# CHAPTER 1

# INTRODUCTION

This chapter provides an overview of the study, including its background, objectives, and significance. It outlines the problem being addressed, the research goals, and the importance of developing an IoT-Based Wireless pH Monitoring System for Aquariums to help maintain water quality and protect aquatic life. Additionally, it defines the scope and limitations of the study, ensuring a clear focus on the project's objectives. Key terms relevant to the study are also provided to establish a common understanding of the concepts discussed.

## Background of the Study

Many people enjoy keeping aquariums whether at home, in schools, or in offices, because they bring beauty, peace, and a connection to nature. However, taking care of an aquarium is more than just feeding the fish. The water inside the tank must be clean and safe for the fish to survive. One important factor in keeping the water healthy is monitoring its pH level.

The pH level tells us how acidic or basic the water is. If the pH level is too high or too low, it can harm or even kill the fish. For example, some fish prefer slightly acidic water, while others need water that's more neutral. Because of this, aquarium owners need to check the pH regularly.

The problem is, many people forget to check the pH or don't know how to do it properly. Traditional pH test kits are often manual and time consuming. Worse, if no one notices a dangerous change in pH in time, it can lead to fish deaths.

This project was created to solve that problem using modern technology. Our team developed an IoT-Based Wireless pH Monitoring System that can watch the pH level in an aquarium 24/7. "IoT" stands for Internet of Things, which means using smart devices that can collect data and send it over the internet.

Our system uses a small device with sensors (called a prototype) to read the pH level in the water. It sends that data to a web application, where the owner can check the water condition anytime using a phone or computer. If something goes wrong, the system also sends an SMS notification right away to alert the owner even if they're not online.

By building this project, we hope to make aquarium care easier, smarter, and more reliable. With real-time monitoring and instant alerts, fish lovers can relax knowing their aquatic pets are living in safe and healthy water.

**Statement of the Problem**

Many aquarium owners struggle to keep the water in their tanks at the right pH level. Most of the time, they either forget to check it or don't notice changes until it's too late. This can lead to poor water quality, stress for the fish, or even death. The traditional way of checking the pH involves using test kits or strips. These methods are manual, time-consuming, and easy to overlook. There is no easy way to check the pH remotely or get alerted right away when something goes wrong.

This project aims to solve the following problems:

1. How can we help aquarium owners monitor the pH level of their tank water automatically and continuously?
2. Is there a way to notify the owner immediately when the pH level becomes dangerous?
3. How can we display the data in a simple, user-friendly way so anyone can understand it?

## Objectives of the Study

This project has both general and specific goals:

***General Objective:***

To develop an IoT-based system that can automatically monitor the pH level in aquarium water and send alerts through SMS and a web application.

***Specific Objectives:***

1. To design and build a working prototype using an ESP32 microcontroller, pH sensor, and GSM module that can read the pH level in real-time and send SMS notifications when needed.
2. To create a simple web application using React (frontend), Laravel (backend), and MySQL (database) to display real-time pH readings in a clear and easy-to-understand format.
3. To enable automatic SMS alerts when the pH level goes beyond the safe range, allowing aquarium caretakers to take immediate action.

4. To allow real-time monitoring of the pH level without needing user accounts or logins—making it easy to access the data from a local device or network.

## Significance of the Study

This study is important for the following groups:

***Aquarium Owners***

They will benefit the most from this system. It helps them keep their fish healthy without the hassle of manual testing. The system gives peace of mind, knowing they'll be alerted instantly if there's a problem.

***Pet Shops and Fish Breeders***

Businesses that handle many aquariums can use this technology to monitor multiple tanks efficiently. It can save money and time by preventing fish losses and water problems.

***Students and Researchers***

This project can serve as a great learning tool. It combines knowledge from electronics, programming, and biology. It also shows how technology can solve everyday problems.

***Technology Enthusiasts and Developers***

It demonstrates the practical use of IoT in real-life situations. Developers can expand this idea into other areas, such as agriculture or water purification systems.

## Scope and Delimitation

This project scope focuses on creating a system that helps monitor the pH level of water in an aquarium. It includes both hardware and software components working together to give real-time updates. This is designed for personal or small-scale use, such as home aquariums, school science projects, or small pet stores.

The system has three main parts:

1. ***Hardware Prototype*** – Built using an ESP32 microcontroller, a pH sensor, and a GSM module. This device is placed in the aquarium to measure the pH level. It uses Wi-Fi to send the pH data to a web server and sends SMS alerts using the GSM module when the reading goes out of the safe range.

2. ***Web Application*** – A simple website developed using React (for the front end), Laravel (for the API), and MySQL (for storing data). This app displays the current pH readings in a clear and readable format, allowing users to easily monitor the condition of the aquarium water.

3. ***SMS Notifications*** – When the pH level becomes too high or too low, the system automatically sends an SMS to notify the owner so they can act quickly.

While the system is helpful, there are some things it cannot do:

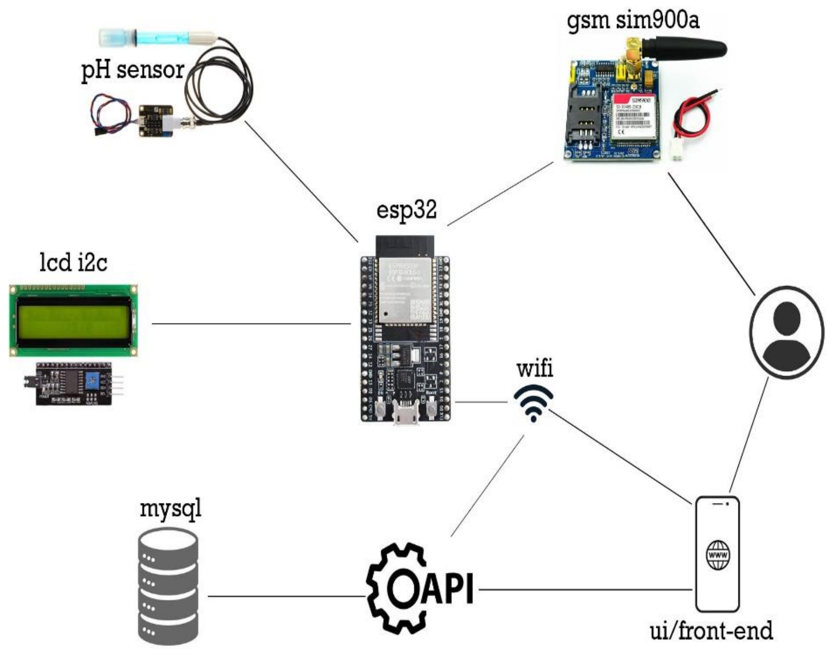
1. ***No User Accounts or Login System*** – The web application does not include user registration or login. It is built for a single user or local setup only.

2. ***No Remote-Control Features*** – The system only monitors the pH level and sends notifications. It cannot adjust or control the water's pH automatically.

3. ***Wi-Fi Dependency*** – The system needs a stable Wi-Fi connection to send data from the ESP32 to the web server. Without Wi-Fi, the pH data won't be updated on the website.

4. ***Single Parameter Monitoring*** – This system only measures the pH level. It does not track other important factors like water temperature, ammonia, or nitrate levels.

5. **Sensor Accuracy and Maintenance** – The pH sensor may require calibration and regular maintenance to ensure accurate readings




**System Architecture**

***Figure 1: System Architecture***

The figure illustrates the project's system architecture shows the structure of how ESP32 interact with each component through the web application.

**CHAPTER II**

**CONCEPTUAL FRAMEWORK**

This chapter provides the review of related literature that includes both foreign and local and relates studies both foreign and local, conceptual model and the definition of terms that are used in this research study.

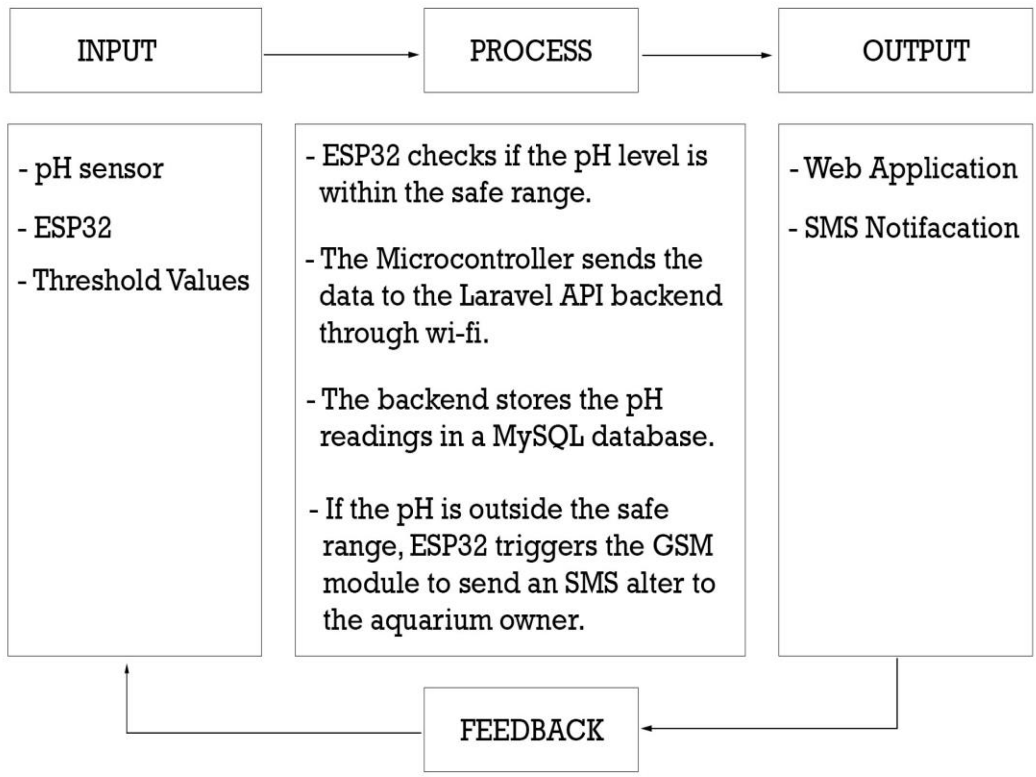



***Figure 2: Conceptual Framework***

## Conceptual Framework of the Study

The conceptual framework of this project follows the Input-Process-Output (IPO) model, ensuring a structured approach to the design and development of the system. This framework outlines how each stage contributes to the successful completion of the IoT-based pH monitoring system for aquariums.

***Input***

This stage involves all the essential requirements and components needed for the development of the system. These inputs are grouped into three categories:

- ✓ *User Requirements* - Focuses on creating a simple and easy-to-use system that allows aquarium owners to monitor pH levels without needing advanced technical knowledge. The system must be reliable, provide real-time updates, and send SMS alerts when necessary.
- ✓ *Hardware Requirements* - includes the physical components used in building the prototype:
    - ESP32 Microcontroller
    - pH Sensor
    - GSM Module
    - Power Supply
    - Wires and circuit components for integration
- ✓ *Software Requirements* - Involves the development tools and platforms needed for programming and building the web-based system:
    - Backend: Laravel (PHP Framework)
    - Frontend: React (JavaSrcipt Library)
    - Database: MySQL
    - Microcontroller Programming: Arduino IDE for ESP32

***Process***

This phase includes all the technical and development procedures used to bring the system to life. It consists of:

- ✓ *System Design* - Planning how each component will work together, including data flow between the hardware and the software.
- ✓ *Hardware Integrations* - Connecting the pH sensor, ESP32, and GSM module to function as one system.
- ✓ *Software Development* - Creating the Laravel API to store and handle sensor data, building the React web app to display data, and setting up the MySQL database.
- ✓ *Testing and Calibration* - Making sure the sensor reads accurately, the notifications work, and the system runs as expected.
- ✓ *Evaluation and Troubleshooting* - Fixing any bugs, improving system performance, and ensuring reliability.

***Output***

The final output of the project is a working IoT-Based Wireless pH Monitoring System for Aquariums that:

- ✓ Automatically monitors the pH level of the water in real time.
- ✓ Sends SMS notifications when the pH is outside safe levels.
- ✓ Displays pH data through a web-based interface for easy monitoring.
- ✓ Helps aquarium owners protect their aquatic life with minimal manual effort.

## Review of Related Literature and Studies

### *Review of Local Literature*

Local studies and articles have discussed the challenges faced by aquarium hobbyists and small-scale fish farmers in maintaining good water quality. According to *Santos (2019)*, many local aquarium owners still rely on manual water testing, which is time-consuming and often inaccurate. This can lead to poor water conditions that may harm or even kill fish if unnoticed.

In another article by *Reyes and Mendoza (2020)*, the authors recommend using automated alert systems to help address the lack of regular monitoring. They suggested that SMS notifications are helpful in local settings where internet connectivity may be unstable, as most people can still receive text messages. However, the article did not include a system that provides both SMS alerts and access to real-time pH data through a website.

This project aims to build on these ideas by developing an IoT-based system that combines the benefits of both SMS notifications and a web application. The system uses Wi-Fi to send data to a backend server, which stores and displays the information on a simple web interface. At the same time, it uses a GSM module to send alerts when pH levels go beyond safe limits. This provides a more complete solution for monitoring aquarium water quality in real-time, helping local fishkeepers keep their aquatic environments safe and healthy.

### ***Review of Local Studies***

Several local studies have explored the use of technology to improve water monitoring and fish care in the Philippines. These studies highlight the growing need for automated systems that reduce manual labor and improve accuracy.

In the study by *De la Cruz et al. (2018)* from a local state university, the researchers developed a basic water monitoring system that used sensors to detect temperature and turbidity in fish ponds. The data was shown on an LCD screen, helping fish farmers monitor conditions on-site. However, their system did not include wireless transmission or mobile alerts.

Another study by *Garcia and Lopez (2020)* focused on an automatic feeder for aquariums. While the main goal was to automate feeding times, the researchers recommended adding water quality monitoring in future versions to help keep fish healthier. This shows a growing interest in applying automation to everyday aquarium tasks.

*Rodriguez (2021)* conducted a study on the effectiveness of using GSM modules in rural farming systems for sending SMS notifications. The results showed that even in areas with limited internet access, SMS could still provide real-time alerts, which were found useful by local users.

These studies support the idea that automation and wireless communication can improve fishkeeping. However, none of the reviewed studies combined sensor-based monitoring, SMS alerts, and a web-based interface in one system. This current project aims to fill that gap by developing a system that monitors pH levels in real-time, sends SMS alerts through a GSM module, and allows users to view updates through a web application connected via Wi-Fi.

***Review of Foreign Literature***

In other countries, many articles and publications have discussed the use of technology to monitor water quality more efficiently. These literatures show how Internet of Things (IoT) and automation can help solve common problems in maintaining safe water conditions for fish.

An article published in *Electronics for You (2019)* explained how IoT-based water monitoring systems are becoming more common in smart agriculture and aquaculture. These systems use sensors and microcontrollers to measure water properties like pH, temperature, and dissolved oxygen. The article emphasized that automatic monitoring reduces the need for constant manual checking and helps prevent water-related problems before they get worse.

Another article in *TechBriefs (2020)* discussed how GSM modules can be integrated into microcontroller-based systems to send SMS alerts. This technology is especially helpful in remote areas or when internet access is limited, allowing users to receive important updates even without logging into a website.

The website *IoTForAll.com* published a feature in *2021* explaining the use of cloud-based dashboards and IoT devices to display sensor data. It pointed out that visual interfaces can help users understand data faster and make quicker decisions when water conditions are unsafe.

Although many of these articles focus on larger farming or industrial setups, the technologies they describe such as IoT devices, pH sensors, GSM modules, and web dashboards can also be applied to smaller setups like home aquariums. This project takes inspiration from these ideas and applies them to a more personal and small-scale environment, helping regular aquarium owners keep their fish healthy with the help of both SMS and web-based monitoring.

***Review of Foreign Studies***

Many international studies have explored the use of IoT (Internet of Things) to monitor environmental conditions, especially in aquaculture and water quality management. These studies show how smart systems can help fish keepers and farmers maintain healthy water conditions using automated tools and real-time alerts.

A study by *Rahman et al. (2018)* in Bangladesh developed an IoT-based water quality monitoring system for fish ponds. Their prototype used a microcontroller and various sensors to measure water temperature, pH, and turbidity. The data was uploaded to a cloud platform where users could view it using a smartphone or computer. This study proved that IoT systems could successfully help fish farmers improve their water management and reduce fish deaths.

In another study by *Nguyen and Tran (2020)* from Vietnam, the researchers created a smart aquarium system that used sensors and Wi-Fi to monitor pH and temperature. Unlike traditional methods, their system provided real-time data to a web-based dashboard. However, it lacked an

SMS alert system, which could be important for people who are not always connected to the internet.

*Chen et al. (2021)* from China built a monitoring system using ESP32 and cloud technology. Their system focused more on large-scale fish tanks for commercial use. The system displayed real-time water data online and included early-warning messages when conditions changed. This showed the effectiveness of automation in reducing manual monitoring work and improving aquatic health.

These foreign studies support the use of sensor-based monitoring and IoT for better water management. However, many focused on either cloud systems or basic Wi-Fi dashboards. This current project expands on those ideas by adding both a web-based platform and SMS alerts, making it more suitable for small aquarium owners who need reliable updates — even without constant internet access.

**Definition of Terms**

- ✓ ***IoT (Internet of Things)*** – A technology that connects devices like sensors and microcontrollers to the internet, allowing them to collect and share data automatically.
- ✓ ***pH Level*** – A measure of how acidic or basic the water is. Fish need the right pH level to stay healthy; if the pH is too high or too low, it can harm or kill them.
- ✓ ***ESP32*** – A small and powerful microcontroller used to connect sensors to the internet. In this project, it sends pH data from the sensor to the web app and controls the SMS alerts.

- ✓ ***pH Sensor*** – A device that measures the pH level of water. It helps monitor if the aquarium water is safe for fish.
- ✓ ***GSM Module*** – A component that sends SMS (text message) alerts when the pH level is unsafe. It works like a mobile phone inside the system.
- ✓ ***SMS Notification*** – A text message sent automatically to inform the aquarium owner when the water pH becomes too high or too low.
- ✓ ***Web Application*** – A simple website that shows pH data in real time. It is developed using React for the frontend and Laravel for the backend.
- ✓ ***Frontend (React)*** – The part of the web application that the user sees. It displays the pH readings and updates.
- ✓ ***Backend (Laravel)*** – The part of the system that manages how data is stored and processed. It receives the pH data from the ESP32 and sends it to the database.
- ✓ ***MySQL*** – A database used to save the pH readings so they can be reviewed later.

# CHAPTER III

# RESEARCH DESIGN

## Methods of Research

This study relies on qualitative research. Qualitative data is gathered through user interviews and feedback sessions to understand user requirements and preferences. This method provides detailed insights into user experiences, helping to develop and improve the system based on feedback from potential users.

## Methodology

The project follows Agile Methodology, specifically the Scrum Framework. Scrum has been selected because of its iterative and incremental style, where the development process is divided into sprints, which the features are gradually designed, tested, and improved based on user feedback.

## Approach

### *Data Collection*

System Testing and Performance Evaluation: Measuring the accuracy, reliability, and effectiveness of the pH monitoring.

### *Data Analysis*

The data will be analyzed through thematic analysis that involves identifying and analyzing patterns or themes. It involves examining data, such as interview transcripts or text documents, to find recurring ideas, topics, and patterns of meaning. The goal is to understand the underlying narratives and significant meanings within the data.

### *Sources of Data*

**Literature Review** – Extensive review of academic journals, books, and articles related to automated water quality monitoring systems, IoT applications in aquariums, and wireless pH sensor technologies to gather relevant knowledge and best practices for the project development.

**Surveys and Interviews -** Conducted among aquarium owners and hobbyists to understand their challenges in monitoring water quality and their interest in automated solutions. Recruitment efforts involved visiting local pet shops and aquarium clubs to identify and engage participants for questioning and surveying. The aim was to assess user needs, satisfaction with current methods, and gather suggestions for improving the proposed pH monitoring system. Anonymity and confidentiality were maintained throughout the survey process to encourage honest and open feedback.

***System Development***

1. Product Creation – Define project features, requirements, and user needs.
2. Planning – Prioritize tasks and plan short development cycles.
3. Execution and Development – Develop the system in iterations, with frequent testing and integration.
4. Scrum Meeting – Conduct stand-ups to track progress, discuss challenges, and adjust plans.
5. Review and Testing – Demonstrate completed work, test functionalities, and gather user feedback.
6. Retrospective and Improvement – Analyze what worked, identify areas for improvement, and adjust future sprints.
7. Final Deployment – After multiple iterations, release the fully developed and tested system.

**Requirements Documentation**

1. User Requirements
    a. *Aquarium Owners and Hobbyists* - Need a simple and reliable system to monitor the water pH levels automatically, helping them maintain a healthy environment for their fish without constant manual testing.
2. Functional Requirements
    a. *Automated pH Monitoring* - Continuously measure the pH level of the aquarium water using a sensor and send real-time data to the backend system.
    b. *SMS Notification System* - Automatically send SMS alerts to the owner when the pH level goes outside the safe range to allow timely action.
    c. *Data Transmission* - Use Wi-Fi (via ESP32) to send sensor data to the web application backend.
    d. *Web Application Interface* - Display the current pH readings clearly on a simple web interface for easy monitoring.
3. Non-Functional Requirements
    a. *Accuracy* - The system should provide accurate pH readings within an acceptable error margin to ensure reliable monitoring.
    b. *User-Friendly Interface* - The web application should have a clear and easy-to-understand display of pH values without complicated controls.

c. *Reliability* - The system must operate continuously and consistently without frequent failures or errors.

d. *Durability* - The hardware components should be robust enough to function in an aquarium environment over a long period.

e. *Scalability* - The system design should allow future enhancements, such as adding other water quality sensors or notification methods.

4. Hardware Requirements

a. *ESP32 Microcontroller* - Acts as the main controller, reading data from the pH sensor and handling communication with the web backend and GSM module.

b. *pH Sensor* - Measures the acidity or alkalinity of the aquarium water and provides analog or digital signals to the ESP32.

c. *GSM Module* - Sends SMS notifications to the aquarium owner when abnormal pH levels are detected.

d. *Wi-Fi Module (integrated in ESP32)* - Sends pH data wirelessly to the backend server via the internet.

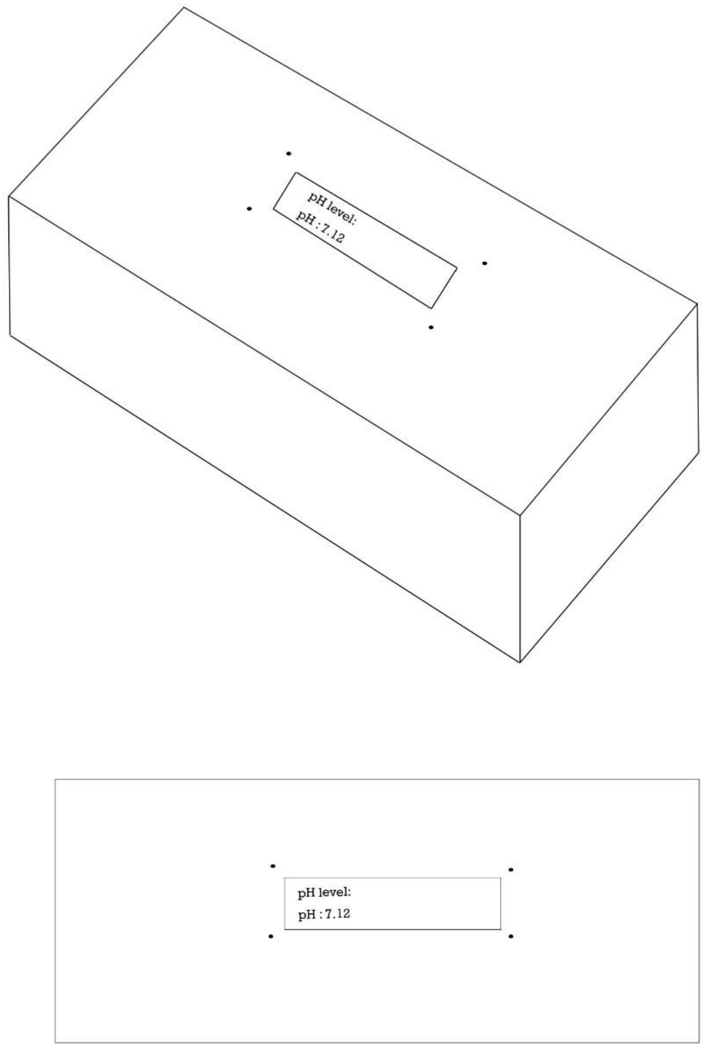
e. *Power Supply* - Provides stable power to the hardware components.

f. *Connecting Wires and Accessories* - Connects the various hardware components securely.

g. *LCD 16x2 with I2C Interface* - Displays current pH readings locally on the device for quick and easy viewing without needing to access the web application.

5. Software Requirements

    a. *React* - Used for developing the front-end web application that displays the pH data to the user.
    b. *Laravel* - Serves as the backend API handling data reception from the ESP32 and storing it in the database.
    c. *MySQL* - The database system used to store pH readings and system logs.
    d. *Arduino IDE* - For programming the ESP32 microcontroller to read sensor data, send it via Wi-Fi, and trigger SMS alerts through the GSM module.
    e. *Visual Studio Code* - The primary code editor used to develop both the backend API (Laravel) and frontend (React). It offers a user-friendly interface, debugging tools, and supports multiple programming languages.

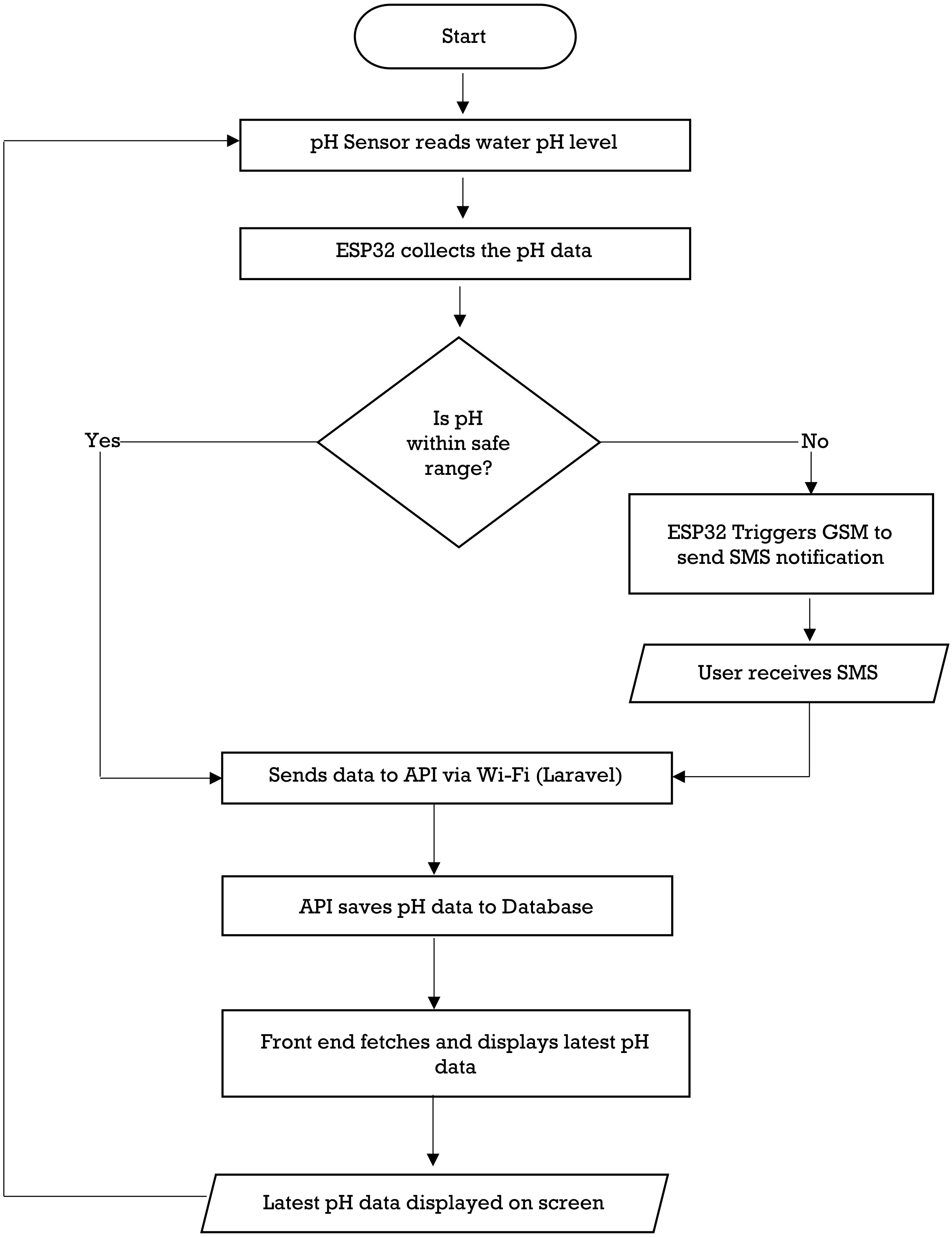



**Design of Prototype**

***Figure 3. Design Prototype***

**System Flow Chart**

***Figure 3. Design Prototype***



**Project Timeline**

| *Phase* | *Duration* | *Activities* |
|---|---|---|
| Planning & Research | Week 1 – Week 2 | Research, materials gathering, feasibility study |
| System, App Design and Documentation | Week 3 – Week 4 | Architecture, UI mockups, database and API design |
| Prototype Development | Week 5 – Week 6 | Hardware assembly, coding for ESP32 and GSM module |
| Web App Development | Week 7 – Week 8 | Frontend and backend programming |
| Testing & Troubleshooting | Week 9 | System integration, data verification, SMS testing |
| Finalization & Documentation | Week 10 | Completion of project report and presentation prep |

# CHAPTER IV

## PRESENTATION, ANALYSIS, AND INTERPRETATION OF DATA

This chapter presents, analyzes, and interprets the data gathered from the testing of the pH Monitoring with Web Application. The data collection methods included system performance testing, observational assessments, and functionality checks to evaluate the effectiveness, usability, and reliability of the device.

### Statistical Treatment Applied

As the researcher gathered the data from testing the pH Monitoring, they were combined and tabulated. These data were subjected to statistical treatment to answer the problems of the research. The statistical tools that were used include frequency distribution, percentage, and mean.

The formula used to compute for the percentage is:

$$P = \frac{F \times 100}{N}$$

Whereas P stands for Percentage, F for Frequency, and N for Number of Respondents.

To determine the mean of responses for Likert-scale questions, the formula used is:

$$M = \frac{F\,x\,W}{N}$$

Whereas M stands for Mean, F for frequency, W for weight of responses, and N for Number of Respondents.

For the interpretation of weighted means, the following scale was used:

| Scale | Range | Verbal Interpretation |
|---|---|---|
| 5 | 4.50 – 5.00 | Excellent/Very Satisfied |
| 4 | 3.50 – 4.49 | Good/Satisfied |
| 3 | 2.50 – 3.49 | Average/Neutral |
| 2 | 1.50 – 2.49 | Poor/Dissatisfied |
| 1 | 1.00 – 1.49 | Very Poor/Very Dissatisfied |

***Table 1. Likert-Scale***

| Category | Type of Group | Number of Respondents | Percentage |
|---|---|---|---|
| Gender | Female | 6 | 60% |
| | Male | 4 | 40% |
| Age | 60 - 69 | 5 | 50% |
| | 70 - 80 | 5 | 50% |

***Table 2. Demographic Profile of Respondents***

Table provides the demographic profile of the respondents that has been subjected to the researcher's survey as a form of data gathering procedure.

## System Performance Testing Results

The pH Monitoring with Web Application was subjected to rigorous testing to ensure its reliability, accuracy, and functionality. The following sections present the results of these tests.

### *pH Reading Accuracy Test*

This table shows the accuracy of the pH reading mechanism.

| Parameter | Number of Events | Percentage |
|---|---|---|
| Successful pH readings | 9 | 90% |
| Delayed data updates | 1 | 10% |
| Failed data readings | 0 | 0% |

***Table 3. pH Reading Accuracy Test Results***

The testing revealed a 90% of successful rate of pH readings, with only one delayed update. The delayed updates occurred due to temporary network connectivity issues.

### *Alert System Effectiveness*

| Alert Type | Number of Events | Number of Successful Alerts | Success Rate |
|---|---|---|---|
| SMS Notification | 10 | 8 | 80% |

***Table 4. Alert System Effectiveness Results***

The result reveals that the SMS notification feature had the lowest success rate at 80%, which was attributed to network-related issues.

***User Experience Survey Results***

A user experience survey was conducted to evaluate the overall effectiveness, ease of use, and satisfaction level with the pH Monitoring System and its Web Application. Feedback was gathered from a sample group of aquarium owners, who rely on accurate pH monitoring to maintain healthy aquatic environments.

***Web Application Assessment***

This presents the respondents' evaluation of the web application used in the pH Monitoring System, focusing on its functionality, usability, and overall user satisfaction.

| Test Description | Weighted Mean | Verbal Interpretation |
|---|---|---|
| User Interface Design | 4.10 | Good |
| User-friendliness | 4.20 | Good |

***Table 6. Web Application Assessment***

The web application received positive ratings across all aspects. The respondents found the app to be comprehensive and effective, though there is room for improvement in terms of design and wide-used in any platform.

***User Satisfaction and Recommendations***

This presents the overall satisfaction levels of the respondents and their likelihood to recommend the pH Monitoring System with web application to other aquarium owners.

| Aspect | Weighted Mean | Verbal Interpretation |
|---|---|---|
| Overall satisfaction with the pH Monitoring System | 4.20 | Good |
| Overall satisfaction with the web application | 4.20 | Good |
| Likelihood to continue using the pH Monitoring System and web app | 4.80 | Excellent |
| Likelihood to recommend to other aquarium owners | 4.50 | Excellent |

***Table 7. User Satisfaction and Recommendation Likelihood***

The results indicate a high level of satisfaction with both the pH Monitoring System and its web application. Respondents, primarily aquarium owners, expressed a strong likelihood to continue using the system and to recommend it to other aquarium enthusiasts, with this aspect receiving an “Excellent” rating.

## Analysis of Open-Ended Responses

In addition to the quantitative data, respondents were asked to provide open-ended feedback regarding their experience with the pH Monitoring System and its web application.

Most responses were positive, highlighting the system's accuracy, ease of use, and helpfulness in maintaining optimal water conditions for their aquariums. Many users appreciated the real-time monitoring and SMS notification feature that alerts them immediately when the pH level goes out of the safe range.

Common suggestions included enhancing the web application's user interface, adding mobile app compatibility, providing more detailed water quality reports, and offering multilingual support.

Overall, the open-ended feedback supported the survey findings, confirming user satisfaction and providing valuable insights for future system improvements.

### *Most Useful Features*

The following features of the pH Monitoring System were highlighted as the most useful by users:

1. **Real-Time Monitoring:** Users appreciated the continuous and accurate pH data readings, which helped them maintain optimal water conditions.
2. **SMS Notifications:** The immediate alerts sent via SMS when pH levels went out of the safe range were highly valued for prompt action.

3. **Web Application Interface:** The user-friendly web app, which allows users to easily view the latest pH reading remotely, was praised for its convenience.
4. **Easy Access:** Users valued being able to quickly check the current water conditions anytime through the web interface.

***Issued Encountered***

During the testing and use of the pH Monitoring System, a few issues were encountered:

1. **Connectivity Problems:** Some users experienced intermittent issues with the GSM module, causing delays in SMS notifications. This was primarily due to network signal instability in certain areas.
2. **Sensor Accuracy Fluctuations:** Occasionally, the pH sensor readings showed slight inconsistencies, which were attributed to environmental factors or sensor calibration needs.
3. **Web Application Performance:** Some users reported slow loading or delayed updates on the web application, especially when accessing it via older or low-spec devices.
4. **Notification Timing:** A few users mentioned that although SMS alerts were helpful, sometimes delays affected timely response to abnormal pH levels.

***Suggestion of Improvement***

Based on user feedback and testing results, several suggestions for improving the pH Monitoring System were made:

1. **Voice Alerts:** Users suggested adding voice alerts to complement SMS notifications, improving accessibility and timely responses.
2. **Web Application Enhancements:** Users expressed interest in additional features such as displaying historical pH trends, customizable alert settings, and a more intuitive user interface for easier navigation.
3. **Multi-Language Support:** Users from diverse backgrounds recommended offering multiple language options to make the system more accessible to non-English speakers.
4. **Backup Power Solution:** Some users recommended integrating a battery backup or alternative power source to ensure continuous monitoring during power outages.
5. **Sensor Calibration Ease:** Suggestions were made to simplify sensor calibration procedures to maintain accuracy without requiring technical expertise.

These suggestions highlight opportunities to further enhance the user experience, ensuring that the device serves a broader audience with even more reliable performance.

**Interpretation of Data**

The data collected from user surveys and system testing provided valuable insights into the effectiveness and usability of the pH Monitoring System with web application. Key findings indicate that the system successfully assists aquarium owners in maintaining optimal water quality by providing timely alerts through SMS and displaying real-time pH data on the web interface. Users reported satisfaction with the system's ease of use and the convenience of remote monitoring.

Issues encountered, such as occasional network connectivity interruptions affecting SMS notifications, were relatively minor and manageable. Feedback on the web application highlighted opportunities for enhancement, including the addition of historical data visualization and customizable alert settings, to improve user engagement and decision-making.

Suggestions for improvements, such as adding voice alerts and implementing a backup power solution, reflect user needs for greater accessibility and system reliability, especially in situations where timely response to pH fluctuations is critical. Overall, the data supports the conclusion that the pH Monitoring System fulfills its purpose of facilitating effective water quality management, while also identifying areas for further development to enhance user experience and system robustness.

# CHAPTER 5

# SUMMARY, CONCLUSION, AND RECOMMENDATION

This chapter summarizes the key features of the study and reviews the findings from the data analysis and interpretation. It presents the conclusions drawn based on these results and provides recommendations for future improvements and developments.

## Summary of Findings

This study is a qualitative investigation designed to evaluate the effectiveness of a pH Monitoring System with a web application for aquarium owners. The project focused on addressing the challenges of maintaining optimal water quality by providing real-time pH monitoring and timely alerts to users.

***Key Research Findings:***

1. **Water Quality Management Challenges Identified:** The study revealed that many aquarium owners struggle with continuously monitoring and maintaining stable pH levels in their tanks. Common challenges include:
    - Inconsistent manual pH testing schedules
    - Delayed responses to abnormal pH fluctuations
    - Limited access to real-time water quality data
    - Lack of automated alert systems to notify owners of potential issues
2. **System Performance Results:** The pH Monitoring System demonstrated high reliability and functionality:
    - **Real-Time Data Display:** The system provided continuous, accurate pH readings visible on the web application interface.
    - **SMS Alert Effectiveness:** SMS notifications for pH levels outside the acceptable range achieved a high success rate, though occasional delays occurred due to network issues.

- **User Interface Performance:** The web application was found to be user-friendly and accessible, allowing aquarium owners to monitor water quality remotely.

3. **User Experience and Satisfaction:** Survey results from aquarium owners indicated:
   - High satisfaction with the system's real-time monitoring capabilities
   - Appreciation for timely SMS alerts that enable quick corrective actions
   - Interest in future enhancements such as historical data visualization and improved accessibility features
4. **Most Valued Features:** Users identified the following features as most beneficial:
   - Continuous and accurate pH monitoring
   - Instant SMS alerts for abnormal pH levels
   - Remote access to water quality data via the web interface
5. **Technical Implementation Success:** The ESP32-based system successfully integrated key components including:
   - pH sensor for water quality measurement
   - GSM module for SMS notifications
   - Web application for real-time data visualization and user interaction

## Conclusion

Based on the comprehensive analysis of data collected through system testing, user surveys, and observational assessments, the following conclusions are drawn:

### *Research Objectives*

The pH Monitoring System with Web Application successfully addressed the primary research objectives by:

- Providing an effective solution for real-time monitoring of water quality in aquariums
- Enabling timely alerts for abnormal pH levels to prevent harm to aquatic life
- Offering a user-friendly web-based interface accessible to aquarium owners with varying levels of technical expertise

### *Problem Resolution*

The system effectively addressed key challenges in aquarium water management by:

- Eliminating the need for manual and intermittent pH testing
- Reducing response times to water quality issues through instant SMS notifications
- Providing continuous access to water quality data for proactive maintenance

### *Technology Integration Success*

The integration of the ESP32 microcontroller with web technologies and GSM communication proved highly effective, demonstrating:

- Reliable wireless connectivity for data transmission and alert delivery
- Accurate and continuous pH measurement with timely notifications
- Scalable architecture allowing for future system enhancements

### *User Acceptance and Satisfaction*

Positive feedback from aquarium owners indicates:

- Strong acceptance of IoT-based water monitoring solutions
- Increased confidence in maintaining stable aquatic environments
- Appreciation for remote access and automated alerting features

### *Contribution to Environmental Monitoring Technology*

This research contributes to the growing field of IoT-enabled environmental monitoring by:

- Demonstrating the viability of affordable, real-time water quality monitoring solutions
- Providing a practical tool for hobbyists and small-scale aquarium owners
- Establishing a model that can be adapted for other water monitoring applications

**Recommendations**

Based on the research findings, analysis, and user feedback, the following recommendations are proposed to enhance the pH Monitoring System with Web Application:

***For System Improvement***

1. Enhanced Connectivity Solutions
   - ✓ Implement redundant communication channels to improve reliability of SMS alerts, such as integrating Wi-Fi backup or alternative messaging protocols.
   - ✓ Develop offline capabilities to ensure continuous pH data logging during network outages.
2. Accessibility Enhancements
   - ✓ Integrate voice alerts to notify users of abnormal pH levels, improving accessibility for visually impaired aquarium owners.
   - ✓ Offer multi-language support to accommodate diverse user groups.
   - ✓ Add customizable visual and audio alert settings, including adjustable display size and sound volume.
3. Web Application Development
   - ✓ Develop a mobile-friendly version or dedicated mobile application to provide easier access and notifications on the go.

- ✓ Implement data visualization features for historical pH trends to help users better analyze water quality over time.
- ✓ Include user personalization options such as custom alert thresholds and notification preferences.
- ✓ Ensure secure data transmission and storage by applying encryption standards and authentication measures.

4. Hardware Improvements
   - ✓ Improve sensor accuracy and calibration processes to ensure precise pH measurements.
   - ✓ Optimize the enclosure design for better water resistance and easier maintenance.
   - ✓ Explore power supply enhancements, including battery backup, to ensure uninterrupted monitoring during power failures.
   - ✓ Enhance physical alert mechanisms (e.g., LED indicators, buzzers) for immediate on-site notifications.

***For Future Research***

1. Long-term Monitoring Studies
   - ✓ Conduct extended testing to evaluate system durability and reliability over time in real aquarium environments.
   - ✓ Assess the impact of continuous pH monitoring on aquatic health and aquarium maintenance practices.
2. Technology Advancement

- ✓ Investigate integration with other water quality parameters such as temperature, turbidity, or ammonia levels for comprehensive monitoring.
- ✓ Explore IoT platforms for remote control and automation of aquarium maintenance tasks based on sensor data.
- ✓ Research potential for AI-driven predictive alerts to prevent water quality issues before they occur.

3. Comparative Analysis
   - ✓ Compare system performance, usability, and cost-effectiveness against commercial aquarium monitoring products.
   - ✓ Evaluate user satisfaction and adoption rates across different types of aquarium owners (e.g., hobbyists vs. professionals).

The successful development and implementation of the pH Monitoring System with Web Application demonstrates the significant potential for technology to address critical water quality monitoring challenges faced by aquarium owners. The positive user feedback and reliable system performance provide a strong foundation for continued development and wider adoption of similar solutions in communities requiring real-time environmental monitoring.

This research contributes valuable insights to the growing field of IoT-based environmental monitoring and establishes a framework for delivering innovative, user-friendly, and accessible technological solutions. The recommendations offered provide clear pathways for system enhancement and future research that can further improve the system's effectiveness and broaden its impact in aquatic health management.

## BIBLIOGRAPHY

Chen, X., Liu, Y., & Zhang, H. (2021). *Real-time monitoring system for large-scale fish tanks using ESP32 and cloud technology*. Chinese Journal of Aquaculture Technology, 39(4), 56–62.

De la Cruz, R. M., Santos, J. L., & Dizon, P. R. (2018). *Development of a basic sensor-based monitoring system for fish pond conditions*. State University Research Journal, 14(2), 45–51.

Electronics for You. (2019). *IoT-based water monitoring systems in smart farming and aquaculture*. https://www.electronicsforu.com

Garcia, D. A., & Lopez, M. J. (2020). *Automatic fish feeder with future integration for water monitoring*. Philippine Journal of Applied Technology, 12(1), 33–38.

IoTForAll. (2021). *Using cloud-based dashboards for real-time IoT sensor monitoring*. https://www.iotforall.com

Nguyen, T. M., & Tran, H. P. (2020). *Smart aquarium system with real-time monitoring using IoT*. International Journal of Smart Technology and Applications, 8(3), 102–110.

Park, K., & Lim, S. (2012). *Construction of a medication reminder synchronization system based on data synchronization*. International Journal of Bioscience and Biotechnology, 4, 1–10.

Rahman, M. A., Hossain, M. S., & Kabir, M. N. (2018). *Design and implementation of an IoT-based water quality monitoring system for aquaculture*. Journal of Environmental Monitoring Systems, 9(1), 77–85.

Reyes, L. G., & Mendoza, V. R. (2020). *Utilizing SMS alerts for water monitoring in rural aquaculture*. Philippine ICT Journal, 8(1), 19–24.

Rodriguez, P. D. (2021). *Application of GSM modules in remote rural farming for SMS alerts*. Journal of Agricultural Technology, 11(2), 89–95.

Santos, M. J. (2019). *Challenges in manual water testing among local aquarium hobbyists*. Philippine Aquatic Life, 7(1), 12–18.

TechBriefs. (2020). *GSM modules and IoT: A solution for offline environments*. https://www.techbriefs.com

## APPENDIX A – RESEARCHERS PROFILE

# CHARLIE PATANAO SUMALAG


0929-574-971

charliesumalag1991@gmail.com

Burgos, Rodriguez, Montalban Rizal


### SKILLS

- Front-End (HTML,CSS,Tailwind CSS, JS,React JS
- Backend(PHP,Laravel, MySQL)
- Microsoft Office (Word,Excel, and Powerpoint

### PERSONAL INFORMATION

| | |
|---|---|
| Date of Birth: | Dec. 2, 1991 |
| Place of Birth: | Agusan Del Sur |
| Age: | 32 |
| Sex: | Male |
| Citizenship: | Filipino |

### EDUCATION

**Teritiray**

2021-Present
ICCT Colleges Cainta, Rizal
Bachelor of Science in Information Technology

**Secondary**

2006-2010
Cantapoy National High School
Malimono Surigao Del Norte

**Primary**

2001-2006
Bayugan Central Elementary School
Agusan Del Sur

# CAMPANAN, ALBERT JHON L.

0970-757-9359

albertcampanan44@gmail.com

blk28b lot10 phase 2 southville
9 baras pinugay

## SKILLS

- Basic Programming (Java, C++, Javascript, Phyton)
- Microsoft Office (Word,Excel, and Powerpoint

## PERSONAL INFORMATION

| | |
|---|---|
| Date of Birth: | March 12, 2004 |
| Place of Birth: | Antipolo City |
| Age: | 21 |
| Sex: | Male |
| Citizenship: | Filipino |

## EDUCATION

**Teritiray**

2022-Present
ICCT Colleges Cainta, Rizal
Bachelor of Science in Information Technology

**Secondary**

2017-2022
Bagong Nayon National High School
Antipolo City

**Primary**

2011-2017
Peace Village Elemantary School
Antipolo City

# Mendoranda, Vincent V.


0928-073-5205

vincentmedoranda71@gmail.com

Meralco Village, Brgy. San Juan, Taytay, Rizal


**SKILLS**

- Basic Programming (Java, C++, Javascript, Phyton)
- Microsoft Office (Word,Excel, and Powerpoint

**PERSONAL INFORMATION**

| | |
|---|---|
| Date of Birth: | August 15, 2000 |
| Place of Birth: | Taytay Rizal |
| Age: | 24 |
| Sex: | Male |
| Citizenship: | Filipino |

**EDUCATION**

**Teritiray**

2022-Present
ICCT Colleges Cainta, Rizal
Bachelor of Science in Information Technology

**Secondary**

2014-2018
Taytay National High School
Taytay Rizal

**Primary**

2008-2014
Muzon Elementary School
Taytay Rizal

# Salazar, Wilmar

0954-290-9144

wilmarsalazar1010@gmail.com

89sitio dalisay brgy san Isidro Antipolo city

**SKILLS**

- Basic Programming (Java, C++, Javascript, Phyton)
- Microsoft Office (Word,Excel, and Powerpoint

**PERSONAL INFORMATION**

| | |
|---|---|
| Date of Birth: | Oct. 10, 2001 |
| Place of Birth: | Antipolo City |
| Age: | 23 |
| Sex: | Male |
| Citizenship: | Filipino |

**EDUCATION**

**Teritiray**

2022-Present
ICCT Colleges Cainta, Rizal
Bachelor of Science in Information Technology

**Secondary**

2014-2018
San Isidro national high school
Antipolo City

**Primary**

2008-2014
San Isidro elementary school
Antipolo City

# Sandoval, Edsan

0931-774-0072

johntenshi77@gmail.com

Phase 1 tanza 1 Barangay
San Jose Antipolo City

**SKILLS**

- Basic Programming (Java, C++, Javascript, Phyton)
- Microsoft Office (Word,Excel, and Powerpoint

**PERSONAL INFORMATION**

| | |
|---|---|
| Date of Birth: | Jan. 16, 2004 |
| Place of Birth: | Antipolo City |
| Age: | 21 |
| Sex: | Male |
| Citizenship: | Filipino |

**EDUCATION**

**Teritiray**

2022-Present
ICCT Colleges Cainta, Rizal
Bachelor of Science in Information Technology

**Secondary**

2021-2022
Maximo L Gatlabayan Memorial National High School
Antipolo City

**Primary**

2015-2016

Tanza 2 Elementary school

Antipolo City

# Velasco, Sidney Cortes


0976-181-3693

sidneyvelasco2005@gmail.com

091 Siruna Phase 1 Brgy
Mambugan Antipolo City


**SKILLS**

- Basic Programming (Java, C++, Javascript, Phyton)
- Microsoft Office (Word,Excel, and Powerpoint

**PERSONAL INFORMATION**

| | |
|---|---|
| Date of Birth: | August 5, 2001 |
| Place of Birth: | Antipolo City |
| Age: | 23 |
| Sex: | Male |
| Citizenship: | Filipino |

**EDUCATION**

**Teritiray**

2022-Present
ICCT Colleges Cainta, Rizal
Bachelor of Science in Information Technology

**Secondary**

2013-2018
Mambugan National High School
Antipolo City

**Primary**

2007-2013
JoseFina Elementary School
Antipolo City

# Nazareno, Jacob D.

0976-4517-042

Nazarenojacob102544@gmail.com

115 Building 15, Eusebio Village, Jenny's Avenue

**SKILLS**

- Basic Programming (Java, C++, Javascript, Phyton)
- Microsoft Office (Word,Excel, and Powerpoint

**PERSONAL INFORMATION**

| | |
|---|---|
| Date of Birth: | Nov. 29, 2002 |
| Place of Birth: | Pasig City |
| Age: | 22 |
| Sex: | Male |
| Citizenship: | Filipino |

**EDUCATION**

**Teritiray**

2022-Present
ICCT Colleges Cainta, Rizal
Bachelor of Science in Information Technology

**Secondary**

2015-2018
Mona Lisa Academy
Pasig City

**Primary**

2005-2006
El Elyon Learning Center
Pasig City

# Ivan, Divinagracia R.

0964-735-4074

ivanrosdiv99@gmail.com

269B Bayabas St. Napico
Manggahan Pasig City

**SKILLS**

- Basic Programming (Java, C++, Javascript, Phyton)
- Microsoft Office (Word,Excel, and Powerpoint

**PERSONAL INFORMATION**

| | |
|---|---|
| Date of Birth: | Nov. 8, 1999 |
| Place of Birth: | Roxas City |
| Age: | 25 |
| Sex: | Male |
| Citizenship: | Filipino |

**EDUCATION**

**Teritiray**

2022-Present
ICCT Colleges Cainta, Rizal
Bachelor of Science in Information Technology

**Secondary**

2021-2022
Capiz National High School
Roxas City

**Primary**

2005-2006
Filamer Christian University
Roxas City

# MENDEZ, SAMUEL J. JR.

0906-565-0429

mycasper01@gmail.com

86 Westbank Floodway
Maybunga Pasig city

**SKILLS**

- Basic Programming (Java, C++, Javascript, Phyton)
- Microsoft Office (Word,Excel, and Powerpoint

**PERSONAL INFORMATION**

| | |
|---|---|
| Date of Birth: | Nov. 1, 1995 |
| Place of Birth: | Pasig City |
| Age: | 29 |
| Sex: | Male |
| Citizenship: | Filipino |

**EDUCATION**

**Teritiray**

2014-Present
ICCT Colleges Cainta, Rizal
Bachelor of Science in Information Technology

**Secondary**

2013-2014
Eusebio high school
Pasig City

**Primary**

2009-2010
Maybunga Elementary school
Pasig City

## APPENDIX B – COPY OF PROJECT DESIGN

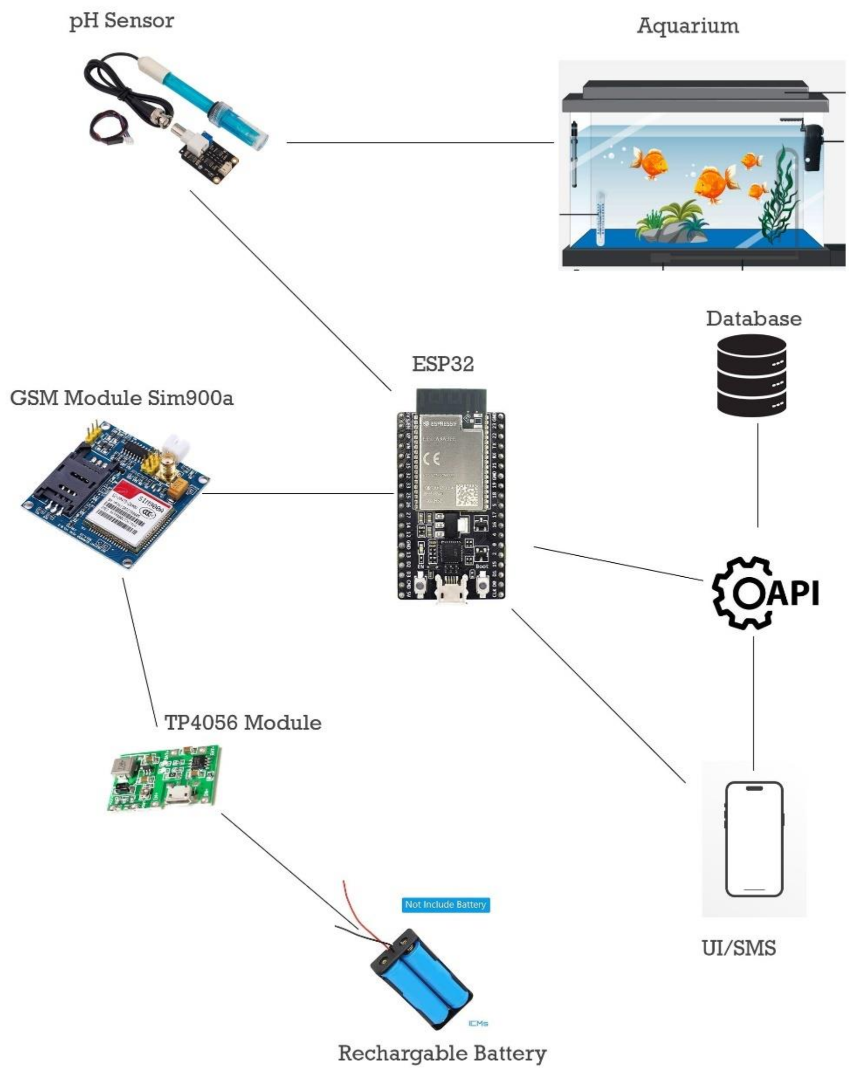



***Figure 4:*** Project Design of the IoT-Based Aquarium pH Monitoring System with SMS Alerts and Web Application for Real-Time Water Quality Management

## APPENDIX C – TECHNICAL BACKGROUND

### Hardware

| Image | Description |
|---|---|
|  | ESP32<br><br>A compact microcontroller with a metallic RF shield, GPIO pins, and an onboard antenna. It processes inputs, controls peripherals, and connects via Wi-Fi and Bluetooth for IoT and automation tasks. |
|  | LCD 1602 I2C 16x2<br><br>A 16x2 character LCD display with I2C interface, allowing you to display up to sixteen characters on each of the two lines. |
|  | GSM module<br><br>A GSM (Global System for Mobile Communications) module is a device that allows you to send and receive SMS (Short Message Service) messages and make voice calls over a cellular network. |
| | DFRobot pH Sensor |

| | |
|---|---|
|  | The DFRobot pH Sensor is a high-precision analog sensor designed for measuring the acidity or alkalinity (pH level) of a liquid. It is commonly used in water quality monitoring applications, including aquariums, hydroponics, and environmental studies. |
|  | TP4056 with built in booster<br>The TP4056 module with a built-in booster is a A compact board that charges 3.7V Li-ion batteries and boosts output to 5V, combining charging, protection, and power supply in one module—ideal for portable and IoT projects. |
|  | Wire for connections<br>Insulated copper wire is used to connect the different components in an electronic circuit. Typically, flexible, and available in various gauges. |
|  | Battery Holder<br>Holds three Lithium battery connected in parallel. Suitable for low-voltage applications like powering a TP4056 module and ESP32. |

| | |
|---|---|
|  | Lithium Battery 3.7V<br><br>Rechargeable battery setup providing stable 3.7V output with increased capacity, ideal for powering GSM modules via a TP4056 charging and boost circuit. |

**Software**

| Name | Description |
|---|---|
| | Arduino IDE<br><br>A free, open-source program that allows users to write and upload code to Arduino boards. It's used to edit, compile, and upload code to Arduino devices. |
| | Visual Studio Code<br><br>Visual Studio is a powerful and comprehensive Integrated Development Environment (IDE) developed by Microsoft. It's designed to be a one-stop shop for software development, allowing users to write, edit, debug, build, and publish applications. |
| | Postman<br><br>A user-friendly API testing tool that simplifies the process of developing, testing, and |

| | |
|---|---|
| | managing APIs with features like request building, automation, and collaboration. |
| | Laragon<br>Laragon is a local development environment that includes Apache (a web server) to serve your websites and MySQL (a database server) to manage your databases, making it easy to build and test web applications on your computer. |

**APPENDIX D – CODE**

```
#include <WiFi.h>
#include <HTTPClient.h>
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include <HardwareSerial.h>

// WiFi credentials
const char* ssid = "Charlesss";
const char* pass = "012345678";

const char* serverIP = "192.168.233.160";
const int serverPort = 8000;
const char* apiPath = "/api/readings";
// pH sensor and serial pins
#define PH_SENSOR_PIN 34
#define RXD2 16
#define TXD2 17

// Calibration values
float voltageAtPH7 = 1.91;
float slope = 5.7;

// Timing
unsigned long lastSMSTime = 0;
```

```
const unsigned long smsInterval = 60000; // 1 minute between SMS

// LCD & SIM900A
LiquidCrystal_I2C lcd(0x27, 16, 2);
HardwareSerial sim900(2);  // UART2 for SIM900A

void setup() {
 Serial.begin(115200);
 sim900.begin(9600, SERIAL_8N1, RXD2, TXD2);
 lcd.init();
 lcd.backlight();

 lcd.setCursor(0, 0);
 lcd.print("Connecting WiFi");

 WiFi.begin(ssid, pass);
 while (WiFi.status() != WL_CONNECTED) {
  delay(1000);
  Serial.print(".");
 }

 lcd.clear();
 lcd.setCursor(0, 0);
 lcd.print("PH LEVEL:");
 Serial.println("WiFi Connected");

 delay(3000); // SIM900A boot delay
}

void loop() {
 int adcValue = analogRead(PH_SENSOR_PIN);
 float voltage = adcValue * 3.3 / 4095.0;
 float pHValue = slope * (voltage - voltageAtPH7) + 7.0;

 // LCD Display
 lcd.setCursor(0, 1);
 lcd.print("pH: ");
 lcd.print(pHValue, 2);
 lcd.print("     ");

 // Serial Monitor
 Serial.print("ADC: ");
 Serial.print(adcValue);
 Serial.print(" | Voltage: ");
 Serial.print(voltage, 3);
 Serial.print(" V | pH: ");
 Serial.println(pHValue, 2);
```

```
  // Send to server
  sendToServer(pHValue);

  // Send SMS if out of range
  if ((pHValue < 6.5 || pHValue > 7.5) && (millis() - lastSMSTime >
smsInterval)) {
    sendSMS(pHValue);
    lastSMSTime = millis();
  }

  delay(10000); // Wait 10 seconds
}

void sendToServer(float ph) {
   if (WiFi.status() == WL_CONNECTED) {
    HTTPClient http;

    String url = String(apiPath);  // Just the endpoint path
    http.begin(serverIP, serverPort, apiPath); // ESP32 HTTPClient supports
this overload
    http.addHeader("Content-Type", "application/json");

    String json = "{\"ph\": " + String(ph, 2) + "}";

    int httpResponseCode = http.POST(json);
    Serial.print("HTTP Response code: ");
    Serial.println(httpResponseCode);

    if (httpResponseCode > 0) {
      String response = http.getString();
      Serial.println("Server response: " + response);
    } else {
      Serial.println("Error sending POST request");
    }

    http.end();
  } else {
    Serial.println("WiFi not connected!");
  }
}

void sendSMS(float ph) {
  String message;

  if (ph < 6.5) {
    message = "pH " + String(ph, 2) + " is LOW. Check water.";
  } else if (ph > 7.5) {
    message = "pH " + String(ph, 2) + " is HIGH. Check water.";
```

```
  } else {
    return;
  }

  Serial.println("Sending SMS...");
  sim900.println("AT");
  delay(1000);
  sim900.println("AT+CMGF=1");
  delay(1000);
  sim900.println("AT+CMGS=\"+639295749771\""); // Change number as
needed
  delay(1000);
  sim900.print(message);
  sim900.write(26); // CTRL+Z to send SMS
  delay(5000);
  Serial.println("SMS Sent: " + message);
}
```