# IoT BASED SMART WATER QUALITY MONITORING SYSTEM FOR ENVIRONMENTAL PROTECTION AND SUSTAINABILITY

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***Abstract*** **- The major source of accessible fresh water, rivers, faces contamination from various sources including population growth, industries, and agriculture, posing significant health risks. Continuous monitoring of parameters like pH, turbidity, dissolved oxygen (DO), and biological oxygen demand (BOD) is essential to ensure safe water supply. Traditional manual methods are inefficient and time-consuming. Integrating Wireless Sensor Networks (WSN) with IoT offers a cost-effective solution for real-time data collection, transmission, and analysis. Sensors placed at different sampling locations gather data which is then pre-analyzed and transmitted to a central office for monitoring. WSN provides autonomy, reliability, and cost-effectiveness, revolutionizing water quality monitoring practices.**

***Key words: Water Quality, Monitoring, Internet of Things, Sensors***

## I INTRODUCTION

Water pollution poses a significant threat to ecosystems and human health, underscoring the urgent need for advanced monitoring technologies. The scarcity of safe water is exacerbated by factors such as population growth, pollution, and climate change, making water pollution a major impediment to sustainable development [1]. Continuous monitoring of drinking water quality is essential to ensure a safe supply. Hence to avoid serious health issues, minimize load in water treatment plant and ensure the safe supply of drinking water there is a need for continuous monitoring of these parameters [2]. They include pH, turbidity, dissolved oxygen (DO), biological oxygen demand (BoD) etc.

Traditional methods are manual, which includes sample collection and laboratory-based analysis and are less effective, costly, time consuming, and lack of real-time results and hence challenging. Thus there is a need to rely on wireless sensor networks or wireless technology, which present challenges including data security vulnerabilities, limited communication coverage, and energy consumption management issues.

The emergence of the Internet of Things (IoT) has revolutionized water quality monitoring by facilitating the development of more efficient, secure, and cost-effective systems with real-time capabilities.

By leveraging IoT technology, stakeholders can address the pressing need for comprehensive water quality management, mitigating the adverse impacts of pollution and fostering sustainable practices in the face of global challenges [3, 4].

## II CONCEPTS OF IoT IN WATER QUALITY MONITORING

Integrating Wireless Sensor Networks (WSN) with the Internet of Things (IoT) represents an innovative approach for real-time data collection, transmission, and processing in water quality monitoring systems [4]. Sensors placed strategically at various sampling locations within water sources detect key parameters, with the collected data undergoing initial analysis before transmission to a centralized office. Subsequently, sensor data is routed through a gateway to the cloud or stored within software via communication networks.

Key sensors employed in these systems encompass pH, turbidity, conductivity, dissolved oxygen, and biological oxygen demand sensors. Management software platforms such as Arduino UNO, Raspberry Pi, ZigBee, and XBee facilitate data handling and analysis [5-7]. Continuous monitoring ensures adherence to quality parameters.

The benefits of employing wireless sensor networks are manifold, including autonomy, reliability, robustness, flexibility, speed, accuracy, and cost-effectiveness [8]. By harnessing these advantages, stakeholders can enhance water quality management, addressing environmental concerns and safeguarding public health more effectively.

## III RELATED WORK

Petkovski et al. conducted an SLR on IoT-based aquaculture systems, defining five research questions regarding sensor types, single-board computers, data transport protocols, cloud platforms, and IoT benefits. They found 17 sensor types, with temperature, pH, and DO most common. Raspberry Pi, Arduino, and ESP were the top single-board computers. However, the study lacked details on sensor manufacture, models, and costs, leaving gaps in practical implementation understanding. Manoj reviews Water Quality Monitoring Systems (WQMS) for fish ponds, focusing on IoT solutions and implementing a water quality management system with underwater sensors.

They identify fifteen recent papers on WQMS, mostly incorporating IoT and pH and temperature sensors. The authors note limited information on sensor costs, mostly deeming them low-cost. Notably, some papers highlight the use of nitrate ($NO^{-3}$) and ammonia ($NH_3$, or AmmoLyt) sensors to gauge freshwater concentrations, crucial for managing total nitrogen levels.

Silva et al. review online and in situ water quality monitoring advancements, focusing on various parameters like color, temperature, DO, turbidity, chlorine, fluorine, metals, nitrogen, pH, phosphorus, ORP, algae, cyanobacteria, coliforms, and E. coli. They highlight optical and electrochemical sensors as common measurement methods, urging for robust real-world assessments to validate recent technological developments. Alexander et al. developed an affordable water quality monitoring system using commercial electrochemical sensors, integrated with WSN and GSM technology. The system accurately monitors water parameters and displays real-time results via a web interface. Tested against standard laboratory setups and Horiba handheld multi-tester, it provides valuable insights into water quality. The system comprises off-the-shelf sensors, a microcontroller, wireless communication, and a customized buoy, disseminating data via a web portal and preregistered mobile phones.

Rahman et al. integrated a smart sensor interface device with Arduino to monitor water quality parameters such as pH, turbidity, temperature, dissolved oxygen, and salinity. The system utilizes Node MCU for online data transmission and features QR codes for users to verify water safety. Suitable for agriculture and public water supply, this innovative solution enables real-time monitoring and ensures safe water consumption.

## IV COMPONENTS OF IOT IN SWQM SYSTEM

As an example of high-level flow chart of how an IoT system for water monitoring might work, the sequence of information flow may look like the following (Figure 1). Various components include: Sensors -Water quality sensors are installed in the water sources for real time monitoring [3]. These sensors collect data on various parameters such as pH, temperature, and dissolved oxygen levels; Data collection and transmission- The data collected by sensor is transmitted to a central server or cloud service using a wireless communication protocol such as WiFi, Bluetooth, or cellular [9, 10]; Data storage and processing- The sensor data is stored on the central server or cloud service and then processed and analyzed by algorithms or software to identify trends and patterns; Alerts- If the sensor data indicates that there is a problem with the water quality an alert is sent to the appropriate authorities [11]; Database- The authorities can gather information in database for taking action to address the issue and for future reference.

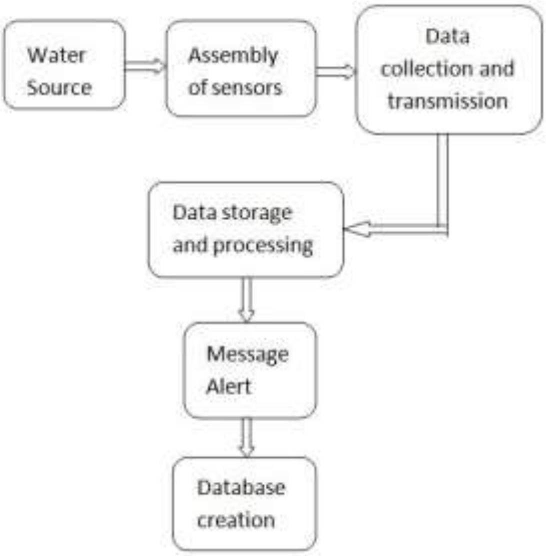


**Fig1. Schematic arrangement of IoT components for WQM**

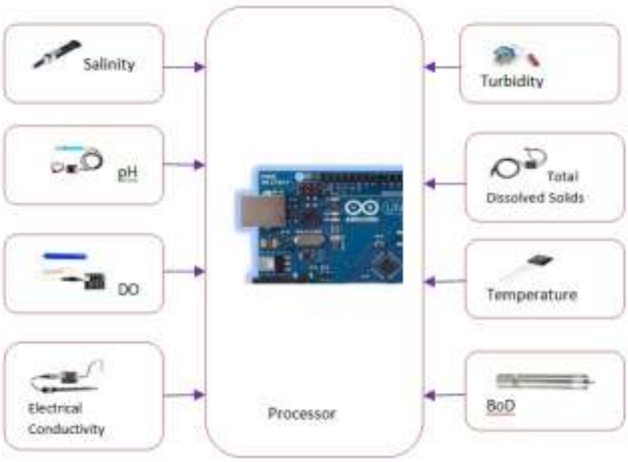


**Fig. Various Components identified with IoT**

## V ADVANCES OF IoT IN WATER QUALITY MONITORING

**Continuous Monitoring**: IoT devices enable continuous data collection, providing real-time insights into water quality parameters such as temperature, pH, and oxygen levels [5, 8].

**Remote Access and Analysis**: Data collected by IoT devices can be accessed and analyzed remotely, facilitating monitoring of water quality in remote or inaccessible locations.

**Quick Response to Issues**: Continuous monitoring allows for early detection of water quality issues, enabling prompt intervention to prevent further deterioration and mitigate risks to human health and the environment [13, 14].

**Increased Efficiency**: IoT technologies streamline the process of water quality assessment, leading to more efficient and cost-effective monitoring practices.

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