HydroSense

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ABSTRACT

The United Nations' Sustainable Development Goal (SDG) 6 guarantees universal and equitable access to safe, affordable drinking water. Despite global initiatives, many rural, remote, and underserved communities still struggle to secure clean water, leading to elevated risks of waterborne illnesses from contaminated sources. In response, HydroSense was developed as a comprehensive monitoring solution. Powered by Arduino, it employs sensors to measure Total Dissolved Solids (TDS), turbidity, pH, and temperature. Real-time data is relayed to a web application, allowing users to visualize water quality metrics and receive tailored purification guidance. Beyond monitoring, HydroSense also offers educational hydrology materials to increase awareness of water management and safety practices. By combining sensor-driven analysis with a user-friendly interface, HydroSense makes direct strides toward SDG 6, promoting access to clean, safe water and underscoring the vital role of technology in safeguarding public health and sustainable water usage.

INFORMATION TECHNOLOGY CONCEPTS

•IoT-based Water Management •Sensor Integration •Real-time Water Quality Monitoring •Data Logging and Analysis

KEYWORDS

Water Quality, TDS, pH Levels, Turbidity, Arduino, Data Visualization, Web Application, Hydrology Resources, Real-time Monitoring

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1 INTRODUCTION

Clean water is essential to life, as hydration is the most basic function of water, necessary to keep the body of a living organism hydrated. It is important to preserve and sustain water availability for bodies that rely on water for digestion, metabolism, transportation of nutrients, and temperature regulation.[1] One of the Sustainable Development Goals (SDG) is SDG 6, clean water and sanitation, adopted by the United Nations (UN). SDG 6 clean water and sanitation goal is to ensure the availability and sustainable management of water sanitation for all and achieve universal and equitable access to safe and affordable drinking water for all. [2]

Billions of people worldwide still live without safely managed drinking water, safely managed sanitation, and basic hygiene services, especially in rural areas and least developed countries. Globally, 44 percent of all household wastewater flows are not safely treated. Thus, access to clean water is fundamental to human health and well-being. They are essential to improving nutrition, preventing disease, and enabling health care. [3]

In 2020, 47.46% of Filipinos need access to clean drinking water.[4] Contaminated water and poor sanitation are linked to the transmission of diseases such as cholera, diarrhea, dysentery, hepatitis A, typhoid, and polio.[5] Based on an article reported by the Department of Health (DOH) in 2023, there is a 101% rise in the number of people who suffer from typhoid fever. 3,285 compared to 1,633 from the same period in 2022.[6]

Access to safe water and adequate sanitation is a basic human right. While progress has been made towards achieving the Sustainable Development Goal on water and sanitation (SDG 6), the trends and status of access to water and sanitation cause concern. There is an urgent need to devise solutions that accelerate progress and ensure no one is left behind.[7] This leads the team to propose a software and hardware project that integrates sensors to determine the waters safety level to ensure drinking waters safety and quality. Sensors provide valuable insights into contaminants such as heavy metals, organic pollutants, pathogens, and other harmful substances in drinking water. HydroSense is a

software-hardware integration application essential in preventing waterborne diseases and ensuring water safety for communities worldwide.

HydroSense goes beyond a mere technological breakthrough, offering a crucial solution for communities battling waterborne illnesses linked to insufficient access to clean water. It does more than detect contaminants; it facilitates informed, data-driven decisions. By providing trustworthy resources and guides on hydrology, it equips users with essential knowledge of water management and purification strategies. These materials serve as invaluable references for understanding and effectively managing water resources. Through its integrated software and hardware components, HydroSense empowers communities to monitor and maintain water quality proactively, mitigating risks and safeguarding public health.

1.1 Project Scope

The HydroSense project aims to deliver a comprehensive solution for assessing and improving water quality. To collect essential data, an Arduino-powered device equipped with advanced sensors—measuring TDS, turbidity, temperature, and pH—was developed. A dedicated web application analyzes and visualizes this information, offering real-time insights and suggestions for improving water quality. Ultimately, the goal is to empower individuals to make informed decisions about their water sources and take effective steps to preserve or enhance water quality.

2 METHODOLOGY

The HydroSense project methodology emphasizes creating an accessible and efficient real-time water quality monitoring system by integrating sensors with user-friendly software. The system utilizes an Arduino-based microcontroller and sensors to measure essential water parameters such as Total Dissolved Solids (TDS), pH, turbidity, and temperature. These sensors continuously collect data, which is processed and transmitted to a web application, providing users real-time insights into water quality. This approach ensures dependable data collection and ease of use, particularly for communities with limited resources.

The web application is the primary interface, featuring intuitive data visualization through graphs and charts. Users monitor trends, receive personalized water treatment recommendations, and log or export historical data in CSV format for further analysis. Additionally, the system includes a comprehensive library of hydrology resources, offering educational materials on water management and purification techniques.

2.1 Design and Implementation Controls

The design and functionality of HydroSense are shaped by several key considerations. Ensuring continuous device operation and accurate data collection for reliable water quality monitoring is fundamental to achieving its objectives. Environmental influences on sensor accuracy and durability are also carefully assessed to maintain system reliability. Furthermore, dependable internet connectivity is crucial for transmitting real-time data, underscoring the importance of a stable network. By proactively recognizing and addressing these challenges, the team ensures that HydroSense remains practical and effective over the long term.

2.2 Technology Deployment

HydroSense relies on both hardware and software to function seamlessly. The hardware consists of an Arduino platform paired with various sensors, while the software is a web application dedicated to data visualization and recommendations. A stable internet connection is critical for real-time transmission of sensor readings to the web server, allowing users to access and analyze water quality data from any internet-connected device.

Effective hardware selection is vital for implementing the HydroSense system. Essential components include the ESP32-WROOM-32D and Arduino Nano, sensors for TDS, pH, turbidity, and water temperature, a 0.96-inch OLED display, a microSD storage module, and an external 5V power source. Table 1 summarizes all required components and their respective models for building HydroSense.

Components	Model	
Microcontrollers	Arduino UNO	
	ESP32-WROOM-32D	
Sensors	SEN0422	TDS
	SEN0161	pH
	TSW-20M	Turbidity
	DS18B20	Water Temperature
Device Screen	SSD1306	0.96-inch OLED
Storage	HW-125	mSD module
Power	External 5v Power Supply	

Table 1: Hardware Requirements.

HydroSense relies on a stable internet connection and WiFi compatibility to facilitate seamless communication. This connectivity enables the device to link with the web application, transmitting real-time water quality data and receiving updates or

recommendations. Various browsers are critical for deploying and testing the web application. At the same time, a dependable internet connection is essential for integrating the device and ensuring smooth access to online services, such as APIs. (see table 2)

Component	Specification
Mode of Connection	Wi-Fi
Wi-Fi Range	~15 – 20 meters in line of sight
Internet Speed	10 Mbps

Table 2: Connectivity Requirements.

2.3 Features and Functionalities

The web application guides users through the interfacing process with step-by-step prompts. Successful interfacing guarantees smooth data transmission from the sensors to the web application. Figure 1 provides an overview of HydroSense features and functionalities in a simplified format.

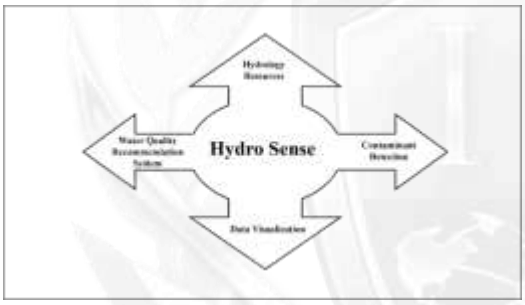

Figure 1: Features and Functionalities of HydroSense.

The water quality recommendation system measures key parameters such as TDS, pH, and turbidity in a water sample. Once these readings are collected, the system integrates them to assess overall water quality, identify potential health risks, and deliver targeted treatment recommendations. Users view the test results, associated health concerns, and suggested interventions through the contaminant detection module.

Data collection begins with immersing a sensor in the water and confirming successful data transmission. Users start and stop data logging using a user-friendly interface with data visualization features. The gathered information is stored in a CSV file, providing real-time and historical data views. An export option allows users to download data for further analysis or documentation.

Including comprehensive hydrology resources within the system is crucial for offering thorough and practical insights. These resources deliver detailed information about water characteristics and treatment methods, enhancing users' understanding of water quality issues and potential solutions.

2.4 Interface and Interactions

HydroSense provides a comprehensive platform divided into four main sections: Homepage, Data Insights, Hydrology Resources, and About. The Homepage features real-time water quality monitoring, interactive gauges displaying pH, TDS, turbidity, and temperature, and options for data logging and receiving recommendations. The Data Insights section offers detailed analyses and historical data visualization through interactive graphs and tables, enabling users to track water quality trends over time. The Hydrology Resources section serves as an educational hub, providing valuable information on water safety, pH levels, and treatment methods through articles and videos. Lastly, the About section introduces the HydroSense project, its development team, and its technical framework.

2.5 Performance Testing and Evaluation

The ISO/IEC 9126[8] software quality model was applied to evaluate the software components of HydroSense, focusing on usability, efficiency, and functionality. Particular emphasis was placed on the usability attribute to assess the user experience quality across features such as hydrology resources, data visualization, and the water quality recommendation system. Table 3 outlines the criteria used for evaluating the software aspects of HydroSense.

Product Features	Software Quality Models and Attributes	Software Quality Criteria
Hydrology Resources	Usability (ISO/IEC-9126)	Understandability
		Learnability
		Operability
		Attractiveness
		Compliance
Contaminant Detection	Functionality (ISO/IEC-9126)	Accuracy
		Interoperability
		Compliance
Data Visualization	Efficiency (ISO/IEC-9126)	Resource Utilization
		Time Behavior
		Compliance
Water Quality Recommendation	Usability (ISO/IEC-9126)	Understandability
		Learnability
		Operability
		Compliance

Table 3: Software Quality Model.

The ISO/IEC 30141[9] IoT system reference architecture model was utilized to evaluate the hardware aspects of HydroSense, emphasizing trustworthiness, architecture, and functional characteristics. Trustworthiness was measured by availability, confidentiality, integrity, reliability, resilience, and safety, ensuring continuous operation, secure data transmission, accurate sensor readings, and system recovery from environmental challenges. Regarding architecture, HydroSense was assessed for composability, heterogeneity, modularity, and scalability, enabling seamless integration or replacement of sensors, compatibility across various sensor types, and the system ability to expand by incorporating additional sensors. (see table 4)

Hardware	Characteristics of IoT System	Related Characteristics
Hydrosense	IoT system trustworthiness characteristics	Availability
		Confidentiality
		Integrity
		Reliability
		Resilience
		Safety
	IoT system architecture characteristics	Heterogeneity
		Modularity
		Network Connectivity
	IoT system functional characteristics	Compliance
		Data Characteristics
		Real-time Capability

Table 4: Hardware Quality Model.

3 RESULTS

The results for HydroSense were derived from a one-day collection of water quality data using multiple sensors that measured TDS, pH, turbidity, and temperature. The system logged data every five minutes, resulting in over 86,400 data points. These readings were processed and displayed through the web application, enabling real-time trend visualization and the generation of water quality recommendations based on predefined sensor thresholds. The system demonstrated consistent performance, accurately detecting changes in water quality and delivering actionable insights to users. All data was stored in CSV format to facilitate further analysis and validation.

3.1 Data Visualization and Historical Data Logging

HydroSense addresses the need for continuous monitoring and historical tracking of water quality data. Over one day, the system collected more than 86,400 data points by logging sensor readings at one-minute intervals. These data points, including TDS, pH, Turbidity, and temperature measurements, were processed and presented through the web application, offering users clear, real-time visualizations in graphs and charts. There is a slight deviation in water temperature as it is affected by the room temperature where the test occurred.

3.2 Water Quality Recommendation

The hydrology resources feature of HydroSense enhances real-time data collection and recommendations by providing educational materials to help users interpret test results more effectively. With over 86,400 data points collected during the one-day test, these resources offered vital background knowledge on managing and treating water based on observed trends and anomalies. They enabled users to look beyond immediate sensor readings, fostering an understanding of the long-term implications of water quality management. These resources guided users through best practices for purification and sustainable water management during and after the testing phase.

3.3 Hydrology Resources

The hydrology resources feature of HydroSense enhances real-time data collection and recommendations by providing educational materials that assist users in interpreting test results more effectively. During the one-day test period, which generated over 86,400 data points, these resources offered crucial background knowledge on managing and treating water based on observed trends and anomalies. They allowed users to move beyond immediate sensor readings, gaining insights into the long-term implications of water quality management. These resources guided users in adopting best practices for water purification and sustainable management during and after the testing phase.

4 CONCLUSION AND RECOMMENDATIONS

The conclusion of this capstone provides a summary of the solutions developed to tackle the identified challenges in water quality monitoring and highlights potential opportunities for future improvements. This section consolidates the results obtained during the testing phase and emphasizes the systems' overall achievements. Its objective is to present a clear and comprehensive overview of the project findings and outcomes, demonstrating its effectiveness in real-time water quality monitoring and user support.

4.1 Conclusion

HydroSense effectively achieves the objectives outlined in its design and implementation, delivering an integrated system that combines hardware, software, and user-friendly interfaces to facilitate water quality monitoring and awareness.

4.1.1 Device Development. An Arduino-based system with sensors to measure TDS, pH, turbidity, and temperature was developed. The device was designed to provide real-time water quality data, prioritizing accessibility and operability in various environments.

4.1.2 Web Application Integration. A web application was implemented to grant users access to real-time water quality data through a centralized platform. The application displayed data visually using graphs and charts, enabling easy interpretation while supporting historical data logging and analysis.

4.1.3 Data Visualization and Historical Data Logging. The system recorded over 86,400 data points during a one-day test. These data were processed, visualized, and stored in CSV format, offering users a detailed record of water quality trends and anomalies over time.

4.1.4 Water Quality Recommendations. The system successfully analyzed sensor data to provide specific water treatment suggestions. Recommendations were tailored to TDS, pH, turbidity, and temperature levels, offering actionable guidance to users for improving water quality.

4.1.5 Hydrological Resources. Addressed by integrating educational materials into the system. Users were provided with articles, guides, and tutorials on water purification and management, allowing them to better understand their water quality data and adopt sustainable water practices.

In conclusion, HydroSense presents a system that incorporates real-time monitoring, data visualization, personalized recommendations, and educational resources, aligning with the projects design objectives.

4.2 Recommendations

A good way to improve HydroSenses ability to assess a wider range of water quality parameters is to integrate additional sensors that are able to detect contaminants such as dissolved oxygen, nitrates, and heavy metals. HydroSense has the potential to provide a more comprehensive water quality analysis by expanding the range of measurable parameters, making it suitable for use in more diverse environments.

Also, having a dedicated mobile application is more convenient for users than accessing HydroSense through a browser. One positive of having a dedicated mobile application is the capability of using push notifications to alert users when the water quality exceeds safe limits.

Lastly, shifting to cloud-based data storage offers several advantages, including remotely monitoring HydroSense data or storing large volumes of historical data. This allows users to access their data from multiple devices and perform more advanced data analysis over longer periods.

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