Water Quality Monitoring and Measures of Water Usage in Homes

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Abstract
Water quality and resource usage are important problems in residential areas where drinking water security and sustainable consumption patterns should be monitored. In this paper, we propose a simple system architecture to facilitate an application to develop smart water monitoring and simultaneous water usage for houses. The system is built with an ESP32 microcontroller, pH sensor, Turbidity Sensor, Flow Sensor, and LCD. The pH sensor tracks water's acidity or alkalinity concentration to ensure it is within one level for safe drinking. The flow sensor tracks how much water is used at any point, while the turbidity sensor measures turbidity to indicate purity. Once the data from the sensors are displayed on an LCD, it is further transmitted to the Thingspeak IoT platform for remote monitoring and analysis. The system includes an alert component, beeping whenever there is a problem with water quality or when abnormal sensor readings continue beyond pre-set threshold values. This instant feedback allows users to take immediate corrective action, protecting water quality and aiding in the responsible use of this vital resource. This technology offers a robust and on-demand solution to household water monitoring regarding usage and quality trends. The IoT-enabled water management solution provides a scalable approach to conserving resources and protecting public health. This paper aims to present the architecture, implementation, and performance evaluation of a large-scale multi-SAN semantic overlay focusing on its practicality for smart home environments.

Keywords: Water Quality Monitoring, Water Usage, ESP32, IoT, pH Sensor, Turbidity Sensor, Flow Sensor, Home Automation, Smart Home, Thingspeak, Real-time Monitoring.

1. Introduction

The value of awareness about water quality and drinking habits has also become more crucial in recent years. Increased attention to environmental sustainability and public health is creating a demand for water systems that are secure and optimally operated in terms of available supplies. We solved these problems in this study and developed an intelligent water monitoring system that can be used at home. By integrating many sensor points with IoT technology, an entire home solution is reached where minute-to-minute water quality information and usage data are delivered. The quality of the water is very important to protect public health. Dirty water carries the risk of respiratory diseases, bacterial and viral infections, and chronic illnesses such as cancer. They evaluate the quality of water based on pH, Turbidity, and impurities present. Moreover, how the pH of water reflects its acidity or alkalinity, which may manifest in taste and safety since the light gets scattered as it passes through a liquid. Turbidity shows how easily visible light can pass through suspended particles in water and provides insight into inadequate filtration or pollution. It makes continuous monitoring of these constituents important to provide safe drinking water.

It makes it essential to monitor drinking water supply in terms of its level, i.e., quantity and quality. The problem of water scarcity, particularly in semi-arid regions, is increasingly pronounced. So, saving water is very, very important to protect the environment. Regarding water practice, this means excessive use of valuable resources at home and huge costs in utility bills and other utilities or even downpipes for rainwater. Individuals can also help conserve overall water by regularly monitoring usage patterns to identify wastage and control it appropriately. In the past, water quality monitoring systems were time-consuming and inefficient, with limited real-time information to make quick decisions. The testing methods were long and cumbersome for inspections, creating a massive backlog from when results could be obtained. The water monitoring system we demonstrate in this work solves these inefficiencies by exploiting the advanced technological capabilities of components, which, in our case, are restored to real-time functionality using Wi-Fi communication. At the heart of our system is an ESP32 microcontroller, which has recently become quite popular. While the ESP32 has a great track record for working with various kinds of sensors and Wi-Fi, our three main Sensors in operation (pH, Turbidity, flow) get their data directly from the Hardware board itself, i.e., they communicate over I2C to each other via ESP32.

One sensor measures pH, the level of acidity or alkalinity in water. High water pH levels are dangerous to the health and affect the way treatment methods work and taste. This sensor can be effortlessly integrated into the system, and users will get live data regarding the pH of the water they are using that allows them to act then and there if needed. Turbidity is an indirect measure of the level of transparency in water due to sediment, microorganisms, and organic matter. High turbidity levels could indicate the presence of particles or the need for improved filtration techniques. With the turbidity sensor on board, users can track changes in water clarity and immediately know when the system needs attention. This flow sensor data gives information about water utilization, in particular, the speed of the stream through a pipe. The data informs users of trends in their water use, enabling them to recognize potential problems indicative of a leak or wastage. This information is vital in making informed evaluations of water conservation and optimal utilization of existing supplies.

The Thingspeak IoT platform plays another key role in the design of smart water monitoring systems. Thingspeak: to store sensor data in real-time using a cloud platform. The system will be capable of being further automated through this integration, and now, customers will have internet control over the quality and usage of their water from a web interface or app. Offers Water Condition Statistics Available To Understand How The water is at a distance from any other reading, this makes it even more significant as you get way beyond Intermediate benefits. It monitors and alerts anyone required to alert as a top-of-the-line system. Moreover, what happens to these two alarms/alerts when this buzzer goes off if it has an over-the-threshold reading for a sensor? Issues such as poor water quality and over-abundant consumption can immediately be addressed to mitigate risks.

There are a variety of components and steps that go into setting this process up, as well as a breakdown of how it is done. The ESP32 is the main microcontroller that reads data from the sensors and IoT-based service, i.e., Thingspeak. The pH, Turbidity, and flow sensors are each carefully calibrated to ensure peak performance. By comparison, the LCD offers feedback directly to consumers on location, and notifications shine as an alert. This smart water monitoring system could be considered a major leap in-home water supply. A complete water quality monitoring and conserving solution through smart sensors using existing

technology such as IoT. It raises awareness about the system among people and encourages them to care more about water quality.
The following section of this article will outline the system's overall structure, the technical specifications of each component, the integration process, and the performance assessment outcomes. The study will also explore the potential for continued utilization and advancement of the existing system within the framework of smart homes and environmental safety.

2. LITERATURE SURVEY

Aravinda S. Rao et al. [1] The gadget was developed with the Autonomous Live Animal Response Monitor (ALARM) toxicity biosensor placed in a stream to be continually immersed. The Victorian Centre launched ALARM for Aquatic Pollution Identification and Management (CAPIM). They are working on developing a low-cost wireless device that will remain in the water, continuously monitoring its attributes to make sure it remains drinkable. The salinity, temperature, light intensity level, and pH of the water, along with its electrical conductivity TDS, as well as basic properties in terms of the physicochemicals, are detected by this system. These features provide a comprehensive overview of the current water state and help recognize contamination points using sensors and open-source tools.
IoT-based water quality monitoring systems by Konde et al. [2] presented a study. This study's conclusion shows that different kinds of sensors, FPGA design boards, and Zigbee-based wireless communication modules can be integrated with a customized sensor interface device for wide-range monitoring and assessment ability to implement the SWQM efficiently in an IoT environment. This allows some of the most important water data to be monitored continuously and in real time. With the growing water contamination problem worldwide, it is a feasible fix.
As reported by Lakshmikantha et al. Survey results have confirmed that water pollution is a problem and that this issue must be checked from increasing further[3]. Swift detection is essential to any inexpensive IoT smart water quality monitoring system designed to prevent contamination, maintain animal and human health, and preserve the environmental balance.
Apart from programming, Budiarti et al.[4] an integrated water quality monitoring system on Raspberry Pi and environment sensors using the IoT platform. Being an online, automated, and real-time control system for water quality and sustainability of water resources, the study Development of an IoT-based Automated Water Quality Monitoring System found that their proposed system produced satisfactory results.
Hawari et al. [5] considered using an IoT to enable real-time monitoring, e.g., of a water quality system. This work proposes designing and implementing an Internet-of-Things (IoT)-enabled real-time water quality monitoring system. Using these pH, Turbidity, and temperature sensors, the system can measure each quickly to monitor water quality. The paper illustrates ways to store data on the cloud, process WQI for analyzing information, deploy over multiple locations, use power management to increase battery life and build a mobile application that is very useful and reliable at work.
Haque et al. R. Rutjanaprom [6] designed a Zigbee technology-based Internet of Things (IoT) water quality monitoring system in which sensor nodes are used for collection and level measurement. Sophisticated sensors track temperature, conductivity, pH, dissolved oxygen, and Turbidity. Using Zigbee, the microcontrollers process and transmit the collected data to a central controller, i.e., Raspberry Pi. Results show how well the system continuously assesses water quality, is fair for different uses, and is easy to access data whenever necessary via cloud computing through any web browsing.
Muhammad et al. [7] present a Water Quality Monitoring System in Softshell Crab Farm Using IoT Techn-

ology: they conducted a study about a water quality monitoring system using the Internet of Things (IoT) for softshell crab farming management purposes. The aim is to train farmers' skills and prolong the fragile crabs. Ajith et al. [8] presented research on developing a cloud-based IoT smart water quality monitoring system. A Smart Internet of Things (IoT) based system for water quality monitoring is proposed in this paper. The system uses cloud computing and deep learning. Problems in India due to water pollution were planned to be solved through continuous and real-time Water quality monitoring. NodeMCU devices stream data into the hosted solution using sensors to measure several metrics. Sophisticated deep learning algorithms are applied to predict when water is safe, as the data gets updated in cloud storage.

Pasika et al. developed an inexpensive Internet of Things (IoT) device for monitoring water quality [9]. This paper proposes a cost-effective Water Quality Monitoring (WQM) system using the Internet of Things to provide potable water supply and reliable, continuous monitoring. The device gets many inputs in pH and Turbidity. Water levels and weather data are measured via many sensors to measure temperature, humidity, etc., using a standard controller-based interface to control pumps and fans on ozonation. The data is first passed through the Microcontroller Unit (MCU), which then gets moved to the cloud over a ThinkSpeak program.

Smitha et al. [10] configured a wireless sensor with the IoT for water monitoring. The results indicate that the proposed technique successfully gives immediate water quality data. Using LoRaWAN technology, this system is the perfect blend of long-distance, low-cost, and energy-efficient communication to manage resources optimally for conserving them.

Shanmugam et al. In the case of [11], an IoT system for monitoring and evaluating Malaysia's water quality was developed. The recommendation is intended to address some of the water contamination problems accompanying urban growth by improving water quality control and preservation and reducing disruption in systems for distributing water. Raji et al. created an Android app for an IoT-based water quality monitoring device [12]. These results make it possible to provide clean water with an affordable system that integrates various sensors for continuous monitoring of contaminants and user-friendly UI.

Das et al. designed and deployed an IoT-based water quality monitoring system [13] for continuous real-time surveillance. The results show the system performs autonomous decision-making, real-time data acquisition, and remote Internet access. This creates cost-saving efficiencies, and the general result is a public health gain because more properties will be tested for lead, and less in-person laboratory testing of water samples will be required.

Prasad et al. have developed a state-of-the-art technology tool using remote sensing and IoT to monitor Fiji's water quality [14]. It focuses on the systematic collection of data such that an overview can be made over time to monitor the water quality in the region. It also includes industrial and agricultural impacts on water quality.

Al Metwally et al. improved a pervasive Internet of Things (IoT) home water quality monitoring and control system [14]. To do this, sensors are used for temperature and pH measurements, and additional turbidity probes are used to provide the right adjustments for each of these water quality factors. The system should be able to improve public health, eliminate the need for offline laboratory analysis, use real-time data collection, and provide intuitive configuration and monitoring interfaces, resulting in lower costs.

Kamaludin et al. [16] also discuss another IoT to test the water quality and propose RFID combined WSNs in IP-based communication systems. The system utilizes the 920 MHz Digi Mesh protocol, designed to support operation in areas with foliage. Within the study, the lake of the Universiti Sains Malaysia campus is chosen for discussion. The communication range and energy consumption of this proposed pH level detection method are collectively evaluated.

NB-IoT technology will be used to develop the aquaculture pond water quality monitoring system. Huan et al. [17] allow monitoring and control, ensuring strict standards. It also allows real-time data acquisition, such as temperature, PH level, and dissolved oxygen, to be transferred instantaneously. The Changzhou system in Jiangsu Province earned verified and consistent operation. The temperature control accuracy topped at 0.12°C, the dissolved oxygen maintained a still impressive min level of 0.55 mg/L, and pH will be controlled to no less than ±0.09mg/l. These initiatives' technological and informational support greatly helps farm productivity management and water quality control.

Vijayakumar et al. [18] present a system to regularly check water quality using IoT technology. Our system comprises five sensors (dissolved oxygen, conductivity, pH sensor, temperature, and Turbidity). Sensor data is processed by the central controller of their system, a Raspberry Pi B+ model. This shows how effectively this cloud data visualization helps ensure the availability of potable water through the system.

Hong et al.'s study [19] focused on the potential suitability of Arduino-based sensors in water quality monitoring applications. The results indicate that although the system may appear reliable, it is error-prone and needs to be supplemented with human judgment. In other words, the report shows us that we might be transitioning into an Internet of Things-enabled system.

3. Proposed System

The block diagram of the proposed system is shown in Fig. 1.

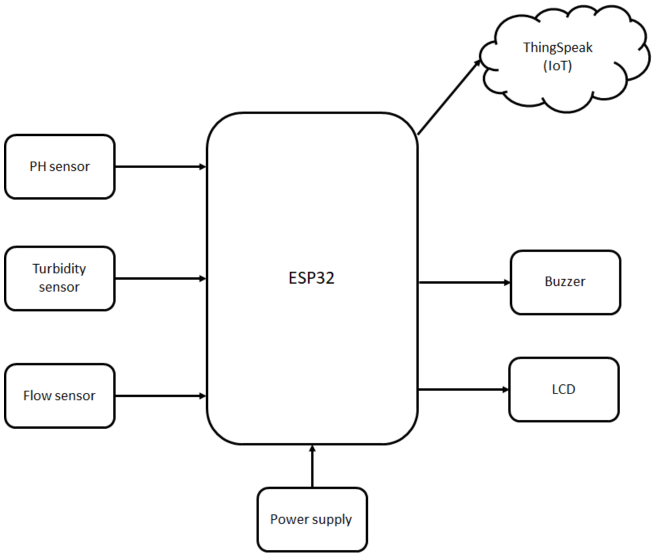

Fig. 1. Block diagram of the proposed system

The built-in block diagram comprises an overall residential water management system for monitoring automatic metering and measuring functions concerning domestic drinking water consumption as well as the trends observed at various scales. The system monitors available water quality and who uses it so that users are guaranteed clean drinking water and can responsibly measure how many lengthy showers they may or may not treat themselves to. The system starts from the water supply, where many sensors are supplied with water. Primary sensors such as Flow, Turbidity, and pH are used. The pH sensor describes the acidity/ basicity of water, which is very important information about whether we can drink the water. The electrical signal produced by the apparatus is proportional to the amount of hydrogen ions in water. The turbidity sensor tells how clear the water is, signaling possible contamination or lack of filtering. This sensor uses a photodetector and an infrared light source, which can detect the volume of scattered light as Turbidity.

Moreover, the flow sensor prevents water from flowing through pipes. Water flowing through the structure causes a turbine or revolving impeller to turn in most models. This rotational speed is in hand with flow capture and turns into an electrical signal; then, we can get data for water consumption. The ESP32 microcontroller collects all information from the sensors on this system. The pH, Turbidity, and flow sensors give analog signals, which the ESP32 reads to store digitally for analysis. This microprocessor also controls an LCD and the Thingspeak IoT network. The Sensor values are stored in the cloud using a platform called Thingsepeak. Users can connect to the data from their web or mobile app and analyze it remotely. The LCD receives the data processed and simultaneously displays this as real-time feedback to users on site. LCDs the actual pH, Turbidity, and flow rate values in real-time, resulting in immediate action. There is also a siren that the ESP32 can turn on if sensor readings go above certain thresholds. This alarm prevents users from receiving the necessary help at an appropriate time for problems like contaminated water or oversized use.

Integrating the two types of monitoring use and water quality allows us to provide a whole solution or comprehensive scheme. Through state-of-the-art sensors and Internet of Things (IoT) technology, homeowners gain a valuable tool to control their usage intelligently while protecting water quality. The combined block drawing illustrates how the mixture of all elements can support a complete solution for water management while ensuring sustainable and healthy housing conditions.

4. RESULT AND ANALYSIS

The following section shows the results of various tests conducted on smart water monitoring systems. This section considered the water quality and use monitoring outcomes of defined threshold conditions.

A. Water Quality Monitoring

For the first time, the system was employed to test disturbing water samples with different pH values and turbidity levels to investigate its accuracy. The pH sensor displayed good precision with the prediction of acidic or alkaline water conditions, producing results close to what was expected. The water was also found to be cloudy by the turbidity sensor and exhibited a high correlation with the normal way of being measured.

- pH Sensor Performance: The sensor gave pH readings between 6.9 and 7.5, which matches the tested samples' target (actual) pH values. This suggests the sensor can monitor pH levels within drinking water guidelines in real-time.
- Turbidity Sensor Performance: The turbidity sensor elicited accurate responses to aggravated and cleansed water visibility, reading in NTU according to incoming suspended particles within the sampled water.

B. Water usage measurement

The flow sensor tested how much water was turned on during a given period. The sensor consistently gave an unbiased flow rate measurement cross-validated against manual measurements. This data indicated that the system could accurately track water use at high resolution.

C. Data Visualization and Analysis

The sensors collected data, transmitted it to the Thingspeak IoT platform, and stored it for visualization. The microcontroller and sensor data interface had a customized Thingspeak script, allowing users to view real-time water quality and usage information to enable remote feedback reports.

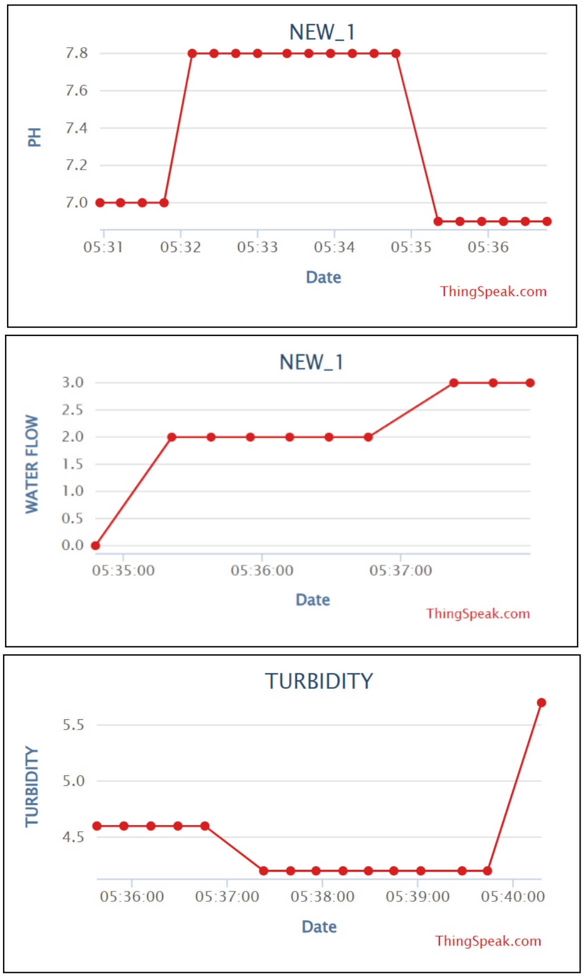

Fig. 2. Readings of the sensor on the ThingSpeak platform

The findings show the potential and efficiency of a smart water monitoring system for household-level water conservation practice. Its measured water quality parameters, monitor water usage, and friendly user interface and alert mechanisms make it a convenient tool for safe drinking water and efficient utility. The analysis indicates that it could be a valuable system to enhance water management, providing real-time knowledge and warnings for increased quality of water use parts per million practices.

5. Conclusion

This paper aims to implement integrated water quality and usage monitoring systems in household water treatment. This system utilizes onboard advanced sensing technology and Internet of Things (IoT) capabilities, ensuring that only clean drinking water is provided and maximizing water use. The system utilizes sensors that capture various water parameters such as flow, Turbidity, and pH and provides the data with real-time updates. This pH sensor monitors the acidity or alkalinity of water, ensuring it remains within a good range. Turbidity sensor: This tests the water to make sure it is clear and does not contain any components of pollution that may have been acquired. It interfaces with a flow sensor to keep track of water usage, signaling users for user-controlled and automatic shutoff settings in events like leaks or high consumption. It includes the ESP32 Microcontroller for Easy Data Manipulation and Communication. It handles the Thingspeak IoT platform interactions for remote monitoring and processes sensor data before converting it to digital format. Users benefit from the on-site and remote real-time data visualization using the cloud-based platform.

Also, there is a buzzer that alerts the trap. The system can instantly alert if sensor readings, which should remain under (for example) a certain threshold value, exceed it so you can better address the issue before they get out of control. A dispute monitor in the Field of Water Monitoring is introduced to increase sustainability, preserve resources further, and improve water quality Management. By catering to the latest trends in smart home tech and sustainability, it offers a modular solution suitable for residential environments. With real-time monitoring, the system can benefit households by ensuring their water is clean, safe to consume, and working efficiently. Now, introducing additional sensors (notably ones intended to be placed on a water main rather than individual outlets), sophisticated data analytics algorithms, and further integration with other smart home systems could enable wider-scale solutions for multi-pipe or pipe-infested homes.

The smart water monitoring system is expected to evolve in several interesting ways. Future developments may involve the encapsulation of other sensors to measure water quality parameters such as dissolved oxygen, conductivity, or some contaminants for a more extensive analysis of the state of water. Advanced data analytics predict water quality trends and optimize utilization patterns to improve a system's effectiveness. For example, one could adapt the flow control or water treatment measures in real time according to available metrics. As a means for water management applications in domestic and commercial settings, the tool's scope could be expanded even further by enabling it to handle more sources or larger-scale applications.

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