

Smart Sensor-Driven Water Monitoring and Controlled Dispensing Framework

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Abstract - Our project presents the design and development of a Hydro Track and Automatic Water Dispenser system that monitors water quality and controls water dispensing using an Arduino-based architecture. The system integrates multiple sensors including an ultrasonic sensor for water-level detection, a flow sensor for measuring water usage. TDS and pH sensors for assessing water purity, and a Dallas temperature sensor for thermal analysis. An I2C LCD provides real-time parameter display, while red and green LEDs indicate water quality status, A relay-controlled DC water pump automates the dispensing process, and a GSM module enables remote monitoring or alert notifications. This design aims to provide an efficient, automated, and cost-effective solution for maintaining water quality and ensuring safe water distribution in domestic, agricultural, and industrial applications.

I. INTRODUCTION

Water is one of the most critical natural resources for human survival, agricultural productivity, and industrial development. Rapid population growth, urbanization, and industrial expansion have significantly increased the demand for clean and safe water. However, water contamination and inefficient distribution systems have emerged as major global challenges. Polluted water not only affects human health but also causes long-term environmental damage and economic losses. Therefore, continuous monitoring of water quality and controlled water distribution have become essential requirements in modern water management systems.

Traditional water monitoring and dispensing methods largely rely on manual inspection and mechanical control, which are often time-consuming, error-prone, and inefficient. These systems lack real-time monitoring capabilities and fail to provide immediate responses when water quality deviates from safe standards. In many domestic, agricultural, and industrial environments, water is dispensed without prior verification of quality parameters, leading to potential health risks and wastage of resources. This highlights the need for an automated and intelligent solution that ensures both water quality assessment and controlled dispensing.

Advancements in embedded systems, sensor technology, and wireless communication have paved the way for smart water management solutions. Microcontroller-based systems integrated with multiple sensors enable real-time monitoring of physical and chemical parameters of water. Parameters such as water level, flow rate, total dissolved solids (TDS), pH value, and temperature are critical indicators of water suitability for various applications. By continuously analyzing these parameters, intelligent systems can ensure safe water usage and reduce human intervention.

In this context, the proposed Hydro Track and Automatic Water Dispenser System presents an efficient and cost-effective approach to water quality monitoring and automated dispensing. The system is designed using an Arduino-based architecture that integrates multiple sensors for comprehensive water analysis. An ultrasonic sensor is employed to detect water levels accurately, preventing

overflow and dry-run conditions. A flow sensor measures the quantity of water dispensed, enabling effective water usage monitoring and conservation.

Water purity assessment is achieved through the integration of TDS and pH sensors, which play a crucial role in identifying chemical contamination and ensuring compliance with safe drinking water standards. A Dallas temperature sensor is used to monitor water temperature, which is an important parameter influencing water quality and system performance. Real-time sensor readings are displayed on an I2C-based LCD, providing users with instant visibility of water conditions.

To enhance user awareness and safety, visual indicators such as red and green LEDs are incorporated to represent unsafe and safe water quality conditions, respectively. The automatic water dispensing process is controlled using a relay-driven DC water pump, which activates only when water quality parameters fall within acceptable limits. This automation minimizes water wastage and ensures that only safe water is distributed.

Furthermore, the system integrates a GSM communication module to enable remote monitoring and alert notifications. In case of abnormal water quality or system faults, alerts can be sent to authorized users, allowing timely corrective actions. This feature is particularly beneficial in agricultural fields, industrial plants, and remote locations where continuous manual monitoring is impractical.

The proposed system offers a scalable and flexible solution that can be adapted to various applications, including domestic water supply systems, irrigation management, and industrial water processing units. By combining real-time sensing, automation, and wireless communication, the Hydro Track and Automatic Water Dispenser System contributes to sustainable water management practices.

Overall, this project demonstrates how modern embedded systems and sensor technologies can be effectively utilized to address critical water quality and distribution challenges. The system aims to improve reliability, efficiency, and safety in water usage while reducing operational costs and human effort, making it a practical solution for smart water management in today's rapidly evolving technological landscape.

II. LITERATURE REVIEW

Recent advancements in smart water management systems have emphasized the integration of embedded systems, sensors, and communication technologies to ensure safe and efficient water usage. Several researchers have highlighted that conventional water supply and dispensing systems lack real-time monitoring and automated control, leading to water wastage and distribution of contaminated water. As a result,

automated water quality monitoring and dispensing systems have gained significant attention in domestic, agricultural, and industrial domains.

Many studies have focused on microcontroller-based water monitoring systems using platforms such as Arduino and PIC controllers. These systems primarily utilize sensors to measure basic water parameters such as temperature, pH, and water level. Researchers have demonstrated that Arduino-based systems offer a low-cost, flexible, and easily programmable solution for real-time monitoring applications. However, several early systems were limited to data display and did not include automated control mechanisms for water dispensing.

Water quality assessment using pH and Total Dissolved Solids (TDS) sensors has been widely explored in the literature. Studies indicate that pH is a critical indicator of chemical contamination, while TDS reflects the concentration of dissolved salts and impurities in water. Researchers have successfully implemented pH and TDS-based monitoring systems to evaluate drinking water quality, but many of these systems required manual intervention for corrective actions, limiting their practical usability.

Water level monitoring using ultrasonic sensors has been extensively studied due to its non-contact measurement capability and high accuracy. Literature reports show that ultrasonic sensors are effective in preventing overflow and dry-run conditions in water tanks. Similarly, flow sensors have been used to measure water consumption and detect leakage, contributing to efficient water resource management. However, most existing implementations focus only on monitoring rather than automated dispensing control.

Temperature monitoring using Dallas temperature sensors (DS18B20) has also been discussed in prior research, as temperature affects water quality, microbial growth, and sensor accuracy. Several authors have emphasized the importance of temperature compensation while evaluating water quality parameters, particularly in agricultural and industrial environments.

In recent years, the integration of IoT and GSM-based communication modules has enhanced remote monitoring capabilities. Research studies demonstrate that GSM-enabled water monitoring systems can send alerts and notifications when water quality exceeds safe thresholds. Although these systems improve responsiveness, many reported works lack seamless integration between sensing, decision-making, and automated actuation.

A few researchers have proposed automated water dispensing systems using relay-controlled pumps, where dispensing is based on predefined conditions. These systems show promising results in reducing water wastage and ensuring

controlled supply. However, most of them rely on limited parameters or do not provide comprehensive water quality validation before dispensing.

From the literature survey, it is observed that while individual aspects such as water quality monitoring, level detection, flow measurement, and remote alerting have been widely studied, a fully integrated system combining multi-parameter water quality analysis, automatic dispensing control, real-time display, and remote communication is still limited. This research gap motivates the proposed Hydro Track and Automatic Water Dispenser System, which aims to integrate all these features into a single, cost-effective, and automated solution suitable for domestic, agricultural, and industrial applications.

III. METHODOLOGY

The methodology adopted for the proposed Hydro Track and Automatic Water Dispenser System is designed to ensure accurate water quality monitoring, efficient automated dispensing, and reliable communication. The system follows a structured approach that integrates sensing, data processing, decision-making, actuation, and remote monitoring. The overall methodology emphasizes automation, real-time operation, and cost-effective implementation using an Arduino-based embedded platform.

Initially, the system performs sensor data acquisition by continuously collecting real-time measurements from all connected sensors. The ultrasonic sensor measures the water level in the tank or reservoir to detect low-level or overflow conditions. Simultaneously, the flow sensor monitors the rate and quantity of water being dispensed, enabling effective tracking of water usage. The TDS sensor and pH sensor analyze water purity by measuring dissolved solids and acidity or alkalinity levels, while the Dallas temperature sensor records water temperature to support accurate water quality assessment.

Once the sensor data is collected, it is transmitted to the Arduino microcontroller for processing. The microcontroller performs analog-to-digital conversion where required and applies calibration and threshold logic to each parameter. Predefined safe ranges for pH, TDS, temperature, and water level are stored in the program memory. The system continuously compares real-time sensor values with these reference thresholds to determine the suitability of water for dispensing.

Based on the processed data, the system executes decision-making and control logic. If the measured water quality parameters fall within acceptable limits and sufficient water level is available, the microcontroller activates the relay module to switch on the DC water pump. This enables automatic and controlled dispensing of water. In contrast, if any parameter exceeds safe limits or the water level is

insufficient, the pump remains deactivated to prevent unsafe water distribution and equipment damage.

To provide immediate user feedback, the processed parameters are displayed on an I2C-based LCD, allowing users to monitor water quality and system status in real time. Visual indicators such as green and red LEDs are used to represent safe and unsafe water conditions, respectively. This visual feedback mechanism enhances usability and ensures quick interpretation of system status without the need for external devices.

The methodology also incorporates remote monitoring and alert generation using a GSM communication module. When abnormal conditions such as poor water quality, low water level, or system faults are detected, alert messages are automatically sent to predefined mobile numbers. This enables timely intervention, especially in remote or unattended installations.

Finally, the system operates in a continuous loop, ensuring real-time monitoring, automated control, and reliable communication. The methodology ensures minimal human intervention, efficient water usage, and enhanced safety. By integrating multi-sensor monitoring, intelligent control logic, automated dispensing, and wireless communication, the proposed system provides a robust and scalable solution for smart water management in domestic, agricultural, and industrial environments.

IV. RESULTS

The proposed Hydro Track and Automatic Water Dispenser System was successfully designed, implemented, and tested under controlled experimental conditions to evaluate its effectiveness, accuracy, reliability, and automation capabilities. The obtained results clearly demonstrate that the system is capable of continuously monitoring water quality parameters and intelligently controlling the water dispensing process without human intervention. The integration of sensing, processing, actuation, display, and communication modules resulted in a stable and efficient smart water management solution.



During experimentation, the ultrasonic sensor consistently provided accurate water-level measurements. It effectively detected low-level and high-level conditions in the water tank, thereby preventing pump dry-run and overflow scenarios. The sensor response was fast and reliable, enabling timely control decisions. The flow sensor accurately measured the volume and rate of water dispensed, allowing

effective tracking of water usage. The recorded flow values closely matched actual dispensed quantities, validating the system's ability to support water conservation and consumption analysis.



The pH sensor played a crucial role in determining water safety. Throughout multiple test cycles, the sensor reliably identified variations in water acidity and alkalinity. When the pH value remained within the predefined safe range, the system allowed water dispensing. In contrast, when the pH crossed unsafe thresholds, the system immediately disabled the pump and activated warning indicators. This confirms the effectiveness of the decision-making logic in preventing unsafe water distribution.



Similarly, the TDS sensor accurately measured the concentration of dissolved solids in water. The system successfully differentiated between acceptable and contaminated water conditions based on TDS values. High TDS readings were correctly flagged as unsafe, and water dispensing was automatically stopped. This ensured that only purified and safe water was supplied to the end user, demonstrating the reliability of chemical contamination detection.

The Dallas temperature sensor provided stable and precise temperature readings throughout system operation.

Temperature variations were continuously monitored and displayed, supporting accurate interpretation of water quality parameters. The temperature data also ensured that the system could operate effectively under varying environmental conditions, which is particularly important for agricultural and industrial applications.

The I2C LCD display functioned efficiently by presenting real-time values of water level, flow rate, pH, TDS, and temperature. The display enhanced system transparency and user interaction, enabling instant monitoring without additional equipment. The LED indicators operated as intended, where the green LED indicated safe water conditions and the red LED signaled unsafe or abnormal conditions. This visual feedback mechanism simplified system status interpretation for users.

The relay-controlled DC water pump responded accurately to the control signals generated by the Arduino microcontroller. The pump was activated only when all monitored parameters were within acceptable limits and sufficient water level was available. The relay switching time was minimal, ensuring quick response and real-time automation. This significantly reduced manual effort and water wastage.

The GSM communication module successfully transmitted alert messages during abnormal conditions such as unsafe water quality or low water levels. Alert notifications were received promptly, confirming reliable remote monitoring and fault notification capabilities. This feature proved especially useful for remote and unattended installations, where continuous physical monitoring is impractical.

The system was tested for extended periods to evaluate stability and robustness. No significant sensor drift, communication failure, or control malfunction was observed during continuous operation. Power consumption remained within acceptable limits, indicating suitability for long-term deployment. Overall, the experimental results validate that the proposed system effectively integrates water quality monitoring, automated dispensing, real-time display, and remote alerting into a single platform.

In conclusion, the combined results confirm that the Hydro Track and Automatic Water Dispenser System is a reliable, cost-effective, and efficient solution for smart water management. The system successfully meets its design objectives and demonstrates strong potential for practical deployment in domestic, agricultural, and industrial environments, contributing to safe water distribution and sustainable resource utilization.

V. DISCUSSION

The testing of the Fake Product Detection and Traceability System showed not only excellent technical performance but also revealed valuable insights into the practical, economic, and operational aspects of the application of such a multilayer anti-counterfeiting solution across real-world supply chains. It is pointed out that the combination of AI-driven visual authentication with blockchain-driven traceability creates a paradigm shift in the strategies of counterfeit prevention since both physical and digital vulnerabilities are being addressed

at one go. This AI-based mechanism as an intelligent frontline barrier can detect highly sophisticated imitation methodologies which traditional methods fail to detect regularly. This again has much significance in view of the fact that with advanced printing capabilities, computer-assisted design software, and perfect-laser replication techniques, counterfeiters are in a position to replicate legitimate packaging with unprecedented levels of accuracy. For these reasons, human inspectors often cannot differentiate between genuine and fake products due to fatigue, subjective judgment, or inability to observe minute micro-pattern variations. AI overcomes these with high-dimensional feature extraction and pattern recognition to offer consistent, objective, and fast counterfeit detection. In the process, blockchain technology ensures the results obtained from the implementation and testing of the **Hydro Track and Automatic Water Dispenser System** highlight the effectiveness of integrating embedded systems, sensor technologies, and wireless communication for intelligent water management. The discussion focuses on the interpretation of results, system performance, practical implications, and comparison with existing approaches, emphasizing the advantages and limitations of the proposed system.

One of the major strengths of the proposed system is its **multi-parameter water quality monitoring capability**. By simultaneously measuring pH, TDS, temperature, water level, and flow rate, the system provides a comprehensive assessment of water quality and availability. Unlike traditional systems that rely on single-parameter evaluation, this integrated approach ensures more accurate and reliable decision-making. The observed consistency in sensor readings demonstrates that the selected sensors are suitable for real-time water monitoring applications.

The **automated decision-making logic** plays a crucial role in enhancing system safety and efficiency. The experimental results show that the system successfully prevented water dispensing whenever any quality parameter exceeded safe limits. This automatic control mechanism eliminates the dependence on human judgment, reducing the risk of distributing contaminated water. The fast response time of the relay-controlled pump further confirms the effectiveness of real-time automation in water dispensing systems.

The use of an **Arduino-based architecture** contributes significantly to the system's flexibility and scalability. Arduino platforms are widely recognized for their ease of programming, low cost, and extensive community support. This makes the proposed system adaptable to different environments and requirements. Additional sensors or communication modules can be easily integrated, allowing the system to evolve with changing water management needs.

The **visual feedback mechanisms**, including the I2C LCD display and LED indicators, greatly improve user interaction and system transparency. Real-time display of water quality parameters allows users to make informed decisions and increases trust in the system. The LED indicators provide immediate visual cues regarding water safety, which is especially useful in environments where continuous LCD monitoring may not be feasible.

Remote monitoring through the **GSM communication module** enhances the system's practicality, particularly for agricultural fields, industrial plants, and remote installations. The timely alert notifications observed during testing demonstrate the reliability of the communication module. This feature enables proactive maintenance and rapid response to abnormal conditions, minimizing potential risks and system downtime.

From a sustainability perspective, the system contributes to **efficient water resource utilization**. Accurate flow measurement and controlled dispensing help reduce water wastage, while continuous quality monitoring ensures safe usage. These aspects align with global efforts toward sustainable water management and conservation, making the system relevant in regions facing water scarcity and quality challenges.

Despite its advantages, certain limitations were identified during system evaluation. Sensor calibration is critical for maintaining long-term accuracy, and periodic maintenance may be required to prevent sensor drift. Additionally, GSM-based communication may be affected by network availability in remote areas, which could impact real-time alert delivery. Power consumption, although within acceptable limits, may require optimization for long-term standalone deployment, particularly in off-grid locations.

When compared to existing water monitoring systems reported in the literature, the proposed system offers a more **integrated and automated solution**. Many existing approaches focus solely on monitoring without automated dispensing or rely on limited parameters. The combination of quality assessment, automatic control, user display, and remote alerts in a single platform distinguishes the proposed system from conventional designs.

Overall, the discussion indicates that the **Hydro Track and Automatic Water Dispenser System** successfully addresses key challenges in water quality monitoring and distribution. The system demonstrates strong potential for real-world deployment due to its reliability, cost-effectiveness, and adaptability. With minor enhancements such as advanced data analytics, IoT cloud integration, and renewable power support, the system can be further improved to meet future smart water management requirements.

VI. CONCLUSION

This paper presented the design and implementation of a Hydro Track and Automatic Water Dispenser System aimed at providing an efficient, automated, and reliable solution for water quality monitoring and controlled water distribution. The proposed system successfully integrates multiple sensors, embedded control, automated actuation, real-time display, and wireless communication into a single cohesive platform, addressing key challenges associated with conventional water management systems.

The experimental results confirm that the system is capable of accurately monitoring essential water quality parameters such as pH, total dissolved solids, temperature, water level, and flow rate. By continuously evaluating these parameters

against predefined safety thresholds, the system ensures that only water meeting acceptable quality standards is dispensed. This automated decision-making process significantly reduces the risk of distributing contaminated water and minimizes the need for manual intervention.

The use of an Arduino-based architecture provides flexibility, scalability, and cost-effectiveness, making the system suitable for deployment in domestic, agricultural, and industrial environments. Real-time visualization through an I2C LCD and intuitive LED indicators enhances user awareness and system transparency. Furthermore, the integration of a GSM communication module enables remote monitoring and timely alert notifications, improving system responsiveness and reliability, particularly in remote or unattended installations.

Overall, the proposed Hydro Track and Automatic Water Dispenser System demonstrates strong potential as a smart water management solution. It promotes efficient water utilization, enhances safety, and supports sustainable resource management practices. With further enhancements such as cloud-based data analytics, renewable energy integration, and advanced sensing techniques, the system can be extended to meet future requirements of intelligent and large-scale water distribution systems.

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