection and real-time monitoring aligns with the goals of our system.

WANG, H., ZHANG, Y., & LIU, Z. (2018). "A REAL-TIME MONITORING SYSTEM FOR WATER QUALITY USING EMBEDDED SYSTEMS," ENVIRONMENTAL MONITORING AND ASSESSMENT, VOL. 190, NO. 6.

This paper describes a real-time water quality monitoring system that uses embedded systems to measure multiple water quality parameters, including pH, turbidity, and dissolved oxygen. The study focuses on integrating the sensors with a microcontroller and a local display, providing real-time feedback. The system also incorporates a cloud-based platform for data logging and remote access. The embedded system design used in this research provides a solid basis for our approach, particularly in the integration of sensors and microcontroller for real-time water monitoring.

MOHAN, M., & SIVASUBRAMANIAN, K. (2017). "DEVELOPMENT OF AN IOT-BASED WATER QUALITY MONITORING SYSTEM," INTERNATIONAL JOURNAL OF ENGINEERING & TECHNOLOGY, VOL. 7, NO. 4, PP. 2211-2215.

This paper explores the use of the Internet of Things (IoT) for real-time water quality monitoring. The authors discuss a system that integrates multiple water sensors and transmits data to a remote server via Wi-Fi for analysis and visualization. The study also addresses the challenges of power consumption and sensor calibration, making it relevant for our project. While our system does not rely on IoT, the concepts related to sensor integration, data transmission, and real-time monitoring provide valuable insights for our design.

KUMAR, S., & GOPAL, V. (2016). "A NOVEL LOW-COST WATER QUALITY MONITORING SYSTEM BASED ON ARDUINO," JOURNAL OF ENVIRONMENTAL MANAGEMENT, VOL. 186, PP. 350-357.

This study focuses on a low-cost water quality monitoring system based on Arduino, designed to monitor water parameters such as pH, turbidity, and TDS. The authors highlight the affordability of the system and its suitability for rural and underserved areas. They emphasize ease of implementation and scalability, both of which are key goals for our project. The paper provides a framework for sensor integration and the use of microcontrollers in cost-effective environmental monitoring**.**

ZHANG, L., & YU, W. (2019). "DESIGN OF AN AUTOMATIC WATER QUALITY MONITORING SYSTEM BASED ON INTERNET OF THINGS," WATER, VOL. 11, NO. 5, PP. 968-977.

This paper proposes a smart water quality monitoring system using IoT technology to collect data on various water parameters, including turbidity, temperature, pH, and conductivity. The system features real-time data transmission and cloud-based data storage for easy access. The study's focus on real-time data collection and user alerts is relevant to our project, although we focus on a non-IoT solution.

JEETENDRA KUMAR, RASHMI GUPTA, SUVARNA SHARMA, TULIKA CHAKRABARTI, PRASUN CHAKRABARTI, AND MARTIN MARGALA "IOT-ENABLED ADVANCED WATER QUALITY MONITORING SYSTEM FOR POND MANAGEMENT AND ENVIRONMENTAL CONSERVATION", VOL.12, IEEE EXPLORE 2024

This paper proposes wireless acquisition system for monitoring real-time water quality that makes use of the Arduino (ESP32) microcontroller. This system allows us to collect data in real-time. This cutting-edge technology collects data from a variety of pond locations utilizing three individual sensors to perform remote measurements of three critical parameters: turbidity, TDS, and pH. The integration of the system with an aquatic boat enables complete sampling from the center as well as the sides of the pond, which is a significant step forward in terms of innovation. The collected information, which may include pH, turbidity, and TDS readings, is uploaded to the cloud so that it may be evaluated in real-time using the AquaSpecs app. The effectiveness of the proposed system has been proven by deployment in four ponds in Chhattisgarh; these ponds are named Birkona Pond, Budha Pond, Dagania Pond, and Kushalpur Pond.

PRAVEENA, 2RENUGHA.S.S , 3SABARI VASAN.P, 4SANTHOSH.R, 5RAGUL GANDHI, "REAL-TIME WATER QUALITY MONITORING USING IOT " IJCRT | VOLUME 11, ISSUE 5 MAY 2023 | ISSN: 2320-2882.

This paper proposes numerous ways to consume water. People use municipal water, borewells, and many other resources. But is it safe to drink straight from the ground or to filter it in any way? It might have dangerous substances in it, making it unfit for drinking. Drinking such water could have a number of negative health effects. Several things can contaminate water. Water pollution has an impact on both people and flora. We can determine its pollution level using IoT. We can keep an eye on the water's quality for drinking, agricultural, and domestic use. Knowing the water's quality allows us to change the filtering method. This water quality monitoring system aims to determine the water quality, or how clean the water is. This water quality monitoring system uses various sensors and microcontrollers to find water quality, i.e., how the water's pH content and dissolved oxygen contents vary, and send the data to the users. The user can check the previous data and can know the pattern of the varied data, if any. This whole system fits in any water point. The values from the sensors are checked with the standard water qualities and the data is displayed in the web application from the cloud server.

H.M. FORHAD [A], MD.RIPAJ UDDIN [B], R.S. CHAKROVORTY [A], A.M. RUHUL [A], H.M. FARUK [A], SARKER KAMRUZZAMAN [A], NAHID SHARMIN [A], AHM SHOFIUL ISLAM MOLLA JAMAL [B], MD. MEZBA-UL HAQUE [C], AKM M MORSHED , "IOT BASED REAL-TIME WATER QUALITY MONITORING SYSTEM IN WATER TREATMENT PLANTS (WTPS)" VOLUME 10, ISSUE 23, SCIENCE DIRET15 DECEMBER 2024, E40746

This study presents the development and implementation of an Internet of Things (IoT)-based real-time water quality monitoring system tailored for water treatment plants (WTPs). The system integrates advanced sensor technologies to continuously monitor key water quality parameters such as pH, dissolved oxygen (DO), total dissolved solids (TDS), and temperature. Data collected by these sensors is transmitted through a robust communication network to a centralized monitoring platform that utilizes cloud-based storage and analytics. The system's design includes a PLC-based control mechanism, allowing for flexible setup modifications and the easy addition of new monitoring parameters. The IoT-based system, powered by a low-energy 29-W configuration, offers accurate and reliable data with a minimal error margin of 0.1–0.2 across various parameters. The research highlights the system's ability to provide real-time alerts, historical data logging, and remote monitoring, all of which contribute to enhanced operational efficiency, proactive maintenance, and informed decision-making. This innovative approach to water quality management not only improves the effectiveness of WTP operations but also ensures environmental sustainability and public health safety. The study underscores the significant potential of IoT technologies in revolutionizing water quality monitoring practices.

FARMANULLAH JAN, NASRO MIN-ALLAH ,DILEK DÜŞTEGÖR, "IOT BASED SMART WATER QUALITY MONITORING: RECENT TECHNIQUES, TRENDS AND CHALLENGES FOR DOMESTIC APPLICATIONS", *WATER* 2021, *13*(13), 1729; HTTPS://DOI.ORG/10.3390/W13131729,MDPI.

Safe water is becoming a scarce resource, due to the combined effects of increased population, pollution, and climate changes. Water quality monitoring is thus paramount, especially for domestic water. Traditionally used laboratory-based testing approaches are manual, costly, time consuming, and lack real-time feedback. Recently developed systems utilizing wireless sensor network (WSN) technology have reported weaknesses in energy management, data security, and communication coverage. Due to the recent advances in Internet-of-Things (IoT) that can be applied in the development of more efficient, secure, and cheaper systems with real-time capabilities, we present here a survey aimed at summarizing the current state of the art regarding IoT based smart water quality monitoring systems (IoT-WQMS) especially dedicated for domestic applications. In brief, this study probes into common water-quality monitoring (WQM) parameters, their safe-limits for drinking water, related smart sensors, critical review, and ratification of contemporary

DOI: 10.17148/IARJSET.2024.111211

IoT-WQMS via a proposed empirical metric, analysis, and discussion and, finally, design recommendations for an efficient system. No doubt, this study will benefit the developing field of smart homes, offices, and cities.

SUMMARY OF LITERATURE SURVEY

These studies highlight the growing trend of developing cost-effective, real-time water quality monitoring systems that use sensors and microcontrollers to measure and report key parameters. The focus on Arduino-based solutions and the use of sensors for continuous monitoring aligns closely with the objectives of this project. However, many of the existing solutions either focus on IoT systems or are not fully focused on providing user-friendly, localized data visualization. Our approach combines the strengths of these previous works by developing a system that is both low-cost and efficient, without relying on the complexities of IoT-based systems. The integration of Arduino-based sensors with a local display and real-time alerts makes this solution more accessible for users who may not have access to advanced infrastructure or technical expertise.

III. SYSTEM DESIGN AND COMPONENTS

The water quality monitoring system integrates a variety of hardware components, each chosen for its ability to accurately measure specific water quality parameters. The hardware setup includes:

Arduino Microcontroller: The core of the system is an Arduino microcontroller, an open-source platform that acts as the brain of the system. The Arduino is responsible for collecting sensor data, processing the information, and controlling various components. It is chosen for its versatility, low cost, and ease of programming, making it an ideal choice for building real-time environmental monitoring systems. The microcontroller connects all the sensors and ensures that the collected data is appropriately handled, whether for display or transmission.

pH Sensor: The pH sensor is used to measure the acidity or alkalinity of water. pH is a critical parameter in determining water quality, as extreme values can indicate pollution or the presence of harmful substances. The sensor works by detecting the concentration of hydrogen ions in the water, providing a real-time measurement of the pH level. It is particularly important for monitoring aquatic ecosystems and ensuring the safety of drinking water.

Turbidity Sensor: The turbidity sensor measures the clarity of the water by detecting the amount of suspended particles. High turbidity levels indicate that the water contains suspended solids, such as dirt, algae, or pollutants, which can be harmful to both aquatic life and human health. The turbidity sensor uses a light source and photodetector to measure the scattering of light caused by particles in the water. It is crucial for determining water cleanliness and can help in detecting pollution sources.

Temperature Sensor: The temperature sensor monitors the water's temperature, which is a vital parameter in assessing water quality. Temperature affects the solubility of oxygen in water, influencing the survival of aquatic organisms. It can also indicate thermal pollution, where industries or power plants discharge hot water into nearby water bodies. The temperature sensor continuously measures the water temperature and provides important data for assessing the overall health of the aquatic environment.

TDS Sensor (Total Dissolved Solids): The TDS sensor measures the concentration of dissolved solids in the water, including salts, minerals, and metals. A high TDS level often signifies pollution, as it can indicate the presence of chemicals or other harmful substances in the water. The TDS sensor works by measuring the electrical conductivity of the water, which increases with the number of dissolved particles. Monitoring TDS is essential for ensuring that water is safe for consumption and aquatic life.

Flow Sensor: The flow sensor is responsible for measuring the rate at which water flows through a pipe or a water body. Monitoring water flow helps in understanding water distribution systems and can detect any unusual changes that may signify blockages or leakages. It is also useful in assessing water usage and ensuring that the water supply remains constant. The flow sensor works by measuring the velocity of water passing through a tube and converting this into a flow rate measurement.

Wi-Fi Module: The Wi-Fi module provides wireless communication capabilities, allowing the system to transmit collected data to a remote server or cloud platform. This enables real-time monitoring and access to data from anywhere. The Wi-Fi module ensures that the system can operate remotely, making it ideal for large-scale deployments in rivers, lakes, or industrial areas where manual monitoring would be impractical.

TFT Display: The TFT (Thin-Film Transistor) display is used to visually display the real-time data collected by the sensors. It provides a user-friendly interface where parameters like pH, turbidity, temperature, TDS, and flow rate are shown in real-time. The display is an essential component for providing immediate feedback to users and enabling quick response actions when any parameter exceeds the predefined thresholds.

DOI: 10.17148/IARJSET.2024.111211

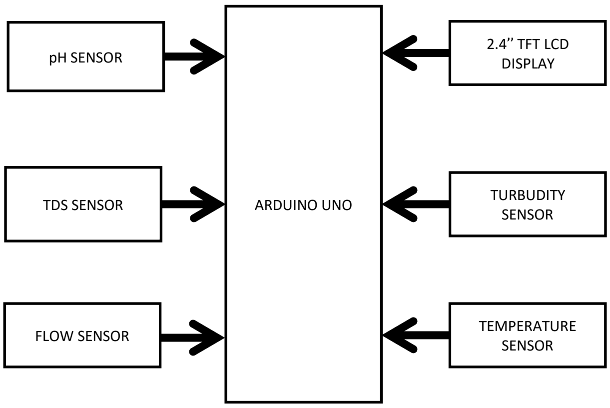

Fig 1. Block diagram

IV. CONCLUSION

The possible outcomes of the proposed project s real-time water quality monitoring system that is accurate, reliable, and cost-effective, leveraging advanced technologies to provide continuous and real-time data on essential water quality parameters such as pH, turbidity, temperature, and flow rate. By utilizing a combination of sensors and a microcontroller, the system ensures precise measurements while remaining affordable and accessible, making it an ideal solution for both small-scale and large-scale applications. This system not only offers immediate feedback on water quality but also allows for the detection of potential contamination issues before they escalate, enhancing the overall safety of water sources. Additionally, the project plans to expand the system to monitor additional water quality parameters such as dissolved oxygen levels, heavy metals, and other contaminants, making it even more comprehensive. These advancements will further improve the system's versatility, scalability, and applicability across different industries, from environmental monitoring to industrial wastewater management, ensuring that the system remains at the forefront of real-time water quality monitoring and contributes to better, more sustainable water resource management in the future.

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