DEVELOPMENT OF AN IOT- BASED MONITORING SYSTEM FOR WATER QUALITY IN CATFISH FARMING

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DEDICATION

This study is a dedication to all the farmers and aquaculture experts who are dedicated to the long-term expansion and improvement of catfish farming. Dedicate this research as well to the scientists, researchers, and innovators in the field of aquaculture.

ABSTRACT

The growing worldwide population highlights the crucial need for sustainable food supply, with aquaculture, specifically catfish farming, emerging as a possible alternative. However, difficulties such as water contamination affect catfish farming production, and thus the supply of this protein source. Catfish aquaculture considerably improves food security in impoverished areas worldwide. It provides cash and protein to many households, both rural and urban. Catfish farmer, however, encounter various problems during production. One of the most important aspects is the monitoring and management of production resources. Water is the primary resource used in the fish farming process. Insufficient monitoring of water quality, including temperature,dissolved oxygen, pH and ammonia level has resulted in resource waste and low productivity for farmers. This research aims to develop an IoT-based monitoring system for water quality in catfish farming, focusing on identifying factors causing decline in catfish production. This IoT device enable parameter checking such dissolved oxygen, pH, temperature and ammonia level. Choosing appropriate IoT sensors based on accuracy, dependability, compatibility, and cost-effectiveness is crucial for selecting the right sensors. The approach uses the Internet of Things (IoT) to collect water quality data via sensors. Real-time updates on water quality will be provided via a cloud platform. The farmer can then act based on the information presented, or the model can act on the farmer's behalf using predefined actions. The model's data can be extracted and evaluated in many ways. Analyzing and visualizing the data is essential for providing useful insights to catfish farmers. The system will enhance water quality monitoring, improve catfish farming practices, and guide aquaculture industry advances. The findings will promote sustainable and efficient practices, ensuring a reliable and high-quality seafood supply for the growing population.

ABSTRAK

Pertumbuhan penduduk di seluruh dunia menyerlahkan keperluan penting akan bekalan makanan yang mampan, dengan akuakultur, khususnya penternakan keli, muncul sebagai alternatif yang mungkin. Walau bagaimanapun, kesulitan seperti pencemaran air memberi kesan kepada pengeluaran penternakan keli, dan dengan itu bekalan sumber protein ini. Akuakultur keli secara signifikan meningkatkan keselamatan makanan di kawasan miskin di seluruh dunia. Ia menyediakan pendapatan tunai dan protein kepada banyak isi rumah, sama ada di kawasan luar bandar atau bandar. Namun, penternak keli menghadapi pelbagai masalah semasa pengeluaran. Salah satu aspek yang paling penting adalah pemantauan dan pengurusan sumber pengeluaran. Air adalah sumber utama yang digunakan dalam proses penternakan ikan. Pemantauan yang tidak mencukupi terhadap kualiti air, termasuk suhu, oksigen terlarut, pH, dan tahap amonia, telah mengakibatkan pembaziran sumber dan produktiviti rendah untuk penternak. Penyelidikan ini bertujuan untuk membangunkan sistem pemantauan berdasarkan IoT untuk kualiti air dalam penternakan keli, dengan memberi tumpuan kepada mengenal pasti faktor-faktor yang menyebabkan penurunan dalam pengeluaran keli. Peranti IoT ini membolehkan pemeriksaan parameter seperti oksigen terlarut, pH, suhu, dan tahap amonia. Memilih sensor IoT yang sesuai berdasarkan ketepatan, kebolehpercayaan, keserasian, dan kos yang berkesan adalah penting untuk pemilihan sensor yang betul. Pendekatan ini menggunakan Internet of Things (IoT) untuk mengumpul data kualiti air melalui sensor-sensor. Kemas kini secara langsung mengenai kualiti air akan disediakan melalui platform awan. Penternak kemudian boleh bertindak berdasarkan maklumat yang dipaparkan, atau model boleh bertindak bagi pihak penternak dengan menggunakan tindakan yang telah ditentukan sebelumnya. Data model boleh diekstrak dan dinilai dalam pelbagai cara. Menganalisis dan memvisualisasikan data adalah penting untuk memberikan pandangan yang berguna kepada penternak keli. Sistem ini akan meningkatkan pemantauan kualiti air, meningkatkan amalan penternakan keli, dan membimbing kemajuan industri akuakultur. Penemuan ini akan mempromosikan amalan yang mampan dan efisien, memastikan bekalan makanan laut yang boleh dipercayai dan berkualiti tinggi untuk penduduk yang semakin meningkat.

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LIST OF SYMBOLS AND ABBREVIATIONS

DO	-	Dissolved oxygen
pH	-	Potential hydrogen
DOF	-	Department of fisheries
NH_4^+	-	Ammonium ions
NH_3	-	unionised ammonia
IoT	-	Internet of things
°C	-	Degree celcius
SMPS	-	Switch mode power supply
mg/L	-	milligrams per liter

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CHAPTER 1

INTRODUCTION

1.1 Background

Malaysia's population will be 34,671,895 in 2024, up 1.06% from the previous year. This pattern is consistent with the annual population growth rate, demonstrating the country's ongoing demographic expansion. In 2023, the population was 34,308,525, up 1.09% from 33,938,221 in 2022. Similarly, the population in 2021 was 33,573,874, a 1.13% increase over 2020's total of 33,573,874 (Macrotrends., 2024).

The rising population should strive for sustainable food consumption, as social, environmental, and health implications are all significant considerations. Food is essential for survival, hence food safety is a fundamental human right. Unsafe food poses a risk to billions of people worldwide. Every year, millions of people become ill and hundreds of thousands pass away.

As more people need food to survive, the growing human population may result in a shortage of food supplies. This can be particularly difficult in places with little water, arable land, or food transportation facilities. Natural disasters and climate change can also have an impact on food supply and production, worsening the problem. Sustainable agriculture is one of several strategies that can be used to address these problems. Using farming methods that are environmentally friendly and can boost crop yields without deteriorating soil quality or depleting natural resources is part of this. Next, aquaculture, also known as fish farming, has the potential to assist in resolving the issue of a lack of food supplies, particularly for people who depend on seafood as a source of protein. Fish farming is the practise of growing fish on a small or large scale in aquariums, ponds, or ocean cages.

Almost all fish consumed by people and animals comes from the sea. Even though the fishing industry is developing because to the introduction of new cutting-edge equipment and techniques, one aspect has not changed is catching fish in their natural habitat. Several issues have recently affected the fishing industry. One of them is the issue of water contamination, which can result from hazardous waste discharged from factories, oil spills, insecticide use, or weeds that have also put the fishing sector in danger. Aquaculture does not provide a fix for the issues facing the fishing sector. That is one method of ensuring the sea's food supply is covered.

The Fisheries Act of 1985 defines aquaculture as the breeding of fish seeds or the preservation of fish breeds during all or a portion of their life cycle through livestock companies (Perikanan et al., 2022). Aquaculture also refers to any activities involved in the production, processing, and marketing of aquatic products. Enhancing livestock quality and quantity is the primary objective. The expansion of aquaculture is thought to have great potential for commercial development in order to boost production and ensure the nation's fish supply in addition to fish from marine sources. To make the nation's aquaculture industry more profitable and able to handle fish as a source of protein, it must be strengthened. From three perspectives, namely as a significant contributor to the national economy, a plan to end poverty, and the primary source of food that the citizens of this country require, the aquaculture sector is considered as playing a significant role.

The market need for seafood is occasionally unmet. Hence, freshwater fish farmers can contribute to the availability of food sources to fulfil demand, but their numbers are still quite low. The government offers assistance as part of a strategy to promote aquaculture participation in order to boost productivity and improve the nation's fish production. In addition, Red Tilapia and Catfish have been targeted for farming throughout Malaysia by the Department of Fisheries (Jabatan Perikanan Malaysia, 2021). This species is not only simple to breed but also fairly steady in the market. In many countries around the world, including the United States, Asia, and Africa, Catfish is a popular and commonly consumed freshwater fish. Millions of people all over the world love the commonly eaten dish Catfish. There is an unmet demand for Catfish as a result of Catfish production being unable to keep up with the rising market demand. One of the reasons is that the quality of the water has a significant impact on the growth and productivity of Catfish. Catfish are unable to supply the demand when the water quality is insufficient for several of reasons.

1.2 Problem Statement

An important part of the aquaculture business, Catfish farming offers many communities a considerable source of food and a means of livelihood. The health and growth of Catfish, however, depend on maintaining ideal water quality conditions because low water quality can cause stress, disease outbreaks, and decreased productivity. Traditional water quality monitoring techniques for Catfish farming are frequently manual, labor-intensive, and prone to human error, which limits their effectiveness in assuring prompt action and proactive management.

Maintaining indicators of water quality within the advised ranges, such as dissolved oxygen levels, temperature, pH, ammonia, and nitrate levels, is very difficult in the absence of real-time monitoring equipment. The inability of Catfish farmers to quickly identify and address possible problems, which can lead to financial losses and environmental concerns, is made difficult by the lack of reliable and timely data on water quality criteria.

The accuracy and dependability of the monitoring procedure are further endangered by the difficult and error-prone manual data collection process from several sensors distributed across the fish farm. Due to this inefficiency, Catfish farming operations are not flexible and have higher operating expenses.

The Internet of Things (IoT) is a rapidly developing technology that has many uses in daily life. IoT is referred to as a network of linked devices that may exchange data and communicate (Suherman et al., 2022). To provide real-time, precise, and continuous monitoring of water quality indicators, it is necessary to develop an IoT-based monitoring system that is specifically created for Catfish farming. With the use of such a system, farmers would be able to remotely monitor and manage the water quality conditions, get timely alerts and messages, and manage their Catfish farms more effectively using data.

The productivity, sustainability, and profitability of Catfish farming operations will be significantly increased by addressing these issues through the development of an IoT-based monitoring system for water quality, while also promoting environmental conservation and ensuring the delivery of high-quality Catfish products to the market.

1.3 Research Objective

The main aim of this research is to develop an IoT-Based monitoring system for water quality in Catfish farming. Specifically, the objectives are as follows:

a) To develop an IoT device to monitor water quality parameters in catfish ponds including pH level, dissolved oxygen, ammonia levels and temperature.

b) To test the functionality model to monitor water quality parameters in catfish ponds.

1.4 Scope of Research

The scope of this research are as follows:

- The research was restricted to the Catfish raised in Alai, Melaka.
- Develop an IoT-based monitoring system capable of real-time data collection for pH, dissolved oxygen, ammonia levels, and temperature in catfish ponds.
- The IoT device will be designed to track and record data based on the criteria that have been discovered. To gather, process, and transmit the data, the device will have sensors, wireless communication modules, and a microcontroller.
- Develop a user-friendly interface allowing easy access to real-time and historical water quality data for catfish pond management.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Numerous studies are currently being done to evaluate the water quality for fish farming and create monitoring systems that allow for efficient regulation of the water conditions. Additionally, fish producers benefit from improving these monitoring systems using IoT. More information about catfish farming, water quality criteria, and monitoring systems should be included in this section. The equipment in the monitoring system and the parameters of water quality for catfish farming are two reasons why this subtopic is particularly crucial.

2.2 Catfish Farming

Aquaculture is the most rapidly expanding animal food producing industry. As human populations continue to rise and fishing production slows down, aquaculture must change to meet societal demands for aquatic products (Gao et al., 2019). One of the top items in the market that is expanding quickly is freshwater Catfish, which is also the key driver of Malaysia's rising aquaculture production (Hawari & Hazwan, 2022). There are various economic advantages to Catfish farming that benefit farmers and local economies. Catfish farming offers a steady source of income for farmers, especially in rural locations where other possible sources of revenue may be limited. The expansion of the business spurs economic growth by generating jobs not only in farms but also in allied industries including feed production, equipment manufacturing, transportation, and fish processing. Catfish farming also can be profitable with the right management techniques.

Due to its year-round marketability and relatively quick production cycles, Catfish farmers can take advantage of consumer demand and increase profits. Catfish farming is a lucrative business venture since it offers a high return on investment. Besides, Catfish fish farming is essential to address food security and provide a sustainable supply of protein. Catfish farming helps increase dietary diversity and nutritional well-being because it is a nutrient-rich fish species, especially in places with limited access to other protein sources. Fish is better than other food sources for essential nutrients because it contains not only protein but also healthy fats, vitamins, and minerals (Zuriati et al., 2021). Understanding the statistical data, as well as the difficulties and issues that currently surround fish farming, is important before beginning this research.

2.2.1 Statistical Data

The world's fish supply is expected to increase to 187 million metric tonnes (mt) by 2030. Production in Malaysia's freshwater aquaculture sector increased by 8.6% in 2020, or from 490 to 790 million mt annually (Hawari & Hazwan, 2022).

Figure **2.1** shows information regarding Catfish production from 2017 to 2020. The information was taken from the Department of Fisheries Malaysia's (DOF) annual fisheries statistics from the years 2018 to 2020. Based on Figure **2.1**, it can be stated that fish production is going to rise in 2020 after decreasing from 2017 to 2019.

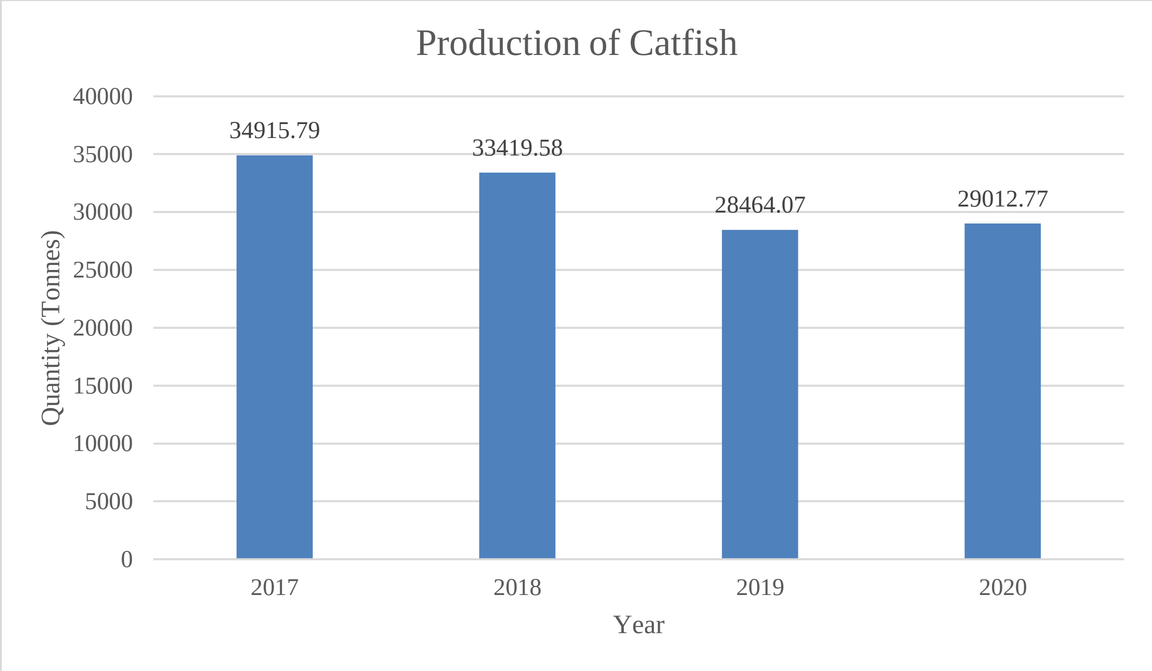


Figure 2.1 The Graph of Catfish Production

2.2.2 Problem and Current Issues

Due to the popularity and high demand for Catfish products, one significant issue Catfish farmers deal with is their inability to satisfy consumer demand. Substantial changes in the local temperature and weather have also had a substantial impact on the water quality used in aquaculture, which has led to many fish deaths and productivity losses for fish farmers (Hawari & Hazwan, 2022). Changes in weather patterns, particularly variations in rainfall, can influence the hydrological cycle and water quality. Runoff from heavy rains can introduce contaminants, nutrients, and debris into fishponds and other cultural systems.

The main issue facing most fish farmers nowadays is maintaining the water quality because it results in large fish kills and causes them to lose a lot of money (Billah et al., 2019). Fish farming activities depend on the quality of the water, hence specific standards must be met. Aquatic life will be impacted by excessive water quality factors. It has been found that some breeders ignore to maintain their ponds, which worsens the water quality and has an impact on fish mortality and hibernation (Zamzari et al., 2022).

2.3 Parameters of Water Quality

The ecosystem, people, and aquaculture all depend on high-quality water. To accurately measure water quality, a few variables must be taken into consideration, including temperature, pH level, and ammonia toxicity. Depending on what it will be used for, the water's quality will change. Water quality measurement levels differ based on the target of water. Different aquatic life species require a variety of factors. To ensure growth and survival, water quality must be monitored because it differs depending on the species. With the costs associated with getting a product to market, the water quality in the production systems may have a significant impact on the organism's health (Zamzari et al., 2022).

Maintaining ideal water quality conditions in Catfish farming operations has various impacts, including on Catfish growth, survival rates, and production effectiveness. Water temperature, pH levels, and feeding based on Catfish growth are all factors that influence Catfish growth (Rohim et al., 2022). Furthermore, the study discovered that water quality parameters like dissolved oxygen, pH temperature, pH and ammonia level were necessary for Catfish farming.

2.3.1 Dissolved Oxygen

The volume of oxygen that has been dissolved in water is known as DO (Environmental Protection Agency, 2023). Dissolved oxygen (DO) has the potential to have a significant impact on fish growth and survival. Fish growth requires a huge quantity of energy usage. Fish may spend more energy on growth when there is enough DO in the environment. Fish metabolism rates increase considerably in DO-saturated aquatic habitats (Qiang et al., 2019).

The fact that Catfish typically live in an environment with a dissolved oxygen content of 4 mg/l is another factor that must be taken into consideration (Rohim et al., 2022). The ideal specification parameter for dissolved oxygen in a water quality system is 5 to 8 mg/L (Yasruddin et al., 2022). Due to the reduced solubility of oxygen and other gases at higher temperatures, colder lakes and streams may have higher DO levels than warmer ones (Adeleke et al., 2023).

2.3.2 Potential Hydrogen (pH)

The pH can be used to determine how acidic or alkaline the water is by measuring the hydrogen ion (H+) concentration in the water. 7 is considered neutral on a scale that ranges from 0 to 14. A pH of 7 or above indicates baseness, while a pH of 7 or less indicates acidity. Since pH has an impact on the metabolism and other physiological processes of cultured organisms, it is essential to maintain pH consistency and always within a safe range. The pH of water can be altered by both natural and artificial factors. The environment and natural variables interact, causing changes in the variables. pH levels should be between 6.5 and 9 (Zamzari et al., 2022).

Fish in ponds often range in pH from 6 to 7.5. Fish are going to die if the pH falls below 4 or rises over 11. Low pH results from acidic water, and high pH results in increased levels of fish-unfriendly ionised ammonia. The fish will remain alive, but stress will cause them to grow slowly at a pH between 4 and 6 (Ahmad et al., 2020). Fish cell membranes are destroyed at high pH levels, such as 9 to 14. The pH rating varies and changes at different rates during the day and night. where pH likewise tends to rise during the day and gradually drop during the night most of the time (Arafat et al., 2020).

Acidity or an appropriate pH for Catfish is between 6.5 and 9.0. A pH of less than 5 is particularly harmful for Catfish since it will lead to mucus clogging in the gills, while a pH of 9 and above would result in Catfish losing appetite (Rohim et al., 2022). According Ndlovu et al., (2022) assess water quality by ensuring pH ranges from 7.5-8.5, as unacceptable values can lead to fish deaths..

2.3.3 Temperature

The primary factor in fish culture that affects the fishes' respiration, food intake, and immune systems is temperature (T. Abinaya et al., 2019). Fish may reduce stress when the temperature changes by exhibiting heat-regulating behaviours such as tolerance, resistance, or preference. Water temperature is an important factor influencing the early growth of fish, to which they can adapt within specified ranges. While an increase in temperature within a specific range can accelerate fish embryo development, shorten incubation time, and promote first-feeding of newly developed larvae, exceeding that range when too high or low can result in abnormalities, development stagnation, or even embryonic death (Qiang et al., 2019).

Fish prefer a temperature range of 26 to 36 °C. Fish will die if the temperature rises above 36 °C because warm water makes oxygen insoluble. Pond fish will become stressed and eventually die due to the high temperatures (Ahmad et al., 2020). The metabolism, feeding rates, and other components of water are all significantly affected by temperature. For instance, it has an impact on the levels of dissolved oxygen, ammonia, and oxygen (Zamzari et al., 2022).

The temperature ratings for day and night are different, as are the rates of change. In the daytime, the temperature rises, and at night, it drops. Their metabolism is mostly impacted by temperature. Therefore, a sudden shift in water temperature stresses fish and could affect their ability to grow (Arafat et al., 2020).

The ideal water temperature for Catfish growth is between 27 °C and 31 °C. The Catfish can withstand high temperatures, and because the water temperature ranges from 25 to 34 °C, it provides a favourable habitat for growth (Yoyok Sukrismon, 2019). According research by Rohim et al., (2022), the optimal temperature for Catfish growth is 29 °C. In intense Catfish rearing, 25–30 °C is the ideal water temperature.

Fish activity can be affected by temperature. The ideal temperature for fish keeping is between 25 and 32 °C Celsius. If the water temperature is too low or too high, fish or other aquatic inhabitants may become stressed and die. 24 to 28 °C is the ideal water temperature for freshwater fish ponds (Suherman et al., 2022).

2.3.4 Ammonia

Ammonium ions (NH_4^+) and unionised ammonia (NH_3) are the two types of ammonia. Unionised ammonia is hazardous, whereas ammonium ions are non-toxic. The water's temperature and pH have an impact on how much of each is present compared to the other. It has been determined that the low ammonia level of 0.021 ppm, as revealed by the study, is safe for fish to hibernate. While temperature and pH have a strong correlation, they have minimal impact on ammonia levels. When the amount of ammonia in the water is high enough, aquatic creatures may die because they are unable to evacuate the toxin, which accumulates up in internal tissues and blood (Zamzari et al., 2022).

Since ammonia is poisonous to fish, its presence in the pond has an impact on fish growth. Ammonia is present because fish discharge from its gills. The pH and temperature of the water have an impact on the ammonia level in fish water. Ammonia's unionised value rises at lower temperatures and lower pH levels, making it hazardous to fish. Therefore, the ideal range for the ammonia content in the fish tank is between 0.0125 and 0.02 mg/L (T. Abinaya et al., 2019). In aquaculture systems, the ideal range of water quality parameters for ammonia is 0 to 0.05mg/L (Tumwesigye et al., 2022). Fish can be poisoned by elevated pH and ammonia levels. Too much ammonia can prevent fish from efficiently obtaining energy from food, which may result in death (Fajar Budiman, 2019).

2.3.5 Summary of Specification Parameters Water Quality System

A summary of the water quality parameters from previous research that are suggested for Catfish farming is shown Table 2.1.

Table 2.1 Summary of specification parameters water quality system

Author	DO (mg/L)	pH	Temperature (°C)	Ammonia (mg/L)
(Rohim et al., 2022)	4	6.5 – 9	25 - 30	
(Yasruddin et al., 2022)	5-8			
(Zamzari et al., 2022)		6.5 - 9		
(T. Abinaya et al., 2019)		7 – 7.2		0.0125 - 0.02
(Udanor et al., 2022)		6.5 – 8.2	25.5 – 30.5	
(Fajar Budiman, 2019)		6.5 – 7.5		
(Ahmad et al., 2020)			26 - 36	
(Yoyok Sukrismon, 2019)			27 - 31	
(Suherman et al., 2022)			25 - 32	
(Ndlovu et al., 2022)		7.5 – 8.5		
Tumwesigye et al., 2022		6.5 – 8.5	28 -32	0 – 0.05

2.4 Water Quality Monitoring System

Maintaining best water quality levels improves fish growth and decreases the risk of fish diseases.Due to the skill and time required, maintaining the water quality in ponds can be very difficult. To avoid the existence of fish infections that can lead to future death and significant losses for the aquaculture business, important water quality factors such as temperature, dissolved oxygen (DO), and pH in rearing tanks need to be regularly monitored (Yasruddin et al., 2022).

In addition, collecting water samples by manually for fish death study takes a lot of time, requires a lot of time, and is expensive in terms of equipment. To track the water quality in real-time, a system is therefore required. The benefit of the water quality monitoring system is a routine test to check the water's safety based on the water quality index (Ahmad et al., 2020).

In both business and agriculture, monitoring water quality parameters is a critical concern (Chuyen et al., 2023). The growth rate, feed consumption, and general health of fish are all impacted by water quality. Fish have died because of farmers' poor management of pond water (Udanor et al., 2022).

2.4.1 Type of Sensor

Important aspects of water quality are measured using a variety of sensors and probes. These include pH metres, ammonia sensors, temperature sensors, and dissolved oxygen sensors. The sensors' real-time information on water conditions allows farmers to monitor and adjust water quality parameters as required.

The dissolved oxygen content of water is determined using a D-6800 dissolved oxygen sensor. The D-6800 dissolved oxygen sensor is used in the proposed system (T. Abinaya et al., 2019). The water's dissolved oxygen content is also measured using the Atlas Scientific Dissolved Oxygen Sensor with the EZO DO sensor module (Billah et al., 2019) and DF Robot Dissolved Oxygen Sensor Probe .

To determine how acidic the water is, a PH sensor will detect the water's pH level (Ahmad et al., 2020). Apart from that, there’s similarity between research by (Udanor et al., 2022) and because both authors use DFROBOT pH sensor to measure the pH level. While (Susanti et al., 2022) using the SKU SEN0161 pH Sensor to measure pH content in water with accuracy ±0.1.

A temperature sensor will measure the water's temperature (Ahmad et al., 2020). Authors (Susanti et al., 2022) use DS18B20 waterproof temperature sensor is used to track the temperature water's state. It determines the water's temperature in Celsius. A waterproof sensor with low power (3V-5.5V DC) consumption is the DS18B20 Digital Temperature Sensor. Digital data are shown. It can measure between -55 and 125°C with an accuracy of 0.5 °C. Precision between -10 °C and +85 °C. In less than 750 ms, this sensor can check the temperature. It is the excellent sensor for accurately sensing aquaculture's temperature (Nagib Mahfuz, 2020).

The proposed system uses an ammonia gas detector with the model number TIA 2100 (T. Abinaya et al., 2019T) and a MQ-137 ammonia gas sensor ((Zamzari et al., 2022)(Udanor et al., 2022)). Ammonia has been found on the water's surface due to the ammonia gas sensor. The ammonia sensor was positioned above the pond's water and continuously monitors the toxicity and concentration of ammonia there (Udanor et al., 2022).

2.4.2 Microcontroller

The main component of the monitoring system is a microcontroller. It manages the collection of data from multiple sensors, analyses it, and offers a user interface for data visualisation and analysis.

The main controller for this project is an Arduino, which processes data from input to output. An Arduino will receive data from a sensor attached to a riverbank and process it. (Ahmad et al., 2020). The Arduino microcontroller receives data collected from several sensors. The microcontroller has been configured such that it performs the appropriate action if the observed parameters exceed the specified threshold value (T. Abinaya et al., 2019).

The microcontroller utilised was the NodeMCU ESP32 that manages water quality sensors in aquaponics fishponds for both author (Udanor et al., 2022) and (Zamzari et al., 2022). Due to its built-in WiFi, the NodeMCU also serves as a Wi-Fi module (Zamzari et al., 2022).

Next, the NodeMCU ESP8266 microcontroller then processed the data gathered from the sensors. The system's circuitry and software instructions are housed on the NodeMCU ESP8266 microcontroller chip (Zuriati et al., 2021). ATmega328P (Nagib Mahfuz, 2020), Raspberry PI (Ramadani et al., 2021), and CC3200 Launchpad (Billah et al., 2019) are three examples of microcontrollers that have also been used in previous studies. The ATmega328P is an 8-bit AVR microcontroller with great performance.

2.4.3 IoT Embedded

The concept of the IoT refers to a network of connected objects with distinctive identities that may collect data, transfer data over a transmission media, and receive control signals over the same transmission means all without requiring human contact. Real-time water quality monitoring is necessary because the pond's water quality can change drastically in a matter of hours (Zamzari et al., 2022).

The IoT system will be made up of several kinds of components, including a database to store data, apps for Node Red, sensors, parts, and circuits. For fish farmers facing problems with water quality brought on by climate change, an IoT real-time water monitoring system will be the best solution (Hawari & Hazwan, 2022). Remotely monitoring both safe and dangerous water conditions is more effective with IoT (Adeleke et al., 2023)

The benefit of using IoT technology is that it can remotely and in real time monitor the condition of our ponds and other devices, so the cultivator has no trouble keeping track of and assessing the pond's state (Fachrul Rozie, 2020).

New IoT technology is being used by developed nations like the Netherlands, the US, China, and Korea to increase prawn and fish farming productivity, which has significant economic benefits and lowers production costs. Applying this innovative technique to aquaculture has also resulted in significant financial gains. The use of IoT in aquaculture is enabling this sector to transition from qualitative to precise production based on gathered data and the collection, synthesis, and analysis of statistics (Chuyen et al., 2023).

CHAPTER 3

METHODOLOGY

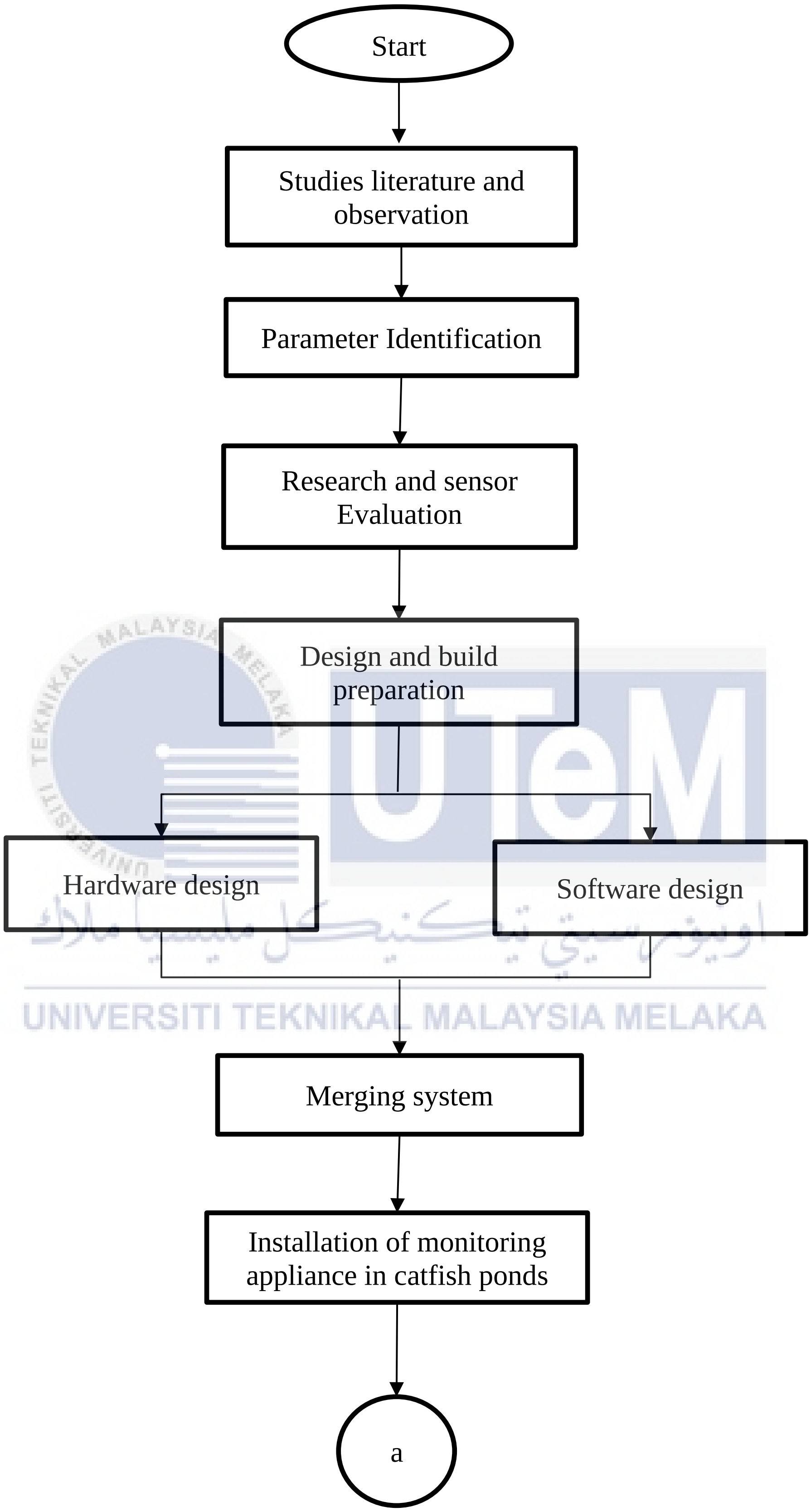
3.1 Introduction

The methodological approach utilised in the research is presented in this chapter. Based on the discussions in chapter two, it explains the methods and instruments used to collect data for the development of the application and how the research developed.

3.2 Process Flow

The process flow is depicted in the flowchart in Figure 3.1. When the project starts, it will keep track of all the water quality parameters related to the sensors employed, namely the pH, dissolved oxygen, ammonia and water temperature sensors. Users can log into the website using any device such a laptop, tablet, or mobile phone.

The research project aims to better understand the issues that catfish farmers confront, particularly in terms of water quality, and to identify key criteria that influence their health and productivity. The study then looks into the usage of IoT-based monitoring devices to gather precise data on water quality metrics. The system is planned and built, with sensors deployed in catfish ponds to provide real-time monitoring. A microcontroller processes the acquired data before uploading it to a central server for secure storage. The data is then delivered to a user interface, so catfish farmers may see real-time water quality measures and make informed decisions regarding their farming techniques.


Start
Studies literature and observation
Parameter Identification
Research and sensor Evaluation
Design and build preparation
Hardware design
Software design
Merging system
Installation of monitoring appliance in catfish ponds
a

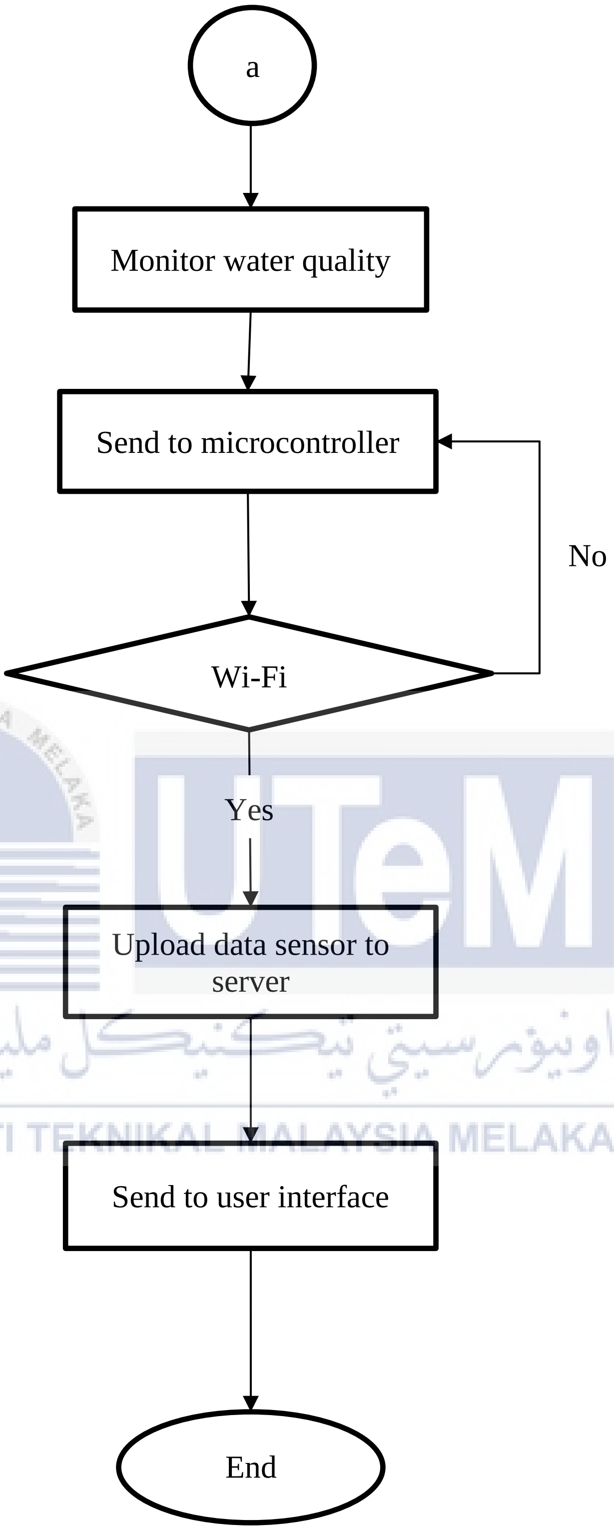


Figure 3.1 Process flow

3.3 Parameters selection

Due to the direct impact that water quality has on Catfish growth, health, and productivity, it is essential for the effective production of Catfish. Catfish farmers may dramatically lower production-related issues and increase the profitability of their businesses by determining and perfecting the ideal water quality criteria. Table 3.1 shows the ideal range for parameters of water quality.

In order for Catfish to grow and develop to their full potential, certain environmental conditions are necessary. Their metabolic rate, feed utilisation efficiency, and overall growth are directly influenced by variables like temperature, dissolved oxygen levels, and pH. Catfish can grow faster and reach market size more effectively if these factors are kept within the ideal ranges.

Table 3.1 Specification Parameter of Water Quality

Parameter	Ideal Range
Dissolved oxygen (DO) (mg/L)	5 - 8
Potential hydrogen (pH)	6.5 – 7.5
Temperature (°C)	25 - 30
Ammonia (mg/L)	0 – 0.02

3.4 Sensor deployment

Sensor deployment is essential for obtaining precise and accurate readings when water quality is being monitored for Catfish farming. Farmers are able to make knowledgeable decisions on the health and welfare of their Catfish due to accurate data. Specific water quality factors including pH, dissolved oxygen (DO), temperature and ammonia can all be measured using different sensors.

3.4.1 Dissolved oxygen sensor

Figure 3.2 show the DFROBOT Dissolved Oxygen Sensor which is used to determine the amount of dissolved oxygen in the water.

Figure 3.2 DFROBOT dissolved oxygen sensor

3.4.2 pH sensor

The pH electrode probe E-201-C sensor is shown in Figure 3.3 and is used to determine the pH level. A pH sensor used for measures the amount of alkalinity and acidity in water.

Figure 3.3 pH electrode probe E-201-C sensor

3.4.3 Temperature sensor

Figure 3.4 shows a DS18B20 waterproof temperature sensor used to track the temperature of the water's state. It determines the water's temperature in Celsius. A waterproof sensor with low power (3V-5.5V DC) consumption is the DS18B20 Digital Temperature Sensor. Digital data are shown. It can measure between -55 and 125°C with an accuracy of 0.5°C. Precision between -10°C and +85°C. In less than 750ms, this sensor can check the temperature. It is the excellent sensor for accurately sensing aquaculture's temperature (Nagib Mahfuz, 2020).

Figure 3.4 DS18B20 waterproof temperature sensor

3.4.4 Ammonia sensor

The MQ-137 ammonia gas sensor shown in Figure 3.5 is used to determine the content of ammonia. Ammonia has been found on the water's surface due to the ammonia gas sensor. The ammonia sensor was positioned above the pond's water and continuously monitors the toxicity and concentration of ammonia there (Udanor et al., 2022).

Figure 3.5 MQ-137 ammonia gas sensor

3.5 Microcontroller selection

Figure 3.6 shown NodeMCU ESP8266 microcontroller will used to regulate the water quality sensors in the aquaponic fishponds. The NodeMCU also functions as a Wi-Fi module because it has built-in WiFi.

Figure 3.6 ESP 8266

3.6 Arduino Uno

Figure 3.7 shown the Arduino is an open-source microcontroller designed by Arduino. The board contains digital and analogue input or output pins that can be attached to numerous expansion shields. It is programmable using the Arduino integrated development environment via a type B USB connector.

Figure 3.7 Arduino UNO

3.7 Switch mode power supply

A switched-mode power supply (SMPS) is an electronic power supply that uses a switching regulator to efficiently convert electrical power. An SMPS, like other power supplies, transfers power from a DC or AC source (often mains power; see AC adapter) to DC loads, such as a personal computer, while converting voltage and current characteristics.

Figure 3.8 SMPS

3.8 Blynk application

The Blynk application connects data from the microcontroller to the smartphone. For this project, the Blynk application used nodeMCU to connect to the cloud via Wi-Fi. It displays parameter values from sensors and on the smartphone.

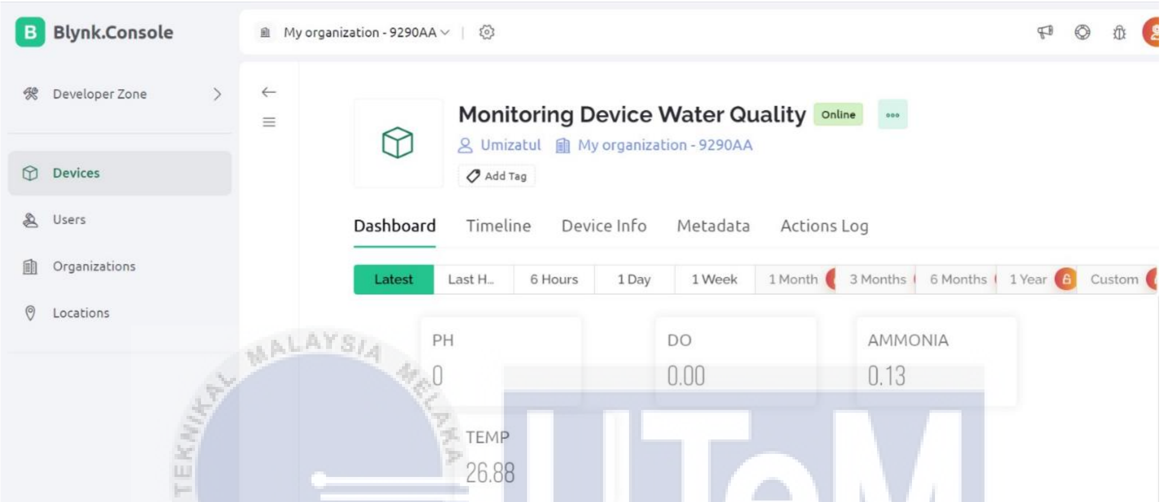


Figure 3.9 Blynk application

3.9 Coding component

The main system's functionality was to monitor the water quality parameters of the fish pond. The sensors deployed would monitor the various water quality parameters. The system administrator must use the IDE to write instruction code for the sensors. Figure 3.10 depicts the code that illustrates the overall structure of the programme execution. To establish a secure connection with the server, initialise the hardware using the appropriate libraries and provide the authentication code. The primary execution function uses a loop to constantly query the sensors at predetermined intervals. Figure 3.11 displays a sample execution code for measuring water levels. The blynk app executes a function that operates in PUSH mode to update the water level widget.

```
#include <Arduino.h>
#include <OneWire.h>
#include <SoftwareSerial.h>
#include <ArduinoJson.h>
#include <EEPROM.h>
#include <Wire.h>
#include <LiquidCrystal_I2C.h>

#define RL 47  //The value of resistor RL is 47K
#define m -0.263 //Enter calculated Slope
#define b 0.42 //Enter calculated intercept
#define Ro 150 //Enter found Ro value
#define MQ_sensor A1 //Sensor is connected to A4
#define DO_PIN A2
#define fan 7

#define VREF 5000    //VREF (mv)
#define ADC_RES 1024 //ADC Resolution

//Single-point calibration Mode=0
//Two-point calibration Mode=1
#define TWO_POINT_CALIBRATION 0

#define READ_TEMP (25) //Current water temperature ℃, Or temperature sensor function



//Single point calibration needs to be filled CAL1_V and CAL1_T
#define CAL1_V (1400) //mv 131
#define CAL1_T (29)   //℃ 25
//Two-point calibration needs to be filled CAL2_V and CAL2_T
//CAL1 High temperature point, CAL2 Low temperature point
#define CAL2_V (1300) //mv
#define CAL2_T (15)   //℃

const uint16_t DO_Table[41] = {
  14460, 14220, 13820, 13440, 13090, 12740, 12420, 12110, 11810, 11530,
  11260, 11010, 10770, 10530, 10300, 10080, 9860, 9660, 9460, 9270,
  9080, 8900, 8730, 8570, 8410, 8250, 8110, 7960, 7820, 7690,
  7560, 7430, 7300, 7180, 7070, 6950, 6840, 6730, 6630, 6530, 6410
};

uint8_t Temperaturet;
uint16_t ADC_Raw;
uint16_t ADC_Voltage;
uint16_t DO;

int16_t readDO(uint32_t voltage_mv, uint8_t temperature_c)
{
#if TWO_POINT_CALIBRATION == 00
  uint16_t V_saturation = (uint32_t)CAL1_V + (uint32_t)35 * temperature_c - (uint32_t)CAL1_T * 35;
  return (voltage_mv * DO_Table[temperature_c] / V_saturation);
```

```
#else
  uint16_t V_saturation = (int16_t)((int8_t)temperature_c - CAL2_T) * ((uint16_t)CAL1_V - CAL2_V) / ((uint8_t)CAL1_T - CAL2_T) + CAL2_V;
  return (voltage_mv * DO_Table[temperature_c] / V_saturation);
#endif
}

#define SCOUNT  30

const int NumReadings = 5;
int Index = 0;

int PhReadings[NumReadings];
int PhTotal = 0;
int PhAverage = 0;

double Ph7Buffer = 6.86;
double Ph4Buffer = 4.00;


double Ph7Reading = 720; //720
double Ph4Reading = 775; //775


double PhRatio = 0;
double PhValue = 0;



float voltage, phValue;
int samples = 10;
float adc_resolution = 1024.0;
int analogBuffer[SCOUNT];
int analogBufferTemp[SCOUNT];
int analogBufferIndex = 0;
int copyIndex = 0;

float averageVoltage = 0;
//float temperature = 16;
float temperature = 25;

OneWire  ds(2);  // on pin 7 (a 4.7K resistor is necessary)

LiquidCrystal_I2C lcd(0x27, 16, 2);
SoftwareSerial nodeMCU(8, 9 );
boolean state1 = true;
boolean state2 = true;

int reading() {

  PhTotal = PhTotal - PhReadings[Index];
  PhReadings[Index] = analogRead(A0);

  PhTotal = PhTotal + PhReadings[Index];
  Index = Index + 1;



  if (Index >= NumReadings) {
    Index = 0;
    PhAverage = PhTotal / NumReadings;
  }
  PhValue = (Ph7Reading - PhAverage) / PhRatio + Ph7Buffer;

}
void setup() {
  pinMode(MQ_sensor, INPUT);
  pinMode(fan, OUTPUT);
  digitalWrite(fan, LOW);
  Serial.begin(115200);
  nodeMCU.begin(9600);
  lcd.begin();
  lcd.backlight();
  lcd.clear();

  for (int PhThisReading = 0; PhThisReading < NumReadings; PhThisReading++)
    PhReadings[PhThisReading] = 0;

  PhRatio = (Ph4Reading - Ph7Reading) / (Ph7Buffer - Ph4Buffer);
}

void loop() {
```

```
StaticJsonBuffer<200> jsonBuffer;
JsonObject& data = jsonBuffer.createObject();

digitalWrite(fan, HIGH);

reading();

delay(15);

float temperature_Read = readTemperature();          // read your temperature sensor to execute temperature compensation

delay(15);

Temperaturet = (uint8_t)READ_TEMP;
ADC_Raw = analogRead(DO_PIN);
ADC_Voltage = uint32_t(VREF) * ADC_Raw / ADC_RES;

unsigned int DO_read = (readDO(ADC_Voltage, Temperaturet) / 1000);

delay(15);

float VRL; //Voltage drop across the MQ sensor
float RS; //Sensor resistance at gas concentration
float ratio; //Define variable for ratio



VRL = analogRead(MQ_sensor) * (5.0 / 1023.0); //Measure the voltage drop and convert to 0-5V
RS = ((5.0 * RL) / VRL) - RL; //Use formula to get Rs value
ratio = RS / Ro; // find ratio Rs/Ro
float ppm = pow(10, ((log10(ratio) - b) / m));

lcd.clear();
lcd.setCursor(0, 0);
lcd.print("PH:");
lcd.setCursor(3, 0);
lcd.print(PhValue, 2);
lcd.setCursor(9, 0);
lcd.print("T:");
lcd.setCursor(11, 0);
lcd.print(temperature_Read);
lcd.setCursor(0, 1);
lcd.print("DO:");
lcd.setCursor(3, 1);
lcd.print((readDO(ADC_Voltage, Temperaturet) / 1000));
Serial.println("DO:\t" + String((readDO(ADC_Voltage, Temperaturet) / 1000)) + "\t");
lcd.setCursor(9, 1);
lcd.print("G:");
lcd.setCursor(11, 1);
lcd.print(ppm);
```

```
  data["PH"] = PhValue;
  data["DO"] = (readDO(ADC_Voltage, Temperaturet) / 1000);
  data["AM"] = ppm;
  data["T"] = temperature_Read;
  data.printTo(nodeMCU);
  jsonBuffer.clear();

//  delay(2000);
}

float readTemperature()
{
  byte i;
  byte present = 0;
  byte type_s;
  byte data[12];
  byte addr[8];
  float celsius;

  if ( !ds.search(addr)) {
    //    Serial.println("No more addresses.");
    //    Serial.println();
    ds.reset_search();
    delay(250);
    return;
  }
```

```
//  Serial.print("ROM =");
for ( i = 0; i < 8; i++) {
  //    Serial.write(' ');
  //    Serial.print(addr[i], HEX);
}

if (OneWire::crc8(addr, 7) != addr[7]) {
  //    Serial.println("CRC is not valid!");
  return;
}
//  Serial.println();

// the first ROM byte indicates which chip
switch (addr[0]) {
  case 0x10:
    //      Serial.println("  Chip = DS18S20");  // or old DS1820
    type_s = 1;
    break;
  case 0x28:
    //      Serial.println("  Chip = DS18B20");
    type_s = 0;
    break;
  case 0x22:
    //      Serial.println("  Chip = DS1822");
    type_s = 0;
    break;
```

```
    default:
      //      Serial.println("Device is not a DS18x20 family device.");
      return;
  }

  ds.reset();
  ds.select(addr);
  ds.write(0x44, 1);        // start conversion, with parasite power on at the end

  delay(1000);     // maybe 750ms is enough, maybe not
  // we might do a ds.depower() here, but the reset will take care of it.

  present = ds.reset();
  ds.select(addr);
  ds.write(0xBE);         // Read Scratchpad

  //  Serial.print("  Data = ");
  //  Serial.print(present, HEX);
  //  Serial.print(" ");
  for ( i = 0; i < 9; i++) {           // we need 9 bytes
    data[i] = ds.read();
    //    Serial.print(data[i], HEX);
    //    Serial.print(" ");
  }



  //  Serial.print(" CRC=");
  //  Serial.print(OneWire::crc8(data, 8), HEX);
  //  Serial.println();

  // Convert the data to actual temperature
  // because the result is a 16 bit signed integer, it should
  // be stored to an "int16_t" type, which is always 16 bits
  // even when compiled on a 32 bit processor.
  int16_t raw = (data[1] << 8) | data[0];
  if (type_s) {
    raw = raw << 3; // 9 bit resolution default
    if (data[7] == 0x10) {
      // "count remain" gives full 12 bit resolution
      raw = (raw & 0xFFF0) + 12 - data[6];
    }
  } else {
    byte cfg = (data[4] & 0x60);
    // at lower res, the low bits are undefined, so let's zero them
    if (cfg == 0x00) raw = raw & ~7;  // 9 bit resolution, 93.75 ms
    else if (cfg == 0x20) raw = raw & ~3; // 10 bit res, 187.5 ms
    else if (cfg == 0x40) raw = raw & ~1; // 11 bit res, 375 ms
    //// default is 12 bit resolution, 750 ms conversion time
  }
  celsius = (float)raw / 16.0;
  return (celsius);
}
```

Figure 3.10 Coding

```
#define BLYNK_TEMPLATE_ID "TMPL6Ya1Fne0t"
#define BLYNK_TEMPLATE_NAME "Monitoring Device Water Quality"
#define BLYNK_AUTH_TOKEN "WX37y6kd-ey98ek6J1CrEfwNDgewFKpj"


// Comment this out to disable prints and save space
#define BLYNK_PRINT Serial


#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>

char auth[] = BLYNK_AUTH_TOKEN;

// Your WiFi credentials.
// Set password to "" for open networks.
char ssid[] = "dlink-12E0";
char pass[] = "kuwnh36237";

BlynkTimer timer;
BlynkTimer timer1;

//const int baja1 = D1; //D1
//const int baja2 = D2; // D4
//const int pump = D7; // D4
//



//int baja_1 = 0;
//int baja_2 = 0;
//int lock;
//int locker;


#include <SoftwareSerial.h>
#include <ArduinoJson.h>

//D5 = Rx & D6 = Tx
SoftwareSerial nodemcu(D7, D8);

void send_data() {
  StaticJsonBuffer<200> jsonBuffer;
  JsonObject& data = jsonBuffer.parseObject(nodemcu);

  if (data == JsonObject::invalid()) {
    Serial.println("Invalid Json Object");
    jsonBuffer.clear();
    return;
  }
```

```
  Serial.println("JSON Object Received");
  Serial.print("Received PH:  ");
  float phReading = data["PH"];
  Serial.println(phReading);
  Blynk.virtualWrite(V0, phReading);

  Serial.print("Received DO:  ");
  float doReading = data["DO"];
  Serial.println(doReading);
  Blynk.virtualWrite(V1, doReading);

  Serial.print("Received AM:  ");
  float amReading = data["AM"];
  Serial.println(amReading);
  Blynk.virtualWrite(V2, amReading);

  Serial.print("Received T:  ");
  float tReading = data["T"];
  Serial.println(tReading);
  Blynk.virtualWrite(V3, tReading);

  Serial.println("----------------------------------------");



}

//void send_Sensor() {
//
//  //  if ((lock == 1) && (locker == 1)) {
//  //    digitalWrite(D7, HIGH);
//  //  }
//
//}

//BLYNK_WRITE(V3) {
//  baja_1 = param.asInt();
//  Serial.println(baja_1);
//  if (baja_1 == 1)  {
//    digitalWrite(D1, HIGH);
//    delay(1000);
//    digitalWrite(D1, LOW);
//    lock = 1;
//    Serial.println(lock);
//  }
//
//  //  else {
//  //    digitalWrite(D1, LOW);
//  //    lock = 0;
```

```
// //    Serial.println(locker);
// //  }
//
//}

//BLYNK_WRITE(V4) {
//  baja_2 = param.asInt();
//  Serial.println(baja_2);
//  if (baja_2 == 1)  {
//    digitalWrite(D2, HIGH);
//    delay(1000);
//    digitalWrite(D2, LOW);
//    locker = 1;
//  }
//
// //  else {
// //    digitalWrite(D2, LOW);
// //    locker = 0;
// //  }
//
//}

void setup() {


  Serial.begin(9600);
  nodemcu.begin(9600);
  while (!Serial) continue;
  Blynk.begin(auth, ssid, pass);
  timer.setInterval(100L, send_data);
//  timer1.setInterval(100L, send_Sensor);

}

void loop() {
  Blynk.run();
  timer.run();
  timer1.run();
}
```

Figure 3.11 Execution code

3.10 Block diagram of purposed system

Figure 3.12 depicts a block diagram for Water Quality Monitoring. This project uses an Arduino as the primary controller to process data from input to output. The system is powered by an alternative current as the primary power supply. Four types of input sensors will be employed to measure water quality parameters such as pH, temperature, dissolved oxygen, and ammonia. Data will be saved in the cloud and accessible through user interface devices like laptops and mobile phones for monitoring purposes.

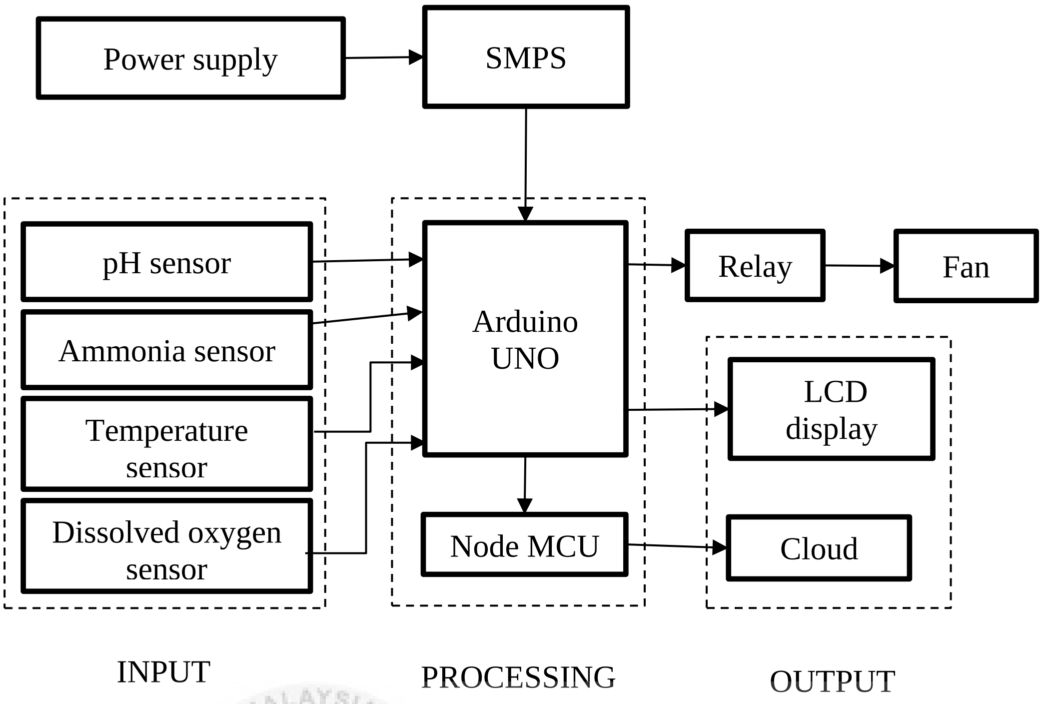


Figure 3.12 Block diagram

3.11 Experimental Setup

The sensors are positioned in the water to prepare the experiment for testing the monitoring system's operation as shown in Figure 3.13. The water used to test the sensors is a simulation of the water found in a at fish tank, with the exception that it does not filter out the chlorine, which has no impact on the reading the sensors produce.

The temperature sensor, pH sensor, DO sensor, and ammonia sensor will all be tested as a result. Catfish farmers can depend on the accuracy and dependability of the data gathered by testing these sensors. This makes it possible for immediate actions and modifications to maintain the best possible circumstances for Catfish water quality, encouraging their health, growth, and overall production.

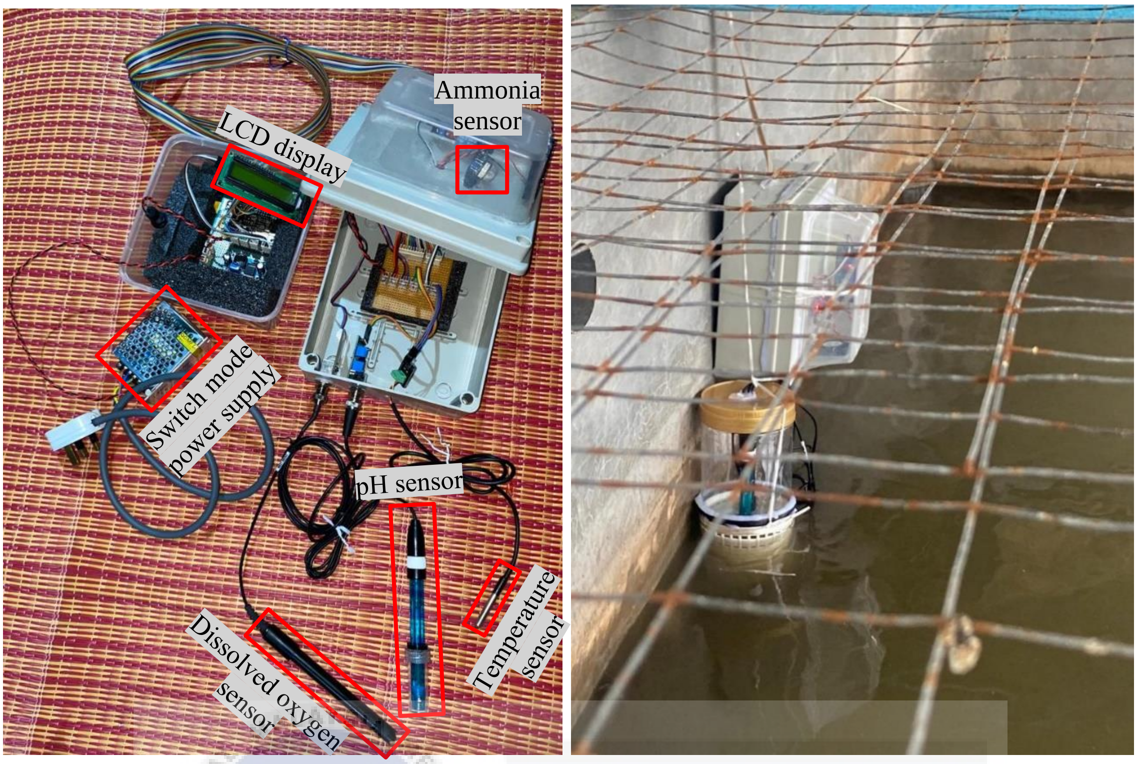


Figure 3.13 Experimental setup

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

This system monitors water quality parameters such as temperature, pH, dissolved oxygen, and ammonia toxicity using the Blynk application and the node MCU ESP 8266 microcontroller. The sensor data was presented and recorded in the Blynk app.

4.2 Data collection

Table 4.1 displays data obtained from the monitoring system during 24 hours. Water quality data samples in catfish ponds are automatically measured using a variety of sensors, including dissolved oxygen, pH, temperature, and ammonia.

Data will be processed by an embedded controller and transmitted to a Blynk in real-time. Data collected is automatically analysed by the controller system. The Blynks apps will display all water quality data.

Table 4.1 Data collection

Time	Dissolved oxygen (mg/L)	pH	Temperature (°C)	Ammonia (ppm)
0	0	6.08	26.5	0.2
1	0	6.7	26.48	0.22
2	0	5.92	26.5	0.24
3	0	8	26.44	0.26
4	0	8.21	26.44	0.28
5	0	6.7	26.44	0.28
6	0	8.21	26.44	0.26
7	0	10.19	26.38	0.26
8	0	4.42	26.38	0.15
9	0	7.54	26.38	0.15
10	0	7.74	26.4	0.19
11	0	10.55	26.4	0.22
12	0	8.21	26.44	0.18
13	0	5.46	26.69	0.15
14	0	4.78	26.81	0.19
15	0	4.52	26.88	0.18
16	0	4.05	26.88	0.17
17	0	4.21	26.88	0.15
18	0	3.38	26.88	0.15
19	0	2.75	26.65	0.17
20	0	4.78	26.56	0.17
21	0	3.53	26.56	0.19
22	0	4.03	26.5	0.18
23	0	4.32	26.5	0.2

4.3 Dissolved oxygen analysis

Accurate measurement of dissolved oxygen (DO) is crucial in aquaculture, particularly catfish farming, because it has a direct impact on the health and growth of aquatic life. However, throughout the data collection phase, difficulties in retrieving precise values for dissolved oxygen presented an unforeseen barrier. The sensor utilised could only provide whole number numbers, so when immersed in the pond, it produced empty readings.

Closer analysis and subsequent experimentation revealed that the sensor's limitations precluded it from capturing DO values below 1. This limitation was clear when the sensor was tested in a controlled environment with air bubbles, which produced whole number responses. This means that the dissolved oxygen levels in the catfish pond may fall below the sensor's minimum detectable threshold, potentially suggesting values less than 1.

It is important to note that the absence of recorded dissolved oxygen values does not mean that the DO level in the catfish pond is zero, as fish can survive in water with low but still present oxygen concentrations. However, the sensor's failure to record these lower levels creates a barrier in providing a full assessment of water quality.

In conclusion, while dissolved oxygen data for the catfish pond remains unattainable due to sensor limitations, recognising this limitation encourages advancements in sensor technology, resulting in more robust monitoring systems for comprehensive water quality assessment in catfish farming and other aquaculture contexts.

4.4 pH analysis

The monitoring of pH levels is critical in assessing water quality for catfish farming since it has a significant impact on the health and growth of aquatic animals. However, an unforeseen problem developed during the data collection phase about the accuracy of pH readings. Figure 4.1 show that the resulting pH value graph showed erratic oscillations, implying abrupt and quick changes in pH values that appeared incongruous and impossible.

After thorough analysis, it was discovered that the inconsistent behaviour shown in the pH value graph could be related to the use of an inaccurate and poor pH sensor. The sensor's poor quality led in incorrect readings, which depicted extremely rapid variations in pH levels. This instability indicates an inconsistent and variable pH reading, which does not correspond to the predicted and realistic pH changes found in the catfish farming environment.

The irregularity in the pH value graph emphasises the importance of using high-quality, precise sensors in water quality monitoring systems. The inconsistencies created by the faulty pH sensor restricted the collection of consistent and reliable pH data, restricting our capacity to monitor and respond effectively to swings in water quality indicators.

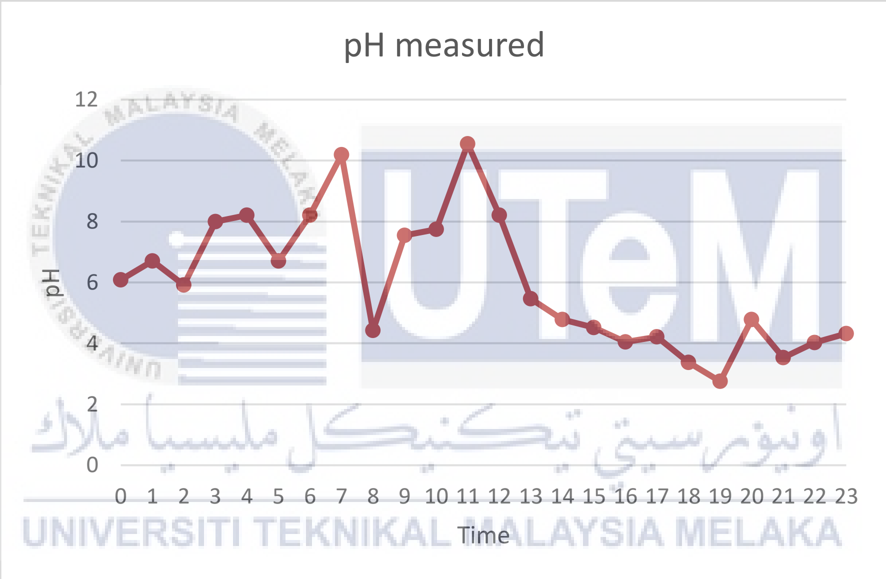


Figure 4.1 pH graph

4.5 Temperature analysis

Monitoring water temperature is an essential aspect of determining and maintaining optimal conditions for catfish production. The temperature data collected over a 24-hour period, from 0000 to 2300, depicts changes in water temperature in the catfish farming environment. Based on Figure 4.2, temperatures ranged from 26.38°C to 26.88°C throughout the monitoring period.

Temperature changes in the catfish pond follow different patterns during the observation period. Temperatures dropped significantly between midnight until 9 a.m., indicating a progressive cooling trend in the aquatic environment. The drop may be attributed to a variety of midnight variables, such as no sunlight and cooler surrounding air temperatures, resulting in a decrease in overall water temperature.

Following the graph, temperatures increased until 1400 hours. This upward pattern reflects a period of warming, which may be affected by increased solar radiation and daytime heating impacts. The temperature increase over this time period could also be attributed to external factors such as air temperature, sunlight exposure, and changes in water movement or circulation inside the pond.

From 1500 to 1800 hours, the temperature stabilised at 26.88 degrees Celsius. This continuous temperature range represents a period of relative thermal balance in the pond. The catfish pond's temperature remains steady during these hours, indicating a balance between external and internal environmental variables governing it.

However, after this stable phase, a decrease in temperature was noted between 6 and 2300 hours. The temperature drop during this time period could be impacted by variables such as reduced sunshine exposure and cooling of the surrounding environment.

In conclusion, the observed temperature changes highlight the significance of continuous monitoring and management of water temperature in catfish ponds. These insights enable informed decision-making aimed at maintaining optimal circumstances for successful catfish farming.

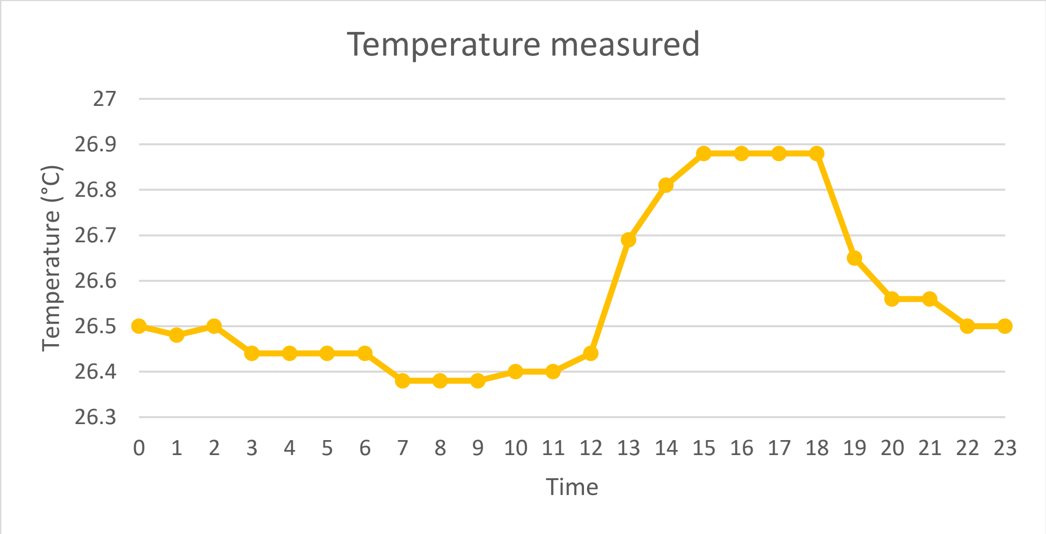


Figure 4.2 Temperature Graph

4.6 Ammonia level analysis

Figure 4.3 shown the observed ammonia levels in the catfish pond show noticeable changes across the 24-hour observation period. These fluctuations indicate dynamic processes occurring in the aquatic environment, which may be influenced by elements such as organic decomposition and fish waste.

From midnight to 0400 hours, ammonia levels increased significantly, from 0.2 ppm to 0.28 ppm. This increase shows increased ammonia production, which might be attributed to organic matter decomposition, or waste development in the pond environment.

Following the increase, ammonia levels remained reasonably stable until 0500 hours, when they reached 0.28 ppm, indicating a period of ammonia concentration stability. Ammonia levels then decreased, reaching 0.15 ppm at 0900 hours. This drop could be attributable to increased microbial action, potential aeration effects, or decreased ammonia generation due to changes in environmental conditions during the early daylight hours.

However, ammonia levels changed between 0900 hours and 1900 hours, with alternating increases and decreases ranging from 0.15 ppm to 0.2 ppm. These variations could be the result of a complex interaction of factors, such as feed inputs or changes in water quality parameters that influence ammonia generation and removal.

Additionally, from 1900 until 2300 hours, ammonia levels consistently increased before stabilising at 0.2 ppm. This kept increase reflects a potential change in environmental circumstances, increased waste production, or decreased removal mechanisms during this time, resulting in an increase in ammonia concentrations inside the pond.

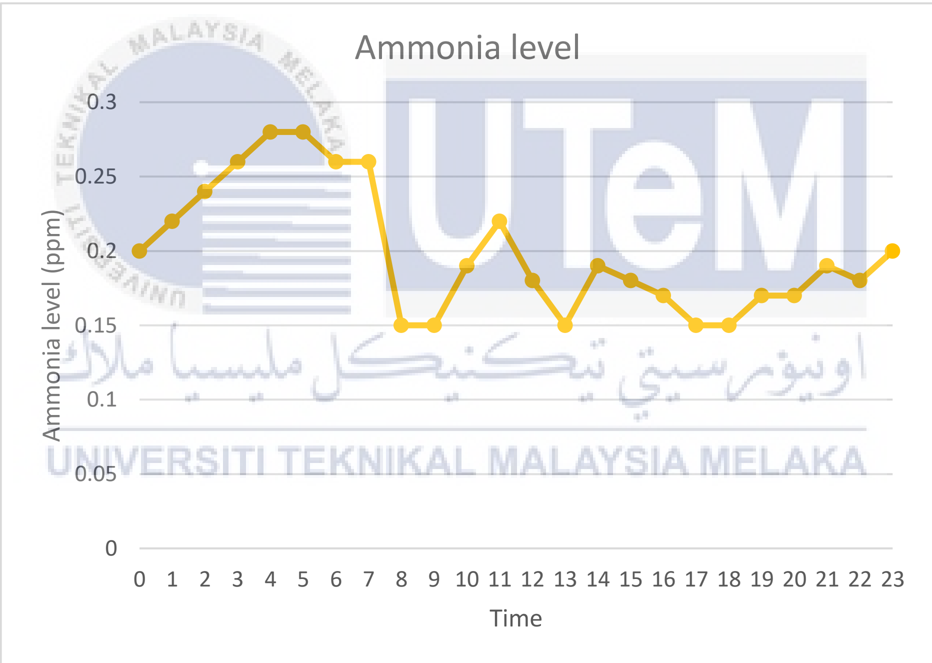


Figure 4.3 Ammonia graph

CHAPTER 5

CONCLUSION

5.1 Conclusion

Aquaculture, especially catfish farming, appears as a essential option in the search of sustainable food supply to fulfil the world's ever-increasing need. The end of this research journey was the development of an innovative IoT-based monitoring system customised to the specific issues faced by catfish farmers in Alai, Melaka. This thesis aims to improve catfish farming practices and, by extension, the larger field of aquaculture by thoroughly investigating the background, problem definition, research objectives, and actual execution of the system.

Monitoring water quality is crucial for fish survival due to their sensitivity to environmental changes. This study found that most fish farmers do not regularly check water quality for changing conditions. This has resulted in losses and made fish farming an expensive attempt because farmers spend in expensive supplies such as feeds, which do not transfer into earnings. Real-time monitoring and response are essential for addressing environmental changes.

The methodology used Internet of Things (IoT) technologies, including sensors, microcontrollers, and a customised app for seamless data visualisation. The use of particular sensors, such as the DFROBOT Dissolved Oxygen Sensor, pH electrode probe, DS18B20 waterproof temperature sensor, and MQ-137 ammonia gas sensor, addressed the critical need for precise readings while monitoring water quality parameters.

Despite the demanding development and execution of the system, difficulties were encountered during the data collection and analysis stages. The dissolved oxygen sensor's limitations in catching readings less than 1 highlighted the need for advances in sensor technology. The variability in pH measurements was traced back to the use of a low-quality sensor, highlighting the vital need of using precise sensors to obtain reliable results. However, the constant monitoring of water temperature and ammonia levels demonstrated the IoT-based system's ability to deliver useful insights into the changing aquatic environment.

In conclusion, the developed IoT-based monitoring system for water quality in catfish farming represents a significant step towards sustainable aquaculture methods. Despite its shortcomings, the system serves as a platform for continual improvement and innovation. Monitoring temperature and ammonia levels reveals the significance of proactive management for optimal conditions in catfish ponds.

5.2 Recommendations

Following reviewing literature and questioning experts, it became clear that there are several aspects to consider when ensuring catfish welfare. Additional sensors could be added to expand the model to a fully operating system. The limitations discovered with dissolved oxygen and pH sensors highlight the essential requirement for advances in sensor technology. Future research should concentrate on the creation and integration of more precise and dependable sensors for these parameters.

Implement a regular calibration programme for all sensors connected to the IoT-based monitoring system. Regular calibration ensures that the sensors deliver consistent and accurate data over time. Establishing a regular calibration methodology would improve the precision of water quality data, increasing the overall usefulness of the monitoring system.

5.3 Project potential

The development of an IoT-based monitoring system for water quality in catfish farming has immense consequences for both the aquaculture industry as well as environmental sustainability. As we end our research, it is critical that we investigate and communicate the different aspects of the project's potential impact, as well as the options it opens for future developments.

The project's principal potential is to significantly boost the efficiency of catfish farming operations. The IoT system's real-time monitoring capabilities allow farmers to proactively regulate water quality factors like pH, dissolved oxygen, temperature, and ammonia levels. This, in turn, creates ideal circumstances for catfish development, health, and productivity.

The use of IoT technology in catfish farming corresponds with larger sustainability goals. The capacity to monitor and regulate water quality parameters in real time helps to promote sustainable and responsible practices in the aquaculture sector. It reduces the environmental impact of fish farming by avoiding excessive resource usage and limiting risks associated with poor water quality.

Beyond immediate farming applications, the project's potential includes long-term environmental monitoring. The acquired data can be used to inform broader environmental research projects, providing insights into the influence of aquaculture on local ecosystems.

This data-driven strategy is consistent with worldwide attempts to balance food production with environmental conservation.

In conclusion, the project's potential is multifaceted, with transformative implications for the catfish farming sector and beyond. From economic rewards and sustainability improvements to technological innovation and educational opportunities, the IoT-based monitoring system is a revolutionary attempt with far-reaching consequences for aquaculture and environmental stewardship.

REFERENCES

Adeleke, I. A., Nwulu, N. I., & Ogbolumani, O. A. (2023). A hybrid machine learning and embedded IoT-based water quality monitoring system. *Internet of Things (Netherlands)*, *22*. https://doi.org/10.1016/j.iot.2023.100774

Ahmad, I., Ridzuan, N. I. S. N., Hassan, W. N. H. A. W., & Maz, M. R. R. (2020). Water quality monitoring using wireless sensor networks. *AIP Conference Proceedings*, *2291*. https://doi.org/10.1063/5.0025040

Arafat, A. I., Akter, T., Ahammed, M. F., Ali, M. Y., & Nahid, A. Al. (2020). A dataset for internet of things based fish farm monitoring and notification system. *Data in Brief*, *33*. https://doi.org/10.1016/j.dib.2020.106457

Billah, M., Mohd, Z., #2, Y., Kadir, K., Malik, A., Ali, M., & #5, I. A. (2019). *Quality Maintenance of Fish Farm: Development of Real-time Water Quality Monitoring System*. http://18.218.173.185:1880/ui

Chuyen, T. D., Nguyen, D. D., Cuong, N. C., & Thong, V. V. (2023). Design and manufacture control system for water quality based on IoT technology for aquaculture in the Vietnam. *Bulletin of Electrical Engineering and Informatics*, *12*(4), 1893–1900. https://doi.org/10.11591/eei.v12i4.5180

Environmental Protection Agency. (2023). *Indicators: Dissolved Oxygen*. Environmental Protection Agency. https://www.epa.gov/national-aquatic-resource-surveys/indicators-dissolved-oxygen

Fachrul Rozie, I. S. M. U. H. A. R. (2020). *Design and implementation of Intelligent Aquaponics Monitoring System based on IOT*.

Fajar Budiman, M. R. M. A. N. (2019). *Monitoring and Control System for Ammonia and pH Levels for Fish Cultivation Implemented on Raspberry Pi 3B*.

Gao, G., Xiao, K., & Chen, M. (2019). An intelligent IoT-based control and traceability system to forecast and maintain water quality in freshwater fish farms. *Computers and Electronics in Agriculture*, *166*. https://doi.org/10.1016/j.compag.2019.105013

Hawari, H. F., & Hazwan, M. A. (2022). Development of Iot Monitoring System for Aquaculture Application. *2022 International Conference on Green Energy, Computing and Sustainable Technology, GECOST 2022*, 330–334. https://doi.org/10.1109/GECOST55694.2022.10010661

Jabatan Perikanan Malaysia. (2021, July 15). *Akuakultur*. https://www.dof.gov.my/soalan-lazim/faq-akuakultur/

Nagib Mahfuz, S. Md. A.-M. (2020). *Smart Monitoring and Controlling System for Aquaculture of Bangladesh to Enhance Robust Operation*.

Ndlovu, S., Moyo, S., Nleya, S., & Dube, S. (2022). Precision Fish Farming Systems: A Mapping Study. *2022 1st Zimbabwe Conference of Information and Communication Technologies, ZCICT 2022*. https://doi.org/10.1109/ZCICT55726.2022.10045996

Perikanan, J., Bahagian Dasar, M., Perancangan, D., Aras, S., & Presint, W. T. (2022). *Annual Fisheries Statistics 2021 (Volume 1)*.

Ramadani, M. E., Raafi'u, B., Mursid, M., Ash-Shiddieqy, R. H., Zain, A. T., & Fauzan Ladziimaa, A. (2021). Design and Development of Monitoring System on Carp Farming Ponds As IoT- Based Water Quality Control. *ICRACOS 2021 - 2021 3rd International Conference on Research and Academic Community Services: Sustainable Innovation in Research and Community Services for Better Quality of Life towards Society 5*, 148–153. https://doi.org/10.1109/ICRACOS53680.2021.9701980

Rohim, A. M., Cahyono, E., & Iswari, R. S. (2022). Development of Tools Growth Catfish Based on the Internet of Things (IoT). *Physics Education Research Journal*, *4*(1), 51–56. https://doi.org/10.21580/perj.2022.4.2.12178

Suherman, T. E., Widianto, M. H., & Athalia, Z. (2022). Internet of Things System for Freshwater Fish Aquarium Monitoring and Automation Using Iterative Waterfall. *2022 4th International Conference on Cybernetics and Intelligent System, ICORIS 2022*. https://doi.org/10.1109/ICORIS56080.2022.10031310

T. Abinaya, J. Ishwarya, & M. Maheswari. (2019). *A Novel Methodology for Monitoring and Controlling of Water Quality in Aquaculture using Internet of Things (IoT)*.

Tumwesigye, Z., Tumwesigye, W., Opio, F., Kemigabo, C., & Mujuni, B. (2022). The Effect of Water Quality on Aquaculture Productivity in Ibanda District, Uganda. *Aquaculture Journal*, *2*(1), 23–36. https://doi.org/10.3390/aquacj2010003

Udanor, C. N., Ossai, N. I., Nweke, E. O., Ogbuokiri, B. O., Eneh, A. H., Ugwuishiwu, C. H., Aneke, S. O., Ezuwgu, A. O., Ugwoke, P. O., & Christiana, A. (2022). An internet of things labelled dataset for aquaponics fish pond water quality monitoring system. *Data in Brief, 43*. https://doi.org/10.1016/j.dib.2022.108400

United Nations Population Fund. (2022). *8 billion lives, Infinite Possibilities*. United Nations Population Fund. https://www.unfpa.org/swp2023

Worldometer. (2023). *Current world population*. Worldometer. https://www.worldometers.info/world-population/

Yasruddin, M. L., Amir Hakim Ismail, M., Husin, Z., & Tan, W. K. (2022). Development of Automated Real-Time Water Quality Monitoring and Controlling System in Aquarium. *2022 12th IEEE Symposium on Computer Applications and Industrial Electronics, ISCAIE 2022*, 241–245. https://doi.org/10.1109/ISCAIE54458.2022.9794472

Yoyok Sukrismon, A. N. H. N. M. A. N. H. G. J. H. (2019). *Smart Fish Pond for Economic Growing in Catfish Farming*.

Zamzari, N. Z., Kassim, M., & Yusoff, M. (2022). Analysis and Development of IoT-based Aqua Fish Monitoring System. *International Journal of Emerging Technology and Advanced Engineering*, *12*(10), 191–197. https://doi.org/10.46338/ijetae1022_20

Zuriati, Z., Supriyatna, A. R., & Arifin, O. (2021). Design and Development of Feeding Automation System and Water Quality Monitoring on Freshwater Fish Cultivation. *IOP Conference Series: Earth and Environmental Science*, *1012*(1). https://doi.org/10.1088/1755-1315/1012/1/012077

APPENDICES

APPENDIX A Gantt chart for PSM 1.

Development of an IoT-Based Monitoring System for Water Quality in Catfish Farming.		Mar 2023		April 2023			May 2023					June 2023			
Task	**Plan vs Actual**	**W1**	**W2**	**W3**	**W4**	**W5**	**W6**	**W7**	**W8**	**W9**	**W10**	**W11**	**W12**	**W13**	**W14**
Define project objective	Plan														
	Actual														
Conduct literature review	Plan														
	Actual														
Identify water quality parameter	Plan														
	Actual														
Select appropriate IoT sensor	Plan														
	Actual														
Identifying Data Analysis and Visualization Needs	Plan														
	Actual														
Researching Cloud-Based Storage Solutions	Plan														
	Actual														
Submission of Draft Final Report PSM 1 and presentation	Plan														
	Actual														

APPENDIX B Gantt chart for PSM 2

PSM 2 SCHEDULE															
Development of an IoT-Based Monitoring System for Water Quality in Catfish Farming.		**October 2023**				**November 2023**				**December 2023**			**January 2024**		
Task	**Plan vs Actual**	**W1**	**W2**	**W3**	**W4**	**W5**	**W6**	**W7**	**W8**	**W9**	**W10**	**W11**	**W12**	**W13**	**W14**
Phase 1: System Design															
Design overall system architecture	Plan														
	Actual														
Develop data acquisition module	Plan														
	Actual														
Design cloud-based data storage	Plan														
	Actual														
Develop mobile app interface	Plan														
	Actual														
Phase 2: Implementation															
Purchase IoT sensors and equipment	Plan														
	Actual														
Install and integrate sensors	Plan														
	Actual														
Set up cloud-based storage	Plan														
	Actual														
Develop real-time data visualization	Plan														
	Actual														
Phase 3: Testing and Evaluation															
Conduct system functionality tests	Plan														
	Actual														
Perform water quality measurements	Plan														
	Actual														
Analyze data and evaluate system	Plan														
	Actual														
Phase 4: Documentation and Finalization															
Prepare project report	Plan														
	Actual														
Finalize project documentation	Plan														
	Actual														