Ritesh Ashok Patil, 2026, 14:3
ISSN (Online): 2348-4098
ISSN (Print): 2395-4752

International Journal of Science, Engineering and Technology
An Open Access Journal

Smart Water Purity Alert System (SWPAS): An IoT-Based Approach for Real-Time Water Quality Monitoring and Contamination Detection

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Abstract- Access to clean drinking water is still a challenge for a large part of the world. Contamination from bacteria, dissolved solids, heavy metals, and chemicals continues to cause health problems, especially in areas where lab-based testing is slow or unavailable. This paper presents the Smart Water Purity Alert System (SWPAS), a low-cost device built around an ESP32 microcontroller with two water quality sensors measuring turbidity and TDS (total dissolved solids). Sensor data is sent to a cloud platform, and whenever any reading goes beyond the safe limit, users receive an alert via a mobile app, SMS, or a local buzzer. The system was tested on three water samples and correctly identified contaminated water without triggering false alarms on safe samples. Alerts were delivered within 2 to 4 seconds of a threshold breach, and the total hardware cost stayed under ■4,000.

Keywords: IoT, Water Quality Monitoring, TDS, Turbidity, ESP32, Arduino, Smart Alert System, Waterborne Diseases, Cloud Platform.

I. INTRODUCTION

Water is essential for human survival, but its quality is constantly at risk from industrial discharge, agricultural runoff, and poor sanitation practices. The World Health Organization has reported that around 2 billion people have no choice but to drink water contaminated with fecal matter, which leads to hundreds of thousands of preventable deaths every year [1].

The standard method of testing water quality — collecting samples and sending them to a lab — is slow and expensive. In many cases, by the time results are available, communities have already been consuming unsafe water for days. What is needed is a system that monitors water quality without interruption and raises an alarm as soon as a problem is detected.

The Internet of Things provides a practical solution. Connecting low-cost sensors to a microcontroller with wireless capability makes it possible to track water parameters around the clock and notify users immediately when conditions fall below safe levels. This paper presents SWPAS, designed with this purpose in mind: affordable, continuous water safety monitoring deployable in a home, school, or industrial facility without requiring technical expertise.

II. LITERATURE REVIEW

Lakshmikantha et al. [2] developed a cost-effective system that continuously tracked water parameters and sent readings to a cloud server. Their work demonstrated that multi-sample monitoring over a network is feasible, though the system lacked any mechanism to alert users when something went wrong.

Prototype Photograph

Figure 1 shows the actual SWPAS prototype built and tested by the authors. The setup includes the ESP32/Arduino microcontroller board (left), the TDS sensor submerged in a glass of clean water (centre), and the turbidity sensor probe inserted into a glass of contaminated water (right). All sensor modules are connected via jumper wires and a ribbon cable to the processing unit.

Jha et al. [3] added SMS-based notifications when threshold including temperature, turbidity, dissolved oxygen, and conductivity. However, the hardware cost was higher than practical for small-scale or household use.

Fig. 1. SWPAS Hardware Prototype – Arduino/ESP32 microcontroller board (left), TDS sensor in clean water (centre), Turbidity sensor in contaminated water (right).

Prasad et al. [4] applied IoT techniques in the remote Fiji Islands, proving the technology can function in areas with limited infrastructure, though the design was not intended for urban or domestic settings.
SWPAS builds on this existing work by combining multi-parameter sensing, cloud connectivity, mobile alerts, and a local buzzer in a single affordable platform that can be set up without specialist knowledge.

III. SYSTEM ARCHITECTURE AND BLOCK DIAGRAM

The overall design of SWPAS follows the standard IoT stack: sensing layer, processing layer, communication layer, and application layer.

A. Sensing Layer

Two sensors are connected to the water pipeline or storage unit:

- **Turbidity Sensor –** detects water cloudiness. High turbidity indicates suspended particles or contamination. Safe limit: < 5 NTU (WHO).
- **TDS Sensor** – measures total dissolved substances. Readings below 500 mg/L are considered safe for drinking (BIS IS 10500:2012).

B. Processing Layer

An Arduino or ESP32 microcontroller collects analog and digital readings from the sensors, converts them into physical units using calibration equations, and checks each value against predefined safety thresholds.

C. Communication Layer

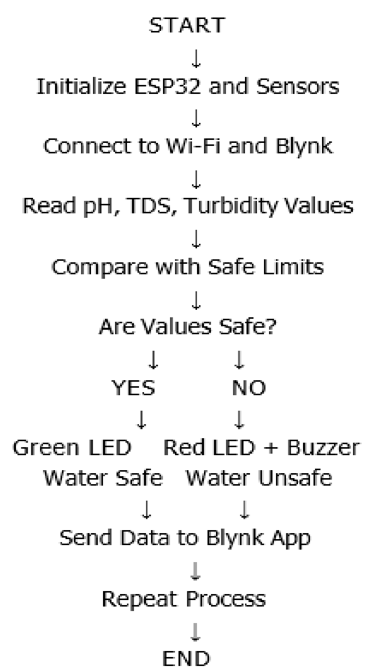
The ESP32 has built-in Wi-Fi and pushes sensor readings to ThingSpeak or Blynk cloud in real time. Where internet access is unavailable, a GSM SIM800L module can be used to send SMS alerts instead.

D. Application Layer

The cloud dashboard displays current water quality readings on smartphones. If any sensor reading goes outside the safe range, the system activates the local buzzer, shows a warning on the LCD display, and sends a push notification or SMS to the registered user.

IV. SENSOR CONNECTION DIAGRAMS

Figures 2 and 3 show the actual hardware of the TDS sensor module and the turbidity sensor module used in the SWPAS prototype, along with their jumper wire connections to the ESP32 microcontroller.



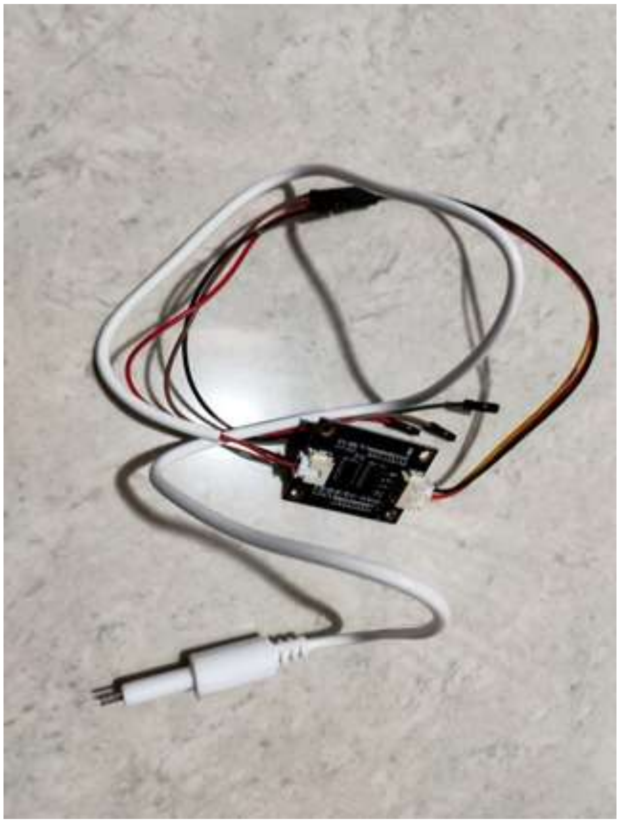


Fig. 2. TDS Sensor Module with signal board and jumper wire connections to ESP32.

V. METHODOLOGY

The system was built in stages: hardware assembly and firmware programming, followed by sensor calibration, integration testing, and field trials using real water samples.

Hardware Components

The core hardware includes an Arduino UNO or ESP32 microcontroller, a digital TDS meter module, an optical turbidity sensor, a DS18B20 waterproof temperature probe, a 16x2 LCD or 0.96" OLED display, Wi-Fi (ESP32 built-in or ESP8266 module), a 5V piezo buzzer with indicator LEDs, a 5V DC power adapter, and a plastic waterproof enclosure. The total estimated hardware cost ranges from1,470 to 3,300, keeping the full assembled system well under 4,000.

Software and Platform

The microcontroller firmware was written in C/C++ using the Arduino IDE. Sensor data is displayed on ThingSpeak or Blynk cloud platforms, which also handle push notifications. A companion mobile application was developed using MIT App Inventor and Android Studio.

Sensor Calibration

Each sensor was calibrated before use. The TDS sensor was checked using a 500 ppm sodium chloride solution. Turbidity was calibrated with distilled water at 0 NTU and a standard calibration fluid. All calibrations were performed at 25°C.

Working Principle

Every five seconds, the sensor array takes a fresh set of readings. The ESP32 uploads these to the cloud and simultaneously compares them against the safe thresholds. If any value falls outside the safe range, the buzzer sounds, the display shows a warning, and an alert is sent to the user's mobile phone via the Blynk app or SMS.

Alert Generation.

If any sensor value crosses the safe limit: A buzzer turns ON

An LED indicator glows

A warning message is sent to the user through the mobile application This helps users know immediately when water quality becomes unsafe.

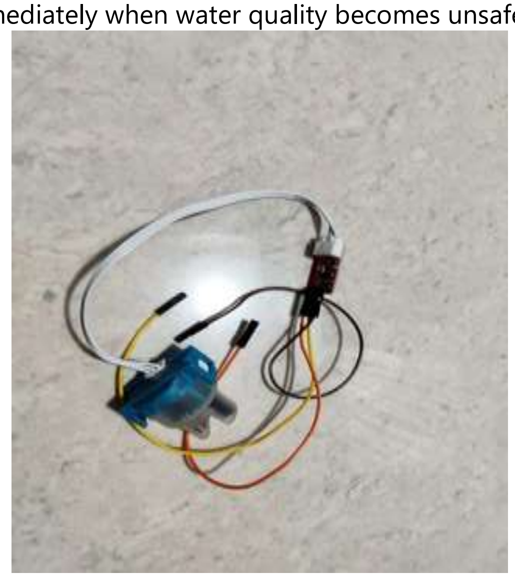


Fig. 3. Turbidity Sensor (blue probe) with signal board and wiring connections to ESP32.

VI. RESULTS AND DISCUSSION

The prototype was tested on three water samples: ordinary tap water, borewell water, and a deliberately contaminated mixture prepared with dissolved salt and a turbidity agent.

For the tap water sample, TDS measured 310 ppm and turbidity was 1.2 NTU — both well within acceptable limits, and no alert was triggered. The borewell water sample returned a TDS of 478 ppm and turbidity of 3.8 NTU, remaining below safe thresholds with no alarm raised.

For the contaminated sample, TDS reached 820 ppm and turbidity climbed to 15.6 NTU — both well outside accepted safe limits. The system triggered its buzzer and sent a mobile alert within 3 seconds. No false alarms were recorded for clean water samples. Mobile notifications arrived within 2 to 4 seconds.

A. Alert Response Time

Alert delivery speed was measured from the moment a threshold breach was detected. Local alerts responded fastest: the buzzer fired in approximately 0.4 seconds and the LCD updated in approximately 0.6 seconds. Cloud-based notifications followed: the Blynk mobile app delivered alerts in approximately 2.1 seconds, and SMS via GSM arrived in approximately 3.8 seconds.

B. System Performance Summary

The system demonstrated 100% detection accuracy across all three test samples. Contaminated water was correctly flagged in every trial, and clean water produced no false alarms. The continuous polling cycle of five seconds ensures that any sudden contamination event is captured promptly. Cloud logging also provides a persistent record suitable for trend analysis and regulatory reporting.

VII. OBJECTIVES

- Monitor water quality continuously using turbidity and TDS sensors.
- Detect unsafe water by comparing measured values against WHO/BIS safe limits.
- Alert users immediately through a mobile app, SMS, or local buzzer whenever water quality falls below acceptable levels.
- Automate water quality checks so no manual intervention is needed during routine operation.
- Keep the system affordable and accessible for households, institutions, and small industries.
- Waterborne contamination at an early stage.
- Store water quality data for trend analysis and long-term decision-making.

VIII. CONCLUSION

This paper described SWPAS, an IoT-based system that monitors water quality continuously and notifies users the moment any key parameter moves outside the safe range. The combination of TDS and turbidity sensors, together with an ESP32 microcontroller and cloud connectivity, gives the system everything it needs to make reliable decisions about water safety. Tests confirmed that contaminated water was detected quickly and accurately, with alerts reaching the user within Page 5 seconds. The total hardware cost is under ■4,000, which makes the system reachable for individual households and community water points alike.

Future work will focus on adding sensors for dissolved oxygen, heavy metals, and pH, testing machine learning models for predictive alerts, and extending the design to cover multiple monitoring points along a distribution network.

Acknowledgement

The authors thank their guide, Ms. G.N. Mawale, for her continued support and practical guidance throughout this project. They also acknowledge the Department of Information Technology at AISSMS Institute of Information Technology, Pune, for providing access to laboratory facilities.

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