SWIMCLEAN: AN EMBEDDED REAL TIME WATER QUALITY ASSESSMENT FOR MAN-MADE RECREATIONAL WATER ENVIRONMENT WITH MOBILE APPLICATION

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ACADEMIC INTEGRITY DECLARATION

We, **PAMELA JIRAH M. CASAMA** and **MICHAEL JOHN A. PALMA** declare that this Capstone/Thesis is our own original work. Most stipulations presented herein and ours alone. Borrowed ideas are given due recognition and are properly acknowledged. With the best ability, this investigation was treated with utmost are to adhere internationally known standard/policies on academic integrity.

We attest further that this piece of academic requirements has not been submitted previously for an academic credit in this or in any other courses.

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ABSTRACT

Pamela Jirah M. Casama, Michael John A. Palma. "**SWIMCLEAN: AN EMBEDDED REAL-TIME WATER QUALITY ASSESSMENT FOR MAN-MADE RECREATIONAL WATER ENVIRONMENT WITH MOBILE APPLICATION" (**Undergraduate Thesis**).** Davao Oriental State College of Science and Technology. July 2020

Adviser: **Engr. Junee Warren M. Riogelon**

The project entitled "SwimClean: An Embedded Real-Time Water Quality Assessment for Man-Made Recreational Water Environment with Mobile Application" was conducted in order to give assistance to the City Health Office of Mati City have a device that will be able to read water quality easily. The system has three parameters, namely; (1) pH meter, (2) Turbidity, and (3) Total Dissolved Solids (TDS). The system's readings can be viewed through the device's LCD and the system's mobile application. The mobile application will have a few seconds delay on what the device will display it is due to the uploading process of the water readings to the cloud server of the device. The researchers used the prototype development model which is a software development method that enables the developers to build a preliminary prototype and then after, the prototype will undergo testing process and after, it will be reworked and the final prototype will be built. After all the development process, the outcome of the project is satisfactory. All the objectives of the project was successfully achieved and implemented. The system is now ready for deployment but still, the system has more rooms for improvement.

Keywords: real-time water quality

CHAPTER I

INTRODUCTION

1.1 Rationale of the study

Maintaining your pool water in a safe balanced state can be a daunting prospect for most pool owners. Bacteria can multiply in pool water it is because there are too many people bathing together. Some factors that affects the cleanliness of the water are dirt, leaves, pollen, human perspiration, and many more.

Recreational Water Illnesses (RWIs) are caused by germs and chemicals found in the water where people swim in. They are spread by swallowing, breathing in mists or aerosols of, or having contact with contaminated water in swimming pools, hot tubs, water parks, water play areas, interactive fountains, lakes, rivers, or oceans. RWIs can also be caused by chemicals in the water or chemicals that turn into gas in the air and cause air quality problems at indoor aquatic facilities. Knowing the basic facts about RWIs can make the difference between an enjoyable time at the pool, beach, or waterpark, and getting a rash, having diarrhea, or developing other, potentially serious illnesses. (Recreational Water Illness, 2019) And because of that, an estimate of 829,000 people dies each year from diarrhea (World Health Organization, 2019).

The Sustainable Development Goals or SDG, also known as the Global Goals, were adopted by all United Nations Member Estates in 2015 as a universal call to action to global problems. The 17 Sustainable Development Goals designed to bring the world to zero poverty, hunger, aids, discrimination and more. The proponents are targeting to deliver this project in line with the SDG's goal number 3 and 6 which are to ensure healthy lives and promote well-being for all ages and to ensure availability and

sustainable management of water and sanitation for all (Sustainable Development Goals, 2019).

After the proponents conducted an interview, the hurdles encountered of the proponents' chosen organization which is the City Health Office – Mati City, after getting a sample water from a pool on a resort, the Sanitation inspector have to deliver the sample water to Tagum City for hours and pay for the chemical laboratory at the Provincial Health Office. The Sanitation Office can have the result after one week. The resort's permit will be assessed by the sanitary inspector based on the results given by the Provincial Health Office.

The project entitled SwimClean: An Embedded Real-time Water Quality Assessment for Man-Made Recreational Water Environment with Mobile Application is a system designed for Mati City, City Health Office – Environmental Health and Sanitation Services. It is a combination of an embedded system and a mobile application that assess water quality of any man-made recreational water environment.

1.2. Purpose and Project Description

The purpose of this project is to provide a helping hand for the residents in Mati City, to ensure their safety every time they go out for a swim. This project will also be a useful tool that assesses recreational water for the residents of Mati City avoid diseases such as diarrhea and other Recreational Water Illnesses (RWI).

SwimClean provides a friendly user-interface, which helps the user visualize and analyse the quality of the water better. In this phase, the chemical parameters in the water are determined. The mobile application will serve as the platform which the users can actually see the results of the test made in the embedded system or the device.

The parameters used are pH, Turbidity, and Total Dissolved Solids (TDS). The pH value measures the acidity, alkalinity or basicity of water and directly affects some of the chemical reactions that occur in the swimming pool water. The ability of chlorine to oxidize matter and kill microorganisms is directly affected by pH. As the pH raises this ability is adversely affected. In addition, at a pH over 8.0 scaling (precipitation of mineral components) and cloudy water may result. As pH falls below 7.0 the acidic condition will cause irritation to the eyes and mucous membranes of swimmers. Low pH (acidic water) can also corrode metal parts of a pool system and damage the plaster finish. For effective disinfection, the pH value must also be monitored, because the influence of pH on disinfection efficiency is the same as described for chlorine as a disinfectant.

Turbidity is a measure of the amount of suspended matter in water, and the more turbid the water, the less clarity. Turbidity needs to be controlled both for safety and for effective disinfection. Turbidity testing is simple; approaches to establishing appropriate, facility-specific turbidity standards are 0 – 0.5 nephelometric turbidity unit (NTU). Exceedance of a turbidity standard suggests both a significant deterioration in water quality and a significant health hazard. Such exceedance merits immediate investigation and should lead to facility closure unless the turbidity can rapidly be brought within standards.

Total dissolved solid (TDS) is the weight of soluble material in water. Disinfectants and other pool chemicals as well as bather pollution will increase TDS levels. The real value of detecting an increase in TDS levels is as a warning of overloading or lack of dilution, and TDS levels should be monitored by comparison between pool and source water. If TDS is high, dilution is likely to be the correct management action. (Word Health Organization, 2006)

Swimming pool Parameter	World Health Organization Standard Range	Remarks
pH	7.2 – 7.8	If the result exceeds standard range, overall remarks will be marked as "Failed".
Turbidity	0 NTU – 0.5 NTU	If the result exceeds standard range, overall remarks will be marked as "Failed".
Total Dissolved Solids (TDS)	300mg/L – 600mg/L	If the result exceeds standard range, overall remarks will be marked as "Failed".

Table 1.1 Swimming pool Parameter Standard Range

1.3. Objectives of the Study

The overall goal of this project is to articulate a broad planning and standards for more effective and comprehensive work for City Health Office Mati – Environmental Health and Sanitation Services and for the residents in Mati City. The project aims to:

1. Design and develop a device and a mobile application called SwimClean that could help the City of Mati, City Health Office – Environmental Health and Sanitation Services that will be capable of:
    a. Assessing the water quality easily of any man-made recreational water environment through a handheld device with 3 different sensors and chemical parameters (pH, turbidity, and TDS).

b. Provide functionality on the mobile application that enables the user to view the overall remarks of the three parameters based on the live readings.

c. Ensure that the results from the device's assessed water are accurate.

d. Provide logs or records on the mobile application to view all saved assessment.

2. Evaluate the SwimClean in order to determine if it complies with the ISO (International Standards Organization) 9126 standards;

3. To prepare an implementation plan for the deployment of the SwimClean app.

1.4. Significance of the Study

The results of the study will be substantial information and a benefit to the following:

a. **Residents in Mati City –** The residents are considered as the beneficiaries to the proposed project in a way that they will be at ease, comfort, and enjoyment; and ensure their safety every time they go out for a swim on any pool resorts in Mati City.

b. **Pool Resort Owners –** The proposed project will be a great advantage to the Inland Pool Resort Owners, they'll be able to gain their permit to run their business and ensure their customers' safety.

c. **City Health Office Mati - Environmental Health and Sanitation Services –** The proposed project will be a great tool for the City Health Office sanitary inspectors, in a way that their hurdles in getting the sample water, paying, and waiting for the results to be delivered will be lessen.

1.5. Scope and Limitations

1.5.1 Scope

- The handheld device will assess the quality of the sample water in a glass.
- The handheld device contains three sensors, namely pH sensor, Turbidity sensor, and TDS sensor.
- The mobile application will read the assessment from the device through the three chemical parameters. (pH, Turbidity, TDS)
- The overall result will be marked as "Passed" or "Failed".
- In determining the overall remarks for the results, if the result of pH, turbidity and TDS exceeds the standard range of each parameter, the result will automatically be marked as "Failed".
- The mobile application will run on Android smartphones version 3.1 and higher.
- All saved assessment on the mobile application can be seen on the logs or records.
- All connected handheld device to the user's mobile app can be connected and disconnected and each have a device manual.
- Wi-Fi Connection will be used in connecting the handheld device to the smartphone.

1.5.2 Limitations

- The system can only run on Android platform.
- Averaging the results of the three parameters is not applicable, for the three parameters holds different standard ranges.

1.6. Conceptual Framework

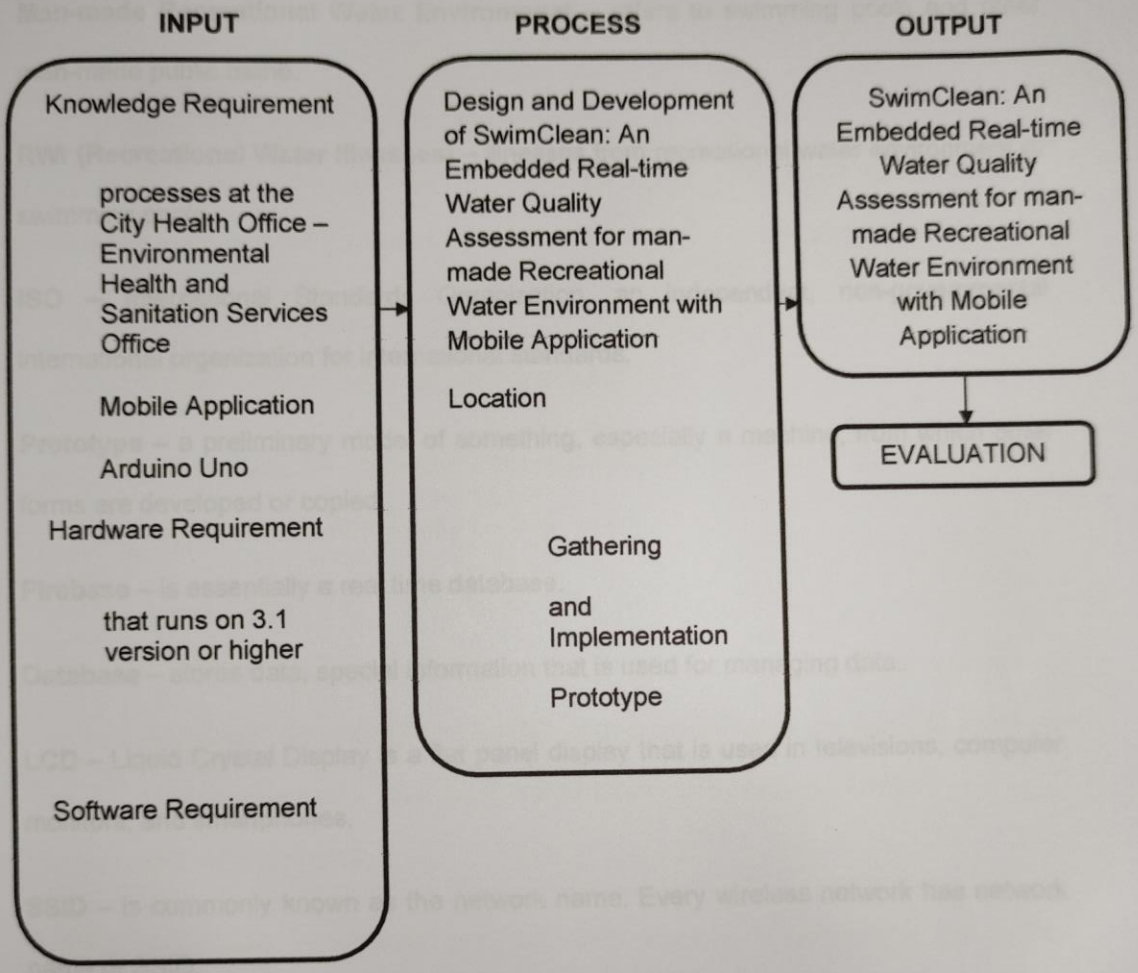

Figure 1.1 Conceptual Framework

1.7. Definition of Terms

Man-made Recreational Water Environment – refers to swimming pools and other man-made public bathe.

RWI (Recreational Water Illnesses) – illnesses from recreational water environment or swimming pools.

ISO – International Standards Organization, an independent, non-governmental international organization for international standards.

Prototype – a preliminary model of something, especially a machine, from which other forms are developed or copied.

Firebase – is essentially a real time database.

Database – stores data, special information that is used for managing data.

LCD – Liquid Crystal Display is a flat panel display that is used in televisions, computer monitors, and smartphones.

SSID – is commonly known as the network name. Every wireless network has network name or SSID.

CHAPTER II

REVIEW OF RELATED LITERATURE

2.1. Technical Background

SwimClean is a combination of embedded system and mobile application. The developers used different technological approach during the development of the system, and these were the following:

2.1.1 Details of the Technology to be used

These are the computer applications/tools and devices that researchers might be using in the development of this project:

- **Arduino IDE**

  The developers used Arduino in assigning designated commands into the board. Arduino Software (IDE) allows you to write programs and upload them to your board. (Getting Started with Arduino Products, 2019)

- **MIT App Inventor**

  The developers used MIT App Inventor in developing the mobile application. App Inventor is an online platform for developing mobile applications. The researchers used this in order to save time in developing the application. The MIT App Inventor can create mobile application by dragging and dropping components into a design view.

- **Balsamiq Mock-ups**

The developers used Balsamiq Mock-ups for the designing of the mock-up of the system. It enables the developers to better provide an enhanced design of the system's mock-up design.

- **Arduino pH meter**

  Device used for measuring the pH or the acidity and alkalinity of the water. The proponents add this device to the system so that the proponents will have accurate measurement in terms of acidity and alkalinity of the water.

- **Arduino TDS sensor**

  The proponents added this device to the system so that the proponents will have an accurate measurement of Total Dissolved Solids in the water.

- **Arduino Turbidity Sensor**

  The proponents added this device to the system so that the proponents will be able to determine the cloudiness or the haziness of the water. Turbidity Sensor will be able to determine the exact parameter for the proponents to deliver an accurate reading of the quality of water.

2.2. Related Literature

The relativity of the proponent's proposed project to the existing systems is that it enables the user to manually assess water quality without bringing water sample to a chemist. The proposed system which is a device that assesses water quality is a device which is portable and easy to use.

Chemical Sensors for Water Analysis uses chemical sensors that can be classified into electrochemical, gravimetric and optical. The output of electrochemical

sensors relies on the flow of the charge carriers between the sensor surface and the analyte.

The Value of Clean Water Resources: Estimating the Water Quality Improvement in Metro Manila, Philippines is a study in which unfavorable hydrological and ecological changes in most urban river systems and has created environmental problems. This study investigates the relationship between poor water quality and resident's willingness to pay (WTP) for improved water quality in Metro Manila. The water quality in rivers, streams, lakes, and canals in many Southeast Asian countries has been deteriorating because of rapid population growth, urbanization, and industrialization, especially in densely populated urban areas. The situation is particularly alarming in Metro Manila, where waterbodies are heavily polluted. Water quality measurements conducted by monitoring stations at various locations along the rivers have indicated that most of them are biologically dead. The term "biologically dead" refers to the absence mainly of dissolved oxygen (DO) in a waterbody. A waterbody is considered biologically dead when it has a zero DO level (meaning it has undergone complete "eutrophication"). The government of Metro Manila adopted measures to improve water quality in the city's waterbodies, among them building new sewage treatment facilities, expanding sewerage infrastructure, and relocating informal settlers along the riverbanks. (The Value of Clean Water Resources: Estimating the Water Quality Improvement in Metro Manila, Philippines, 2017)

Resolving the Water Pollution Crisis in the Philippines: The Implication of Water Pollution on Public Health and the Economy – To compare policy options, this analysis sets forth four criteria. The first criteria is that the best solution must be relatively inexpensive to implement. The budget limitations on implementation must be

acknowledged. Second, the plan must also be cost-effective in the long term. This is to reduce long-term costs, more potential waste, and further implications form the lack of available clean water. Third, the ideal option must attempt to reach the majority of, if not all, citizens affected by the problem. The inability to access clean water is a national problem, and therefore all citizens are affected and deserve relief. Finally, the option chosen must strive for longevity, meaning that the option must seek a permanent solution to the current problem. These criteria will help assess which option is the most effective solution to the current problem. The proponents relate this literature to the proposed system it is because the literature cited talks about the clean air act and the water quality and water pollution in the Philippines. Therefore, the cited literature is related to the proposed system in a way that it has the same goal, it is to prevent and resolve polluted water and assess water quality in a specific area to avoid crisis and unsafe water environment for the people. (Resolving the Water Pollution Crisis in the Philippines: The Implication of Water Pollution on Public Health and the Economy, 2018)

The proponents aim to deliver the system with proper functions and add features based on what the user finds satisfactory. SwimClean may have a same type of existing system, but looking to the point of developing and the purpose of building the system, the proponents find it satisfactory to the needs of the client and user.

2.3. Related Systems

Field analysis free chlorine in water samples by a smartphone-based colorimetric device with improved sensitivity and accuracy, a smartphone-based portable colorimetric device was designed for field analysis. A long-path colorimetric tube with self-focusing was designed for high sensitivity. The intensity of light source was monitored in real time by air internal reference. Baseline drift of absorbance was

corrected by a double-wavelength strategy. Visual colorimetry is a cost-effective method to monitor the concentration of residue chlorine in water. To reduce the errors from estimating the hue by naked eyes and to enhance the sensitivity. (Jianzhi Dou, Jian Shang, Qi Kang, Dazhong Shen., 2019)

Developments of microfluidic paper-based analytical devices (μPADs) for water analysis. Water pollution is a serious environmental problem affecting millions of people, and the demand for frequent water quality monitoring is increasing. The need for analytical platforms that combine high sensitivity, selectivity and accuracy with low cost, portability and user friendliness remains a challenge. Microfluidic paper-based analytical devices (μPADs) are recognised as a powerful analytical platform that can satisfy these requirements. μPADs have been developed for the determination of important water quality parameters, such as nutrients, metals and organic contaminants, in a range of waters. (M. Inês G.S.Almeida, B. Manori Jayawardane, Spas D.Kolev, Ian D.McKelvie, 2017)

2.4. Synthesis

The proponents come up with this project to enhance capabilities in terms of assessing water quality.

CHAPTER III

MATERIALS AND METHODS

3.1 Software Methodology

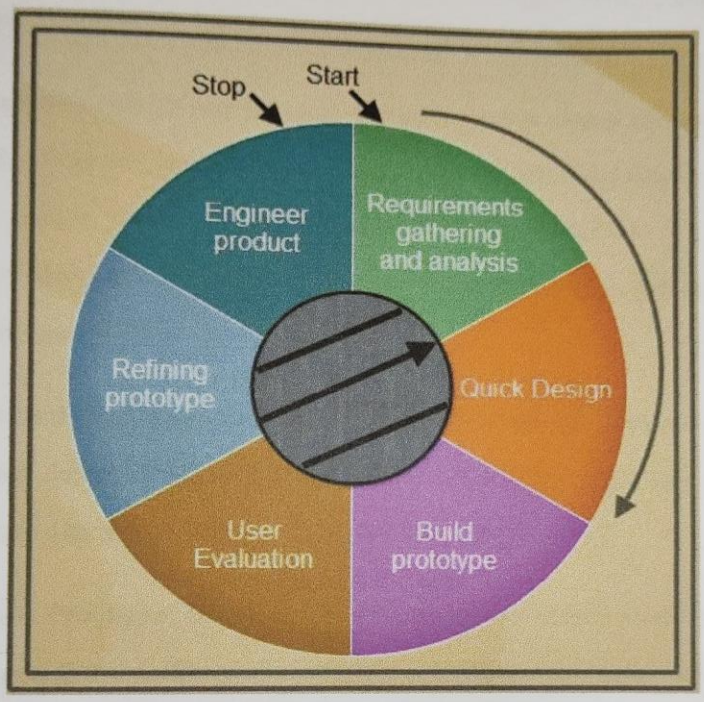

Figure 3.1 Prototype Model (Thakur, 2019)

As shown in Figure 3.1, the researchers will use the Prototype Model in developing the system. In this system development model, the researchers will undergo a process in which defining, designing, testing and implementing a new software application is needed. Development of the prototype starts from the preliminary version of requirements specification.

The steps/stages of building the prototype the researchers used in the project entitled "**SwimClean: An Embedded Real-time Water Quality Assessment for Man-Made Recreational Water Environment with Mobile Application**", requirements gathering and analysis, quick design, build prototype, user evaluation, refining prototype, engineering product.

Requirements gathering and analysis, in this phase the researchers first conducted an interview with the City Health Office, Environment Health and Sanitation Office to identify the requirements needed in the development of prototype. The researchers also conducted a short interview to the pool owners in Mati City on how they maintain the cleanliness of the pool.

Quick design, the information that the researchers gathered were analyzed and build a quick design. The data that were analyzed go through selection and all needed and essential data will be used in creating the final design.

Build Prototype, phase is the start of the development and creation of the prototype and all the design on the hardware devices and application will be finalized in this phase.

User Evaluation, this phase allows the user to evaluate and test the system. This phase also will recognize the strengths and weaknesses of the system in terms of functionality, reliability, usability, efficiency, portability and maintainability. Feedbacks were given to the researchers after this phase. Survey questionnaires were given to the user and all the data that are collected during this phase were analyzed.

Refining prototype, in the previous phase, user were given the privilege to critic the prototype and all the suggestions and feedbacks on the user's evaluation were

incorporated and were given account in the improvement of the system. But since the study focuses on the objectives and the scope and limitations of the study, the researchers did not do major revisions and modification of the system but instead used the user's evaluation into a valuable recommendation for the betterment of the future researchers that ought to continue and improve this study.

The last phase is **Engineering product**, once all the requirements were met and completed, the user accepts the final prototype. The final product was deployed to the end-user and clients, including the maintenance of the system.

3.2 Requirement Analysis

3.2.1 Documentation of the Current System

The process of monitoring the quality of water in every pool in Mati City is done in these steps:

- City Heath Office, Environmental Health and Sanitation Services Officer will take sample in a small container and put it in a sealed box for transport to Tagum City Provincial Health Office.
- The Environmental Health and Sanitation Services Department will now wait for a week for the results.

3.3 Requirements Documentation

3.3.1 System Architecture

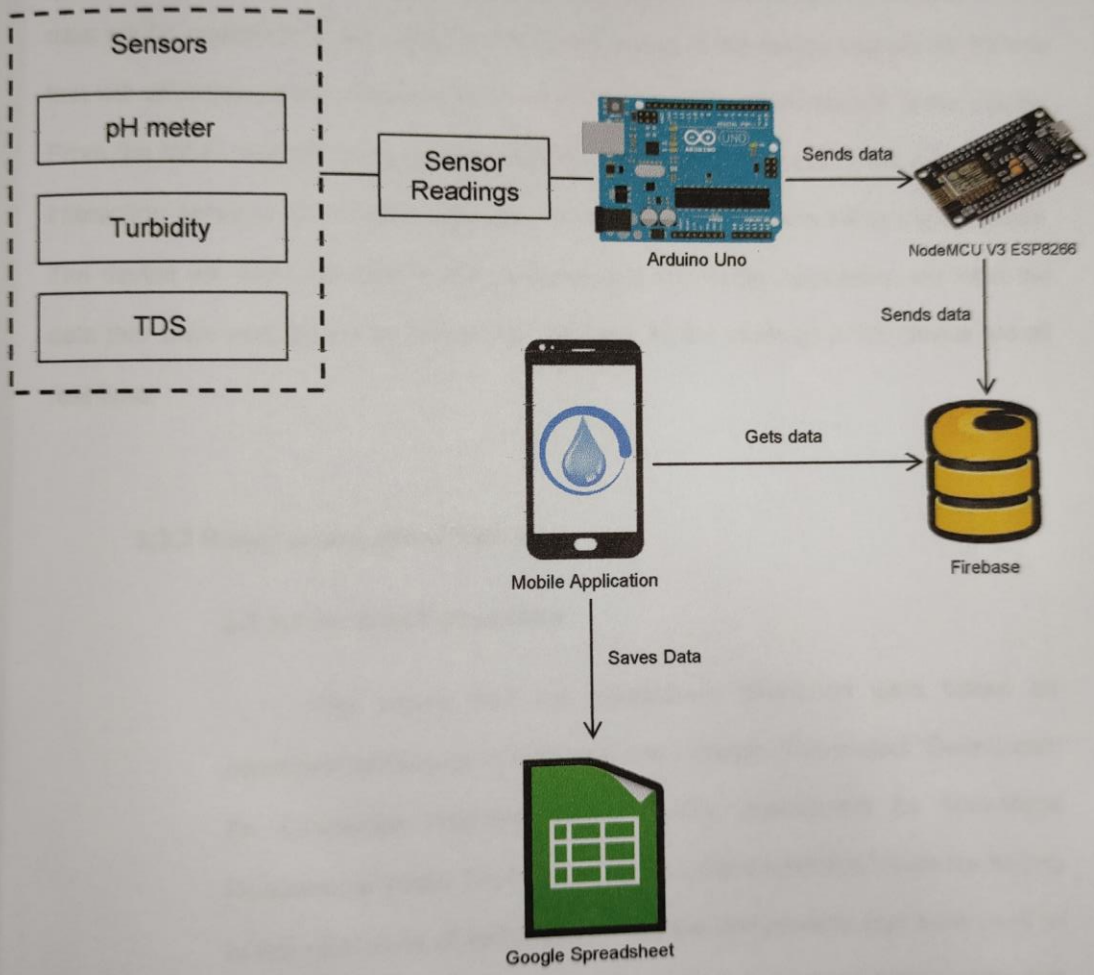

Figure 3.2 SwimClean: An Embedded Real-time Water Quality Assessment for Man-Made Recreational Water Environment with Mobile Application System Architecture

Figure 3.3 shows the flow and the process of the system entitled "**SwimClean: An Embedded Real-time Water Quality Assessment for Man-Made Recreational Water Environment with Mobile Application**". The system is composed of three (3) sensors namely: pH meter, Turbidity and TDS sensors. From the sensor's readings, the data will be passed onto the Arduino Uno which is part of the device that will be the one that will send the data to the NodeMCU V3 ESP8266 or the Wi-Fi module of the device. From the Wi-Fi module, it will directly send the data to the database of the system. The interaction between the mobile application and the device happens within the database. The device will send the data to the database and the mobile application will fetch the data that were sent by the device to the database. All the readings in the device are all real-time.

3.3.2 Requirement Specification

3.3.2.1 Product Perspective

The project that the researchers developed were based on combined technology of hardware and software. This project "SwimClean: An Embedded Real-time Water Quality Assessment for Man-Made Recreational Water Environment with Mobile Application" does not belong to the new trend of technologies and the components that were used in this project are already existing. This project is an embedded system that will give advantage to the City Health Office – Environmental Health and Sanitation Services office to easily monitor water quality in every public pools here in Mati City. It also gives a big help to the pool owners, in a way that the pool owners will automatically know if the water in the pool is

already not fit for swimming. This project mainly focuses in monitoring the water quality in man-made recreational water environment.

3.3.2.2 Product Features

The researchers provided product feature for the end-users to easily understand the system and its functionalities. Product features includes the hardware components such as the devices and sensors that were used in the system.

3.3.2.3 User Classes and Characteristics

The main user of this system is the employees in City Health Office – Environmental Health and Sanitation Services office, as this project is designed for them to easily evaluate water quality in pool areas.

3.3.2.4 Operating Environment

The researchers used different tools and technologies in order for this project to be complete. This includes:

Hardware Platform

The researchers used Arduino IDE software tool in uploading commands through the device which is coded in C++ programming language. In order for the device to work, the sensors must be submerged in the pool water.

Mobile Application Platform

The developers used MIT App Inventor in developing the mobile application. App Inventor is an online platform for developing mobile applications. The researchers used this in order to save time in developing the application. The MIT App Inventor can create mobile application by dragging and dropping components into a design view.

3.3.2.5 Design and Implementation Constraints

Hardware Constraints

In this project, the hardware of the system is composed of sensors that determine the quality of the water in every pool. Each sensor holds different data that corresponds to the quality of the water. The sensors present in this project are, pH meter for determining the acidity or alkalinity of the water, TDS sensor for the total dissolved solids that are present in the water, and the turbidity that determines the cloudiness or the haziness of the water. The attached sensors in the device are only limited to what data the sensors can acquire during the process. When it comes to other parameters in the water such as temperature can no longer be determined by the device.

3.3.2.6 User Documentation

Hardware

The two components of the system are hardware and software. The researchers provided manuals to the user in order for the user to understand properly how to use and operate the system. The manual also provide information about the sensors and what are the uses of each sensor in the system. It also includes the functionalities of the system, which gives user the knowledge on how the system works.

3.3.2.7 Other Non-functional Requirements

Safety Requirements

To ensure the safety of the user, the researchers didn't include any harmful elements in the device that can cause contamination of the water. The data will automatically be saved to the database of the system to ensure that the data is real-time and cannot be changed.

Security Requirements

The system does not require a login, for the system is used for real-time water reading and to provide accurate and reliable data for the quality of the water. But the user must know the SSID of the device's wifi and it's password for the user to be able to connect to the device.

Software Quality Attributes

The system possesses the following attributes:

Efficiency

To ensure the efficiency of the system, the researchers used updated and known sensors. In terms of coding, the researchers used C++ programming language for it is known to have compatibility with the hardware.

Reliability

To ensure the reliability of the system, the researchers tested the system multiple times before deploying the system. Before deploying, researchers already fixed bugs and made sure that the system is properly working.

Usability

In terms of the usability of the system, the researchers provided guides on how the system works, to ensure the usability of the system. All the information that will be displayed through the device's LCD and in the mobile application, the researchers made sure that it is readable and clear.

Portability

In terms of usability, the researchers made sure that the system can be easily installed and can be brought lightly.

3.4 Design

3.4.1 Use Case Diagram

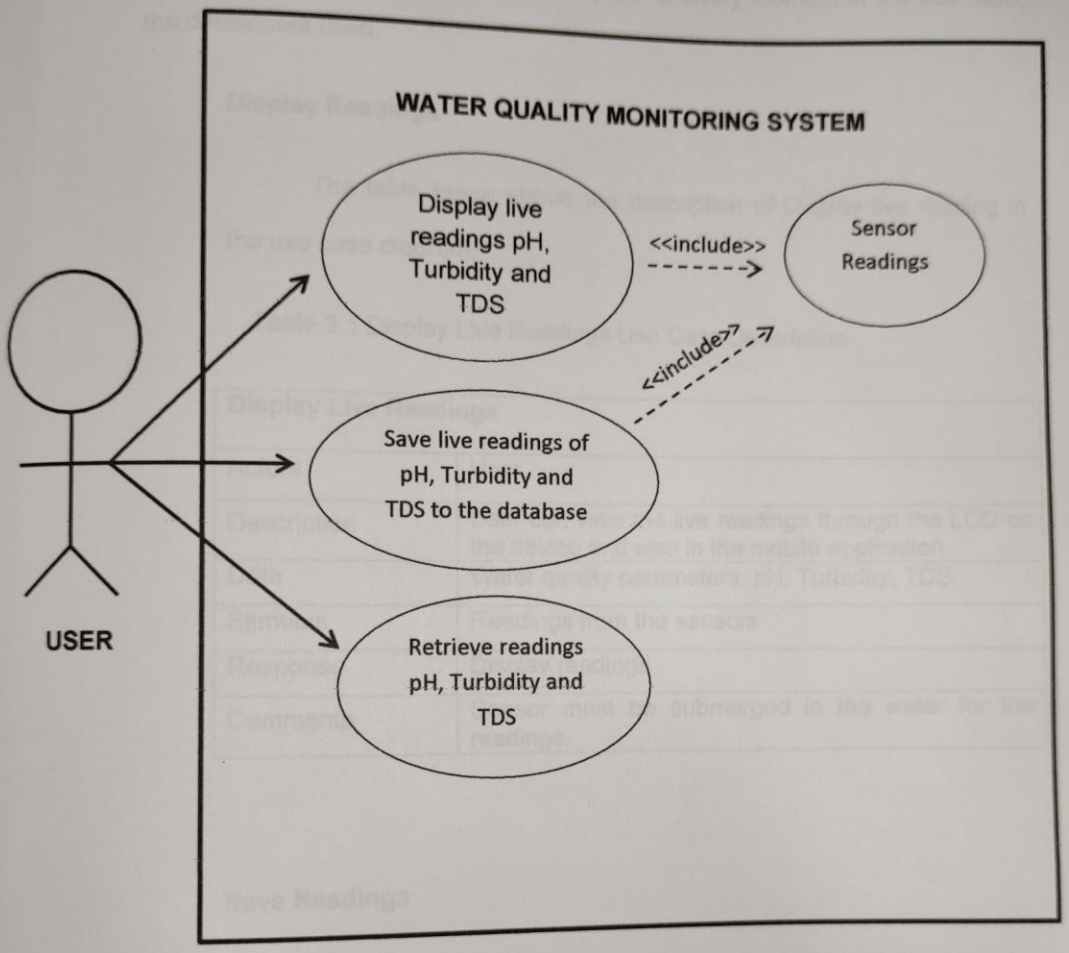

Figure 3.3 shows the use case diagram of the water quality monitoring system. It indicates the user's interaction with the system by the use cases; the system displays the water readings in the LCD of the device and in the mobile application, as well as save the live readings of the water. The user can also retrieve data from the system's database.

3.4.2 Use Case Description

This will explain/show the description of every element in the use case, the developers used.

Display Readings

The table below shows the description of Display live reading in the use case diagram.

Table 3.1 Display Live Readings Use Case Description

Display Live Readings	
Actors	User
Description	User can view the live readings through the LCD on the device and also in the mobile application
Data	Water quality parameters: pH, Turbidity, TDS
Stimulus	Readings from the sensors
Response	Display readings
Comments	Sensor must be submerged in the water for the readings.

Save Readings

The table below shows the detailed descriptions of the Save live readings in the use case diagram.

Table 3.2 Save Readings Use Case Description

Save Live Readings	
Actors	User, Mobile Application, Device
Description	The device will get the readings and will send it to firebase (database) then the mobile application will get the readings and will display it to the LCD of the device and to the mobile application.
Data	Water quality: pH, Turbidity, TDS
Stimulus	Mobile Application, Device
Response	Saves water quality to the database
Comments	Sensor must be submerged in the water for the readings.

Retrieve Readings

The table shows the detailed description of the Retrieve readings in the use case diagram.

Table 3.3 Retrieve Readings Use Case Diagram

Retrieve Readings	
Actors	User, Mobile Application
Description	The mobile application will directly retrieve files to the database of the system and will display through the mobile application's logs.
Data	Water quality: pH, Turbidity, TDS
Stimulus	Readings from sensor
Response	Retrieve Readings through app's logs
Comments	Mobile application must be connected to the device to view logs.

Sensor Readings

The table shows the detailed description of the Sensor Readings in the use case diagram.

Table 3.4 Sensor Readings Use Case Diagram

Sensor Readings	
Actors	User, Device
Description	The Arduino Uno will get the readings from the sensor and will command the Wi-Fi module to send it to the database of the system, and then the mobile application will fetch the data.
Data	Water quality: pH, Turbidity, TDS
Stimulus	Readings from sensor
Response	Sends water quality to the Arduino
Comments	Sensor must be submerged in the water for the readings.

3.4.3 Schematic Diagram

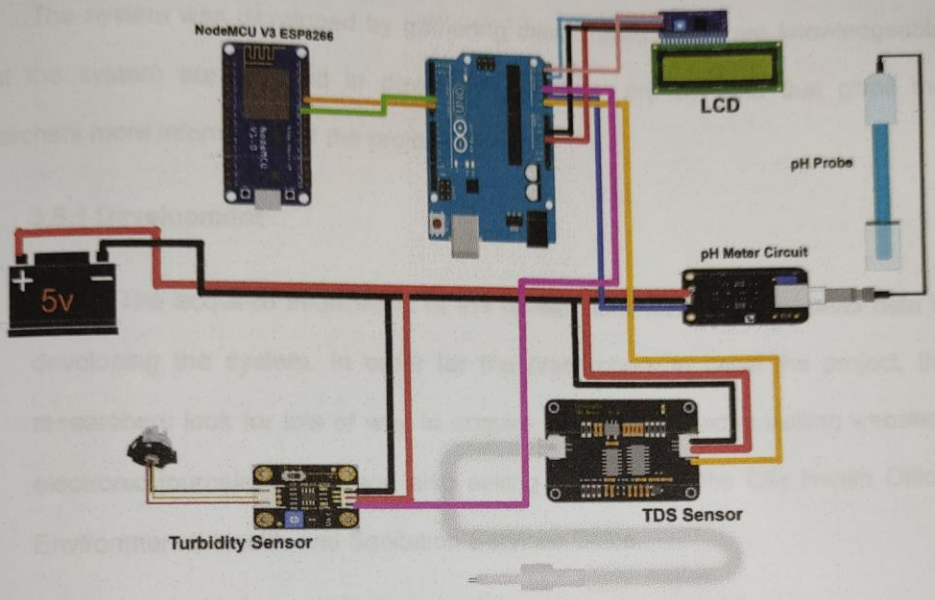

Figure 3.4 SwimClean: An Embedded Real-time Water Quality Assessment for Man-Made Recreational Water Environment with Mobile Application Schematic Diagram

Figure 3.4 shows the schematic diagram that is being developed by the researchers. It is composed of three (3) sensors namely: pH meter, Turbidity and TDS. The device has its own LCD for the live reading and NodeMCU V3 ESP8266 for the Wi-Fi.

3.5 Development and Testing

The system was developed by gathering data. Persons that are knowledgeable about the system are involved in developing for they are the one that gives the researchers more information of the project.

3.5.1 Development

The acquired information of the researchers was used as useful data in developing the system. In order for the researchers to finish the project, the researchers look for lots of way to acquire data. This includes visiting websites, electronic journals, books and also asking questions to the City Health Office, Environmental Health and Sanitation Services Office.

Prototype model was used by the researchers in developing the system. In this method, the researchers were able to conduct partial testing and gather feedbacks for the improvement of the system.

Prototyping includes several stages in development; the requirements gathering and analysis, quick design, building of the prototype, user evaluation, refining prototype and engineering product.

In the requirements gathering and analysis phase, the researchers gathered data from the City Health Office, Environmental Health and Sanitation Services Office. After gathering data, researchers filtered useful data for the system development. In designing the prototype, the researchers based the design on to what the data collected best suits the system. The researchers then proceeds to building the prototype. After the building of the prototype, the researchers tested the prototype in order to see improvements and to see if there

are bugs in the system. After that, user evaluation is needed for the system in order to have feedbacks from the user. After all the evaluation, thorough refinement of the system was done. After the refinement of the system was the finalization of the overall design and functions of the system. Deploying the system includes maintenance.

3.5.2 Testing

To test the device, the researchers need to go to public pool areas here in Mati City. The device must be submerged to the water in order for the device to work and display the live readings of the water.

The researchers prepared an evaluation form for the testing phase of the system. The evaluation form will be filled out by the user and it will be taken as useful feedback for the researchers.

But, due to the covid-19 pandemic, the researchers didn't have the chance to deploy the system for it requires face to face testing. The figure below is a sample of the researchers' evaluation form.

Items	Weighted Mean	Interpretation
Functionality		
1. The system is able to read water quality.		
2. The system can save current water readings.		
3. The mobile app and the device's water readings are the same and accurate.		
Reliability		
1. The device does not contain harmful chemicals and safe to use.		
2. The system is easy to use.		
3. I can easily read water quality using this system.		
Usability		
1. The system is user-friendly.		
2. The system is easy to use.		
Maintainability		
1. The device can be easily tested.		
Efficiency		
1. The system is able to read real-time water quality.		
2. The system can save the current data with accuracy.		
Portability		
1. The device can easily be installed easily.		

Table 3.5 Evaluation Form

1	**Strongly Disagree**
2	**Disagree**
3	**Average**
4	**Agree**
5	**Strongly Agree**

CHAPTER IV

RESULTS AND DISCUSSION

4.1 Achievement per Objective

The main objective of the study is to enhance and find a better way for the City Health Office, Environmental Health and Sanitation Services in Mati City, in assessing water quality of pools in Mati City. The researchers developed a system that successfully achieved the following objectives:

Design and develop a device and a mobile application called SwimClean that could help the City of Mati, City Health Office – Environmental Health and Sanitation Services that will be capable of:

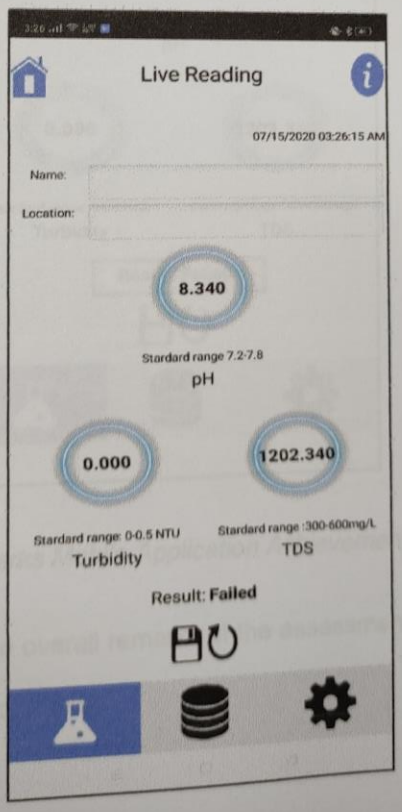

Figure 4.1 Image of Water Quality Readings Achievement per Objective

Figure 4.1 shows the function of the mobile app that assesses water quality parameters: pH, turbidity and TDS, with the use of the device and displayed on the mobile application and the device's LCD.

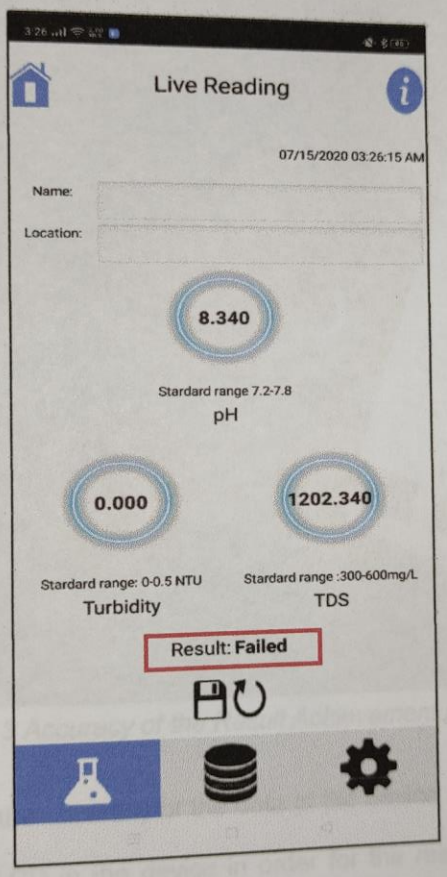

Figure 4.2 Remarks Mobile Application Achievement per Objective

Figure 4.2 shows the overall remarks of the assessment of the water quality. The remarks is either "Passed" of "Failed".

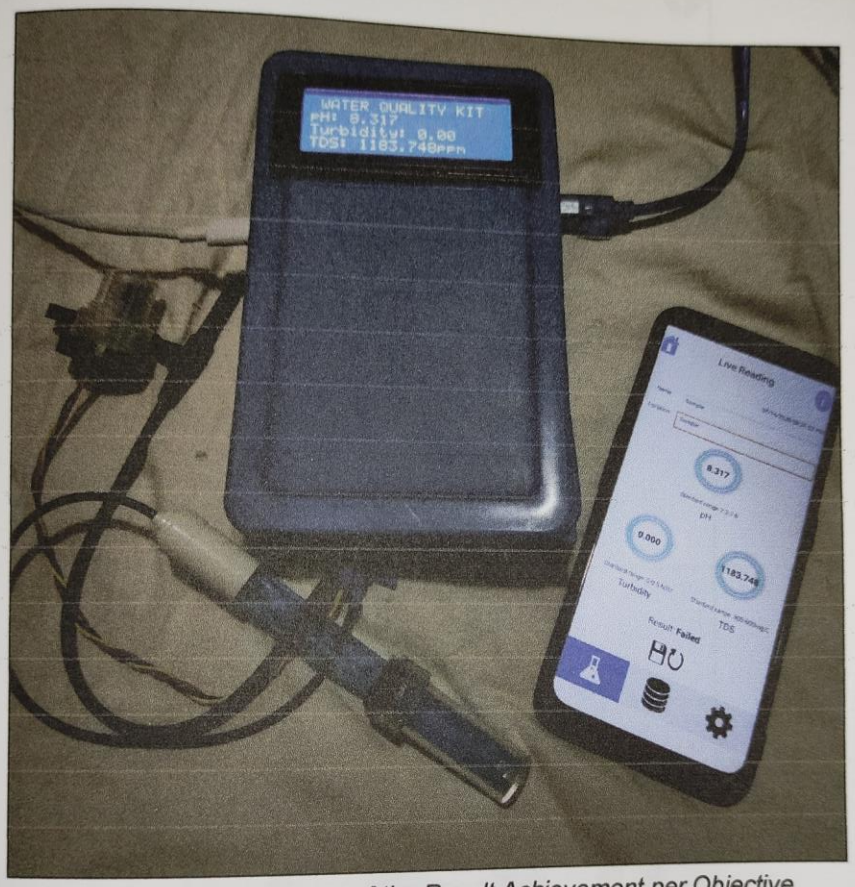

Figure 4.3 Accuracy of the Result Achievement per Objective

In determining the accuracy of the data of the device and mobile application, the researchers installed LCD in the device in order for the researchers and the users to know if the readings of the parameters will be the same readings the mobile application will show. The mobile application has a few seconds of delay on what the device will display, it is due to the process in which the device will upload the data to the cloud and then the mobile application will get it.

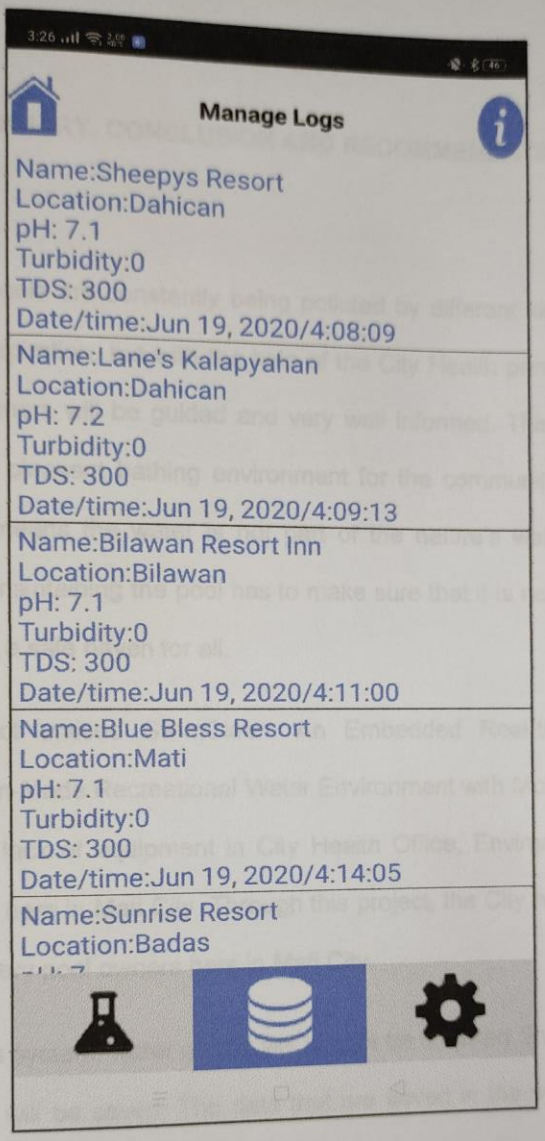

Figure 4.4 Logs Achievement per Objective

Figure 4.4 shows that all the readings done in the system will be saved to the database of the system. The user will be able to review logs and the previous readings made in the system.

CHAPTER V

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Summary

Swimming pools are constantly being polluted by different kinds of environment dirt and human perspiration, but with the help of the City Health personnel, through this device, the pool owners will be guided and very well informed. This project aims for a peaceful and more pleasant bathing environment for the community. Swimming pools are man-made, it means the water is not part of the nature's water formations. The people involved in maintaining the pool has to make sure that it is not just a crystal clear pool water, but also a safe haven for all.

The project entitled SwimClean: An Embedded Real-time Water Quality Assessment for Man-Made Recreational Water Environment with Mobile Application was formed due to the lack of equipment in City Health Office, Environmental Health and Sanitation Services here in Mati City. Through this project, the City health can be able to give guidance to every pool owners here in Mati City.

Through this system, water quality will always be checked. Every data that will be read in the system will be saved. The data that are saved in the system's database, it will be prepared in Google spreadsheet for printing. Also, the data that will be gathered will be saved in the mobile application and can be used for future references.

5.2 Conclusion

The development of SwimClean: An Embedded Real-time Water Quality Assessment for Man-Made Recreational Water Environment with Mobile Application was

designed in order to improve the current process of reading water quality in City Health Office in Mati City. The researchers were confident about the system that it will be a big help to the City Health Office.

The researchers successfully implemented the system's objectives. The following are the objectives of the project:

- Design and develop a device and a mobile application called SwimClean that could help the City of Mati, City Health Office – Environmental Health and Sanitation Services that will be capable of:
    i. Assessing the water quality easily of any man-made recreational water environment through a handheld device with 3 different sensors and chemical parameters (pH, turbidity, and TDS).
    ii. Provide functionality on the mobile application that enables the user to view the remarks of each parameter and its overall results on their smartphone.
    iii. Ensure that the results from the device's assessed water are accurate.
    iv. Provide logs or records on the mobile application to view all saved assessment.

5.3 Recommendation

The implementation of the system reached its full potential in terms of the objectives of the study. The result of this study will serve as a guide for future developers that will continue and enhance this system. Some users were looking for something to

add up to the system in order for it to reach its full potential. The following are the recommendations for the SwimClean project:

- More appropriate sensors for better water quality readings
- The turbidity sensor that the researchers used is not completely submergible to the pool water, changing it into an industrial on that will be completely submerged into the water.
- The waterproof enclosure for the device. As of now, the device is not fully water proof due to the cost constraints. If there will be improvements in the device, the proper enclosure will be any use for protecting the device and make the device invulnerable to water.

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