IoT Based Water Quality Control System

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Abstract- **Water quality is a crucial global concern, with implications for human health, agriculture, and ecosystem sustainability. Traditional water testing methods are manual, expensive, and time-consuming, lacking real-time monitoring capabilities. This paper presents an Internet of Things (IoT) based real-time water quality monitoring and control system. The system employs an ESP32 microcontroller integrated with sensors measuring pH, turbidity, Total Dissolved Solids (TDS), and temperature. Data is transmitted to a cloud platform via Wi-Fi, allowing remote access and analysis. The system is designed to be cost-effective and suitable for urban and rural deployment. Sample Arduino code and circuit diagrams are provided, demonstrating practical implementation. A literature review comparing seven existing approaches to water monitoring systems is also included.**

I. INTRODUCTION

Access to clean drinking water is essential for public health. With increasing urbanization, pollution, and population growth, the demand for real-time water quality monitoring has surged. Traditional laboratory testing is inefficient for large-scale or continuous monitoring. Internet of Things (IoT) technology offers a practical solution for automating and scaling water quality monitoring by providing remote sensing and control capabilities.

The proposed system utilizes an ESP32 microcontroller, which supports Wi-Fi communication, and various water-quality sensors. Data collected from these sensors is displayed locally via LCD and remotely through a web dashboard. The system also makes it possible to trigger alerts or actuators based on pre-set quality thresholds, aiding in water management and contamination prevention.

II. LITERATURE REVIEW

Several researchers have explored water quality monitoring using IoT, sensor networks, or wireless technologies. A summary of relevant works is given below:

Author(s)	Title	Sensors Used	Connectivity	Year	Features	Limitation
Kedia et al.	Water Quality Monitoring for Rural Areas	pH, Turbidity, TDS	Sensor Cloud	2015	Economical solution for rural areas	No auto-correction
Bhatt &Patoliya	Real-Time Water Quality Monitoring System	pH, Temp, DO, TDS	Zigbee, Cloud	2016	Cloud-based UI	Limited scalability
Lom et al.	Industry 4.0 as Part of Smart Cities	Environmental sensors	IoT Platforms	2016	Smart City framework	Lacks water-specific focus
Sun et al.	QoI-Aware Energy Management	Multi-sensors	Custom Protocol	2016	Energy-optimized IOT	Complex implementation
Kartakis et al.	Adaptive Edge Analytics	pH, Pressure	Edge Analytics	2017	Burst detection	High initial setup cost
Haron et al.	Remote Water Monitoring via	Wired sensors	Wireless Transceiver	2008	Remote analysis	Poor UI support

Author(s)	Title	Sensors Used	Connectivity	Year	Features	Limitation
He et al.	Wireless Sensors Water Quality Monitoring Based on WSN	Multi-param	Zigbee	2012	Real-time alerts	Limited cloud integration

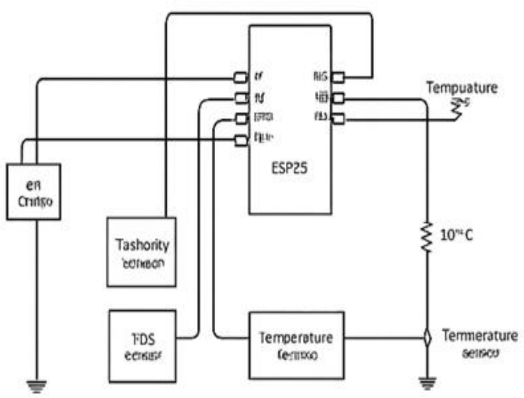
Analysis:
The reviewed literature highlights various implementation methodologies. Most systems lack real-time responsiveness, user-friendly interfaces, or are limited by their connectivity modes (e.g., Zigbee). Our system aims to overcome these limitations by using a Wi-Fi-enabled microcontroller and cloud accessibility.

III. METHODOLOGY

Hardware Architecture
The core of the system is the ESP32 DevKit v1 board, which controls and processes input from the sensors and communicates over Wi-Fi. The sensors used include:

- **pH Sensor** – Measures hydrogen ion concentration
- **Turbidity Sensor** – Measures suspended particles via light scatter
- **TDS Sensor** – Evaluates the mineral content in water
- **LM35 Temperature Sensor** – Monitors ambient water temperature

Circuit Diagram



Circuit diagram

Key Connections:

Component	ESP32 Pin
pH Sensor	A0 (Analog)
Turbidity	A1 (Analog)
TDS Sensor	A2 (Analog)
LM35	A3 (Analog)
LCD (I2C)	SDA/SCL

Software Implementation
The Arduino IDE was used to program the ESP32 in C/C++. The device hosts a local webpage showing real-time sensor readings. Data is processed in the microcontroller and served to a Wi-Fi client.

Sample Code Snippet

```
cpp
CopyEdit
#include <WiFi.h>
#include <Wire.h>
#include "LiquidCrystal_I2C.h"

#define TdsPin 32
#define TurbPin 34
#define TempPin 39

LiquidCrystal_I2C lcd(0x27, 16,
2);

const char* ssid = "YourSSID";
const char* password =
"YourPassword";

void setup() {
Serial.begin(115200);
lcd.begin();
lcd.backlight();
WiFi.begin(ssid, password);
  while (WiFi.status() !=
WL_CONNECTED) delay(1000);
lcd.setCursor(0, 0);
lcd.print("Connected");
}

void loop() {
  float tds = analogRead(TdsPin) *
(3.3 / 4096.0) * 1000;
  float turb = analogRead(TurbPin)
* (5.0 / 4096.0);
  float temp = analogRead(TempPin)
* (5000.0 / 4096.0) / 10;
```

```
lcd.setCursor(0, 0);
lcd.print("TDS: ");
lcd.print(tds);
lcd.setCursor(0, 1);
lcd.print("Temp: ");
lcd.print(temp); lcd.print(" C");

delay(2000);
}
```

IV. IMPLEMENTATION & TESTING

The system was tested with both clean and contaminated water samples. Turbidity and TDS values varied as expected, indicating sensitivity to water impurities. The web dashboard updated values in real time. Alerts were triggered for TDS values beyond 150 ppm.

Key Observations:

- Clean water had TDS ~100 ppm, Turbidity <10 NTU.
- Muddy water exceeded 250 ppm TDS and showed >300 NTU turbidity.

V. CONCLUSION

This paper presents a low-cost, real-time water quality monitoring system using IoT. The integration of ESP32 with multiple sensors and wireless communication enables flexible, scalable deployments in both rural and urban settings. The inclusion of LCD for on-site reading and web-based access makes the system practical and user-friendly. Future developments could integrate machine learning to predict contamination and integrate actuation systems for automatic purification.

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