IJIRIS: International Journal of Innovative Research in Information Security E-ISSN: 2349-7017
Volume 11, Issue 11, November 2025 P-ISSN: 2349-7009
https://www.ijiris.com/archives
https://doi.org/10.26562/ijiris.2025.v1111.05

Urban Aqua-Smart Residential Water Quality Detection System

Dr.A.Poonguzhali
Professor& Head, Department of ECE
Sri Sairam College of Engineering, Bangalore, India
poonguzahali.ece@sairamce.edu.in
https://orcid.org/0000-0001-5393-9861
Vidyashree V S, Monisha N, Hamsa B S, Ramya Y S
Department of ECE
Sri Sairam College of Engineering, Bangalore, India
sce22ec122@sairamtap.edu.in, sce22ec002@sairamtap.edu.in
sce22ec111@sairamtap.edu.in, sce22ec114@sairamtap.edu.in

Publication History
Manuscript Reference No: IJIRIS/RS/Vol.11/Issue11/NVISXI10084
Research Article Open Access| Double-Blind Peer-Reviewed| Article ID: IJIRIS/RS/Vol.11/Issue11/NVISXI10084 Received: 28, October 2025, Revised: 05, November 2025, Accepted: 12, November 2025, Published Online: 21, November 2025.
https://www.ijiris.com/volumes/Vol11/iss-11/05.NVISXI10084.pdf
Citation: Dr.Poonguzhali,Vidyashree,Monisha,Hamsa,Ramya(2025),Urban Aqua-Smart Residential Water Quality Detection System, IJIRIS: International Journal of Innovative Research in Information Security, Volume 11, Issue 11 of 2025 pages 755-759 **Doi:>** https://doi.org/10.26562/ijiris.2025.v1111.05
BibTeX Key:Dr.Poonguzhali@Urban
IJIRIS papers should be cited as IJIRIS (International Journal of Innovative Research in Information Security, AM Publications, India 2025, ISSN 2349-7017, https://doi.org/10.26562/ijiris.2025.v1111.05 The journal's official abbreviation is IJIRIS. Orcid: https://orcid.org/0009-0004-9398-7488

Abstract: Urban Aqua – Smart Residential Water Quality Detection System is an IoT- and blockchain-enabled solution designed to ensure safe, transparent, and continuous monitoring of water supplied to urban households. Residential apartments often rely on shared water tanks where quality deterioration from pipe corrosion, stagnation, and improper treatment goes unnoticed. Traditional manual testing is slow, inconsistent, and lacks reliable documentation, while cloud-based systems remain vulnerable to data tampering. To solve these limitations, UTKARSH integrates ESP32 NodeMCU with calibrated sensors to measure pH, Total Dissolved Solids (TDS), turbidity, and temperature in real time. Sensor readings are transmitted to the Thing Speak cloud platform for visualization and to the Blynk mobile application for instant alerts when unsafe values are detected. Every data packet is additionally hashed using SHA-256 and stored on a private blockchain ledger, ensuring immutability, security, and trust in the recorded information. An on-board OLED display provides instant, offline access to the latest quality metrics. The proposed system is low-cost, scalable, and ideal for household-level deployment. By combining IoT sensing, mobile connectivity, and blockchain-based verification, UTKARSH enables proactive decision-making, prevents exposure to contaminated water, and supports smart, sustainable living in modern urban communities.
Keywords: IoT, Blockchain, Water Quality Monitoring, ESP32, pH Sensor, TDS Sensor, Turbidity Sensor, Temperature Sensor, ThingSpeak, Blynk App, Smart Homes, SHA-256 Hashing, Real-Time Alerts, Secure Data Logging, Urban Water Safety.

I. INTRODUCTION

Access to safe and clean water is essential for maintaining public health, yet urban households especially those living in apartments often rely on water supplied through tankers and shared storage systems with no mechanism for continuous quality monitoring. Contamination due to pipe corrosion, stagnant storage, mixing of untreated water, or external pollutants can occur at any stage of the supply chain. Since most residential communities depend on manual testing or occasional laboratory checks, changes in water quality often remain undetected until they lead to health issues or visible deterioration in water clarity and taste. This lack of real-time insight creates a significant risk of waterborne diseases and undermines trust between residents and water suppliers. With the rapid growth of smart cities and IoT technologies, there is a growing need for an affordable and intelligent system that can continuously monitor water quality and provide transparent, data-driven reporting. Traditional IoT-based water monitoring solutions often store data on cloud servers, where the information may be vulnerable to manipulation or accidental loss. To ensure reliability, the system must not only monitor water quality effectively but also protect the integrity of the collected data.

UTKARSH: Urban Aqua – Smart Residential Water Quality Detection System addresses these challenges by integrating real-time sensing with secure data management. The proposed system uses an ESP32 microcontroller along with pH, TDS, turbidity, and temperature sensors to monitor essential water parameters. The data is transmitted to the Thing Speak cloud for visualization and the Blynk mobile app for instant user alerts.

To guarantee trust and transparency, each reading is encrypted with SHA-256 and stored on a private blockchain network, ensuring that the data remains immutable and tamper-proof. An onboard OLED display provides immediate access to current readings even without internet connectivity. By combining IoT, cloud computing, mobile applications, and blockchain technology, UTKARSH offers a reliable, cost-effective, and scalable solution for modern residential communities. It empowers households with real-time insights, enhances transparency in water supply systems, and supports smart-city initiatives aimed at improving public health and environmental sustainability.

2. RELATIVE WORK

Authors: Harish N., Lakshmi Prasad
Year: 2024
Findings: The authors designed a smart-city water-quality framework using ESP32, where multiple sensors transmitted data to a centralized cloud dashboard. The system worked efficiently for municipality-level monitoring but failed to provide data credibility at the consumer level. Their results showed that centralized cloud systems are extremely vulnerable to:

- Data tampering by intermediaries such as tanker suppliers,
- Accidental overwriting during maintenance,
- Loss of historical records during server downtime,
- Misreporting, because residents cannot verify the authenticity of readings.

Furthermore, the researchers highlighted that cloud-only systems create a “trust gap” between end-users and water service providers. They strongly recommended future systems to incorporate decentralized verification, secure time stamping, and immutable storage, which UTKARSH achieves through its private blockchain ledger and SHA-256 hashing, ensuring that no reading can ever be manipulated or deleted.

Author: Aishwarya B., Mohammad Rehan
Year: 2023
Findings: Their IoT-based household water alert system demonstrated good performance in detecting sudden spikes in turbidity and pH imbalance. However, long-term testing revealed multiple weaknesses:

- The Blynk cloud occasionally failed to sync readings, causing delays in alerts.
- Sensor drift over time led to inaccurate values, with no integrated mechanism for recalibration.
- The system lacked fault detection, so sensor malfunctions often went unnoticed.
- Data was stored in the cloud without encryption, exposing it to modification, duplication, and unauthorized access.
- The model did not include an offline fallback, making it unusable during Wi-Fi outages.
  Their conclusion clearly emphasized the need for systems that combine secure data logging, self-verifying storage, accurate sensor calibration, and offline visibility — all of which UTKARSH integrates through blockchain-backed validation, precision sensors, and an OLED display for on-site reading.

Author: Uday Bhanu Ghosh, Rohan Sharma
Year: 2023
Findings: The authors developed an IoT + machine learning model to classify water quality levels and predict future contamination trends. While the predictive performance was promising, the researchers stored all data in a centralized server without verification, making the predictions dependent on data that could be altered or corrupted. Without proof of-integrity techniques like hashing or blockchain, the system’s long-term reliability was limited. They also highlighted that ML models require clean, tamper-proof historical data to maintain accuracy, something their system could not guarantee. Their work stresses the need for secure, decentralized, immutable data storagea feature UTKARSH delivers through its blockchain layer, ensuring accurate analysis and trustworthy records. that could redefine auditory information sharing in both public and commercial environments.

2.1 Methodology

The methodology of UTKARSH – Urban Aqua: Smart Residential Water Quality Detection System is designed to provide continuous, accurate, and secure monitoring of household water quality by integrating IoT sensing, wireless communication, and blockchain technology into a single unified framework. The process begins with the deployment of four essential water-quality sensors pH, TDS, turbidity, and temperature installed at the apartment water tank or the incoming water line. These sensors continuously collect real-time information about the chemical and physical characteristics of the water. Their analog signals are fed into the ESP32 NodeMCU, which functions as the central microcontroller of the system. Before reading the measurements, the ESP32 performs signal conditioning, noise reduction, and ADC conversion to ensure that only calibrated and reliable values are processed. Once the sensor data is validated, the microcontroller formats the readings along with their timestamps into structured data packets. Following this, the ESP32 uses its inbuilt Wi-Fi module to transmit the processed data to two cloud endpoints. The first endpoint is ThingSpeak, which stores the readings in real time and generates visual graphs that help track long-term trends in water quality. The second endpoint is the Blynk IoT Application, which displays live values on the user’s smartphone and immediately notifies residents when parameters exceed safe limits such as high TDS, abnormal pH, or increased turbidity. Alongside cloud storage, every reading is secured using a blockchain-based immutability layer. Each dataset is hashed using the SHA-256 algorithm, assigned a timestamp, and stored in a private blockchain ledger, ensuring that the values cannot be modified, deleted, or tampered with by any unauthorized person.

This decentralized verification layer increases trust between residents, building management, and water suppliers, as the blockchain guarantees authenticity, transparency, and safety compliance. An OLED display is integrated into the system to provide instant offline access to sensor readings in locations where cloud connectivity is unavailable, such as inside the pump room or near the overhead tank. This ensures that maintenance staff and residents can check water quality even during network failures. The system operates continuously, with the ESP32 monitoring threshold values for each parameter and triggering alerts when unsafe conditions are detected. Throughout the development process, the system undergoes several calibration and testing stages including sensor accuracy checks, waterproofing validation, Wi-Fi stability testing, blockchain integrity confirmation, and stress testing under fluctuating water conditions. By combining real-time IoT sensing, secure blockchain storage, cloud dashboards, mobile alerts, and offline visibility, the UTKARSH methodology delivers a highly reliable and transparent water-quality monitoring solution suitable for modern urban households.

SYSTEM ARCHITECTURE

The system architecture of **UTKARSH** is designed as a multi-layered IoT framework that integrates real-time sensing, intelligent processing, secure data storage, and user-friendly visualization. It combines calibrated water-quality sensors with an ESP32 microcontroller to continuously capture and analyze key parameters. The architecture supports seamless cloud communication through Wi-Fi while ensuring data integrity using a private blockchain ledger. Together, these layers create a reliable, transparent, and scalable solution for residential water-quality monitoring.

1. Input Layer (Sensing Unit)

The Input Layer consists of the essential water-quality sensing components that continuously measure the physical and chemical characteristics of the water. This includes the pH sensor, TDS sensor, turbidity sensor, and the DS18B20 temperature sensor. These sensors are installed at the water tank or the inlet pipe, where they capture real-time variations in acidity, dissolved solids, clarity, and temperature. Each sensor produces analog or digital signals that reflect the current condition of the water. Before forwarding these signals to the microcontroller, the sensors undergo calibration to ensure accuracy in reading. This layer forms the foundation of the system by gathering raw, real-time data needed for processing and decision-making.

2. Processing Layer (ESP32 Core Unit)

At the center of the architecture lies the Processing Layer, handled by the ESP32 microcontroller. This layer is responsible for converting the raw sensor signals into usable numerical values through ADC (Analog-to-Digital Conversion). The ESP32 performs filtering to eliminate noise, validates the incoming data, and compares the readings with predefined safe thresholds. It attaches timestamps to each measurement and organizes the data into structured packets for transmission. The microcontroller plays a crucial role in ensuring that the system remains accurate, responsive, and capable of identifying abnormal water quality patterns such as high TDS or acidic pH levels. This processing layer acts as the decision-making engine of the UTKARSH system.

3. Communication Layer (Wi-Fi & Cloud Connectivity)

The Communication Layer is responsible for sending the processed data to external platforms for storage, visualization, and user notification. Using its built-in Wi-Fi capability, the ESP32 transmits data to the ThingSpeak cloud platform, where readings are stored and represented graphically for long-term analysis. Simultaneously, the data is sent to the Blynk IoT mobile application, which provides users with a real-time dashboard of all parameters. This layer also sends instant push notifications whenever water quality crosses unsafe limits. By maintaining a dual cloud communication strategy, the system ensures reliability, redundancy, and continuous access to data for residents.

4. Security and Storage Layer (Blockchain Integration)

The Security & Storage Layer introduces a critical enhancement through blockchain-based data protection. Each sensor reading is converted into a secure SHA-256 hash and added to a private blockchain ledger along with a timestamp. This decentralized storage mechanism ensures that all entries are immutable, meaning they cannot be modified, deleted, or tampered with. The blockchain layer solves the major issue found in traditional cloud-based systems—data manipulation or accidental loss. By maintaining an unalterable chain of records, UTKARSH provides complete transparency and trustworthiness, allowing residents and housing authorities to rely confidently on the historical water-quality data.

5. Output and User Interface Layer (Display & Alerts)

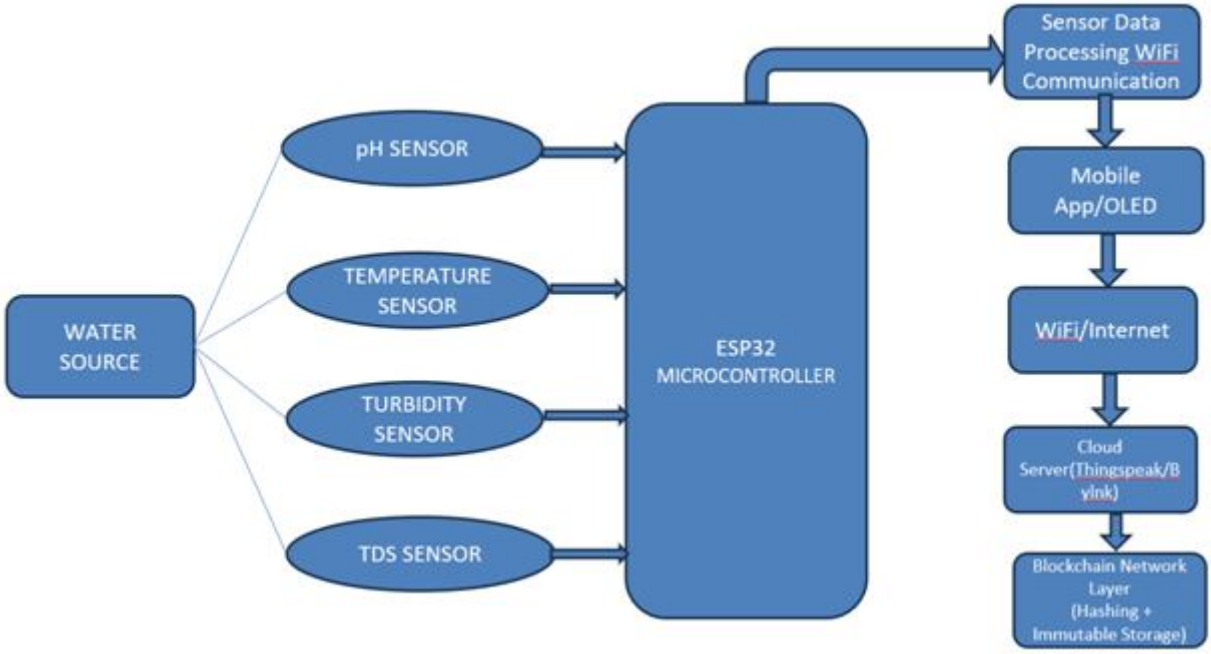
The Output and User Interface Layer presents the processed data to the end users in real time. An OLED display attached to the system provides instant on-site visibility of current pH, TDS, turbidity, and temperature readings, even without internet connectivity. The Blynk mobile application serves as the primary user interface, delivering a clean graphical dashboard and sending instant alerts whenever unsafe water conditions are detected. Additionally, the ThingSpeak cloud dashboard offers detailed graphs and historical trends, helping users track water quality over days, weeks, or months. This layer ensures that residents have clear, continuous, and convenient access to safe water information at all times.

MODULE IDENTIFICATION

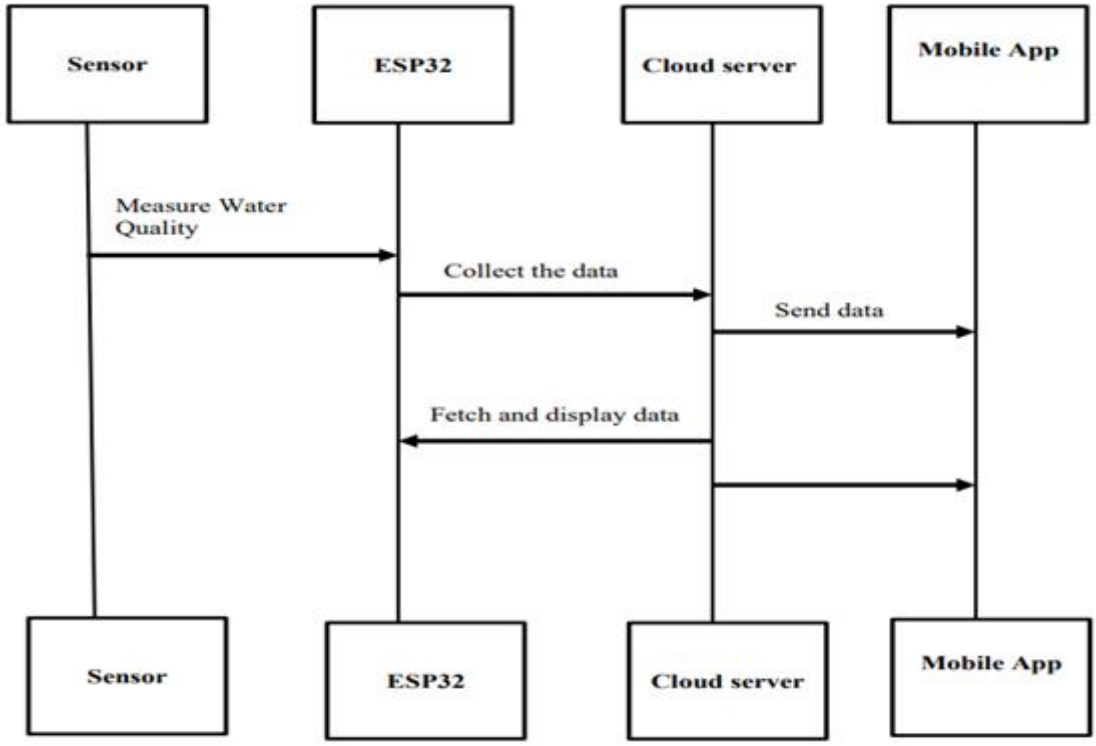
1. Sensor Acquisition Module

This module is responsible for continuously capturing real-time water-quality parameters using calibrated sensors. It includes the pH sensor, TDS sensor, turbidity sensor, and DS18B20 temperature sensor. These sensors detect changes in acidity, dissolved solids, water clarity, and temperature, converting physical water properties into electrical signals.

IJIRIS: International Journal of Innovative Research in Information Security E-ISSN: 2349-7017
Volume 11, Issue 11, November 2025 P-ISSN: 2349-7009
https://www.ijiris.com/archives
https://doi.org/10.26562/ijiris.2025.v1111.05



Circuit Diagram



Sequence Diagram

The primary function of this module is to provide accurate, raw input data to the system, forming the foundation for all subsequent processing and analysis.

2. Processing & Decision Module (ESP32 Core Unit)

The ESP32 microcontroller forms the heart of this module. It receives raw sensor signals and performs ADC conversion, filtering, and validation to ensure accurate readings. The ESP32 then compares sensor values with predefined safety thresholds and generates decision outputs such as alerts or warnings. It also attaches timestamps, structures the data packets, and prepares them for transmission. This module acts as the intelligent decision-making unit of the UTKARSH system.

3. Communication & Cloud Module

This module handles the wireless transmission of processed data to external platforms using the ESP32's inbuilt Wi-Fi. It sends real-time readings to the ThingSpeak cloud, enabling long-term visualization and trend analysis, and to the Blynk mobile application, which provides a live dashboard and instant notifications. The module ensures uninterrupted data flow between the device, cloud servers, and user interfaces, enabling seamless access to water-quality information.

4. Blockchain Security Module

To ensure data authenticity and prevent manipulation, this module secures every water-quality reading using SHA-256 hashing and stores it in a private blockchain ledger. Each entry is time-stamped and linked cryptographically to previous blocks, making the data immutable. This module guarantees that no reading can be modified, deleted, or altered, thereby maintaining high transparency and trust for residents, housing authorities, and water suppliers.

5. User Interface & Display Module

This module provides both online and offline access to water-quality data. It includes an **OLED display** mounted on the system for local, on-site reading, ensuring visibility even during network outages. It also includes the Blynk app interface and ThingSpeak dashboard, which display detailed graphs, live sensor values, and alert messages. The module enhances usability by ensuring that water-quality information is available anytime, anywhere, in a clear and understandable format.

CONCLUSION

The UTKARSH system successfully demonstrates a modern, reliable, and intelligent approach to residential water-quality monitoring by integrating IoT sensing, cloud connectivity, and blockchain-based data security into a unified platform. By continuously measuring key parameters such as pH, TDS, turbidity, and temperature, the system provides residents with real-time awareness of water safety and ensures timely alerts whenever contamination occurs. Unlike traditional manual testing or cloud-only systems, UTKARSH eliminates the risk of data manipulation by storing every reading in a tamper-proof private blockchain ledger, thus offering complete transparency and trustworthiness. The inclusion of dual cloud platforms, mobile app dashboards, and an OLED offline display ensures consistent accessibility and uninterrupted monitoring. Overall, UTKARSH delivers a cost-effective, scalable, and user-friendly solution that enhances public health, strengthens accountability in water supply chains, and supports the vision of smart and sustainable residential living.

REFERENCES

1. Harish N. and Lakshmi Prasad, “Smart-City Water Quality Monitoring Using IoT and Cloud Platforms,” International Journal of Smart Systems, vol. 12, no. 4, pp. 45–52, 2024.
2. Aishwarya B. and Mohammad Rehan, “Real-Time Domestic Water Safety Alert System Using Blynk and ESP32,” Journal of IoT Research and Applications, vol. 10, no. 2, pp. 88–96, 2023.
3. Ketan Patel and S. Ramesh, “IoT-Based Water Tank Monitoring Using NodeMCU for Residential Complexes,” Smart Cities Innovation Journal, vol. 9, no. 1, pp. 27–34, 2022.
4. Li Wei and Chen Yong, “Long-Range LoRa-Based Water Monitoring Network for Rural Infrastructure,” IEEE Sensors Letters, vol. 5, no. 3, pp. 134–140, 2021.
5. Meenakshi R. and Praveen Kumar, “GSM-Based pH and Turbidity Monitoring System for Household Water,” International Journal of Embedded Technologies, vol. 7, no. 2, pp. 60–66, 2020.
6. Hassan Iqbal and Rana Faisal, “Machine Learning Enhanced IoT Water Quality Prediction System,” International Conference on Sustainable IoT Systems, pp. 112–118, 2023.
7. D.Kumar and R.Patil, “Secure IoT Data Storage Using Blockchain Technology for Environmental Monitoring,” IEEE Transactions on Blockchain, vol. 3, pp. 55–63, 2022.
8. S.Verma and A.Gupta, “Blockchain-Enabled Smart Water Management System,” International Journal of Distributed Systems, vol. 11, pp. 101–108, 2021.
9. ThingSpeak Documentation – MathWorks, “IoT Analytics and Data Visualization Platform,” 2024. [Online]. Blynk IoT Platform, “Real-Time Mobile Dashboard for IoT Devices,” 2024. [Online