CHAPTER I

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 [PM2024]. One of the Sustainable Development Goals (SDGs) 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. [OD2021]

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. [UN2021]

In 2020, 47.46% of Filipinos had no access to clean drinking water [BC2021]. Contaminated water and poor sanitation are linked to the transmission of diseases such as cholera, diarrhea, dysentery, hepatitis A, typhoid, and polio [WH2023]. According to an article by the Department of Health (DOH), the number of people suffering from typhoid fever rose 101% to 3,285 compared to 1,633 in the same period in 2022 [DV2023].

To ensure safe water and proper sanitation is widely recognized as a fundamental human right. Although there has been some advancement toward meeting the Sustainable Development Goal on water and sanitation (SDG 6), current trends and levels of access remain troubling, highlighting the urgent need for solutions that accelerate progress and include everyone. In light of these concerns, the team proposes a combined software-hardware initiative that uses sensors to evaluate water safety levels, ensuring safe and high-quality drinking water. These sensors offer critical insights into contaminants such as heavy metals, organic pollutants, pathogens, and other harmful substances. As a fully integrated solution, HydroSense plays a pivotal role in preventing waterborne diseases and safeguarding drinking water quality for communities around the globe.

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 proactively monitor and maintain water quality, mitigating risks and safeguarding public health. HydroSense user-friendly interface ensures accessibility for users of all skill levels, encouraging widespread adoption. By raising awareness about waterborne diseases and prevention, it empowers communities to manage their water resources. Its scalable design enables integration with regional systems, creating pathways for more robust and comprehensive solutions.

1.1 Purpose

This project focuses on creating an Arduino-based device equipped with TDS, turbidity, temperature, and pH sensors to evaluate water quality and transmit real-time data to a web application. By doing so, HydroSense contributes to the United Nations' Sustainable Development Goal 6, which aims to ensure safe water and sanitation for everyone. The web application displays the collected data and provides tailored recommendations for water purification methods based on detected contaminants and raises awareness about health risks linked to consuming contaminated water. By integrating hardware and software, HydroSense empowers individuals and organizations to make informed decisions about water safety and take appropriate steps to secure access to clean, safe water, ultimately supporting the broader goal of achieving sustainable development worldwide.

1.1.1 Device Development

HydroSense was developed to address individuals' concerns about the quality of their drinking water at home. By providing a reliable and user-friendly device, HydroSense ensures accessibility for all users, empowering them to assess and maintain their water quality effectively. This user-centric approach promotes informed decision-making and proactive management of water resources.

1.1.2 Web Application Integration

The integration of web applications into HydroSense aims to create a centralized platform for real-time water quality monitoring and data visualization. This integration provides users access to sensor data from any smartphone or

computer, facilitating timely decision-making and intervention. The web application features an intuitive interface, personalized water purification recommendations, and educational resources on water safety. It also supports historical data analysis and remote monitoring, adding value for individual and institutional users. Overall, this integration enhances HydroSense usability and effectiveness, advancing the goal of ensuring clean and safe drinking water.

1.1.3 Data Visualization

By enabling users to interpret water quality data collected by the sensors effectively, data visualization plays a crucial role in HydroSense. Users are able to quickly grasp key water quality parameters, identify trends, and spot anomalies. This visual representation facilitates informed decision-making and helps users take appropriate actions to ensure water safety. Additionally, it enhances user engagement and understanding, making complex data accessible to individuals with varying levels of technical expertise. Data visualization supports proactive water management and maintains clean and safe water sources.

1.1.4 Water Quality Analysis

Evaluating water safety and suitability for consumption and other purposes is vital in HydroSense. By examining data gathered from TDS, turbidity, temperature, and pH sensors, users gain a well-rounded view of water quality, helping to identify contaminants and pollutants such as dissolved solids and uncover potential health risks. Early detection of these risks enables swift and appropriate measures to ensure safe water. Additionally, the water quality analysis feature generates tailored recommendations for purification based on real-time

sensor data. For instance, high TDS levels prompt a recommendation for filtration, whereas elevated turbidity suggests sedimentation. These customized suggestions help users effectively address specific contaminants and maintain safe drinking water. Ultimately, water quality analysis and the accompanying recommendations empower individuals to make informed decisions about water treatment.

1.1.5 Hydrology Resources

In HydroSense, hydrology resources supply users with extensive information and educational content on water quality and management, helping them understand various treatment methods. By offering a comprehensive selection of articles, guides, and tutorials, these resources broaden users' knowledge of water safety, sources of contamination, and effective purification strategies. This equips individuals to make informed decisions about water consumption and treatment. Additionally, hydrology resources encourage awareness of the importance of maintaining clean water and adopting sustainable water management practices. Ultimately, they are essential in promoting water safety and sustainability, supporting the project goal of ensuring clean and safe water is accessible to everyone.

1.2 Technical Review of Related Systems

The existing water quality system and devices, such as Yinmik Bluetooth Multi-Parameter Water Analyzer [YM2009], Gain Express WQM-341 [GE2003], and Lepmerk Mini 991W Bluetooth Remote Monitoring App [LM2021], have been a reference in the project. The current applications' systems and devices differ from those in the applications

the developers plan to develop. The concept distinguishes itself by integrating Arduino-based sensors and a companion web application for real-time monitoring and data transmission. The features include water treatment advice and support structured decision-making processes to ensure water safety. The developers project outlines criteria for the system and device objectives, addressing challenges, data transmission, data visualization, hydrology resources, and power source. Evaluation against existing devices highlights HydroSense advanced comprehensive water quality monitoring capabilities. Achieving these goals effectively relies on completing the prerequisites, as indicated in Table 1.

HydroSense Criteria	Yinmik Bluetooth Multi-Parameter Water Analyzer	Gain Express WQM-341	Lepmerk Mini 991W Bluetooth Remote Monitoring App	HydroSense
Sensor Used	pH, TDS, EC	pH, EC, TDS, Salinity, SG, Water Temperature	pH, EC, TDS, SG, Water Temperature	TDS, pH level, Turbidity, Water Temperature
Data Transmitted	Bluetooth	Wi-Fi	Bluetooth	Wi-Fi
Data Visualization	Sensor Variables	Sensor Variables	Sensor Variables	Sensor Variables, Graphs, Charts and Recommendation
Hydrology Resources	Does not apply	Does not apply	Does not apply	Provides hydrology resources
Power Source	Internal, External	External	External	Internal, External

Table 1. Comparative Matrix of Related Systems.

1.2.1 Sensor Used

This criterion employs sensor technology to gather essential water parameters, forming the cornerstone for detailed water quality analysis. The system integrates sensors and collects data on crucial metrics such as pH levels, Total Dissolved Solids (TDS), and Electrical Conductivity (EC). This enables users to

obtain precise measurements of diverse water quality indicators vital for monitoring and assessment.

The Yinmik Bluetooth Multi-Parameter Water Analyzer utilizes sensors for pH, TDS, EC, and other pivotal parameters, facilitating a thorough water quality analysis. In contrast, the Gain Express WQM-341 incorporates sensors for pH, EC, TDS, Salinity, SG (Specific Gravity), and water temperature, offering a wider range of data for comprehensive assessment. Similarly, the Lepmerk Mini 991W Bluetooth Remote Monitoring App integrates pH, EC, TDS, SG, and water temperature sensors, ensuring a comprehensive grasp of water quality dynamics.

These sensor-equipped systems significantly enhance the efficiency of data collection, empowering users to access accurate and diverse information crucial for informed decision-making and environmental monitoring. On the other hand, HydroSense employs sensors for TDS, pH level, Turbidity, and water temperature, providing vital insights into various aspects of water quality.

1.2.2 Data Transmitted

This aspect addresses data transmission via Bluetooth and Wi-Fi in various water analyzers and monitoring applications, serving as a key indicator of these devices' connectivity capabilities. Bluetooth and Wi-Fi facilitate seamless interaction between the devices and user interfaces, enabling users to monitor water parameters remotely and in real-time, thus enhancing accessibility and convenience. Ultimately, this feature ensures that users effectively employ water quality monitoring and analysis tools, leading to more efficient data collection, management, and analysis processes.

The Yinmik Bluetooth Multi-Parameter Water Analyzer transmits data using Bluetooth, allowing users to connect the device to compatible smartphones or tablets for real-time monitoring and analysis of water parameters. Similarly, the Lepmerk Mini 991W Bluetooth Remote Monitoring App employs Bluetooth for transmitting data, enabling users to monitor water quality remotely using their smartphones or tablets. On the other hand, the Gain Express WQM-341 and HydroSense utilize Wi-Fi for data transmission, enabling users to connect the devices to local networks for centralized data management and analysis.

This criterion ensures that water analyzers and monitoring applications offer versatile connectivity options catering to users' diverse needs and preferences. The devices facilitate seamless data transmission through Bluetooth or Wi-Fi for efficient water quality monitoring and analysis applications.

1.2.3 Data Visualization

This criterion assesses the quality of data visualization in water analyzers and monitoring applications. It evaluates how effectively these tools present sensor variables through graphs, charts, and recommendations. Data visualization is crucial for aiding users in comprehensively interpreting and analyzing water parameters.

The Yinmik Bluetooth Multi-Parameter Water Analyzer, Gain Express WQM-341, and Lepmerk Mini 991W Bluetooth Remote Monitoring App primarily concentrate on data collection and transmission. However, they do not include features for graphical visualization or provide any recommendations based on the collected data. As a result, users rely solely on raw data readings without visual aids

like graphs or charts to support interpretation. Moreover, these devices do not offer suggestions for potential actions drawn from data analysis.

In contrast, HydroSense distinguishes itself through its robust data visualization features. It displays sensor measurements via graphs and charts, complemented by in-depth recommendations based on thorough analysis. This all-encompassing strategy ensures that users not only understand the current water quality status but also gain actionable guidance on steps to improve or maintain water quality effectively.

1.2.4 Hydrology Resources

This criterion evaluates the presence of hydrology resources within the water analyzers and monitoring applications considered. While the Yinmik Bluetooth Multi-Parameter Water Analyzer, Gain Express WQM-341, and Lepmerk Mini 991W Bluetooth Remote Monitoring App do not offer a hydrology resource, HydroSense distinguishes itself by providing users with access to one.

The Yinmik Bluetooth Multi-Parameter Water Analyzer, Gain Express WQM-341, and Lepmerk Mini 991W Bluetooth Remote Monitoring App prioritize data collection, transmission, and visualization functionalities without incorporating a hydrology resource. Users primarily rely on these devices to monitor and analyze water parameters.

On the other hand, it goes beyond basic functionality by offering users a hydrology resource. These components potentially include tutorials, guides, or articles to enhance users' understanding of water quality management principles, sensor technology, and best practices for interpreting data. By providing a

hydrology resource alongside its core features, it contributes to users' knowledge and proficiency in water quality monitoring and management.

1.2.5 Power Source

This criterion pertains to the power sources utilized by the water analyzers and monitoring applications considered. It addresses whether these devices rely on both internal, external, or a combination. Understanding the power source is crucial for users in determining the flexibility and reliability of these tools in various operational environments.

The Yinmik Bluetooth Multi-Parameter Water Analyzer and the Lepmerk Mini 991W Bluetooth Remote Monitoring App offer flexible power source options, allowing operation from an internal or external supply. This adaptability makes it easy for users to accommodate different environments, plugging into available power outlets when possible or using internal batteries for convenient portability.

Similarly, the Gain Express WQM-341 relies solely on external power sources, ensuring consistent and reliable operation if connected to a power supply. On the other hand, HydroSense offers flexibility between internal and external power sources, providing users with options based on their specific needs and preferences.

1.3 Project Scope

The HydroSense project scope provides a holistic solution for monitoring and improving water quality. It involves creating an Arduino-based device equipped with advanced sensors to measure TDS, turbidity, water temperature, and pH. In tandem, a web

application visualizes and analyzes the collected data, delivering real-time insights into water quality and offering suggestions for improvement. Ultimately, the project objective is to empower individuals to make informed decisions about their water sources and take action to maintain or enhance water quality.

1.3.1 Arduino-Powered Device

The HydroSense project involves designing and constructing a water quality monitoring device based on the Arduino platform. This device integrates sensors for measuring TDS, Turbidity, water temperature, and pH levels to ensure accurate data acquisition. It includes a screen for displaying real-time data, making it easy for users to monitor water quality directly from the device. This setup ensures that users are able to effectively assess and maintain water quality.

1.3.2 Sensor Types

The HydroSense water quality monitoring device incorporates high-quality sensors specifically selected to measure essential parameters such as TDS, turbidity, water temperature, and pH. These sensors, chosen for their precision and sensitivity, ensure accurate and dependable data collection, offering crucial insights into water quality. By using these advanced sensors, the device thoroughly evaluates water conditions, enabling users to detect contaminants and respond effectively. Incorporating advanced sensors is fundamental to achieving efficient water quality monitoring and management.

1.3.2.1 TDS (Total Dissolved Solids) Sensor

This sensor quantifies the concentration of dissolved solids in water, including salts, minerals, metals, and organic compounds. This

measurement provides valuable information about the waters overall mineral content and purity. High TDS levels potentially indicate the presence of contaminants or pollutants, such as heavy metals or agricultural runoff, which are able to affect water quality and pose health risks to consumers. Health risks include gastrointestinal problems, such as stomach pain and diarrhea, and in extreme cases, cause kidney disease, liver disease, and even death. [TD2022]

1.3.2.2 pH Sensor

The pH sensor is essential for determining the acidity or alkalinity of the water, providing critical information about its chemical balance. Monitoring pH levels helps detect potential contaminants or pollutants, such as acids or bases, that potentially affect the water safety for consumption. This sensor ensures that users are aware of any water quality changes that may require intervention. The pH sensor plays a crucial role in maintaining water safety and purity.

1.3.2.3 Turbidity Sensor

The turbidity sensor measures the cloudiness or haziness of the water, indicating suspended particles. By monitoring turbidity levels, users are able to assess the aesthetic quality and potential contamination of the water. High turbidity levels potentially suggest the presence of pollutants or pathogens, prompting necessary treatment actions. This sensor is vital for ensuring the waters clarity and overall safety.

1.3.2.4 Water Temperature Sensor

The water temperature sensor tracks the water temperature during testing, an essential factor for accurate water quality evaluations. Because temperature affects various chemical and physical properties including TDS readings monitoring, the device can refine TDS measurements for greater precision. As a result, users obtain reliable water quality data, enhancing the overall effectiveness of the monitoring system.

1.3.3 Web Application and Device Compatibility

The software development process includes building a web application as a unified hub for displaying and analyzing real-time water quality measurements gathered by the Arduino-powered device. Users can examine and interpret this data from any internet-capable device such as a smartphone, tablet, or computer, access recommendations to enhance water quality, and consult various hydrology resources. By offering a user-friendly interface, the application facilitates seamless interaction with the Arduino device and delivers valuable insights into water sources.

1.3.4 Data Visualization Features

In the context of the water quality monitoring project, the data presented in the web application include various visualizations to represent water quality parameters effectively. These visualizations potentially include graphs and color-coded indicators to comprehensively overview TDS, Turbidity, water temperature, and pH levels. By using these visual aids, users are able to interpret the data intuitively and make informed decisions regarding water quality management. The

goal is to present the data in a format that is easy to understand for users with varying levels of expertise and to facilitate quick insights into the quality of the water being monitored.

1.3.5 Water Quality Recommendation System

Based on the collected sensor data, the water quality recommendation system is designed to offer tailored guidance for water purification methods based on real-time sensor data analysis. This system analyzes the collected data from TDS, Turbidity, water temperature, and pH sensors, identifying specific contaminants and their concentrations in the water. By gathering this information through the water, the system generates personalized recommendations for effective water treatment strategies, such as filtration or sedimentation. These recommendations be integrated into the web application interface, providing users with actionable insights to address water quality issues promptly and ensure access to clean and safe drinking water. The Water Quality Recommendation System equips users with tools for effective water management and sustainable practices.

1.3.6 Hydrology Resources

This project develops a hydrology resource to provide users with knowledge and insights into water safety practices and sustainable water management. Integrated into the web application, this resource offers articles and guides that cover a range of topics—including the importance of monitoring water quality, the impact of contaminants on human health and the environment, and best practices for water purification and conservation. Through HydroSense, users are equipped

with the tools and information to enhance awareness, foster engagement, and ensure global access to clean water.

This chapter underscores the critical importance of water quality management and highlights the health risks of inadequate water supplies. HydroSense combines Arduino devices and a web application to provide real-time monitoring, data analysis, and actionable recommendations, ensuring clean, safe water access. By integrating sensors, data visualization, and targeted guidance, HydroSense enables users to confront water quality challenges effectively. Moreover, it directly advances SDG 6, which focuses on clean water and sanitation, by curbing the spread of waterborne illnesses and improving public health outcomes.