

Smart IoT Water Quality Detection System for Drinking Water

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ABSTRACT: This paper proposes a cost-effective water quality monitoring system that uses ESP32 and a TDS sensor. The system monitors the total dissolved solids in real-time and categorizes the water quality for drinking purposes. The readings can be viewed on an OLED display. The design is compact, energy-efficient, and can be utilized for IoT-based water monitoring solutions. Index Terms—Water Quality, TDS Sensor, ESP32, IoT

KEYWORDS: Water Quality, TDS Sensor, ESP32, IoT, Smart Monitoring

I. INTRODUCTION

The availability of clean and hygienic drinking water is critical for the well-being of humans and their existence on Earth. Unhygienic water can cause many diseases, including cholera, typhoid, and diarrhea. Hence, water quality needs to be continuously monitored to ensure its consumption. However, conventional techniques used for water quality testing are time-consuming and involve laboratory tests.

Total Dissolved Solids (TDS) is a key measure used to ascertain the quality of water. TDS refers to the amount of dissolved materials like salts and minerals in the water. High levels of TDS mean poor quality water, whereas low levels mean safe water for consumption. Measuring TDS can help one ascertain the suitability of water for drinking and other uses.

This work proposes a smart water quality testing system that uses an ESP32 microcontroller with TDS Sensor. The proposed system takes measurements based on water conductivity and converts them to TDS reading expressed in ppm. The collected data is processed using ESP32 and the measurement result is shown on the OLED display. The proposed system is small, cost-effective, and useful for monitoring the quality of water.

II. USE CASE

This system is employed in monitoring the quality of water being consumed in real-time. The TDS sensor measures the amount of dissolved solids in the water, and this data is then passed to the ESP32. The results obtained can be shown on the OLED display screen to demonstrate whether the water is safe for consumption or not.

A. System Overview

The intelligent water quality monitoring system that is proposed consists of the TDS meter sensor and ESP32 microcontroller that measures the total dissolved solids (TDS). The monitoring system operates continually, conducting the measurements and processing them. The obtained data on TDS content are then used to ascertain whether the water is drinkable. Due to the compact size and low energy consumption, the system can be portable.

III. PROPOSED SYSTEM

System Components The proposed system design includes TDS sensor, ESP32 microcontroller, OLED display, and power supply. The TDS sensor senses the electrical conductivity of water and converts into TDS. The ESP32 microcontroller takes the output from the sensor and processes the signal. This processed value will be displayed on the OLED display. This system will monitor water conditions in real-time.

The whole system is made to be affordable, portable, and easy to use. The proposed solution can be used at home, in laboratories, on farms, and in water treatment systems. The system cuts down on manual testing and allows for the continuous monitoring of water quality.

The TDS probe is connected directly to the analog input of the ESP32, which makes it possible to obtain conductivity measurements. Signal processing and conversion of the analog input signal to digital values occur within the ESP32 through the internal ADC. These processed values are then mapped into TDS readings in ppm.

Furthermore, the system can operate using low power, making it ideal for use in portable devices. The simple hardware design makes it less complex and hence reliable. This system is a practical way of ensuring effective real-time monitoring of water quality.

IV. HARDWARE COMPONENTS

The proposed water quality monitoring system consists of the following hardware components:

A. ESP32 Microcontroller

The ESP32 is the primary controller to be used in the proposed design. It receives the analog output from the TDS sensor, computes the result, and shows the results on screen. The ESP32 controller incorporates Wi-Fi capabilities, consumes low power, and has high computing speed.

B. TDS Sensor

The TDS sensor is employed to determine the amount of dissolved elements in water. This sensor functions through electrical conductivity. The greater the conductivity, the higher the number of dissolved elements in the water sample. The output of the TDS sensor is analog and is received by the ESP32 to get the ppm values.

C. OLED Display

The device uses a battery-powered or USB-powered energy supply to power the system. The ESP32 microcontroller and the TDS sensor run on low power supply, which makes the entire system portable.

D. Power Supply

The system is powered using a battery or USB power source. The ESP32 and TDS sensor operate at low voltage, making the system portable and suitable for field applications.

V. METHODOLOGY

This system will detect the quality of water through a TDS sensor which works based on conductivity and which is combined with an ESP32 microcontroller. The methodology comprises four processes such as sensing, signal processing, converting, and displaying water quality parameters in real-time mode. The TDS sensor will be placed in the water sample and the water sample is being measured by using this sensor. Conductivity of water is being calculated through a small voltage application from one electrode to another.

The analog output from the TDS sensor is supplied to the analog input terminal of the ESP32 microcontroller. The ESP32 measures the analog voltage input and converts it to digital output using an in-built ADC. Conversion of the measured ADC values into ppm using mathematical conversion factors is then done. Temperature compensation may also be done to enhance accuracy.

Once the value of the TDS has been calculated, ESP32 compares it to some predefined threshold values. After that, the water condition can be classified into various categories, such as extremely pure, drinkable, good, bad, or extremely bad. This classification makes it easier for users to comprehend the quality of water. The TDS reading and the quality of water are shown on the OLED screen. The readings keep updating on the screen, thus enabling real-time monitoring of the quality of water. The device runs continuously, giving stable results for various types of water. The approach employed guarantees that there is an accurate measurement and a quick response rate at minimal energy usage.

VI. WORKING

Working of the suggested system is explained below. The TDS detector is positioned in water to calculate its conductivity. Analog output generated by the detector depends upon the dissolved substances. The detector sends the analog output to ESP32, which then converts the analog reading into digital value using ADC. Then, the calculated value is shown on OLED display as the concentration in ppm form. This output will reflect the quality of water continuously.

At first, the system is energized using either battery power or USB supply. After energization, the ESP32 then activates the OLED display and input sensors. The electrodes of the TDS sensor are submerged in the sample water, and the conductivity measurement starts immediately. The voltage readings of the sensor change according to the quantity of dissolved materials. The ESP32 senses the analog voltage periodically and uses the conversion formula to derive the TDS reading. The derived TDS reading is analyzed against pre-set standard ranges for determining the water quality. Depending upon the calculated TDS reading, the water is categorized into various classes including very pure, safe, acceptable, borderline, or unsafe. The OLED LCD display indicates both the TDS reading and water quality. The readings are constantly updated to offer real time monitoring. If the quality of water changes, the system updates the readings automatically.

A. Units

- TDS readings are recorded in units of parts per million (ppm). The readings obtained by using conductivity are converted to ppm readings for easier understanding.
- The voltage levels for both the ESP32 and the TDS sensor should be within 3.3V to 5V to work efficiently.
- Temperature changes can affect the conductivity readings; consequently, the readings should be taken at normal room temperature.
- The recorded readings are displayed in figures on the OLED display indicating whether the water is safe, acceptable, or not safe.

B. Abbreviations and Acronyms

The following are the abbreviations that have been used in this study: Total Dissolved Solids (TDS), Internet of Things (IoT), and Liquid Crystal Display (OLED). The abbreviations have been defined at their first point of mention. The micro-controller used in this paper for data acquisition is the ESP32. The TDS readings are taken in ppm. These abbreviations have been used consistently throughout the paper.

C. Authors and Affiliations

The authors of this paper belong to the Department of Electronic and Electrical Communication Engineering, Chettinad College of Engineering and Technology, Karur, India. The authors played an important role in designing, developing, and experimenting with the suggested water quality monitor. Each one of the authors has been involved in developing hardware, programming software, and analyzing results.

D. Identify the Headings

The headings have been used to categorize the contents of the water quality monitoring system being proposed. The major headings in this paper are Introduction, Problem Statement, Proposed System, Hardware Components, Methodology, Working, Results, and Conclusion. Such headings have helped in presenting the data in an organized way. Subheadings have been used for describing the various hardware components of the system, like ESP32, TDS Sensor, OLED Display, Power Supply, etc.

E. Figures and Tables

a) Positioning Figures and Tables: Figures and tables are used for illustrating the physical structure and TDS readings of the proposed system for water quality monitoring. They are positioned either on the top or bottom of the columns. Larger figures such as the structure of the system or circuit diagrams are included in both the columns. The caption of a figure is given below the figure, whereas that of a table is mentioned above the table. Figures and tables are added to the document immediately after their citations in the text. While mentioning a figure in the text, "Fig. 2" is written.

The legends for the figures contain particular descriptions such as TDS value, Water Quality, and Sensor Output. The units are given in parentheses where necessary. The block

TDS Measurement System

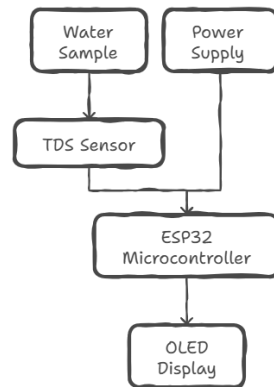


Fig. 1. Block Diagram

TABLE I
TDS WATER QUALITY CLASSIFICATION

S.No	TDS (ppm)	Range	Water Quality
1	0-50		Very Pure
2	50-150		Ideal Drinking Water
3	150-300		Acceptable
4	300-500		Marginal
5	>500		Unsafe for Drinking

diagram depicts the interconnection of the TDS sensor, ESP32 controller, OLED display, and power supply. Table 1 represents the classification of water quality depending on the TDS readings.

V. ACKNOWLEDGMENT

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REFERENCES

As seen from the references provided in the current paper, all researches were concerned about monitoring the water quality through sensors and the Internet of Things. Prior to that, some of the researches described the method of measuring the total dissolved solids and pH level for the assessment of the water quality. Other researches mentioned the use of embedded systems and microcontrollers for real-time monitoring. Such references can serve as a basis for the current study of the smart water quality monitoring system utilizing ESP32 and TDS sensors.

VI. RESULTS

The design of the water quality measurement system was evaluated using various water samples. The TDS sensor was

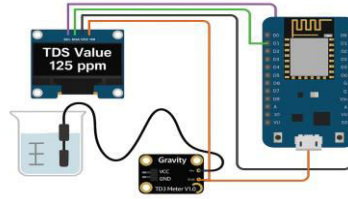


Fig. 2. Circuit Diagram



Fig. 3. Hardware Setup

used to detect the conductivity of water, and the ESP32 was responsible for analyzing data before displaying it on the OLED display screen. The results obtained from the evaluation show that the system measured and categorized water quality. Table II shows the experimental results for various water samples. The results illustrate the efficiency of the system under consideration in terms of determining whether the drinking water is safe or not safe.

TABLE II
MEASURED TDS VALUES FOR DIFFERENT WATER SAMPLES

Sample	TDS Value (ppm)	Water Quality
Distilled Water	45	Very Pure
Drinking Water	120	Safe
Tap Water	240	Acceptable
Borewell Water	420	Marginal
Salt Water	650	Unsafe

This system ensures accurate and continuous measurement of water quality. It can be observed from the findings above that the designed system can indeed detect changes in TDS levels and accurately classify the water quality. The OLED display is clearly able to indicate the readings taken, thereby making it ideal for water quality monitoring purposes.

VII. FUTURE SCOPE

The system can be improved by incorporating extra sensors like pH sensors, turbidity sensors, and temperature sensors to enhance the accuracy of the water quality test. The system can be combined with IoT technology to enable remote monitoring through mobile applications. It can be improved to incorporate cloud computing technology to store and analyze data. Auto-mated alert mechanisms can be incorporated to notify the user whenever the water quality is no longer safe.

VIII. CONCLUSION

The study proposed a water quality monitoring system based on ESP32 microcontroller and TDS sensor. The water quality monitoring system detects total dissolved solids in water and analyzes the quality of water in real-time. The readings of the system are shown on the OLED display to facilitate easy reading and understanding. The system is cost-effective, portable, and user-friendly. The system allows detection of whether water is safe to drink or not.

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