DESIGN AND IMPLEMENTATION OF A WEB-BASED MOBILE APPLICATION FOR WATER QUALITY MONITORING

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ABSTRACT. *This study presents the design and development of a web-based mobile application for water quality monitoring at Surigao del Norte State University-Mainit Campus, Surigao del Norte, Philippines. Utilizing IoT, Raspberry Pi, and the system is dedicated to Nile Tilapia fishponds and is accessible via the Internet. The temperature, pH levels, humidity, total dissolved solids (TDS), and oxygen-reduction potential (ORP) can be read through the GUI and saved in a web server for effective monitoring and examination of the water's quality and for ensuring accessible, real-time data for fishpond operators. The study found that the end-users are satisfied with the system in terms of usability, operability, and functionality. The proponents deployed the system to the recipient, and it significantly improved the management of water quality in aquaculture environments. Moreover, users can make adjustments to ensure the health and growth of the Nile Tilapia. The findings suggest that such technological integrations can revolutionize aquaculture practices, making them more sustainable and less reliant on labor-intensive processes.*

Keywords: IoT, Aquaculture Monitoring, Water Quality Management, Real-time Data Analysis, Sustainable Fish Farming

1. INTRODUCTION

The Internet of Things (IoT) enables items to communicate with one another over the Internet or other networks [1], allowing for remote tracking of data to provide feedback that supports decision-making in commercial [2] industrial, and residential applications [3]. The utilization of sensors serves as a good framework for performing coupled with a back-to-base system [4]. The Internet of Things (IoT) is a unique platform gaining popularity [5]. The growing development and advancement of technology [6], and its ability to link to everything, raise essential considerations for every individual [7].

Water is essential for the survival of all living organisms, and all are very dependent on it [8]. All living things require water to survive; without it, they will perish. It serves as a critical component for survival and main sustenance [9]. Water is an infinite natural resource, as it can be acquired from various sources [10, 11], including those above and below the soil surface [12], as well as seawater used on land [13]. Additionally, the sources of water include various groundwater, different ecological and anthropogenic environments, including springs, rivers, marshes, lakes, and reservoirs. The multifaceted nature of water resources underscores their importance in maintaining and balancing ecosystems and supporting biodiversity [14].

Several research studies have demonstrated the evaluation of water content and the determination of natural ecosystems that contribute to effective management and processing of water sources [15]. Manual methods are crucial for checking water content in environmental systems, such as capturing water samples using equipment like a glass, a scoop, and other items like bottles [16]. The laboratory conducts testing and provides findings on water samples collected to determine their water content [17]. Depending on the criteria the proponents wish to monitor and investigate, this manual procedure might take 1 to 30 days [18]. The manual approach's outcomes strongly depend on how skilled and observant the water measurement process is [19].

Although the Internet of Things (IoT) remains popular, the field of water quality monitoring for aquaculture, particularly in Nile Tilapia fishponds [20], presents a gap in research, despite its growing advancements and usefulness [21]. The current methods for determining water content rely on manual sampling and laboratory testing. Most of the time, these methods are considered time-consuming, exert much human labor, and are dependent on the abilities of the operator.

Hence, these factors and limitations often slowed down the response time and hindered the real-time monitoring capabilities [22].

Moreover, the monitoring of critical factors for Nile Tilapia, such as pH, temperature, and oxygen content, is necessary to maintain optimal conditions for their growth and reproduction [23]. For this reason, the design and implementation of a Web-based Mobile Application for Water Quality, which offers real-time data, thus empowering fishpond owners to make timely and proper decisions?

The objective of the study is to develop a web-based application for water quality monitoring utilizing IoT and Raspberry Pi. The system is dedicated to Nile Tilapia fishponds and is accessible via the Internet [24]. This study created an Internet of Things on a linked conventional device using a Raspberry Pi to solve several problems. Enabling them to monitor the water quality will benefit the neighbourhood and fishpond growth. The modular system consists of several water sensors for multi-parameter measurements [25].

This study is beneficial to the Surigao del Norte State University-Mainit Campus, Surigao del Norte, Philippines, since excessive or high parameters can have significant impacts. Extreme temperatures can affect the Fishpond, potentially reducing the growth of natural food organisms [26]. Tilapia species, size, and environmental conditions determine essential pH values [27]. Moreover, the critical pH values vary according to the Nile Tilapia species, the size of the individual species, and other environmental conditions [28].

2.MATERIALS AND METHODS

Materials

Figure 1 depicts the components needed for the system. It involves the brain of the operations, which is the Raspberry Pi 4 on the right, and the sensors on the left, which read the needed parameters for the monitoring of the water quality, such as the detected temperature, pH, TDS, ORP, and humidity.

Figure 1 Components of the System

Design of a Web-based Mobile Application for Water Quality Monitoring

Figure 2 shows the construction of a Web-based Mobile Application for Water Quality Monitoring, along with the devices used in the system and their respective functions.

There is a source of electricity, which provides an electrical load via a component of an electrical system called a power supply. The basic job of a power supply is to change the form of an electric current. The water quality tester features a multi-parameter sensor made of ABS (acrylonitrile butadiene styrene). Its dimensions are 250 x 180 x 70 mm (9.84 x 7.09 x 2.76 inches), and its parameters are temperature, humidity, PH, ORP (oxidation-reduction potential), and TDS (total dissolved solids).

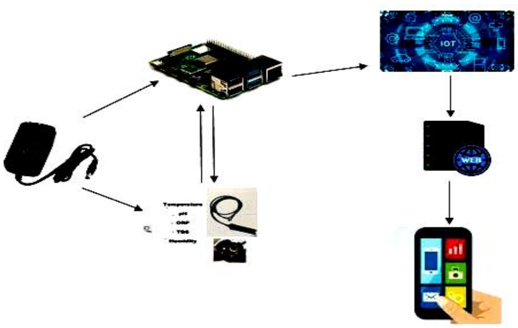

Figure 2 Development of a Web-based Mobile Application for Water Quality Monitoring

The Raspberry Pi 4 utilized is the 8 GB variant and features an upgraded circuit board. In addition, the Raspberry Pi 4 comes equipped with a USB-C connector, which also serves as a charger for the device. When combined with the appropriate power supply unit (PSU), this port can also supply additional power to the device's peripherals. The Raspberry Pi, on the other hand, cannot function on voltages higher than 5 volts; it can only function on voltages between 5 and 12 volts. The initial Raspberry Pi 4 board has a flaw in its design that makes it impossible to utilize e-marked USB connections purchased from a third party.

Internet of things: The phrase "Internet of things" refers to actual physical products that include sensors, computing power, software, and other technologies. They may link to different systems and devices and exchange data with them over the Internet or other communications networks.

With internet connectivity, web server hardware enables data exchange with other connected devices, while the server software controls how a user hosts files. A cellular/smartphone phone with an integrated computer and other features, such as an operating system (OS), web surfing, and the capacity to run software programs, that were not previously found in phones. Consumers and those who use smartphones for work or business both utilize them.

3. RESULTS AND DISCUSSIONS

Implementation of a Web-based Mobile Application For Water Quality Monitoring

Figure 3 highlights the assembly of the experimental setup, showcasing how the antenna and impulse radar are mounted on a mobile cart and connected to a laptop computer for data acquisition.

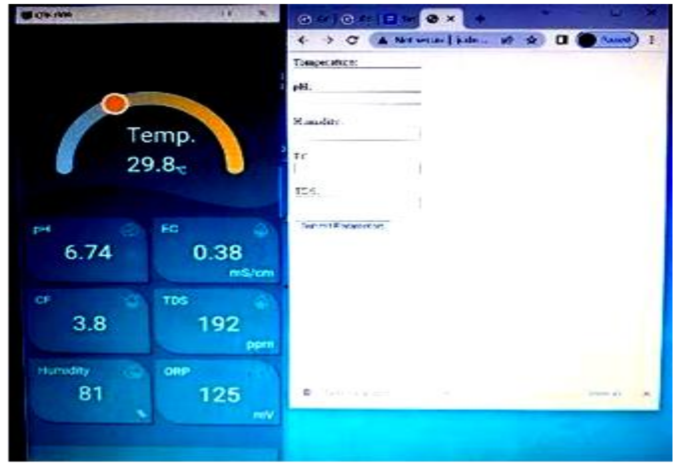

Figure 3. First Step of Implementation

This configuration is critical for the study as it facilitates the mobility required to scan simulated concrete blocks, thereby collecting comprehensive radar data. The setup's design underscores the practical application of the research, demonstrating an effective method for on-site structural assessment with enhanced radargram results.

The web server program's graphical user interface (GUI), designed for data recording, is displayed in Figure 4. The GUI features a menu with various functions, each accessible via separate buttons. "Manage user" makes it easier to specify and maintain user accounts, allowing for restricted system access. Users can view recorded measurements across several parameters under "Data logging," and they can also choose particular dates for investigation. Information about user activity on the web server, such as the number of people logged in and their details, can be found in the "Manage admin" section.

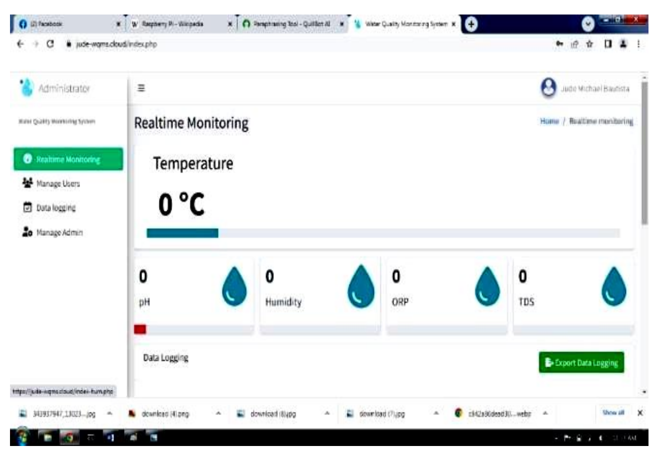

Figure 4. GUI for Website

Additionally, users can create printable forms, such as PDF, Excel, and CSV, by exporting data logging and graph data logging choices, which improves data accessibility and sharing possibilities. The user-friendly interface facilitates the management and analysis of data while meeting the various requirements of users who take measurements and monitor the data.

In Figure 5, the program GUI of the mobile application, in the home button, shows the display of the application. Our display background is the Fishpond in the SNSU Mainit campus, where the proponents conducted the study. The water quality button is where the measurement of each parameter is collected. The sections present all the data based on the objectives.

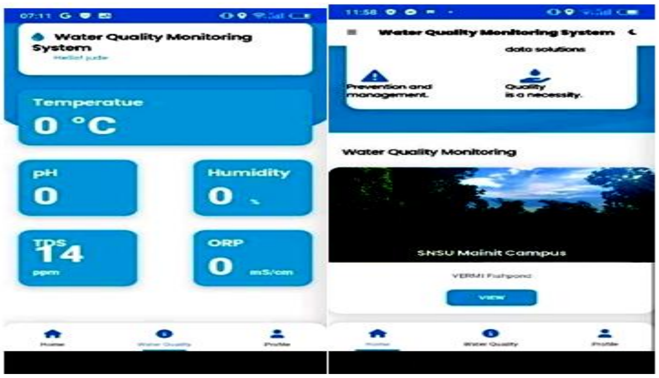

Figure 5. GUI for Mobile Application

Data Collection

Figure 6 shows the collection of all parameters using the GUI. The parameters include temperature, pH levels, humidity, TDS (total dissolved solids), and ORP (oxygen-reduction potential). Figures 7 to 10 were screenshots of the real-time data gathered from the water. Also, the developed Web-based Mobile Application for Water Quality Monitoring can recover previous data for analysis and research purposes.

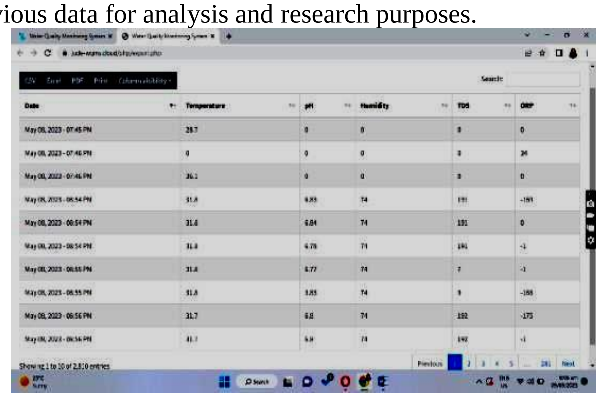

Figure 6. Data Collected in all Parameters

Figure 7 shows the pH parameter based on data collected from May 8-9, 2023, with a measurement of around 6.80. Figure 8 shows the Temperature parameter. As seen in the graph, the temperature data log shows a drop in temperature around 31-32 °C on May 8-9, 2023. Figure 9 shows the Humidity parameter with the steady measurement around 74-76% May 8-9, 2023. Figure 10 shows the TDS parameter and its measurements, ranging from -150 to -170 ppm. On May 8-9, 2023, it collected the data log.

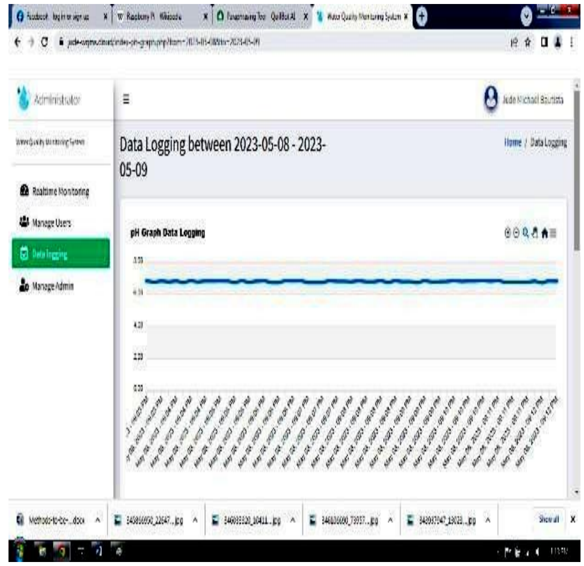

Figure 7. The pH level

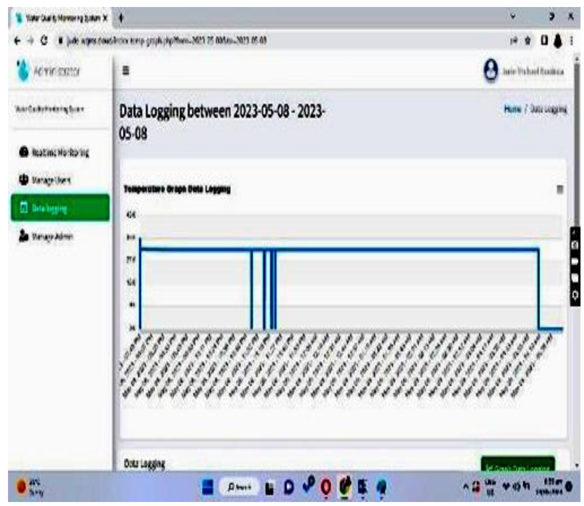

Figure 8. Temperature

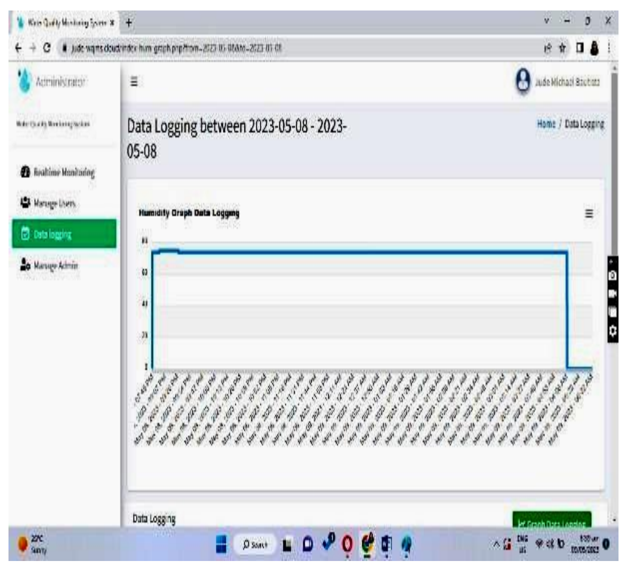

Figure 9. Humidity

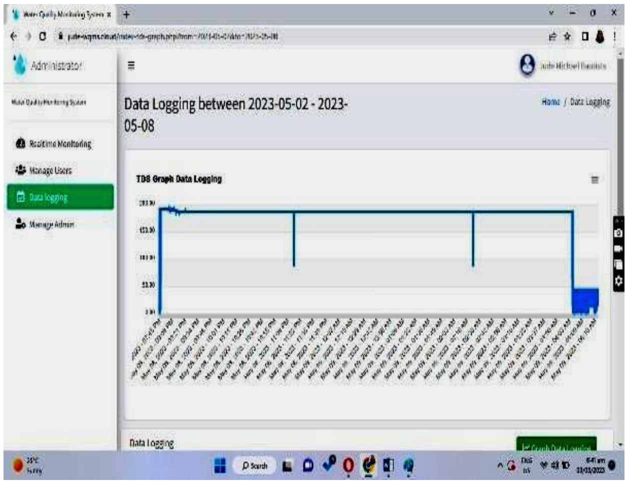

Figure 10. TDS (Total Dissolved Solids)

Results of the Survey

Table 1 presents the results of a technology acceptance survey conducted among eight users/participants to evaluate the system's operability, functionality, and usefulness from a user's perspective. The study demonstrated high user satisfaction, with participants providing favorable evaluations of the system's usability and functionality. The users felt that the system was reliable and effective, as it could satisfy both their requirements and expectations.

Table 1. Technology Acceptance Survey

Participants	Usability	Operability	Functionality
1	4.00	5.00	4.00
2	4.00	3.00	5.00
3	3.00	4.00	3.00
4	5.00	4.00	3.00
5	5.00	5.00	4.00
6	4.00	3.00	4.00
7	5.00	4.00	5.00
8	4.00	5.00	4.00
Total: 8	M =4.25	M = 4.13	M = 4.00

4. CONCLUSIONS

The findings of the study drew the following conclusions.

The proponents have successfully designed and implemented a Web-based Mobile Application for Water Quality Monitoring, which monitors water quality in fishponds based on the Internet of Things (IoT). Using a multi-parameter sensor, the system could support real-time monitoring and the remote exchange of data. The monitored data parameters are temperature, pH levels, humidity, total dissolved solids (TDS), and oxygen-reduction potential (ORP). The information gathered on the Surigao del Norte State University- MAINIT campus was saved on a web server, allowing for more effective monitoring and examination of the water's quality. The device performance was rated high in user satisfaction, yielding good evaluations concerning the system's usability and functionality. The users felt that the system was reliable and effective, as it could satisfy both their requirements and expectations. The findings indicate that the developed Web-based Mobile Application for Water Quality Monitoring is well-designed and capable of offering dependable and user-friendly monitoring solutions for fishponds. Moreover, it also concluded that the integration of Internet of Things technology and water quality monitoring has the potential to contribute to the environmentally responsible management of water resources and promote the healthy growth of ecosystems within fishponds.

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